# GREATER VANCOUVER GATEWAY COUNCIL

## LOWER MAINLAND RAIL INFRASTRUCTURE STUDY

# Final Report

December 17, 2004

Transport Canada / Transports Canada

Western Economic Diversification Canada / Diversification de l'économie de l'Ouest Canada

City of Vancouver, British Columbia · Canada

British Columbia Ministry of Transportation

Greater Vancouver Transportation Authority GVTA

BOREALIS

CN

PORT VANCOUVER

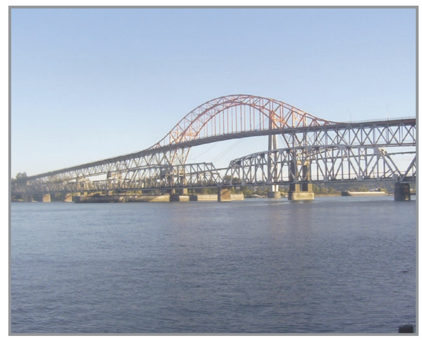
FRASER RIVER PORT

Canadian Pacific Railway

BNSF Burlington Northern Santa Fe Railway

Southern Railway of British Columbia

RAC The Railway Association of Canada



IBI GROUP

in association with

Hatch Mott MacDonald, Golder Associates Ltd. & PricewaterhouseCoopers LLP

December 17, 2004

Mr. R.V. Wilds
Managing Director
Greater Vancouver Gateway Council
#1905 – 800 Robson Street
UBC @ Robson Square
Vancouver, BC  V6Z 3B7

Dear Mr. Wilds:

***Lower Mainland Rail Infrastructure Study:  Final Report***

IBI Group, in association with Hatch Mott MacDonald, PricewaterhouseCoopers LLP and Golder Associates, is pleased to submit this Final Report for the Lower Mainland Railway Study.

In accordance with the Terms of Reference, this project examined the current capacity of the railway system in the Lower Mainland to accommodate freight traffic forecasts and forecast passenger rail traffic as provided by participating stakeholders, and to determine deficiencies and required infrastructure improvements.  This study confirmed that most of the improvements identified in the Major Commercial Transportation System: Rail Capacity Study undertaken by the Gateway Council are required, as well as some additional improvements, in order to accommodate the very substantial increase in traffic expected over the planning period to 2021.

One of the primary issues examined was the capacity of the New Westminster Rail Bridge, a critical link in the railway network in the Lower Mainland.  Current capacity of this bridge is expected to be reached by 2010, unless cooperative operating arrangements can be made among the railways to share rail capacity, similar to the recently announced cooperative rail operating arrangements between CN and CP.  Five key recommendations stem from our analysis:

1. Carry out an engineering analysis to confirm the physical feasibility and risk of maintaining and rehabilitating the existing New Westminster Rail Bridge.
2. Encourage all appropriate parties to develop an implementation strategy to expand the capacity of the railway system by constructing the improvements described herein.
3. Do not release land for other uses in the Waterfront and False Creek Flats areas until railway requirements are determined.
4. Pursue a strategy of coordinated rail operations among the railway companies.
5. Work with the railways to help resolve mainline capacity issues.

In the event that the engineering investigation of the New Westminster Rail Bridge determines that the bridge cannot be rehabilitated to provide security of use over the planning period to 2021, then the preferred improvement alternative is to replace the bridge with a new, higher level, lift bridge, at a cost of approximately $110 million, much less than the $420 million cost of a tunnel.  The benefits accruing to the railways, the ports and Canadian economy, of maintaining the rail service and capacity in the Lower Mainland, including the continued functioning of the New Westminster Rail Bridge, are well in excess of the costs of the network improvements.

We would like to take this opportunity to express our appreciation for the assistance provided by the many stakeholders involved in the project. The cooperation of the stakeholders in the provision of the current and forecast freight volumes was very helpful to our efforts to successfully undertake this project.

Yours truly,

**IBI GROUP**

R. A. McNally, P. Eng.
Director

cc: Mike Kieran – IBI Group
Philippe Raymond – PricewaterhouseCoopers LLP
Doug Hinton – Hatch Mott MacDonald

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# 1.0 EXECUTIVE SUMMARY

The Major Commercial Transportation System (MCTS): Rail Capacity and Regional Planning Issues Overview, dated February, 2003, prepared by the Greater Vancouver Gateway Council, presents a proposal to make best use of existing transportation infrastructure and provide a blueprint for investments in new infrastructure in the Lower Mainland.

Railways are an essential component of the MCTS, and they are vital to the success of port operations in the Greater Vancouver area and therefore to the metropolitan, provincial and national economies. Over the past decade, the rail companies have responded to considerable growth in traffic volumes, but the dramatic growth in demand for Vancouver Port and Fraser Port is showing no signs of abatement in the foreseeable future. Rail capacity limitations are emerging which may constrain future economic growth.

The **objective** of the Lower Mainland Rail Infrastructure Study is to complete an assessment of future infrastructure needs based on forecast freight transportation demand, while being responsive to regional economic and social development goals and related emerging rail passenger, tourism and commuter needs. Port and Railway services in Vancouver are vital to successful international trading relationships of the nation. There is a clearly expressed interest in exploring critical improvements to the rail infrastructure, key among them being the Fraser River crossing options, in sufficient detail for traffic justification, technical feasibility assessment, economic and financial feasibility and compatibility with the long term strategic plans for the Region.

The **Steering Committee** of the Lower Mainland Rail Infrastructure Study comprises a wide range of stakeholder interests, including the Greater Vancouver Gateway Council, federal departments of Western Economic Diversification, and Transport Canada, the Railway Association of Canada (and representatives of each of CN, CPR, BNSF, BC Rail and Southern Railway of BC-SRYBC), the Vancouver Port Authority, the Fraser River Port Authority, Borealis Infrastructure Fund, the Greater Vancouver Transportation Authority (GVTA), the City of Vancouver and the Province of British Columbia. Consequently, the scope of the assessment to be carried out is multi-faceted and comprehensive.

IBI Group, in association with Hatch Mott MacDonald, PricewaterhouseCoopers LLP and Golder Associates, conducted this rail infrastructure assessment/needs study.

## 1.1 GENERAL BACKGROUND

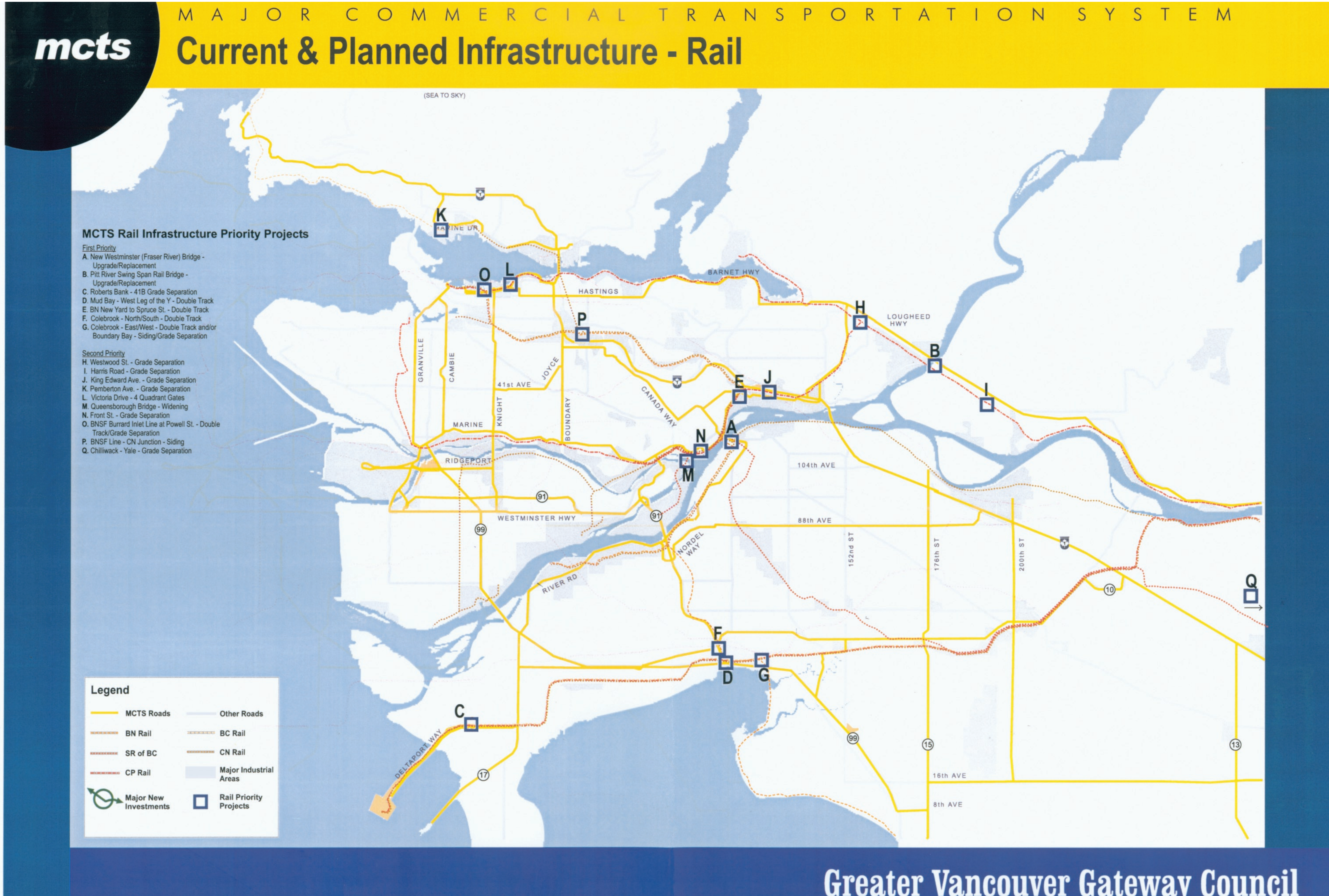
This study is “pre-feasibility” in nature and strategic in orientation. This means that data used in the study are from existing sources and previous studies. The strategic orientation is represented by a long range projection to the year 2021, and a scope that encompasses technical, operational, economic and financial evaluations. Primary research, inspections or investigations are not carried out beyond visiting key facilities and interviewing officials to obtain information and insights.

Confidentiality of proprietary data is also a concern for parties that have provided information on their commercial operations. In order to respect this concern, conclusions and observations reported in this document are aggregate views of the information analyzed.

The Major Commercial Transportation System Report (2003) identified a number of proposed improvements to the rail system in the Lower Mainland, shown in **Exhibit 1.1** The most significant improvement is the replacement of the New Westminster Rail Bridge (NWRB), which is considered a constraint to rail growth in the region.

This study carried out an economic and financial assessment of the benefits and costs of alternative scenarios for replacement of the bridge, and individual cost estimates and aggregated benefits associated with the other MCTS recommended improvements, as well as improvements identified by the project team.

**Exhibit 1.1 MCTS Proposed Rail Improvements**



The NWRB is owned by the Government of Canada, operated and maintained by CN, and used by all the railways in the area, except West Coast Express at present. The bridge is 100 years old and has sustained major closures due to marine accidents and bridge fires over its life. The bridge is a swing bridge and is closed to rail traffic approximately 5 hours per day to accommodate marine traffic on the Fraser River. As a result, the capacity of the bridge is limited to approximately 65 train movements per day. It carries approximately 46 train movements per day at present, mostly CN and SRYBC. Clearly, continued growth in rail movements will be constrained by the capacity of the bridge, unless other remedies are pursued.

This study examined alternative rail operating procedures to determine whether rail traffic growth, freight and passenger traffic, can be accommodated by operational arrangements, or whether the bridge needs to be replaced. Under **Status Quo Operations**, each railway operates generally on its own tracks within the study area, seeking to minimize its own costs. The Status Quo case represents a peak-traffic 24-hour interval in 2001 for which data on all train movements in the Study area were provided by the railways. Status Quo projections represent growing these operations by applying the overall traffic growth rate for the Lower Mainland to each segment of the network.

An alternative rail operations strategy, and one which the railways are pursuing incrementally on an "as needed" basis, involves the railways sharing, in a coordinated arrangement using commercial agreements, the available rail capacity. With such a **Coordinated Rail Operations** arrangement there is substantial network capacity available to accommodate projected growth, at least to 2021. Co-production initiatives recently announced by CN and CPR represent an example of Coordinated Rail Operations; coordinated rail operations does not mean open rail access to all parties. Accordingly, three improvement scenarios are identified to meet projected market demands. They are as follows:

Scenario #1. **Status Quo Operations with a New Bridge**: Under this scenario, the NWRB is replaced with a new bridge at a capital cost of $110 million, plus a number of other network improvements to increase capacity, and the Status Quo arrangements for railway operations would be continued;

Scenario #2. **Status Quo Operations with New Tunnel**: Under this scenario the NWRB is replaced with a new tunnel at a capital cost of $420 million instead of a new bridge, and otherwise it is similar to Scenario #1; the additional network investments for Scenarios 1 and 2 cost about $70 million ($2004).

Scenario #3. **Coordinated Rail Operations**: Under this scenario, the NWRB is not replaced, but rehabilitated at regular time intervals, and all infrastructure improvements projects required to achieve Coordinated Rail Operations would be implemented – (approximately $90 million $2004), i.e. $20 million more than Scenarios 1 and 2, but does not require the replacement of the NWRB.

These three improvement scenarios are compared to Status Quo Operations (without improvements) in order to capture the marginal benefit relative to marginal cost. Status Quo represents rail operations in 2001, prior to recently announced co-production initiatives of CN and CPR.

While the NWRB is an important aspect of this study, it is recognized that it is one element in a larger system and its adequacy should be reviewed in the larger system context.

For purposes of this study, the Greater Vancouver Gateway Council identified three distinct corridors that comprise the Lower Mainland rail system:

- Corridor 1 extends from Burrard Inlet Port Complex, where it serves the commodity and container terminals, to the US border and contains the New Westminster Rail Bridge (NWRB).
- Corridor 2 is the CPR main line that serves the Port of Vancouver and handles traffic destined to and from the North American market; and,

- Corridor 3 is the 23-mile BC Rail Port Subdivision that connects the Class 1 railways and Southern Railway of BC to port terminals at Roberts Bank.

### 1.1.1 Stakeholders and their Respective Agendas

The need or urgency for making major additions to the physical infrastructure in the rail network depends on the pace and effectiveness with which all participants collaborate in striving for a common vision. Various solitudes and divergent priorities characterize the present situation, as summarized below:

- Port Authorities -- Least complex for purposes of this study because they are naturally dependent on concerted actions and are already aligned with objectives for growth in the system; as landlords, they have much to gain from overall rail efficiency and effectiveness by being in a stronger position to attract shipping lines.
- Shipping Lines – Naturally indifferent to Vancouver Gateway issues; they are the customers for this market and will be attracted by reliable service and low costs – capacity is key to that. Their ships, like water on which they float, will follow the path of least resistance.
- Terminal Operators – Primarily focussed on their own local concerns despite multi-national ownership, striving for market share within the Port – complexity is introduced in terms of coordinated arrangements that would require sharing benefits with a competitor, confidentiality is a sensitive topic for these stakeholders.
- The Railways –
    - CN, CPR and BNSF (the Class 1 Railways) are competitors on a North American scale and highly driven by market share;
    - BC Rail Port Subdivision and SRYBC have minor positions in the global market, but they do have much to gain by being focussed on market size;
    - VIA, AMTRAK, West Coast Express and Rocky Mountaineer Railtours have local focus and are indifferent to market share/size issues for freight so long as their plans can be accommodated;
    - Railway motivations are very complex because the main assets they have are people, infrastructure, motive power, and rolling stock, and they work together by necessity rather than by choice;
    - CN and CPR have announced co-production arrangements in the Waterfront and North Shore areas while this report was being edited; these arrangements were implemented concurrent with the study, but no data is available, concerning carloads handled.
- GVTA -- Regional transportation priorities may sometimes conflict with freight efficiency needs. Passenger mobility issues, and impacts of freight movement on the major roads network in the Lower Mainland are the main overlapping priority areas .
- City of Vancouver -- Vancouver is a special case because of the historic role of the Waterfront and False Creek Flats. Local land use, public response to trains, and traffic issues dominate their interest; and, there is continuing pressure to free up existing railway lands for urban development.
- Other Municipalities -- Langley, Surrey and Delta have issues with future rail traffic growth in the Roberts Bank Corridor which may also overlap GVTA issues. North Vancouver has priorities for waterfront development that may influence future rail access development on the North Shore.
- The Government of British Columbia – The Government of British Columbia is preparing a Ports Strategy that is intended to provide an environment that will ensure that the Pacific Ports are an efficient, reliable and competitive port system.

- Government of Canada – Trade and economic growth are high on the federal agenda (market size) and the focus is global.

## 1.2 ANALYSES AND MAIN OBSERVATIONS

The core concept of the study methodology is to develop a "logical" description of the Lower Mainland Railway system as a network comprising links connecting nodes. The goal is to set up a model to capture all of the key routing options for traffic and operations in the study area. Computerized mathematical models are used to analyse traffic demand characteristics (i.e. inputs) and to generate projected flows over links in the network, subject to minimizing operating costs (i.e. outputs).

### *1.2.1 Integrated Network*

The central notion is that the entire Lower Mainland rail network is one integrated system. Changing one area or corridor cannot be isolated because it causes changes to the entire network. The approach of this study seeks the most efficient and effective use of all network resources for a given demand. It is most appropriate for strategic policy and plans with respect to future demand, operations and infrastructure investments affecting all stakeholders. It is high-level and aggregate in nature, tuned to system-effects and useful to identify and assess major resource allocation options.

This systems approach is especially significant in the case of the present study because of the great complexity of overlapping institutional jurisdictions, operational and regulatory practices, and financial interests. This is particularly crucial to keep in mind concerning the Waterfront and False Creek Flats, where land is seriously constrained and subject to many pressures from most port stakeholders.

### *1.2.2 Sustained Market Growth*

Market demand is represented by actual and forecast freight traffic. Forecasts are provided by Vancouver Port Authority (VPA) and Fraser Port Authority (FPA) by year and by commodity for the period 1999 to 2020 in the case of VPA, and for the period 1999 to 2007 in the case of FPA. Growth rates provided by Vancouver Port Authority are applied to carload and domestic intermodal traffic on the railways, and for Fraser Port estimates beyond 2007.

Historical information includes allocation of traffic to port areas (i.e. groups of terminals) to match the rail network with port facilities. Interviews and inspection trips with railway and port officials and the consultants' general knowledge of the rail operations of the region were the main sources for traffic assignment. Data are aggregated to maintain confidentiality of commercially sensitive information proprietary to individual railways, marine terminal operators, importers and exporters.

Various levels of future demand are considered and evaluated allowing for variation in a wide range of factors such as growth rates by year or by commodity type, allocation of growth to different port areas, and varying conversion factors used to translate port data (in metric tonnes) to railway workload in carloads and train loads. The study methodology is based on weekly time frames; thus the annual data are converted to weekly amounts based on 52 weeks in a year.

**Exhibit 1.2** provides aggregated highlights of trainload forecasts for selected years. The base case is represented for 2003. The planning reference case is represented for 2011 and 2021. Train movements are estimated based on tonnes originating and terminating in each port area and typical carload and trainload characteristics for each commodity.

**Exhibit 1.2 Estimated Weekly Train Movements**

| Terminal Node | 2003 Weekly Train Movements | | 2011 Weekly Train Movements | | 2021 Weekly Train Movements | |
|---|---|---|---|---|---|---|
| | EastBound/ Southbound | Westbound/ Northbound | EastBound/ Southbound | Westbound/ Northbound | EastBound/ Southbound | Westbound/ Northbound |
| Port Coquitlam | 14 | 14 | 24 | 24 | 37 | 37 |
| Sapperton | 9 | 9 | 10 | 10 | 11 | 11 |
| Thornton Yard | 22 | 23 | 25 | 26 | 26 | 27 |
| Livingston | 3 | 3 | 0 | 0 | 0 | 0 |
| North Vancouver | 31 | 31 | 43 | 41 | 49 | 46 |
| Burrard Inlet | 37 | 34 | 57 | 50 | 73 | 63 |
| Lulu Island | 5 | 5 | 6 | 5 | 6 | 5 |
| Annacis | 1 | 1 | 2 | 2 | 2 | 2 |
| Fraser Surrey | 9 | 12 | 11 | 13 | 13 | 16 |
| Roberts Bank | 74 | 65 | 94 | 79 | 122 | 100 |
| Port Moody | 15 | 15 | 19 | 19 | 24 | 24 |

Train movements in **Exhibit 1.2** represent originating and terminating traffic by area. Operational analysis is based on these data and supplemented by estimates of local train movements and passenger train movements on each link of the network.

Growth rates for bulk and breakbulk traffic are lower than those for automobiles and container traffic by a significant margin. The former is expected to grow approximately 25% to 35% by 2021, while the latter is anticipated to almost triple in magnitude over the same time frame. The combined impact is that terminals will likely see rail traffic double, considering all commodities, by 2021.

The terminal areas expected to see the highest participation in future growth are Burrard Inlet (Vancouver Waterfront between Canada Place, Second Narrows Bridge and south to the False Creek Flats), Roberts Bank, and North Vancouver.

### *1.2.3 Economic and Financial Evaluation*

**Economic Output**

The Lower Mainland rail network is a key part of the integrated national transportation network and improvements to the network in any one area have a positive impact on direct and indirect users throughout the country. If demand for rail transportation exceeds capacity in the Lower Mainland, the Canadian economy as a whole will suffer. It is estimated that an estimate of additional direct economic output for the Canadian economy of over $700 million[1] in 2021 if the rail capacity constraints in the Lower Mainland are resolved. Economic output adds all revenues at each stage of production together as a measure of total production in the economy. This economic output estimate is based on economic impacts studies on the Port of Vancouver undertaken by InterVISTAS Consulting Inc in August 2001 and in March 2003, and several broad assumptions were necessary to translate the capacity constraint into direct economic output. This figure should be taken as an order of magnitude estimate of the direct economic value of addressing the capacity constraint.

**Incremental Benefits and Costs**

In addition to the direct economic output for the Canadian economy, the report assesses the incremental benefits and costs for the primary stakeholders, the railway companies and the ports, for each scenario

[1] Amount in $2004.

compared to Status Quo Operations without improvements[2]. Incremental costs include the additional costs required to build, maintain, rehabilitate, and operate the rail network compared to the Status Quo Operations without improvements. Incremental benefits are the additional benefits to stakeholders of eliminating the bottlenecks (i.e. rail capacity constraints) in the Lower Mainland.

**Incremental costs** occur every year for all three scenarios. **Exhibit 1.3** shows the estimated annual incremental costs at selected points in time over the study period (5-year intervals) for the three scenarios, and the net present value during the study period to 2021 and over 100 years, the life of the improvement. The Net Present Value ("NPV") is calculated using a discount rate of 8% real based on an estimate of the weighted average cost of capital (WACC) for organizations such as railway companies.

**Exhibit 1.3 Incremental Costs versus the Status Quo Scenario**

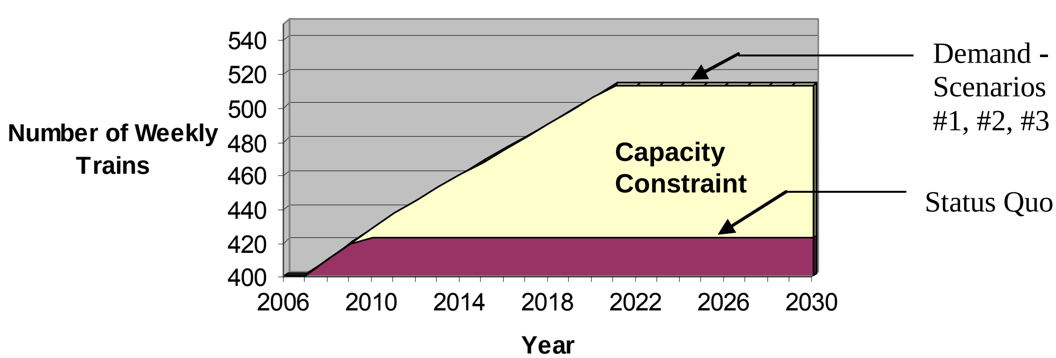
| Costs:($ 000's, in 2004 real dollars) | Year | | | | NPV @ 8% real as of 2004 | |
|---|---|---|---|---|---|---|
| | 2006 | 2011 | 2016 | 2021 | 2006 - 2021 | 2006 – 2105 |
| Scenario #1 Status Quo Operations – New Bridge | 85,987 | 7,431 | 331 | 15,356 | 147,828 | 150,478 |
| Scenario #2 Status Quo Operations – New Tunnel | 189,320 | 10,031 | 2,931 | 17,956 | 435,563 | 446,333 |
| Scenario # 3 Coordinated Rail Operations, Rehabilitated Bridge. | 57,705 | 7,216 | 13,316 | 15,151 | 71,547 | 93,855 (*) |

(*) Assuming there is another 100-year life on the NWRB.

In all of the scenarios examined, the cost figures shown are the incremental cost or savings over the Status Quo Operations with no improvements. The NPV of future costs appears to almost double comparing the New Bridge to the Coordinated Rail Operations Scenarios, and triple comparing the New Tunnel to the New Bridge Scenarios. Clearly, the least cost alternative is Scenario #3.

**Incremental benefits** are calculated based on the avoided rail network capacity constraints in the Lower Mainland if scenarios #1, #2 or #3 are achieved. **Exhibit 1.4** presents the estimated weekly train movements by year for each of the three scenarios, compared to the Status Quo Operations without improvements.

**Exhibit 1.4 Lower Mainland Rail Network Production**




This exhibit shows that the Lower Mainland rail network is currently operating slightly below capacity. Under the Status Quo Operations without improvements, by 2010 the Lower Mainland rail network would reach its

[2] Status Quo Operations without improvements assume there would only be required safety improvements to the NWRB and the rest of the rail network, but no other improvement projects to the Lower Mainland rail network.

theoretical capacity of 423 freight trains per week inbound plus outbound due to rising demand. The critical link in the system is the NWRB, and it would reach its capacity at this overall train volume.

Demand after 2010 could be met if scenarios #1, #2 or #3 are achieved. Each scenario requires a different treatment to the NWRB, but all scenarios require the implementation of common improvement projects in the Lower Mainland needed for the entire system to grow. These are referred to as the Common Elements. Implementing any one of these scenarios would avoid facing a capacity constraint in the Lower Mainland rail network (i.e. demand would exceed supply).

**Incremental benefits** for the purposes of the scenario analysis are derived from avoiding the capacity constraint shown in **Exhibit 1.4**. Benefits quantified in this report are the ones estimated to accrue to the railway companies and ports. These benefits amount to approximately $97 million in 2021, and have a net present value of $229 million for the period 2006-2021. The benefits are associated with expanding rail capacity and they are calculated based on the net income that would be foregone if they could not accommodate the forecasted rail traffic due to rail capacity constraints. The majority of the benefits quantified in this report due to avoided rail capacity constraints accrue to the railway companies with the remainder to the ports. However, other stakeholders would also benefit from the improvements such as commuters, municipalities, marine traffic, road users and the overall Canadian economy.

In addition to the benefits quantified above for the railway companies and the ports, there are other benefits that would accrue to various stakeholders such as:

- Rail capacity benefits for passenger trains;
- Marine traffic benefits due to fewer bridge closings;
- Reduced accident risk due to marine collisions with the bridge;
- Improved Seismic Protection in the case of a new bridge or new tunnel;
- Avoided capacity losses due to bridge fire in the case of a new bridge or new tunnel;
- Avoided employment losses due to any bridge disruption, whether structural, seismic, accident or fire;
- Additional employment benefits due to increased freight movements.
- Travel time savings for rail, car and truck users;
- Environmental benefits as a result of greater use of rail rather than truck freight movements; and
- Social impacts.

The **Net Benefits** are calculated by subtracting the incremental costs from the incremental benefits and they serve as the basis to calculate the internal rate of return (IRR) of each Scenario. **Exhibit 1.5** presents the estimated IRR of the net benefit streams associated with each of the scenarios compared to the Status Quo Operations without improvements. These IRR are presented for a typical rail trip length of 1,200 miles (approx. 1,900 km).

**Exhibit 1.5 Estimated Internal Rates of Return for the Three Major Scenarios**

| **Note: Internal Rates of Return (IRR) are in real terms** | **Scenario #1: Status Quo Operations – New Bridge** | **Scenario #2: Status Quo Operations – New Tunnel** | **Scenario #3: Coordinated Rail Operations, Rehabilitated Bridge** |
|---|---|---|---|
| **Average rail trip length of 1,200 miles** | | | |
| IRR for study period horizon (2006-2021) | **14%** | **2%** | **24%** |
| IRR for whole life of assets (2006-2105) | **18%** | **10%** | **27% (*)** |

(*) Assuming there is another 100-year life on the NWRB.

These figures show that Scenario #3 (Coordinated Rail Operations, Rehabilitated Bridge) generates the highest return, followed by Scenario #1 (Status Quo Operations, New Bridge), and that Scenario #2 (Status Quo Operations, New Tunnel) has the lowest return. All three scenarios generate similar benefits, but Scenario #3 has lower costs, therefore, it would appear to be the Preferred Scenario.

This finding is contingent, however, upon successful implementation of Coordinated Rail Operations, particularly in the Burrard Inlet, and continued functioning of the NWRB and all other assets. Multi-lateral agreements among railway companies to share risks and benefits to achieve the best overall result is an essential aspect of Scenario #3. While the ranking of Scenarios is clear, justification of an investment decisions is more complicated for this reason.

One principle of Coordinated Rail Operations is that the benefits are distributed across all carriers of rail traffic. Each individual project is part of a larger system, not isolated. Thus, no single party accrues a dominant share of the benefits. Further complicating the matter is the fact that the calculation of incremental benefits is based on a total average journey from inland terminal to onboard ship; but the incremental costs apply only to the Lower Mainland rail network and not to the entire rail network. The threshold IRR for a railway to take on the investment could be higher than this IRR to the extent that mainline capacity shortcomings would have to be addressed concurrently.

The larger picture of rail capacity issues and the associated costs of developing and maintaining the required mainline capacity across the country need to be taken into account before investment decisions can be made. Under the coordinating role of Transport Canada, these costs and benefits associated with the mainline improvement need to be determined to complete the financial assessment.

## 1.3 CONCLUSIONS

This analysis indicates, that if coordinated operations among the railways can be achieved by no later than 2008, and if the detailed engineering analyses confirms that the bridge life can be extended through rehabilitation to at least 2021, then Scenario #3 is preferred and is the recommended strategy.

If coordinated operations among the railroads cannot be achieved, or if the existing function of the bridge cannot be maintained through the planning period (2021), then the preferred Scenario is replacement of the bridge with a lift bridge i.e. Scenario #1.

Scenario #2 (construction of a railway tunnel) is not recommended.

Regardless of the major strategy selected, there are immediate bottlenecks in the system that would need to be dealt with. Such actions are referred to as the Common Elements.

### *1.3.1 Common Elements*

The important elements needed to sustain the entire system, regardless of which scenario actually materializes are the following:

1. Grade Separation at 41B St. in Delta to provide rail and road user benefits by permitting greater efficiency in the building of long container trains at Roberts Bank; the estimated cost over 20 years is $ 5,300,000 (constant $ 2004). Although this project is considered

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[3] Economic Impact Analysis of Investment in a Major Commercial Transportation System for the Greater Vancouver Region, Greater Vancouver Gateway Council, 2003, by Delcan and Economic Development Research Group.
[4] For Scenario 3, it is assumed that the NWRB can be operational for up to 100 years more, provided it is rehabilitated at periodic intervals, costs of which are included; whether it is feasible to maintain the bridge for another 100 years requires an engineering assessment and risk analysis.

immediate priority, an alternative of closing 41B St. should also be examined, because of the constraint that the constructed overpass may impose on further construction of parallel tracks in this important corridor.

2. New Siding between Roberts Bank and Hydro – most likely as recommended by MCTS in Mud Bay – to add needed capacity to the system; the estimated cost over 20 years is $7,620,000 (constant $ 2004); this project is an immediate priority.
3. New Siding between Blaine and the NWRB -- most likely as recommended by MCTS in Mud Bay – essential for adding to AMTRAK frequency and to meet freight growth ; the estimated cost over 20 years is $7,000,000 (constant $ 2004); there is immediate need for one siding, and there is a forecast need for further expansion around 2016 to meet freight growth projections, for additional cost around $8,600,000 (constant $2004).
4. Add double track and/or sidings between Roberts Bank and Mission Bridge (5 to 8 miles) – not included in MCTS portfolio -- a consequence of expanding Deltaport according to latest growth projections; total cost around $22,400,000 (constant $ 2004); future need 2011 – 2016, depending on actual growth rate and timing of Deltaport expansion.
5. Add a second main track to CN Yale between Matsqui Jct. and Hydro – not included in MCTS portfolio – this link can become a bottleneck depending on how Roberts Bank grows and on the extent to which cooperation among the three Class 1 railways is achieved – even with optimal cooperation this would become a bottleneck towards the end of the study period; the estimated cost is $15,800,000 because the terrain is very difficult; the timing would be 2016 – 2021.
6. Several important grade separation projects are considered (e.g. Westwood, Harris Road, King Edward Avenue), but the direct road user benefits alone are not sufficient to justify the grade separations. Rather, further potential benefits, such as benefits to local rail operations, safety and accident benefits, environmental benefits, aspects which are beyond this study, need to be considered by the transportation authorities in evaluating these grade separations.

Three other types of project can be considered as Common Needs based on the MCTS recommendations, but which are not common to all scenarios investigated in this study. Three projects in this area include:

7. Install double track between the BNSF yard in New Westminster and Spruce St. -- this is about half a mile in a difficult area; the project cost is estimated to be $3,200,000 (constant $ 2004); railways indicate the need for this is immediate.
8. Install a new siding near Willingdon (BNSF/CN Junction); the project cost is estimated to be $6,800,000 (constant $ 2004); this also is considered an immediate need by the railways;
9. Powell Street double track and road/rail grade separation; the estimated cost of this is $11,200,000 for a grade separation and $2,900,000 for installation of double track; this also was identified as an immediate need in the MCTS.

The rationale for these projects is based on yard and terminal operations that require detailed simulations to validate. Such simulations would be included in subsequent design and planning work rather than within the scope of this study. Status Quo operations identifies these as urgently needed projects. The capacity that would be added by these projects does not appear to be required as quickly with Coordinated Rail Operations, because much of the traffic would be arriving at the waterfront over the CPR route. However, it is reported there are problems today on account of yard activities in these areas, and the analysis carried out in this study is not sensitive to yard switching factors. While these projects are expected to be needed some time over the next 10 – 15 years, detailed analysis is required for definitive conclusions on the timing for these projects.

Finally, one new area of need is addition of receiving tracks for full trains in the Waterfront area from Second Narrows to Canada Place including the False Creek Flats. It may be argued that this is a common need for all scenarios, because of the complex operations that now occur and the congestion that follows as a consequence. This was not included in the MCTS, and it has significant institutional implications for all stakeholders, especially CPR, CN and BNSF. It is included in the Coordinated Rail Operations scenario to enable termination of trains close to the marine terminals; 4 receiving tracks of 7,000 feet to be installed over a 17 year period at a total cost of $37,200,000 (constant $ 2004) including soft costs to work out the arrangements between existing stakeholders. Soft costs in this case can be substantive (a provision of $10 million for this alone is included in capital costs). At this time it is unlikely that one of these receiving tracks could be located in the Waterfront area without obtaining agreement among the several landowners. Because of this difficulty, such an option has not seriously been considered in the past. However, potential benefits are great enough to seriously encourage public incentives for port terminals, the railways, and the other stakeholders in the waterfront area, such as GVTA, to work together to develop sufficient receiving tracks within the existing footprint and/or using the adjacent land such as False Creek Flats, to handle this future rail traffic growth.

### *1.3.2 NWRB Replacement*

One of the central questions motivating the sponsors to engage in this research is whether or not the existing NWRB can accommodate future demand. Previous trends signalled warnings that the NWRB was rapidly running out of capacity to handle trains; this trend is confirmed through the present analysis of "Status Quo Operations" scenarios.

However, CN and CPR have initiated some ”Coordinated Rail Operations” in the Vancouver terminal area since the “Status Quo Operations” data were generated by them. Those changes have resulted in improved operating efficiencies, and have relieved the bottleneck for the present.

There is an engineering and safety perspective which is extremely important also. The existing NWRB is of century vintage. There would need to be a full primary survey and inspection of the bridge, beyond the scope of this study, to determine how long its useful life can be extended and how much money that would take. The analyses reported in this study consider need for rehabilitation of approximately $20 million near 2020, and the financial projections were based on a similar amount being required every 20 years. More detailed assessment of this would require a detailed engineering survey and inspection to compare the cost of maintaining the bridge with building a new bridge and to identify the most appropriate circumstances that would trigger replacement.

Estimates of the expected life of the bridge and risks to safety and continuity are carried out here only to the extent that existing documentation would support. Many studies have been carried out over the years, but a conclusive bridge survey is not available. This would need to be carried out before any final determination of the need for replacing the NWRB could be made. External benefits cited in Section 1.2 should be incorporated in the scope of such a review.

If cooperative operations cannot be fully implemented, then straightforward projection of the historical operations indicates the need to replace the NWRB within 7 years.

The main issues that need to be resolved for the future is to determine: whether the NWRB has a physical and economic life that extends up to 2021 for safe operations; and second, whether Coordinated Rail Operations can be implemented throughout the entire Lower Mainland rail network, while also including all four existing freight railways.

Status Quo operations will likely advance the need to replace the NWRB. Recent cooperative initiatives by CN and CPR bought time for what was emerging as a crisis need.

The ultimate potential of Coordinated Rail Operations as evaluated in this study suggests that the NWRB would not be the main bottleneck in the network, and would provide adequate capacity beyond the study time horizon of 2021.

### *1.3.3 Waterfront (Including False Creek Flats)*

One of the busiest areas for freight in the Port of Vancouver is Burrard Inlet. The waterfront is also an important area for passenger cruise ships, public transportation (including the Seabus, SkyTrain, West Coast Express, Harbourlynx ferry, Heliport terminals and Float Planes), and pleasure craft. The waterfront also includes the rail facilities in False Creek Flats.

The rail lines serving the Port in this area are regarded by some as an obstacle to other social and economic pursuits. Backup land for marine port facilities and for efficient rail operations is a serious constraint in this area. These facilities are located in waterfront areas that carry a high appeal for other social and economic purposes (e.g. tourism, commercial development and housing).

The West Coast Express (WCE) downtown terminal is in this Waterfront area. In approximately 1993, WCE made a significant investment in mainline track improvements and yard storage for its cars between Mission and its downtown terminal. As part of this, WCE built its own storage area both at Waterfront and in Mission. This investment provided additional capacity for the operation of commuter trains and provided enhanced operational flexibility in the rail corridor.

The land is owned by various interests, including the railways as separate entities. There are serious constraints in the area, and potential for conflicting purposes and pursuits. The City of Vancouver has expressed its desire to examine the City's need to continue to serve the downtown, the Port, and the False Creek Flats by rail and how to respond to the emerging development pressures occurring in the area.

False Creek Flats is also the location of Pacific Central Station that serves:

- AMTRAK -- 2 trains per day at present, with plans to expand to 6 trains per day ( 3 each way - the higher frequency of service is incorporated in the traffic levels that are simulated in this study); expanding this service has capacity implications considered in the analysis, and incorporated in the study results.
- Rocky Mountaineer Railtours (RMR) – 6 trains per week (3 each way) between May and October at present, with occasional departures over the balance of the year; RMR has indicated plans to increase service frequency;
- VIA Rail Canada -- 6 trains per week (3 each way), and a rail passenger equipment maintenance facility in False Creek Flats; VIA has stated its intentions to increase to daily service in both directions.

Both CPR and CN point out that increases in frequency for VIA and RMR are entirely contingent upon mainline capacity additions to accommodate them. Such additions would have to be funded by passenger train sponsors. The current level of 26 passenger trains per week could remain the same or increase to as much as 70 trains per week. The highest level of activity will likely require the existing VIA Rail yard facilities to expand.

With respect to freight activity, the Glenn Yard and both the CN Yard and the BNSF Yard are used as staging and back up storage for the Port operation. CN has an arrangement with BNSF to store cars on the south side of Industrial Avenue. The ultimate requirement for tracks and track configuration in this area depends upon cooperative efforts that remain uncertain at this time. It would be natural to expect BNSF to seek a higher return on its own surplus land assets in the area, and this would more likely be through sale for development or co-development rather than short-term leases for rail car storage.

Future planning of the False Creek Flats area by the City of Vancouver must take into account these growing needs for freight and passenger rail traffic and terminal requirements.

### *1.3.4 Roberts Bank*

Roberts Bank also has a number of issues, but they are different from those in downtown Vancouver. The rail corridor runs from Mission through Langley and Boundary Bay and onto the Causeway. There is a steady volume of coal trains for export, and container traffic in both directions. Container trains operate at lengths over 3.5 kilometres regularly.

A significant portion of the line is owned by the province of British Columbia (as the BC Rail Port Subdivision, which has been retained by the Province following the sale of BC Rail to CN). The Port Subdivision controls train movements over the line, but does not operate any of its own trains. All four operating railways (BNSF, CN, CPR, and SRYBC) use at least portions of the line.

This line cuts through a populated and growing area. There are numerous level crossings at present, and interference between rail and road traffic is an important consideration in planning the future infrastructure requirements in this area.

Projects identified as being common to all scenarios feature prominently on this route. The 41b Street grade separation, Mud Bay sidings and future double track are all needed eventually regardless of who operates the trains going into the Causeway.

Long trains and high growth pose a real challenge for rail, port terminals and communities hosting the rail line. Proximity issues and future urban development affecting level crossing traffic volumes are all planning issues that will require close cooperation between Railway planners and surrounding municipalities.

## 1.4 RECOMMENDATIONS

The Lower Mainland rail system is complex and the stakes are large. There are many directions that might be taken once the initial steps are successfully completed towards meeting future freight demand expectations.

The outstanding questions concerning the need to replace the NWRB are technical and institutional. If a detailed survey and inspection of the bridge establish that the bridge cannot be expected to continue beyond 2021, then that becomes the determining issue concerning replacement of the bridge. None of the work done to date is sufficiently detailed or current to respond to this question.

Therefore **Recommendation #1 is: Carry out an engineering condition assessment and risk assessment of the NWRB, to establish the remaining life expectancy, maintenance requirements and structural vulnerability, to verify it can sustain traffic for the planning period (2021) and to quantify the disruption period that would be caused by a seismic event, ship collision or bridge failure.**

The result of such a review would either confirm or cause modification to the financial and economic estimates upon which the conclusions of this study are based. The Pitt River and Mission Bridges are also crucial to future capacity of the network. Although there are no immediate issues apparent, a similar assessment should also be considered for these bridges.

**Recommendation #2 is: Commence discussions with all appropriate parties to negotiate sponsorship arrangements for implementing MCTS projects identified as Common Elements and, if required, replacement of the NWRB.**

The economic analysis of system enhancements identified the railways as the major beneficiaries. If it were as simple as that, then the respective railways would proceed with the projects over their own lines, to incur the costs and reap the benefits. This analysis, however, is incomplete without further information or detailed participation from the railways. In this analysis, benefits associated with the increased traffic are calculated over the entire inland rail movement, while the only costs included in this analysis are within the Lower Mainland Rail network. The railways argue that margins on the traffic are insufficient to provide for all of the capacity needs from origin to destination. This needs to be brought forward in more specific detail to assess the nature of the benefits and costs accordingly and to identify who should be the main participants in undertaking the risks of proceeding.

There is scope for an innovative approach to establish financial incentives for the "Common Elements" projects, i.e. the distribution of costs and benefits between the railways - if all are going to use portions of the network. There is potential for an active role by some neutral third party, or governments, to facilitate a network investment plan such that each railway would not necessarily have to be fully responsible for all of the investments on their own track. There are models to consider for this approach, such as the CREATE project in Chicago , and the Alameda Corridor in California.

The same requirement applies in part to the issue of NWRB replacement. The railways would be the main beneficiaries from a capacity point of view. However from a technical and safety perspective, the Government of Canada as the owner of the existing facility is a direct participant as well. The need for the technical information is covered above in Recommendation # 1. Participation in risks and rewards over service enhancements made possible by a new facility should become part of the larger negotiations on sponsorship arrangements.

**Recommendation #3 is: Determine the rail network and operational requirements in the Waterfront and False Creek Flats areas and do not release land for other uses until such needs are determined.**

This recommendation deals more with process than a specific outcome. The City of Vancouver is taking the initiative and is attaching urgency to determining the future usage of False Creek Flats. As a major stakeholder, this urgency is significant for all the other stakeholders. It would be a common interest of all concerned to identify both crucially important and potentially surplus railway lands so that all stakeholders could proceed with long-term plans and continue to work cooperatively with other parties.

The Waterfront area will be accommodating significant growth by 2021 and congestion delays will pose a critical limiting constraint unless there is a significant change in the fundamental way in which the terminals in this area are serviced. In the False Creek Flats area, there will be additional need for support services for freight activities on the waterfront. At the same time there will be significant passenger growth, potentially to a level and scope that will require expansion of the existing yard. While it is possible that not all of the lands in the False Creek Flats will be needed for rail support, it is important nevertheless to carry out the detailed planning for rail service requirements before releasing significant parcels of land to alternative use.

One of the biggest challenges will be to find the appropriate incentives for parties with diverse and sometimes competing interests to strive for maximization of growth potential in this valuable and congested area.

**Recommendation # 4 is: Pursue a strategy of Coordinated Rail Operations.**

Coordinated Rail operations has proven itself to be successful in several locations in the Lower Mainland. However, the challenge in the downtown waterfront is much more complicated because of the long history and established footprints of many varied stakeholders. The systems analysis carried out in this study, and the economic analysis that follows from it clearly indicate that the economic benefits of achieving efficient cooperation throughout the network are substantial compared to the scenario that continues to project the Status Quo operating arrangements.

It will be important for these discussions with railways to focus on getting a sense of the scope and dimension of Coordinated Rail Operations, in what timeframe, and to what degree of implementation. Less than full Coordinated Rail Operations will require some projects to be implemented sooner. These issues and timing need to be determined with the railways.

**Recommendation #5 is: Work with railways to help resolve mainline capacity issues.**

This course of action would not only assist in understanding a fuller picture of the costs and benefits of the Lower Mainland Rail system improvements, as reflected in Recommendation number 2, but it is also crucial to ensuring that whatever improvements are made in the local network can be carried through to the end customer, otherwise it would be all for naught. A secondary benefit is in providing an opportunity for both railways and other stakeholders in the Lower Mainland to build mutual trust and understanding.

Finally, these recommendations speak to launching processes that bring parties together seeking a common set of goals related to economic trade development. The analyses carried out in this study point to a vision with potential benefits. As discussions evolve, so also the vision and goals might evolve commensurately. If directions are changing, then it would be appropriate to make a deliberate decision to proceed on with the change of course, or else to correct and get back on course. The process of establishing timeframes, expectations and milestones or checkpoints should be included on the agenda of progressing with any of the recommendations above.

# 2.0 INTRODUCTION

The Major Commercial Transportation System: Rail Capacity and Regional Planning Issues Overview (MCTS Report), dated February, 2003, prepared by the Greater Vancouver Gateway Council, presents a proposal to make best use of existing transportation infrastructure and provide a blueprint for investments in new infrastructure in the Lower Mainland.

Railways are an essential component of the MCTS, and they are vital to the success of port operations in the Greater Vancouver area and therefore to the metropolitan, provincial and national economies. Over the past decade, the rail companies have responded to considerable growth in traffic volumes, but the dramatic growth in demand for Vancouver Port and Fraser Port is showing no signs of abatement in the foreseeable future. Rail capacity limitations are emerging which may constrain future economic growth.

The **objective** of the Lower Mainland Rail Infrastructure Study is to complete an assessment of future infrastructure needs based on freight transportation demand, while being responsive to regional economic and social development goals and related emerging rail passenger, tourism and commuter needs. Port and Railway services in Vancouver are vital to successful international trading relationships of the nation. There is a clearly expressed interest in exploring critical improvements to the rail infrastructure, key among them being the Fraser River crossing options, in sufficient detail for traffic justification, technical feasibility assessment, economic and financial feasibility and compatibility with the long term strategic plans for the Region.

The **Steering Committee** of the Lower Mainland Rail Infrastructure Study comprises a wide range of stakeholder interests, including the Greater Vancouver Gateway Council, federal departments of Western Economic Diversification, and Transport Canada, the Railway Association of Canada (and representatives of each of CN, CPR, BNSF, BC Rail and Southern Railway of BC-SRYBC), the Vancouver Port Authority, Fraser River Port Authority, Borealis Infrastructure Fund, the Greater Vancouver Transportation Authority (GVTA), the City of Vancouver and the Province of British Columbia. Consequently, the scope of the assessment to be carried out is multi-faceted and comprehensive.

