ANALYSIS FRAMEWORK
for the
Trans Canada Highway
Corridor Management Plan
(Kamloops to Alberta Border)

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BRITISH
COLUMBIA

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Glossary of Terms

3-S2	5 axle tractor/semitrailer combination
3-S3-S2	8 axle B-train
a/mv	Accidents/million vehicles
a/mvk	Accidents/million vehicle kilometers
AADT	Average Annual Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
AD	Access Density (approaches/km)
AR	Accident Rate
AVI	Automatic Vehicle Identification
B/C	Benefit Cost Ratio
BCI	Bridge Condition Index
BCTFA	BC Transportation Financing Authority
CMP	Corridor Management Plan
CO	Carbon Monoxide
CPI	Consumer Price Index
CR	Critical Rate
d	Desired precision. The precision is in the same units as the proportion.
DHV	Design Hour Volume
ESAL	Equivalent Single Axle Load
FHWA	Federal Highway Administration (U.S.)
HLRP	Highway Locational Referencing Project
HSIS	Highway Safety Information System
HV150	150th highest hourly volume of the year
K	= DHV/AADT
Kn	= HVn/AADT
LKI	Landmark Kilometer Inventory
LOS	Level of Service
MAE	Multiple Account Evaluation
MU	Multiple Unit Truck
MV104	Form used by police to file accident reports
MVA	Motor Vehicle Accident
MVK	Million Vehicle Kilometers
n	Years remaining to the end of the planning period (for calculating salvage)
N	Sample size required to estimate the proportion
NPV	Net Present Value
P	assumed population proportion expressed as a decimal
PDI	Pavement Distress Index
PDO	Property Damage Only accident
PHP	Provincial Highway Plan
PQI	Pavement Quality Index
PV	Present Value

R2	Coefficient of Correlation
RA	Rural Arterial
RCI	Ride Quality Index
RE	Rural Expressway
RF	Rural Freeway
RP	Rural Primary
RS	Rural Secondary
RV	Recreational Vehicle
SADT	Summer Average Daily Traffic
SU	Single Unit Truck
t95%	the t statistic for (N-1) degrees of freedom and the 95% confidence interval (t95% = 1.960 for large samples)
TAC	Transportation Association of Canada
TCH	Trans Canada Highway
TRARR	Traffic on Rural Roads (a simulation model)
UA	Urban Arterial
UE	Urban Expressway
UF	Urban Freeway
UP	Urban Primary
US	Urban Secondary
v/c	Volume to capacity ratio
V85	85th Percentile operating speed
VOC	Vehicle Operating Cost
ROW	Right of Way
WIM	Weigh-in-Motion

Analysis Framework
Trans Canada Highway
Corridor Management Plan
Kamloops to Alberta Border

1. Introduction

This analysis framework has been developed as a tool for the Trans Canada Highway (TCH) Kamloops to Alberta Border corridor management plan (CMP). It is not intended to be definitive, but to assist the Ministry in the development of its planning process and products. While designed for the TCH, the framework includes components which could also be applied to any other CMP, Systems Plan or the Provincial Highway Plan :

- Corridor Segmentation
- Performance Measurement
- Benefit Cost Analysis
- Multiple Accounts Evaluation
- Population Forecasts
- Accident Reduction Factors

This analysis framework has been developed to support CMPs in guiding operational, maintenance, rehabilitation, capital and management or policy decisions affecting a corridor. The CMP does this using tools such as performance measurement, Multiple Account Evaluation, and benefit/cost analyses to examine the technical, financial, economic, social and environmental issues surrounding development of the corridor.

Improvements recommended through this framework must consider the potential upstream and downstream impacts on the overall performance of the associated corridor(s). This encourages the practitioner to look at a corridor investment package in the context of a provincial transportation role rather than a series of stand alone projects. Under this framework, the analyses do more than assess highway plant deficiencies. They also take direction from the *Provincial Highway Plan's* (PHP) goals and objectives which represent Provincial and Ministry goals, growth strategy initiatives, other modal plans, and public input.

Through this process corridor improvements and regional system plan improvements are integrated into a Provincial strategy to help the Ministry:

- facilitate decision making,
- develop business plans to achieve its corporate strategies,
- acquire funding and FTEs, and
- implement investment plans.

Therefore every CMP needs to culminate in a recommended ***investment strategy*** with three time frames:

- a *short term investment plan (1 to 5 years)*;
- a *medium term investment plan (6 to 15 years)*, and
- a *long range investment plan (16 to 25 years)*.

The *short term investment plan* represents current corridor needs which are ordinarily more tangible than *medium and long range plan* future needs, which are less tangible being based upon forecasts over a 25 year planning horizon and which may be subject to changing provincial and local priorities.

2. Segment and Corridor Delineation

2.1 Segment Delineation

Segments should represent a logical breakdown of a highway into reasonably homogeneous highway sections which could be used for corridor analysis. As such, segments should be delineated so they may be rolled up into sub-corridors and corridors. Generally they are delineated by:

1. Service Class
2. Urban (population >5,000) or Rural land use
3. Major changes in terrain
4. Major highway junctions

These are a minimum. Finer segmentation based on additional criteria such as accident rate, access density, pavement condition, traffic volume, highway closures, travel speed etc. could also be considered in delineating smaller segments. They can always be applied at the corridor planning stage, but are not used here for several reasons:

a) Most other factors are correlated to the 4 items above (i.e. speed and access are usually correlated to land use and service class)
b) The number of segments becomes unmanageable at the Provincial Highway System level
c) Highway characteristics are saved as continuous data not forced into discrete segments.

Discrete segments are not needed for data storage purposes. In digital files, it is more effective to store data in the segment length appropriate to the parameter being measured. There is no reason for example to force a segment of deteriorated pavement to fit into a segment of highway delineated according to land use. This results in the pavement data being "buried". What is needed is the location where the deteriorated pavement starts and ends. Segments defined later will then show how much of the segment has deteriorated pavement instead of a value averaged over the segment length.

The Ministry's LKI (Landmark Kilometer Inventory) system dated 1 April, 1995, is used to delineate segment break points. Segments proposed for the TCH - Kamloops to Alberta Border, are presented in exhibit 2.1.

