Highway 1/Vedder Interchange Reconstruction Project

Problem Definition

Highway 1, as part of the Trans-Canada Highway (TCH), passes through the Chilliwack area approximately 90 km east of Vancouver in British Columbia. The highway severs the communities of old Chilliwack (to the north) and South Chilliwack (to the south). There are four north-south crossings of the TCH in Chilliwack (Prest, Young, Vedder and Lickman), each being a 2 lane grade-separated facility.

Chilliwack has experienced significant and sustained growth over much of the past decade, resulting in increased congestion on its arterial road network. The need for increased crossing capacity across the TCH in order to improve connectivity and access between the communities has become critical.

A planning study, jointly funded by Chilliwack and the Province in 2000/2001, recommended four-lane crossings of the TCH at Prest, Young, Vedder, and Lickman, and a two-lane crossing at Evans by 2020. Vedder Road, a key arterial providing access to recreation, parks, downtown and major commercial/retail developments, is the most congested of the routes. Reconstruction of the Highway 1/Vedder Road interchange (Vedder I/C) as a full movement 4 lane interchange was identified as being the highest and first priority for improving safety and capacity.

The Vedder I/C was built in 1958 and is showing its age. It is a full cloverleaf type and is constructed with old and outdated standards. The underpass is a narrow two-lane bridge with high curbs and a narrow sidewalk. It is structurally sound and wide enough to accommodate two lanes in the same direction.

The Interchange has serious safety deficiencies on all four ramps. It has a very high number of collisions and is ranked as one of the worst along the TCH corridor between 160th (Greater Vancouver) and Hope. Ramp deceleration and acceleration lanes are significantly below standard, and radii of the ramps are very tight. Because of the short weave distances and the tightness of the loops radii, traffic coming on and exiting must do so at very low speeds relative to the through traffic speed. The speed differential poses a safety concern, especially as traffic volumes reach a critical level. Another problem associated with the Interchange is the multiple exit and entrance points that affect the operation of the TCH. Also, unless additional capacity is provided on Vedder Road, immediately north and south of the interchange, future traffic congestion and queuing will detrimentally affect and interfere with the performance of the interchange.

Traffic volumes through the Highway 1/Vedder Road interchange (Vedder IC), have grown over the past decade to a point that performance is poor and congested. Population growth and economic development in the area will continue to exacerbate the situation. Current and forecasted traffic volumes for the subject area are as follows:

Location	AADT 2001	AADT 2020
Vedder Road (north of Interchange)	27,000	30,000
Vedder Road (south of Interchange)	30,000	42,000
TCH Hwy 1 (west of Interchange)	22,500	36,000
TCH Hwy 1 (east of Interchange)	14,000	30,000

Background

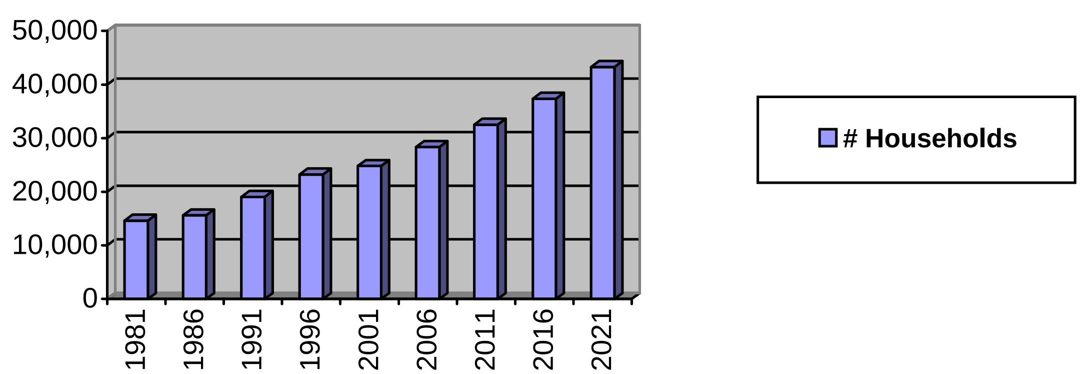
Chilliwack: Growth and Development

The current population of Chilliwack is estimated at 68,000. Over eighty-two percent of the population lives in urban communities or suburban neighbourhoods, and the balance reside in the rural hillsides and farming areas.