IBI Group, in association with Hatch Mott MacDonald, PricewaterhouseCoopers LLP and Golder Associates, conducted this rail infrastructure assessment/needs study.

## 2.1 STUDY SCOPE

The Greater Vancouver Gateway Society identified three distinct corridors in the Lower Mainland that comprise the study network:

- Corridor 1 extends from Burrard Inlet Port Complex, where it serves the commodity and container terminals, to the US border and contains the New Westminster Rail Bridge (NWRB).
- Corridor 2 is the CPR main line that serves the Port of Vancouver and handles traffic destined to and from the North American market; and,
- Corridor 3 is the 23-mile Port Subdivision line owned by B.C. Rail that connects the Class 1 railways and Southern Railway of BC to port terminals at Roberts Bank.

The plan was to conduct this study on a corridor-by-corridor basis, beginning with Corridor 1 and including the following assets/locations that are identified in the MCTS Report:

- New Westminster Rail Bridge (NWRB) – Upgrade or replacement of the Fraser Crossing
- Colebrook Junction (North/South Siding; East/West Siding and/or Boundary Bay – Siding/Grade Separation)
- Mud Bay – West leg of the wye

- CN Junction (with Burlington Northern and Santa Fe) – siding
- Grade Separations – King Edward Ave; Front Street
- False Creek Flats
- Spruce Street – Double track
- Powell Street – Double track/Grade Separation

In effect, that is what happened, but it was quickly determined that the system interactions between corridors required the analysis to widen its scope, giving equal treatment to all three corridors within an integrated rail system.

## 2.2 GENERAL BACKGROUND

The study is “pre-feasibility” in nature and strategic in orientation. This means that data used in the study are from existing sources and previous studies. The strategic orientation is represented by a long range projection to the year 2021, and a scope that encompasses technical, operational, economic and financial evaluations. Primary research, inspections or investigations are not carried out beyond visiting key facilities and interviewing officials to obtain information and insights.

Confidentiality of proprietary data is also a concern for parties that have provided information on their commercial operations. In order to respect this concern, conclusions and observations reported in this document are aggregate views of the information analyzed.

The most significant improvements to the rail system identified in the MCTS Report is replacement of the New Westminster Rail Bridge (NWRB).

This study carries out an economic and financial assessment of the benefits and costs of alternative scenarios for replacement of the bridge, including individual cost estimates and benefits associated with the other MCTS recommended improvements. Estimates of benefits are computed on an aggregated basis for the entire system.

The NWRB is owned by the Government of Canada, operated and maintained by CN, and used by all the railroads in the area except West Coast Express at present. The bridge is 100 years old and has sustained major closures due to marine accidents and bridge fires over its life. The bridge is a swing bridge and is closed approximately 5 hours per day to accommodate marine traffic on the Fraser River. As a result, the capacity of the bridge is limited to approximately 65 train movements per day. It carries approximately 46 train movements per day at present. Clearly, continued growth in rail movements will be constrained by the capacity of the bridge, unless other remedies are pursued.

This study examined alternative rail operating procedures to determine whether rail traffic growth, freight and passenger traffic, can be accommodated by operational arrangements, or whether the bridge needs to be replaced. Under **Status Quo Operations**, each railway operates generally on its own tracks within the study area, seeking to minimize its own costs. The Status Quo case represents a peak-traffic 24-hour interval in 2001 for which data on all train movements in the Study area were provided by the railways. Status Quo projections represent growing these operations by applying overall traffic growth rate for the Lower Mainland to each segment of the network.

An alternative rail operation strategy, and one which the railways are pursuing incrementally on an “as needed” basis, involves the railways sharing, in a coordinated arrangement and on a commercial basis, the available rail capacity. With such a **Coordinated Rail Operations** arrangement there is substantial network capacity available to accommodate projected growth, at least to 2021. Accordingly, three improvement scenarios are identified to meet projected market demands. They are as follows:

Scenario #1. **Status Quo Operations with a New Bridge**: Under this scenario, the NWRB is replaced with a new bridge at a capital cost of $110 million, plus a number of other network improvements to increase capacity, and the Status Quo arrangements for railway operations would be continued;

Scenario #2. **Status Quo Operations with New Tunnel**: Under this scenario the NWRB is replaced with a new tunnel at a capital cost of $420 million instead of a new bridge, and otherwise it is similar to Scenario #1; the additional network investments for Scenarios 1 and 2 cost about $70 million ($2004).

Scenario #3. **Coordinated Rail Operations**: Under this scenario, the NWRB is not replaced, but rehabilitated at regular time intervals, and all infrastructure improvements projects required to achieve Coordinated Rail Operations would be implemented – (approximately $90 million $2004), i.e. $20 million more than Scenarios 1 and 2, but does not require the replacement of the NWRB.

These three improvement scenarios are compared to Status Quo Operations (without improvements) in order to capture the marginal benefit relative to marginal cost.

While the NWRB is an important aspect of this study, it is recognized that it is one element in a larger system and its adequacy should be reviewed in the larger system context. The other MCTS projects described in the previous section are critical elements in the larger system.

### *2.2.1 Stakeholders and their Respective Agendas*

The need or urgency for making major additions to the physical infrastructure in the rail network depends on the pace and effectiveness with which all participants collaborate in striving for a common vision. Various solitudes and divergent priorities characterize the present situation, as summarized below:

- Port Authorities -- Least complex for purposes of this study because they are naturally dependent on concerted actions and are already aligned with objectives for growth in the system; as landlords, they have much to gain from overall rail efficiency and effectiveness by being in a stronger position to attract shipping lines.
- Shipping Lines – Naturally indifferent to Vancouver Gateway issues; they are the customers for this market and will be attracted by reliable service and low costs – capacity is key to that. Their ships, like water on which they float, will follow the path of least resistance.
- Terminal Operators – Primarily focussed on their own local concerns despite multi-national ownership, striving for market share within the Port – complexity is introduced in terms of coordinated arrangements that would require sharing benefits with a competitor, confidentiality is a sensitive topic for these stakeholders.
- The Railways –
    - CN, CPR and BNSF (the Class 1 Railways) are competitors on a North American scale and highly driven by market share;
    - BC Rail Port Subdivision and SRYBC have minor positions in the global market, but they do have much to gain by being focussed on market size;
    - VIA, AMTRAK, West Coast Express and Rocky Mountaineer Railtours have local focus and are indifferent to market share/size issues for freight so long as their plans can be accommodated;
    - Railway motivations are very complex because the main assets they have are people, infrastructure, motive power, and rolling stock, and they work together by necessity rather than by choice.

- GVTA -- Regional transportation priorities may sometimes conflict with freight efficiency needs. Passenger mobility issues, and impacts of freight movement on the major roads network in the Lower Mainland are the main overlapping priority areas .
- City of Vancouver -- Vancouver is a special case because of the historic role of the Waterfront and False Creek Flats. Local land use, public response to trains, and traffic issues dominate their interest; and, there is continuing pressure to free up existing railway lands for urban development.
- Other Municipalities -- Langley, Delta and Surrey, for example, have issues with future rail traffic growth in the Roberts Bank Corridor which may also overlap GVTA issues. North Vancouver has priorities for waterfront development that may influence future rail access development on the North Shore.
- The Government of British Columbia – The Government of British Columbia is preparing a Ports Strategy that is intended to provide an environment that will ensure that the Pacific Ports are an efficient, reliable and competitive port system.
- Government of Canada – Trade and economic growth are high on the federal agenda (market size) and the focus is global.

### 2.2.2 Geographical Context

The rail system of interest for this study extends from terminal facilities of the Vancouver Port Authority and the Fraser Port Authority to the US borders at Blaine and Sumas, Washington in the South and to the Mission Railway Bridge in the East. The area actually specified in the models developed here extends to Burlington, Washington in the South and to Kamloops towards the East. This is done to make the analysis more realistic with a single point of entry from either direction.

Five of the nine Railway Companies mentioned above own and operate property in the study area:

- CPR -- enters the study area from the North Shore of the Fraser River at Mission and continues to the downtown waterfront through Coquitlam and Port Moody and then along the south shore of Burrard Inlet; CPR also owns the Mission Bridge and the line connecting Mission to the US border at Sumas through Abbotsford; other industrial and local connections are owned and operated by CPR in the study area, including a rail link between Port Coquitlam and New Westminster via Sapperton Junction (connecting to CN and BNSF).
- CN -- enters the study area from the south shore of the Fraser River and continues to the south side of the New Westminster Rail Bridge (NWRB); it connects with CPR at the Mission Bridge and with SRYBC and BNSF at the NWRB; CN also provides connections to Fraser Port facilities at Lulu Island and to North Vancouver and beyond, over the Second Narrows Rail Bridge; CN has direct access to the Vancouver downtown waterfront terminal facilities via False Creek Flats and the Heatley Diamond.
- BNSF -- Burlington Northern Santa Fe enters the study area at Blaine, Washington and continues North through White Rock and Boundary Bay along the shoreline, turning North near Mud Bay to enter Vancouver via the NWRB; their main yard is in New Westminster north of the NWRB along a joint section of track owned by BNSF and shared with CN, SRYBC and CPR, which continues onto the waterfront; this joint section is an important bottleneck area for attention in this study as it carries almost all of the north-south current and forecast freight and passenger rail traffic; BNSF also connects with the study area but does not enter at the Sumas/Huntington Border Crossing.
- SRYBC -- Southern Railway of British Columbia is a privately owned short line and is active in serving Marine terminal facilities on Annacis Island (e.g. auto carriers); the main terminal is in New Westminster, west of the NWRB. The railway operates through New Westminster,

Surrey, Langley, Abbottsford, and Chilliwack serving local industries and providing interchange services with all of the Class 1 railways.

- BC Rail – BCR Port Subdivision is a provincially owned railway connecting Roberts Bank to the other railway networks over its 23 mi. Port subdivision. This is a vital link for the study, and it was not part of the arrangement with CN to take over the operations of BC Rail; BC Rail does not operate any trains, but it is responsible for track maintenance and traffic control on this section.

The study network is illustrated in **Exhibit 2.1**, which shows the rail lines ownership and joint running rights.

There are other parties that operate passenger trains in the network which can represent a significant amount of traffic. These are:

- VIA Rail Canada -- operates three transcontinental trains per week year round in each direction between Pacific Station in the False Creek Flats area and Alberta, via the Mission Bridge, using CN's route;
- Rocky Mountaineer Railtours -- operates three trains per week in each direction during the period from May through October, and on an occasional basis over the balance of the year; these trains follow the same path as the VIA trains within the study area;
- West Coast Express -- operates on the CPR line between Mission and the downtown waterfront during weekdays; five trains operate inbound during the morning peak, returning to Mission during the p.m. peak.
- AMTRAK -- operates one train per day year round in each direction between Seattle and Vancouver, using the BNSF route between the border and Pacific Station; Amtrak has plans to increase the frequency of this service to three trains daily in each direction. There are serious concerns that existing capacity is not adequate in this corridor; this issue is taken up in this report.

VIA Rail, Rocky Mountaineer and West Coast Express also have plans to add services during the study time horizon.

The downtown Vancouver waterfront is an important area for bulk and general cargo (e.g. containers, grain and forest products) marine traffic. It is also an important area for passenger cruise ships, public transportation (including the Seabus, SkyTrain, West Coast Express, Harbourlynx ferry, Heliport terminals and Float Planes), and pleasure craft. The rail lines serving the Port in this area are regarded by some as an obstacle to these other pursuits. Backup land for marine port facilities and for efficient rail operations is a serious constraint in this area, affecting rail lines along the waterfront as well as CPR trackage east of the second Narrows Bridge and the False Creek Flats area for CN and BNSF.

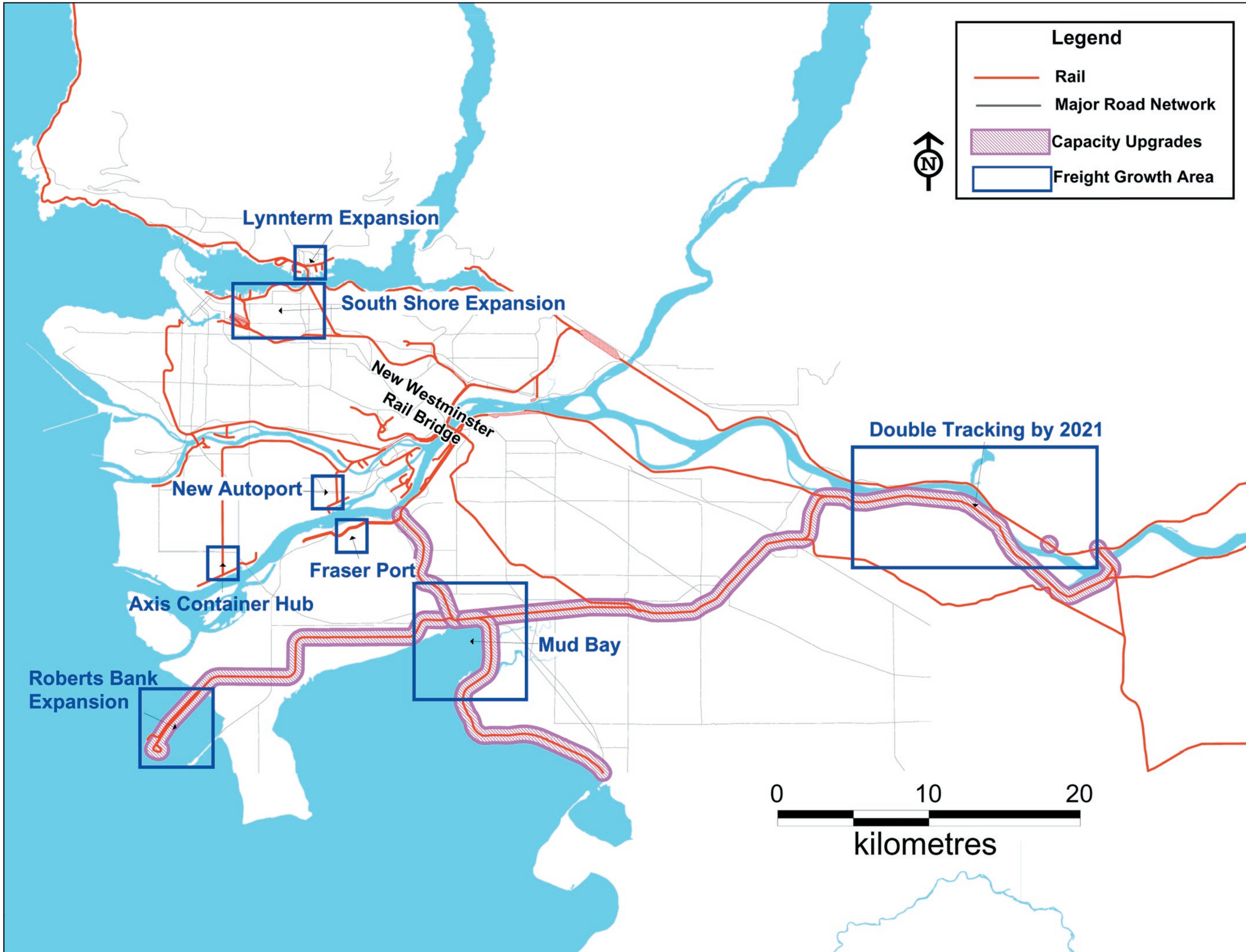
There are no easy solutions to expand rail throughput capacity; rail scenarios and potential solutions could involve significantly different ways of making use of the available land in this area. The same observation could also apply to other areas in the study where rail congestion and port capacity are interrelated with each other and with broader planning issues. **Exhibit 2.2** illustrates the locations where port facility expansion is proposed and where rail network expansion planning issues may occur.

These land use constraints are discussed in detail in a later section of this report.

Exhibit 2.1 Lower Mainland Rail Study Network

# Vancouver

Exhibit 2.2 Growth Areas and Potential Congestion Issues



## 2.3 Rail Improvements

The topography of the region presents significant challenges and contributes to the difficulty of increasing capacity on the existing rail network. Specific solutions that have been proposed by service providers to meet capacity problems of the current network include:

- **New Lift Bridge or New/Upgraded Swing Bridge:** Lift or swing bridges require coordination with marine traffic for bridge closures. Scheduled and unscheduled marine traffic requires bridge closures which add to capacity constraints, particularly at peak hours.
- **Tunnels**: Tunnels under major water crossings offer rail users higher levels of service and complete separation from marine traffic.
- **High Level Bridges:** New bridges with greater clearance over marine traffic provide uninterrupted rail capacity.
- **Road – Rail Grade Separations:** At-Grade road crossings are both safety issues and contributors to road delays, that can be overcome through the construction of over/underpasses in order to segregate vehicular and train movements. It has been suggested that consideration should be given to closing some roads and consolidating some other road crossings, in order to reduce the number of at-grade road crossings.

The Major Commercial Transportation System Report identified a number of proposed improvements to the rail system in the Lower Mainland, the most significant of which is the replacement of the New Westminster Rail Bridge. The NWRB is a single track swing span bridge constructed in 1904 to accommodate movements of both rail and marine traffic. It is owned by the Government of Canada and operated and maintained by CN. It spans the Fraser River which is an important marine commercial artery, and it is an important railway facility for virtually all of the rail stakeholders in the region, rail freight as well as passenger train operations. The Bridge is a vital component that has been seen as a key limiting constraint to trade and travel growth, because of speed restrictions and time delays associated with Bridge openings for marine traffic. The projected growth in passenger rail traffic crossing the bridge further limits the available capacity for growth in freight traffic.

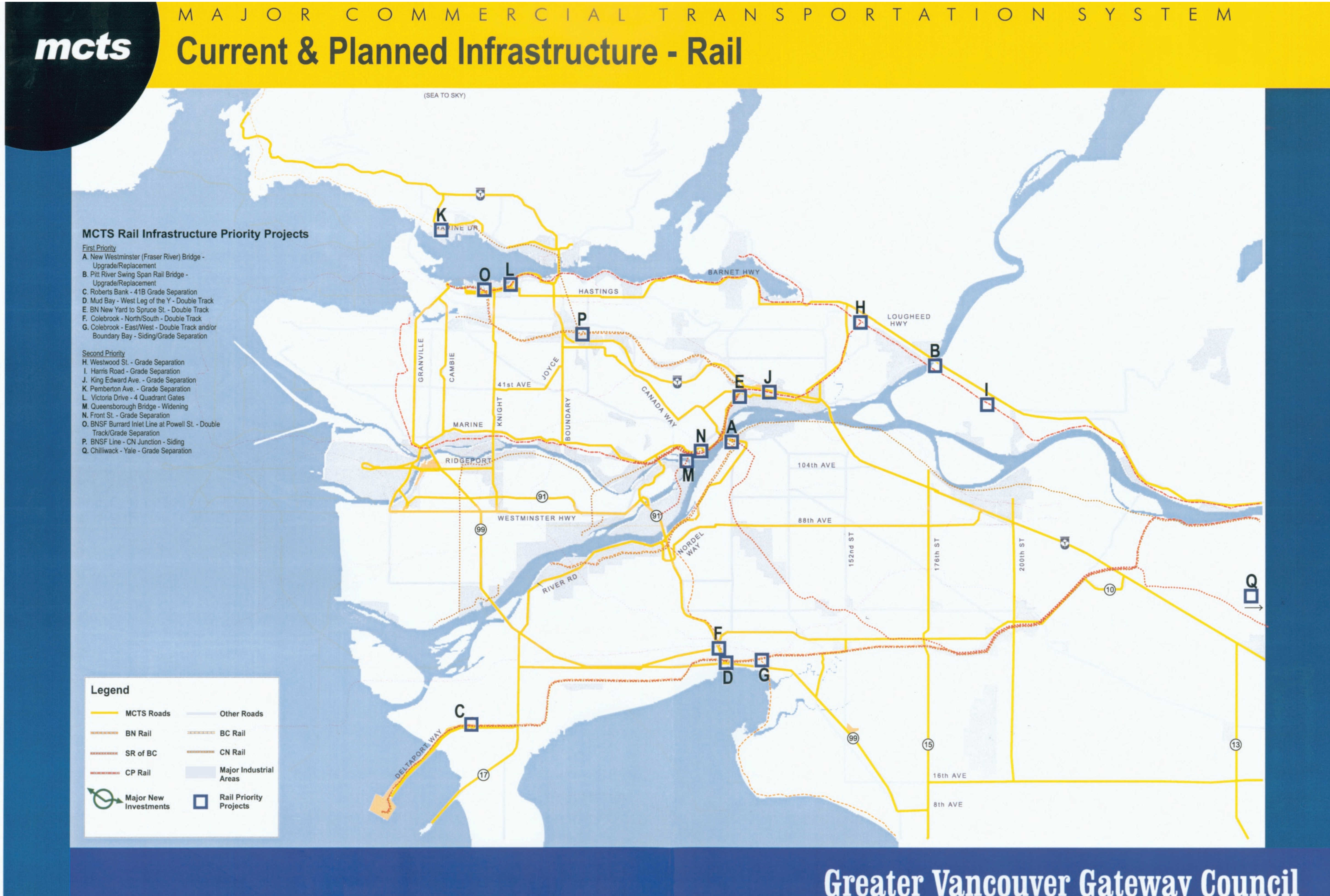
Various studies have been undertaken over the last two decades on the safety, capacity and economic impacts of the NWRB. A number of these have suggested that the NWRB should be replaced in the near future. One of the main objectives of this study was to examine whether the NWRB needs to be replaced with a higher capacity facility, and if so, should it be a bridge or a tunnel.

Aside from replacing the existing NWRB with a new bridge or tunnel, the 16 separate Major Commercial Transportation System (“MCTS”) project improvements to the Lower Mainland rail network are also vital to expanding the capacity of the rail networks to meet the growing freight and passenger rail demand. These improvements are shown in Exhibit 2.3. At the same time, population in the Lower Mainland is growing, and with it traffic on the road system. This will contribute to increasing pressure on level rail crossings, for example in rapidly growing areas such as Langley, Surrey and Delta.

In addition to infrastructure solutions, there are longer-term strategic issues associated with the regional sustainability of railway transport. Such issues include:

- Retention of industrial lands;
- Compatibility with adjacent land uses;
- Competition with other land uses; and
- Use of rail corridors for urban rail transit.

**Exhibit 2.3 MCTS Proposed Rail Improvements**

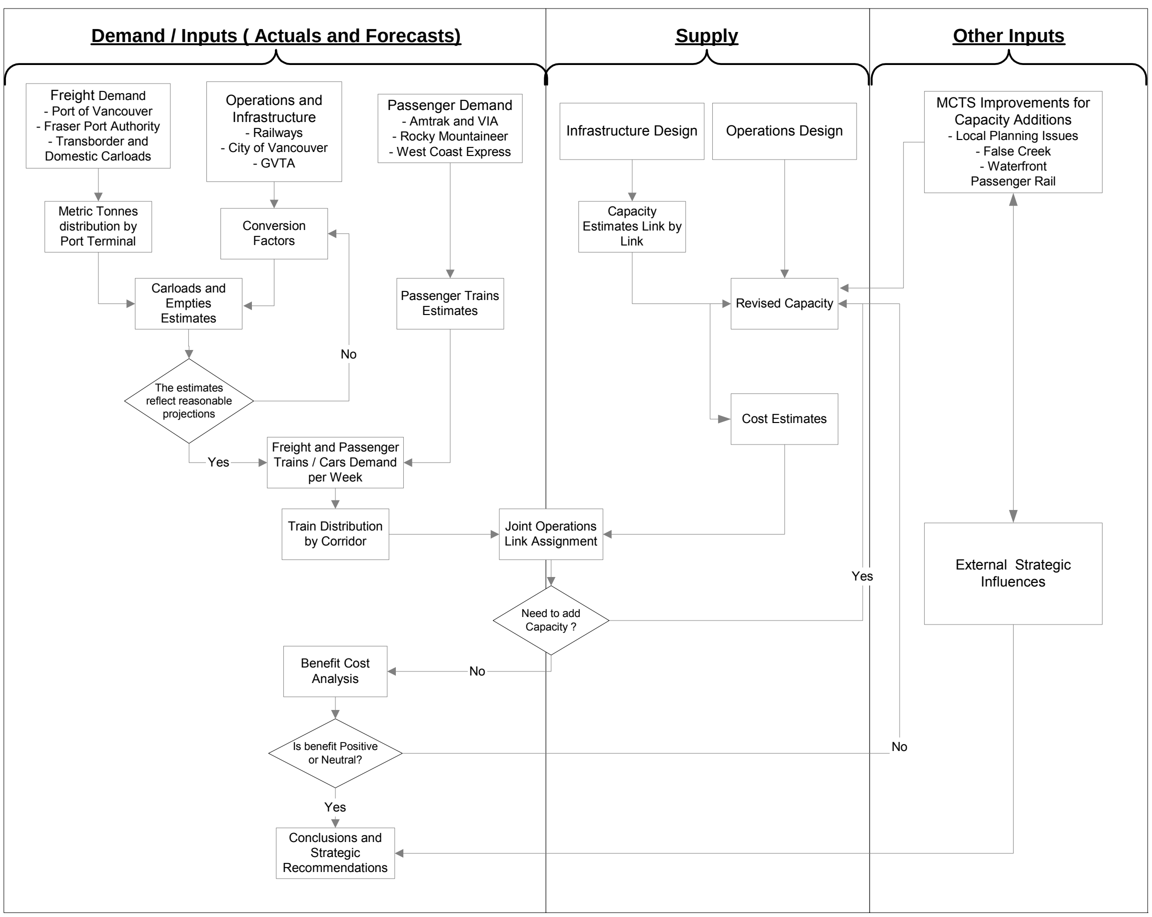


## 2.4 STUDY METHODOLOGY

An innovative approach was developed, to blend planning skills and methods with technical and engineering expertise and project financing strategies. Quantitative analytical techniques (e.g. cost and capacity models, engineering estimating techniques, financial models etc.) were combined with experience and knowledge of team members to meet the needs of the sponsoring stakeholders.

An overview of the methodology employed is provided in **Exhibit 2.4 Study Methodology**. Rail transportation demand information was obtained from study sponsors and stakeholders and information on operations and infrastructure was also obtained from service providers. Other inputs were provided, such as the results of the Major Commercial Transportation System (MCTS) study that had previously been conducted by the Gateway Council.

**Exhibit 2.4 Study Methodology**




Transportation demand information was provided by VPA and Fraser Port, expressed in terms of metric tonnes. Passenger train movements and carloads of domestic and transborder rail traffic were provided by railway sources. All demand data were converted to weekly movements of rail carloads and trains by origin and destination.

Infrastructure and operations information were used to determine train capacities and to establish unit costs for each segment. The demand and supply data were input to the network transportation model that assigned traffic through the network from origin to destination to achieve the lowest total cost to the system, subject to capacity constraints. If the model failed to produce a feasible solution, or if a solution was found that exceeded capacity threshold tolerances, then operational or infrastructure changes were estimated and the model was rerun until solution criteria were met.

Required infrastructure changes were evaluated for cost and technical feasibility, and output statistics were summarized in terms of operating cost and workload. All of this information was used as input to the economic and financial analysis, and ultimately in the formulation of conclusions and strategic recommendations.

Further discussion of the assumptions used and the details of the process at each step will be found in the appropriate sections of this report as results are being described.

In the final analysis, a large number of cases and sensitivity variations were evaluated to arrive at the conclusions reached by this study.

The types of variations examined include:

- Three different freight market growth projections (base case, optimistic and pessimistic);
- All of the conversion factors used to translate metric tonnes into train loads are modifiable, for example to test the impact of long container trains;
- a full set of solutions was developed for 2003, 2006, 2011, 2016, and 2021, for each of the market growth projections; and
- each case was examined for four different ways of distributing the growth between port areas;
- passenger train sensitivity cases were run, mainly by varying the number of trains, especially Amtrak trains, over highly utilized lines;
- Each time there were changes made to track capacity, the models were rerun in order to capture the full system effects.

## 2.5 Report Structure

The amount of information produced during the course of this study was considerable, and while much of it was helpful in arriving at conclusions, it would be excessively cumbersome to go through all the details in this report. Thus, the report is organized to present the main findings from the study in as clear and concise a manner as possible with appropriate justification for key findings.

Section 3, immediately following, describes the market projections that drive the main findings of the study. The actual forecasts are presented in terms of carloads and train loads for each major area of the Vancouver Gateway. This level of aggregation was used to drive the solutions, and it was also appropriate to preserve confidentiality of commercially sensitive information from various sources who cooperated with this study.

Section 4 provides a more detailed description of the rail network analysis methodology and input parameters.

Section 5 summarizes the conceptual designs and cost estimates for significant civil works considered in this project.

Section 6 presents the network systems analysis and the synthesis of operational, infrastructure and market demand elements. This section goes into some detail on the strategic requirements for new infrastructure capacity and the timing associated with them.

Section 7 describes the assessment of solutions including the financial and economic analysis of strategic alternatives. Delivery mechanisms for candidate projects are also discussed in this section.

Section 8 contains the conclusions and recommendations.

Appendices A1 – 4 present details of the infrastructure improvements and costs, while Appendix B presents examples of rail project delivery models and Appendix C presents rail infrastructure precedents across North America.

# 3.0 FREIGHT MARKET PROJECTIONS

The market for Vancouver Gateway ports is driven by Trans-Pacific trade. Vancouver is located advantageously with respect to this market, and it has been recording growth rates in excess of 6% in recent years, including 6.2% in 2003. The market for general cargo and containers is projected to grow by 50% over 2001 traffic levels by the end of 2005. PIERS (Port Import Export Reporting Service, Journal of Commerce), Maritime Research results are reported in the July 2004 edition of Containerization International showing Trans-Pacific trade to the USA up by 10.2% in 2003 over 2002. North East Asia accounts for most of this growth (Japan, Taiwan, Hong Kong, South Korea, Peoples Republic of China, and Macao).

This growth rate is more or less keeping in line with the growth in supply of cellular ship capacity in this market. Automobiles and the automotive sector are significant in this trade, registering growth rates above average. Such growth has also been evident in the traffic handled through the Fraser Port auto terminals, and it is reflected in expansion plans.

The bulk and breakbulk sectors are also growing; however the trends in this area follow more traditional lines, rather than the explosive growth of container traffic mentioned above.

A central question for this study is whether or not dramatic growth rates will continue over the foreseeable future. The Vancouver Port Authority and the Fraser Port Authority are both making plans for long-term sustained growth, by expanding capacities of their port facilities. The railways, on the other hand, have taken a more conservative view of growth potential and have been caught off guard by recent, unexpected significant increase in traffic, to the extent that service backlogs have occurred during the time frame of this study.

The short-term capacity issues are being dealt with through existing business processes and arrangements between shippers and carriers. This study is directed at longer-term needs for railway network capacity in support of foreign trade through Vancouver Gateway ports. In that regard, the consensus appears to be for sustained high growth rates over the foreseeable future. While specific projections may vary among Global Insight, PIERS, ECRI (Economic Cycle Research Institute), Drewry Shipping Consultants and others, there is general agreement in the overall trend of sustained growth.

It is evident that capacity of port terminal facilities and inland transportation corridors will weigh heavily on the distribution of traffic demand, particularly along the west coast of North America. The Vancouver Gateway, with rail connections direct to marine terminals and good service to the US Mid-West, has potential to take advantage of this growth in international trade. In fact, the Vancouver Port Authority projects that containerized cargo volume could triple between 2003 and 2021, and the same is possible for Fraser Port.

All of these factors have been taken into account by the Port Authorities in preparing their long term forecasts for strategic planning purposes. The forecasts prepared by the ports were used as the base case starting point for future projections. High and Low variations of the port forecasts were generated also, to represent the broader range of what may happen, such as to reflect the higher growth projected by some shipping lines, or the lower more pessimistic projection associated with an economic slowdown and/or competition from the U.S. ports. Freight forecasts were developed in terms of metric tonnes and TEUs (20 ft. equivalent units) for containers. A methodology was developed in this study to translate the port-generated forecasts into appropriate railway demand in terms of movements of cars and trains over a network of links and nodes. The methodology and the results are described in the following paragraphs.

## 3.1 Traffic Projections

Actual and forecast freight traffic from the ports was provided by year and by commodity for the period 1999 to 2020 in the case of Vancouver Port, and for the period 1999 to 2007 in the case of Fraser Port. Growth rates provided by Vancouver Port Authority were applied for Fraser Port estimates beyond 2007.

Historical traffic information was used by port area to reconcile and match port traffic and rail movements provided by the railways. Interviews and inspection trips with railway officials and the consultants' general knowledge of the rail operations of the region were the main sources for traffic assignment. Aggregation of destinations served two important purposes: first, to make the analysis of traffic flows manageable; and second, to maintain confidentiality of commercially sensitive information proprietary to railways, marine terminal operators, importers and exporters.

A set of conversion factors was developed to convert the original cargo data (in thousand metric tonnes) to total carload movements. These factors were calibrated to historical traffic information.

### *3.1.1 Conversion Factors for Calculation of Carloads*

The conversion factors for each commodity are shown in **Exhibits 3.1 and 3.2** for Vancouver Port and Fraser Port respectively.

**Exhibit 3.1 Port of Vancouver Conversion Factors, Cargo to Rail Cars**

| Commodity Type | Commodity Type (Proposal Classification) | Import | | | | | |
|---|---|---|---|---|---|---|---|
| | | % Import | % Rail | Weight / Car | TEU / Car | % Empty Return | Cars / Train |
| COAL | Coal | 0% | 0% | 91 | N/A | 0% | 100 |
| GRAIN | Grains | 0% | 0% | 91 | N/A | 0% | 100 |
| SULPHUR | Fertilizer Material | 0% | 0% | 91 | N/A | 0% | 100 |
| POTASH | Fertilizer Material | 0% | 0% | 91 | N/A | 0% | 100 |
| METAL ORES & CONCENTRATES | Other Freight | 0.75% | 100% | 91 | N/A | 100% | 100 |
| WOOD CHIPS | Forest Products | 0% | 0% | 80 | N/A | 0% | 100 |
| OTHER DRY PRODUCTS | Other Freight | 0% | 0% | 100 | N/A | 0% | 100 |
| PETROLEUM PRODUCTS | Other Freight | 18% | 67% | 90 | N/A | 100% | 100 |
| PETROCHEMICALS | Other Freight | 18% | 67% | 90 | N/A | 100% | 100 |
| VEGETABLE OILS / TALLOW | Other Freight | 50% | 50% | 90 | N/A | 100% | 100 |
| OTHER LIQUID BULK PRODUCTS | Other Freight | 50% | 50% | 90 | N/A | 100% | 100 |
| LUMBER | Forest Products | 0% | 0% | 85 | N/A | 0% | 100 |
| WOOD PULP | Forest Products | 0% | 0% | 85 | N/A | 0% | 100 |
| OTHER BREAKBULK PRODUCTS (3) | Other Freight | 67% | 25% | 85 | N/A | 51% | 100 |
| CONTAINER CARGO | Containers and Trailers | 40% | 43% | 7.2 | 3 | 20% | 100 |
| **Commodity Type** | **Commodity Type (Proposal Classification)** | **Export** | | | | | |
| | | % Export | % Rail | Weight per Car | TEU / Car | % Empty Return | Cars / Train |
| COAL | Coal | 100% | 100% | 95 | N/A | 100% | 100 |
| GRAIN | Grains | 100% | 100% | 91 | N/A | 100% | 100 |
| SULPHUR | Fertilizer Material | 100% | 100% | 91 | N/A | 100% | 100 |
| POTASH | Fertilizer Material | 100% | 100% | 91 | N/A | 100% | 100 |
| METAL ORES & CONCENTRATES | Other Freight | 0% | 0% | 100 | N/A | 0% | 100 |
| WOOD CHIPS | Forest Products | 0% | 0% | 80 | N/A | 0% | 100 |
| OTHER DRY PRODUCTS | Other Freight | 0% | 0% | 100 | N/A | 0% | 100 |
| PETROLEUM PRODUCTS | Other Freight | 82% | 67% | 90 | N/A | 100% | 100 |
| PETROCHEMICALS | Other Freight | 82% | 67% | 90 | N/A | 100% | 100 |
| VEGETABLE OILS / TALLOW | Other Freight | 50% | 50% | 90 | N/A | 100% | 100 |
| OTHER LIQUID BULK PRODUCTS | Other Freight | 50% | 50% | 90 | N/A | 100% | 100 |
| LUMBER | Forest Products | 100% | 50% | 85 | N/A | 76% | 100 |
| WOOD PULP | Forest Products | 100% | 50% | 85 | N/A | 100% | 100 |
| OTHER BREAKBULK PRODUCTS (3) | Other Freight | 33% | 25% | 85 | N/A | 0% | 100 |
| CONTAINER CARGO | Containers and Trailers | 60% | 43% | 12 | 3 | 11% | 100 |

**Exhibit 3.2 Fraser Port Conversion Factors, Cargo to Rail Cars**

| Commodity Type | Commodity Type (Proposal Classification) | Import | | | | | |
|---|---|---|---|---|---|---|---|
| | | % Import | % Rail | Weight / Car | TEU / Car | % Empty Return | Cars / Train |
| LUMBER | Forest Products | N/A | 0% | 85 | N/A | 0% | 100 |
| OTHER | Other Freight | N/A | 50% | 85 | N/A | 0% | 100 |
| PULP | Forest Products | N/A | 0% | 85 | N/A | 0% | 100 |
| AUTOS | Other Freight | N/A | 80% | 35 | N/A | 100% | 100 |
| CHEMICALS | Other Freight | N/A | 0% | 90 | N/A | 0% | 100 |
| PAPER | Forest Products | N/A | 0% | 85 | N/A | 0% | 100 |
| WOOD P. | Forest Products | N/A | 0% | 85 | N/A | 0% | 100 |
| G. CARGO 1 | Container and Trailers | N/A | 50% | 36 | N/A | 10% | 100 |
| G. CARGO 2 | Container and Trailers | N/A | 50% | 17.1 | 3 | 10% | 100 |
| STEEL | Other Freight | N/A | 50% | 91 | N/A | 51% | 100 |
| **Commodity Type** | **Commodity Type (Proposal Classification)** | **Export** | | | | | |
| | | % Export | % Rail | Weight per Car | TEU / Car | % Empty Return | Cars / Train |
| LUMBER | Forest Products | N/A | 50% | 85 | N/A | 100% | 100 |
| OTHER | Other Freight | N/A | 30% | 85 | N/A | 0% | 100 |
| PULP | Forest Products | N/A | 100% | 85 | N/A | 100% | 100 |
| AUTOS | Other Freight | N/A | 100% | 35 | N/A | 0% | 100 |
| CHEMICALS | Other Freight | N/A | 60% | 90 | N/A | 100% | 100 |
| PAPER | Forest Products | N/A | 100% | 85 | N/A | 100% | 100 |
| WOOD P. | Forest Products | N/A | 50% | 85 | N/A | 100% | 100 |
| G. CARGO 1 | Container and Trailers | N/A | 50% | 36 | N/A | 0% | 100 |
| G. CARGO 2 | Container and Trailers | N/A | 60% | 36 | 3 | 0% | 100 |
| STEEL | Other Freight | N/A | 0% | 91 | N/A | 0% | 100 |

There are six conversion parameters under the import and export sections of the conversion factors table: percentage of import/export, percentage of rail, weight per railcar, number of TEUs per car, percentage of empty return, and number of cars per train. Each commodity type may have a different set of conversion factors.

These parameters used for import and export traffic are described below:

- Percentage of import/export: the percentage of the total tonnage cargo that is imported. Total export cargo is the remaining share.
- Percentage of Rail: this is the percent of total cargo distributed by train, rather than truck.
- Weight per Car: this factor converts the total tonnage of cargo into the number of carloads. The weight per car is defined in tonnes.
- Number of TEUs per car: In addition to total tonnage cargo, the original data provided by the Ports also show container data expressed in number of TEUs. The number of TEUs per car is the factor that converts the total number of containers into carloads.
- Percentage empty return: accounts for the number of empty cars coming back from their destination points. The percentage empty return factor is used to increase the number of carloads to include the empty cars flowing through the network.
- Number of Cars per train: is a factor that transforms carloads to the number of trains flowing through the network.

Traffic was estimated based on historical information from previous studies, to account for domestic and transborder movements through the study area.

### *3.1.2 Carload Movements Projections*

Having estimated total annual carload movements originated at or destined to a specific node in the network, the final set of factors was used to determine routings. Annual carload movements were divided into outbound from the Lower Mainland (eastbound/southbound) and inbound into the Lower Mainland (westbound/northbound) movements for each commodity and summed. The outbound flow is equal to the import carloads plus the export empty cars. The inbound flow is equal to the import empty cars plus the export carloads.

All calculations described above were executed for years 1999 to 2005 and the factors were used to calibrate all the conversion factors for the base case forecasts.

Carload movement projections were then developed for years 2006, 2011, 2016 and 2021. The annual growth rates are provided in **Exhibit 3.3** by port and commodity.

**Exhibit 3.3 Cargo Demand Growth Rates by Port**

| Port Terminal / Commodity Type | | Annual Growth Rates | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Base Case | | | Optimistc | | | Pessimistic | | |
| | | 06-11 | 11-16 | 16-21 | 06-11 | 11-16 | 16-21 | 06-11 | 11-16 | 16-21 |
| **Vancouver Port Authority** | | | | | | | | | | |
| Coal | | 0.40% | 0.00% | 0.00% | 0.40% | 0.00% | 0.00% | 0.40% | 0.00% | 0.00% |
| Grain | | 0.90% | 0.00% | -0.50% | 0.90% | 0.00% | -0.50% | 0.90% | 0.00% | -0.50% |
| Fertilizer Material | Sulphur | 0.70% | 0.00% | 0.00% | 0.70% | 0.00% | 0.00% | 0.70% | 0.00% | 0.00% |
| | Potash | 2.00% | 1.00% | 0.60% | 2.00% | 1.00% | 0.60% | 2.00% | 1.00% | 0.60% |
| Forest Products | Wood Chips | 3.10% | 1.10% | 1.50% | 3.10% | 1.10% | 1.50% | 3.10% | 1.10% | 1.50% |
| | Lumber | 4.60% | 3.30% | 0.00% | 4.60% | 3.30% | 0.00% | 4.60% | 3.30% | 0.00% |
| | Wood Pulp | 0.90% | 1.10% | 1.10% | 0.90% | 1.10% | 1.10% | 0.90% | 1.10% | 1.10% |
| Mineral and Metals | | - | - | - | - | - | - | - | - | - |
| Containers & Trailers | | 4.65% | 4.13% | 4.13% | 6.00% | 6.00% | 6.00% | 2.50% | 2.00% | 1.50% |
| Other Freight | Metals Ores and Concentrates | 2.60% | 0.00% | 0.00% | 2.60% | 0.00% | 0.00% | 2.60% | 0.00% | 0.00% |
| | Petroleum products | 9.40% | 4.00% | 2.90% | 9.40% | 4.00% | 2.90% | 9.40% | 4.00% | 2.90% |
| | Petrochemicals | 0.60% | 1.10% | 1.50% | 0.60% | 1.10% | 1.50% | 0.60% | 1.10% | 1.50% |
| | Vegetable oils / Tallow | 1.90% | 0.80% | 0.20% | 1.90% | 0.80% | 0.20% | 1.90% | 0.80% | 0.20% |
| | Other Liquid Bulk products | 1.00% | 0.00% | 0.00% | 1.00% | 0.00% | 0.00% | 1.00% | 0.00% | 0.00% |
| | Other breakbulk products | 2.00% | 1.00% | 0.80% | 2.00% | 1.00% | 0.80% | 2.00% | 1.00% | 0.80% |
| **Fraser Port Authority** | | | | | | | | | | |
| Coal | | - | - | - | - | - | - | - | - | - |
| Grain | | - | - | - | - | - | - | - | - | - |
| Fertilizer Material | | - | - | - | - | - | - | - | - | - |
| Forest Products | | 0.00% | 1.80% | 1.60% | 0.00% | 1.80% | 1.60% | 0.00% | 1.80% | 1.60% |
| Mineral and Metals | | - | - | - | - | - | - | - | - | - |
| Containers & Trailers | | 0.00% | 1.80% | 1.60% | 6.00% | 6.00% | 6.00% | 0.00% | 1.00% | 1.00% |
| Other Freight | Autos | Import=1.5% Export=14.4% | Import=1.8% Export=6% | Import=1.6% Export=2% | 6.00% | 6.00% | 6.00% | 1.47% | 1.80% | 1.60% |
| | Chemicals | 8.00% | 5.00% | 2.50% | 8.00% | 5.00% | 2.50% | 8.00% | 5.00% | 2.50% |
| | Steel | 0.00% | 1.80% | 1.60% | 0.00% | 1.80% | 1.60% | 0.00% | 1.80% | 1.60% |
| | Other | 0.00% | 1.80% | 1.60% | 0.00% | 1.80% | 1.60% | 0.00% | 1.80% | 1.60% |

### *3.1.3 Final Carload Movement Table*

The final carload movement table was then developed by converting the total annual train movement projections into weekly train movements, based on 52 weeks in a year.

**Exhibit 3.4** provides aggregated highlights of the carload and trainload forecasts for selected years. The base case is presented for 2003. The planning reference case is presented for 2011 and 2021. The projected volume by railway terminal area is also shown. The specific assumptions leading to it are described more fully in the following sections.

The total carload movement and train movement data outlined in this final table represent the traffic that is assigned in the network flow transportation model.

**Exhibit 3.4 Estimated Weekly Train Movements**

**Base Case**

| | 2003 | | 2011 | | 2021 | |
|---|---|---|---|---|---|---|
| Terminal Node | Weekly Train Movements | | Weekly Train Movements | | Weekly Train Movements | |
| | EastBound/ Southbound | Westbound/ Northbound | EastBound/ Southbound | Westbound/ Northbound | EastBound/ Southbound | Westbound/ Northbound |
| Port Coquitlam | 14 | 14 | 24 | 24 | 37 | 37 |
| Sapperton | 9 | 9 | 10 | 10 | 11 | 11 |
| Thornton Yard | 22 | 23 | 25 | 26 | 26 | 27 |
| Livingston | 3 | 3 | 0 | 0 | 0 | 0 |
| North Vancouver | 31 | 31 | 43 | 41 | 49 | 46 |
| Burrard Inlet | 37 | 34 | 57 | 50 | 73 | 63 |
| Lulu Island | 5 | 5 | 6 | 5 | 6 | 5 |
| Annacis | 1 | 1 | 2 | 2 | 2 | 2 |
| Fraser Surrey | 9 | 12 | 11 | 13 | 13 | 16 |
| Roberts Bank | 74 | 65 | 94 | 79 | 122 | 100 |
| Port Moody | 15 | 15 | 19 | 19 | 24 | 24 |

# 4.0 RAIL TRAFFIC FORECASTS

## 4.1 ANALYTICAL APPROACH

The core concept of the study methodology was to synthesize all the information provided through processes described in the preceding sections, and to develop a "logical" description of the Lower Mainland Railway system as a network comprising links connecting nodes. The goal was to set up a rail freight assignment model to capture all of the key routing options for traffic and operations in the study area.

A linear programming model was adapted for present use -- a model with algebraic linear expressions describing a quantitative objective function (i.e. in this case, to minimize operating costs) subject to constraints (i.e. in this case, within available capacity determined for each link). The rail network consists of:

Nodes: represent terminals or junction points, some of which are defined as locations where traffic can enter or leave the network.

Links: connect the nodes and carry the flow associated with the network. They have an associated value per unit of flow (i.e. cost, distance, time) that defines a specific characteristic. Upper and lower bounds of flow define the capacity of any link. The capacity of each link is estimated using a set of equations developed by the consultant, and which are based on parametric analysis of multiple detailed simulations of track configurations and operating circumstances.

The flow that minimizes total link cost is considered the optimal flow.

In this report, the central notion of optimal flow is that the network would allow “Coordinated Rail Operations” and every link or node would be available to all traffic entering or leaving the system. This is an approach that makes best and most profitable use of all network resources, and it is therefore appropriate for evaluating long-term strategic policy and plans with respect to future demand, operations and infrastructure investments affecting all stakeholders. The use of the term “Coordinated” implies reciprocal commercial arrangements between established railways. It is not to be confused with a notion of “open access”, to which railways are opposed.

## 4.2 DESCRIPTION OF THE NETWORK FLOW TRANSPORTATION MODEL

The network flow transportation model consists of a set of components with specific characteristics, for example, track capacity, cost per train-mile (km), local and passenger trains handled per section of track, and demand / supply at terminal facilities. These characteristics were introduced to the model for each section of railway track. Following is a brief description of the components of this section of the model.

***Track Capacity***
Track capacity was determined using a parametric model that takes into consideration track and traffic mix characteristics. The parametric model determines the maximum number of trains per day that each specified section can accommodate over the long term.

***Local and Passenger Trains***
Local trains and passenger train movements were derived from data supplied by the railways. Local trains and passenger trains were allocated capacity prior to running the network optimization process.