Exhibit 2.1
Proposed Segments Kamloops to Alberta Border

Start Segment	Start km	Start Description	Length (km)	Basic Lanes	Service Class	Land Use	Terrain
2050	0	Afton Interchange	12.07	4	UF	Urban	L
925	0	Yellowhead F/O #2379	4.97	4	UA	Urban	L
925	4.97	Tanger Rd (E. of Kamloops)	20.93	4	UE	Urban	L
935	0	Hwy 97 at Monte Creek	27.42	2	RA	Rural	L
935	27.42	Chase West Exit	11.18	2	RA	Rural	M
935	38.6	Squilax Bridge #0481	6.95	2	RA	Rural	L
935	45.55	Cobeaux Road #102	3.46	2	UA	Urban	L
935	49.01	Blind Bay Road #67	29.03	2	RA	Rural	L
935	78.04	Salmon River Bridge #1187	7.68	2	UA	Urban	L
950	0	Jct. Hwy 97B	5.86	2	UA	Urban	L
950	5.86	Canoe Beach Drive East Ent.	19.79	2	RA	Rural	M
950	25.65	RW Bruhn Bridge #0897	1.54	2	RA	Rural	L
960	0	Hwy 97A Sicamous	3.25	2	RA	Rural	L
960	3.25	Kerr Road # 636 East Ent	8.54	2	RA	Rural	L
960	11.79	Gravel Pit (start 4 lane)	8.76	4	RE	Rural	L
960	20.55	Malakwa Dump Road #642	8.42	2	RA	Rural	L
960	28.97	Perry River Br.	41.18	2	RA	Rural	R
960	70.15	Hwy 23(S) Revelstoke	1.27	2	UA	Urban	R
975	0.29	Hwy 23(N) Revelstoke	4.69	2	UA	Urban	R
975	4.98	Revelstoke E. City Bdy.	12.92	2	RA	Rural	R
975	17.9	Mt. Revelstoke Park W. Bdy.	103.92	2	RA	Rural	M
985	29.66	Columbia River Br. at Donald	26.40	2	RA	Rural	L
990	0	Hwy 95 Golden	25.93	2	RA	Rural	M
995	0	Yoho Park W. Bdy.	45.30	2	RA	Rural	M
			441.46				

2.2 Highway Corridors

Highway corridors are defined as a "strip of land between two termini, over which traffic, topography environment and other characteristics are evaluated for transportation purposes". How a corridor is delineated depends on what is being analyzed. "Corridor" plans usually address relatively small sections of highway in a great amount of detail. Provincial Highway planning is concerned with corridor performance at a higher level and uses a length equivalent to a long distance trip taking several hours or more to make.

For this analysis, highway corridors are defined at two levels including major corridors and sub-corridors.

Major Corridors

These are intended to show overall performance of a highway corridor without regard to the performance of individual segments. The performance is measured over a length of highway used which might be used for long distance trips of a day or more. Nine major highway corridors in the Province are identified:

Highway 3	Hope to Alberta Border
Highway 16	Prince Rupert to Tete Jaune Cache
Highway 5/16	Kamloops to Alberta Border
Highway 1/5/1	Vancouver to Alberta
Highway 97	U.S. Border to Yukon
Highway 1/97	Hope to Yukon
Highway 1/19	Victoria to Port Hardy
Highway 99	Vancouver to Clinton (Hwy 97)
Highway 37	Terrace to Yukon

Sub-Corridor

In some cases, such as highway closures or corridor studies for example, it is useful to consider something shorter than one of the nine major corridors. The sub-corridors are delineated in exhibit 2.2 by major population centers or highway junctions.

Exhibit 2.2
Sub-Corridors

Sub-Corridor Number	Hwy	Start Description	End Description	Distance
		Highway 1/5/1 - Vancouver to Alberta Border Corridor		**818.68**
1	1	Ferry Toll Booth (Horseshoe Bay)	Clover Valley Underpass (Hwy 15)	53.43
2	1/3	Clover Valley Underpass (Hwy 15)	Othello Interchange (Hwy 5/3)	121.99
3	5	Othello Interchange (Hwy 5/3)	Afton Overpass (Hwy 5/1)	196.07
4	1	Afton Overpass (Hwy 5/1)	Intersection Hwy 97A (Sicamous)	150.88
5	1	Intersection Hwy 97A (Sicamous)	Alberta Border	290.58
		Highway 1/97 - Hope to Yukon Border Corridor		**1978.74**
6	1	Intersection Hwy 1/3 (Hope)	Intersection Hwy 1/97 (Cache Creek)	193.46
7	97	Intersection Hwy 1/97 (Cache Creek)	Intersection Hwy 97/16 (Prince George)	431.42
8	97	Intersection Hwy 97/16 (Prince George)	Intersection Hwy 97/2 (Dawson Creek)	405.96
9	97	Intersection Hwy 97/2 (Dawson Creek)	Yukon border	947.9
		Highway 3 - Hope to Alberta Corridor		**830.04**
10	3	Orthello Interchange (Hwy 5/3)	Alberta Border	830.04
		Highway 16 - Prince Rupert to Tete Jaune Corridor		**1058.29**
11	16	Rail Crossing @ Fairview Terminal (Prince Rupert)	Intersection Hwy 16/97 (Prince George)	797.45
12	16	Intersection Hwy 16/97 (Prince George)	Intersection Hwy 16/5 (Tete Jaune)	260.84
		Highway 5/16 - Kamloops to Alberta Corridor		**415.02**
13	5/16	Intersection Hwy 5N/1	Alberta Border	415.02
		Highway 97 - US to Trans Canada Highway Corridor		**253.93**
14	97	Canada/US Border	Intersection Hwy 97/3A (Kaleden)	51.5
15	97	Intersection Hwy 97/3A (Kaleden)	Intersection Hwy 97/97A (Swan Lake)	136.98
16	97A	Intersection Hwy 97/97A (Swan Lake)	Intersection Hwy 97A/1 (Sicamous)	65.45
17	97B	Intersection Hwy 97A/97B (Grindrod)	Intersection Hwy 97B/1 (East of Salmon Arm)	14.39
		Highway 1/19 - Victoria to Port Hardy Corridor		**500.86**
18	1	Tolmie Avenue (Victoria)	George Pearson Bridge (Nanaimo)	109.45
19	19	George Pearson Bridge (Nanaimo)	Campbell River Bridge (Campbell River)	156.13
20	19	Campbell River Bridge (Campbell River)	Ferry Toll Booth (Bear Cove)	235.28
		Highway 99 - Vancouver to Cache Creek Corridor		**307.32**
21	99	Intersection Hwy 99/1 (Horseshoe Bay)	Whistler Road (Whistler)	98.54
22	99	Whistler Road (Whistler)	Intersection Hwy 99/97 (North of Cache Creek)	208.78
		Highway 37 - Terrace to Yukon Corridor		**724.97**
23	37	Intersection Hwy 37/16 (South of Kitwanga)	Yukon border	724.97