Chilliwack went through two growth spurts in the last 25 years – from 1979 to 1981 and from 1987-1994. From 1981 to 2001, Chilliwack grew at an average of 2.5% p.a. By 2010, its population could reach the OCP's target of 85,000.

The population growth is primarily driven by migration from the Greater Vancouver Regional District (GVRD), with interregional migration accounting for up to 80% of the growth in times of boom. Many residents commute to work in GVRD, and although this pattern will continue as part of its population growth, many migrants are being attracted to Chilliwack by local employment opportunities. The economic attraction reflects successes in economic development and coming-of-age as a medium-sized community.

Chart 1 Growth in No of Chilliwack Households



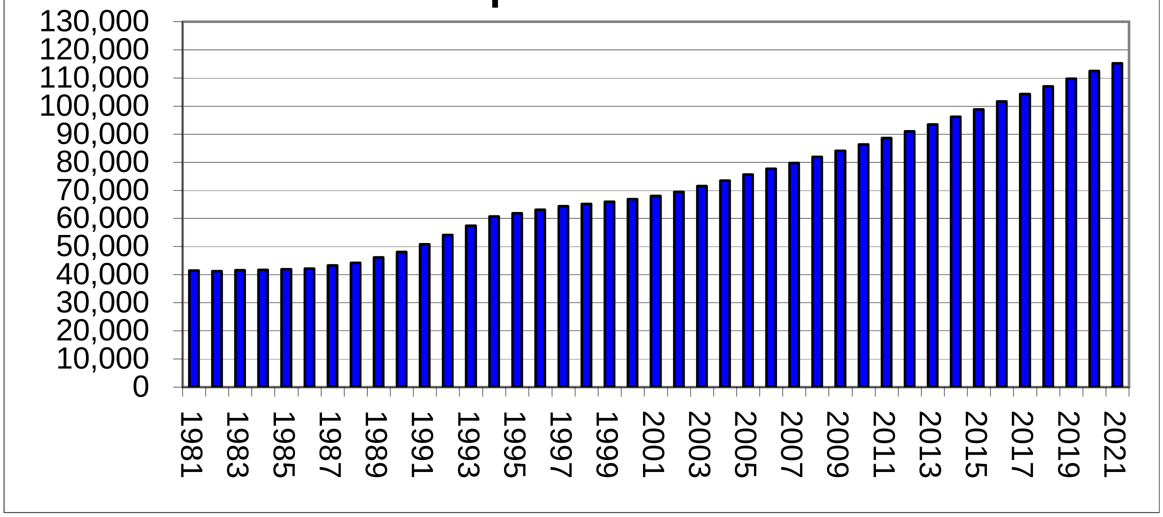


Chart 2 Chilliwack: Historic and Projected Populations

The growth of Chilliwack has manifested in its property assessment. Since 1986, property assessment in Chilliwack has grown from $1.4 billion to $4.5 billion, a three-fold increase. As expected, much of the growth has occurred in the residential sector, which now constitutes over 70% of the assessment total. (Charts 4 &5). The assessment peaked in 1994 and has since stay close to that level despite a real estate recession that caused a drop in real estate values of 12-30%, attesting to the strength of the City's growth and development. Chilliwack is optimistic about its future, and is earnest in planning infrastructure development to meet the future challenge of growth.