***Operating Cost Per Train***
The operating cost per train was calculated for each section of track. This cost involves four variables: cost per train-mile, track section distance, impedance cost and penalty factor. All of those variables are flexible, but for the analysis they were kept at fixed levels. Track distance was taken from operating timetables of the Railways. The cost per train-mile for the cases shown is arbitrarily set at $25 per train mile ($15.60 per train km) to represent the variable costs for train crew, fuel, locomotives, and car equipment. Impedances and penalty factors were only applicable to some track sections. Those costs were included to force the model to produce solutions that are closer to real railway operations (for

example, impedance was used to discourage running against the flow on directional-running sections, or to prevent leaving a node over a physical connection that does not exist).

***Demand / Supply At Terminal Facilities***
The supply and demand data at terminal facilities were taken from the forecasts described previously. Based on the traffic data provided by the Port Authorities, the number of train movements destined to and departing from each facility was estimated. The transportation model used those estimations to balance the network and to accommodate the traffic, while minimizing transportation costs.

## 4.3 Rail Capacity and Operational Analysis

The import and export models were built with macro programming instructions incorporated in Excel spreadsheets, and used Solver, the Excel linear programming tool. The results provide the number of train movements assigned to each section of track so that demand and supply is met while minimizing transportation cost. Those preliminary results provide the basis for the operational railway indicators used for the analysis of the railway network.

The variables that carry the input data for these models are flexible. This flexibility allows for the simulation of projected years and possible scenarios. Results generated from these runs allow the analysis of trends, future bottlenecks, capacity shortages, etc.

***Results Compilation***
All units internal to the analysis are Imperial measure (miles, short tons, ton-miles, etc.) similar to those used by the railway industry. Selected indicators referred to in this report are described below:

Percentage Capacity: This indicator is calculated per section of track. It measures the percentage of track capacity usage. It is calculated using the total number of through trains against the net track capacity assigned to through trains. This is the key parameter used in the text to describe and compare cases.

Weekly train-miles: This indicator is calculated per section of track. Through train miles, Local train-miles, Passenger train-miles, and Total train-miles are all calculated. These indicators are calculated multiplying the number of Thru, Local and Passenger trains assigned to each section of track times the number of miles for each track section.

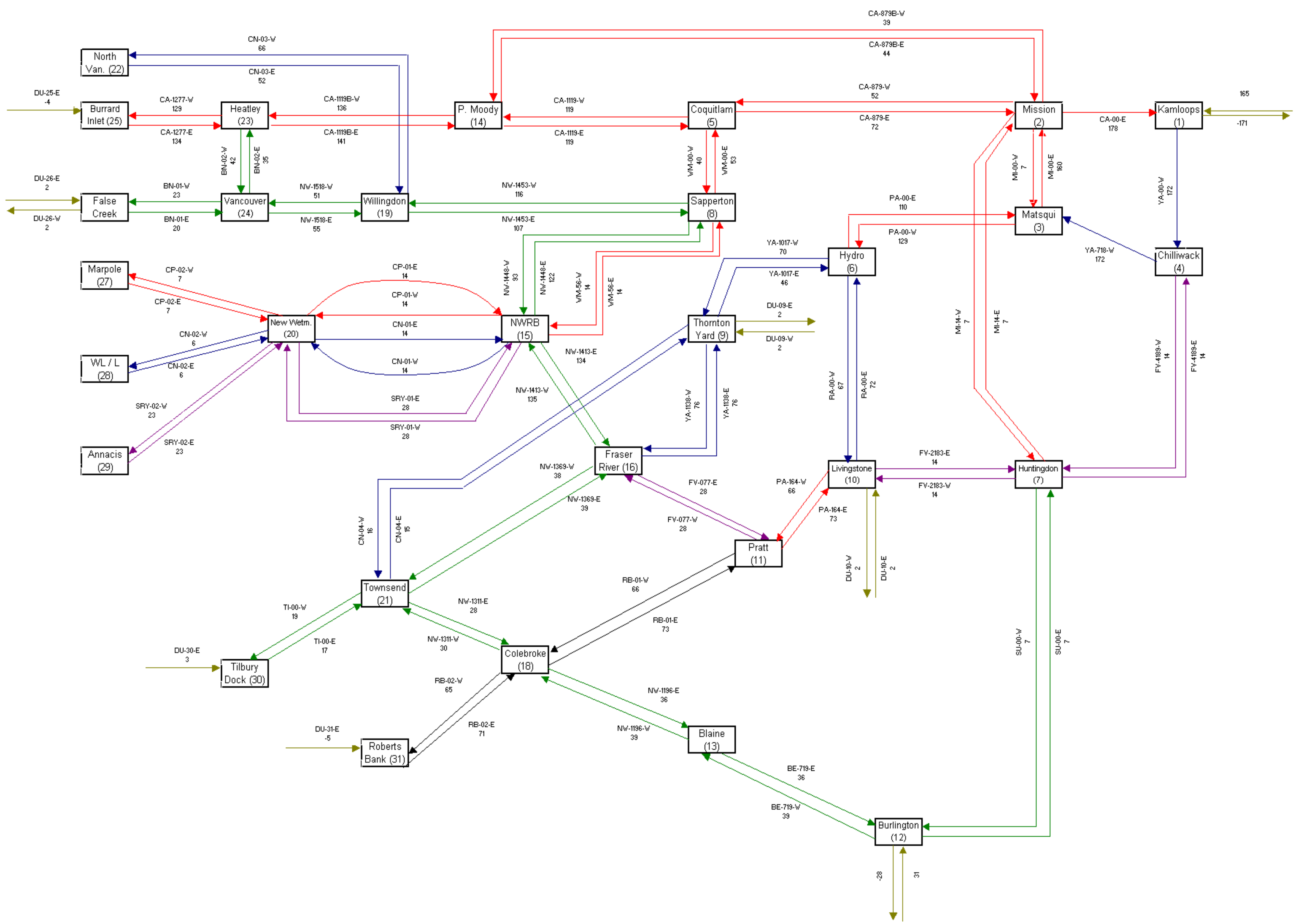
Weekly Cost: This indicator is also divided into two sub-indicators, Train operating cost and Variable track maintenance. To calculate Train Operating Cost, the total number of trains assigned to each section of track is multiplied by its operating cost per train. To calculate the Variable track maintenance cost, Gross ton-miles are multiplied by the estimated variable cost, approximated as $C 1.00 per MGTM (i.e. one thousand gross ton-miles – gross tons equal the weight of a train including engines, cars and contents).

## 4.4 Graphical Rail Network Representation

The graphical representation in Exhibit 4.1 reproduces a spatial illustration of the Lower Mainland railway network. This graphic shows the total number of trains assigned to each section of track (thru trains, local trains and passenger trains). This graphic also shows the demand and supply flow at each terminal node. Sections of track assigned zero flow are not shown in the graphic.

The case shown in Exhibit 4.1 is the calibrated estimate for 2003. The principal nodes used to define the logical network are shown inside boxes, while arrows between the boxes represent weekly flows of trains by direction. Each box carries a label that is used in the logic of the model to define a grouping of rail nodes. The numbers shown below the label for each arrow represent the number of trains per week, on average.

## Exhibit 4.1 Graphical Network Representation – Base Case 2003



# 5.0 RAIL CAPACITY ENHANCEMENT PROJECTS AND COSTS

This section elaborates on the engineering issues of each project that was studied, except for those that were deferred and non-MCTS projects. We define the key technical issues of each project and which assumptions were made to arrive at the cost estimates for each project.

This section does not provide recommendations or a financial analysis of the projects. That, among other topics, is covered in Section 7 of this report.

The projects are categorized as First Priority projects and Second Priority projects, in accordance with MCTS reports. These correspond to the projects categorized in Section 7 as “Capacity expansion projects” and Secondary projects”.

Drawings of each project, along with description sheets, are included in Appendix A .

## 5.1 FIRST PRIORITY PROJECTS

The projects identified in the MCTS report “Rail Capacity & Regional Planning Issues Overview” (Feb. 2003) as “First Priority” are as listed below:

- A - New Westminster Rail Bridge
    1. Retain existing bridge
    2. Replace bridge with a new vertical-lift bridge
    3. Replace bridge with a tunnel
- C - Roberts Bank - 41B St. - Overpass
- E – BN New Yard to Spruce St. - Double Track
- F – Colebrook North/South - Siding
- G – Colebrook East/West – Siding

Each of these infrastructure improvement projects is discussed in this section following.

### *5.1.1 A - New Westminster Rail Bridge*

Currently, the New Westminster Rail Bridge (NWRB) is a 100 year old, single-track swing bridge, which carries 46 trains per day and opens 17 times per day for marine traffic. Its navigation clearance of 6.7m high by 51m wide is restrictive for most chip barges that pass through, thus requiring openings for most of them. Moreover, the bridge is prone to ship collision due to the narrow openings for marine traffic. Of the 7,000 ship movements under the bridge, there were 60 collisions with the bridge in a 40 year period.

Regarding the structural condition of the bridge, the creosote-soaked wooden approach trestles will eventually need to be upgraded on both ends due to fire risk. The structural state of the steel truss superstructure is between fair and poor, based on structural inspections that have been carried out by CN. The bridge also needs to be seismically upgraded.

Regarding train speed, the 13-degree horizontal curves result in a maximum speed of only 11mph (18 km/h) over the bridge, which was recently increased from 8mph (13km/h).

Clearly, this bridge represents a constraint to both rail and marine traffic growth, as well as the potential significant risks to the rail transportation system due to possible loss from fire, ship collision and/or seismic events. These are significant risks which will need to be examined in more detail to determine whether the bridge can be rehabilitated to provide service beyond the 2021 planning period. For this reason, this study examined alternatives involving rehabilitation of the bridge, as well as replacement, as described below.

Another factor to be considered in the debate whether to rehabilitate or replace the bridge is the likely increase in marine traffic and the consequent increase in bridge openings. Discussions were held with several stakeholders and no clear consensus could be reached as to whether marine traffic will grow appreciably and therefore affect bridge openings and capacity. Growth in marine traffic is another parameter that requires further consultation and analysis as part of the review of the feasibility of retaining and rehabilitating the existing bridge.

#### 5.1.1.1 Alternative A.1 – Retain Existing Bridge

Alternative A1 is the status quo i.e. retain the bridge, maintain and operate it for another 20 years. This includes routine maintenance of the tracks, structural steel substructure and swing mechanism. Additional rehabilitation work includes painting and collision repair. Furthermore, the seismic vulnerability of the bridge should be investigated and upgraded if necessary.

An additional option for Alternative A1 is to fully upgrade the bridge by replacing the approach trestles with steel or reinforced earth approaches to improve fire safety, and to modify the track curves and rail locking mechanism in order to increase train speed allowance over the bridge. This additional option has not been included in the cost estimate summary. Only routine maintenance, rehabilitation costs, and operating costs have been included in the cost estimate summary, as this reflects a true “status quo” situation.

To arrive at a cost estimate for operating, maintaining, and periodically rehabilitating the bridge, historical costs provided by CN authorities were taken into account, in addition to forecasted figures. The costs are broken down below. All costs are in real 2004 dollars.

**Annual Operating Costs**

| | | |
|---|---|---|
| Four bridge tenders’ salaries | $ | 620,000 |
| Damage repair costs | $ | 340,000 |

**Annual Maintenance Costs**

| | | |
|---|---|---|
| Bridge | $ | 200,000 |
| Track | $ | 45,000 |
| Turnouts | $ | 35,000 |
| Routine Maintenance | $ | 310,000 |

**Rehabilitation Costs – every 20 years**

| | | |
|---|---|---|
| Steel Painting/Corrosion Protection | $ | 8,000,000 |
| General Repair | $ | 12,000,000 |
| Mechanical Repair | $ | 2,000,000 |

Thus the total cost for retaining the bridge amounts to $46,800,000 over 20 years, in 2004 dollars.

#### 5.1.1.2 Alternative A.2 – Replace Bridge with a New Bridge

To replace the existing bridge, several technical requirements must be met, in addition to the capacity requirements outlined already in this report. The basic technical requirements are included in the Design Criteria, which are shown in Appendix A-1. These criteria cover the applicable design codes, geometry of the tracks, loads on the structure, and clearances. The main sources of these criteria are Transport Canada regulations, CN Guidelines, and AREMA – “American Railway Engineering and Maintenance of Way Association.”

The track alignment that was chosen is shown in Appendix A-3, and summarized in Exhibit 5.1. To arrive at this alignment, the narrowest part of the Fraser River adjacent to the existing bridge was chosen to minimize the amount of bridge structure in the river and to enable tie-ins with the Sapperton and Fraser River yards. The chosen alignment also minimizes the interference with existing structures such as the Pattullo Bridge, SkyTrain Bridge, SkyTrain Millennium Line, and commercial buildings on the south bank of the Fraser River. In order to increase the horizontal curves of the bridge to achieve speeds of 20mph (32km/h), land acquisition is unavoidable on the South bank.

Two types of bridges were considered: a swing bridge and vertical-lift bridge. Due to the frequency of barge traffic in the river that exceeds the clearance of the proposed new bridge at the closed position, a vertical lift bridge was chosen due to its much faster opening and closing cycle time.

The vertical navigation clearance under the bridge at the closed position was maximized at 11.7m from the highest high water level (HHWL on drawings). This is an increase of 5m over the existing bridge and will reduce the number of required openings for chip barges by approximately 90%. According to Rivtow and Seaspan, very few chip barges would be filled up higher than this clearance (10% maximum). Furthermore, as stated in the previous paragraph, the vertical lift bridge can accommodate the relatively small extra height needed for those 10% of barges much more efficiently than a swing bridge.

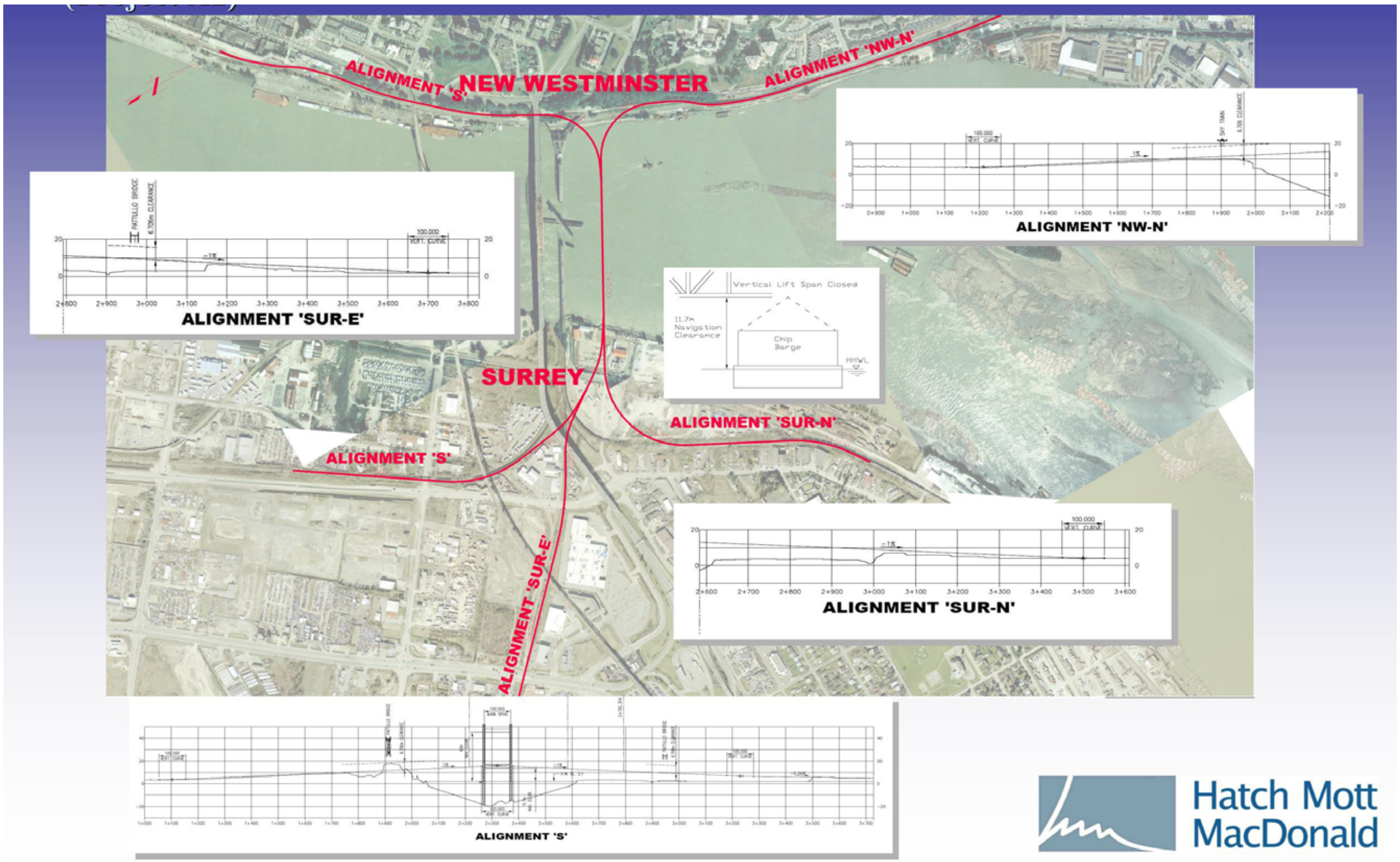
In determining the vertical alignment of the new bridge, the maximum vertical clearance possible became restricted by clearance under the existing SkyTrain structure. The maximum straight line track grade allowed in the design criteria was set at 1% and when combined with the vertical clearance of the SkyTrain Millennium Line on the northeast side of the NWRB, a navigation clearance of 11.7m is obtained, eliminating 90% of the current openings for chip barges. Increasing the grade may eliminate the openings for chip barges, but grades above 1.0% may cause operational problems. For this reason, this design parameter was assumed in this study; during more detailed design, the operational impacts as well as actual chip barge sizes and operational river elevations need to be examined to determine the most appropriate maximum grades.

The horizontal navigation clearance under the bridge was assumed to be 100m, twice the existing clearance, thus reducing ship collision risk significantly.

The train clearances under the Pattullo Bridge approach spans on the south bank are tight, but acceptable. To tie in with the existing tracks on the approaches on both ends, 7250 metres of fill, new track, and ballast will be needed to “chase” the existing track back to its original elevation, again due to the maximum 1% grade. This accounts for over 10% of the capital cost of the bridge. If more detailed study determines that higher grade is feasible, then the amount of required fill and new track could be reduced for potential capital cost savings.

The bridge has been designed to be single track but upgradeable to double track in the future. This is achieved by building piers that can accommodate a wider superstructure in the future. The superstructure has been assumed to be a steel truss for the long spans combined with steel girder for shorter spans. The track will be super-elevated around the bends to increase the allowable speed. The soft soils on the south side of the Fraser River will be an engineering challenge and will drive the foundation selection. A solution could be deep caisson construction for the river piers and piles for the lighter approach structures, similar to the SkyTrain bridge downstream.

## Exhibit 5.1 Fraser River Rail Bridge: Replacement with New Bridge



The capital cost estimate for the A.2 Alternative includes the following elements:

- Bridge structure capital cost
- Land acquisition
- Track costs (incl. fill and ballast)
- Turnouts/switches
- Mechanical system for vertical lift
- Lost time due to construction of track tie-ins
- Signals & controls
- Fibre Optics
- Contingency and engineering costs

The total cost for Alternative A2, replacing the existing bridge with a new bridge, is $140,000,000 over the next 20 years. The construction duration is estimated to be 30 months, taking into consideration critical components such as the lift-bridge mechanisms, soft soils requiring pile driving, and length of approach trestles and track.

The environmental considerations for a bridge crossing at this location are fish habitat and effluents. Since the Fraser boasts one of the world's most productive salmon river systems, supporting five salmon species and 57 other species of fish, including steelhead and red-listed white sturgeon, impacts of the project on fish and fish habitat will need to be mitigated. Any and all construction effluents shall be treated before release. The substructure should not be built during the salmon and other fish spawning seasons. Also, contaminated water from construction activities must be treated and disposed of in a safe manner. Any environmentally hazardous materials such as coolants, lubricants, and fuels must bear WHMIS signs and all procedures must comply with WCB regulations.

### 5.1.1.3 Alternative A.3 – Replace Bridge with a Tunnel

The most obvious advantage of a tunnel would be the complete elimination of both railway and marine traffic disruptions. Unlimited navigation clearance and aesthetics are other advantages.

The tunnel alignment was prepared utilizing the same Design Criteria used in A2, included in the appendix. Although tunnel design may reduce certain challenges, other issues specific to tunnels need to be addressed.

Several options for an immersed tube tunnel (ITT) and a bored tunnel were evaluated. It became obvious after reviewing the site conditions that an ITT was not the most feasible option. It was ruled out for the following reasons:

1. Low navigation draft clearance on the riverbed -- 15m water depth in the navigation span at low tide. With the height of the tunnel section being 10m, this leaves only a 5m draft for marine vessels, which is not sufficient. Burying the tunnel sections in the riverbed is expensive due to the soft riverbed and strong currents of the Fraser River.
2. With a maximum grade of 1%, most of the tunnel would be bored, rendering the ITT portion a small portion of the total tunnel length. This is uneconomical because a transition would have to be made from ITT to bored tunnel.

The bored tunnel plan that was chosen (see drawing for A3 in Appendix A and Exhibit 5.2) takes a straight line path rather than a circular spiral path to return to the grade elevation for economical reasons i.e. a straight boring is less expensive, and extra reinforcement is not needed as it would be when the tunnel is stacked one on top of the other, as in a spiral configuration. The minimum radius of horizontal curvature is 219m, thus allowing a train speed of 30mph (48 km/h).

Due to the soft soil on the south side of the Fraser, the bored tunnel can continue until it reaches 17m below grade. After that point, cut and cover construction would be more economical. The alignment for cut and cover has been chosen to minimize interference with existing buildings. The north side of the Fraser is glacial till; so boring is feasible all the way to where the tunnel emerges at-grade on a steep slope - near the current SkyTrain Millennium Line tunnel portal.

The tunnel section is a concrete-lined tunnel, which is not expandable to double-track in the future. It includes ventilation, lighting, and an emergency exit tunnel.

Environmental considerations of the tunnel construction include spoil disposal, i.e. where to dump the material removed from boring. The material could be either treated if necessary and dumped in the ocean, used as a landfill, or reuse the material elsewhere. Water treatment of the tunnel inflows is another issue. Once water has seeped into the tunnel working area, it can easily get contaminated by construction chemicals and needs to be treated before it can be re-released into the environment.

The capital cost estimate for the tunnel option includes the following elements:

- Bored Tunnel Direct costs:
    - Tunnel drive
    - Lining
    - Invert
- Indirect Bored Tunnel Costs, Profit, and Contingency
- Boat section of Tunnel (transition between Cut & cover and bored)
- Cut and Cover Section
- Track work
- Lighting, Ventilation, Emergency Exits, Controls, Substation, Drainage

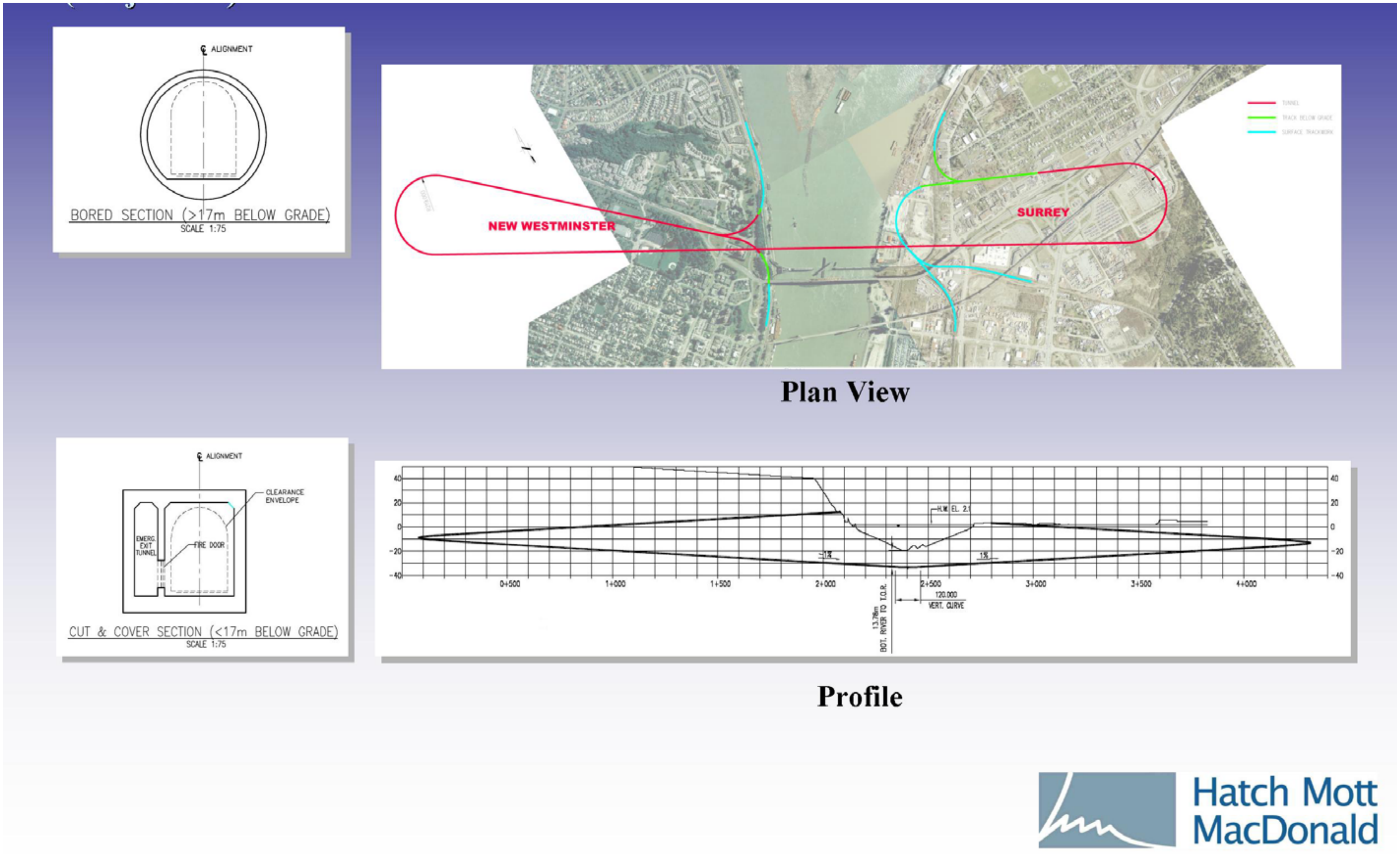
The unit rates for all items are based on historical data per length of duty performed. The total cost for Alternative A3, replacement of NWRB with a Tunnel, is $502,000,000 over the next 20 years, in 2004 dollars. The construction duration is estimated to be three years. An allowance of $2 million for each of the following was included in the estimate: maintenance, operation, and rehabilitation. The high maintenance and operation costs account for the ventilation, lighting, and dewatering of the tunnel.

### *5.1.2 C - Roberts Bank – 41B St. - Overpass*

The overpass proposed in the MCTS Study at 41B St. over DeltaPort Road and the BC Rail line in Delta is a relatively small and typical project, so its preliminary design and cost estimate were straightforward. The objectives are as follows: to allow unrestricted switching of trains, allow building of trains that are greater than 10,000 ft in length, increase safety and reduce road closures by about 2 hours per day.

The Design Criteria for road overpasses in the Gateway Project is the second part of the document used for Rail Bridges and Tunnels, included in Appendix A. These criteria are split into two sections: the Overhead (Grade Separation) and the Approach Roads. The Overhead section covers applicable design codes, structure loading and lane/shoulder/ sidewalk widths. The Approach Roads section covers grades, vertical curvature, and lane/shoulder widths, among others. The main sources of these criteria are the S6-00 Bridge Design Standard, the B.C. MoT Bridge Standards and Procedures, the MoT Standard Specifications for Highway Construction, and TAC - Geometric Design Guide for Canadian Roads.

## Exhibit 5.2 Fraser River Rail Bridge: Replacement with Tunnel



The design of the overhead at 41B St. minimizes cost by using pre-stressed concrete girders and a maximum grade of 10%. This satisfies the rail and road clearance requirements while minimizing material quantities. Typical profile and cross-sections for a typical overpass are shown in Exhibit 5.3. Locations of the overpass projects also are shown in Exhibit 5.3.

The capital cost estimates for all overpasses in this study are based on historical rates for similar overpasses in the Lower Mainland, based on the following items multiplied by unit rates:

- Deck Area;
- Fill and pre-loading volume;
- Asphalt quantity;
- Roadway barriers;
- MSE walls;
- Land acquisition (if applicable)
- Utilities Relocation (if applicable)
- Contingency and Engineering cost

The total cost for Alternative C, Roberts Bank - 41B St. Overpass, is $5,300,000 over the next 20 years, in 2004 dollars. There is no operating cost on this overpass. The annual maintenance cost is assumed to be $5,000 based on inspections, cleaning, and repair from accidents, vandalism, and natural causes if needed. The rehabilitation cost in 20 years is forecast at $300,000, which includes bearing replacement, joints, and asphalt repair (paving). The construction duration is estimated to be 4 months for the overpass itself, and up to one year for pre-loading of the existing soil for the approaches, which is likely to be necessary at this location. Total construction would be about 16 months. The drawing for Project C (and all other projects) can be found in Appendix A. A detailed cost breakdown is presented in Appendix A.

Although the structure of the 41B St. Overpass is relatively simple and costs are relatively modest, such a structure could be limiting future expansion of rail capacity in the corridor in terms of additional parallel track. In view of the possible rail expansion limitations, and the relatively low current and forecast auto traffic crossing the tracks on 41B Street, serious consideration should be given to closing the crossing and rerouting traffic via an alternative route. This requires discussion with the Municipality of Delta and other stakeholders.

### *5.1.3 E – BN New Yard to Spruce St. - Double Track*

Exhibit 5.4 presents typical rail sidings and double track improvements which are contemplated as part of the MCTS improvements.

For Project E – BN New Yard to Spruce Street, the proposed 800 metres of double tracking is essentially an extension of the siding along the main line between Spruce Street and the BN New Yard. This siding will become a double line and will provide additional queuing capability. The issues with this project are:

1. The area is very congested due to Brunette Ave. being a major truck route through New Westminster and it could get worse when Hwy. 1 is widened in the future.

2. Proximity of the SkyTrain Millennium line, which limits construction space.

## Exhibit 5.3 Grade Separations (Road Overpasses)

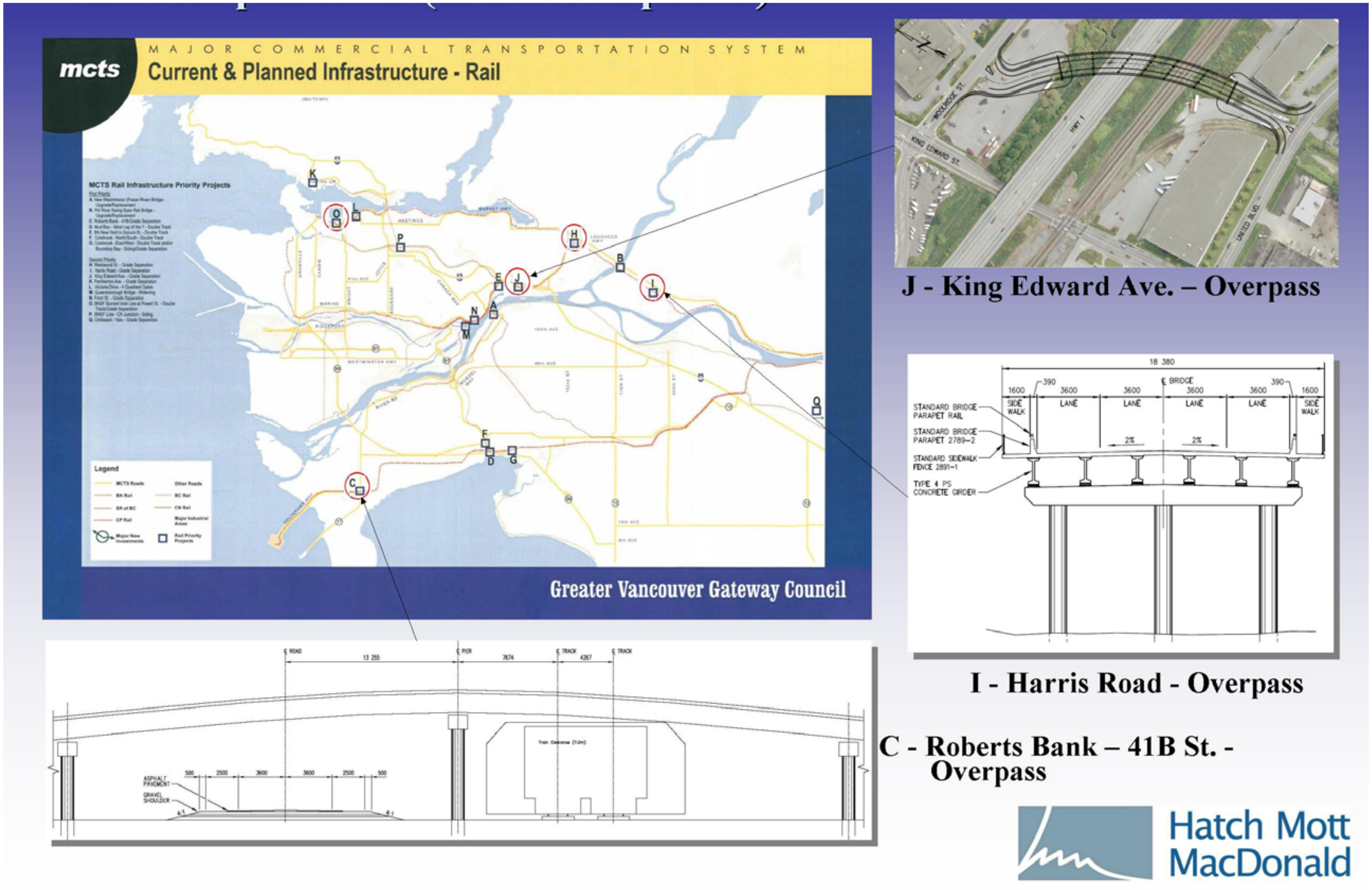
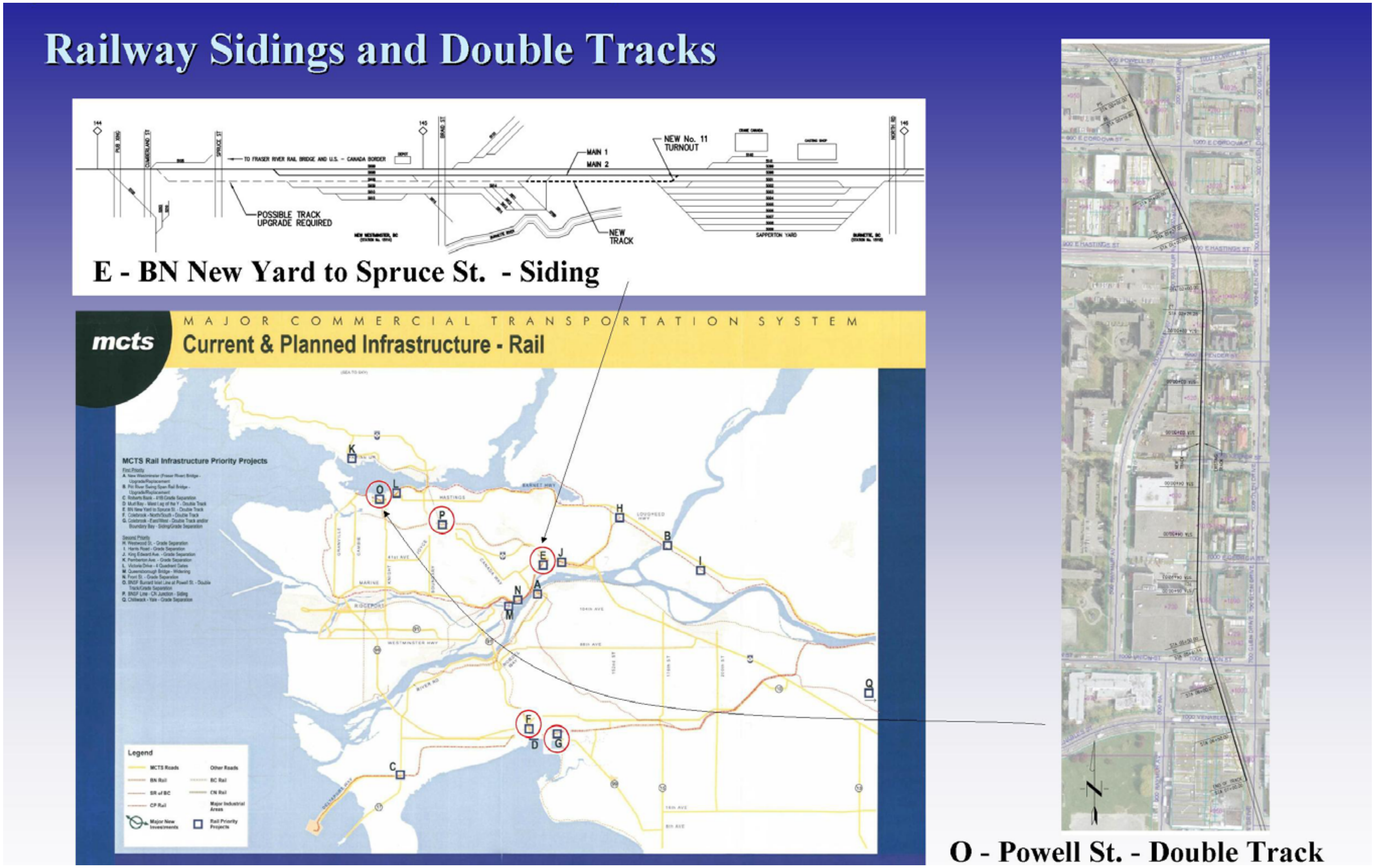


**Exhibit 5.4 Railway Siding and Double Tracks**



The double track cost estimate is shown below. This breakdown applies to all double-tracks and sidings covered in sections 5.1.3 & 4 and 5.2.4 & 5

**Exhibit 5.5 Cost Components for Track Construction**

| CATEGORY | WORK DESCRIPTION |
|---|---|
| **Civil** | Granular Excavation<br>Rock Excavation<br>Granular Placement<br>Granular Supply and Placement<br>Rock Placement<br>Ditching<br>Sub-Ballast<br>Stripping<br>Clearing & Grubbing<br>Mod/Demob |
| **Expropriation** | Industrial Zoned land – 3 large lots |
| **Trackwork** | New Track 115RE CWR, Wood Tie, Ballast<br>New #11 Turnouts |
| **Structures** | Overpasses modified (if applicable) |
| **Signals and Communication** | Signals<br>Power<br>Switch Heaters<br>Installation including signal, cables, bungalows & gas |
| **Fibre Optics** | Fibre Equipment Racks<br>Fibre Optics 36C Cable<br>Installation including splice boxes and conduit |
| | CONTINGENCY (30%)<br>ENGINEERING (12%)<br>TOTAL COST |
| **NOTES:**<br>Assumes no culverts required and fibre optic cable relocation costs are borne by the fibre company.<br>Signals costs need to be confirmed by signals engineer.<br>Fill depths are assumed. | |

The total cost for Alternative E, BN New Yard to Spruce St. Siding, is $3,200,000 over the next 20 years. The operation costs are included in the railways costs, the maintenance costs are $5,000 per year, and the rehabilitation costs amount to $100,000 over 20 years. The construction duration is estimated to be 4 months.

### 5.1.4 F – Colebrook North/South Siding

This 2590m siding runs along the east side of Highway 91 just north of Hwy 99. Its purpose is to alleviate the congestion resulting from future increase in Amtrak train usage. The engineering issues here are:

- Drainage needs to be upgraded – culvert extensions and extra ditches;
- Proximity of golf course and wetlands; and
- Two roadway overpasses possibly need span widening due to increased track width.

Two turnouts at the mid-point will facilitate the egress of shorter trains from the siding and will allow two short trains to park simultaneously.

The cost estimate has the same elements as shown in Exhibit 5.5, except for the cost of overpass widening. Trackwork and signalling accounts for 70% of the total cost. The total cost for Alternative F, Colebrook North/South Siding, is $7,000,000 over the next 20 years, in 2004 dollars. The operation costs are included in the railway's costs, the maintenance costs are $10,000 per year, and the rehabilitation costs amount to $300,000 over 20 years. The construction duration is estimated to be about 9 months.

Possible environmental concerns may exist due to the proximity of Burns Bog, a 4,000 hectare environmentally protected area.

### 5.1.5 G – Colebrook East/West Siding

This 10,000 ft. siding runs along the North side of Highway 99 in Surrey, just West of King George highway. Its purpose is to increase efficiency in handling trains by allowing parking space for 10,000ft trains (or greater if needed) The engineering issues here are:

- Drainage needs to be upgraded – culvert extensions and extra ditches.
- Proximity of environmentally sensitive wetlands.
- Four at-grade crossings of small farm roads are needed (or the roads could be re-routed).

Two alternatives exist for this project – one option is to place the siding east of the current at–grade Colebrook Road crossing, and the other is to begin the siding west of that crossing. The advantage of placing the siding east of the crossing is that it eliminates one at-grade crossing, and the disadvantage is that if the siding were to be lengthened in the future, it would run into the King George Hwy. overpass.

As in Project F, two turnouts at the mid-point will facilitate the egress of shorter trains from the siding and will allow two shorter trains to park simultaneously.

The cost estimate has the same elements as shown in Exhibit 5.5. The total cost for Alternative G, Colebrook East/West Siding, is $7,620,000 over the next 20 years, in 2004 dollars. Trackwork and signalling accounts for about 60% of the total cost. The operation costs are included in the railways costs, the maintenance costs are $11,000 per year, and the rehabilitation costs amount to $300,000 over 20 years. The construction duration is estimated to be about 10 months. Possible environmental concerns may exist due to the proximity of the Serpentine River, an environmentally sensitive area that is part of the Boundary Bay ecosystem.

## 5.2 SECOND PRIORITY PROJECTS

This section outlines the preliminary design methodology and cost estimate basis associated with each of the projects identified in MCTS's Second Priority projects. These projects are all roadway overpasses, except for Project O part B, and Project P, which are additional sidings.

They are listed as follows:

- H -Westwood St. –Overpass
- I – Harris Road – Overpass
- J – King Edward – Overpass
- O – Powell St.
  - a. Powell St. – Overpass
  - b. Powell St. – Double Track
- P - BNSF/CN Junction – Siding

### *5.2.1 H -Westwood St. -Overpass*

This proposed overpass aims to reduce the amount of road closures, increase safety, and increase train switching capabilities.

The engineering issues with this overpass are:

- Proximity of commercial buildings and access to them from Westwood St. will be difficult;
- Land acquisition is required to build access roads for the overpass;
- Davies Road extension under overpass needed to tie-in with adjacent properties;
- Possible utilities relocation under fill area; and
- Raising grade of existing side-roads to tie-in to overpass required to maintain traffic flow.

The option of re-routing Davies road to the east side of the overpass instead of underneath it was considered, but in that case commercial land acquisition would be necessary. This was deemed too expensive and not beneficial to the economic viability of this commercial district.

The total cost for Alternative H, Westwood St. Overpass, is $12,480,000 over the next 20 years, in 2004 dollars. The construction duration of the project is estimated to be 1 year, with no obvious environmental concerns.

### *5.2.2 I - Harris Road – Overpass*

Harris Road overpass is almost identical to the Westwood overpass in its scope and very similar in its cost. The purpose of this overpass is the same as that of Westwood. The costs are slightly less because land acquisition and fill quantities are less. The total cost for Alternative I, Harris Road Overpass, is $10,460,000 over the next 20 years, in 2004 dollars. The construction duration of the project is estimated to be 1 year, with no obvious environmental concerns.

### 5.2.3 J - King Edward – Overpass

This overpass will alleviate traffic congestion in one of the most restricted crossings in the Lower Mainland. There is a high amount of train switching taking place 24 hours a day, and this area is a growing industrial and commercial area.

The main engineering challenge is crossing over Highway 1, which is elevated on fill at this location due to the King Edward underpass. Three options exist:

- Cross Hwy 1 on the existing King Edward alignment with an overpass
- Widen the existing underpass
- Cross Hwy. 1 at a different location and tie back into King Edward

The third option was chosen as the most feasible. The first option was ruled out because of the high cost of such a large structure, and the approaches would be set too far back even with a maximum grade. Also, closures of the underpass would be necessary and not acceptable in this busy area. The second option was ruled out because of flooding potential, traffic closures, and the safety risk associated with such a confined area.

Therefore the final alternative was to place the overpass at the location shown on the drawing Appendix A-2 . The alignment is curved so that the existing parking lot on the north side can be used as a close tie-in with the King Edward intersection and so the approach on the south side can fit between the two buildings. The north approach doesn't go right up to the intersection because that would be too expensive.

The cost estimate was based on the same as that of the other overpasses, except vibrocompaction was added. This was deemed necessary in this area due to soft soils. The total cost for Alternative J, King Edward Overpass, is $19,200,000 over the next 20 years, in 2004 dollars.

### 5.2.4 O– Powell St.

The Powell St. project is split into two parts: the Powell St. Overpass and the Powell St. Double Track. Each will be explained separately.

#### 5.2.4.1 A. Powell St. – Overpass

There have been some serious accidents at this crossing, and an overpass would greatly benefit auto traffic congestion.

The main engineering challenge of this overpass is that it is located in a very congested area, with rail on one side and commercial buildings on the other. Also, the fork in the road just 80m to the west of the intersection will have to be accommodated by the overpass. This increases the capital cost due to the extra roadway and fill quantities. Furthermore, the trolley buses use an overhead catenary system here which will need to be replaced.

A drawing of this overpass is shown in Appendix A-2. The total cost for Alternative O Part A, Powell St. Overpass, is $11,200,000 over the next 20 years, in 2004 dollars. The construction duration is estimated at 1 year. Construction of this overpass will result in several month-long road closures, large roadway detours for buses and auto traffic, and the severe disruption of businesses on this stretch of road.

### 5.2.4.2 B. Powell St. – Double Track

This 850m double-track is proposed to run from Powell St. in the north to the Glen railway yard in the south. It is in a congested area, but there is room to build another track adjacent to the existing one, so buildings do not have to be demolished to construct it.

The track currently crosses 5 roads, and passes underneath Hastings St. Therefore added to this cost are modifications to the at-grade crossings.

The total cost for Alternative O Part B Powell St. Double Track, is $2,900,000 over the next 20 years, in 2004 dollars. The construction duration is estimated to be 6 months.

### *5.2.5 P - BNSF/CN Junction – Siding*

The purpose of this 8500 ft long siding is to keep the double track clear. Presently one track is used for train parking, reducing rail traffic flow. The engineering issues are that it is a slightly congested area, and it must cross a few relatively busy roads near the east side of the siding.

The total cost for Alternative P, BNSF/CN Junction, is $6,800,000 over the next 20 years, in 2004 dollars. The construction duration is estimated to be 1 year.

## 5.3 SUMMARY OF COSTS OF PROJECTS

The final Cost Summary of all projects covered in this chapter is shown in Exhibit 5.6 below:

**Exhibit 5.6 Cost Estimate Summary for all MCTS Non-Deferred Projects**

| Project | Project Name | Capital Cost [1] | Annual Operating Costs [2] | Annual Maint. Costs [2] | Rehabilitation Costs [3] | Expected Life (years) | Total Cost after 20 years | Required Completion Date |
|---|---|---|---|---|---|---|---|---|
| A - Alt. 1 | New Westminster Rail Bridge: | | | | | | | |
| | - retain existing bridge | $ - | $ 650,000 | $ 590,000 | $ 22,000,000 | 20 | $ 46,800,000 | |
| A - Alt. 2 | - build new bridge | $ 110,000,000 | $ 650,000 | $ 750,000 | $ 2,000,000 | 100 | $ 140,000,000 | 2008 |
| A - Alt. 3 | - build tunnel | $ 420,000,000 | $ 2,000,000 | $ 2,000,000 | $ 2,000,000 | 100 | $ 502,000,000 | 2008 |
| C | Roberts Bank - 41B St. - overpass | $ 4,900,000 | $ - | $ 5,000 | $ 300,000 | 100 | $ 5,300,000 | 2006 |
| D | Mud Bay - West Leg of Wye | | | | | | | |
| E | BN New Yard to Spruce St. | $ 3,000,000 | $ - | $ 5,000 | $ 100,000 | 100 | $ 3,200,000 | 2006 |
| F | Colebrook North/ South - siding | $ 6,500,000 | $ - | $ 10,000 | $ 300,000 | 100 | $ 7,000,000 | 2006 |
| G | Colebrook East/West - siding | $ 7,100,000 | $ - | $ 11,000 | $ 300,000 | 100 | $ 7,620,000 | 2011 |
| H | Westwood St. -overpass | $ 11,800,000 | $ - | $ 9,000 | $ 500,000 | 100 | $ 12,480,000 | |
| I | Harris Road - overpass | $ 9,800,000 | $ - | $ 8,000 | $ 500,000 | 100 | $ 10,460,000 | |
| J | King Edward Ave. - overpass | $ 18,000,000 | $ - | $ 10,000 | $ 1,000,000 | 100 | $ 19,200,000 | |
| O - part A | Powell St. - overpass | $ 10,000,000 | $ - | $ 10,000 | $ 1,000,000 | 100 | $ 11,200,000 | |
| O - part B | Powell St. - double track | $ 2,700,000 | $ - | $ 5,000 | $ 100,000 | 100 | $ 2,900,000 | 2006 |
| P | BNSF/CN Junction - siding | $ 6,300,000 | $ - | $ 10,000 | $ 300,000 | 100 | $ 6,800,000 | 2006 |

*Notes:*
1. Capital Cost period and other details shown on Project Description Sheets and Drawings
2. Total Operating Costs and Maintenance Costs have been averaged to yield an Annual amount.
3. Rehabilitation Costs are in 2004 Dollars and required after a 20 year service life, and every 20 years after that.