3.0 Performance Measurement and Problem Definition

3.1 Provincial Objectives

Performance measures reflect the objectives they are trying to gauge. The higher level objectives for the Provincial Highway System flow from the MoTH mission statement :

"To facilitate the safe and efficient movement of people and goods, and the realization of government objectives by planning delivering and operating British Columbia's highways and infrastructure, and, by licensing and regulating it's users"

From the mission statement, the objectives which apply to the Provincial Highway System include:

- A safe highway system
- Efficient movement of people and goods
- Realization of other Government Objectives

Other Government Objectives outlined in the BC21 document "Going Places"[1] and "British Columbia Provincial Highway Plan - Strategy Component[2]" include:

Infrastructure Condition	Maintain the infrastructure in a state of readiness to provide service, without running down the assets
Equity	Fair distribution of costs and benefits
Efficiency	Allocation of resources to get the maximum output
Environmental Sustainability	Avoid impacts that could threaten the viability or function of the ecosystem
Economic Development	Contribute to the establishment and ongoing support of appropriate economic activities in the Province.
Community Development	A highway system consistent with and supportive of economic and land use goals

[1] "Going Places Transp[ortation for British Columbians", BC Transportation Financing Authority, 1996

[2] "British Columbia Provincial Highway Plan - Strategy Component" Preliminary Draft, BC Ministry of Transportation and Highways, June 30, 1995.

3.2 Objectives for the Provincial Highway Plan

Translating Provincial objectives into objectives for the Provincial Highway Plan, the plan should:

1. Maintain mobility and safety in the system and
2. Protect the investment in Highway infrastructure

To implement these objectives, the plan should include:

a) Problem identification - areas in the Provincial Highway System with the poorest performance
b) Problem definition - General causes of the problems
c) General solutions based on available corridor/systems plans or on more generic solutions consistent with the level of detail available
d) Benefit cost/MAE analysis of the alternatives as a tool for allocating a fixed budget across the Province

The objective of this phase of the PHP is to address the problem identification and problem definition steps above.

3.3 General Approach

Problem Identification:

Problem identification is distinct from problem definition. Low travel speed for example, identifies a problem. The reason (problem definition) may be low capacity, poor geometry, high access density etc. but the problem perceived by the highway user remains the same.... travel speed. Problems are identified using *Performance Measures* to determine **if** and **where** there is a problem. The measures used should be simple and applied on an equal basis across the Provincial Network.

Regardless of the underlying cause, deficient highway performance will manifest itself in four ways:

1. low travel speed
   traffic delays usually due to congestion or development
2. high accident rate
   accident frequency is above average
3. poor reliability
   frequent highway closures
4. deteriorating infrastructure
   Bridges or pavement in need of repair

For each performance measure a convention of "Good", "Fair" or "Poor" is defined and used in the analysis. Poor ratings *do not necessarily mean that action must be taken*. A poor rating only identifies a need. The decision to take action depends on affordability, cost/ benefit and Multiple Account arguments.

Problem Definition:

Problem definition looks at the underlying causes in order to:

- identify general types of solutions
- supply the data needed to generate and analyze solutions at the PHP level.

Problem definition is discussed in the following sections in the context of each performance measure - ***travel speed, safety, reliability and infrastructure***.

The problem definition data needed to support a Provincial highway plan is more general in nature than for a corridor plan. A provincial highway plan might simply address the number of signals in a corridor, while a corridor plan might look at intersection capacity analysis and signal progression.

Even the general nature of data needed to support problem definition at the PHP level can absorb a disproportionate amount of effort if it is applied across the entire highway system. The approach in the PHP is to collect the data needed to identify the problem areas first (travel speed, safety, reliability, infrastructure condition). Once the problem areas are identified, further data collection is limited to the identified problem areas. This reduces the amount of data collected about highway segments for which there is no problem.

Benefit cost and MAE are not normally done at the Provincial or system level. They are done at the project level and then summed to provide the Provincial or system level assessment

3.4 Travel Speed

Travel speed is the first performance measure. Travel speed represents the highway user's perspective since it includes all stops or delays related to traffic operation. It is not the, design or posted speed of the highway. Travel speeds measured over the length of a *corridor* show how the highway performs overall. Speeds measured over a *segment* will identify individual problem areas which may be causing the poor corridor performance.

3.4.1 Corridor Travel Speeds

Corridor travel speeds show how the highway performs over long distance trips. Proposed rating criteria for highway corridors are stratified by Strategic Class (primary, secondary) instead of Functional Class (Freeway, expressway, arterial). A corridor often includes more than one service class, but the strategic class remains constant, reflecting the inter-regional role of a highway. The strategic class also determines what level of service *should* be provided at the corridor level while service class defines *how* that level of service is delivered for a given traffic volume.

Problem Identification for Corridor Speeds:

The goal is to ensure adequate performance at the corridor level not just the segment level. Individual segments in a corridor may be performing adequately for their given service class, but if for example, there are too many *urban segments* in what is primarily a *rural corridor*, the corridor as a whole cannot meet its mobility goals.

The speed measured, should represent the average travel speed of a continuous trip through the corridor during the typical peak period of the year, such as a summer weekday.

The issue of what constitutes an adequate corridor speed is subjective. The National Highway Policy recommends a 90 km/hr minimum operating speed. This is desirable but is not a reasonable short term goal in B.C. since it would imply building about 60 bypasses around communities on the National Highway System[3] in order to maintain 90 km/h.

Rural primary corridors: This includes all primary highways outside the Lower Mainland. A reasonable interim goal is to achieve an overall travel speed of 80 km/hr including 90 km/hr operation outside of built up areas within the rural corridor.

Rural Secondary Corridors: The corridor speed criteria of 75 km/h assumes the corridor is comsits entirely of rural arterial segments.