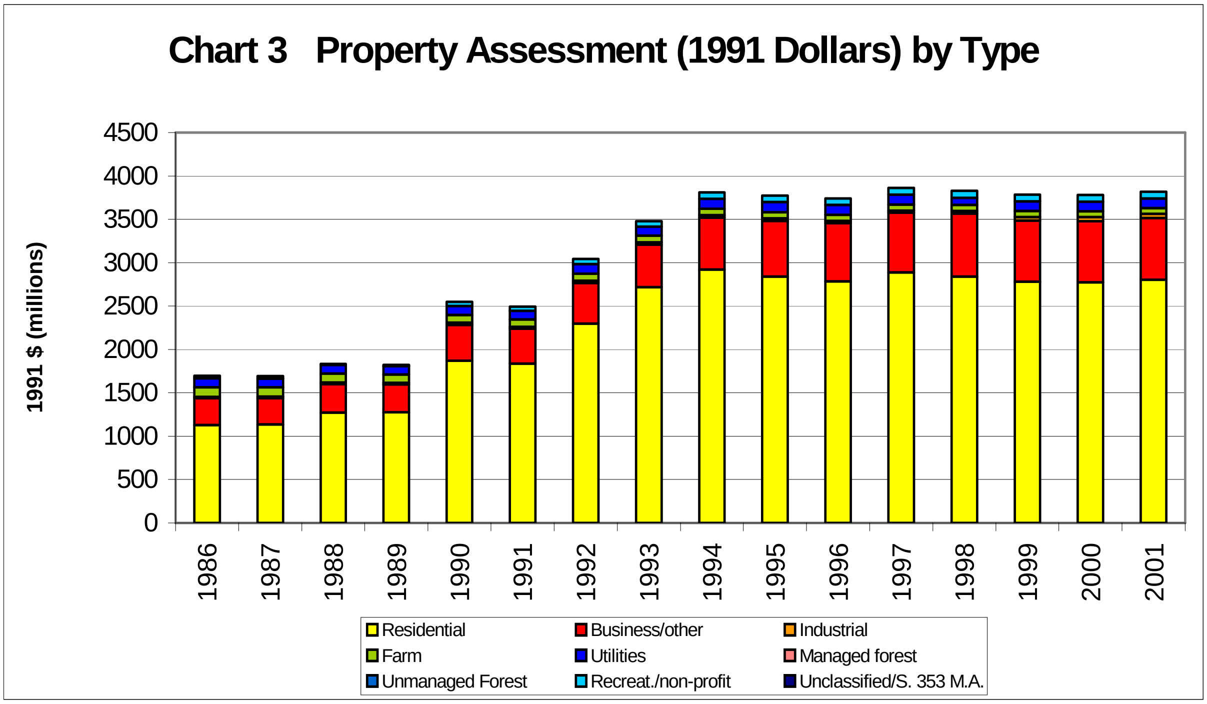


Chart 3 Property Assessment (1991 Dollars) by Type
1991 $ (millions)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Residential
Business/other
Industrial
Farm
Utilities
Managed forest
Unmanaged Forest
Recreat./non-profit
Unclassified/S. 353 M.A.