# 6.0 NETWORK SYSTEMS ANALYSIS

The preceding sections of this report introduced the essential freight transportation problems confronting stakeholders in the Vancouver Gateway and solutions under consideration. From this point onward, the emphasis is on synthesis of study elements to formulate strategic recommendations to enhance participation of Greater Vancouver ports in the explosive growth of international trade.

This report presents two main rail operations arrangements among the railways:

- Status Quo Operations -- separate ownership, operation and access rights in the railway network serving the region and the ports.
- Coordinated Rail Operations – shared use of railway and port infrastructure to minimize the railways' cost (i.e. train miles operated) within the study area used as an analytical proxy for achieving the lowest overall economic cost in the rail system.

"Status Quo Operations" using existing infrastructure will represent the base case for comparing alternatives in the financial and economic analyses. The Status Quo case is based upon railway operating information developed for simulation studies that were carried out by Vancouver Port Authority in parallel to this study. This information consisted of a listing of train movements and switching assignments operated in the study area over a peak traffic day during 2001. Projections of future traffic levels for "Status Quo operations" were carried out by applying annual traffic growth rates for total train-miles to each link in the network.

Since the data from the railways were compiled, CN and CPR entered into new joint operation arrangements. Some CN trains are operating directly to the waterfront terminal area over the CPR Cascade subdivision, thereby avoiding the NWRB and Thornton Yard. Also, an equivalent number of CPR trains are operating directly across the Second Narrows. In both cases, the Railways state considerable savings are achieved by operating trains through to destinations and avoiding a number of local transfers that would otherwise have added to network congestion and cost.

The railways see this as an extension of the existing "co-production" arrangements that they have implemented to achieve directional running through the Fraser and Thompson Canyons.

"Coordinated Rail Operations" as defined for this study, extends the "co-productive" concept further to explore the consequences of maximizing through trains to destination marine terminals, including in the analysis issues of terminal track capacity. The cases described in this report use the base case traffic forecasts described in Section 3, and a projected modal share for rail at 65% of container and auto imports and exports, with existing modal shares for other commodities.

The work actually carried out encompasses a wide range of cases that would be cumbersome to report at length herein. As considered appropriate, reference is made to some of these cases by way of sensitivity analysis.

Consequently, scenarios involving replacement of the existing bridge with a new bridge or tunnel are evaluated only in the context of Status Quo operations. A significant finding in the Coordinated Rail Operations scenario is that capacity of the existing NWRB can accommodate demand throughout the study time horizon, subject to more extensive engineering and risk assessment of the continued performance of the bridge beyond 2021.

## 6.1 STATUS QUO OPERATIONS

The "base case" railway data, as mentioned previously, represents a peak operating day in 2001. Information provided by the railways was translated into train movements (passenger, local and through freight) over each link in the network. This volume was projected uniformly over the network using the workload growth rate driven by the traffic forecasts.

The capacity of each link was estimated using IBI's proprietary parametric rail capacity model described above. The application in this study area uses links that are somewhat shorter than would be typical for this tool; therefore, a contingency allowance of 15% is applied as a conservative measure for interpreting capacity results. Consequently, volume/capacity ratios 85% or above are taken as indicative of need to add capacity for future growth for the Status Quo.

**Exhibit 6.1** shows the results of volume/capacity analyses in the context of Status Quo operations. The rows represent MCTS projects that have already been identified to increase railway capacity. In fact, with one exception, these projects represent all of the links that reach the 85% threshold within the time horizon. The one exception is a single track section of the CN Yale subdivision between Matsqui Jct. and Hydro which appears to be at its capacity limit currently. Interestingly, operating changes including the Coordinated Rail Operations introduced by CN and CPR in recent months, effectively mitigated this issue for the time being.

**Exhibit 6.1 Status Quo Volume/Capacity Estimates**

| Project | Project Name | Scope of Work | Link Involved | 2003 | 2006 | 2011 | 2016 | 2021 | Transition | Completion assumed by |
|---|---|---|---|---|---|---|---|---|---|---|
| A Option 1 | New Westminster Rail Bridge | Retain Existing bridge | NW-1413 | 75% | 85% | 94% | 103% | 111% | 2006-2010 | 2008 |
| B | Pitt River Swing Bridge | | CA-879B | 26% | 30% | 33% | 36% | 39% | N/A | N/A |
| C | Roberts Bank - 41B St. Overpass | Grade Separation - road overpass | RB-02 | 69% | 79% | 88% | 95% | 103% | 2009-2012 | 2006 |
| E | BN New Yard to Spruce St. | Double Track from FRRB to BN Yard | NW-1448 | 74% | 84% | 94% | 102% | 110% | 2006-2009 | 2006 |
| F | Colebrook North/ South | New Siding - 8500 ft | NW-1196 | 50% | 57% | 63% | 69% | 74% | N/A | 2006 |
| G | Colebrook East/West | New Siding - 10,000 ft | RB-01 | 69% | 79% | 88% | 95% | 103% | 2009-2012 | 2006 |
| O | Powell St. | Grade Separation - road overpass and double track | BN-02 | 20% | 22% | 25% | 27% | 29% | N/A | 2006 |
| P | BNSF/CN Junction | New Siding | NW-1453 | 76% | 86% | 96% | 105% | 113% | 2005-2008 | 2006 |
| R | Hydro-Matsqui Double Track | | PA-00 | 95% | 100% | 120% | 131% | 141% | 2003 | |

Note: Status Quo represents a peak period, therefore 85% is used as threshold capacity, highlighted by shading.

The exhibit shows for each of these projects, the ratio of volume to capacity that would have been experienced theoretically, i.e. in the absence of any changes. In practice, traffic volumes would have had to level off at ratios of 85% and further growth would have been curtailed. The two columns on the far right hand side of **Exhibit 6.1** provide a time span over which transition to improved capacity would have to take place, and finally, the year in which the capacity addition is deemed to have been completed for purposes of the financial and economic analysis described later in this report. This table indicates that all of the MCTS projects are required in the short term, 2006 – 2008.

One of the critical links in the system under Status Quo operation is the NWRB. In fact, the criterion for evaluation of alternatives is that under separate operations, capacity of the system is consumed when the bridge can no longer handle additional trains. Under the Status Quo set of assumptions, this situation is imminent, and replacement or at least upgrading the capacity of the bridge would be required by 2008. Apparently, the recent introduction of some Coordinated Rail Operations provided some relief, but the urgency of alleviating the constraint remains high.

Additional observations from **Exhibit 6.1** include:

- Pitt River Swing Bridge does not emerge as a network capacity issue in the context of this analysis; however, this bridge is located between Port Coquitlam Yard, and Pitt Meadows Intermodal Terminal, internal operating movements between these facilities might be significant under more detailed examination beyond the scope of this study;
- NWRB capacity has been based on direct calculations of transit windows for passenger and freight trains, after allowing for approximately five hours per day of bridge openings to accommodate marine traffic, as at present. In this scenario, if the number and duration of openings to

accommodate marine traffic were to grow significantly, then the need for replacement capacity would be even more urgent. Current marine traffic trends suggest stability in demand for openings. However, if a new bridge is constructed, it should be designed to provide for higher vertical clearance above the navigation channel to accommodate most marine traffic, reducing the number and duration of opening cycles;

- Grade separation or closing of the 41B St. crossing at Roberts Bank also appears to be an urgent issue due to yard movements associated with building long container trains (e.g. 12,000 feet) at Roberts Bank.
- Powell Street grade separation and double tracking does not emerge as a major priority in any of the rail analysis carried out in this study. On the other hand, Powell Street is very busy with road traffic, and if Status Quo operations were to continue, then there would likely be more local switching in this area relative to overall traffic growth rates, and the grade separation would have higher priority.
- Colebrook North/South results in Exhibit 6.1 indicate that spare capacity exists, but this is misleading because the 2003 data do not reflect Amtrak plans to increase train frequency. Any increase in passenger train frequency would trigger the need to add capacity because of the time window that would be required between New Westminster Yard and the US border; in fact, capacity improvements on this link are urgently needed.

## 6.2 COORDINATED RAIL OPERATIONS

Under the Coordinated Rail Operations scenario, it was assumed that railways would make bi-lateral or multi-lateral commercial arrangements to share the rail network. Key rail links which the railways would share include:

- Access to Vancouver downtown Waterfront terminal facilities, including yard and lead tracks; this is a congested area that is operated as separate sections at present;
- CPR Cascade subdivision from the Mission Bridge to downtown and including access to Pacific Coast Terminals in Port Moody (this is already in place to some extent between CN and CPR); extending this application depends on the ability to receive trains in the Waterfront or in adjacent areas such as False Creek Flats.
- CN and BNSF trackage to connect the Vancouver North Shore to Mission Bridge via the NWRB (this also is already in place to some extent between CN, BNSF and CPR), including track that passes by the BNSF New Westminster Yard;
- False Creek Flats facilities for passenger trains and freight access to the Waterfront across Powell Street.
- Further enhancement of track sharing arrangements at Roberts Bank, to include BNSF.

The issues and solutions in this set of scenarios are driven by market demand expressed as annual tonnages through the ports and translated to average weekly car loadings and train starts and combined with domestic carload traffic estimates and passenger train demand strategies. Capacity requirements need to respond to peak demand situations within reason. This was taken into account by adjusting the capacity threshold to a volume-to-capacity ratio of 70%; in other words, volume assigned to a link in the network triggered the need for capacity improvements if the volume to capacity ratio exceeded 70%. (This factor represents both seasonality and reliability of the capacity estimates, while 85% of capacity used in Section 6.1 represents only reliability of the estimates since the volumes are peak period volumes).

After capacity additions were determined, the model was redeployed to assign market demand to the network. In some cases it was not possible to arrive at a feasible solution without capacity additions to crucial links. Initially, the model seeks to assign traffic to the most efficient route, but volume over a link cannot exceed 100% of capacity. The remedy for this situation is to modify capacity or demand and try again until successful.

## Exhibit 6.2 Coordinated Rail Operations Volume/Capacity Estimates

| Project | Project Name | Scope of Work | Link Involved | 2006 V/C% Before | 2006 V/C% After | 2011 V/C% Before | 2011 V/C% After | 2016 V/C% After | 2021 V/C% After | 2021 V/C% After RB 70% |
|---|---|---|---|---|---|---|---|---|---|---|
| A Option 1 | New Westminster Rail Bridge | Retain Existing bridge | NW-1413 | 26% | 26% | 29% | 29% | 31% | 33% | 30% |
| B | Pitt River Swing Bridge | | CA-879B | 15% | 15% | 18% | 18% | 21% | 23% | 23% |
| C | Roberts Bank - 41B St. Overpass | Grade Separation - road overpass | RB-02 | 86% | 55% | 99% | 63% | 72% | 81% | 81% |
| E | BN New Yard to Spruce St. | Double Track from FRRB to BN Yard | NW-1448 | 27% | 16% | 30% | 18% | 19% | 21% | 19% |
| F | Colebrook North/ South | New Siding - 8500 ft | NW-1196 | 72% | 48% | 79% | 52% | 56% | 61% | |
| G | Colebrook East/West | New Siding - 10,000 ft | RB-01 | 86% | 55% | 96% | 63% | 72% | | 57% |
| O | Powell St. | Grade Separation - road overpass and double track | BN-02 | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| P | BNSF/CN Junction | New Siding | NW-1453 | 25% | 15% | 28% | 17% | 18% | 19% | 19% |
| R | Hydro-Matsqui Double Track | | PA-00 | | | | | 56% | 62% | 50% |
| S | Hydro-Roberts Bank Siding / DT | | RB-02 | | | | | 57% | 65% | 65% |
| T | Blaine-NWRB Siding/DT | | NW-1196 | | | | | | 34% | 60% |

**Projects A to P**
Before Existing Capacity Base Case Scenario C with Amtrak
After MCTS Base Case Scenario C with Amtrak

**Projects R, S and T**
Before MCTS Base Case Scenario C with Amtrak
After Double Track Base Case Scenario C with Amtrak

Note 1: Shaded boxes indicate volumes exceed 70% capacity
Note 2: "V/C% After RB 70%" is sensitivity analysis of 30% of Roberts Bank container traffic routed via Blaine

Exhibit 6.2 shows the volume to capacity ratio for each link that would be modified by a specific project. Cases where capacity in the system is inadequate for a feasible solution are not shown in the Exhibit (for example there is no feasible solution for 2016 or later without capacity improvement).

Each row represents one project and its corresponding link. The data are taken from a Coordinated Rail Operations optimal solution for the entire network using the Base Case forecasts. For each time frame, the V/C is reported for a solution both with and without implementation of the project. For example, Colebrook North/South siding implemented by 2006 would improve the Volume to capacity ratio from 72% (which is beyond the threshold for making changes) to 48%.

Similar to the Status Quo cases, results are presented by reference to the MCTS projects. And, as found in the Status Quo operations cases, the MCTS projects provide the needed capacity through to 2021. Exceptions requiring even further capacity additions are found in the later years of the study period in the north-south Corridor 1 and Roberts Bank access. In both of these Corridors, additional improvements are needed. These are driven by the focus of container growth at Roberts Bank and expansion of north-south services using BNSF.

One of the significant conclusions from this analysis is that the existing NWRB provides ample capacity for the foreseeable future if Coordinated Rail Operations can be achieved, and if terminal capacity is available to dispatch complete trains (for which costs are estimated and incorporated in the analysis). This finding is discussed in greater detail in Section 6.4.1. The Waterfront area is an area that will require major initiatives for this condition to be realized.

Local train movements have been incorporated more or less at the level experienced on a peak day 2001. A key feature in the Coordinated Rail Operations solutions is terminating trainloads within port terminal areas, as distinct from terminating them in railway marshalling yards and feeding shorter transfers to the terminals. This effect, combined with direct routing over the shortest path, produces significant differences in terms of timing and the extent of capacity improvements required, when compared with the Status Quo.

Additional observations pertaining to **Exhibit 6.2** are as follows:

- The line into Roberts Bank, particularly west of Mud Bay, is close to capacity suggesting the need for improvements in the near term.

- Continued growth at Roberts Bank will place even more pressure on the line beginning in 2011 and continuing to require capacity additions at regular intervals; towards the end of the study period, the Yale subdivision between Matsqui and Hydro will be approaching capacity, and in some sensitivity cases that were done it could reach capacity in 15 years.
- Corridor 1 improvements between Blaine and New Westminster include a new siding near Mud Bay, but further improvements could be required depending upon how traffic growth actually materializes throughout the planning horizon; it will also be sensitive to the frequency and operating characteristics of Amtrak passenger trains. The cases used for comparison here include three daily Amtrak trains in each direction. Capacity requirements are sensitive to changes in this type of demand.
- MCTS projects that could be deferred by Coordinated Rail Operations include: double tracking north of the NWRB; Powell Street grade separation and double tracking; and double tracking near CN/BNSF Junction (Willingdon). All of these projects have been brought forward on the basis of interaction between yard operations and mainline trains, and as mentioned previously, resolution of these needs requires more detailed micro-simulation and operational studies with timely and complete railway data. For purposes of the economic and financial analyses, these projects are excluded from the Coordinated Operations scenarios, but they are included in the Status Quo cases.

## 6.3 Summary of Results

Total traffic in the Lower Mainland ports is expected to increase by about 50% over the 18 year study horizon, including containerized cargo and automobiles (in metric tonnes), increasing by 2.5 to 3.0 times.. The model parameters used in this study to convert these forecasts to railcar movements were validated earlier by the Port Authorities. The reference planning scenario is based on growth assumptions reviewed with and agreed by the Study Steering Committee, as follows:

1. By 2021, 60% of Port of Vancouver containers will be handled at Roberts Bank, 25% at Waterfront terminals, and potentially 15% at a new terminal to be constructed on the North Shore at Lynnterm; Fraser Port containers would continue to be handled in Surrey, and Autoport facilities would be expanded on Lulu Island.
2. 65% of containers will enter and leave Gateway ports by rail.
3. Two sub cases were considered: one to reflect the impact of 100% of Roberts Bank traffic moving through the CN/CPR export corridor; and one to reflect only 70% going that route, and 30% being handled in the North-South corridor by BNSF. The latter case is summarized in the far right-hand column of **Exhibit 6.2**.

Under Coordinated Rail Operations, the MCTS improvements would be required by the end of the study period, some more urgently than others. There would also be additional network expansion projects required.

Two new train storage tracks would be needed to support Vancouver Waterfront rail operations. This requirement would be implemented in two stages -- 2006 and 2016 -- with a caveat that detailed planning and simulation studies are required before project justification is confirmed. There would also be a need for support tracks in the Vancouver Waterfront to accommodate this traffic growth. Since waterfront land is scarce, existing rail facilities in False Creek Flats could be an important extension of the Port to accommodate growth. This is an important stakeholder issue that is considered in more depth below.

The main concern in the Waterfront area is that the existing land and operating rights are fragmented. The institutional implications of integrating physical plant and operations from the rail side are significant. The benefits from achieving success are significant and the costs of failure to do so may be prohibitive. The challenge will be to find the appropriate scheme of incentives that make it worthwhile for the parties to pool resources and achieve integrated operations from the Waterside to inland points.

Significant increases in traffic between Mission Bridge and Roberts Bank will exceed the existing and augmented capacity (i.e. MCTS) of these lines. Even with optimized Coordinated Rail Operations, the CN Yale Sub between Matsqui Jct. and Hydro will reach capacity within the planning period.

Also there will be a need to add sidings or equivalent double track west of Hydro. Preliminary analysis in this study indicates the need for about 5 mi. (8 km), or the equivalent of three sidings of 8,500 ft.(approx 3,100 metres). Implementing the addition as one double track segment between Mud Bay and Roberts Bank would probably offer the greatest flexibility, since it would serve both East-West and North-South inland routings. Here again, it should be noted that detailed planning and simulation studies are required before project planning and justification can be confirmed.

Also, and this is specific to a sensitivity analysis whereby 30% of Roberts Banks traffic would be handled by BNSF, analysis shows that the line between Blaine and Brownsville would require one or two additional sidings over and above a Colebrook North-South siding. This amount of diversion is very liberal, an optimistic view of BNSF traffic splits that could happen in the study horizon. In this case, as above, this analysis does not distinguish between two sidings or one equivalent long stretch of double track.

If the coal and container traffic on BNSF is less than 30% of Roberts Bank traffic, and yet significantly more than occasional movements (plus new Amtrak trains), then at least one additional siding should be constructed. In practice this could be implemented as an extension of the planned Colebrook siding to a total of 17,000 ft. (6,200 m).

In all of the cases involving infrastructure additions discussed above, specific location issues are not considered; these would be important considerations in detailed planning and simulations that would follow in subsequent studies.

## 6.4 IMPLICATIONS FOR REGIONAL CONTEXT

The analyses described above provide strategic direction for the issues that were meant to be addressed by this study. These results are at a relatively high-level of aggregation from the perspective of a railway company planning and designing rail infrastructure, however, they require aggregation and synthesis to respond to the broader policy issues in the mandate for this study. This section of the report is intended to relate the details of the analyses carried out to the following major policy themes:

- NWRB Replacement
- Volume/Capacity Sensitivity and Timing
- Land Use Conflicts
- Passenger Train Services

### *6.4.1 NWRB Replacement*

One of the central questions motivating the sponsors to engage in this research is whether or not the existing NWRB can accommodate future demand. Previous trends signalled warnings that the NWRB was rapidly running out of capacity to handle trains; this trend is confirmed through the present analysis of "Status Quo operations" scenarios. However, CN and CPR have initiated some "Coordinated Rail Operations" in the Greater Vancouver area that have resulted in improved operating efficiencies. The ultimate potential of such Coordinated Rail Operations calls into question the need to increase the capacity of the NWRB.

There are three important conditions for achieving maximum benefits from rail infrastructure investments in the Lower Mainland with full CRO implementation. These are:

- first, that freight trains would be routed directly to marine terminals via the shortest path available;
- second, delivery of full trains to destinations reduces the number of movements of smaller trains between marshalling yards and terminals, thereby freeing up track capacity; and,
- third, this implies that there is land and track available at terminals to accept inbound trains and to assemble outbound trains.

The methodology employed in this study automatically seeks the shortest path. Local trains will not be completely eliminated because it would not be practical; general assumptions based on historical operations were used to factor in continuing local movements, and thus meet the second condition. Third, the economic analysis includes provision for terminal areas to process inbound and outbound trains within a peak 24-hour period.

All three conditions are accounted for in Coordinated Rail Operations solutions. However, even in the Status Quo cases, these conditions remain as important determinants of eventual success. Replacement of the NWRB, accompanied by the other MCTS projects, would provide partial relief, but it would not eradicate all the problems.

The reasonableness of the conclusion concerning adequacy of the existing NWRB capacity was tested by comparing total projected traffic flows across screen lines at the NWRB and Pitt River Bridge. The results of this comparison are shown in **Exhibit 6.3**.

**Exhibit 6.3 Cordon Screen Line Demand and Capacity, Coordinated Operations – NWRB/Pitt River**

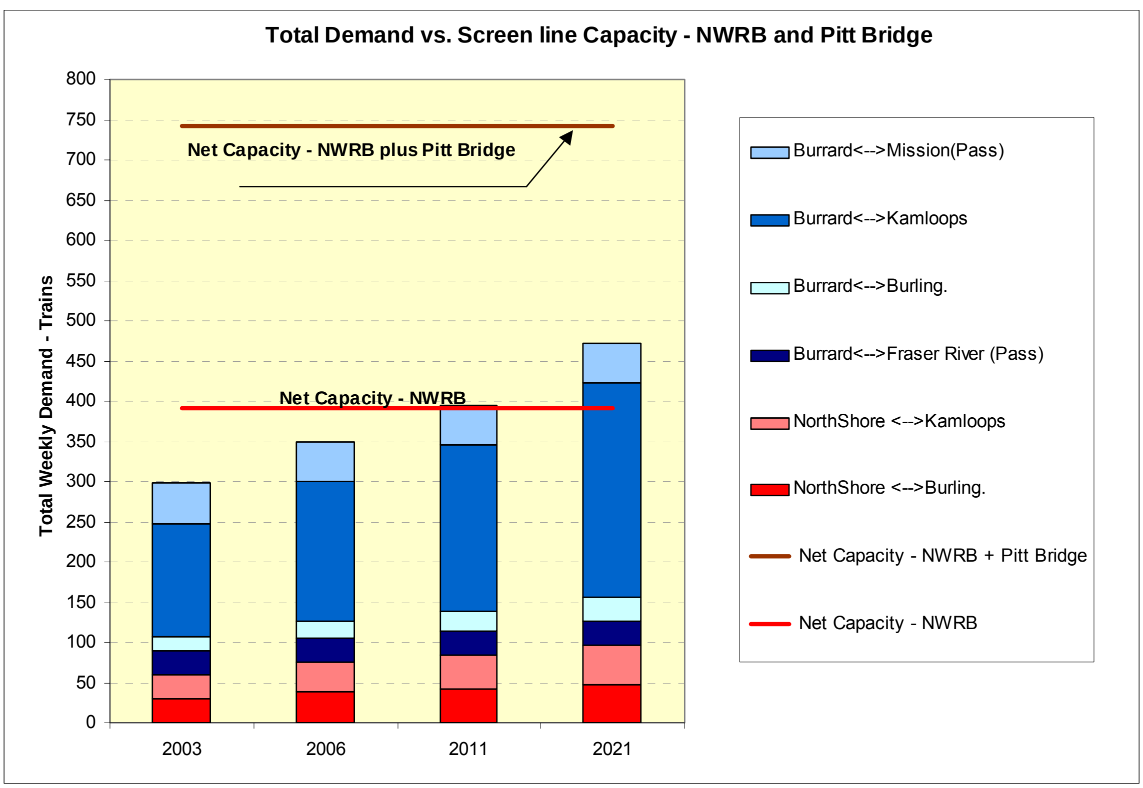
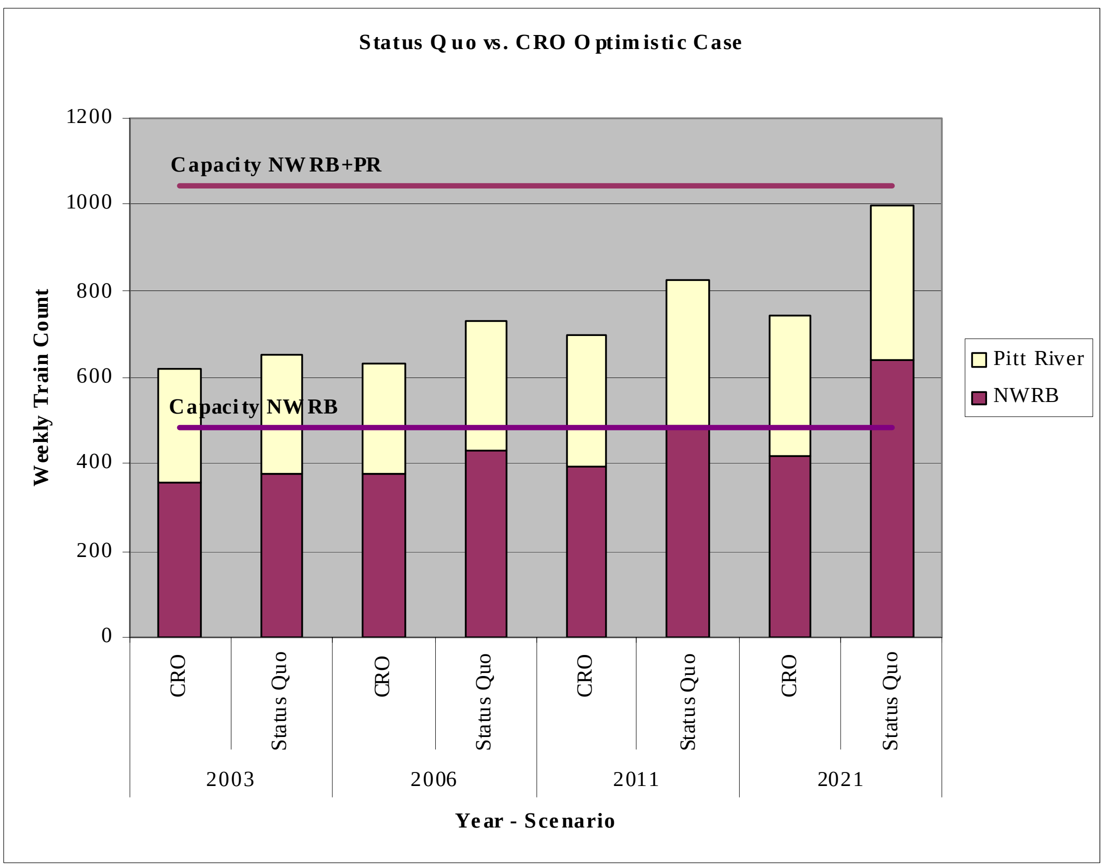


**Exhibit 6.3** shows total demand by time period for train movements that would have to enter or leave the study area using either the NWRB or the Pitt River Bridge. Horizontal lines represent the net capacity of the NWRB (i.e. gross capacity minus provision for local train movement) and the combined net capacity of the NWRB plus the Pitt River Bridge. Between the two there is ample capacity well beyond the study horizon if Coordinated Rail Operations are implemented.

**Exhibit 6.4** presents a comparison of the existing and forecast rail movements across the New Westminster Bridge and the Pitt River Bridge for the Status Quo and the Coordinated Rail Operations (shortened to CRO in the exhibit). The weekly train counts have been factored up by 20% to reflect a typical peak day so that it could be compared directly with the Status Quo data received from the Railways. Amtrak service at a frequency of 3 trains per day in each direction is also included. The analysis was carried out for a number of scenarios, with the Optimistic forecast and all of the Roberts Bank traffic moving east/west.

### Exhibit 6.4 NWRB and Pitt River Bridge Traffic Assignment




The exhibit indicates that, under Status Quo Operations, the forecast rail movements across this screenline reach 85% of the capacity of the New Westminster Rail Bridge by 2006 – 2008 and exceed capacity by 2011. On the other hand, the Coordinated Rail Operations results in rail demand not reaching 85% capacity of the New Westminster Rail Bridge until approximately 2021.

Considering the combined capacity of the two bridges, the rail demand under Status Quo Operations exceeds the demand under Coordinated Rail Operations for all forecast years, and exceeds 85% of the capacity of the two bridges in approximately 2016.

The need to replace the NWRB, therefore, is very much linked with the degree to which the three conditions mentioned above can be achieved, and the extent to which local train movements to the Waterfront area can be converted to more efficient full train loads.

### 6.4.2 Volume/Capacity Sensitivity and Timing

Various scenarios were examined to test sensitivity to a range of parameters.

- Three different market growth projections (base case, optimistic and pessimistic) were tested. The basic conclusions regarding priority improvements do not change, although the timing for the additional investments would advance or be delayed by one or two years, depending on the growth projection.

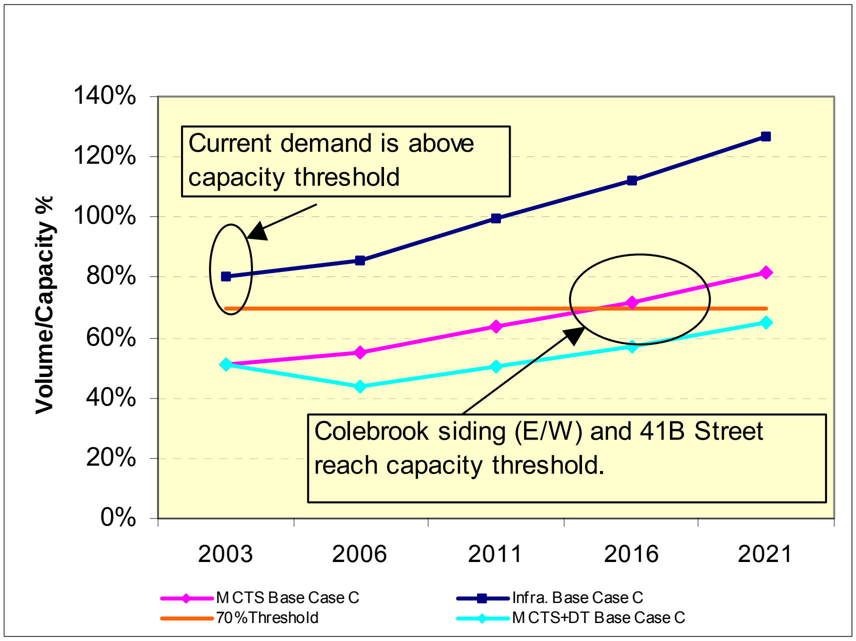
- All of the conversion factors used to translate metric tonnes into train loads are modifiable. For example, long container trains could have a positive impact by diminishing urgency of Roberts Bank access improvements, but not without creating other problems of interference with auto traffic across level crossings.

- Four different ways of distributing the growth between marine terminals were examined. The report concentrates on the distribution suggested by the Port of Vancouver which involves expansion of Deltaport, creation of a container terminal on the North Shore of Burrard Inlet, and expansion of Vanterm and Centerm. However, all of the alternatives generally require the same infrastructure improvements, with some minor variation in timing.

- Passenger train sensitivity cases were run, with variations in the number of Amtrak trains per week. The results referred to here involve 42 Amtrak trains per week terminating in the False Creek Flats area. Higher Amtrak volumes will increase the need and bring forward the timing of infrastructure improvements in the north/south corridor, but these higher volumes are not likely to be realized for at least 10 years.

Roberts Bank represents an interesting case in point to illustrate sensitivity results, because it will experience the most dramatic rail traffic growth in the years ahead. In fact, during the course of the study Vancouver Port Authority forecasts were revised upward and the projected expansion of Deltaport at Roberts Bank resulted in considerably increased train movements for this area. It was found that the MCTS improvements would not be adequate and additional capacity enhancements would be required before the end of the study horizon. This case represents an example to illustrate the study methodology.

**Exhibit 6.5 Volume/Capacity Mud Bay to Roberts Bank**




As mentioned above, the volume/capacity threshold triggering the need for improvements was established at 70% of capacity. **Exhibit 6.5** shows how volume/capacity varies depending upon the track configuration being modeled, and depending on whether it is Status Quo Operations or Coordinated Rail Operations. It shows that with the existing infrastructure and Status Quo Operations, capacity utilization is already above the threshold for improvements, consistent with findings of the MCTS study. Without capacity additions, serious delays or limitations on the number of trains will likely be experienced before the end of the decade.

The MCTS-recommended siding at Colebrook alleviates the capacity constraint for a period of time, but between 2011 and 2016 further improvements (i.e., MCTS + DT Base Case, where DT means double track) will be needed to sustain service levels to the end of the study horizon.

The analyses described above are based on train lengths of about 2,500 m (7,000 ft.). Further detailed studies would have to take into account the operation of fewer longer trains reaching a maximum length of 4,400 m (12,000 ft.).

In addition to the Base Case, sensitivity analyses were carried out for pessimistic and optimistic projections and for alternative distributions of traffic between east/west and north/south traffic lanes. In the case of pessimistic forecasts, the need for additional tracks is extended to 2021. With optimistic projections, the need advances several years, but in turn it could be delayed if some of the new traffic moves north/south, instead of all going east/west via Kamloops. Deltaport expansion plans should incorporate the implications for multiple track or sidings on the access route from Matsqui Junction; the timing for the track enhancements will be determined by the timing and terminal capacity for port facility expansion.

### *6.4.3 Land Use Conflicts in Waterfront and False Creek Flats*

The issue of departing and arriving trains in terminal areas extends beyond transportation implications and is particularly relevant to the interface between port/railway operations and their surrounding communities. Facilities located in waterfront areas carry a high appeal for other social and economic purposes (e.g. tourism and housing).

One of the busiest areas for freight in the Port of Vancouver is Burrard Inlet. The waterfront is also an important area for passenger cruise ships, public transportation (including the Seabus, SkyTrain, West Coast Express, Harbourlynx ferry, Heliport terminals and Float Planes), and pleasure craft. The waterfront also includes the rail facilities in False Creek Flats.

The rail lines serving the Port in this area are regarded by some as an obstacle to other social and economic pursuits. Backup land for marine port facilities and for efficient rail operations is a serious constraint in this area. These facilities are located in waterfront areas that carry a high appeal for other social and economic purposes (e.g. tourism, commercial development and housing).

The land is owned by various interests, including the railways as separate entities. There are serious constraints in the area, and potential for conflicting purposes and pursuits. The City of Vancouver has expressed its desire to examine the City's need to continue to serve the downtown, the Port, and the False Creek Flats by rail and how to respond to the emerging development pressures occurring in the area.

At the present time, the railways maintain marshalling and storage facilities in the area of False Creek Flats. These include the VIA station and maintenance facilities, a new station development by Rocky Mountaineer Railtours (RMR), Glenn Yard and Waterfront Yard. Glenn Yard and Waterfront Yard serve as staging areas for CN and BNSF to access the port by crossing Powell Street.

False Creek Flats is also the location of Pacific Central Station that serves:

- AMTRAK -- 2 trains per day at present, with plans to expand to 6 trains per day ( 3 each way - the higher frequency of service is incorporated in the traffic levels that are simulated in this study); expanding this service has capacity implications considered in the analysis, and incorporated in the study results.
- Rocky Mountaineer Railtours (RMR) – 6 trains per week (3 each way) between May and October at present, with occasional departures over the balance of the year; RMR has indicated plans to increase service frequency;
- VIA Rail Canada -- 6 trains per week (3 each way), and a rail passenger equipment maintenance facility in False Creek Flats; VIA has stated its intentions to increase to daily service in both directions.

Both CPR and CN point out that increases in frequency for VIA and RMR are entirely contingent upon mainline capacity additions to accommodate them. Such additions would have to be funded by passenger train sponsors. The current level of 26 passenger trains per week could remain the same or increase to as much as 70 trains per week. The highest level of activity will likely require the existing VIA Rail yard facilities to expand.

With respect to freight activity, the Glenn Yard and both the CN Yard and the BNSF Yard are used as staging and back up storage for the Port operation. CN has an arrangement with BNSF to store cars on the south side of Industrial Avenue. The ultimate requirement for tracks and track configuration in this area depends upon cooperative efforts that remain uncertain at this time. It would be natural to expect BNSF to seek a higher return on its own surplus land assets in the area, and this would more likely be through sale for development or co-development rather than short-term leases for rail car storage.

Future planning of the False Creek Flats area by the City of Vancouver must take into account these growing needs for freight and passenger rail traffic and terminal requirements.

A significant challenge is posed by both the "Coordinated Rail Operations" and "Status Quo operations" scenarios in this area. Freight traffic congestion can often occur because land and adequate long tracks are in short supply. To complete the analysis in this study it was necessary to consider establishment of 2,200 m (6,000 ft.) tracks reasonably close to Centerm and Vanterm, and cost provisions were made for this purpose. The actual location of such facilities has not yet been addressed, because it requires more detailed planning and simulation work. It is noted, however, that there are serious constraints in the area.

The prospect of running through trains via the CPR line could alleviate some local movements, however such operations would require additional yard and storage track in the immediate vicinity of the waterfront causing the need for backup facilities nearby. Existing facilities at False Creek Flats would be primary candidates.

At first glance, this appears to pose an intractable problem, because it is acknowledged that:

- There does not appear to be any land available in the Waterfront area for such land expansion;
- False Creek Flats is not suitably connected to the Waterfront to be a back up terminal for intensive use, because of the Heatley Diamond and multiple level crossings between the Flats and the Diamond;
- Railways state that the existing tracks are at the limits of potential capacity;

The problem and the opportunity that is presented requires more profound analysis of the ownership and uses of land in the Waterfront Area, including railways, terminals, Vancouver Port Authority, and port-based industries west of Second Narrows and in False Creek Flats. The existing physical configuration arose from historical solutions to the institutional constraints subject to the competitive dynamics of the players. The detailed planning studies that are now being carried out in the area accept those constraints as a starting premise – but is that appropriate considering the bigger economic picture for the region and Canada's foreign trade?

Existing institutional prerogatives should be challenged in addressing long term capacity needs, and new arrangements between the individual participants should focus the Waterfront terminals on maximizing through-put per acre while also respecting established equity positions of those players. Nearby back-up facilities, such as False Creek Flats could handle operations that are important for support, such as car repairs and trans-load facilities, but that are not crucial to the day-to-day maximization of throughput.

The main conclusion from all of this for the Waterfront area is that land which is currently dedicated to railway and Port operations should remain available to address projected growth in rail freight demand and to protect Canada's international trade. Land in False Creek Flats should be protected for rail use until the surplus can be determined by detailed planning and analysis of future rail operations and infrastructure requirements, and no lands released for other uses prior to that time.

### *6.4.4 Passenger Train Services*

Various planning scenarios concerning the future of passenger trains have been under consideration in the study area. Capacity analyses carried out here suggest that there are not likely to be major issues within the study area for mainline availability, except in respect of increasing the frequency of Amtrak trains between Seattle and Vancouver.

In all of the cases examined, Corridor 1 from the US border to downtown Vancouver requires capacity additions. The proposed siding near Colebrook is a significant improvement. It would be essential in order to allow Amtrak frequency to increase from one train pair per day to three train pairs per day. It is also noted that depending upon how growth in the north-south train axis evolves, further additions could be required before 2021; this would likely be the case if more than 3 passenger trains each way were operated between the US border and Vancouver.

With respect to increasing frequency of service by existing West Coast Express (WCE) commuter trains, specific simulations were not carried out, mainly because the volume/capacity on this route is sufficiently below the threshold to accommodate plans that have been identified. WCE invested in mainline track improvements between Mission and downtown and in provision of terminal capacities in Mission and downtown, prior to implementation of the service. This investment has improved capacity on the mainline for freight in periods when passenger trains are not operating. Capacity at the terminus would only be an issue if additional commuter train storage tracks would be required at the waterfront.

With respect to termination of full container trains and passenger train impacts, detailed simulations in the waterfront terminal would be required to identify track improvements to mitigate interference between passenger trains and port switching operations.

Increasing the frequency of VIA and RMR trains over existing routes has also been proposed by the operators. The position of the railways is that capacity limitations outside the terminal area are prohibitive to increasing passenger train frequency. If mainline capacity issues would be resolved, then within the Lower Mainland there would not likely be need for any new capacity enhancement projects over and above those already recommended in the MCTS Study. In other words, provided the mainline capacity issues presented herein are resolved, there do not appear to be any overriding constraints to increase passenger services in the study area.

# 7.0 ASSESSMENT OF SOLUTIONS

This section introduces the three major improvement scenarios that were studied in detail and upon which a benefit/cost analysis was performed. This section defines the major scenarios and presents the methodology for the economic and financial analysis and ensuing results. Finally the section concludes with recommended investment strategies.

## 7.1 MAJOR IMPROVEMENT SCENARIOS

Three improvement scenarios have been analyzed and compared to Status Quo Operations, which assume no improvements to the rail network other than minimal safety improvements. With respect to the New Westminster Rail Bridge ("NWRB"), it is assumed under the Status Quo Operations that the existing bridge is retained with annual operating and maintenance expenditures to keep the bridge usable and safe. The bridge is assumed to undergo a major rehabilitation every 20 years from 2005. The Status Quo Operations serve as the basis for comparison with the three improvement scenarios studied.

Under Status Quo Operations, demand exceeds the rail network's capacity after 2009 and, therefore, the demand for rail traffic that is in excess of supply would either be:

- Met by truck traffic;
- Met by competing ports along the West Coast; or
- Priced out (i.e. resulting in reduced transportation demand due to increased transportation costs).

Aside from replacing the existing NWRB with a new bridge or tunnel, the study team examined 16 separate Major Commercial Transportation System ("MCTS") project improvements to the Lower Mainland rail network (projects A to P in Exhibit 7.1). The study team also examined additional projects at a high level for the purposes of the benefit/cost analysis, but they were not part of the set of MCTS projects (projects R to W in Exhibit 7.1).

Three scenarios have been identified to address the capacity limitations of the Lower Mainland rail network. Each of these is a result of a different combination of the projects in Exhibit 7.1. The three scenarios are as follows:

1) **Status Quo Operations with a New Bridge**: Under this scenario, the NWRB is replaced with a new bridge plus a number of other network improvements to increase capacity.

2) **Status Quo Operations with a New Tunnel**: Under this scenario the NWRB is replaced with a new tunnel plus a number of other network improvements to increase capacity.

3) **Coordinated Rail Operations**: Under this shared operations scenario, the NWRB is not replaced, and all the projects required to achieve the Coordinated Rail Operations would be completed. Furthermore some trains would be re-routed to the Pitt River bridge to avoid capacity constraints at the NWRB.

The following exhibit indicates which projects would need to be implemented for each scenario identified to allow the region's rail network capacity to keep up with demand.

**Exhibit 7.1 Definition of the Three Major Scenarios**

| MCTS Projects | Project Name | Scenario #1: Status Quo Operations with a New Bridge | Scenario #2: Status Quo Operations with a New Tunnel | Scenario #3: Coordinated Rail Operations |
|---|---|---|---|---|
| A – Alt 1 | NWRB: retain existing bridge (*) | | | ✓ |
| A – Alt 2 | NWRB: build new bridge | ✓ | | |
| A – Alt 3 | NWRB: build tunnel | | ✓ | |
| B | Pitt River Swing Bridge (♦) | | | |
| C | Roberts Bank - 41B St. – overpass | ✓ | ✓ | ✓ |
| D | Mud Bay – West Leg of Wye (♦) | | | |
| E | BN New Yard to Spruce St. | ✓ | ✓ | ✓ |
| F | Colebrook North/South – siding | ✓ | ✓ | ✓ |
| G | Colebrook East/West – siding | ✓ | ✓ | ✓ |
| H | Westwood St. – overpass (†) | | | |
| I | Harris Road – overpass (†) | | | |
| J | King Edward Ave. – overpass (†) | | | |
| K | Pemberton Avenue – overpass (♦) | | | |
| N | Front St. – grade separation (♦) | | | |
| O Part a | Powell St. – overpass (†) | | | |
| O Part b | Powell St. - double track | ✓ | ✓ | |
| P | BNSF/CN Junction – siding | ✓ | ✓ | |
| Q | Chilliwack Yale – grade separation (†) | | | |
| **Non MCTS Projects (§)** | | | | |
| R | Negotiations required to achieve Coordinated Rail Operations | | | ✓ |
| S | Double Track (3.6 miles) – Yale Subdivision between Matsqui Jct. and Hydro | ✓ | ✓ | ✓ |
| T | Double Track (5 miles) - Mud Bay to Roberts Bank | ✓ | ✓ | ✓ |
| U | 1 Additional Sidings - Colebrook | ✓ | ✓ | |
| V | 7,000 feet track segments near ports | | | ✓ |

(*) Only this project is required for the Status Quo Operations. It consists of maintaining the NWRB to minimal safety standards and does not include fire and collision improvements.
(†) Secondary Projects.
(♦) Deferrable Projects.
**(§)** Projects R through W were costed at a high level for the purposes of the benefit/cost analysis, but they were not studied in detail.

### *7.1.1 Categorization of Projects*

Projects “A” through “P” (as shown in Exhibit 7.1) represent priority projects that have been identified for the proposed MCTS. These projects fall into three categories:

1) **Capacity expansion projects**: these projects would increase the rail network’s capacity and are part of the core analysis performed in this study. These projects are identified in Exhibit 7.1 as “A”, “C”, “E”, “F”, “G”, “O part b” and “P”.

2) **Secondary projects:** these projects are not required to increase the rail network’s capacity and, therefore, have not been included in the analysis of the three scenarios. These projects are identified in Exhibit 7.1 by the symbol †. These projects are rail grade separation projects and, while not providing benefit to rail operations, provide some benefit to road users in terms of travel time savings.

3) **Deferrable projects**: based on the team's assessment of rail traffic demand versus capacity and other benefits, these projects are not required during the study period (i.e. up to 2021) and these projects are identified in Exhibit 7.1 by the symbol ♦. It is acknowledged that circumstances governing local switching, industrial and yard transfer assignments for one or more railways could alter this deferred status; it would be based on information applicable to detailed simulations considered beyond the scope of this project.

In addition to selected MCTS projects there are five non-MCTS projects which have been identified by the project team as being necessary to meet the capacity requirements of the system.

R) **Negotiation costs:** the cost of reaching agreements for the Coordinated Rail Operations scenario.

S) **Double track – Yale subdivision:** this improvement is required under all Scenarios to meet projected traffic movements. In particular the 3.6 miles of the Yale subdivision between Matsqui Jct. and Hydro needs to be double tracked.

T) **Double track – Mud Bay to Roberts Bank:** this improvement needed for all Scenarios is approximately equal to three sidings of 8,500 ft. This improvement only needs to take place west of Hydro, but in the current specified location it would benefit both East-West and North-South inland routings.

U) **1 Additional Colebrook siding:** this improvement is required to meet the case where coal and container traffic on BNSF is less than 30% of the total traffic and yet significantly more than occasional movements (plus new Amtrak trains). This could be implemented as an extension of the planned Colebrook siding in project "F" in Exhibit 7.1.

V) **7,000 foot track segments:** the Coordinated Rail Operations scenario requires one new 7,000 foot track segment near the port in 2006 and another one in 2016. Examples of locations of these track segments include near Powell Street and in the False Creek Flats.

## 7.2 ECONOMIC AND FINANCIAL ANALYSIS

The Lower Mainland rail network is a key part of the integrated national transportation network. Improvements to the network in any one area benefit direct and indirect users throughout the country. If demand for rail transportation exceeds capacity in the Lower Mainland there is a negative impact on the Canadian economy. Later in this chapter we estimate the direct economic impact of this situation to be greater than $700 million in 2021 alone. The nation's ports and railroads are at the beginning of this value chain and can be the drivers of this increased economic activity. If the value captured by the ports and railroads is sufficient to meet the risk adjusted return on capital associated with the necessary improvements, then the ports and railroads could proceed without external financial support. If on the other hand, the value captured by the ports and railroads is insufficient to meet the internal hurdle rates for the projects or if benefits to other stakeholders can be quantified, then the case for financial support from other stakeholders must be examined.