Proposed Corridor Criteria

	Good	Fair	Poor
Strategic Class	Peak Period Corridor Travel Speed (km/hr)		
RP (Rural Primary)	>or =80	75 to 79	<75
RS (Rural Secondary)	>or =75	70 to 74	<70
UP (Urban Primary)	71	61 to 66	<66
US (Urban Secondary)	37	36 to 32	<32

Urban primary corridors: This includes highways 1, 7, 91 and 99 in the Lower Mainland. The travel speed criteria is 71 km/h which assumes the corridor is made up of 75% urban freeway segments at 80 km/h and 25% urban expressway segments at 40 km/h.

Urban secondary corridors: The speed criteria of 37 km/h assumes the corridor is made up of 50% expressway segments at 45 km/hr and 50% arterial segments at 30 km/hr

Problem Definition for Corridor Speeds:

At the PHP level, problem definition requires enough information to identify the general causes of *low travel speed* in a corridor. This may include:

[3]ADI Limited, "National Highway Policy User Benefits Analysis" Prepared for the National Highway policy Study Committee, November, 1989.

	Cause of Low Travel Speed				
Data Requirement	v/c Ratio	Access	Signals	Geometry	Passing Opportunity
AADT, SADT	✓				
DHV	✓				✓
% trucks	✓				
Laning	✓				
Access Locations		✓			
Access management		✓			
Posted Speed		✓			
Signal Location			✓		
Curvature				✓	
Grade				✓	
Terrain	✓				✓
Passing Lane Location	✓				✓

3.4.2 Segment Travel Speeds

Problem Identification for Segment Speeds:

The peak period speed is used to identify problem areas since declining peak period speeds are usually the first sign of an approaching problem. For each segment, the peak period speed is the average speed on a segment during typical high demand periods. On the TCH for example, this would typically be a summer mid-day travel speed.

Segment speed criteria are stratified by urban and rural classifications. The urban classification is designated using the Functional Classification Manual[4], which defines urban as a population center greater than 5,000. For the PHP, the limits of the urban area are defined by the changes in posted speed which occur at the approach to the developed area. Municipalities with less than 5,000 remain classified as rural even if they have reduced speed zones.

Urban Travel Speed Criteria

Travel speed performance on urban segments is rated using criteria from the Functional Classification Study and the Highway Capacity Manual. The speed being rated is the typical peak period travel speed on the segment. The ratings proposed for the 1997 PHP are revised downwards from the 1995 PHP analysis since the current performance measure is focusing on peak period speeds more than off peak speeds.

[4]British Columbia Highway Functional Classification Study, Ministry of Transportation and Highways, Highway Planning Branch, June 1992

Urban Segments

	Recommended Criteria				
Service Class	Good >or=	Fair <	Poor <	B.C. Functional Classification Manual*	Highway Capacity Manual
	Peak Period Travel Speed (km/hr)				
UF	80	80	75	minimum is 75 km/hr and C/D interface	Depends on Design Speed
UE	45	45	40	minimum is 40 km/hr and C/D interface	Arterial LOS C/D = 35 km/hr
UA	30	30	25	minimum 20 to 40 km/hr and C/D interface	Arterial LOS C/D = 35 km/hr D/E = 27 km/h

**The LOS interfaces shown in this column were adopted from the ASSHTO Green Book (1992). Caution must be excercised when using these as deficiency indicaotors because:*

1. *The definitive justification for improvements comes from Multiple Accounts Evaluation (including benefit cost analysis), discussed later in this report*
2. *Planning and project funding is likely to be limited for the foreseeable future and the case has been made that a "finer screen" should be used for mobility problem identification, which would help focus resources on comprraratively worse areas.*

It is possible that the mobility deficiency criterion could change to LOS D/E for urban highways and rural 4 lane highways , and to LOS C/D for rural 2 lane highways, for regularly occuring peaks.

Rural Travel Speed Criteria

The performance measure for speed on rural highway segments also uses the peak period travel speeds. The criteria for rating speed on rural highway segments were based on the cumulative distribution of rural travel speeds from the 1995 PHP data in exhibits 3.2, 3.3 and 3.4 and are consistent with the previous analysis. Typically, the distribution for each service class displays a knee in the curve, below which the travel speeds drop off rapidly. This generally indicates a failure of some kind and is a good place to intervene, so speeds below the knee are used to define the "poor" speed rating. Speeds in the vicinity of the knee (5 km/h above the poor zone) define the "fair" rating and speeds above the knee are "good". The curves for rural freeway and rural expressway should be treated with caution since the sample size is limited. These speed ratings are more judgmental than statistical.

Rural Segments

Service Class	Good	Fair <	Poor <	Provincial Distribution from 1995 PHP	1994 Highway Capacity Manual Level of Service Interface and Speed
	Peak Period Travel Speed (km/hr)				
RF	>or =95	90 to 94	<90	Exhibit 3.2	C/D = 89 to 110 km/hr
RE	>or =80	75 to 79	<75	Exhibit 3.3	C/D = 72 to 93 km/hr
RA	>or =75	70 to 74	<70	Exhibit 3.4	C/D = 80.5 km/hr D/E = 72.5 km/hr