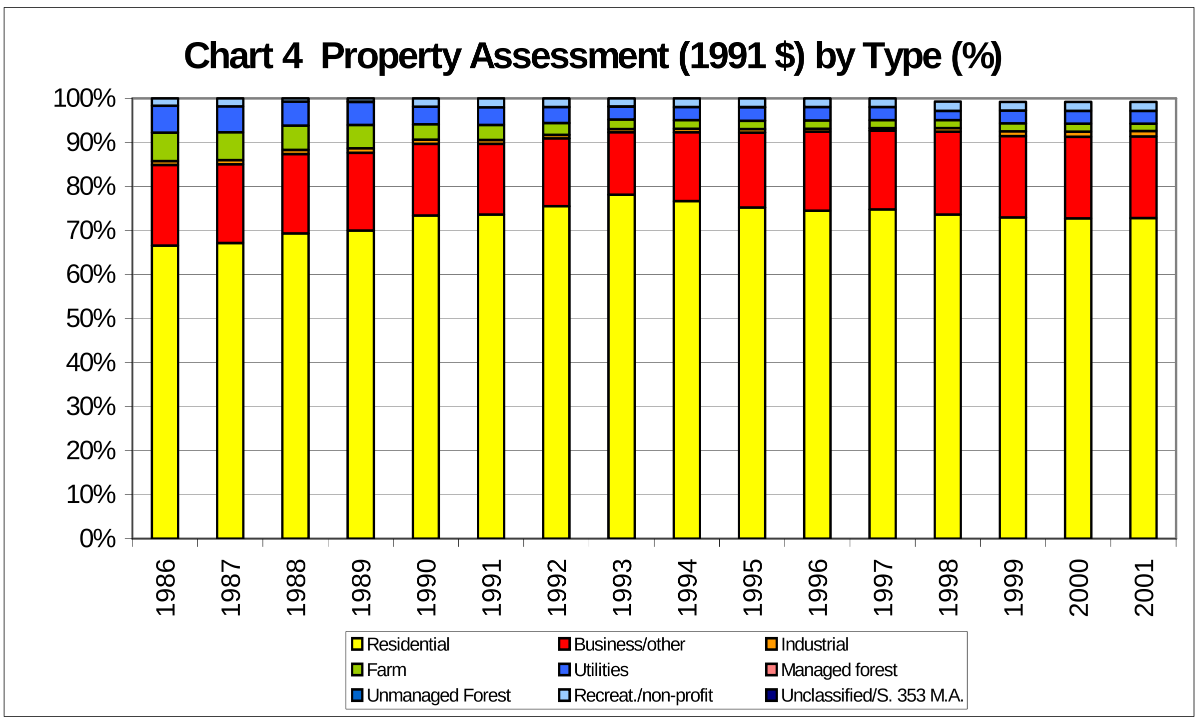


Chart 4 Property Assessment (1991 $) by Type (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Residential
Business/other
Industrial
Farm
Utilities
Managed forest
Unmanaged Forest
Recreat./non-profit
Unclassified/S. 353 M.A.

Potential Societal Benefits

There are significant Provincial, Federal and Municipal benefits to this project, including the following:

- Improved air quality and more efficient use of energy use due to a reduction of idling and stop and go traffic situations.
- Improved safety, performance and reliability to the municipal road network and to the Trans Canada Highway, including decreases in traffic accidents, injuries and fatalities.
- Safety improvements in event of earthquake since the new structure would be built to current seismic standards. Provides local community access across the bridge for emergency vehicles, and provides provincial/federal benefits since the bridge crosses the disaster response route.
- Intermodal benefits, including safer pedestrian and cycling access across the bridge due to dedicated lanes.
- Travel time benefits, both cross-region and national. Benefits including removing ‘friction’ from the interchange and highway as well as improved crossing capacity of Vedder, a vital corridor, across the TCH.
- Supporting economic development in the area. Opportunities include tourism due to easy access off highway for shopping, parks, recreation, camping and hotels, the potential development of the former CFB Chilliwack Base, improved opportunities for nearby First Nations, and improved access to downtown and government services.

<u>Option Generation</u>

Option (1) Vedder Interchange Improvement- This option provides for four lanes, plus turning capabilities, for the interchange structure. Six lanes are provided on Vedder from each of the interchange ramp heads to Yale Road West and Luckakuck. The concept is based on a recommended option from the functional design work undertaken by ET Consulting and UMA. The option used for analysis does not include the eastbound off-ramp connection to Topaz.

Option (2) Two Lane Evans Overpass- This option includes a new two-lane overpass from Yale Road to Luckakuck, with limited access at Luckakuck. The option analyzed does not include TCH on and off-ramps.

Option (3) Four-Lane Evans Overpass – This option is the same as above except it includes a new four-lane overpass from Yale to Luckakuck. The concept is based on a recommended option from the functional design work undertaken by ET Consulting and UMA.

Option (3) was dismissed because the incremental benefits relative to costs from moving from the two lower costs options are minimal. More specifically, (as can be seen by reference to Figure 1), the cost of the four lane Evans option is about $10 million more than the two-lane version, and thus the benefits of the four lane option would need to increase by over $13 Million just to approach the *"Net Present Value"* of the recommended Vedder option. Alternatively, in order to achieve the *"Cost-Benefit Ratio"* of the Vedder option (at 4.160), the upgrade from the two lane version to the four lane version of the Evans Overpass would need to generate over $20 Million of additional benefit.

Also, Option (3) was not felt to be equivalent to the other options in that it provided additional crossing capacity that was not comparable (i.e. 4 lanes vs. 2 lanes additional).

Methodology

A ***Consumer Surplus***[1] approach was used to evaluate the respective options. This approach is superior to the ***Cost-Difference*** approach for projects/evaluations where there are network implications. Micro-BENCOST is designed to model only the Cost-Difference approach where there is limited or no induced travel (or changes in travel behaviour) resulting from the proposed improvements. More specifically, this approach does not accurately capture network or induced travel implications. Appendix 1 provides a more in-depth description of "Consumer Surplus" methodology.

Even though ***Consumer Surplus*** methodology was used rather than Cost-Difference methodology of Micro-BENCOST, the default values of Micro-BENCOST were used for analysis purposes. More specifically, the prescribed discount rate of 6% as well as all other values in the ***"Micro-BENCOST Guidebook: Defaults and Standardized Analysis For Highway Improvement Projects In British Columbia***[2]***"*** was used for analysis purposes.