This section presents both the financial and economic impacts of investments in the Lower Mainland rail system. The financial analysis presents the impacts associated with investments in the rail infrastructure expressed in terms of benefits and costs to the primary stakeholders, the railways and the ports. This information is an estimate of the return that the private sector would yield, should they make an investment in these improvements.

Then this section presents the broader economic impact to the Canadian economy resulting from this investment in the rail system.

The financial analysis section quantifies the costs associated with each of the three scenarios as well as the benefits accruing to the ports, the railroads and the economy. In addition information regarding the key assumptions made in the analysis is provided. The key output is the internal rate of return ("IRR") of each of the three scenarios. The IRR is the interest rate that makes the net present value ("NPV") of all cash flows (costs and benefits) equal to zero. It will be used to compare the absolute and relative attractiveness of each of the three scenarios.

### 7.2.1 Approach

The approach used compares the three scenarios by assessing their incremental costs and benefits to the Status Quo Operations without improvements[5]. This is done by utilizing a financial model. For each scenario the following costs served as inputs:

- Capital;
- Operating;
- Maintenance; and
- Rehabilitation.

Benefits that accrue to the port and the railroad companies were quantified and used as inputs for the analysis. The attractiveness of each scenario from an investment perspective is captured by calculating the IRR of the cash flows representing the incremental costs and benefits of each scenario. If the IRR of a project is greater than the company's internal investment hurdle rate (assumed to be weighted average cost of capital ("WACC")), and the project is not perceived to be materially more risky than the investors' normal business, then they should proceed with that project.

The scenario with the highest IRR will be determined to be the 'Preferred Scenario'. It is acknowledged that factors other than the IRR, such as qualitative factors, may also be important in determining the Preferred Scenario, but these other factors did not serve as the basis to determine it.

### 7.2.2 Assumptions

This section summarizes the key assumptions used to perform the analysis. The assumptions and the ensuing analysis are based on data provided by the Steering Committee and the Study Team. The data has been relied upon as presented. The Study Team makes no representation, warranty or undertaking (expressed or implied) in relation to the assumptions or the results presented in this report. No responsibility is taken or accepted by the Study Team for the adequacy, completeness or accuracy of the results or the assumptions upon which they are based and all liability therefore is expressly excluded. Recipients should carry out their own due diligence.

#### 7.2.2.1 Time Horizon Assumptions

The Steering Committee requested that this analysis should be performed to year 2021 as no port traffic forecasts are available beyond that year. However, this provides only a 16 year period of analysis, which makes it difficult to compare the scenarios as most of the proposed improvements have an expected life of 100 years. For example, a new NWRB would be expected to have a useful life of 100 years and therefore amortizing its costs over only 16 years would make it look overly expensive.

To recognize the longer term benefits of the improvements, the projects were evaluated by including their long term benefits and costs (i.e. approx. 100-year horizon). For the years beyond which forecasts are available, namely after 2021, traffic and benefits were assumed to stay at 2021 levels.

An alternative approach would have been to consider the residual value of the asset at the end of the study period, 2021. This could be done based on terminal benefits and costs or on depreciated value. Both of these methods have drawbacks. In the case of basing residual value on depreciated value, the depreciated value would not necessarily equal the asset's economic value. In the case of basing residual value on terminal benefits and costs:

[5] Status Quo Operations without improvements assume there would only be required safety improvements to the NWRB and the rest of the rail network, but no other improvement projects to the Lower Mainland rail network.

- a discount rate is required to estimate the residual value based on a stream of cashflows. There is no standard discount rate to apply in this case. The advantage of the IRR approach is that the implied discount rate is an output, not an input; and
- due to the short study period and the long life of the assets the residual value of the capital projects in 2021 would be expected to be quite large. As a result the key driver of the results would not be the benefits and costs associated with each scenario, but rather the residual value.

Small changes to the method for determining residual value would likely produce large differences in results and therefore this method has not been used to perform the analysis. The main disadvantage to the choice of evaluating the scenarios based on their long term cash flows is the sensitivity to the assumed growth rate of costs and benefits. Small changes in the growth rates over a long term can have a large impact on results. To be conservative no additional growth to either benefits or costs after 2021 has been assumed.

#### 7.2.2.2 Costs Assumptions

Capital, operating, maintenance and rehabilitation costs for ‘capacity expansion projects’ and ‘secondary projects’ have been described in Section 5 and are summarized below. All figures are in real 2004 dollars. Costs for “deferrable projects” have not been provided. The cost estimates are all preliminary and require further study.

**Exhibit 7.2 Capital costs of selected MCTS projects**

| Project | Project Name | Capital Cost [1] | Annual Operating Costs [2] | Annual Maint. Costs [2] | Rehabilitation Costs [3] | Expected Life (years) | Total Cost after 20 years | Required Completion Date |
|---|---|---|---|---|---|---|---|---|
| A - Alt. 1 | New Westminster Rail Bridge: | | | | | | | |
| | - retain existing bridge | $ - | $ 650,000 | $ 590,000 | $ 22,000,000 | 20 | $ 46,800,000 | |
| A - Alt. 2 | - build new bridge | $ 110,000,000 | $ 650,000 | $ 750,000 | $ 2,000,000 | 100 | $ 140,000,000 | 2008 |
| A - Alt. 3 | - build tunnel | $ 420,000,000 | $ 2,000,000 | $ 2,000,000 | $ 2,000,000 | 100 | $ 502,000,000 | 2008 |
| C | Roberts Bank - 41B St. - overpass | $ 4,900,000 | $ - | $ 5,000 | $ 300,000 | 100 | $ 5,300,000 | 2006 |
| D | Mud Bay - West Leg of Wye | | | | | | | |
| E | BN New Yard to Spruce St. | $ 3,000,000 | $ - | $ 5,000 | $ 100,000 | 100 | $ 3,200,000 | 2006 |
| F | Colebrook North/ South - siding | $ 6,500,000 | $ - | $ 10,000 | $ 300,000 | 100 | $ 7,000,000 | 2006 |
| G | Colebrook East/West - siding | $ 7,100,000 | $ - | $ 11,000 | $ 300,000 | 100 | $ 7,620,000 | 2011 |
| H | Westwood St. -overpass | $ 11,800,000 | $ - | $ 9,000 | $ 500,000 | 100 | $ 12,480,000 | |
| I | Harris Road - overpass | $ 9,800,000 | $ - | $ 8,000 | $ 500,000 | 100 | $ 10,460,000 | |
| J | King Edward Ave. - overpass | $ 18,000,000 | $ - | $ 10,000 | $ 1,000,000 | 100 | $ 19,200,000 | |
| K | Pemberton Ave - overpasss * | $ 5,000,000 | $ - | $ 5,000 | $ 500,000 | 100 | $ 5,600,000 | |
| O - part A | Powell St. - overpass | $ 10,000,000 | $ - | $ 10,000 | $ 1,000,000 | 100 | $ 11,200,000 | |
| O - part B | Powell St. - double track | $ 2,700,000 | $ - | $ 5,000 | $ 100,000 | 100 | $ 2,900,000 | 2006 |
| P | BNSF/CN Junction - siding | $ 6,300,000 | $ - | $ 10,000 | $ 300,000 | 100 | $ 6,800,000 | 2006 |
| Q | Chiliwack Yale - grade separation* | $ 10,000,000 | | $ 10,000 | $ 1,000,000 | 10 | $ 11,200,000 | |
| **Non MCTS Projects** | | | | | | | | |
| R | Negotiations required to achieve joint facilities | $ 10,000,000 | | | | | | |
| S | Double Track - Yale Subdivision | $ 15,000,000 | | $ 25,000 | $ 300,000 | 100 | $ 15,800,000 | 2021 |
| T | Double Track Mud Bay to Roberts Bank | $ 20,000,000 | | $ 75,000 | $ 900,000 | 100 | $ 22,400,000 | 2016 |
| U | 1 Additional Colebrook siding | $ 7,000,000 | | $ 50,000 | $ 600,000 | 100 | $ 8,600,000 | 2016 |
| V | 7,000 track segments near ports | $ 26,400,000 | $ - | $ 25,000 | $ 300,000 | 100 | $ 27,200,000 | 2006, '16,… |

Notes:
1. Capital Cost period and other details shown on Project Description Sheets and Drawings
2. Total Operating Costs and Maintenance Costs have been averaged to yield an annual amount.
3. Rehabilitation Costs are in 2004 Dollars and are required after a 20 year service life and every 20 years after that.

* These projects have been estimated based on their similarities to other MCTS projects.

\# It is assumed for the purposes of this study that there are no annual net costs (payments) in a Coordinated Rail Operations scenario once the negotiations are completed. While there would be access payments made by some railway companies to other railway companies, on an overall basis the network costs are the same.

| **Subtotal by Scenario** | | | | | |
|---|---|---|---|---|---|
| **Project Name** | **Capital Cost** | **Annual Operating Costs** | **Annual Maint. Costs** | **Rehabilitation Costs** | **Total Cost after 20 years** |
| Scenario #1 Separate Operations - New Bridge | $ 182,500,000 | $ 650,000 | $ 946,000 | $ 5,200,000 | $ 219,620,000 |
| Scenario #2 Separate Operations - New Tunnel | $ 492,500,000 | $ 2,000,000 | $ 2,196,000 | $ 5,200,000 | $ 581,620,000 |
| Scenario #3 Coordinated Rail Operations | $ 47,900,000 | $ 650,000 | $ 646,000 | $ 23,300,000 | $ 97,120,000 |

The study time horizon ends in 2021. For analysis purposes operating and maintenance costs were extended over 100 years to match up with the life of most of the improvements. In the Status Quo Operations it is assumed that the refurbishment, maintenance and operation of the existing bridge is possible over 100 years at the costs identified in Exhibit 7.2.

Exhibit 7.3 below shows costs at 5-year intervals over the study period for the three scenarios and the net present value during the study period and over 100 years. The net present value is calculated using a discount rate of 8% real based on an estimate of the weighted average cost of capital ("WACC") for organizations such as railway companies.

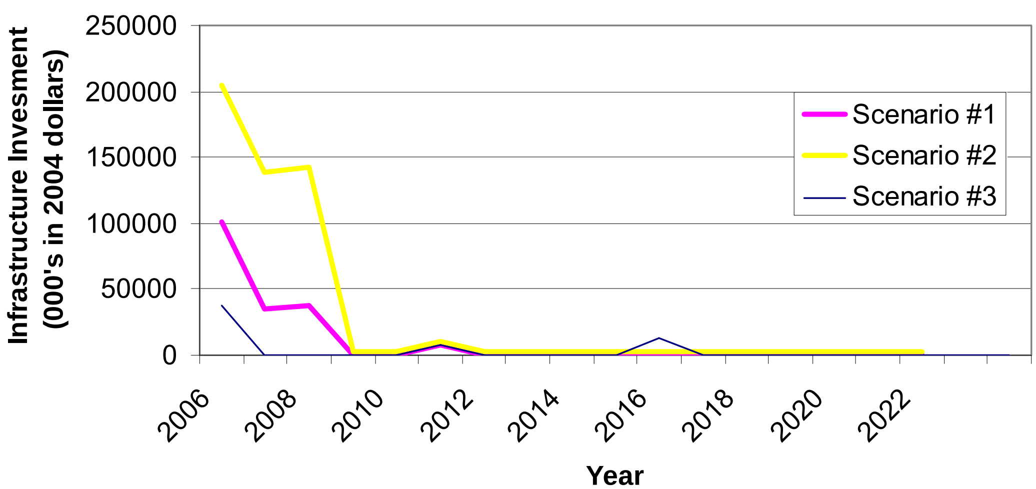
In all of the scenarios, the cost figures shown are the *incremental* cost or savings over the Status Quo Operations without improvements.

**Exhibit 7.3 Incremental Costs over the Status Quo Operations**

| | Year | | | | NPV @ 8% real as of 2004 | |
|---|---|---|---|---|---|---|
| **Costs:($ 000's, in 2004 real dollars)** | **2006** | **2011** | **2016** | **2021** | **2006 - 2021** | **2006 – 2105** |
| Scenario #1 Status Quo Operations with a New Bridge | 85,987 | 7,431 | 331 | 15,356 | 147,828 | 150,478 |
| Scenario #2 Status Quo Operations with a New Tunnel | 189,320 | 10,031 | 2,931 | 17,956 | 435,563 | 446,333 |
| Scenario # 3 Coordinated Rail Operations | 57,705 | 7,216 | 13,316 | 15,151 | 71,547 | 93,855 |

Exhibit 7.4 shows a graphical presentation of the incremental costs during the study period.

**Exhibit 7.4 Graph of incremental costs over time**



#### 7.2.2.3 Benefits Assumptions for Scenarios #1, #2 & #3

Under the Status Quo Operations by 2008 the Lower Mainland rail network will reach 423 freight trains per week, it's theoretical capacity. Currently, the Lower Mainland rail network is operating slightly below this limit. The critical link in the system is the New Westminster Rail Bridge, and it would reach its limit at this overall train volume. Consequently, the upper limit of train capacity for the system was set at this level, with all other factors being equivalent to 2002 operations. Scenarios #1, #2 and #3 all provide additional capacity, which would be needed to meet rising demand. Without this additional capacity the network would suffer a 'capacity constraint' (i.e. demand would exceed supply). This capacity constraint has been quantified and is summarized in the Exhibit 7.5. The capacity constraint is a key input in the benefits quantification.

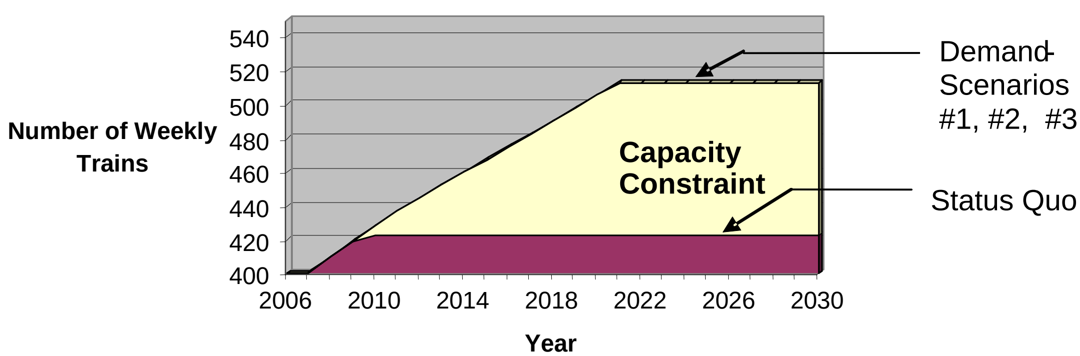
**Exhibit 7.5 Capacity constraint for Status Quo Operations**

| | Year | | | |
|---|---|---|---|---|
| | **2006** | **2011** | **2016** | **2021** |
| Freight train demand under Scenarios #1, #2, #3 (*) | 391 | 437 | 475 | 513 |
| Freight train capacity of Status Quo Operations (**) | 391 | 423 | 423 | 423 |
| ***Capacity constraints for Status Quo Operations (***)*** | ***0*** | ***14*** | ***52*** | ***90*** |

(*) There would be no capacity constraints under these scenarios. These figures represent the existing conservative traffic projections.
(**) Under the Status Quo Operations, the capacity of the rail network is 423 trains per week. In 2006, the demand would be 391 trains and therefore the maximum capacity would not be reached.
(***) Represents the number of freight trains that could not use the rail network under the Status Quo Operations (i.e. demand that would not be satisfied). Beyond 2021, the capacity constraints are assumed to grow linearly at the rate between 2016 and 2021.

These results are expressed graphically below:

**Exhibit 7.6 Lower Mainland rail network production**




Benefits to the railway companies and ports are calculated based on the net income that would be foregone if they could not accommodate the forecasted rail traffic due to rail capacity constraints. For each additional train that can be accommodated by the rail network, a value of benefits for the railway companies of $18,171 per train has been estimated by multiplying:

- Revenue per revenue car-mile: $2.65
- Ratio of revenue car-mile to total car-mile: 57%
- Average miles per trip: 1,200
- Number of cars per train: 100
- Railway net profit margin: 10%

The average distance per trip of 1,200 miles is an estimate of the average distance traveled for trips originating in and destined to Vancouver. If the average distance per trip were reduced to 800 miles, reflecting the average distance per trip for all trains in Canada as published by the Railway Association of Canada, then the benefit per train falls to $12,114.

Another benefit relates specifically to Project C (Roberts Bank – 41B St. Overpass) where this project would generate savings to the railways of $150,000 per annum.

The ports would also benefit from the additional railway capacity through higher traffic at the ports. However, benefits would be lower, because the income lost would be less significant since a proportion of the traffic that could not use the rail network under Status Quo Operations would still pass through the ports and then be transported by truck. This has been assumed to be 50%. Therefore a benefit of $2,500 per train has been assigned to the ports based on multiplying:

- Port/Terminal revenue per car: $500
- Number of cars per train: 100
- Port net profit margin: 10%
- Loss of port traffic due to rail capacity constraints: 50%

Exhibit 7.7 shows the estimated benefits at 5-year intervals over the study period for the three scenarios and the net present value during the study period and over 100 years.

**Exhibit 7.7 Port and Railroad Benefits 2006 to 2021 ($ 000's in 2004 real dollars)**

| | Year | | | | NPV @ 8% real as of 2004 | |
|---|---|---|---|---|---|---|
| | **2006** | **2011** | **2016** | **2021** | **2006 – 2021** | **2006 – 2105** |
| ***1,200 mile average trip*** | | | | | | |
| Port | 0 | 1,865 | 6,772 | 11,703 | 27,542 | 64,093 |
| Railroad | 150 | 13,708 | 49,376 | 85,216 | 201,515 | 467,664 |
| ***Total*** | ***150*** | ***15,573*** | ***56,148*** | ***96,919*** | ***229,057*** | ***531,757*** |
| | | | | | | |
| ***800 mile average trip*** | | | | | | |
| Port | 0 | 1,865 | 6,772 | 11,703 | 27,542 | 64,093 |
| Railroad | 150 | 9,189 | 32,967 | 56,860 | 134,840 | 312,375 |
| ***Total*** | ***150*** | ***11,054*** | ***39,739*** | ***68,563*** | ***162,328*** | ***376,468*** |

The majority of the benefits shown in Exhibit 7.7 accrue to the railway companies with the remainder to the ports. However, the following benefits would be generated for each of the three scenarios in addition to the benefits quantified above and these benefits would accrue to various stakeholders rather than specifically the railway companies and the ports:

[6] Percentage of car miles that generate revenue.

- Rail capacity benefits for passenger trains; - Increasing the capacity of the Lower Mainland rail network would allow more passenger trains to operate and reduce road congestion .
- Marine traffic benefits; - In the case of a new bridge, a significantly reduced number of vessels would require a bridge openings and in the case of a new tunnel there would be no restrictions on vessels, allowing for more efficient marine traffic operations. If the existing NWRB is retained, there is no incremental benefit.
- Reduced accident risk; - In the case of a new bridge, the risk of an accident due to a collision between the bridge and a marine vessel would be greatly reduced as the planned height is much higher and the planned span is much wider. In the case of a new tunnel the risk would be eliminated. If the existing NWRB is retained, there is no incremental benefit. From 1950 to 1983 there was an average of 1.33 collisions per year between the bridge and barges. The vast majority of the collisions resulted in damage to the Main Protection piers with no damage to the bridge. Average annual value of repair costs for that period was $385,000/year (1983 dollars). Some of the other MCTS improvements such as overpasses would also reduce the accident risk
- Improved Seismic Protection – In the case of a new bridge, the design standards would improve its ability to withstand an earthquake. It is estimated that a 6-month bridge closure with a 0.2% probability of occurrence would mean risk-adjusted lost benefits due to capacity constraints of $0.1 million in 2021. The 0.2% is based on the probability (1 in 475 years) of an earthquake occurring in any given year with a magnitude strong enough to cause damage.
- Avoided losses due to bridge fire; - In the case of a new bridge or tunnel the risk of fire would be reduced as the new infrastructure would not be constructed from wood. Due to the wood components of the existing NWRB, if the bridge is retained, the risk of fire remains real and there is no incremental benefit. For instance, there was a fire of the north west approach to the bridge in 1998 caused by vandals. The replacement design consisted of fill embankment with stabilized earth walls, retaining wall sections and two new elevated spans, and the entire construction was completed with minimum closures to the rail traffic.
- Avoided employment losses – If the existing bridge or a new bridge is damaged due to fire or a marine collision, cargo and railroad flows through the Lower Mainland are impaired and there could be employment losses. These losses could be avoided if a tunnel were built and could be minimized with the design of a new bridge.
- New employment – The benefits associated with a higher level of employment, which would be required to meet the increased cargo and rail movements has not been quantified. To some degree it is captured in the Economic Impacts presented in Section 7.2.6.
- Travel time savings for rail, car and truck users; - Direct travel time savings related to overpasses for car and truck users have been quantified for the Secondary Projects and the 41B Street Overpass. The value of travel time savings is not shown above but is quantified separately in Section 7.2.2.4. The general travel time savings for car and truck users generated by the increased rail network capacity have not been quantified. This includes for instance the travel time savings due to reduced congestion in the Lower Mainland because more passenger trains can travel on the rail network or reduced road congestion because more freight traffic is moving by rail rather than truck.
- Environmental impacts; - This could come in the form of reduced Greenhouse Gas emissions, such as if network capacity is not increased, more cargo will have to be transported via truck and there will be more emissions due to the higher levels of congestion. It could also come in the form of avoided environmental disasters in case of a ship collision with the bridge; and
- Social impacts – This could come in many forms. For instance through a better quality of life for the residents living near the improvements such as new overpasses.

However, these benefits have not been included in the analysis at this stage as they were outside the scope of this engagement.

#### 7.2.2.4 Benefits Assumptions for the Secondary projects

Benefits in terms of travel time savings for car and truck users were estimated for the projects defined as "secondary projects" as identified in Exhibit 7.1 with the symbol (†). The secondary projects are those projects that do not necessarily have rail benefits, but provide other benefits to society, including eliminating auto and truck delay, rail/vehicle accidents and reducing environmental impacts. The social benefits resulting from the elimination of auto and truck delays are the most significant and have been estimated in this study.

A model was developed to estimate delay reduction due to elimination of the at grade rail crossings. The model takes into account current and forecast peak hour road traffic, both car and truck, and current and forecast rail movements, as well as ranges of value of travel time.

Road traffic estimates were obtained from current traffic counts and grown for all horizon years, using forecasts from the GVRD's EMME/2 model. Peak period traffic was then factored to daily and annual for the respective years.

The rail movements were based on the Status Quo Operations, that is continued separate operations by the railways, and growth in accordance with the forecast rail growth across the region.

Road traffic delays were calculated by estimating the amount of time that the crossing is closed to accommodate rail traffic, taking into account estimated average daily train volumes, train length, the speed of the train and allowing clearance of 20 – 30 seconds before and after the train crosses the crossing.

Finally, the value of travel time saved was derived from values of time contained in the Gateway Council report entitled "Economic Impact Analysis of Investment in a Major Commercial Transportation System for the Greater Vancouver Region, July 2003." This report suggests that the value of time varies between $7.90 per hour for single occupant cars and $15.80 per hour for multiple occupant vehicles, both for non-work trips; $18.90 per hour for single occupant cars and $37.80 per hour for multiple occupant vehicles, for business travel; $36.00 per hour for empty light trucks and $45.00 per hour for empty heavy trucks; $77.00 per hour for loaded light trucks and $95.00 per hour for loaded heavy trucks. Using typical mix of trip purposes and vehicle occupancies, average values of time of $15.00 per hour for cars and $64.00 per hour for trucks were used in this analysis. The benefits occur in every year and exhibit 7.8 shows the benefits in selected years and the net present value over the study period and over life of the improvements for the secondary projects, using a discount rate of 3.5% in real terms, representing the Social Time Preference Rate.

**Exhibit 7.8 Road User Benefits 2006 to 2021 (in 000's in 2004 real dollars)**

| Project | | Year | | | | NPV @ 3.5% real as of 2004 | |
|---|---|---|---|---|---|---|---|
| | | 2006 | 2011 | 2016 | 2021 | 2006 – 2021 | 2006 – 2105 |
| O Part A | Powell St. Overpass | 62 | 72 | 80 | 88 | 901 | 2,502 |
| H | Westwood St. Overpass | 93 | 106 | 117 | 128 | 1,320 | 3,632 |
| I | Harris Road Overpass | 112 | 136 | 158 | 179 | 1,730 | 4,978 |
| J | King Edward Overpass | 51 | 65 | 71 | 77 | 787 | 2,178 |
| K | Pemberton Ave. Overpass | 354 | 435 | 497 | 560 | 5,477 | 15,608 |
| N | Front St. Overpass | 13 | 17 | 23 | 29 | 238 | 754 |
| Q | Chilliwack Yale Grade Separation | 138 | 172 | 196 | 221 | 2,157 | 6,150 |
| C | 41B St. Overpass | 325 | 421 | 525 | 630 | 5,561 | 16,959 |

Not included in the benefits above are those accruing to the railroads. These are difficult to quantify, but stem from the fact that trains are allowed to travel at higher speeds through grade separated crossings than at grade crossings.

### *7.2.3 Results for Scenarios #1, #2 & #3*

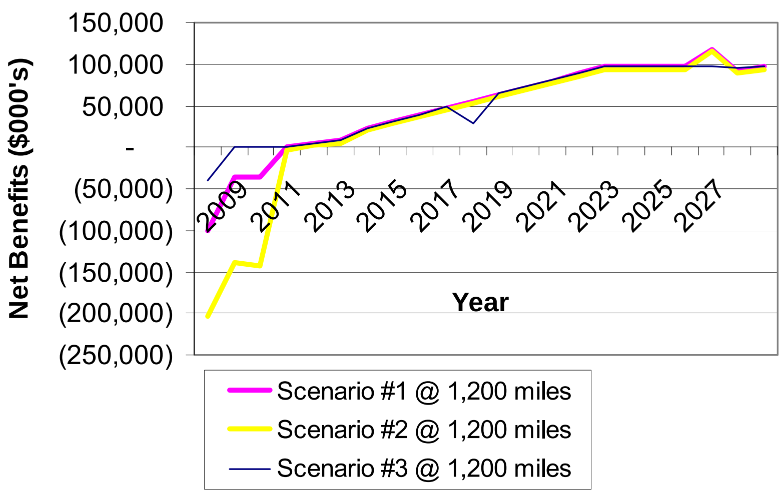
The IRRs can be categorized as one of two types:

- **Financial IRR:** this type of IRR focuses on the financial return to the entity that paid for the assets (e.g. the railroad) based on cash inflows and outflows.
- **Economic IRR**: this type of IRR includes the financial return as well as the impacts on society such as environmental benefits and transportation user time savings. It includes cash and non-cash items.

The analysis of Scenarios #1, #2 and #3 is based on the Financial IRR, while the analysis of Secondary projects is based on the Economic IRR.

In Scenarios #1, #2 and #3, net benefits are the sum of the incremental benefits to freight rail and ports and costs outlined above. Other benefits were not included as they were beyond the scope of this engagement. The following graph shows the net benefits of the three scenarios based on an average trip length of 1,200 miles. All three scenarios have similar benefits and differ primarily in terms of construction costs. The graph for an average trip length of 800 miles is similar but with lower net benefits after 2009.

**Exhibit 7.9 Graph of Net Benefits with Average Trip Length of 1,200 Miles**




Based on the net benefits above, the IRR in real terms for each scenario has been calculated and the results are presented in Exhibit 7.10.

**Exhibit 7.10 Internal Rates of Return for the Three Major Scenarios**

| Note: IRRs are in real terms | Scenario #1: Status Quo Operations with a New Bridge | Scenario #2: Status Quo Operations with a New Tunnel | Scenario #3: Coordinated Rail Operations |
|---|---|---|---|
| **Average rail trip length of 1,200 miles** | | | |
| IRR for study period horizon (2006-2021) | **14%** | **2%** | **24%** |
| IRR for whole life of assets (2006-2105) | **18%** | **10%** | **27%** |
| **Average rail trip length of 800 miles** | | | |
| IRR for study period horizon (2006-2021) | **10%** | **(2%)** | **19%** |
| IRR for whole life of assets (2006-2105) | **15%** | **8%** | **22%** |

These figures show that Scenario #3 generates the highest return because all three scenarios generate similar benefits, but Scenario #3 has lower cost, therefore, it would appear to be the Preferred Scenario. The IRR of Scenario #3 is larger than the WACC of either the railroads or the ports, therefore undertaking the project would be a benefit to shareholders assuming that no other infrastructure investments would be required. Therefore assuming Coordinated Rail Operations are achievable, there is no justification for a new bridge or tunnel. As mentioned elsewhere in this report, this finding is subject to more detailed analyses of the structural integrity and risk of loss of the bridge due to fire, collision or seismic events, and the consequent failure of the bridge before the planning horizon, 2021.

More comments on the results are presented in section 7.3.1 “Comments on results”.

### *7.2.4 Sensitivity Analysis*

As a sensitivity on the IRR results, the forecasted demand was increased based on IBI scenario titled “MCTS Amtrak-Base Case Scenario C”. This scenario is based on:

- Historic Port Traffic Data for 2006;
- Adding MCTS track capacity improvements;
- Adding Amtrak projected passenger trains;
- Including the Gateway development plan scenario; and
- 70% of Roberts Bank Traffic to/from Kamloops.

The result is an increased freight train demand and therefore an increased capacity constraint starting in 2008 and carrying on through to 2021. After 2021 it is assumed that the capacity constraint remains constant. The revised weekly train volumes are shown in Exhibit 7.11 and drive the benefits calculation.

**Exhibit 7.11 Capacity Shortfall for Status Quo Operations and High Growth**

| | Year | | | |
|---|---|---|---|---|
| | **2006** | **2011** | **2016** | **2021** |
| Freight train demand under Scenarios #1, #2, #3 (*) | 467 | 538 | 603 | 657 |
| Freight train capacity of Status Quo Operations | 423 | 423 | 423 | 423 |
| ***Capacity constraints for Status Quo Operations*** | ***44*** | ***115*** | ***180*** | ***234*** |

* This is the IBI scenario titled “MCTS Amtrak-Base Case Scenario C”.

This sensitivity analysis results in higher benefits compared to the original analysis as the demand for weekly trains is higher and therefore the capacity shortfall compared to Status Quo Operations is greater. However the estimated costs would be the same as previously presented since the projects identified under the original scenario would generate enough capacity to handle this level of traffic.

The results based on these higher weekly train volumes are summarized in Exhibit 7.12.

**Exhibit 7.12 Internal Rates of Return for the Three Major Scenarios with Increased Train Volumes**

| **Note: IRRs are in real terms** | **Scenario #1: Status Quo Operations with a New Bridge** | **Scenario #2: Status Quo Operations with a New Tunnel** | **Scenario #3: Coordinated Rail Operations** |
|---|---|---|---|
| **Average rail trip length of 1,200 miles** | | | |
| IRR for study period horizon (2006-2021) | **121%** | **31%** | **486%** |
| IRR for whole life of assets (2006-2105) | **121%** | **32%** | **486%** |
| | | | |
| **Average rail trip length of 800 miles** | | | |
| IRR for study period horizon (2006-2021) | **69%** | **21%** | **183%** |
| IRR for whole life of assets (2006-2105) | **69%** | **23%** | **183%** |

As expected, due to the higher capacity shortfall the IRRs are all higher. The relative ranking of the projects remains unchanged. The same conclusion as with the original IRR results can be made, namely that based on the assumptions Scenario #3 should become the Preferred Scenario and there is currently no financial justification for a new bridge or tunnel.

No scenarios were modeled with lower freight train volume projections as the Base projections are expected to be at the low end of future rail traffic movements..

### *7.2.5 Results for the Secondary projects*

'Secondary projects' are identified in Exhibit 7.1 with the symbol (†) and the IRR for each of them are presented in Exhibit 7.13 below. The results indicate that the Pemberton Avenue and 41B Street overpasses both produce a real IRR above the Social Time Preference Rate over the study period. Over the 100 year time frame these two projects are the only ones with a high enough IRR to justify construction, based solely on travel time benefits. All of the other projects have IRRs that are too low to justify investment based on the benefits attributed to eliminating auto and truck delays. Perhaps if other benefits, such as avoided accidents, train staging and environmental, were quantified and proved material, these projects may prove to be justified.

**Exhibit 7.13 Internal rates of return for selected MCTS projects**

| Project | Project Name | IRR (real) | |
|---|---|---|---|
| | | 2006 to 2021 | 2006 to 2105 |
| H | Westwood St. – overpass | (18%) | 0% |
| I | Harris Rd. – overpass | (14%) | 2% |
| J | King Edward Ave. – overpass | (25%) | (1%) |
| O Part A | Powell St. – overpass | (20%) | 0% |
| K | Pemberton Ave. Overpass | 5% | 10% |
| N | Front St. Overpass | (29%) | (2%) |
| Q | Chilliwack Yale Overpass | (13%) | 2% |
| C | 41B St. Overpass | 6% | 11% |

### *7.2.6 Economic Impacts*

Aside from the internal rate of return, which is focused on the benefits accruing to specific stakeholders, there are larger scale economic impacts. The Port of Vancouver currently measures these impacts in categories such as person years of employment, employment income, GDP and economic output. Economic output adds all revenues at each stage of production together as a measure of total production in the economy. Based on economic impact studies on the Port of Vancouver undertaken by Intervistas Consulting Inc in August 2001 and in March 2003, the value of direct economic output associated with the capacity constraint up until 2021 has been estimated (see Exhibit 7.14 below). Several broad assumptions were necessary to translate the capacity constraint into direct economic output and the figures in the exhibit should be taken as order of magnitude estimates of the direct economic value of addressing the capacity constraint.

**Exhibit 7.14 Economic Impacts**

| | Year | | | |
|---|---|---|---|---|
| | 2006 | 2011 | 2016 | 2021 |
| Weekly Capacity Constraint (number of trains) | 0 | 14 | 52 | 90 |
| Annual Capacity Constraint (number of trains) | 0 | 728 | 2,704 | 4,680 |
| Load factor (% of railcars generating revenue) | 57% | 57% | 57% | 57% |
| Value of one railcar ($ direct economic output in 2004 dollars)[7] | 2,750 | 2,750 | 2,750 | 2,750 |
| Number of railcars per train | 100 | 100 | 100 | 100 |
| **Direct economic output value of capacity constraint ($ million)** | **0** | **114** | **424** | **734** |

The direct economic output in the exhibit above is for Canada as a whole, but the majority of economic output is in BC. This exhibit shows that by 2021, the Canadian economy would lose over $700 million annually in direct economic output if the capacity constraints on the network under Status Quo Operations

[7] Calculated based on data in report titled "2001 Port Vancouver Economic Impact Study" by InterVISTAS Consulting Inc.

are not resolved. The positive economic impacts on the Canadian economy of resolving the capacity constraints can help justify investment by governments in improvements to the national rail and ports systems, including the projects listed above. The case for public investment is described in the next section.

## 7.3 RECOMMENDED STRATEGIES

### *7.3.1 Comments on Results*

In Exhibit 7.10, Scenario #3 has the largest IRR of the three scenarios. If it is assumed that the hurdle rate for corporations such as Canadian railway companies is equal to their WACC, then the hurdle rate would be around 8% in real terms. As a result, all of the scenarios that yield a real IRR above 8% based on forecasted costs and benefits would be beneficial to shareholders. This assumes the risk associated with the project is on par or lower than the risk undertaken by railway companies in the normal course of business. Assuming Scenario #3 meets this caveat and its IRR is above 8%, it should be the Preferred Scenario and would not require any public sector support, subject to the comments below. Furthermore the results imply that a new bridge or tunnel is not required, because Scenario #3 relieves the capacity constraint at the lowest cost.

The rates of return for all scenarios assume that the benefits accruing to the railroads and ports can materialize without additional investment to the ones identified in this report and that the Lower Mainland rail network has capacity to handle forecasted traffic over the study period. If investments outside of the Lower Mainland are required to meet the forecasted benefits and their costs brought the IRR down below the railway companies' return requirement ("WACC"), then there may be justification for public sector support. If demand for rail services in the Lower Mainland continues to grow after 2021 and exceeds the capacity of the Lower Mainland rail network, then additional investments would be required and an analysis of the expected cost and benefits would be appropriate at that time.

There are many categories of benefits that were not quantified. If some of these were material and were included in the analysis, the IRR of all of the scenarios would increase. However, most of these unquantified benefits would not accrue to the railroads or ports and would only serve to increase the Economic IRR, not the Financial IRR. This may not change the investment decision from the perspective of the railroads or ports. If these unquantified benefits prove to be substantial, it may be reasonable to ask other beneficiaries (e.g. government) to contribute to the cost of the project in proportion to their benefits as has been done in other rail projects. Section 7.3.2 discusses North American rail infrastructure projects that have aspects that could prove useful for the delivery of the rail network improvements in the Lower Mainland.

The IRRs in section 7.2.3 do not indicate the ease of implementing each of the scenarios. Scenario #3 requires the four railroads operating in the Lower Mainland to work together. While the railroads are continually working with one another in various projects, the level of co-operation required for Coordinated Rail Operations is high and requires to some degree a loss of autonomy and reduction of traditional competitive behaviour. It only takes one of the operating railroads to effectively block Coordinated Rail Operations. However, co-production agreements announced in October 2004 by the railroads are an encouraging step towards achieving Scenario #3.

Given the possibility that, notwithstanding the highest relative return, scenario #3 might not materialize, Scenarios #1 and #2 must be considered. Based on the IRRs, the benefits accruing to the railroads and the ports would appear to justify an investment without any public sector funding, subject to the caveats presented in this section. Scenario #1 appears more attractive than Scenario #2 as Scenario #1 has the same benefits as Scenario #2, but at a lower cost. This is reflected in Scenario #1's higher IRR. If, because of additional investments by the ports and railroads to increase capacity, the IRRs drop below the WACC or if broader stakeholder benefits can be quantified, then the case for other parties to contribute capital to the project must be examined.

The benefits used to calculate the IRRs associated with the Secondary projects are time savings for auto and truck users. As these benefits are considered to be generated to the society rather than to specific stakeholders such as railway companies, then perhaps a lower IRR could be used to justify moving forward with these projects. An IRR level that could be used as a threshold to justify these projects is the Social Time Preference Rate which is around 3.5% in real terms. The stakeholders investing in these projects, presumably government, should decide however what rate they want to use as a threshold to decide to move forward with these projects. In any event, based solely on time savings for truck and auto drivers very few of the overpass projects are justified. Perhaps if other benefits, such as avoided accidents, train staging and environmental, were quantified, the conclusions would be different.

### *7.3.2 North American Rail Projects*

Based on a search for other rail infrastructure projects that have aspects that could prove useful for the delivery of rail network improvements in the Lower Mainland, five projects were identified:

- Alameda Corridor;
- St. Clair Tunnel;
- Shellpot Bridge;
- Sheffield Junction Flyover; and
- Chicago Region Environmental and Transportation Efficiency Project

Summary information of all five projects is presented below and more details are presented in Appendix C.

The **Alameda Corridor** in California was a capital project of US$2.4 billion that improved significantly rail transport efficiency. It demonstrates how an authority structure can be employed for the benefit of multiple railroads, ports and government. The project was funded by a combination of public sector grants and publicly issued bonds. Bond repayments are paid from fees the railroads pay based on traffic. The project also demonstrates how infrastructure maintenance can be incorporated into the authority model.

The **St. Clair Tunnel** between Sarnia and Port Huron was funded by a railway company without the assistance of the public sector. The benefits to the railroad from this project were substantial and presumably warranted the investment.

The **Shellpot Bridge** in Delaware is an old bridge, that in the mid 1990’s stopped carrying freight trains due to an inability to support the heavy loads. Modest capital upgrades were paid for by the State of Delaware to alleviate this problem. Freight trains are now using the bridge again with a 20 year variable toll structure. As a result freight service to and from the Port of Wilmington has been improved.

The **Sheffield Junction Flyover** in Kansas City eliminated delays at the third busiest rail intersection in the US as well as increased travel speeds. This was a public private partnership involving the Missouri Highways and Transportation Corporation and the 6 railroads operating in the region. The project was financed via bonds and will be repaid over 20 years from fees collected by the flyover users.

The **Chicago Region Environmental and Transportation Efficiency (CREATE) Project** is a public private partnership between six major railroads, and multiple levels of government. Under the CREATE plan, railroads will be making additional investment decisions based on what is best for the overall rail network. The railroads pay for the benefits they receive under the project and the public sector pays for the public benefits generated by the plan.

These projects show there are multiple approaches that can be taken to successfully deliver rail capital projects. Most of these involve the public and private sectors working together, with the railroads always paying for some portion of the improvements, in proportion to the benefits accruing to them.

### 7.3.3 Delivery Models

This section provides a high level description of the range of options available to deliver Scenarios #1 and #2, in particular the delivery of a new bridge or a new tunnel. The same options could be used in Scenario #3, but based on current results, Scenario #3 should be able to be undertaken exclusively by the private sector. A more detailed analysis of delivery models should be undertaken in the future if Scenario #1 or #2 becomes the Preferred Scenario. Additional information required for such an analysis would include the ownership, risk transfer, financing strategy and the exact nature of the project. The stakeholder preferences could then be compared to each of the delivery options and determine which of them is most appropriate.

Scenarios #1 and #2 require a large upfront capital expenditure to replace the existing NWRB, which is owned by the Federal Government. There are a number of ways in which a new asset (either a rail bridge or tunnel) could be delivered by the Federal Government involving to varying degrees, the railway companies, other private sector participants and potentially private finance. Funding issues aside, the simplest way to construct the bridge would be for the Federal Government to implement a design-bid-build tender process for the construction of the new asset. However additional advantages may accrue to the Federal Government by involving the private sector in the project.

At one end of the spectrum is the complete provision of a new bridge or tunnel by the public sector under what is termed traditional procurement. The other end of the spectrum is characterized by a complete lack of public sector involvement, where the Federal Government would not own the bridge. In between there are several options which involve the public and private sectors working together in different roles – these are appropriately referred to as public-private partnerships (PPPs). The Canadian council of Public Private Partnerships defines a PPP as:

*A cooperative venture where there is an allocation of the risks inherent in the provision of public service between the public and private sectors. A successful PPP builds on the expertise of each partner to meet clearly defined public needs and provide a net benefit (or value for money) to the general public through appropriate allocation of resources, risks and rewards.*

Some of the benefits that might accrue to the Federal Government and transportation infrastructure users through successful PPPs include:

**Additional sources of financing**;

Most transportation infrastructure projects are very capital intensive. Where governments are unwilling or unable to increase public debt to meet investment needs, the private sector can supply capital through PPP arrangements without impacting public sector balance sheets, if structured on a full risk transfer basis (i.e. non-recourse financing).

**Improved speed and efficiency of procurement;**

PPPs can speed up the procurement (design, construction and commissioning) of transportation infrastructure as compared to the traditional model of separate design and construction phasing. PPP procurement models provide the private sector with greater latitude to solve problems creatively through integration of design, construction and operations principles.

The traditional approach, with separate design and construction phases, puts up barriers to creativity that reduce opportunities for efficiency, regardless of the talents of those involved.

**Improved operational efficiency;**

The efficiencies achieved by the private sector through organizational best practices and exploiting economies of scale can be greater than that achieved by the public sector. This is not to suggest that the public sector is not capable of developing efficiencies; however the non-competitive environment does not appear to stimulate efficiencies to the same extent as the private sector.

**Value capture;**

The private sector can sometimes capture value that the public sector either cannot realize on or simply cannot visualize. A common value capture element in transportation projects is real estate.

**Transfer of risk from the public sector;**

There are risks to operating any business, and transportation infrastructure is no exception. The purpose of transferring risk is to allocate each type of risk to the party that is best equipped to mitigate it, or in other words, the party best qualified to undertake the activity. This approach minimizes the overall risk and cost of transportation infrastructure, benefiting all parties, including transportation users.

**Quantified cost savings;**

These savings are achieved by a combination of improved operating efficiency, speed and efficiency of procurement, value capture, innovation in design and construction, as well as by replacing infrastructure with longer life assets.

PPPs vary in terms of the type and degree of risk allocated between the partners. The diagram below identifies the primary PPP models and level of risk transfer from the public sector to the private sector.

**Exhibit 7.15 Spectrum of Delivery Models**

| **Public Sector** | ◄ | ***Risk Transfer*** | | ► | **Private Sector** |
|---|---|---|---|---|---|
| Traditional Procurement | Design Build | Authority Model | Design Build Operate (Turnkey Ops or BTO) | Design Build Finance Operate (BOT or BOOT) | Design Build Own Operate |

Appendix B discusses the potential PPP models that could be used for the replacement of the NWRB.

### *7.3.4 Tolling*

Regardless if the private sector or the public sector finances a new bridge or tunnel, they are likely to look to those who benefit from the bridge to pay for some or all of the costs.

While the railroads will be the largest beneficiary of a new bridge or tunnel they will not be the only ones; others include marine users, the ports and government (i.e. taxpayers). Payments can take several different forms, including tolls based on volume, availability payments, shadow tolls and hybrid versions.

In the case of a Design Build Finance Operate (DBFO) structure to complete a new bridge, the private sector partner is selected via a competitive process and given a long term concession to build and operate the bridge for a specified time period (e.g. 30 years). The concession term is influenced by several factors including the amount of capital outlay, life of assets, debt terms available in the capital markets and public sector concerns. Based on information available, 30 years is not unreasonable.

The private partner then completes the design and construction of the asset, providing finance for some or all of the costs of delivering the asset and will operate and maintain it and earn revenue from users and/or beneficiaries to cover the capital, operating and maintenance expenditures, taxes, and financing costs over the life of the concession.

The revenue, as already referenced, can either come in the form of availability payments, be based on the usage of the asset or be a hybrid version including multiple forms of payments.

An availability payment would be based on the availability of the bridge or the tunnel. If the asset is available and can be used by the railway users, then the private partner will receive payment. However, if the asset is unsafe or unusable, then payments will stop until the asset is fixed. The private partner gets paid based for availability rather than usage of the asset.

Under a volume based payment approach, the private partner would receive payments based on the usage of the asset. The higher the traffic, the higher the payments to the private partner. Volume based payments could be real tolls or shadow tolls. Real tolls would be direct tolls paid by the users crossing the bridge or tunnel. Shadow tolls are tolls paid by a third party that is not directly using the asset such as the government. Overall, volume-based payments are generally riskier than availability payments because the private partner would not be paid if the asset is unavailable (because no traffic can pass through when the asset is closed) and it is exposed to the willingness of the users to pass through the bridge or tunnel.

Indicative tolls for a new bridge were calculated based on the following assumptions:

- Capital cost (bridge) $110,000,000
- Annual operating cost $650,000
- Annual Maintenance cost $750,000
- 20 year Rehabilitation cost (annualized) $100,000
- Time to construct new bridge or tunnel (years): 3
- Length of operating concession (years): 30
- Weighted average cost of capital (pre tax, real) 8.00%
- Train Volumes by year

| Year | 2006 | 2011 | 2016 | 2021 | 2026 | 2031 |
|---|---|---|---|---|---|---|
| Weekly Freight Train Volume | 215 | 249 | 282 | 314 | 351 | 391 |

The construction, operating and maintenance and rehabilitation costs of a new bridge (or tunnel) used in the analysis are the same as those outlined in Exhibit 7.2. They do not include any other rail network improvements or other costs associated with Scenarios #1 or #2. The WACC is consistent with historical railroad WACC and those used by the Canadian Transportation Agency “For Regulatory Purposes Other Than Grain and Interswitching Rates”. The train volumes are based on the original case “2003 Existing Status Quo Case”. These assumptions produce the following results.

**Exhibit 7.16 Bridge and Tunnel Tolls (rounded to nearest dollar)**

| | |
|---|---|
| **NEW BRIDGE: toll required to repay capital and meet operating and maintenance requirements ($/railcar)** | **$8** |
| **NEW TUNNEL: toll required to repay capital and meet operating and maintenance requirements ($/railcar)** | **$30** |

Based on the same assumptions above and the operating, annual maintenance and rehabilitation costs in Exhibit 7.2, the additional toll required to meet the future costs associated with the existing NWRB is $1.62/car (Scenario #3, excluding all MCTS projects).

The work on tolls can be refined after additional information becomes available namely:

- More accurate costs, including breakdown of costs into different asset classes;
- Financing assumptions: debt to equity ratio, debt and equity terms etc. This will be heavily dependent on whether or not the private sector partner is accepting volume risk;
- Exact length of the concession;
- Risk allocation between the private and the public partner;
- Concession structure; and
- Funding allocation between parties.