Exhibit 3.2

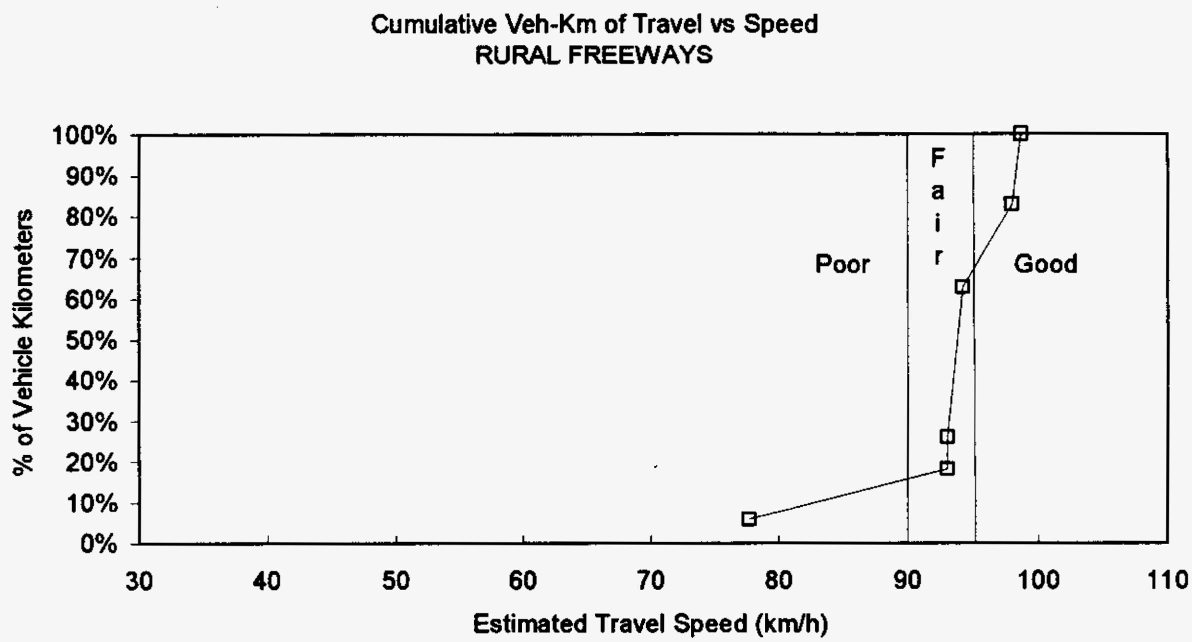


Exhibit 3.3

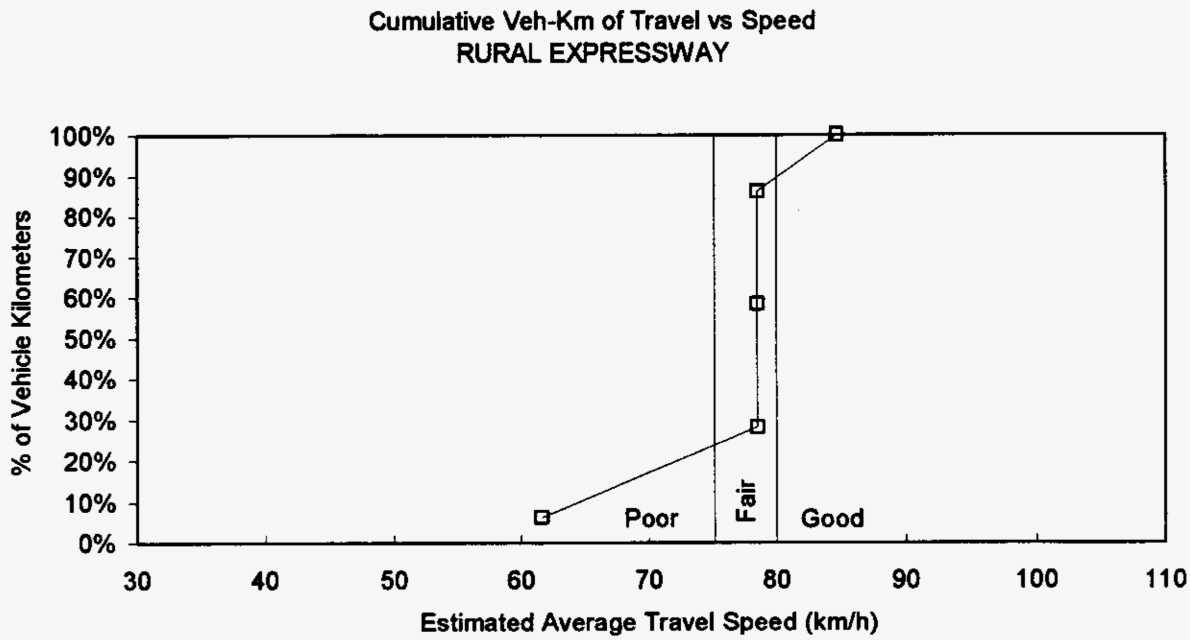
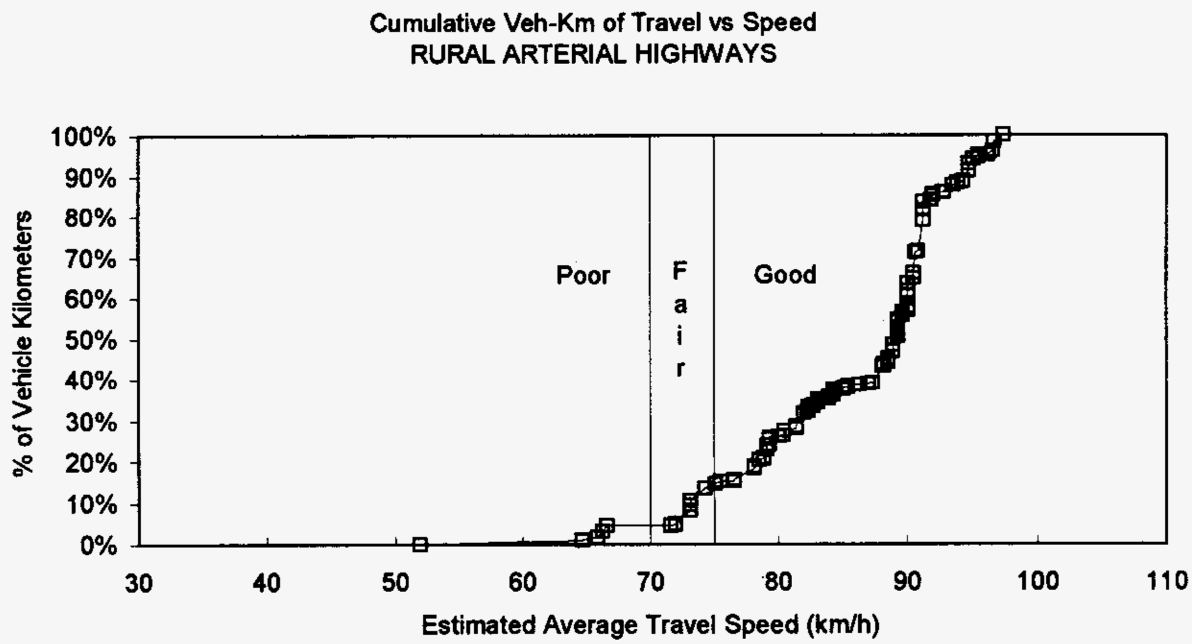


Exhibit 3.4



Problem Definition:

If a travel speed is identified as poor, then further information is needed to define and analyze the problem. This is the same as the information collected under problem definition for corridor speeds, if it has not already been collected.