Option Evaluation

Financial Account[3]:

- Construction Costs – A cost estimate for the interchange was developed using the Wolski[4] spreadsheet methodology. This method tabulates construction costs using a quantity take off system extended by unit rates. It then applies factors to the construction costs to develop soft cost items such as design, engineering, project/program management, resident engineering and contingency. Standard MoT unit rates and factors were used in this estimate. Costs for the Vedder Road Interchange have been included from the north side of the Luckakuck Way intersection to the south side of the Yale Road intersection. All of the interchange ramps have been included in the cost estimate. The City of Chilliwack provided land

[1] This approach assumes network implications (changes in travel behaviour) with their corresponding induced travel implications.
[2] 1998
[3] Costs provided UMA.
[4] Cost-estimating methodology named after its creator, Ernie Wolski of E. Wolski Consulting. .

acquisition costs. The cost estimate is in 2002 dollars. Costs for the 2-lane Evans Road overpass were also developed in a similar manner by UMA using the Wolski spreadsheet methodology.

- Property Costs- the costs in the table below were prepared by UMA, unit costs were provided by the City of Chilliwack. The property costs identified in Figure 1 (below) include the costs required for right-of-way acquisition but are not offset by the cost recovery related to surplus land sales. For additional details regarding property costs, UMA prepared a report entitled *Chilliwack's Interchanges Project Development, January 2002*.

- Maintenance and Rehabilitation- road, bridge and signal maintenance costs were based on Ministry costs for the year 2000. Rehabilitation costs are from Ministry of Transportation's "Construction and Rehabilitation Estimating Book", February 1997.

Annual Maintenance Costs

Item	Amount	Units
Road	13,581	$/lane-km
Signal	3,600	$/signal
Bridge	7.3	$/sq.m.

Rehabilitation Costs

Item	Hot Mix	Cold Mill
$ /lane-km.	50,000	25,000
Year	15	7

- Salvage – salvage value was assumed to be 24% of the combined construction and property costs. The apportion value was derived from a review of several regional projects proposed for the Lower Mainland (Lower Mainland Systems Level Analysis-Stage 2)

Customer Service Account (Benefits)

- Travel Time Savings – Using the consumer surplus approach these benefits were calculated for the period modeled, the 2020 afternoon peak hour. These results were then factored up to represent a day, then a year respectively. Factors of 8.6 and 300 were used to convert the afternoon peak hour to a day and a day to a year. The factor to convert the afternoon peak hour to a day was derived based on Chilliwack traffic count data. Annual benefits were then taken over the 20 year analysis period and discounted back to the investment year at 6% per annum.
- Vehicle Operating Cost Savings – These were calculated as a proportion of travel-time savings. The ratio apportioning values were derived from recent Ministry regional studies that incorporated a consumer surplus approach (Lower Mainland Systems Level Analysis- Stage 2)
- Accident Costs Savings - These were calculated as a proportion of travel-time savings. The ratio apportioning values were derived from recent Ministry regional

studies that incorporated a consumer surplus approach (Lower Mainland Systems Level Analysis- Stage 2). As the calculation of accident savings on a link-by-link basis that is aggregated up to a network level would entail significant financial resources, the apportioning method was adopted by UMA as a crude estimation of potential accident savings. The accident savings would be created through improved design, redistribution of traffic and thus decreased exposure, and fewer rear-end specific accidents. However, there is usually an offset to these accidents savings that is attributable to increased speed. More specifically, this offset has been addressed through the Consumer Surplus approach in that the accident savings attributable to the improvements are much larger than the offset due to increased speed.

Economic Indicators (COST BENEFIT ANALYSIS: Financial &Customer Service Accounts)

- The Net Present Value of both options are favorable, although the Vedder Interchange upgrade generates a much better NPV of $28 Million. However, from a Benefit-Cost ratio perspective, the difference between the Vedder project coefficient of 4.2 and the coefficient for the Evans Road project of 4.8 is small and probably statistically not valid. Furthermore, on large projects, the proper measure is the NPV with only secondary importance to the B/C ratio. The B/C ratio will always favor small projects. NPV measures the net incremental benefit to society not the comparison of costs relative to benefits. Nevertheless given fiscal constraints the B/C ratio should still be used as a secondary decision-making tool. In other words, since the NPV of the Vedder option exceeds the NPV of the Evans option, and the two options have similar B/C ratios, then the preferred option is Vedder option. An additional consideration here is that the Evans 2 lane option , unlike Vedder, has no access to the TCH and as a flyover is primarily a municipal element providing minimal provincial and federal benefits.