### 7.3.5 Next Steps

Going forward the railroads need to decide which of the three scenarios, if any, they intend to pursue. Based on the scope of the analysis, the railroads generate sufficient benefits from Scenario #3 – Coordinated Rail Operations to pursue this scenario without the financial involvement of other stakeholders. If the railroads stakeholders decide to pursue Scenario #3, more detailed analysis will be required, in particular refining the definition of projects, the delivery models and determining funding and cost sharing arrangements. If the railroads reach a different conclusion with respect to Scenario #3 because of:

a) lower benefits, and/or
b) additional investments are required to achieve the benefit levels, and/or
c) benefits to other stakeholders are quantified

they should bring forward information so that additional analyses can be performed. With this information the case for external funding could be re-examined.

Scenario #2, Status Quo Operations with a New Tunnel, provides relatively few incremental benefits over Scenario #1, Status Quo Operations with a New Bridge, while carrying a significant cost premium and additional risks associated with tunnelling. Therefore a new bridge would be recommended over a tunnel if Scenario #3 would not materialize. Based on the assumptions and analysis, Scenario #1 should not require financial support from the public sector. Again if the railroads reach a different conclusion with respect to Scenario #1 because of:

a) lower benefits, and/or
b) additional investments are required to achieve the benefit levels, and/or
c) benefits to other stakeholders are quantified

they should bring forward information so that additional analyses can be performed. With this information the case for external funding could be re-examined.

If a new bridge and other network improvements become the Preferred Scenario more detailed analysis will be required. This would include refining the project definition, including costs. In addition more detailed analyses on different delivery options and work towards completing a business case for the preferred option would be required.

# 8.0 CONCLUSIONS AND RECOMMENDATIONS

The objective of this study is to complete an assessment of future rail infrastructure needs based on freight transportation demand while being responsive to emerging passenger, tourism and commuter needs. The Port and Railway services in Vancouver are both vital to successful international trading relationships.

The results indicate that if Coordinated Rail Operations among the railways can be achieved and if the detailed engineering analyses confirms that the bridge life can be extended through rehabilitation, then Scenario #3 is preferred and is the recommended strategy.

If Coordinated Rail Operations among the railways cannot be achieved, or if the existing function of the bridge cannot be maintained through the planning period (2021), then the preferred Scenario is replacement of the bridge with a lift bridge i.e. Scenario #1.

Scenario #2 (construction of a railway tunnel) is not recommended.

Regardless of the major strategy selected, there are immediate bottlenecks in the system that would need to be dealt with. Such actions are referred to as the Common Elements.

Analysis of the Secondary Projects, primarily grade separations, indicate that none of the projects identified to date, except the Pemberton Avenue overpass and the 41-B Street overpass, produce a positive return based on travel time savings to road users over the study period. Therefore based solely on time savings for truck and auto drivers there appear to be insufficient benefits to justify proceeding with these projects except for the two projects mentioned above. Perhaps if other benefits, such as avoided accidents and environmental, were quantified and proved material, the conclusions would be different.

The benefits used to calculate the IRRs associated with the Secondary projects are time savings for auto and truck users. As these benefits are considered to be generated to the society rather than to specific stakeholders such as railway companies, then perhaps a lower IRR could be used to justify moving forward with these projects. An IRR level that could be used as a threshold to justify these projects is the Social Time Preference Rate which is around 3.5% in real terms. The stakeholders investing in these projects, presumably government, should decide however what rate they want to use as a threshold to decide to move forward with these projects.

## 8.1 CONCLUSIONS

### *8.1.1 Common Elements*

The important elements needed to sustain the entire system, regardless of which scenario actually materializes are the following:

1. Grade Separation at 41B St. in Delta to provide rail and road user benefits by permitting greater efficiency in the building of long container trains at Roberts Bank; the estimated cost over 20 years is $ 5,300,000 (constant $ 2004). Although this project is considered immediate priority, an alternative of closing 41B St. should also be examined, because of the constraint that the constructed overpass may impose on further construction of parallel tracks in this most important corridor.
2. New Siding between Roberts Bank and Hydro – most likely as recommended by MCTS in Mud Bay – to add needed capacity to the system; the estimated cost over 20 years is $7,620,000 (constant $ 2004); this project is an immediate priority.
3. New Siding between Blaine and the NWRB -- most likely as recommended by MCTS in Mud Bay – essential for adding to AMTRAK frequency and to meet freight growth ; the estimated cost over

20 years is $7,000,000 (constant $ 2004); there is immediate need for one siding, and there is a forecast need for further expansion around 2016 to meet freight growth projections, for additional cost around $8,600,000 (constant $2004).

4. Add double track and/or sidings between Roberts Bank and Mission Bridge (8 to 12 Km) – not included in MCTS portfolio -- a consequence of expanding Deltaport according to latest growth projections; total cost around $22,400,000 (constant $ 2004); future need 2011 – 2016, depending on actual growth rate and timing of Deltaport expansion.
5. Add a second main track to CN Yale between Matsqui Jct. and Hydro – not included in MCTS portfolio – this link can become a bottleneck depending on how Roberts Bank grows and on the extent to which cooperation among the three Class 1 railways is achieved – even with optimal cooperation this would become a bottleneck towards the end of the study period; the estimated cost is $15,800,000 because the terrain is very difficult; the timing would be 2016 – 2021.
6. Several important grade separation projects are considered (e.g. Westwood, Harris Road, King Edward Avenue), but the direct road user benefits alone are not sufficient to justify the grade separations. Rather, further potential benefits, such as benefits to local rail operations, safety and accident benefits, environmental benefits, aspects which are beyond this study, need to be considered by the transportation authorities in evaluating these grade separations.

Three other types of project can be considered as Common Needs. The MCTS recommendations included three projects in this area, as follows:

7. Install double track between the BNSF yard in New Westminster and Spruce St. -- this is about half a mile (.8 km) in a difficult area; the project cost is estimated to be $3,200,000 (constant $ 2004); railways indicate the need for this is immediate.
8. Install a new siding near Willingdon (BNSF/CN Junction); the project cost is estimated to be $6,800,000 (constant $ 2004); this also is considered an immediate need by the railways;
9. Powell Street double track and road/rail grade separation; the estimated cost of this is $11,200,000 for a grade separation and $2,900,000 for installation of double track; this also was identified as an immediate need.

Status Quo operations identifies these as urgently needed projects. The capacity that would be added by these projects does not appear to be required as quickly with Coordinated Rail Operations, because much of the traffic would be arriving at the waterfront over the CPR route. However, it is reported there are problems today on account of yard activities in these areas, and the analysis carried out in this study is not sensitive to yard switching factors. While these projects are expected to be needed some time over the next 10 – 15 years, detailed analysis is required for definitive conclusions on the timing for these projects.

### *8.1.2 NWRB Replacement*

One of the central questions motivating the sponsors to engage in this research is whether or not the existing NWRB can accommodate future demand. Previous trends signalled warnings that the NWRB was rapidly running out of capacity to handle trains; this trend is confirmed through the present analysis of "Status Quo Operations" scenarios.

However, CN and CPR have initiated some ”Coordinated Rail Operations” in the Vancouver terminal area since the “Status Quo Operations” data were generated by them. Those changes have resulted in improved operating efficiencies, and have relieved the bottleneck for the present.

There is an engineering and safety perspective which is extremely important also. The existing NWRB is of century vintage. There would need to be a full primary survey and inspection of the bridge, beyond the scope of this study, to determine how long its useful life can be extended and how much money that would take. The analyses reported in this study consider need for rehabilitation of approximately $20 million near 2020, and the financial projections were based on a similar amount being required every 20 years. More detailed assessment of this would require a detailed engineering survey and inspection to compare the cost of maintaining the bridge with building a new bridge and to identify the most appropriate circumstances that would trigger replacement.

Estimates of the expected life of the bridge and risks to safety and continuity are carried out here only to the extent that existing documentation would support. Many studies have been carried out over the years, but a conclusive bridge survey is not available. The bridge survey is required prior to determining the need to replace the NWRB.

If cooperative operations cannot be extended, then straightforward projection of the historical operations indicates the need to replace the NWRB within 7 years.

The main issues that need to be resolved for the future is to determine: whether the NWRB has a physical and economic life that extends up to 2021 for safe operations; and second, whether Coordinated Rail Operations can be implemented throughout the entire Lower Mainland rail network while also including all four existing freight railways.

Status Quo operations will likely advance the need to replace the NWRB. Recent cooperative initiatives by CN and CPR bought time for what was emerging as a crisis need.

The ultimate potential of Coordinated Rail Operations as evaluated in this study suggests that the NWRB would not be the main bottleneck in the network, and would provide adequate capacity beyond the study time horizon of 2021.

### *8.1.3 Waterfront (Including False Creek Flats)*

One of the busiest areas for freight in the Port of Vancouver is Burrard Inlet. The waterfront is also an important area for passenger cruise ships, public transportation and pleasure craft. The waterfront also includes the rail facilities in False Creek Flats.

The rail lines serving the Port in this area are regarded by some as an obstacle to other social and economic pursuits. Backup land for marine port facilities and for efficient rail operations is a serious constraint in this area. These facilities are located in waterfront areas that carry a high appeal for other social and economic purposes (e.g. tourism, commercial development and housing).

The land is owned by various interests, including the railways as separate entities. There are serious constraints in the area, and potential for conflicting purposes and pursuits. The City of Vancouver has expressed its desire to examine the City's need to continue to serve the downtown, the Port, and the False Creek Flats by rail and how to respond to the emerging development pressures occurring in the area.

False Creek Flats also serves VIA Rail Canada, Rocky Mountaineer Railtours (RMR) and AMTRAK trains. The current level of 26 passenger trains per week could remain the same or increase to as much as 70 trains per week. The highest level of activity will require the existing passenger rail yard facilities to expand.

With respect to freight activity, False Creek Flats is used for staging and back up storage to support the port operation. The ultimate requirement for tracks and track configuration in this area depends upon cooperative efforts that remain uncertain at this time.

Future planning of the False Creek Flats area by the City of Vancouver must take into account the growing needs for freight and passenger rail traffic and terminal requirements. No land should be released for other uses until the needs for freight and passenger rail traffic and terminal requirements are determined.

### *8.1.4 Roberts Bank*

Roberts Bank also has a number of issues, but they are different from those in downtown Vancouver. The rail corridor runs from Mission through Langley and Boundary Bay and onto the Causeway. There is a steady volume of coal trains for export, and container traffic in both directions. Container trains operate at lengths over 3.5 kilometres regularly.

A significant portion of the line is owned by the province of British Columbia (as the BC Rail Port Subdivision, which has been retained by the Province following the sale of BC Rail to CN). The Port Subdivision controls the entire line, including sections owned by CPR and CN, but does not operate any of its own trains. All four operating railways (BNSF, CN, CPR, and SRYBC) use at least portions of the line.

This line cuts through a populated and growing area. There are numerous level crossings at present, and interference between rail and road traffic is an important consideration in planning the future infrastructure requirements in this area.

Projects identified as being common to all scenarios feature prominently on this route. The 41b Street grade separation, Mud Bay sidings and future double track are all needed eventually regardless of who operates the trains going into the Causeway.

Long trains and high growth pose a real challenge for rail, port terminals and communities hosting the rail line. Proximity issues and future urban development affecting level crossing traffic volumes are all planning issues that will require close cooperation between Railway planners and surrounding municipalities.

## 8.2 RECOMMENDATIONS

Within the Lower Mainland railway environment, the issues are complex and the stakes are large. There are many directions that might be taken once the initial steps are successfully completed towards meeting future freight demand expectations.

The outstanding questions concerning the need to replace the NWRB are technical and institutional. If a detailed survey and inspection of the bridge establish that the bridge cannot be expected to continue beyond 2021, then that becomes the determining issue concerning replacement of the bridge. None of the work done to date is sufficiently detailed or current to respond to this question.

Therefore **Recommendation #1 is: Carry out an engineering condition assessment and risk assessment of the NWRB, to establish the remaining life expectancy, maintenance requirements and structural vulnerability, to verify it can sustain traffic for the planning period (2021) and to quantify the disruption period that would be caused by a seismic event, ship collision or bridge failure.**

The result of such a review would either confirm or cause modification to the financial and economic estimates upon which the conclusions of this study are based. The Pitt River and Mission Bridges are also crucial to future capacity of the network. Although there are no immediate issues apparent, a similar assessment should also be considered for these bridges.

**Recommendation #2 is: Commence discussions with all appropriate parties to negotiate sponsorship arrangements for implementing MCTS projects identified as Common Elements and, if required, replacement of the NWRB.**

The economic analysis of system enhancements identified the railways as the major beneficiaries. If it were as simple as that, then the respective railways would proceed with the projects over their own lines, to incur the costs and reap the benefits. This analysis, however, is incomplete without further information or detailed participation from the railways. In this analysis, benefits associated with the increased traffic are calculated over the entire inland rail movement, while the only costs included in this analysis are within the Lower Mainland Rail network. The railways argue that margins on the traffic are insufficient to provide for all of the capacity needs from origin to destination. This needs to be brought forward in more specific detail to assess the nature of the benefits and costs accordingly and to identify who should be the main participants in undertaking the risks of proceeding.

There is scope for an innovative approach to establish financial incentives for the "Common Elements" projects, i.e. the distribution of costs and benefits between the railways - if all are going to use portions of the network. There is potential for an active role by some neutral third party, or governments, to facilitate a network investment plan such that each railway would not necessarily have to be fully responsible for all of the investments on their own track. There are models to consider for this approach, such as the CREATE project in Chicago , and the Alameda Corridor in California.

The same requirement applies in part to the issue of NWRB replacement. The railways would be the main beneficiaries from a capacity point of view. However from a technical and safety perspective, the Government of Canada as the owner of the existing facility is a direct participant as well. The need for the technical information is covered above in Recommendation # 1. Participation in risks and rewards over service enhancements made possible by a new facility should become part of the larger negotiations on sponsorship arrangements.

**Recommendation #3 is: Determine the rail network and operational requirements in the Waterfront and False Creek Flats areas and do not release land for other uses until such needs are determined.**

This recommendation deals more with process than a specific outcome. The City of Vancouver is taking the initiative and is attaching urgency to determining the future usage of False Creek Flats. As a major stakeholder, this urgency is significant for all the other stakeholders. It would be a common interest of all concerned to identify both crucially important and potentially surplus railway lands so that all stakeholders could proceed with long-term plans and continue to work cooperatively with other parties.

The Waterfront area will be accommodating significant growth by 2021 and congestion delays will pose a critical limiting constraint unless there is a significant change in the fundamental way in which the terminals in this area are serviced. In the False Creek Flats area, there will be additional need for support services for freight activities on the waterfront. At the same time there will be significant passenger growth, potentially to a level and scope that will require expansion of the existing yard. While it is possible that not all of the lands in the False Creek Flats will be needed for rail support, it is important nevertheless to carry out the detailed planning for rail service requirements before releasing significant parcels of land to alternative use.

One of the biggest challenges will be to find the appropriate incentives for parties with diverse and sometimes competing interests to strive for maximization of growth potential in this valuable and congested area.

**Recommendation # 4 is: Pursue a strategy of Coordinated Rail Operations.**

Coordinated Rail operations has proven itself to be successful in several locations in the Lower Mainland. However, the challenge in the downtown waterfront is much more complicated because of the long history and established footprints of many varied stakeholders. The systems analysis carried out in this study, and the economic analysis that follows from it clearly indicate that the economic benefits of achieving efficient cooperation throughout the network are substantial compared to the scenario that continues to project the Status Quo operating arrangements.

It will be important for these discussions with railways to focus on getting a sense of the scope and dimension of Coordinated Rail Operations, in what timeframe, and to what degree of implementation.

Less than full Coordinated Rail Operations will require some projects to be implemented sooner. These issues and timing need to be determined with the railways.

**Recommendation #5 is: Work with railways to help resolve mainline capacity issues.**

This course of action would not only assist in understanding a fuller picture of the costs and benefits of the Lower Mainland Rail system improvements, as reflected in Recommendation number 2, but it is also crucial to ensuring that whatever improvements are made in the local network can be carried through to the end customer, otherwise it would be all for naught. A secondary benefit is in providing an opportunity for both railways and other stakeholders in the Lower Mainland to build mutual trust and understanding.

Finally, these recommendations speak to launching processes that bring parties together seeking a common set of goals related to economic trade development. The analyses carried out in this study point to a vision with potential benefits. As discussions evolve, so also the vision and goals might evolve commensurately. If directions are changing, then it would be appropriate to make a deliberate decision to proceed on with the change of course, or else to correct and get back on course. The process of establishing timeframes, expectations and milestones or checkpoints should be included on the agenda of progressing with any of the recommendations above.

# APPENDIX A1

# Design Criteria

# APPENDIX A-1
# Design Criteria

# Gateway Rail Infrastructure Study

Railway Bridge
Railway Tunnel
Railway Overhead (Grade Separation)

August 2, 2004

Hatch Mott MacDonald

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# 1. DESIGN CRITERIA - RAIL BRIDGE AND TUNNEL

| | |
|---|---|
| (a) Design Codes & Standards | American Railway Engineering and Maintenance of Way Association (AREMA)<br>• Manual for Railway Engineering<br>• Portfolio of Track work Plans<br>Canadian National Railway, Maintenance of Way Standard Practice Circulars<br>Burlington Northern Santa Fe Railway, Standard Plans – Trackworks<br>Burlington Northern Sante Fe Railway, Engineering Instructions Field Manual<br>Transport Canada General Order E-05: Standard Respecting Railway Clearance |
| (b) Railway Companies | • Amtrak<br>• BC Rail (BCR)<br>• Burlington Northern Sante Fe Railway (BNSF)<br>• Canadian National Railway (CNR)<br>• Canadian Pacific Railway (CPR)<br>• Southern Railway of British Columbia (SRYBC)<br>• VIA Rail (VIA)<br>• Rocky Mountaineer |
| (c) Live Load | Cooper E80 |
| (d) Maximum Grade | 1% |
| (e) Design Speed | 20 mph |
| (f) Minimum Tangent Length between Curves | 100 ft (30.5 m) for both horizontal and vertical curves |
| (g) Maximum and Minimum Superelevation, e | Maximum e = 5" (125mm) Minimum e = ¾" (19mm), if any superelevation at all. |
| (h) Radius on Horizontal Curves, R | $R = 4.01V^2 / e$ (V is speed in mph, R is radius in feet) |

| | |
|---|---|
| (i) Degree of Curvature, $D_c$ | $D_c$ = 5729.651/R (R is radius in feet) |
| (j) Maximum $D_c$ | 10 degrees |
| (k) Minimum Spiral Length, $l_s$ for Passenger Trains | Greater of: $1.63e_u$*V or $62e_u$ |
| (l) Minimum Spiral Length, $l_s$ for Freight Trains | Greater of: $1.2e_u$*V or $62e_u$ |
| (m) Maximum Underbalanced Superelvation, $e_u$ | 2" (75mm) for freight trains, 3" (75mm) for passenger trains |
| (n) Compensation for Grade on Curve, $G_c$ | $G_c$ = G + 0.04 $D_c$ ($D_c$ is degree of Curve) |
| (o) Vertical Clearance Requirement | 23ft (7 m) above top of rail |
| (p) Horizontal Clearance Requirement | 8.5 ft (2.6 m) each side of track centerline |
| (q) Additional Clearance on Curves | 1" (25mm) per degree of curve |
| (r) Track Centres | 14 feet (increased 2" (50mm) per degree of curve) |
| (s) Turnouts (Switches) Available | No. 8 CNR 16 mph [Yards & industrial spurs]<br>No. 9 BNSF 10 mph [Yards & industrial spurs]<br>No. 10 BNSF 15 mph [Yards & industrial spurs]<br>No. 10 CNR 21 mph [Yards & industrial spurs]<br>No. 11 BNSF 15 mph [Yards & industrial spurs]<br>No. 12 CNR 28mph [Mainline]<br>No. 14 BNSF 30 mph [Mainline]<br>No. 15 BNSF 30 mph [Mainline] |
| (t) Existing Navigational Clearances | Vertical: 6.7m to H.H.W. - bridge closed<br>Unlimited -bridge open<br>Horizontal: 51.2m (North Swing Span)<br>48.8m (South Swing Span) |
| (u) New Navigation Span | Vertical: 11.7 m to HHW - bridge closed<br>43m to HHW - bridge open<br><br>Horizontal: 100m |
| (v) High and Low Water Elevations (Geodetic) | L.L.W. = -1.24m<br>H.H.W. = +2.10m<br>200 yr. Flood Level = +3.77m |

| | |
|---|---|
| (w) Seismic | Design in accordance with AREMA Vol 2 Ch. 9<br>Three levels of seismic design are required; Serviceability (1/80yr return period), Ultimate (1/458yr) and Survivability (1/2400yr)<br>Typical Zone 4 Acceleration: 0.24g for 1/475yr return period |
| (x) Number of Tracks | Bridge: single track design but the foundations would be designed to allow future expansion of the superstructure to a double track configuration<br><br>Tunnel: single track |

## 2.1 OVERHEAD (GRADE SEPARATION)

| | |
|---|---|
| (a) Design Codes and Standards | • CAN/CSA-S6-00<br>• MoT Bridge Standards and Procedures<br>• Ministry Standard Specifications for Highway Construction |
| (b) Live Load | CL-625 |
| (c) Lanes | Normal width shall accommodate two 3.6 m lanes but 4 lanes will be provides if existing road are 4 lanes. |
| (d) Shoulders | Shoulders shall be a minimum of 1.0m wide on the bridge. |
| (e) Wind | 100 year design wind pressure: 530 Pa |
| (f) Seismic | Classification of bridge: Other<br>Seismic zonal velocity ratio, V = 0.2<br>Seismic zonal acceleration ratio, A = 0.2 |
| (g) Illumination | Urban: required<br>Rural: Not required. |
| (h) Utilities | None |
| (i) Sidewalks | Urban Roads: 1.5 m sidewalks each side<br>Rural Roads: No sidewalk |
| (j) Signage and Pavement Markings | Refer to BC MoT Manual of Standard Traffic Signs & Pavement Markings |
| (k) Clearance to Power Lines | Refer to Utility Policy Manual for Power Line Type and Clearance. |
| (l) Clearance over Roads | 5.0 m |
| (m) Deck Overlay | Provision for 50 mm asphalt topping in the future. |
| (n) Epoxy Coated Reinforcing Steel | The top mat of deck reinforcing steel, both longitudinal and transverse, shall be epoxy-coated. Reinforcing steel on the interior face of the parapets shall also be epoxy-coated. |
| (m) Concrete Cover | The top mat reinforcement in the deck will have 70 mm minimum cover. |

## 2.2 APPROACH ROADS

| | | |
|---|---|---|
| (a) | Design Codes & Standards | TAC- Geometric Design Guide for Canadian Roads<br>BC MoT- Supplement to the TAC Geometric Design Guide |
| (b) | Legal Classification | Rural Local Undivided (RLU), Urban Arterial Undivided (UAU), Urban Collector Undivided (UCU) |
| (c) | Design Speed | 50 km/h |
| (d) | Traffic Volume | Varied - according to Gateway Study |
| (e) | Basic Lanes | Normally 2 lanes but 4 lanes to mach existing roads |
| (f) | Minimum Radius | 90 m (with a maximum superelevation of 0.06) |
| (g) | Min. K Factor – Sag | 12 (based on headlight control for sag curves) |
| (h) | Min. K Factor – Crest | 8 (based on taillight control for sag curves) |
| (i) | Maximum Grade | 9% |
| (j) | Minimum Grade | 0.5% |
| (k) | Max. Superelevation | 6%. Road crossfall shall be no more than 6% in accordance with TAC Standards. |
| (l) | Minimum SSD | 65 m on normal grade, 75m on a 9% grade. SSD shall be in accordance with MoT Standards. |
| (m) | Lane Width | 3.6 m |
| (n) | Shoulder Width | 2.5 m paved, 0.5 m gravel rounding on approaches. |
| (o) | Clear Zone Offset Width | 4.0 m minimum |
| (p) | Bike Lane | Use shoulder |
| (q) | Design Vehicle | WB20 |
| (r) | Signage and Pavement Markings | Refer to BC Ministry of Transportation Manual Of Standard Traffic Signs & Pavement Markings |

# APPENDIX A2

# Project Descriptions

| | |
|---|---|
| **Project:** | A - New Westminster Rail Bridge / Tunnel |
| **Municipality:** | New Westminster |
| **Railway Companies:** | CN, BNSF, CP, Southern, Amtrak, Via |
| **Basic Project Description:** | Three Alternatives:<br>Alt. 1: Retain Existing Bridge<br>- rehabilitation necessary within20 years – structural:Optional: timber trestle upgrade to steel or reinforced earth with ballast decks.mechanical: upgraded rail locking system and track: modify 13 degree curve on north end to increase speed capability.<br>Alt. 2: Replace Existing Bridge with new Bridge<br>- improved navigational width using vertical lift span.Increase marine clearance to 11.7 m while bridge is closed.<br>- single track, upgradeable to double track in future.<br>- larger radii to increase train speeds.<br>Alt. 3: Replace Existing Bridge with new Tunnel<br>- no delays because no openings for nautical traffic<br>- bored tunnel in New West and Surrey, immersed tube in Fraser River.<br>- single track, not combined with road tunnel |
| **Length:** | Alt. 2: Bridge Only: 850 m<br>Total New Track: 4490 m<br>Alt. 3: Tunnel Only: 7500 m<br>Total New Track: 9650 m |
| **Current Use:** | 46 trains per day |
| **Design Life:** | Alt. 1: 20 years     Alt. 2&3: 100 years |
| **Issues / Conflicts:** | Alt. 1: Optional modifications would not reduce openings but reduce delays to river traffic.<br><br>Alt. 2: - Land acquisition required – especially on South side.<br>- Maximum grade: only 1%.<br>- Minimizing disruptions during construction of tie-ins is difficult.<br>- Low clearance of overheads – Patullo Bridge & Skytrain Millennium Line |

| | |
|---|---|
| | Alt. 3: - Land acquisition required – esp. on South side<br>- Maximum grade: only 1%.<br><br>Alt. 3 (cont.):<br>- Soft soils & high water table on South side – cut and cover tunnel method difficult..<br>- Minimizing disruptions during construction of tie-ins is difficult.<br>- Maintenance and operating costs high for ventilation and dewatering.<br>- Track circuits for CTC are problematic this close to bulk terminals. Spillage of corrosives corrode rail and interfere with track circuits. |
| **Capital Cost:** | Alt. 1: $ 0<br>Alt. 2: $ 110,000,000 – over a period of 2.5 years<br>Alt. 3: $ 420,000,000 – over a period of 3 years |
| **Annual Operating Cost:** | Alt. 1: $ 650,000<br>Alt. 2: $ 650,000<br>Alt. 3: $ 2,000,000 |
| **Annual Maintenance Cost:** | Alt. 1: $ 590,000<br>Alt. 2: $ 750,000<br>Alt. 3: $ 2,000,000 |
| **Rehabilitation Cost in 20 years:** | Alt. 1: $ 22,000,000<br>Alt. 2: $ 2,000,000<br>Alt. 3: $ 2,000,000 |

| | |
|---|---|
| **Project:** | C - Roberts Bank - 41B St. Overpass |
| **Municipality:** | Delta |
| **Railway Companies:** | BC and BNSF |
| **Basic Project Description:** | Road Overpass at 41B Avenue over DeltaPort Road and the BC Rail line. The purpose is to allow unrestricted switching of trains, allow building of trains that are >10,000 ft in length, increase safety and reduce road closures by 2 hrs/day. |
| **Length:** | Bridge: 108 m<br>Total with Roadway: 290 m |
| **Current Use:** | 22 trains per day |
| **Design Life:** | 100 years |
| **Issues / Conflicts:** | Rerouting traffic during construction – not major |
| **Capital Cost:** | $ 4,900,000 – over a period of 1 year (accounting for pre-loading time as part of the construction period) |
| **Annual Operating Cost:** | $ 0 |
| **Annual Maintenance Cost:** | $ 5000 |
| **Rehabilitation Cost in 20 years:** | $ 300,000 |

| | |
|---|---|
| **Project:** | E – BN New Yard to Spruce St. Double Track |
| **Municipality:** | New Westminster |
| **Railway Companies:** | All railways |
| **Basic Project Description:** | Extension of the siding along the main line between the Spruce Street and the BN New Yard. This siding will become a double line and will provide additional queuing capability. |
| **Length:** | 800 m |
| **Current Use:** | 46 trains per day |
| **Design Life:** | 100 years |
| **Issues / Conflicts:** | - severe space restrictions due to Skytrain, Hwy 1,and commercial/industrial district.<br>- possible land acquisition required |
| **Capital Cost:** | $ 3,000,000 – over a period of 4 months |
| **Annual Operating Cost:** | $ 0 |
| **Annual Maintenance Cost:** | $ 5000 |
| **Rehabilitation Cost in 20 years:** | $ 100,000 |

| | |
|---|---|
| **Project:** | F – Colebrook North/South Siding |
| **Municipality:** | Delta |
| **Railway Companies:** | CP, CN, BNSF, Amtrak |
| **Basic Project Description:** | Siding to alleviate the congestion of future increase in Amtrak train usage. Considering the length of this siding, there will be 2 switches at the mid-point to facilitate egress of relatively shorter trains. |
| **Length:** | 8500 ft (2590 m) |
| **Current Use:** | 12 trains per day |
| **Design Life:** | 100 years |
| **Issues / Conflicts:** | - Possible widening of two roadway overpasses<br>- Ditches and culvert extensions needed |
| **Capital Cost:** | $ 6,500,000 – over a period of 9 months |
| **Annual Operating Cost:** | $ 0 |
| **Annual Maintenance Cost:** | $ 10,000 |
| **Rehabilitation Cost in 20 years:** | $ 300,000 |

| | |
|---|---|
| **Project:** | G – Colebrook East/West Siding |
| **Municipality:** | Surrey |
| **Railway Companies:** | CP, CN, BNSF, Amtrak |
| **Basic Project Description:** | Lengthen existing siding to increase capacity on the Roberts Bank route. Considering the length of this siding, there will be 2 switches at the mid-point to facilitate egress of relatively shorter trains. |
| **Length:** | 10,000 ft (3048 m) could be increased to 12000 ft (3657 m) |
| **Current Use:** | 12 trains per day |
| **Design Life:** | 100 years |
| **Issues / Conflicts:** | - lack of working space on one side of track<br>- culvert extensions needed<br>- proximity of wetlands / environmentally sensitive area may prevent construction in this area. |
| **Capital Cost:** | $ 7,100,000 – over a period of 1 year |
| **Annual Operating Cost:** | $ 0 |
| **Annual Maintenance Cost:** | $ 11,000 |
| **Rehabilitation Cost in 20 years:** | $ 300,000 |

| | |
|---|---|
| **Project:** | H – Westwood Street Grade Separation |
| **Municipality:** | Port Coquitlam |
| **Railway Companies:** | CP, Southern, WCE |
| **Basic Project Description:** | Road Overpass on Westwood St. to reduce the amount of road closures,increase safety, and increase train switching capabilities |
| **Length:** | Bridge: 54 m<br>Total with Roadway: 394 m |
| **Current Use:** | 60 to 80 trains per day |
| **Design Life:** | 100 years |
| **Issues / Conflicts:** | - proximity of commercial buildings and access to them from Westwood St. will be difficult<br>- land acquisition required<br>- Davies Road extension under overpass needed to tie-in with adjacent properties<br>- possible utilities relocation under fill area<br>- raising grade of existing side-roads to tie-in to overpass required to maintain traffic flow |
| **Capital Cost:** | $ 11,800,000 - over a period of 1 year |
| **Annual Operating Cost:** | $ 0 |
| **Annual Maintenance Cost:** | $ 9000 |
| **Rehabilitation Cost in 20 years:** | $ 500,000 |

| | |
|---|---|
| **Project:** | I – Harris Road Grade Separation |
| **Municipality:** | Pitt Meadows |
| **Railway Companies:** | CP, Southern, WCE |
| **Basic Project Description:** | Road Overpass on Harris Road. to reduce the amount of road closures, increase safety, and increase train switching capabilities |
| **Length:** | Bridge: 60 m<br>Total with Roadway: 350 m |
| **Current Use:** | 45 trains per day |
| **Design Life:** | 100 years |
| **Issues / Conflicts:** | - proximity of commercial buildings and access to them from Harris Rd. will be difficult<br>- land acquisition required<br>- Park Road needs to be extended through overpass<br>- possible utilities relocation under fill area<br>- raising grade of existing side-roads to tie in to overpass |
| **Capital Cost:** | $ 9,800,000 - over a period of 1 year |
| **Annual Operating Cost:** | $ 0 |
| **Annual Maintenance Cost:** | $ 8,000 |
| **Rehabilitation Cost in 20 years:** | $ 500,000 |

| | |
|---|---|
| **Project:** | J – King Edward Grade Separation |
| **Municipality:** | Coquitlam |
| **Railway Companies:** | All railways |
| **Basic Project Description:** | Road Overpass on King Edward Rd. to reduce the amount of road closures into the commercial / industrial district and increase safety. Since there is a very high amount of switching taking place here, an overpass will highly benefit the rail network also. |
| **Length:** | Bridge: 200 m<br>Total with Roadway: 350 m |
| **Current Use:** | 16 trains per day |
| **Design Life:** | 100 years |
| **Issues / Conflicts:** | - Highway 1 is elevated in this area, therefore overpass must cross elsewhere to avoid a very high overpass and allow existing crossing to be used during construction.<br>- low land / high water table makes underpass difficult.<br>- proximity of commercial buildings<br>- land acquisition in United Boulevard area |
| **Capital Cost:** | $ 18,000,000 - over a period of 1.5 years (due to pre-loading and construction over Hwy. 1) |
| **Annual Operating Cost:** | $ 0 |
| **Annual Maintenance Cost:** | $ 10,000 |
| **Rehabilitation Cost in 20 years:** | $ 1,000,000 |

| | |
|---|---|
| **Project:** | O – Powell Street<br>A. Grade Separation<br>B. Double Track |
| **Municipality:** | Vancouver |
| **Railway Companies:** | All railways |
| **Basic Project Description:** | Two parts:<br>A. Roadway overpass on Powell Street where the tracks cross the road – near Powell St. and Raymur Ave. – an accident prone area, with frequent and slow train crossings ie. long waits for cars.<br>B. Double track from Powell St. to the “Glen Yard”, which is located 850 m South of the proposed overpass. |
| **Length:** | Part A: Bridge: 25 m<br>Total with Roadway: 360 m<br>Part B: Double Track: 700 m |
| **Current Use:** | 19 train movements per day |
| **Design Life:** | 100 years for both |
| **Issues / Conflicts:** | Part A:<br>- proximity of buildings on Powell St. and rail lines across the street from these buildings leaves little room for construction.<br>- tie-in with adjacent roads needed - Raymur Ave.needs to be elevated for that.<br>- fork in road creates extra cost.<br>- bus overhead caternary sytem exists.<br><br>Part B: none |
| **Capital Cost:** | Part A. Overpass: $ 10,000,000 - over a period of 1 year<br>Part B. Double Track: $ 2,800,000 - over a period of 6 months |
| **Annual Operating Cost:** | $ 0 |
| **Annual Maintenance Cost:** | Part A: $ 10,000<br>Part B: $ 5,000 |
| **Rehabilitation Cost in 20 years:** | Part A: $ 1,000,000<br>Part B: $ 100,000 |

| | |
|---|---|
| **Project:** | P – Willingdon Siding |
| **Municipality:** | Burnaby |
| **Railway Companies:** | BNSF and CN |
| **Basic Project Description:** | Construct New Siding 8500 ft long to keep the double track clear. Presently one track is used for train parking, reducing rail traffic flow. |
| **Length:** | 8500 ft (2590 m) |
| **Current Use:** | 19 train movements per day |
| **Design Life:** | 100 years + |
| **Issues / Conflicts:** | some road crossings (might need overpasses) |
| **Capital Cost:** | $ 6,300,000 - over a period of 1 year |
| **Annual Operating Cost:** | $ 0 |
| **Annual Maintenance Cost:** | $ 10,000 |
| **Rehabilitation Cost in 20 years:** | $ 300,000 |

# APPENDIX A3

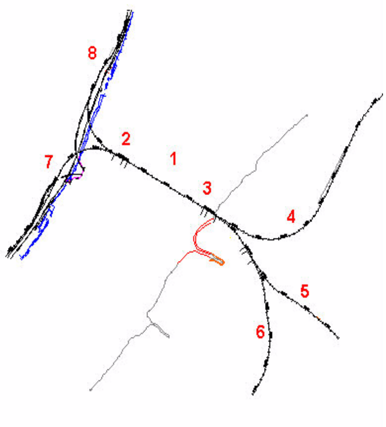
# Project Costs

**Planned Improvements:**

**Option 1:** Retain Existing Bridge

| Cost Breakdown: | Annual Operating Costs | | Annual Maintenance Costs | | Rehabilitation Costs (every 20 years) | |
|---|---|---|---|---|---|---|
| | 4 Tenders | $ 620,000 | Bridge: | $ 200,000 | Bridge: | |
| | Coll. Damage | $ 340,000 | Rail: | $ 45,000 | painting | $ 8,000,000 |
| | | | Turnout: | $ 35,000 | Repair | $ 12,000,000 |
| | | | | | Mech. | $ 2,000,000 |
| | **Totals Annual** | $ 960,000 | | $ 280,000 | | |
| | Totals 20 years | $19,200,000 | | $ 5,600,000 | | $ 22,000,000 |
| | Total Cost for 20 years: | | $ 46,800,000 | | | |

| | |
|---|---|
| Operating Life Remaining: | ~20 years |
| Current speed restriction | Cost to the present railway: New Bridge would boost speed up to 20km/h. Currently it's 11km/h. So the time savings is 2.45 minutes per km length of train. |
| Opening Waits: | Much more significant than speed restriction |
| | Wait times for Swing Span |
| Seismic Vulnerability: | should be investigated and upgraded |




**Option 2:** New Bridge with improved Navigation Clearance - Using Vertical Lift

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cost Breakdown | Bridge Structure Capital Cost: | | | length (m) | width (m) | Cost/m$^2$ | Cap. Cost | | | |
| | | 1. Vertical Lift Span: | | 100 | 5 | 6000 | $ 3,000,000 | | | |
| | | 2. North Appr.over Water: | | 380 | 5 | 3000 | $ 5,700,000 | | | |
| | | 3. South Appr.over Water: | | 370 | 5 | 3000 | $ 5,550,000 | | | |
| | | 4. South-East Tie-in | | | | | | | | |
| | | | Trestle | 500 | 5 | 1500 | $ 3,750,000 | | | |
| | | | Fill | 350 | 5 | 40 | $ 70,000 | | | |
| | | 5. South-Middle Tie-in: | | | | | | | | |
| | | | Trestle | 350 | 5 | 1500 | $ 2,625,000 | | | |
| | | | Fill | 400 | 5 | 40 | $ 80,000 | | | |
| | | 6. South-West Tie-in | | | | | | | | |
| | | | Trestle | 900 | 5 | 1500 | $ 6,750,000 | | | |
| | | | Fill | 0 | 5 | 0 | $ - | | | |
| | | 7. North-West Tie-in | | | | | $ - | | | |
| | | | Trestle | | 5 | 1500 | $ 7,500 | | | |
| | | | Fill | 100 | 5 | 80 | $ 40,000 | | | |
| | | 8. North East Tie-in | | 1040 | | | | | | |
| | | | Trestle | 50 | 5 | 1500 | $ 375,000 | | | |
| | | | Fill | 600 | 5 | 20 | $ 60,000 | | | |
| | | Total | | 4490 | | | $ 28,007,500 | | | fill = 20/m3 |
| | Land Acquisition | | Section | Area (m$^2$) | Cost ( per m$^2$) | | Cap Cost | | | |
| | | | Leg 4 | 54080 | 500 | | $ 27,040,000 | | | |
| | | | Leg 6 | 2540 | 500 | | $ 1,270,000 | total trestle length: | 3000 | m |
| | | | Leg 7 | 2000 | 500 | | $ 1,000,000 | total fill: | 7250 | m^2 (1m thick) |
| | Track Costs: | | assume: | ($175/ft) | ($575/m) | 1750 | $ 1,006,250 | | | |
| | Turnouts: | | One #11 Wye on South side | | | | $ 75,000 | | | |
| | | | Two #11 turnouts on North Side | | | | $ 150,000 | | | |
| | Mechanical System for Vertical Lift | | | | | | $ 5,000,000 | | | |
| | Lost time due to tie-ins (10 days total) | | | assume $100000/day | | | $ 10,000,000 | | | |
| | Signals & Controls | | Signals | | 3 | L.S. | $ 660,000 | | | |
| | | | Power | | 3 | L.S. | $ 174,000 | | | |
| | | | Switch Heaters | | 3 | L.S. | $ 105,000 | | | |
| | Fibre Optics | Relocate Line | | | 1 | L.S. | $ - | | | |
| | CONTINGENCY (30%) | | | | | | $ 22,346,325 | | | |
| | ENGINEERING (12%) | | | | | | $ 8,938,530 | | | |
| | TOTAL CAPITAL COST | | | | | | $ 105,772,605 | **$ 110,000,000** | | |

# Cost Estimate for Projects A1 and A2.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Option 3:** | New Tunnel | | | | | | | | |
| Cost Breakdown | | | | | | | | | |
| 1. Capital Cost | | | | | | | | | |
| | Tunnel Structure | | | | | | | | |
| | | - Bored Tunnel (River Channel) | | | | | $ 28,000,000 | | |
| | | - Cut and Cover Tunnel (South Side?) | | | | | $ 120,000,000 | | |
| | | - Bored Tunnel (North Side) | | | | | $ 168,000,000 | | |
| | | - Transition to at-grade track from tunnel (trench) | | | | | $ 20,000,000 | | |
| | Disposal of Spoil | | | | | | $ 6,000,000 | | |
| | Purchase of Right of Way | | | | | | $ 1,000,000 | | |
| | Ventilation: | | | | | | $ 22,120,000 | | |
| | Track Installation: | | | | | | $ 4,450,000 | | |
| | Lighting,substations, power distribution,controls, drainage, fire life safety | | | | | | $ 31,600,000 | | |
| | Contingency | | | | | | $ 20,058,500 | | |
| | Total: | | | | | | **$ 421,228,500** | | **$ 420,000,000** |
| 2. Annual Operating Costs: | | | | | | | | | |
| | Total: | | | | | | **$ 2,000,000** | | |
| 3. Annual Maintenance Costs | | | | | | | | | |
| | Total: | | | | | | **$ 2,000,000** | | |
| 4. Rehabilitation Costs in 20 years (if any): | | | | | | | | | |
| | Total: | | | | | | **$ 2,000,000** | | |
| Expected Life of the Tunnel: | | | 100 | yrs | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Option 3:** | New Tunnel | BREAKDOWN OF SUMMARY ABOVE | | | | | |
| **Assumptions** | | | | | | | |
| **North Side Tunnel** | | | | | | | |
| Bored Tunnel | | internal diameter | | 8.4 | m | | |
| | | lining | | precast concrete | | | |
| | | lining thickness | | 0.4 | m | | |
| Machine type | | | | EPB | | | |
| Length | | | | 4200 | m | Estimated from sketch | |
| Direct costs | | tunnel drive | | $15,486 | /m | From DRTP estimate | |
| | | lining | | $4,749 | /m | | |
| | | invert | | $2,395 | /m | | |
| | | **subtotal** | | **$22,630** | **/m** | | |
| Indirect at | 10% | | | $2,263 | /m | | |
| | | **subtotal** | | **$24,893** | **/m** | | |
| Profit at | 15% | | | $3,734 | /m | | |
| | | **subtotal** | | **$28,627** | **/m** | | |
| Contingency at | 40% | | | $11,451 | /m | | |
| | | **Total** | | **$40,078** | **/m** | | |
| | | | **USE** | **$40,000** | **/m** | | |
| **Total cost** | | | | **$168,000,000** | | | |
| **South Side Tunnel** | | | | | | | |

**Option 3:** New Tunnel CONTINUED

**South Side Tunnel**

Use as above for either tunnel or cut and cover

| | | | | |
|---|---|---|---|---|
| Length | | 3000 | m | Estimated from sketch |
| | **USE** | **$40,000** | **/m** | |
| **Total cost** | | **$120,000,000** | | |

**South Side Boat Section**

| | | | | |
|---|---|---|---|---|
| Length | | 1000 | m | Estimated from sketch |
| | **USE** | **$20,000** | **/m** | |
| **Total cost** | | **$20,000,000** | | |

**Immersed Tube Under River**

| | | | | | |
|---|---|---|---|---|---|
| Length | | | 700 | m | Estimated from sketch |
| Directs + indirects + profit | | | **$53,000** | **/m** | |
| Contingency at | 40% | | $21,200 | | |
| | **Total** | | **$74,200** | | |
| | | **USE** | **$74,000** | | |
| **Total cost** | | | **$51,800,000** | | |

**Bored Tunnel Under River**

| | | |
|---|---|---|
| length | | 700 |
| cost/m | $ | 40,000 |
| | **$** | **28,000,000** |

difference bewteen ITT and Bored: **$23,800,000**

**Ventilation**

| | | | |
|---|---|---|---|
| Length | | 7900 | m |
| | **USE** | **$2,800** | **/m** |
| **Total cost** | | **$22,120,000** | |

**Track**

| | | | |
|---|---|---|---|
| Length | | 8900 | m |
| | **USE** | **$500** | **/m** |
| **Total cost** | | **$4,450,000** | |

**Lighting,substations, power distribution,controls, drainage, fire life safety**

| | | | |
|---|---|---|---|
| Length | | 7900 | m |
| | **USE** | **$4,000** | **/m** |
| **Total cost** | | **$31,600,000** | |

| | |
|---|---|
| **Project** | C |
| **Project Name** | Roberts Bank - 41B St. Overpass |
| **Jurisdiction** | Delta |
| **Scope of Work** | Grade Separation - road overpass |

**Priority** 1

**Issues:** None

**Expected Life:** 100 yrs

**Cost Analysis:**

| Item | Quantity | Unit | cost/unit | | Cost | | | |
|---|---|---|---|---|---|---|---|---|
| Area of Bridge | 1100 | $m^2$ | 2500 | $ | 2,750,000 | | | |
| Fill | $ 8,480 | $m^3$ | | $ | 212,000 | | | |
| Asphalt on Road | incl in $5M/km | | | | | | | |
| Roadway Barriers | incl in $5M/km | | | $ | 1,000,000 | Cost of Approaches | | |
| | | | | | | | 5mill /km | for roadway |
| MSE Walls | 0 | | | | 0 | | | |
| Contingency | 15% | | | $ | 594,300 | | | |
| Engineering Cost | 8% | | | $ | 316,960 | | | |
| Total Capital Cost | | | | **$** | **4,873,260** | **$ 4,900,000** | | |

| | | |
|---|---|---|
| Annual Operating Cost | **$** | **-** |
| Annual Maintenance Cost | **$** | **5,000** |
| Rehabilitation Cost (20 years) | **$** | **300,000** |

**Cost Estimate** E – BN New Yard to Spruce St. - Double Track

| | | |
|---|---|---|
| 0+00 | Existing Switch Point | |
| 8+00 | New Switch Point | metres |
| 800 | **Total Track** | |

**Granular, Rock and Sub-ballast Volumes**

| Station Range | | | Description | Distance (ft) | Granular Cut Area (ft$^2$) | Granular Cut Volume (yds$^3$) | Rock Cut Area (ft$^2$) | Rock Cut Volume (yds$^3$) | Fill Area (ft$^2$) | Fill Volume (yds$^3$) | Sub-ballast Area (ft$^2$) | Sub-ballast Volume (yds$^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0+00 | - | 08+00 | 5' Fill | 2624.8 | | 0 | | 0 | 40.39 | 3927 | 15.34 | 1491 |
| | | | | | **TOTALS (yds$^3$)** | **0** | | **0** | | **3927** | | **1491** |

**Stripping and Clearing Areas**

| Station Range | | | Description | Distance (ft) | Stripping Width (ft) | Stripping Area (yds$^2$) | Clearing Width (ft) | Clearing Area (yds$^2$) |
|---|---|---|---|---|---|---|---|---|
| 0+00 | - | 08+00 | 5' Fill | 2624.8 | 30 | 8748 | 25 | 7290 |
| | | | | 2624.8 | **TOTALS (yds$^2$)** | **8748** | | **7290** |

Stripping Assumptions:
In fill -- length of slope + width of new fill + 10'
In cut -- length of ditch backslope + dist to new top of cut

Clearing Assumptions:
In fill -- width of new fill + 10'
In cut -- length of ditch backslope + dist to new top of cut

| **Summary** | | |
|---|---|---|
| Granular Cut (yds$^3$) | 0 | Assume 100% of granular excavation is useable as fill |
| Rock Cut (yds$^3$) | 0 | |
| Available Rock (yds$^3$) | 0 | Assume available rock fill is (1.5)*(rock excavation) |
| Fill Required (yds$^3$) | 3927 | |
| Rock Fill (yds$^3$) | 0 | |
| Supply Gran. Fill (yds$^3$) | 3927 | Assume granular fill required = (total fill) - (rock fill) - (granular excavation) |
| Sub-ballast (yds$^3$) | 1491 | |
| Stripping Area (yds$^2$) | 8748 | |
| Clearing Area (yds$^2$) | 7290 | |