Additional Data Requirements

Peak Period Travel Speed	✓
Peak period traffic volume	✓
Off peak travel speed	✓
Off peak traffic volume	✓

In addition, benefit cost analysis will require some additional travel speed information for use in benefit cost analysis. The minimum is the typical travel speed and traffic volume during the peak and off peak periods. This allows the analyst to adjust the default speed volume curve generated by benefit cost models to reflect the actual speeds in the segment. This is recommended since benefit cost models using speed calculations from the highway capacity manual often do not adequately represent actual conditions. The speed measured in the field should be a space mean speed using a floating car technique. This involves driving the segment at the average traffic speed in order to get an average travel speed over the segment. It is different from the spot mean speed which measures speed at a point using radar or a traffic counter/classifier for example.

3.5 Safety

Problem Identification:

The proposed performance measure uses the critical accident rate for a highway segment or major corridor. Critical rate is a function of average accident rate and exposure measured as vehicle-km. The critical rate for a highway section is calculated as:

$$CR = AR + 1.645 \times SQRT(AR/MVK) + 1/(2 \times MVK)$$

Where: CR = critical accident rate for a given highway section
AR = average accident rate for the highway service class on the section
MVK = million veh-km for a the given highway section

At the segment level, critical accident rate is calculated using the average accident rates from Highway Safety Branch by service class[5]

Service Class	Average Rate (a/mvk)	
UA	1.4	Urban Arterial
UE	1.5	Urban Expressway
UF	1.0	Urban Freeway

[5]Highway Safety Branch, "Annual Provincial Traffic Accident Statistics and Trends Manual " Average Provincial Accident Rates by Highway Class - 91/01/01 to 93/12/31

RA	0.7	Rural Arterial
RE	1.2	Rural Expressway
RF	0.6	Rural Freeway

At the corridor level, critical accident rate is calculated using the average accident rates by Strategic Class. These are summarized from the 1995 PHP data.

UP	0.9	Urban Primary
US	1.1	Urban Secondary
RP	0.7	Rural Primary
RS	0.9	Rural Secondary

Differences between urban rates by strategic class and service class may stem from how the roads were classified. The proposed criteria are based on the critical accident rate:

Good:	accident rate is less than the critical rate
Fair:	accident rate is greater than or equal to the critical rate, but less than 1.5 X the critical rate
Poor:	accident rate is equal to or greater than 1.5 X the critical rate

Problem Definition:

Investigating the cause of high accident rates is normally done at the corridor or project level through a micro analysis of accident data or a safety audit. At the Provincial planning level, micro analysis is not practical for the entire highway system. The general approach is to address a limited number of accident factors, only in high accident segments or locations and give some general guidance on the nature of the problem.

The data collected should be include accident frequency and exposure data needed for benefit cost/ MAE analysis and accident factors to define the nature of the accidents on the highway corridor or segments. This includes:

- Number of accidents
- Number fatal accidents (not number of fatalities)
- Number of injury accidents
- Number of Property Damage Only (PDO) accidents
- AADT
- Section length if applicable
- Limited data from the HSIS database

Guidelines on applying the accident frequency data are in chapter 5 on Benefit Cost Analysis.

The underlying problems related to higher than normal accident rates are usually a combination of factors. Highway Safety Branch gives the following distribution for numbered highways in the Province.

Contributing factors	*%*
Human Action	24.6%
Human Condition	20.5%
Animal	11.7%
Environmental Condition	8.2%
Vehicle Condition	2.2%
Road Factor	1.8%
Unknown Factor	31.0%

For the PHP analysis, these contributing factors are expanded into the 8 causal factors below. The data needed to support these causal factors comes form the HSIS database and not from the PHP database. The HSIS database is a compilation of the Police accident report forms (MV104 form).

Causal Factors and Supporting Data for High Accident Locations

	Causal factors							
Supporting Data Required *	Wild Animals	Weather	Driver Condition	Veh Condition	Access	Signals	Geometry	Congestion Points
Type of accident collision	✓							
Apparent contributing factors		✓	✓	✓				
Accident Location					✓			
Traffic Control						✓		
Roadway Character							✓	
Pre-collision action					✓			✓
Roadway Surface Condition		✓						
Weather Conditions		✓						

* Data field names correspond to selected field names on the Police MV104 accident report form. MV104 reports are used to compile the HSIS database.

The causal factors point toward the general solutions appropriate to the Provincial planning level, such as educational, wildlife management, geometric, enforcement or access management actions.

3.6 Reliability

Problem Identification:

District highway offices report highway closure data by fax to the communications center in Burnaby giving the time, duration, cause and general location of the closure. Two years of record covering the Provincial numbered highways showed the following data:

Time period covered	1995 and 1996
Total Number of Closures	394
Average rate of closures	5.23 hrs/km/yr

This data includes a storm lasting several days at the end of 1996 which produced widespread extended highway closures.

Closures can either be point closures such as a motor vehicle accident or closures covering an extended area due to weather conditions. In either case, a closure is assumed to impact an extended length of highway. For this analysis the length of highway impacted by a closure is defined as the length of the lki segment (1995 LKI) in which the closure occurs. This is used to generate the average closure/km/year used in rating highway closure frequency.

The general approach uses the critical closure rate calculated in the same manner as the critical accident rate used by Highway Safety Branch to identify locations with high accident frequency.

The critical closure rate is a statistical function based on average closure rate expressed as hours of closure/km/yr. Exposure is defined as kilometers of highway instead of vehicle-kilometers of travel since highway closures are often unrelated to traffic volume. The critical rate for any highway section is calculated as:

$$CR = AR + 1.645 \text{ X } SQRT(AR/K) + 1/(2 \text{ X } K)$$

Where: CR = critical closure rate for a given highway section in hrs. of closure/km/yr
AR = average closure rate on Provincial numbered highways (5.23 hrs/km/yr)
K = km of highway in a the section for which the critical rate is to be measured

The proposed criteria for rating highway closures are based on the critical accident rate:

Good:	closure rate is less than or equal to the critical rate
Fair:	closure rate is greater than the critical rate, but less than or equal to 1.5 X the critical rate
Poor:	closure rate is equal to or greater than 1.5 X the critical rate

Problem identification would benefit from a standard method of reporting highway closures. The present method relies on written descriptions faxed to the communications center which must be entered manually into a database.