- It should also be stated that another (unquantified) benefit of this project is that considering the significant improvements being undertaken, disruption to the road user during construction is very reasonable. It is expected that impact to users on key movements such as the SB to EB ramp and through traffic on Vedder and TCH will be minimal. Transportation economics is beginning to incorporate disruptions during construction. In fact, there have been some estimates from US studies indicating that, the disruption costs of some projects are never recovered throughout the subsequent useful life of the improvement. It should also be remembered that disruption costs for truck traffic also carry a higher premium than for automobile traffic, and thus are particularly important for trucking and goods movements.

Economic Development Account

- As can be seen by reference to Appendix 1A and 1B, there are economic development benefits from investment, in terms of employment and contribution to provincial GDP. More specifically, by applying the Ministry of Finance multipliers (and appropriate recycling rate) to the respective investments, it is estimated that 203.4 Person Years of employment will be created and $24.4 Million of economic impacts will be generated by the Vedder Interchange[5]. The moderate economic development benefits of this project are consistent with the empirical “Diminishing Marginal Utility” aspect of transportation economics. More specifically, the largest economic development benefits are to be found for those projects where access is created, an impediment to growth is eliminated, or new opportunities are created. This is in contrast to projects such as the proposed Vedder Interchange or Evans Road projects, where the improvement merely provides added capacity or enhances the performance of existing infrastructure and networks, and thus only limited new opportunities are created. Nevertheless, the following opportunities are possible:

- Increased tourism due to easy access off highway for shopping, recreation, camping and hotels;
- Potential development of the former CFB Chilliwack Base;
- Greater access offered to nearby First Nations population; and,
- Improved access to downtown and government services.

Environmental Account

Fuel consumption and vehicle emission components as presented in Figure 1 indicate that both projects would generate equivalent and very favorable environmental implications. Fuel consumption factors at different speeds and vehicle emission coefficients were obtained by UMA Engineering Ltd. from those used in recent Ministry regional studies (New Westminster Area Network Study). Fuel consumption in litres per kilometer were calculated by UMA using Emme/2 output and fuel consumption factors. Total vehicle kilometers for the 2021 PM peak hour were grouped by UMA into categories by the speed at which the vehicles operate. These values were factored up by the consultant to annual values. Emission quantities were calculated by UMA for carbon monoxide, carbon dioxide, nitrogen oxide and hydro-carbons in grams per kilometer (g/km). The four quantities were obtained by factoring Emme/2 speed-based volumes up to annual figures, and subsequently coefficients were applied by UMA to convert these quantities to emissions.

Social Account

The major societal benefits include:

- Safer pedestrian and cycling access across the bridge due to dedicated lanes
- Safety improvements in event of earthquake since the new structure would be built to current seismic standards. Provides local community access across the bridge for emergency vehicles, and provides provincial/federal benefits since the bridge crosses the disaster response route.

[5] Gary Horne, "Provincial Economic Multipliers and How to Use Them", Treasury Board Staff", November 1996,1990 BCIOM INDUSTRY -MEDIUM AGGREGATION- 75% RECYLCING RATE, ***(Industry = Transportation)***