Hatch Mott MacDonald

| | | | | | |
|---|---|---|---|---|---|
| | | **O.M. CAPITAL COST ESTIMATE** | | | |
| PROJECT: | Gateway Study | DATE: | 30-May-04 | | |
| SECTION: | E – BN New Yard to Spruce St. - Double Track | EST. BY: | NJH | | |
| | | PROJECT NO. | XXXXXX | | |

| CATEGORY | WORK DESCRIPTION | QUANTITY | UNITS | UNIT $ | TOTAL $ |
|---|---|---|---|---|---|
| **Civil** | Granular Excavation | 1000 | $yds^3$ | $15.00 | $15,000.00 |
| | Rock Excavation | 500 | $yds^3$ | $125.00 | $62,500.00 |
| | Granular Placement | 1000 | $yds^3$ | $10.00 | $10,000.00 |
| | Granular Supply and Placement | 3927 | $yds^3$ | $25.00 | $98,162.56 |
| | Rock Placement | 0 | $yds^3$ | $12.00 | $0.00 |
| | Ditching | 2624.8 | feet | $5.00 | $13,124.00 |
| | Sub-Ballast | 1491 | $yds^3$ | $30.00 | $44,738.21 |
| | Stripping | 8748 | $yds^2$ | $2.50 | $21,871.15 |
| | Clearing & Grubbing | 7290 | $yds^2$ | $2.50 | $18,225.96 |
| | Mob/Demob | 1 | L.S. | $40,000.00 | $40,000.00 |
| **Expropriation** | Industrial Zoned land: ~ 3 large lots | 3 | lots | $200,000.00 | $600,000.00 |
| **Trackwork** | New Track 115RE CWR, Wood Tie, Ballast | 2625 | feet | $175.00 | $459,340.00 |
| | New #11 Turnouts | 2 | each | $75,000.00 | $150,000.00 |
| **Structures** | | | feet | | $0.00 |
| | | | feet | | $0.00 |
| | | | feet | | $0.00 |
| **S & C** | Signals | 1 | L.S. | $200,000.00 | $200,000.00 |
| | Power | 1 | L.S. | $50,000.00 | $50,000.00 |
| | Switch Heaters | 2 | L.S. | $35,000.00 | $70,000.00 |
| | Installation including signal, cables, bungalows & gas | 1 | L.S. | $50,000.00 | $50,000.00 |
| **Fibre Optics** | Fiber Equipment Racks | 1 | L.S. | $35,000.00 | $35,000.00 |
| | Fiber Optics 36C Cable | 1 | L.S. | $70,000.00 | $70,000.00 |
| | Installation including splice boxes and conduit | 1 | L.S. | $50,000.00 | $50,000.00 |
| | CONTINGENCY (30%) | | | | $617,388.56 |
| | ENGINEERING (12%) | | | | $321,042.05 |
| | TOTAL COST | | | | $2,996,392.49 |

**NOTES:**

Assumes no culverts required and Fibre optic cable relocation costs are borne by fibre company
Signals costs need to be confirmed by signals engineer
Fill depths are assumed

**Cost Estimate**

**Colebrook North/South Siding - 8500' Option**

| | |
|---|---|
| 0+00 | Existing Switch Point |
| 85+00 | New Switch Point |
| 8500 | **Total Track** |

**Granular, Rock and Sub-ballast Volumes**

| Station Range | | | Description | Distance (ft) | Granular Cut Area ($ft^2$) | Granular Cut Volume ($yds^3$) | Rock Cut Area ($ft^2$) | Rock Cut Volume ($yds^3$) | Fill Area ($ft^2$) | Fill Volume ($yds^3$) | Sub-ballast Area ($ft^2$) | Sub-ballast Volume ($yds^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0+00 | - | 85+00 | 5' Fill | 8500 | | 0 | | 0 | 40.39 | 12715 | 15.34 | 4829 |
| | | | | | **TOTALS ($yds^3$)** | **0** | | **0** | | **12715** | | **4829** |

**Stripping and Clearing Areas**

| Station Range | | | Description | Distance (ft) | Stripping Width (ft) | Stripping Area ($yds^2$) | Clearing Width (ft) | Clearing Area ($yds^2$) |
|---|---|---|---|---|---|---|---|---|
| 0+00 | - | 85+00 | 5' Fill | 8500 | 30 | 28331 | 25 | 23609 |
| | | | | 8500 | **TOTALS ($yds^2$)** | **28331** | | **23609** |

Stripping Assumptions:
In fill -- length of slope + width of new fill + 10'
In cut -- length of ditch backslope + dist to new top of cut

Clearing Assumptions:
In fill -- width of new fill + 10'
In cut -- length of ditch backslope + dist to new top of cut

| Summary | | |
|---|---|---|
| Granular Cut ($yds^3$) | 0 | Assume 100% of granular excavation is useable as fill |
| Rock Cut ($yds^3$) | 0 | |
| Available Rock ($yds^3$) | 0 | Assume available rock fill is (1.5)*(rock excavation) |
| Fill Required ($yds^3$) | 12715 | |
| Rock Fill ($yds^3$) | 0 | |
| Supply Gran. Fill ($yds^3$) | 12715 | Assume granular fill required = (total fill) - (rock fill) - (granular excavation) |
| Sub-ballast ($yds^3$) | 4829 | |
| Stripping Area ($yds^2$) | 28331 | |
| Clearing Area ($yds^2$) | 23609 | |

| Hatch Mott MacDonald | | O.M. CAPITAL COST ESTIMATE | | | |
|---|---|---|---|---|---|
| PROJECT: | Gateway Study | DATE: | 30-May-04 | | |
| SECTION: | Colebrook North/South Siding | EST. BY: | NJH | | |
| | | PROJECT NO. | 210532 | | |

| CATEGORY | WORK DESCRIPTION | QUANTITY | UNITS | UNIT $ | TOTAL $ |
|---|---|---|---|---|---|
| **Civil** | Granular Excavation | 0 | $yds^3$ | $15.00 | $0.00 |
| | Rock Excavation | 0 | $yds^3$ | $125.00 | $0.00 |
| | Granular Placement | 0 | $yds^3$ | $10.00 | $0.00 |
| | Granular Supply and Placement | 12715 | $yds^3$ | $25.00 | $317,883.94 |
| | Rock Placement | 0 | $yds^3$ | $12.00 | $0.00 |
| | Ditching | 9000 | feet | $5.00 | $45,000.00 |
| | Sub-Ballast | 4829 | $yds^3$ | $30.00 | $144,877.63 |
| | Stripping | 28331 | $yds^2$ | $2.50 | $70,826.25 |
| | Clearing & Grubbing | 23609 | $yds^2$ | $2.50 | $59,021.88 |
| | Mob/Demob | 1 | L.S. | $60,000.00 | $60,000.00 |
| **Trackwork** | New Track 115RE CWR, Wood Tie, Ballast | 8500 | feet | $175.00 | $1,487,500.00 |
| | New #16 Turnouts | 2 | each | $98,000.00 | $196,000.00 |
| | New #11 Turnouts | 2 | each | $75,000.00 | $150,000.00 |
| **Structures** | Existing roadway overpass widening possible | | feet | | $0.00 |
| | | | feet | | $0.00 |
| | | | feet | | $0.00 |
| **S & C** | Signals | 4 | L.S. | $200,000.00 | $800,000.00 |
| | Power | 3 | L.S. | $50,000.00 | $150,000.00 |
| | Switch Heaters | 6 | L.S. | $30,000.00 | $180,000.00 |
| | Installation including signal, cables, bungalows & gas | 1 | L.S. | $200,000.00 | $200,000.00 |
| | Modify Control Office if existing CTC | 1 | L.S. | $300,000.00 | $300,000.00 |
| **Fibre Optics** | Fiber Equipment Racks | 3 | L.S. | $35,000.00 | $105,000.00 |
| | Fiber Optics 36C Cable | 1 | L.S. | $70,000.00 | $70,000.00 |
| | Installation including splice boxes and conduit | 1 | L.S. | $100,000.00 | $100,000.00 |
| | CONTINGENCY (30%) | | | | $1,330,832.91 |
| | ENGINEERING (12%) | | | | $692,033.11 |
| | TOTAL COST | | | | $6,458,975.72 |

**NOTES:**

Assumes no culverts required and Fibre optic cable relocation costs are borne by fibre company
Signals costs need to be confirmed by signals engineer
Fill depths are assumed

**Cost Estimate** Colebrook East/West Siding

| | | |
|---|---|---|
| 0+00 | Existing Switch Point | |
| 8+00 | New Switch Point | metres |
| 800 | **Total Track** | |

**Granular, Rock and Sub-ballast Volumes**

| Station Range | | | Description | Distance (ft) | Granular Cut Area ($ft^2$) | Granular Cut Volume ($yds^3$) | ock Cut Ar ($ft^2$) | Rock Cut Volume ($yds^3$) | Fill Area ($ft^2$) | Fill Volume ($yds^3$) | Sub-ballast Area ($ft^2$) | Sub-ballast Volume ($yds^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0+00 | - | 85+00 | 5' Fill | 10000 | | 0 | | 0 | 40.39 | 14959 | 15.34 | 5681 |
| | | | | | **TOTALS ($yds^3$)** | **0** | | **0** | | **14959** | | **5681** |

**Stripping and Clearing Areas**

| Station Range | | | Description | Distance (ft) | Stripping Width (ft) | Stripping Area ($yds^2$) | Clearing Width (ft) | Clearing Area ($yds^2$) |
|---|---|---|---|---|---|---|---|---|
| 0+00 | - | 85+00 | 5' Fill | 10000 | 30 | 33330 | 25 | 27775 |
| | | | | 10000 | | | | |
| | | | | | **TOTALS ($yds^2$)** | **33330** | | **27775** |

Stripping Assumptions:
In fill -- length of slope + width of new fill + 10'
In cut -- length of ditch backslope + dist to new top of cut

Clearing Assumptions:
In fill -- width of new fill + 10'
In cut -- length of ditch backslope + dist to new top of cut

| **Summary** | |
|---|---|
| Granular Cut ($yds^3$) | 0 |
| Rock Cut ($yds^3$) | 0 |
| Available Rock ($yds^3$) | 0 |
| Fill Required ($yds^3$) | 14959 |
| Rock Fill ($yds^3$) | 0 |
| Supply Gran. Fill ($yds^3$) | 14959 |
| Sub-ballast ($yds^3$) | 5681 |
| Stripping Area ($yds^2$) | 33330 |
| Clearing Area ($yds^2$) | 27775 |

Assume 100% of granular excavation is useable as fill

Assume available rock fill is (1.5)*(rock excavation)

Assume granular fill required = (total fill) - (rock fill) - (granular excavation)

Hatch Mott MacDonald

| | | | | | |
|---|---|---|---|---|---|
| PROJECT: Gateway Study | | **O.M. CAPITAL COST ESTIMATE** | | | |
| SECTION: Colebrook East/West Siding | | DATE: 30-May-04 | | | |
| | | EST. BY: NJH | | | |
| | | PROJECT 210532 | | | |

| CATEGORY | WORK DESCRIPTION | QUANTITY | UNITS | UNIT $ | TOTAL $ |
|---|---|---|---|---|---|
| **Civil** | Granular Excavation | 0 | $yds^3$ | $15.00 | $0 |
| | Rock Excavation | 0 | $yds^3$ | $125.00 | $0 |
| | Culvert Extensions | | | | |
| | Granular Placement | 0 | $yds^3$ | $10.00 | $0 |
| | Granular Supply and Placement | 14959 | $yds^3$ | $25.00 | $373,981 |
| | Rock Placement | 0 | $yds^3$ | $12.00 | $0 |
| | Ditching | 10000 | feet | $5.00 | $50,000 |
| | Sub-Ballast | 5681 | $yds^3$ | $30.00 | $170,444 |
| | Stripping | 33330 | $yds^2$ | $2.50 | $83,325 |
| | Clearing & Grubbing | 27775 | $yds^2$ | $2.50 | $69,438 |
| | Mob/Demob | 1 | L.S. | $60,000.00 | $60,000 |
| **Trackwork** | New Track 115RE CWR, Wood Tie, Ballast | 10000 | feet | $175.00 | $1,750,000 |
| | New #16 Turnouts | 2 | each | $98,000.00 | $196,000.00 |
| | New #11 Turnouts | 2 | each | $75,000.00 | $150,000.00 |
| **Structures** | | | feet | | $0 |
| | | | feet | | $0 |
| | | | feet | | $0 |
| **S & C** | Signals | 4 | L.S. | $200,000.00 | $800,000.00 |
| | Power | 3 | L.S. | $50,000.00 | $150,000.00 |
| | Switch Heaters | 6 | L.S. | $30,000.00 | $180,000.00 |
| | Installation including signal, cables, bungalows & gas | 1 | L.S. | $200,000.00 | $200,000.00 |
| | Modify Control Office if existing CTC | 1 | L.S. | $300,000.00 | $300,000.00 |
| **Fibre Optics** | Fiber Equipment Racks | 3 | L.S. | $35,000.00 | $105,000.00 |
| | Fiber Optics 36C Cable | 1 | L.S. | $70,000.00 | $70,000.00 |
| | Installation including splice boxes and conduit | 1 | L.S. | $100,000.00 | $100,000.00 |
| | CONTINGENCY (30%) | | | | $1,442,456.36 |
| | ENGINEERING (12%) | | | | $750,077.31 |
| | TOTAL COST | | | | $7,000,721.56 |

**NOTES:**

Assumes no culverts required and Fibre optic cable relocation costs are borne by fibre company
Signals costs need to be confirmed by signals engineer
Fill depths are assumed

**Project** H
**Project Name** Westwood St.
**Jurisdiction** Port Coquitlam
**Scope of Work** Grade Separation - road overpass

**Priority** 2

**Issues:**
May have to move Utilities (under Fill area)
Proximity of commercial district
Davies Road continuation
Raising grade of joining roads to meet same elevation
Rerouting side-road
Land Acquisition <--- instead of passing road through acquire more land

**Expected Life:** 100 yrs

**Cost Analysis:**

| Item | Quantity | Unit | cost/unit | Cost | |
|---|---|---|---|---|---|
| Area of Bridge | 1008 | $m^2$ | 2500 | $ 2,520,000 | |
| Fill | 25000 | $m^3$ | 25 | $ 625,000 | |
| Roads | | | | $ 500,000 | |
| Asphalt on Road | incl in $5M/km | | | | |
| Roadway Barriers | incl in $5M/km | | | $ 2,000,000 | Cost of Approaches 5mill /km for roadwa |
| MSE Walls | 3100 | $m^2$ | 750 | $ 2,325,000 | |
| Utilities Re-routing | | | | $ 200,000 | <--- extra for close proximity of commerical buildi |
| Land Acquisition | | | | $ 1,500,000 | |
| Contingency | 20% | | | $ 1,450,500 | |
| Engineering Cost | 8% | | | $ 653,600 | |
| Total Capital Cost | | | | **$ 11,774,100** | $ 11,800,000 |

| | |
|---|---|
| Annual Operating Cost | **$ -** |
| Annual Maintenance Cost | **$ 9,000** |
| Rehabilitation Cost (20 years) | **$ 500,000** |

**Project** I
**Project Name** Harris Road
**Jurisdiction** Pitt Meadows
**Scope of Work** Grade Separation - road overpass

**Priority** 2

**Issues:** May have to move Utilities (under Fill area)
Proximity of commercial district
Park Road continuation
Rerouting side-road
Land Acquisition

**Expected Life:** 100 yrs

**Cost Analysis:**

| Item | Quantity | Unit | cost/unit | Cost | | | |
|---|---|---|---|---|---|---|---|
| Area of Bridge | 1008 | $m^2$ | 2500 | $ 2,520,000 | | | |
| Fill | 20000 | $m^3$ | 25 | $ 500,000 | | | |
| Asphalt on Road | incl in $5M/km | | | | | Cost of Approaches | |
| Roadway Barriers | incl in $5M/km | | | $ 1,450,000 | | 5mill /km | for roadwa |
| MSE Walls | 3100 | $m^2$ | 750 | $ 2,325,000 | | | |
| Utilities Rerouting | | | | $ 200,000 | <--- extra for close proximity of commerical build | | |
| Land Acquisition | | | | $ 1,000,000 | | | |
| Contingency | 20% | | | $ 1,199,250 | | | |
| Engineering Cost | 8% | | | $ 559,600 | | | |
| Total Capital Cost | | | | **$ 9,753,850** | $ 9,800,000 | | |

| | |
|---|---|
| Annual Operating Cost | **$ -** |
| Annual Maintenance Cost | **$ 8,000** |
| Rehabilitation Cost (20 years) | **$ 500,000** |

| | |
|---|---|
| **Project** | J |
| **Project Name** | King Edward Ave. |
| **Jurisdiction** | Coquitlam |
| **Scope of Work** | Grade Separation - road overpass |

**Priority** 2

**Issues:**
Working over Hwy 1 - expensive Construction (3k/$m^2$)
May have to move Utilities (none shown on our maps)
Curved Alignment
Can't go under Hwy 1 at existing undepass because of flooding potential
Proximity of commercial district, commercial vehicles

**Expected Life:** 100 yrs

**Cost Analysis:**

| Item | Quantity | Unit | cost/unit | Cost | | | |
|---|---|---|---|---|---|---|---|
| Area of Bridge | 2700 | $m^2$ | 3500 | $ 9,450,000 | unit cost is higher because of height of overpass | | |
| Fill | 30,000 | $m^3$ | 25 | $ 750,000 | | | |
| Fill Preloading & Vibrocompaction | | | | $ 2,000,000 | | | |
| Asphalt on Road | incl in $5M/km | | | | | | |
| Roadway Barriers | incl in $5M/km | | | $ 1,200,000 | | Cost of Approaches | |
| | | | | | | 5mill /km | for roadwa |
| Utilities Rerouting | | | | $ 300,000 | | | |
| Land Acquisition | | | | $ 750,000 | | | |
| Contingency | 20% | | | $ 2,167,500 | | | |
| Engineering Cost | 9% | | | $ 1,300,500 | | | |
| Total Capital Cost | | | | **$ 17,918,000** | $ 18,000,000 | | |

| | |
|---|---|
| Annual Operating Cost | **$ -** |
| Annual Maintenance Cost | **$ 10,000** |
| Rehabilitation Cost (20 years) | **$ 1,000,000** |

| | |
|---|---|
| **Project** | O - part A |
| **Project Name** | Powell St. - Road overpass |
| **Jurisdiction** | Vancouver |
| **Scope of Work** | Grade Separation - road overpass |
| **Priority** | 2 |
| **Issues:** | May have to move Utilities (under Fill area)<br>Dead-end of side-road<br>Proximity of commercial district and railways<br>Wye - split |
| **Expected Life:** | 100 yrs |

**Cost Analysis of Overpass:**

| Item | Quantity | Unit | cost/unit | Cost | | |
|---|---|---|---|---|---|---|
| Area of Bridge | 350 | $m^2$ | 2500 | $ 875,000 | | |
| Fill | 20000 | $m^3$ | 25 | $ 500,000 | | |
| Asphalt on Road | incl in $5M/km | | | | | Cost of Approaches |
| Roadway Barriers | incl in $5M/km | | | $ 3,200,000 | | 5mill /km |
| MSE Walls | 3380 | $m^2$ | 750 | $ 2,535,000 | | |
| Utilities Rerouting | | | | $ 200,000 | <--- extra for close proximity of commerical | |
| Land Acquisition | | | | $ 1,000,000 | | |
| Contingency | 20% | | | $ 1,096,500 | | |
| Engineering Cost | 8% | | | $ 584,800 | | |
| Total Capital Cost | | | | **$ 9,991,300** | $ 10,000,000 | |

| | |
|---|---|
| Annual Operating Cost | **$ -** |
| Annual Maintenance Cost | **$ 10,000** |
| Rehabilitation Cost (20 years) | **$ 1,000,000** |

**Cost Estimate** Powell Street Double Track

| | | |
|---|---|---|
| 0+00 | Existing Switch Point | |
| 8+00 | New Switch Point | metres |
| 850 | **Total Track** | |

**Granular, Rock and Sub-ballast Volumes**

| Station Range | | | Description | Distance (ft) | Granular Cut Area ($ft^2$) | Granular Cut Volume ($yds^3$) | Rock Cut Area ($ft^2$) | Rock Cut Volume ($yds^3$) | Fill Area ($ft^2$) | Fill Volume ($yds^3$) | Sub-ballast Area ($ft^2$) | Sub-ballast Volume ($yds^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0+00 | - | 08+50 | 5' Fill | 2788.85 | | 0 | | 0 | 20 | 2066 | 15.34 | 1584 |
| | | | | | **TOTALS ($yds^3$)** | **0** | | **0** | | **2066** | | **1584** |

**Stripping and Clearing Areas**

| Station Range | | | Description | Distance (ft) | Stripping Width (ft) | Stripping Area ($yds^2$) | Clearing Width (ft) | Clearing Area ($yds^2$) |
|---|---|---|---|---|---|---|---|---|
| 0+00 | - | 08+50 | 5' Fill | 2788.85 | 30 | 9295 | 25 | 7746 |
| | | | | 2788.85 | | | | |
| | | | | | **TOTALS ($yds^2$)** | **9295** | | **7746** |

Stripping Assumptions:
In fill -- length of slope + width of new fill + 10'
In cut -- length of ditch backslope + dist to new top of cut

Clearing Assumptions:
In fill -- width of new fill + 10'
In cut -- length of ditch backslope + dist to new top of cut

| Summary | | |
|---|---|---|
| Granular Cut ($yds^3$) | 0 | Assume 100% of granular excavation is useable as fill |
| Rock Cut ($yds^3$) | 0 | |
| Available Rock ($yds^3$) | 0 | Assume available rock fill is (1.5)*(rock excavation) |
| Fill Required ($yds^3$) | 2066 | |
| Rock Fill ($yds^3$) | 0 | |
| Supply Gran. Fill ($yds^3$) | 2066 | Assume granular fill required = (total fill) - (rock fill) - (granular excavation) |
| Sub-ballast ($yds^3$) | 1584 | |
| Stripping Area ($yds^2$) | 9295 | |
| Clearing Area ($yds^2$) | 7746 | |

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**O.M. CAPITAL COST ESTIMATE**

PROJECT: Gateway Study
SECTION: Powell Street Double Track
DATE: 30-May-04
EST. BY: NJH
PROJECT NO. 210532

| CATEGORY | WORK DESCRIPTION | QUANTITY | UNITS | UNIT $ | TOTAL $ |
|---|---|---|---|---|---|
| **Civil** | Granular Excavation | 0 | $yds^3$ | $15.00 | $0.00 |
| | Rock Excavation | 0 | $yds^3$ | $125.00 | $0.00 |
| | Granular Placement | 0 | $yds^3$ | $10.00 | $0.00 |
| | Granular Supply and Placement | 2066 | $yds^3$ | $25.00 | $51,645.32 |
| | Rock Placement | 0 | $yds^3$ | $12.00 | $0.00 |
| | Ditching | 2500 | feet | $5.00 | $12,500.00 |
| | Sub-Ballast | 1584 | $yds^3$ | $30.00 | $47,534.35 |
| | Stripping | 9295 | $yds^2$ | $2.50 | $23,238.09 |
| | Clearing & Grubbing | 7746 | $yds^2$ | $2.50 | $19,365.08 |
| | Mob/Demob | 1 | L.S. | $60,000.00 | $60,000.00 |
| **Trackwork** | New Track 115RE CWR, Wood Tie, Ballast | 2789 | feet | $175.00 | $488,048.75 |
| | New #11 Turnout (at one end only) | 1 | each | $75,000.00 | $75,000.00 |
| **Structures** | | | feet | | $0.00 |
| | | | feet | | $0.00 |
| | | | feet | | $0.00 |
| **S & C** | Signals | 1 | L.S. | $200,000.00 | $200,000.00 |
| | Power | 1 | L.S. | $50,000.00 | $50,000.00 |
| | Switch Heaters | 2 | L.S. | $30,000.00 | $60,000.00 |
| | Installation including signal, cables, bungalows & gas | 1 | L.S. | $200,000.00 | $200,000.00 |
| | Modify Control Office if existing CTC | 1 | L.S. | $300,000.00 | $300,000.00 |
| **Fibre Optics** | Fiber Equipment Racks | 1 | L.S. | $35,000.00 | $35,000.00 |
| | Fiber Optics 36C Cable | 1 | L.S. | $70,000.00 | $70,000.00 |
| | Installation including splice boxes and conduit | 1 | L.S. | $100,000.00 | $100,000.00 |
| | CONTINGENCY (30%) | | | | $537,699.48 |
| | ENGINEERING (12%) | | | | $279,603.73 |
| | TOTAL COST | | | | $2,609,634.79 |

**NOTES:**

Assumes no culverts required and Fibre optic cable relocation costs are borne by fibre company
Signals costs need to be confirmed by signals engineer
Fill depths are assumed

**Cost Estimate** P - BNSF/CN Junction – Siding

| | | | |
|---|---|---|---|
| 0+00 | Existing Switch Point | | |
| 8+00 | New Switch Point | metres | |
| 8500 | **Total Track** | | |

**Granular, Rock and Sub-ballast Volumes**

| Station Range | | | Description | Distance (ft) | Granular Cut Area ($ft^2$) | Granular Cut Volume ($yds^3$) | Rock Cut Area ($ft^2$) | Rock Cut Volume ($yds^3$) | Fill Area ($ft^2$) | Fill Volume ($yds^3$) | Sub-ballast Area ($ft^2$) | Sub-ballast Volume ($yds^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0+00 | - | 85+00 | 5' Fill | 85+00 | | 0 | | 0 | 40.39 | 12715 | 15.34 | 4829 |
| | | | | | **TOTALS ($yds^3$)** | **0** | | **0** | | **12715** | | **4829** |

**Stripping and Clearing Areas**

| Station Range | | | Description | Distance (ft) | Stripping Width (ft) | Stripping Area ($yds^2$) | Clearing Width (ft) | Clearing Area ($yds^2$) |
|---|---|---|---|---|---|---|---|---|
| 0+00 | - | 85+00 | 5' Fill | 8500 | 30 | 28331 | 25 | 23609 |
| | | | | 8500 | **TOTALS ($yds^2$)** | **28331** | | **23609** |

Stripping Assumptions:
In fill -- length of slope + width of new fill + 10'
In cut -- length of ditch backslope + dist to new top of cut

Clearing Assumptions:
In fill -- width of new fill + 10'
In cut -- length of ditch backslope + dist to new top of cut

| Summary | | |
|---|---|---|
| Granular Cut ($yds^3$) | 0 | Assume 100% of granular excavation is useable as fill |
| Rock Cut ($yds^3$) | 0 | |
| Available Rock ($yds^3$) | 0 | Assume available rock fill is (1.5)*(rock excavation) |
| Fill Required ($yds^3$) | 12715 | |
| Rock Fill ($yds^3$) | 0 | |
| Supply Gran. Fill ($yds^3$) | 12715 | Assume granular fill required = (total fill) - (rock fill) - (granular excavation) |
| Sub-ballast ($yds^3$) | 4829 | |
| Stripping Area ($yds^2$) | 28331 | |
| Clearing Area ($yds^2$) | 23609 | |

Hatch Mott MacDonald

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | **O.M. CAPITAL COST ESTIMATE** | | | | | |
| PROJECT: | Gateway Study | DATE: | 30-May-04 | | | | |
| SECTION: | P - BNSF/CN Junction – Siding | EST. BY: | NJH | | | | |
| | | PROJECT NO. | 210532 | | | | |

| CATEGORY | WORK DESCRIPTION | QUANTITY | UNITS | UNIT $ | TOTAL $ |
|---|---|---|---|---|---|
| **Civil** | Granular Excavation | 0 | $yds^3$ | $15.00 | $0.00 |
| | Rock Excavation | 0 | $yds^3$ | $125.00 | $0.00 |
| | Granular Placement | 0 | $yds^3$ | $10.00 | $0.00 |
| | Granular Supply and Placement | 12715 | $yds^3$ | $25.00 | $317,883.94 |
| | Rock Placement | 0 | $yds^3$ | $12.00 | $0.00 |
| | Ditching | 2500 | feet | $5.00 | $12,500.00 |
| | Sub-Ballast | 4829 | $yds^3$ | $30.00 | $144,877.63 |
| | Stripping | 28331 | $yds^2$ | $2.50 | $70,826.25 |
| | Clearing & Grubbing | 23609 | $yds^2$ | $2.50 | $59,021.88 |
| | Mob/Demob | 1 | L.S. | $60,000.00 | $60,000.00 |
| | | | | | |
| **Trackwork** | New Track 115RE CWR, Wood Tie, Ballast | 8500 | feet | $175.00 | $1,487,500.00 |
| | New #16 Turnout (at one end only) | 2 | each | $96,000 | $192,000.00 |
| | Road Crossings at grade | 3 | each | $20,000 | $60,000.00 |
| | | | | | |
| **Structures** | | | feet | | $0.00 |
| | | | feet | | $0.00 |
| | | | feet | | $0.00 |
| | | | | | |
| **S & C** | Signals | 4 | L.S. | $200,000 | $800,000.00 |
| | Power | 3 | L.S. | $50,000 | $150,000.00 |
| | Switch Heaters | 6 | L.S. | $30,000 | $180,000.00 |
| | Installation including signal, cables, bungalows & gas | 1 | L.S. | $200,000 | $200,000.00 |
| | Modify Control Office if existing CTC | 1 | L.S. | $300,000 | $300,000.00 |
| | | | | | |
| **Fibre Optics** | Fiber Equipment Racks | 3 | L.S. | $35,000 | $105,000.00 |
| | Fiber Optics 36C Cable | 1 | L.S. | $70,000 | $70,000.00 |
| | Installation including splice boxes and conduit | 1 | L.S. | $100,000 | $100,000.00 |
| | | | | | |
| | CONTINGENCY (30%) | | | | $1,292,882.91 |
| | ENGINEERING (12%) | | | | $672,299.11 |
| | TOTAL COST | | | | $6,274,791.72 |

**NOTES:**

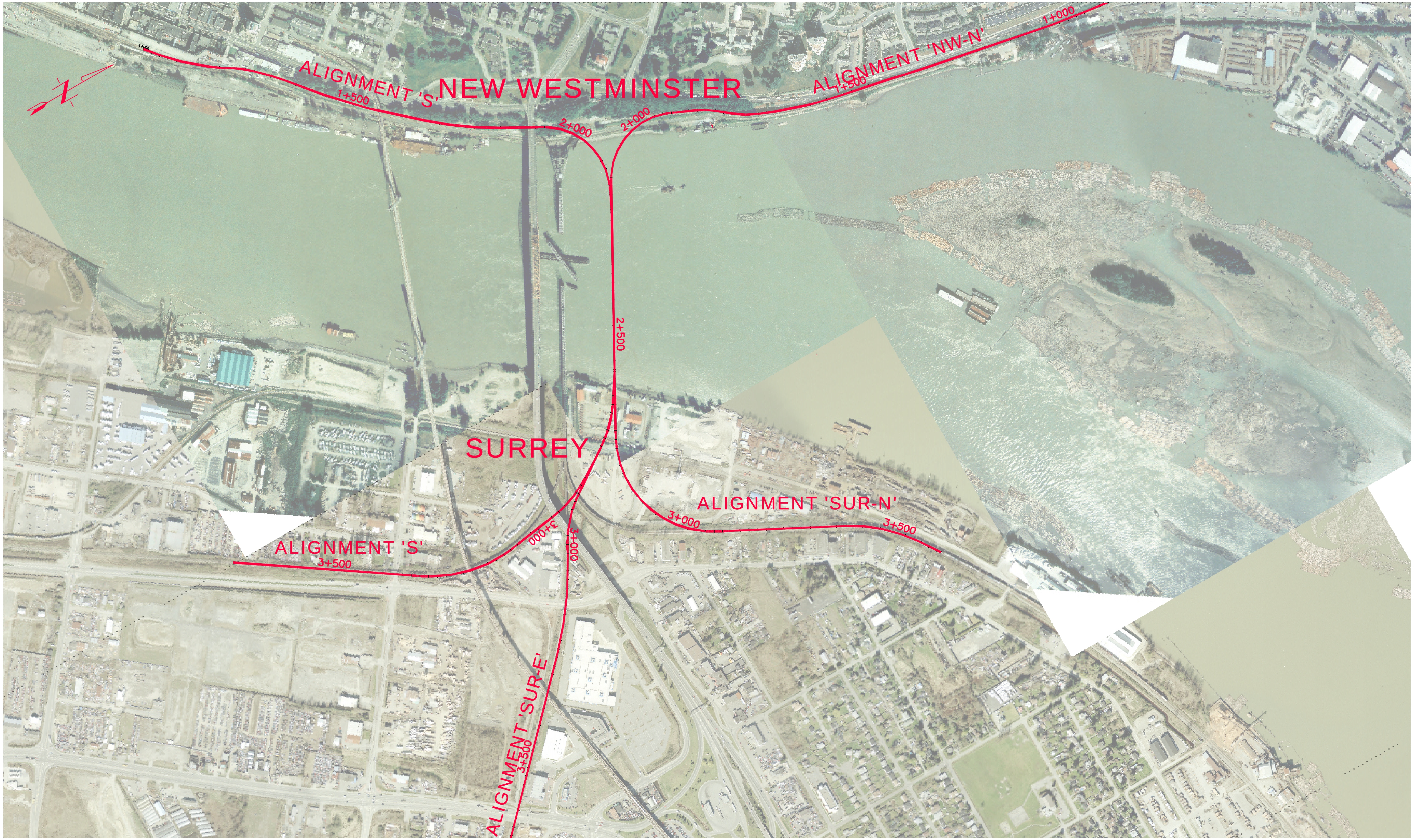
Assumes Fibre optic cable relocation costs are borne by fibre company

Signals costs need to be confirmed by signals engineer

Fill depths are assumed

# APPENDIX A4

# Design Details

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| ISSUE/REVISIONS | | | |

| NO | DESCRIPTION | BY | DATE |
|---|---|---|---|
| ISSUE/REVISIONS | | | |

| SCALE: -- | DATE |
|---|---|
| DESIGN. BY -- | -- |
| DRAWN BY: -- | -- |
| CHECK. BY -- | -- |
| APP. BY: -- | -- |

CLIENT:

IBI GROUP

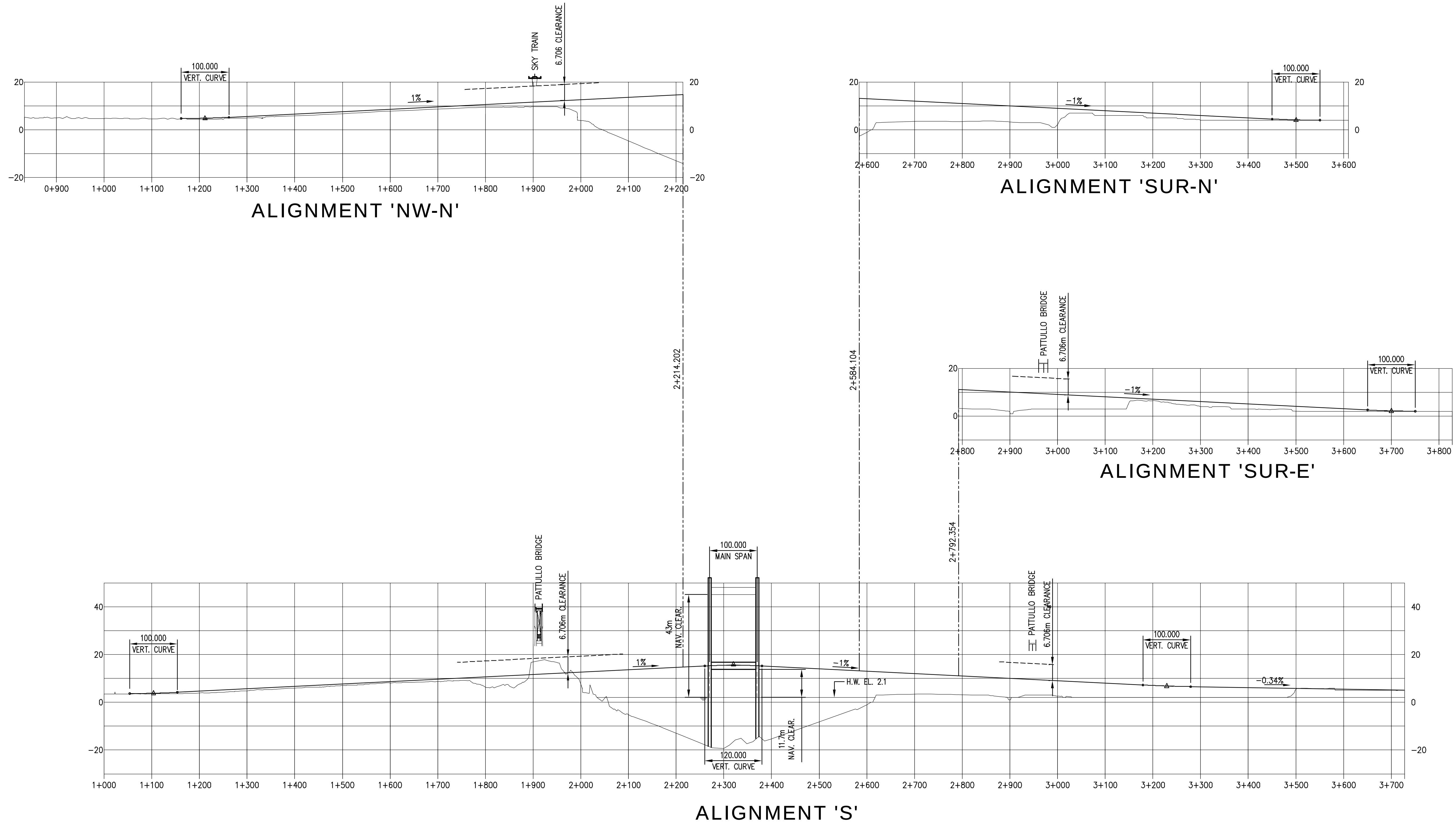
Hatch Mott MacDonald

GATEWAY RAIL INFRASTRUCTURE STUDY

SITE A – ALT. 2
NEW WESTMINSTER
NEW RAILWAY BRIDGE
PLAN

| PROJECT NUMBER | DRAWING NUMBER | REV. |
|---|---|---|
| -- | -- | -- |

ANSI D (864mm x 559mm) FULL SIZE

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| | | | ISSUE/REVISIONS | | | | ISSUE/REVISIONS | | |

| | | |
|---|---|---|
| SCALE: | -- | DATE |
| DESIGN. BY | -- | -- |
| DRAWN BY: | -- | -- |
| CHECK. BY | -- | -- |
| APP. BY: | -- | -- |

CLIENT: IBI GROUP

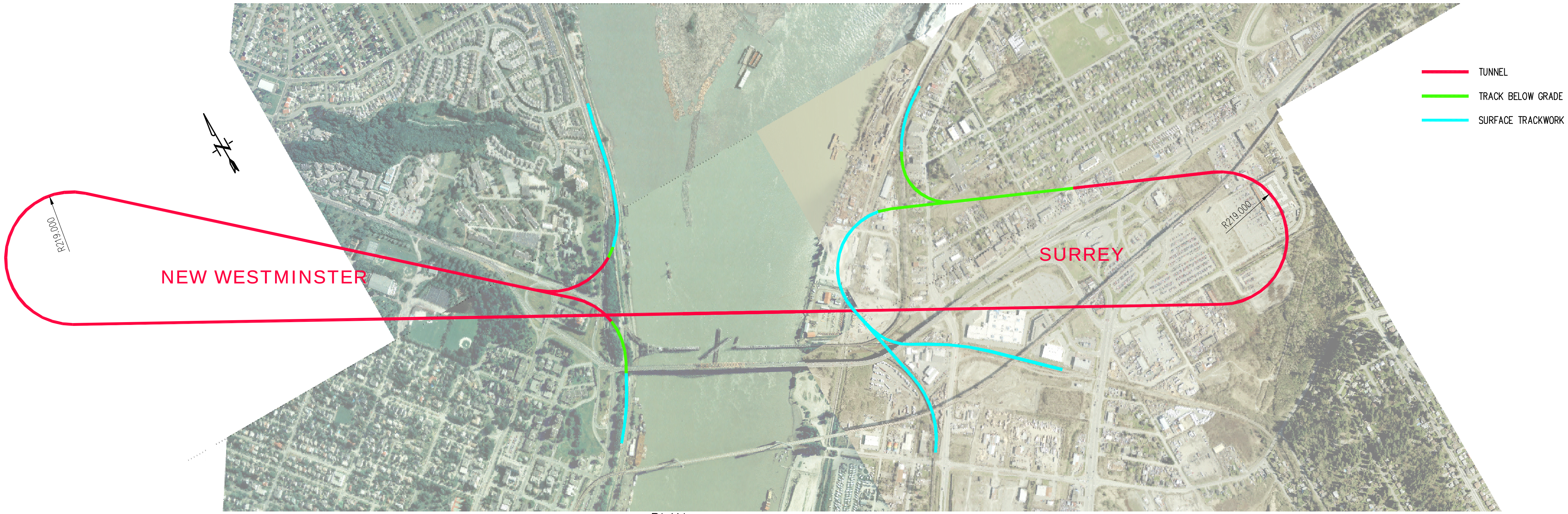
Hatch Mott MacDonald

GATEWAY RAIL INFRASTRUCTURE STUDY

SITE A – ALT. 2
NEW WESTMINSTER
NEW RAILWAY BRIDGE
PROFILES

| PROJECT NUMBER | DRAWING NUMBER | REV. |
|---|---|---|
| -- | -- | -- |

ANSI D (864mm x 559mm) FULL SIZE

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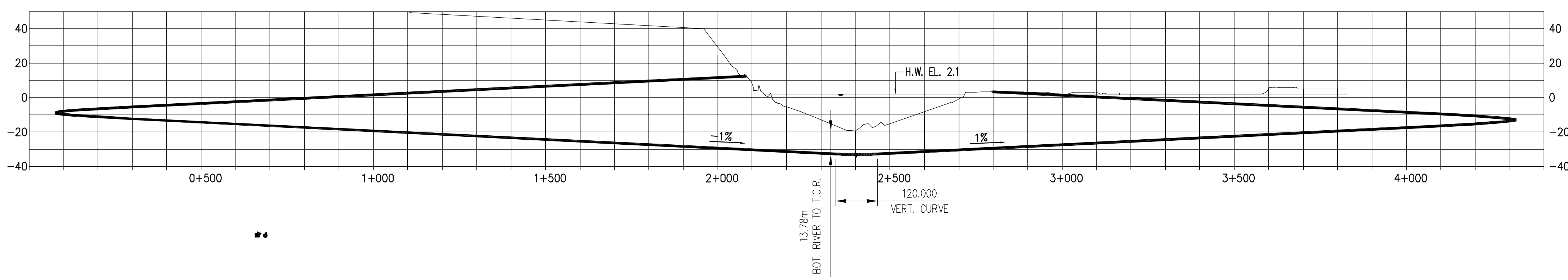


SECTION
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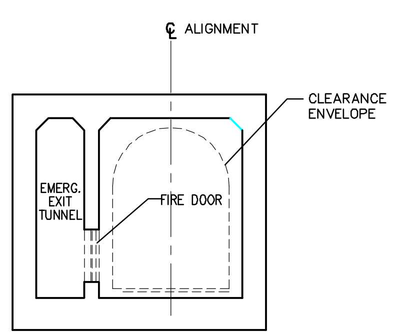
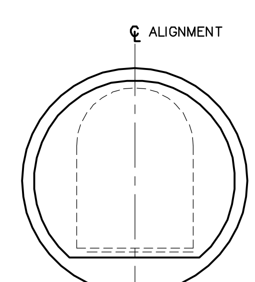
VERT. SCALE 1:3000




CUT & COVER SECTION (<17m BELOW GRADE)
SCALE 1:75




BORED SECTION (>17m BELOW GRADE)
SCALE 1:75


SCALE 1:15000

| DWG. NO. | REFERENCE DRAWINGS |
|---|---|

| NO | DESCRIPTION | BY | DATE |
|---|---|---|---|
| | ISSUE/REVISIONS | | |

| NO | DESCRIPTION | BY | DATE |
|---|---|---|---|
| | ISSUE/REVISIONS | | |

| | | DATE |
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IBI GROUP

Hatch Mott MacDonald

GATEWAY RAIL INFRASTRUCTURE STUDY

SITE A – ALT. 3
NEW WESTMINSTER
RAILWAY TUNNEL
PLAN, PROFILE, & SECTIONS

| PROJECT NUMBER | DRAWING NUMBER | REV. |
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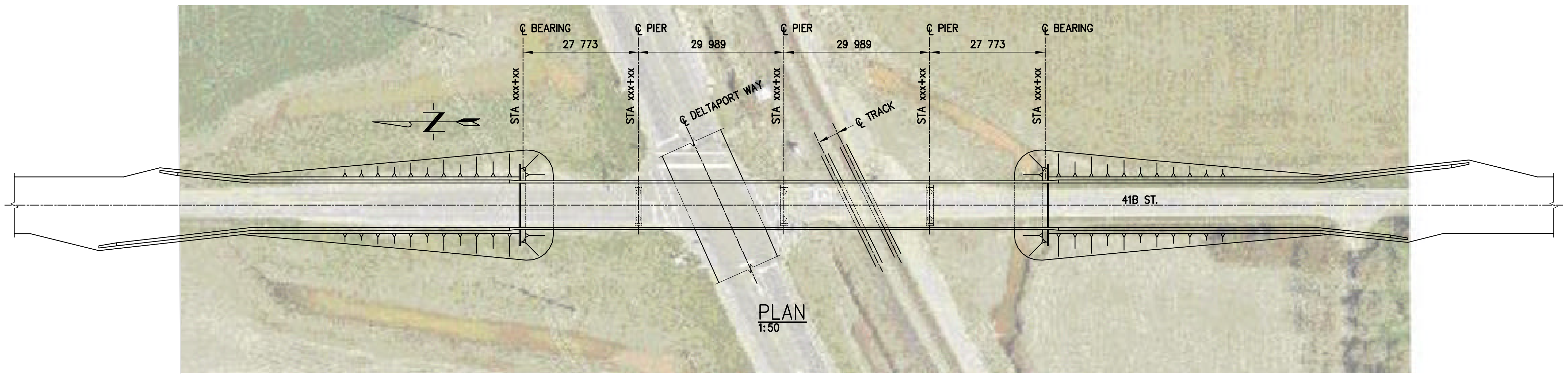


PLAN
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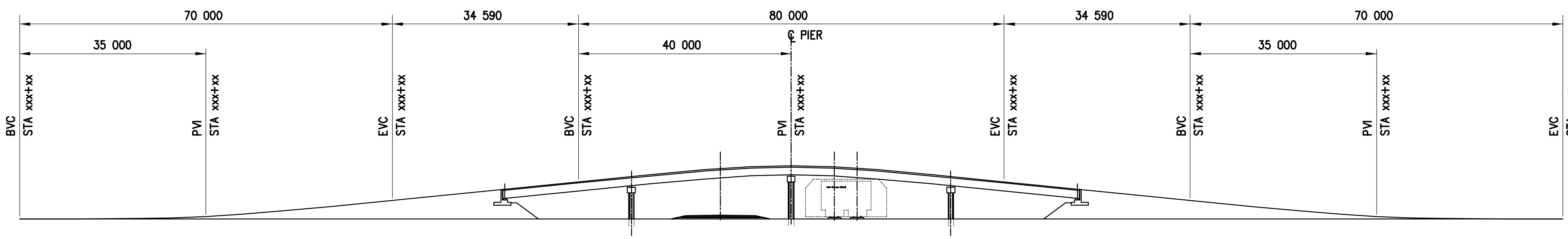


ELEVATION
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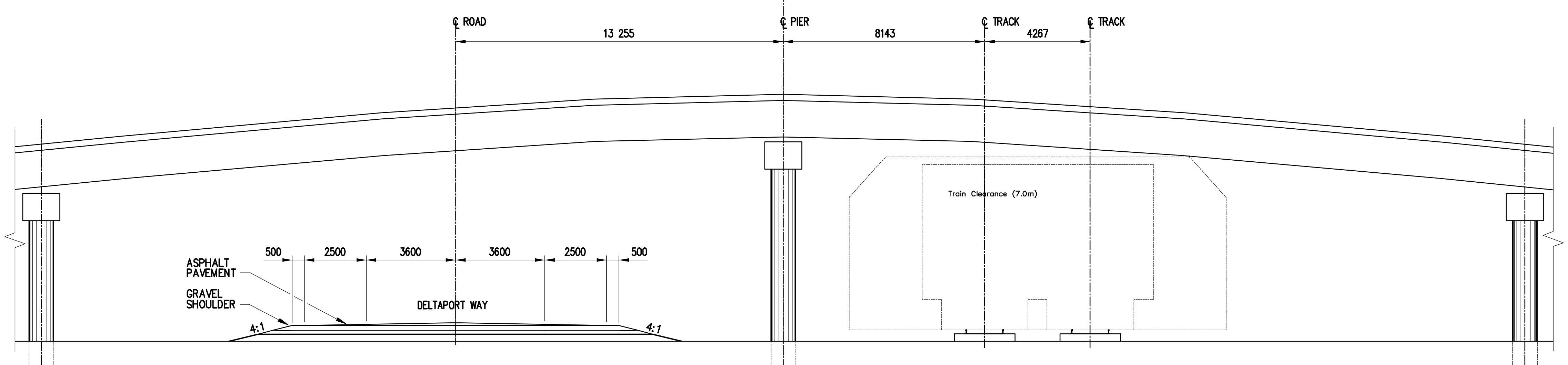