Problem Definition:

Problem definition includes characterizing the frequency and causes of closures to help define corrective actions or programs at the Provincial Level., the reasons and number of occurrences are listed here, based on the 1995 + 1996 data.

Cause	Number of occurrences in 1995 +1996
MVA	158
Weather Conditions	56
Truck Accident (excl. log/lumber)	36
Avalanche/Hazard/Control	35
Rock/Mud Slide	27
Lumber/Log Truck Spill	15
Wash Out/Flood	14
Other	11
Vehicle Recovery	10
Fire	7
Hazardous Materials	6
Downed Power Lines	6
Trucks Without Chains	3
Fallen Trees	3
Scheduled/Construction	2
Emergency Repairs	1
Airplane Crash	1
Rock Work	1
Train Breakdown	1
Total	393

3.7 Pavement Condition

Problem Identification:

Pavement Quality Index (PQI) is used in B.C. to measure overall pavement condition. It is a composite measure derived from the Pavement Distress Index (PDI) and the Ride Comfort Index (RCI) as PQI = 40% (PDI) + 60% (RCI).

PDI is measured on a scale of 1 to 10 with 10 rated very good. PDI measures the type and degree of distress such as cracking or deformation and helps to evaluate the causes of pavement failure. Condition is surveyed every two years on group I (primary) highways and every three years on group II (secondary) highways.

RCI is a measure of riding comfort experienced by the road user as they travel over the road surface. Continuous profile roughness measurements are collected for each wheel-path using either ultra-sonic or laser based automated roughness profile measuring systems. RCI is measured on a scale of 1 to 10 with 10 rated as very good.

The PQI reference system is:

PQI Less than or Equal to:	Rating	Definition
10.0	Very Good	Like new with very few defects
8.5	Good	Many years of serviceable life remaining
7.0	Fair	Close to or needs some type of rehabilitation
5.0	Poor	Should have been rehabilitated within the last few years with potential for accelerated deterioration
3.5	Very Poor	Should have been rehabilitated many years ago and is very deteriorated

PQI is currently available for 1995 for all the Primary Highways. 1996 data will be available for Secondary Highways in Region 2,3,4 and 5 in March . PQI is reported by Highway Engineering in 1 km to 5 km increments using HLRP (Highway Locational Referencing Project) for location

Remaining pavement life was suggested but is not used as the measure of need since there is no formal remaining life data collected. Remaining life is a function of traffic, environmental, rehabilitation and maintenance conditions and varies with individual sites. Instead of estimating remaining life at a given year, the approach is to estimate pavement condition and backlog for a given year. Future pavement condition can be estimated based on age and traffic.

Backlog is the total kilometers of highway that would be rehabilitated under normal pavement management practices. PQI is commonly used by highway agencies as the basis for determining backlog. A trigger value is defined and all sections exceeding this limit represent the current deficiency. A trigger value of PQI = 6.4 is used for the PHP analysis. This takes into account both the pavement distress and roughness condition thresholds in which surface rehabilitation is first warranted.

The proposed performance measure for the Provincial Highway Plan is based on the PQI.

Description	PQI
does not yet need resurfacing	>6.4
needs resurfacing now	< or = 6.4 and >5
Should have been rehabilitated within the last few years. Has potential for accelerated deterioration	< or = 5

Problem Definition:

Pavements are normally designed for a 15 year life before an overlay is required. For a given thickness-design and subgrade, life is governed by environmental conditions and traffic loading. Environmental conditions affect pavement life through freeze thaw conditions. thermal cracking and loss of subgrade support during spring thaw.

Traffic loading is the expected number of equivalent single axle loads (ESALs) over the life of the pavement (1 ESAL = 8,172 kg). If either the number of trucks or the average axle loading increase above those assumed for the original design, then the ESALSs increase and pavement life is shortened accordingly.

At the Provincial level, truck volume relates to mode choice and economic conditions and is generally beyond the scope of a Provincial highway plan to influence:

- mode choice (road vs rail) - railways are concentrating on long distance, bulk transportation and are abandoning branch line service. Solutions may range from supporting short line operation or equitable tax treatment of railways compared to highway.
- Just-in-time Delivery - The higher variability in rail delivery time favours a mode shift to truck.
- Industrial consolidation - Mills and industries closing marginal plants end up shipping raw materials and product further.
- Road Pricing - While trucks pay most or all of the direct costs they impose on the highway system through road taxes, highway traffic in general (both cars and trucks) does not pay the external costs of highway transportation. More effective road pricing would internalize some of these external costs shifting more traffic to rail[6].

This leaves axle loading as the issue under the most direct control of the Province. Overloading usually stems from short haul construction or resource traffic. Long haul traffic

[6] Harmelink, M.D., Lyall,P., "British Columbia Tolling Policy Development Study", Prepared for the BC Transportation Financing Authority, March 1997.

generally traverses several weigh stations en route and is unlikely to be overloaded. Provincial strategies for enforcing legal axle loads include[7]:

- Short haul traffic - Increase mobile enforcement to replace static scales which have limited hours of operation or are not intercepting the short haul traffic.
- Long haul traffic - provide full service inspection stations with 24 hour operation and encourage weigh-in-motion (WIM) and automated vehicle identification (AVI) technologies to reduce delay.

3.8 Bridge and Major Structure Rehabilitation

Bridge rehabilitation includes repairs, upgrades and replacements.

Repairs:	to extend life, reduce maintenance cost or improve safety.
Upgrades:	to improve a structure to a higher standard (i.e. widening).
Replacements:	when it is more cost effective than repairs or upgrades

The Provincial Highway Plan first identifies problems at the corridor level. If a corridor performs well overall, the strategy is to keep it that way through regular maintenance and rehabilitation to maintain safety and level of service. If a corridor exhibits poor level of service or safety performance, then the strategy is to identify the causes and propose general improvements or projects to address them.