Vedder Interchange Project

Figure 1 - Chilliwack - Business Case Summary

			Options	9010	9020
				Opt. 1	Opt. 2
				Vedder I/C	**2 Ln Evans O/P**
Account	Criteria	Measurement	Unit		
Financial	Construction Cost	Present Value	(M$)	10.888	5.881
	Property Cost	ROW req'd for construction	(M$)	0.334	0.979
	Maint. & Rehab Costs	Present Value	(M$)	0.456	0.327
	Salvage Value	Present Value	(M$)	2.693	1.646
Service	Road Network Performance (Consumer Surplus)	Value of Travel Time	(M$)	26.465	18.704
		Value of Operating Costs	(M$)	6.616	4.676
		Value of Accident Costs	(M$)	4.301	3.039
Economic Summary	**Benefits**	**Present Value**	**(M$)**	**37.382**	**26.419**
	Costs	**Present Value**	**(M$)**	**8.985**	**5.540**
	Net Present Value	**Present Value**	**(M$)**	**28.397**	**20.879**
	Benefit/Cost Ratio	**Calculated**	**Ratio**	**4.160**	**4.769**
Economic	Quantitative	Employment	**Person Years**	203.4	129.6
Development		Provinical Economic Impact	**(M$)**	24.4	15.6
	(See Attached Appendices 1A and 1B)				
Environment	Fuel	Fuel consumed	Millions litres	-32.020	-36.347
	Vehicle Emissions	Carbon dioxide	Millions kg.	-83.436	-94.216
		Carbon monoxide	Millions kg.	-3.360	-3.442
		Nitrogen oxide	Millions kg.	-0.121	-0.169
		Hydro-carbons	Millions kg.	-0.371	-0.371

1 Note: Property cost includes the value of ROW required for contstruction, it has not been offset by the value of surplus lands available for development

2 Salvage Costs: Ratio 24% of construction costs and property costs

3 Operating Costs: Ratio 25% of Travel Time Costs

4 Accident Costs: Ratio 13% (of Combined Travel Time and Operating Costs)

Risks/ Sensitivity Analysis

	Baseline	+25% in Cost	-25% in Cost	8% Discount Rate
NPV ($Million)	**28.397**	25.611	31.182	22.290
B/C	**4.160**	3.176	6.030	3.591

Project Implementation

- Scope:

  The scope of this project includes twinning of the bridge, improved lanes & ramps, and improvements to related infrastructure at the Vedder/TCH interchange. Specifically, it includes:

  a) four-lane crossing, full-movement interchange with reconstructed ramps and associated intersection improvements;
  b) improvements and lengthening of each of the acceleration/deceleration lanes on the highway at the interchange;
  c) widening the north leg of Vedder Road from the interchange to the south side of Yale
  d) improvements to the Vedder Road/Yale intersection for traffic approaching from the interchange (i.e. northbound traffic);
  e) widening the south leg of Vedder Road from the interchange to the north side of Luckakuck
  f) improvements to the Vedder Road/Luckakuck intersection for traffic approaching from the interchange (i.e. southbound traffic);
  g) removal of any local accesses on Vedder that interfere with the operation of the interchange.

- Schedule (with federal cost-sharing).

Following is a preliminary project schedule, subject to negotiations:

Obtain project approvals and funding:	2002/2003
Project Definition and Project Agreement	2002/2003
Request for Expressions of Interest	2002/2003
Issuance of RFP	2003/2004
Award contract	2003/2004
Start Construction	2004/2005
Project Completion	2005/2006

- Budget (with federal cost-sharing)

Minstry of Transportation		$4.133 million
SHIP program		$4.133 million
City of Chilliwack to fund	$	$4.133 million
Total Project Cost		$12.40 million

- Forecasted cash flow subject to negotiations and with federal cost-sharing is:

2002/2003	$0.200 million
2004/2005	$6.100 million
2005/2006	$6.100 million

There is also a possibility that ICBC will contribute funds to this project, based on their assessment that the current interchange and related entry and exit points are the scene of numerous accidents.

Conclusions/Recommendations

Based on a review of this project, it is recommended that it proceed for the following reasons:

- the Vedder Road/TCH interchange requires replacement or reconstruction of the highest priority due to the capacity and safety deficiencies
- the proposed improvements will yield large provincial, municipal and federal benefits, hence the opportunity for partnership and cost-sharing
- benefits are significant, with an NPV of $28 million and a B/C ratio of 4.2. They include savings to travel time, vehicle operating, safety and fuel emissions; as well as contributing to community connectivity and economic development.