DETAIL
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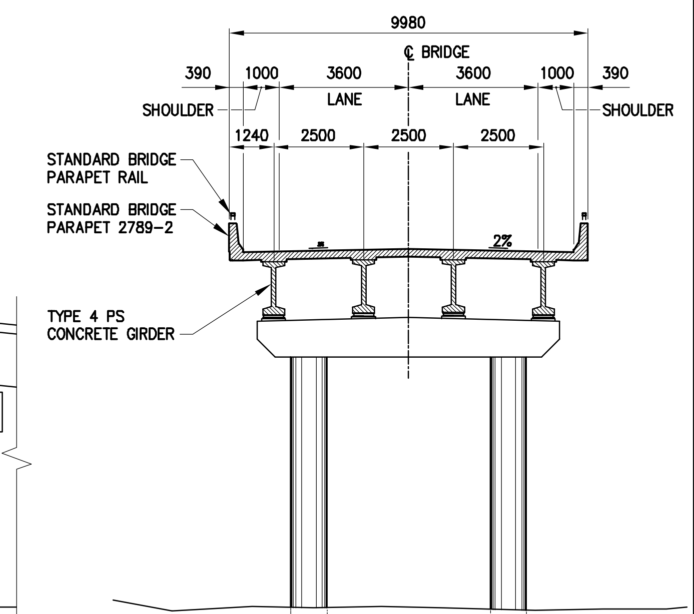


SECTION
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IBI GROUP

Hatch Mott MacDonald

GATEWAY RAIL INFRASTRUCTURE STUDY

SITE C
DELTA
41B ST & DELTAPORT
OVERPASS

| PROJECT NUMBER | DRAWING NUMBER | REV. |
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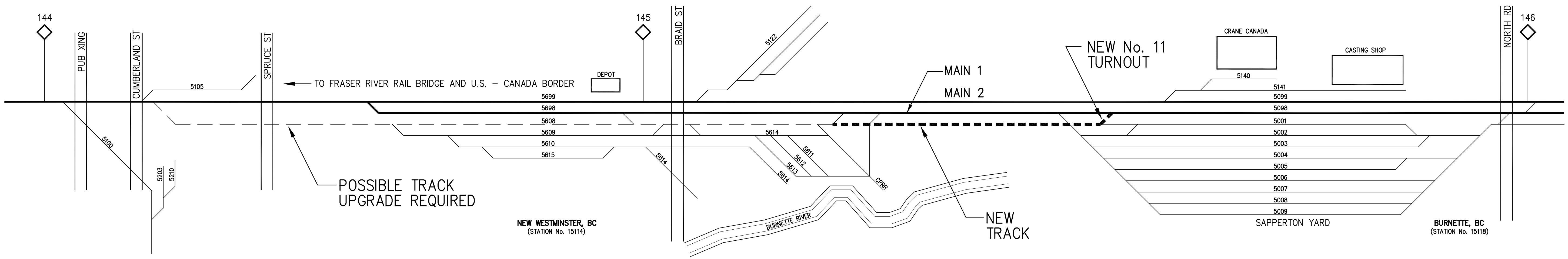
ANSI D (864mm x 559mm) FULL SIZE




## NEW WESTMINSTER, BC

M.P. 144.8
TRACK SCHEMATIC
(NOT TO SCALE)


KEY MAP

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IBI GROUP

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GATEWAY RAIL INFRASTRUCTURE STUDY

SITE E
NEW WESTMINSTER
SPRUCE ST–BN NEW YARD
DOUBLE TRACK

| PROJECT NUMBER | DRAWING NUMBER | REV. |
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IBI GROUP

Hatch Mott MacDonald

GATEWAY RAIL INFRASTRUCTURE STUDY

SITE F
DELTA
COLEBROOK NORTH SOUTH
8,500 FT. RAIL SIDING

| PROJECT NUMBER | DRAWING NUMBER | REV. |
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| 210532 | | |

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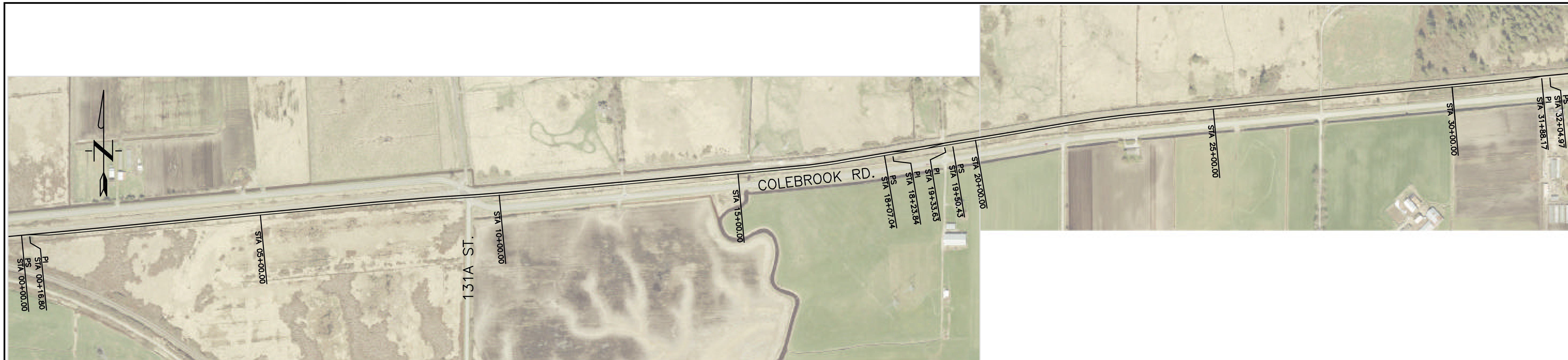
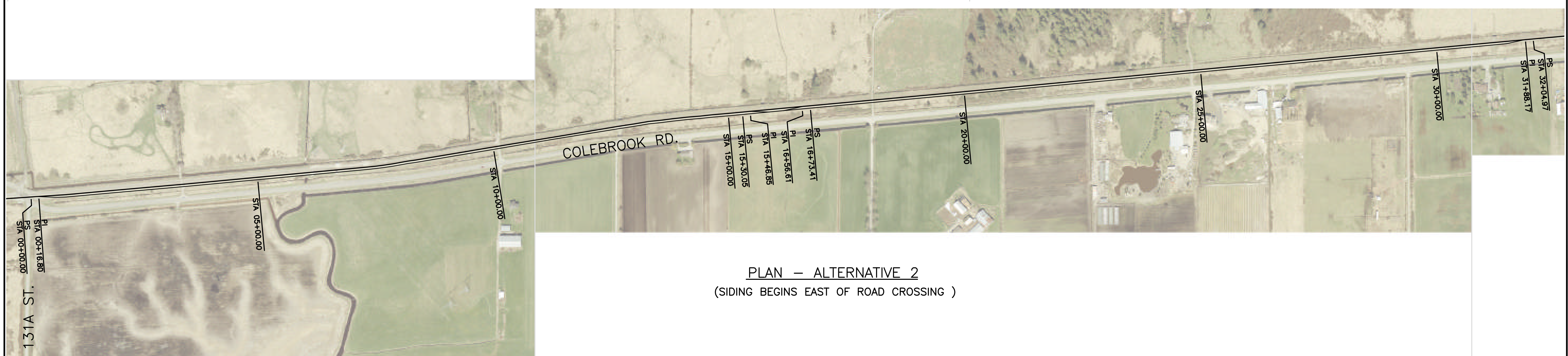



PLAN – ALTERNATIVE 1

(SIDING BEGINS WEST OF ROAD CROSSING )




PLAN – ALTERNATIVE 2

(SIDING BEGINS EAST OF ROAD CROSSING )

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IBI GROUP

Hatch Mott MacDonald

GATEWAY RAIL INFRASTRUCTURE STUDY

SITE G
SURREY
COLEBROOK EAST WEST
10,000 FT. RAIL SIDING

| PROJECT NUMBER | DRAWING NUMBER | REV. |
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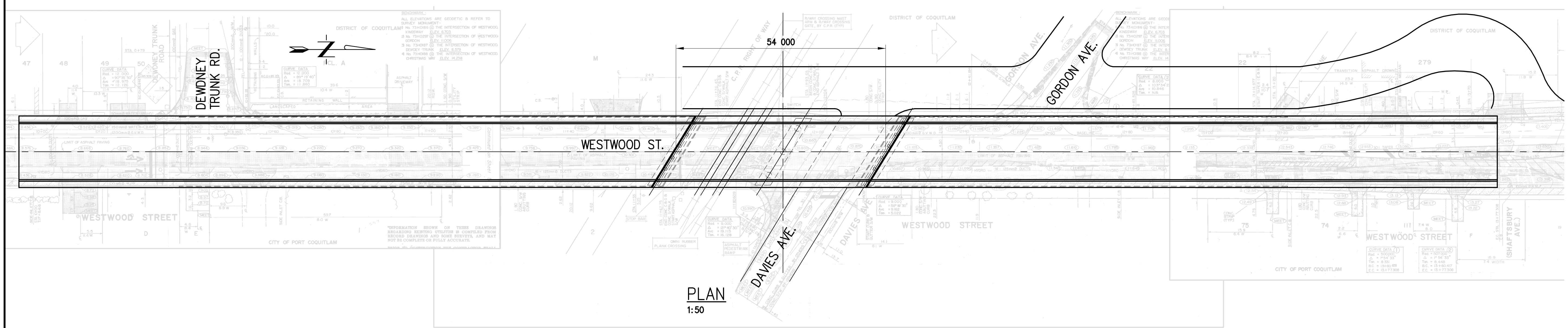
ANSI D (864mm x 559mm) FULL SIZE




PLAN
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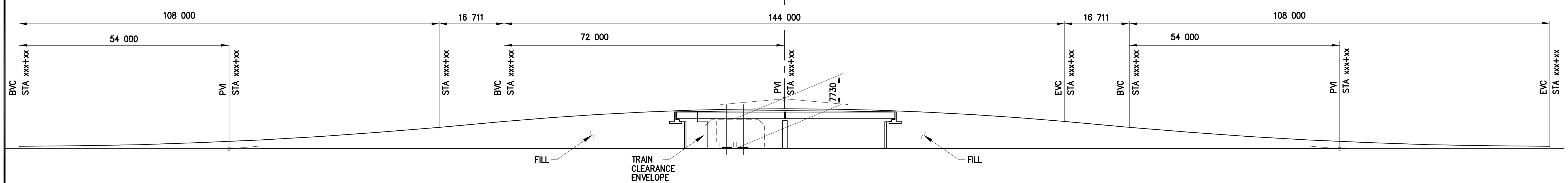
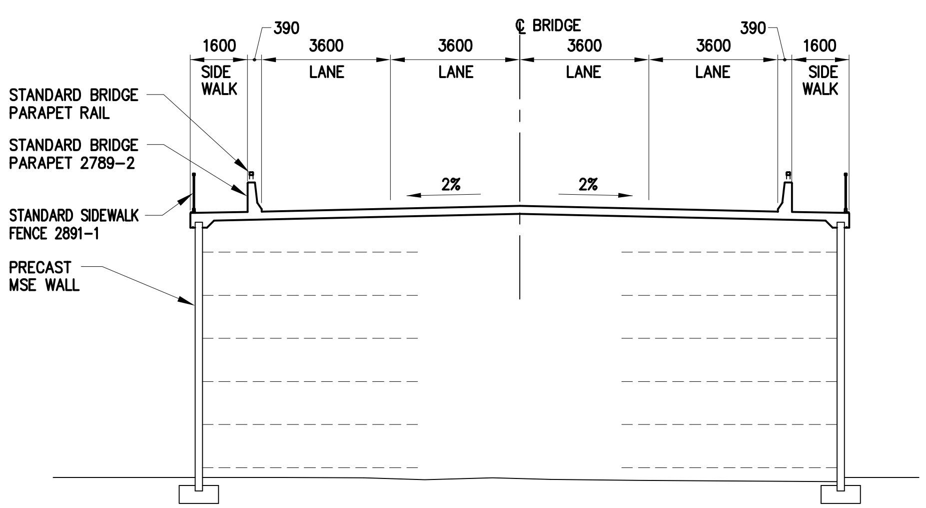



ELEVATION ( AT ROAD ℄ )
1:50

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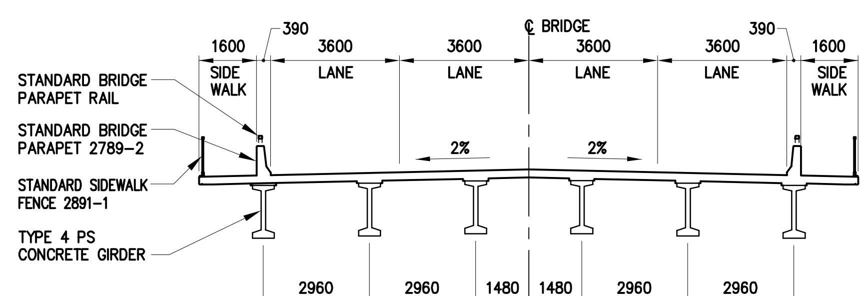


OVERPASS SECTION
1:10

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Hatch Mott MacDonald

GATEWAY RAIL INFRASTRUCTURE STUDY

SITE H
PORT COQUITLAM
WESTWOOD STREET
OVERPASS

| PROJECT NUMBER | DRAWING NUMBER | REV. |
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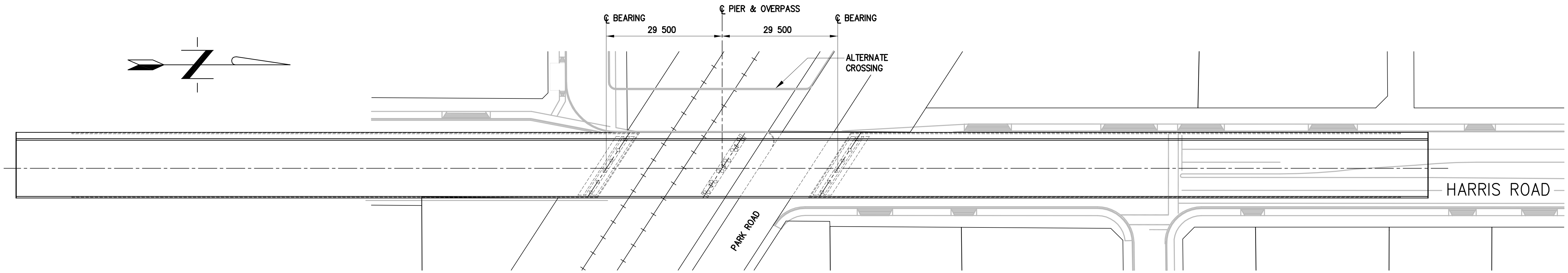
ANSI D (864mm x 559mm) FULL SIZE




PLAN
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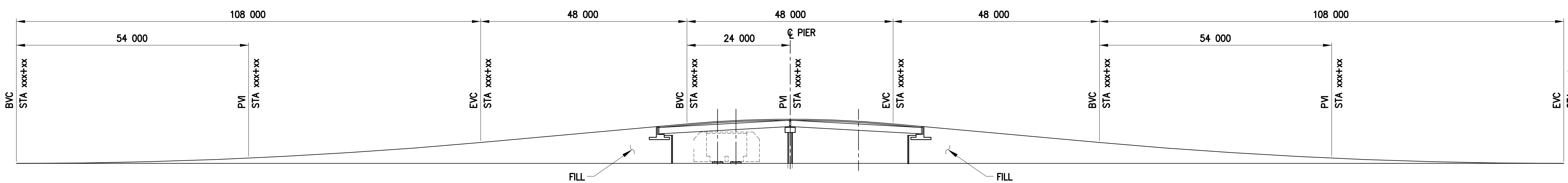


ELEVATION ( AT ROAD ℄ )
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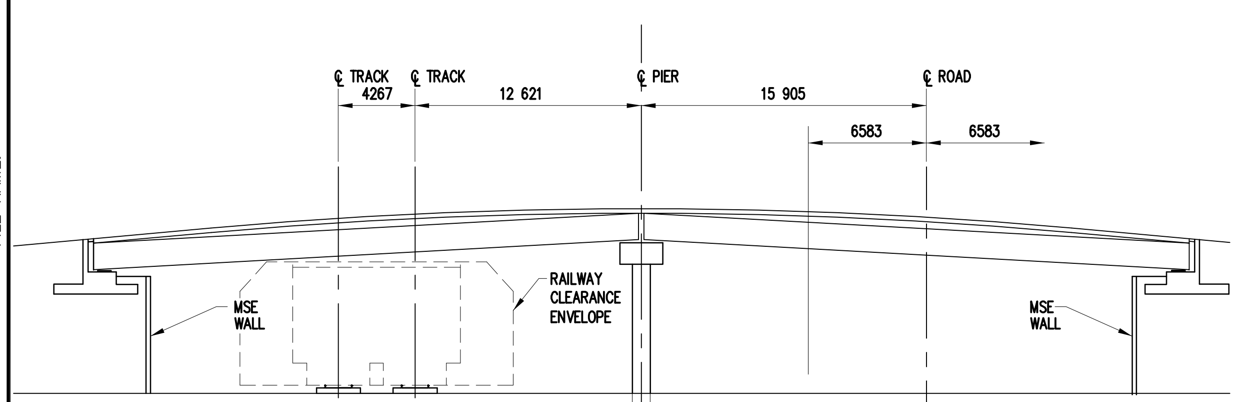


DETAIL
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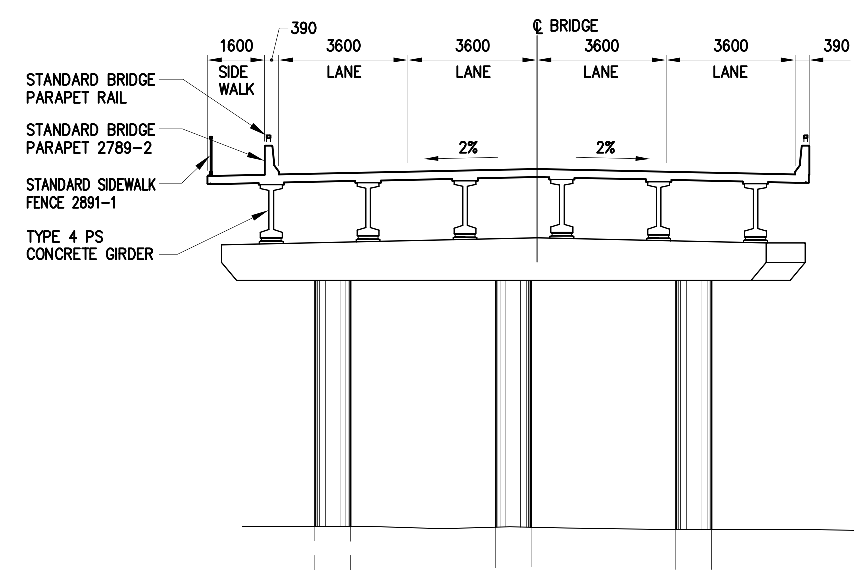
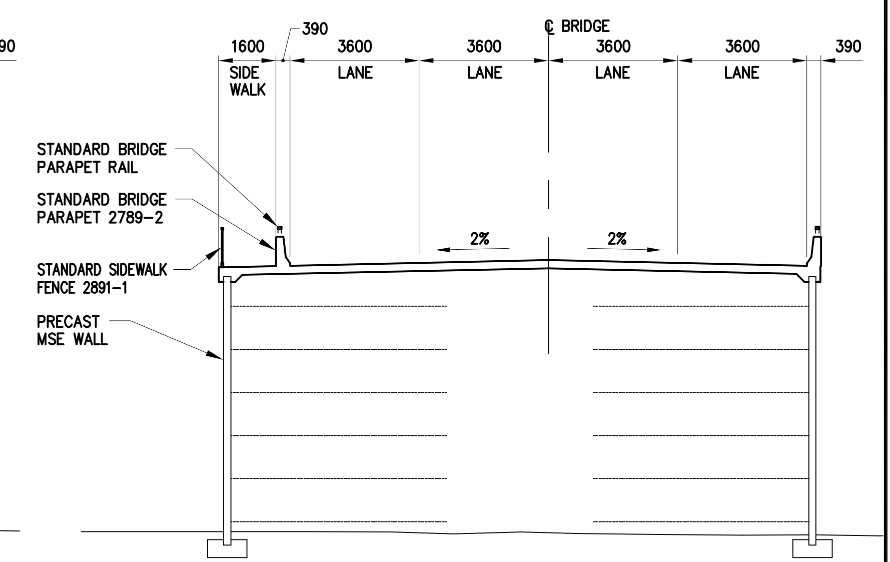



OVERPASS SECTION
1:10




APPROACH SECTION
1:10

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IBI GROUP

Hatch Mott MacDonald

GATEWAY RAIL INFRASTRUCTURE STUDY

SITE I
PITT MEADOWS
HARRIS ROAD
OVERPASS

| PROJECT NUMBER | DRAWING NUMBER | REV. |
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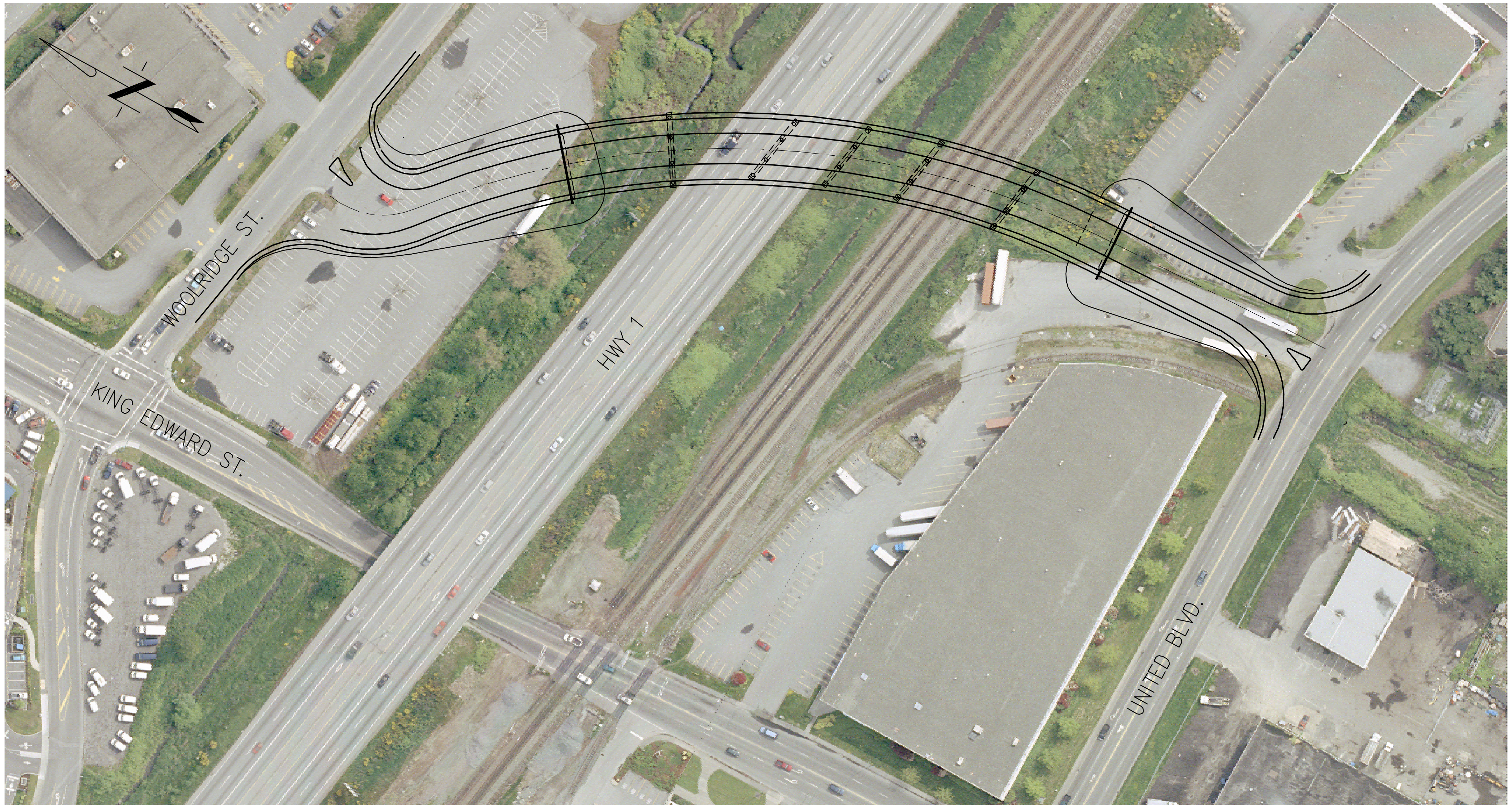
ANSI D (864mm x 559mm) FULL SIZE

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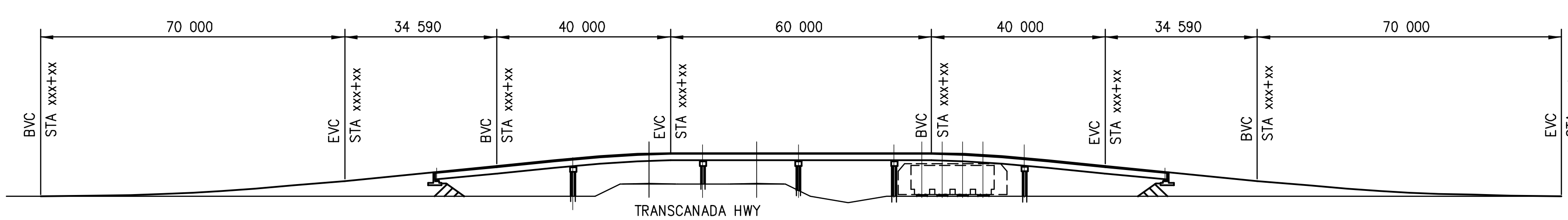


PROFILE
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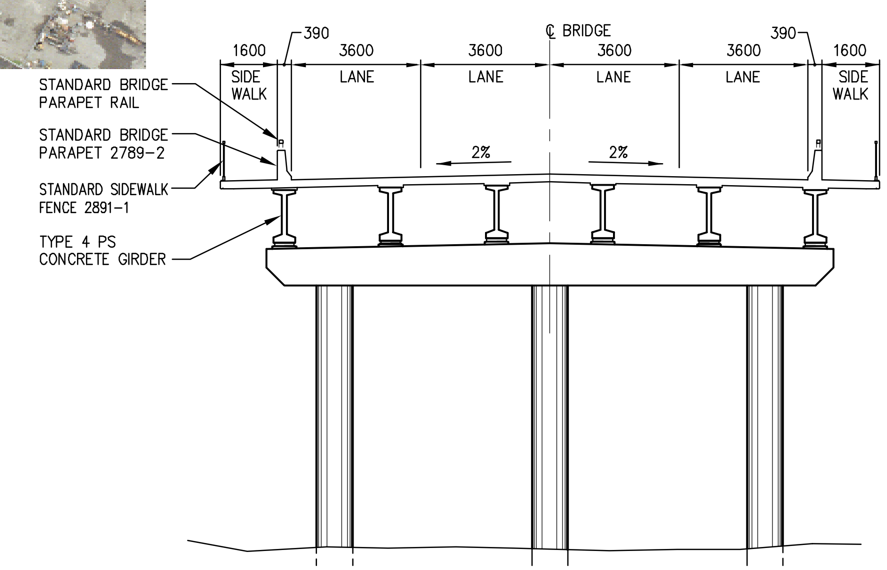


SECTION
1:10

PLOT DATE: 2004-05-31 10:23 USER NAME: str32974 FILE NAME: DXF_plans.dwg

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IBI GROUP

Hatch Mott MacDonald

GATEWAY RAIL INFRASTRUCTURE STUDY

SITE J
COQUITLAM
KING EDWARD ST. OVERPASS
PLAN, PROFILE & SECTION

| PROJECT NUMBER | DRAWING NUMBER | REV. |
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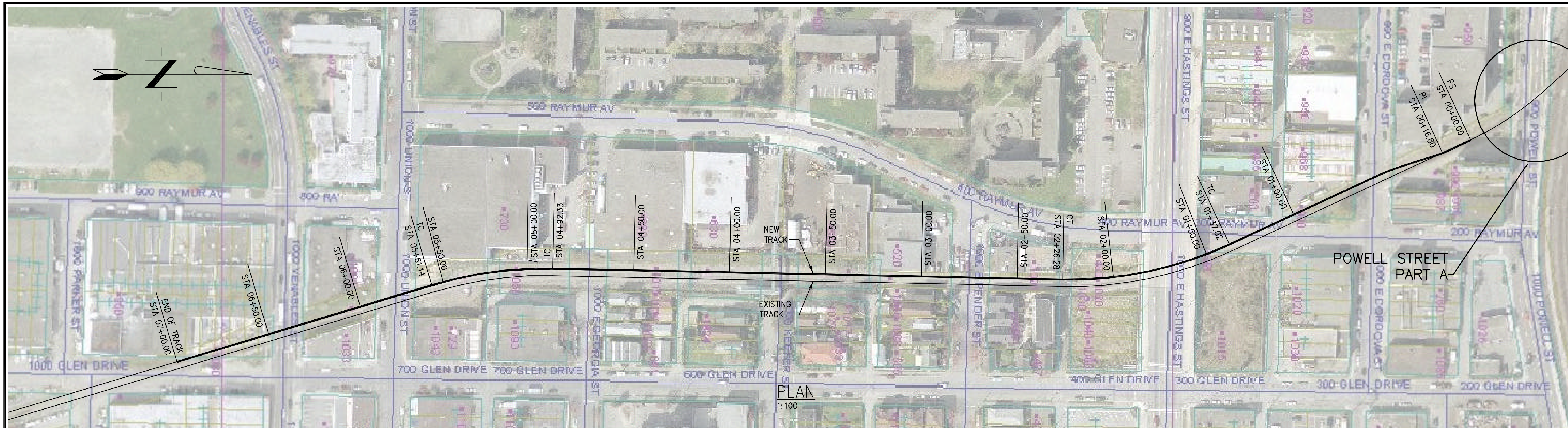
ANSI D (864mm x 559mm) FULL SIZE

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IBI GROUP

Hatch Mott MacDonald

GATEWAY RAIL INFRASTRUCTURE STUDY

SITE O – Part B
VANCOUVER
POWELL ST
DOUBLE TRACK

| PROJECT NUMBER | DRAWING NUMBER | REV. |
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ANSI D (864mm x 559mm) FULL SIZE

PLOT DATE: --
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PLAN
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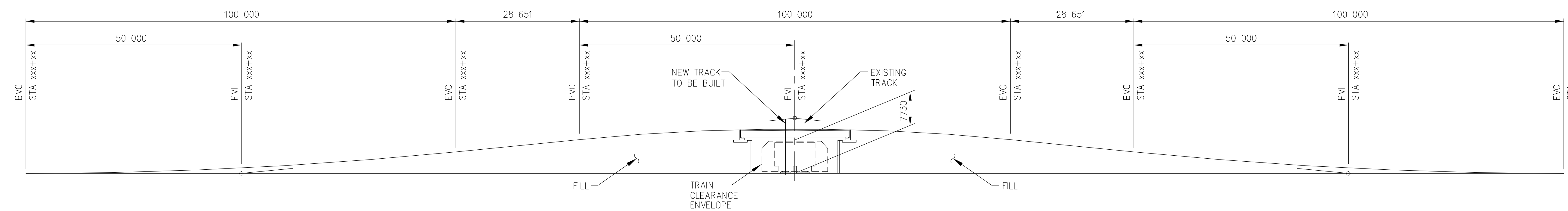
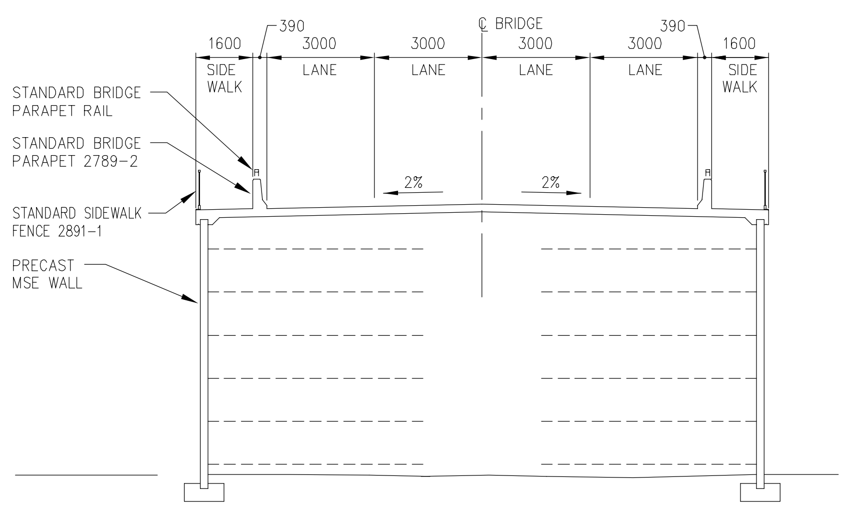



ELEVATION ( AT ROAD ℄ )
1:50




APPROACH SECTION
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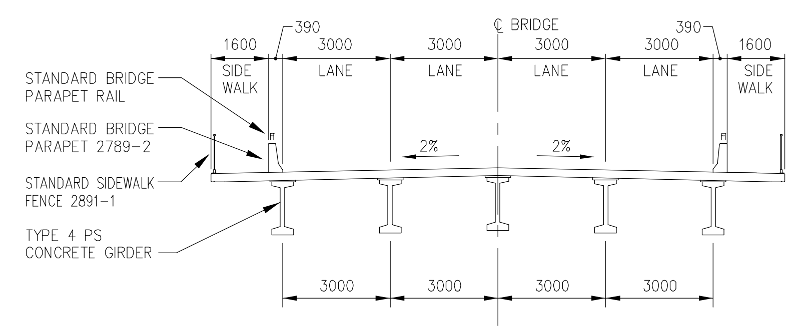


OVERPASS SECTION
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IBI GROUP

Hatch Mott MacDonald

GATEWAY RAIL INFRASTRUCTURE STUDY

SITE O – Part A
VANCOUVER
POWELL ST
OVERPASS

| PROJECT NUMBER | DRAWING NUMBER | REV. |
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ANSI D (864mm x 559mm) FULL SIZE


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IBI GROUP
Hatch Mott MacDonald

GATEWAY RAIL INFRASTRUCTURE STUDY

SITE P
BURNABY
BNSF–CN JUNCTION 8500 ft SIDING
PLAN

| PROJECT NUMBER | DRAWING NUMBER | REV. |
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ANSI D (864mm x 559mm) FULL SIZE

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# APPENDIX B

# Project Delivery Models

## APPENDIX B: PROJECT DELIVERY MODELS

This appendix elaborates on section 7.3.3 Spectrum of Delivery Models, which introduced several different delivery models. These models are listed in the diagram below which identifies the relative level of risk transfer from the public sector to the private sector. Following the diagram is a more detailed description of each model and how they could be applied to delivering new rail infrastructure.

**Spectrum of Delivery Models**

| **Public Sector** | ← | ***Risk Transfer*** | | → | **Private Sector** |
|---|---|---|---|---|---|
| Traditional Procurement | Design Build | Authority Model | Design Build Operate (Turnkey Ops or BTO) | Design Build Finance Operate (BOT or BOOT) | Design Build Own Operate (market approach) |

### Traditional Procurement

Under traditional procurement, referred to as design-bid-build, the public sector starts the project by hiring an engineering firm to design the bridge. Once the design is finalized, a new procurement process starts to select a general contractor. Construction then begins with payments made by the public sector to the general contractor based on monthly progress. While the cost of the project can be estimated in advance, it cannot be known for certainty until after the project is complete. Most risks are for the public sector account. The exceptions are those risks traditionally transferred to the designer or contractor, such as cost of materials and labour risk. After commissioning the public sector is responsible for operating and maintaining the bridge.

### Design-Build

Under a design build ("DB"), the government contracts with a private partner to design and build a bridge that conforms to the standards and performance requirements of the public sector. As the public sector more frequently uses the DB model, it could be considered a form of traditional procurement with more innovation. For example, a DB approach was used on the Millennium Rapid Transit Line.

Once the bridge is built, the public sector takes ownership and is responsible for the operation and maintenance of the facility. Payment can be upon commissioning or major milestones of the project, rather than on monthly progress. Often there are performance guarantees surrounding price and completion dates.

DB arrangements are not always considered PPPs, as the "partnership" element between the public and private sectors is short-term and limited in scope. However, they do represent an alternative to the traditional delivery model for infrastructure procurement. The value driver behind DB is the integration of design and construction that reduces approval steps and can facilitate and accelerate concurrent design and construction.

As well, greater freedom for creativity is afforded by the private sector partner through the use of a performance, rather than prescriptive, specification. The key to this element is that the private sector is told what is required, but not how to achieve it.

Depending on the environment in which a project is to be developed, the DB model can be expected to deliver a bridge faster, subject to fewer claims and cost overruns than traditional procurement. However, the DB model leaves some significant risks to the public sector. The primary risk stems from the usual circumstance that the private partner has no enduring vested interest in ensuring that the bridge will perform satisfactorily over the life of the bridge, as its responsibility for the facility will expire after a relatively short warranty period. This is referred to as whole-life cost risk and the impact of this risk could therefore result in much higher operating, maintenance and rehabilitation costs for the public sector than initially anticipated. If the project sponsors attempt to compensate for this drawback by increasing the detail of the specification and construction in a process for approvals, the benefits of DB could be diluted to the point where the savings over the traditional procurement approach are negligible.

**Authority Model**

Strictly speaking the authority model is a governance structure which has been employed in Canada in several different areas. For example the Federal government transformed the major airports and marine ports into authorities. These entities are responsible for operating and maintenance of their assets as well as raising capital for new infrastructure. At the provincial level there are authorities associated with transportation i.e. Translink and BC Ferries.

The authority model is shown in the middle of the Spectrum of Delivery Models in the exhibit above as it shares attributes of both private sector and public sector ownership. It is not controlled by a profit maximizing firm, while at the same time it is led by a board of stakeholders who are motivated to do act in the best interests of the authority and have the capability to budget over the long term as opposed to receiving a yearly allocation from the Government's Treasury department.

Under an authority model, an authority to build and maintain the bridge would be created by the Federal Government. The authority would be an independent organization whose sole purpose would be to deliver and maintain the bridge. If it is modeled after the airport authority model, it would be a non-share capital corporation led by a board which is not controlled by the Federal Government and which is structured to include stakeholder representatives. The authority has its purpose, board structure, powers, responsibilities and accountabilities established by special legislation. The authority has the ability to determine user fees and other defined revenue measures. It can incur debt which does not appear as part of the debt of any level of government.

With the respect to the delivery of a bridge, the authority is not restricted to any particular delivery method.

The authority model could also be utilized in the Joint Operations Scenario (Scenario #1). Such an authority would be responsible for dispatching trains within the Lower Mainland rail network and undertaking capital improvements to increase capacity as needed. Network users would pay for the capital improvements based on their usage and the benefits they derive from it. This would require railroad companies operating in the Lower Mainland to give up extensive autonomy over their assets. The Alameda Corridor project in California is an example of this type of structure (see Appendix C)

## Design-Build-Operate

Under a DBO, the government owns and finances the project but engages a private partner to design, construct and operate the facility for a specified period of time. The logical services to include in a bridge PPP are those that relate to the design, construction, operation and maintenance of the bridge.

To implement a DBO, the government establishes performance objectives and maintains ownership of the bridge. The private sector partner does not invest in the project and has limited financial interest in the project.

The DBO model is designed to compensate for the primary drawback of DB by having the private sector partner take on operational responsibility for the bridge after it is designed and constructed. By having the same private entity contractually obligated to deliver the bridge and maintain it, the cost of which are related to the successful delivery of the bridge, the interests of the private partner become aligned with those of the public sector. However, the benefits of risk transfer are limited since the private sector partner has limited capital at stake in this type of transaction, meaning it would not lose much if it walked away from the project because of problems incurred. There are ways to mitigate this drawback, for instance the private sector partner can be asked to provide performance guarantees. However, the more guarantees are required from the private sector partner, the more the delivery model will be like a Design-Build-Finance-Operate model which is discussed in the next section. Furthermore the guarantees have a cost and are usually limited and therefore provide limited assurance.

The competitive process for awarding a DBO is an important element of the arrangement. A DBO allows the private partner to optimize the total cost of service delivery by trading initial capital investments against operational needs over a long period. A competitive environment ensures that the benefits of this optimization are realized by the public sector.

## Design-Build-Finance-Operate

Under a DBFO, the private sector operates and **finances** the project. The private sector designs, constructs, finances, maintains and operates the bridge for a specified time, known as the concession period. Like the DBO, the government establishes performance objectives, however, under a well structured DBFO arrangement, the private sector has strong financial incentive to meet these performance objectives and the private capital invested in the project provides a form of insurance policy for the public sector. Although ownership usually rests with the private sector for the portion of the asset financed by them during the concession period, there are ways to structure the transaction so that the public partner owns the bridge. In any event, at the end of the concession period the bridge reverts back to public ownership.

The private sector finance associated needs to be repaid by a payment, which can come from bridge user and/or government. Payments could be based on tolls, shadow tolls or the availability of the bridge. One of the benefits of a DBFO structure is that the private finance brings an element of discipline, rigor and due diligence to the project, and this results in a higher degree of certainty of delivery in the long-term.

The public sector obtains financing at low rates, this is because the cost of its borrowing reflects the risk in the tax base, and the impact of project risk is not specifically taken into account unless the project is material relative the size of Government. In contrast, the cost of private finance appears higher because it is fully reflective of project risk. Therefore, it is not appropriate to consider just the face cost of finance. The cost of finance after the effects of risk transfer must therefore be considered and the projects should be evaluated based on their overall value for money.

For example if a traditionally procured public sector project has lower finance costs, but the public sector retains all risks, then any cost overruns will be borne by taxpayers. Under a DBFO structure the public sector does not finance the project and transfers substantial risk to the private sector. Therefore any cost overruns will not be borne by taxpayers, but rather by the shareholders of the private sector company.

Value for money in a PPP occurs when the expected risk-adjusted costs of the PPP are less than the comparable expected risk-adjusted costs of the same project in a traditional procurement. More than under a DB or a DBO, the public sector is rewarded for allowing the private sector to employ innovation and a whole life approach to costs.

### Design Build Own Operate (market approach)

Under a market approach the private sector is responsible for all aspects of the project, including design, construction, finance, operations and maintenance. In contrast to a DBFO, the public sector does not specify performance objectives (except perhaps on safety grounds) and it is not intended that asset revert back to public ownership in the future. The St. Clair tunnel between Sarnia, Ontario and Port Huron, Michigan is an example of rail infrastructure with a market approach (see Appendix C)

# APPENDIX C

## North American Rail Infrastructure Precedents

# APPENDIX C: NORTH AMERICAN RAIL INFRASTRUCTURE PRECEDENTS

## Alameda Corridor

The Alameda Corridor in California (“the Corridor”) is a 20-mile long multiple track rail corridor designed to link the rail facilities at the Port of Los Angeles (PoLA) and the Port of Long Beach (PoLB) with the main transcontinental rail networks of Union Pacific Railroad (UP) and Burlington Northern Santa Fe Railway (BNSF).

In addition to eliminating around 200 street level traffic crossings, capacity has been increased to 150+ trains per day. The current average is 38 trains per day, with 100 train movements per day projected for 2020.

The infrastructure is owned by the Ports and administered by the Alameda Corridor Transportation Authority (ACTA). The ACTA consists of representatives of the PoLA, PoLB, City of Los Angeles, City of Long Beach and the County of Los Angeles Metropolitan Transportation Authority

The cost of the project was in excess of US$2.4 billion and was funded from a combination of grants, federal loans and bonds. Construction commenced in April 1997, and operations began in April 2002.

UP and BNSF have perpetual use of the line, but have to pay User Fees to ACTA for the lower of 35 years or until all the debt has been repaid. The User Fees cease after this.

The fee structure was set by an agreement between ACTA, PoLA, PoLB, UP and BNSF and was approved by the parties in October 1998.

User Fees are:

- International containers: $15 per TEU when full (this charge is applied to all containers leaving the Ports by Rail whether they use the Corridor or not), $4 per TEU when empty only if they use the Corridor.
- Domestic containers: $4 per TEU, empty or full, only if they use the Corridor.
- Railcars: $8 per TEU, only when full.

These fees are indexed annually by the Consumer Price Index (CPI). Currently, approximately 96% of revenue is from containers.

A separate organization, the Rail Operating Committee (which consists of representatives of PoLA, PoLB, UP and BNSF) sets policy on operations, maintenance, dispatch, security matters etc.

The infrastructure is maintained by the maintenance contractor under a 5 year renewable contract with the Rail Operating Committee. Train operations are controlled by the dispatchers, also under a 5 year renewable contract with the Rail Operating Committee.

### St. Clair Tunnel

The project is a single track tunnel under the St. Clair River between Sarnia, Ontario and Port Huron, Michigan. It opened in May 1995 and replaced a parallel 104 year old tunnel, which was incapable of handling double stacked container trains. The new tunnel is 6,125 feet long.

Before the new tunnel, containers had to be unloaded and barged across the river and then reloaded onto trains.

The cost of the tunnel was Cdn $200 million and was entirely funded by CN.

### Shellpot Bridge

The Shellpot Bridge in Delaware is a swing style railroad drawbridge originally constructed in 1888 on timber piers. The timber framework was replaced by a concrete foundation in 1951. The total length of the bridge is 725 feet. Freight trains stopped using the bridge in 1994 because the bridge foundation couldn't support the loads.

The bridge needed US $13.5 million in repairs, which were paid for by State of Delaware. Norfolk Southern pays a variable toll for 20 years for the use of the bridge which ranges from $35/car for the first 5,000 that cross the bridge in the year to only $5/car after 50,000 car crossings.

With the bridge open, freight service to and from Port of Wilmington has been improved, eliminating costly delays.

### Sheffield Junction Flyover

This project is located in Kansas City, Missouri. It is 3.2 miles of double track bypassing four at grade rail intersections. The flyover not only eliminated delays at the third busiest rail intersection in the US (up to 200 trains a day), but has also allowed train speed at the intersection to increase from 15 mph to a max of 50 mph.

The project cost US $ 74 million and construction began in October 1998 and the flyover opened in July 2000. The project was undertaken as a public private partnership.

The three members of the partnership

1. Kansas City Terminal Railway (KCT) – a consortium of railroads that operate in the Kansas City area. The company provides dispatching services for member railroads whose trains come in and out of Kansas City.
2. KCT Intermodal Transportation Corp. (KCTI) – a joint venture of Burlington Northern and Santa Fe, Union Pacific, Norfolk Southern, Kansas City Southern, Gateway Western and I&M Rail Link
3. Missouri Highways and Transportation Corporation.

KCTI financed the project issuing industrial revenue bonds to KCT and the Missouri Highways and Transportation Corporation. The bonds are expected to be paid by 2020 from fees collected by the flyover's users, primarily Kansas City Southern Lines, Union Pacific Railroad and Burlington Northern Santa Fe Railroad.

**Chicago Region Environmental and Transportation Efficiency Project (CREATE)**

Chicago is North America's busiest intermodal hub. Over the next 20 years, freight volume in Chicago is forecast to increase by approximately 80%. If rail capacity constraints are not relieved, studies suggest that Chicago will lose US $2 billion in production over the next two decades.

CREATE is a public private partnership involving six class I railroads, city of Chicago, state of Illinois and the Association of American Railroads. The project identifies five key rail corridors, only one of which addresses passenger traffic. The plan is to build 25 highway-rail grade crossing separations, build six rail-to-rail flyovers; conduct extensive track and switch replacements and improve train control systems. The project has an estimated cost of US $1.5 billion and construction is tentatively planned to start in 2005 with a ten year build-out phase.

Construction on the project has not yet started and full funding has not been secured. Jointly the railroads have come up with $200 million in funding. The city and state have added funding, bringing the total to about $500 million. Project organizers are looking to the Federal Government for the remaining funding.

Under the CREATE plan, railroads will be making additional investment decisions based on what is best for the overall rail network. The railroads pay for the benefits they receive under the project and the city, state and federal government pays for the public benefits generated by the plan.