Appendix 1A

ECONOMIC IMPACTS AND INHERENT EMPLOYMENT IMPACTS GENERATED BY INVESTMENT IN THE PROPOSED VEDDER INTERCHANGE

INVESTMENT	12.40	**$Million**		
	Direct	Indirect	Induced	Open-Model Output Multilplier
Coefficients	1.00	0.57	0.40	1.97
Economic Impacts ($Million)	**12.4**	**7.1**	**5.0**	**24.4**

	Direct	Indirect	Induced	Open-Model Output Multilplier
Coefficients	7.3	4.7	4.4	16.4
Employment Impacts (Person Years)	**90.5**	**58.3**	**54.6**	**203.4**

Note: 1 Employment impacts are (PY/$Million)

Source: Gary Horne,"Provincial Economic Multipliers and How to Use Them", Treasury Board Staff "November 1996
1990 BCIOM INDUSTRY -MEDIUM AGGREGATION- 75% RECYLCING RATE
(Industry = Transportation)

Appendix 1B

ECONOMIC IMPACTS AND INHERENT EMPLOYMENT IMPACTS GENERATED BY INVESTMENT IN THE PROPOSED 2-LANE EVANS OVERPASS

INVESTMENT	7.90	**$Million**		
	Direct	Indirect	Induced	Open-Model Output Multilplier
Coefficients	1.00	0.57	0.40	1.97
Economic Impacts ($Million)	**7.9**	**4.5**	**3.2**	**15.6**

	Direct	Indirect	Induced	Open-Model Output Multilplier
Coefficients	7.3	4.7	4.4	16.4
Employment Impacts (Person Years)	**57.7**	**37.1**	**34.8**	**129.6**

Note: 1 Employment impacts are (PY/$Million)

Source: Gary Horne,"Provincial Economic Multipliers and How to Use Them", Treasury Board Staff "November 1996
1990 BCIOM INDUSTRY -MEDIUM AGGREGATION- 75% RECYLCING RATE
(Industry = Transportation)

Appendix 2

CONSUMER SURPLUS vs. COST DIFFERENCE METHODOLOGIES

Consumer Surplus

Diagram 1 illustrates the *"Consumer Surplus"* methodology that is the underpinning of all transportation economics. The initial situation is described by the intersection of Demand 1 and Supply 1 and is referred to as the Base Case. This is represented by C_1 and V_1, respectively. Once a transportation improvement is implemented there is an increased number or trips, that includes generated (additional) trips over and above the original number of trips.

Under the proposed improvement the original travellers (V_1) receive an incremental (net) benefit of C_1-C_2 units of cost reduction. More specifically, these travellers would be willing to pay C_1 to travel V_1 but only had to pay the price of C_2. Therefore, the incremental benefits to these users is equal to V1* (C_1-C_2), which is geometrically represented by area A.

The newly generated trips V_2 -V_1, which are encouraged by the lower price C_2, receive a net (incremental) benefit represented by the triangular area B. More specifically, these new users must pay the V_1V_2*C_2, which is represented by the rectangular area C. Therefore, the net benefit is the area B for these new users, which is the difference between the "willingness to pay" and what is actually paid for the service.

In conclusion, the combined incremental benefits is then equal to

= **Area A** (Original Travellers Incremental Benefits) **+ Area B** (New Generated Travellers Incremental Benefits)

MAE and Consumer Surplus

Micro-BENCOST software uses a method sometimes referred to as *"Cost Difference"* which compares total time costs, vehicle operating costs, and accident costs for the proposed project to that of the base (existing) situation. The two methods are identical only when there is no change in the trip pattern. For instance, the added capacity of a passing or climbing lane will not change trip patterns. Conversely, the improvement of an existing facility or the construction of an additional link within an urban centre will have network implications and thus change trip patterns. Therefore, the adoption of the "Consumer Surplus" approach by Translink is not meant as a replacement to the existing MAE and Micro-BENCOST guidelines, but rather a method to supplement or fill a void where existing methodology is deficient. It has long been recognized that Micro-BENCOST is not well suited to capture network or regional implications. However, for the vast majority of projects that are funded by the Ministry of Transportation, where network implications are minimal or non-existent, Micro-BENCOST performs accurate Cost-Benefit analysis in a timely manner. It should also be noted there is currently no transportation economics software that can capture network implications using the *Consumer Surplus* approach.

It should be understood that since the *Consumer Surplus* Method and the *Cost-Difference* Method are both alternative methods of Cost-Benefit Analysis and as such they both address the same two accounts of the MAE framework, Financial and Customer Service. The remaining accounts of Environment, Economic Development and Social implications are not captured through either of these methods. These additional considerations (accounts) are evaluated through the examination of indirect benefits.

Diagram 1

Consumer Surplus