In most cases, poor corridor performance is caused by a range of problems which point to a program of improvements as part of a corridor plan. Depending on the nature of the corridor deficiency, there are many possible actions which could be included in the program. As they relate to structures, these actions may include:

Corridor Deficiency	Possible Causes Related to Structures	Possible Actions Related to Structures
Low Travel Speed	Low Bridge Capacity Poor approach alignment	Added bridge capacity. Realign approaches or bridge.
High Accident Rate	Poor approach or bridge alignment Poor end treatment Substandard width*	Realign approaches or bridge. Widen or replace.
Poor Reliability (closures)	Seismic rating is potentially a cause Bridge Condition	Seismic Rehabilitation New bridge with seismic standard Replace or rehabilitate
Deteriorating Infrastructure/ High Maint. Cost	Bridge Condition	Replace or rehabilitate
Load Restriction	Bridge Condition	Replace or upgrade

[7] Lyall, P. "A Strategy for BC Provincial Weigh Scales" prepared by ADI Limited for MoTH, Project Planning, Victoria BC, September 1995.

	Low original live load design standard Increasing truck weight	
Restricted Vert. Clearance	Poor service design	Replace or upgrade
None	Structures performing adequately Deficiencies not significant at corridor level	Regular maintenance and rehabilitation.

* Substandard bridge width in relation to highway class is considered as a cause of safety or travel speed problems. It is not considered as a problem in itself.

From the Provincial planning perspective, the *need* for action is high if there is:

- A high accident rate
- Poor bridge condition
- Poor travel speed in the corridor, attributable to low traffic capacity on a bridge.
- Detour or restrictions due to a bridge live load or clearance deficiency

While these criteria indicate a need, they do not necessarily mean action should be taken. Solutions depend on the underlying causes of the problems, proposed corridor plans and benefit cost arguments. At the PHP level, solutions are addressed in general terms only.

The following criteria are used to indicate the need. Safety performance is a concern for bridges but it is already captured as a separate performance and is not repeated as a criteria here. A bridge on the primary or secondary system is given an overall fair or poor rating if any of the criteria below are fair or poor.

Measure	Good	Fair	Poor
Condition	BCI < or =2.0	2.0< BCI > =3.0	BCI >3.0
Travel Speed	v/c < = 0.8	0.8 < v/c < = 0.9	v/c > 0.9
Load Restriction	none	>or = to 57 tonnes and < 63.5 tonnes	<57 tonnes
Dimensional Restriction	none		

AR = bridge accident rate in accidents/million vehicles (a/mv)
CR = Critical accident rate for a bridge (a/mv)
BCI = Bridge Condition Index. BCI measures the overall bridge condition based on condition of the channel, substructure, superstructure and deck. This data is complied by regional Bridge Engineers.
v/c = Volume to Capacity Ratio

Load Restriction - This is the maximum allowable gross vehicle weight (GVW) on the bridge. 63.5 tonnes is the legal GVW for an 8 axle B-train. A 6 axle Tractor semitrailer unit has a maximum 45 tonnes.

Dimensional Restrictions - Bridge cross section should generally be consistent with the cross section of the highway it serves. For rural arterial undivided highways the cross sections vary with the design hour volume. The standard for overhead clearance is 5.0 m.

DHV	Lane Width (m.)	Shoulder Width (m.)
<200	3.6	1.5
<=450	3.6	2.0
>450	3.6	2.5

3.9 Seismic Needs

Seismic upgrading is reported separately from bridge rehabilitation since this issue is unique to bridges along the coast in zones of high seismic activity. Funding for seismic upgrading is generally considered separately from bridge replacement and rehabilitation programs. The purpose of the seismic retrofitting program is "to minimize loss of life and injury during earthquakes and to preserve important routes for use after earthquakes"[8].

The Province is mapped into acceleration related seismic zones ranging from 0 (lowest) to 6 (highest). The retrofit program is reviewing about 470 bridges in seismic zones 2,3,4,5 and 6 of which an estimated 250 may require retrofitting. The highest priority bridges are those identified as part of lifeline or emergency routes.

Lifeline route Bridges

The lifeline classification is assigned to major bridges based on SADT, bridge length and detour length. There are 16 lifeline structures in the Province of which 14 are considered vulnerable to damage and collapse and 2 are built to earthquake standards. The vulnerable bridges include 11 in the Lower Mainland plus the Agassiz-Rosedale and Okanagan Lake Bridges.

Emergency route bridges:

Region 1- corridors for emergency vehicles through the lower mainland, based on routes with minimum numbers of vulnerable bridges.
Region 5- routes from Terrace to Prince Rupert and Kitimat
Region 6- routes from Victoria to Swartz Bay, Colwood and Parksville.

For the PHP, a three tier rating scheme is proposed, consistent with criteria for other performance measures in the PHP.

Priority	Lifeline or Emergency Route Bridges	Other Bridges in Seismic Zones
High	• Not designed to 1983 ASSHTO seismic standard or, • Not retrofitted	None
Medium	• Partial retrofit completed	None
Low	• Designed to 1983 AASHTO seismic standard or • Full retrofit completed.	Partial or no retrofit completed.

[8] "bridge Seismic Retrofitting Program",Highway Engineering Branch, Bridge Section, March 1997

4.0 Forecasts

4.1 Introduction

At the *Provincial Highway Plan* level, traffic forecasts are used for:

- benefit cost analysis,
- timing of improvements,
- LOS analysis and
- greenhouse gas estimates for future years.

At the PHP level, a Provincial transportation model would be the preferred approach to forecast traffic volumes but one has not yet been developed. The approach in the PHP uses simpler linear regression models. On a given highway, the correlation is established between historical traffic and population[9]. The regression model is then used to predict future traffic, using population projections as the independent variable.

Transportation models offer more accurate population based forecasting and are useful for predicting diversion to other routes in a network. At the *corridor* level, such as Kamloops to the Alberta Border, the highway is a linear system with little opportunity for diversion and the advantages of a network model are limited mostly to forecasting. For the corridor level it is proposed not to use a network model until a Provincial model is available. Calibrating network models at the corridor level requires a large effort for a relatively small area. It is recommended that one Provincial model be developed rather than repeatedly calibrating smaller regional models.

The proposed approach at the corridor level is to forecast traffic using a population based regression model. At the PHP level the general approach is:

1. Select a representative permanent count station in the corridor.
2. Define the population areas which influence traffic growth at that count station.
3. Obtain historical population and traffic statistics
4. Calibrate historical traffic growth with population growth
5. Forecast traffic growth based on population forecasts
6. Translate the selected permanent count forecasts to the local area of interest
7. Calculate a design hour volume

---

[9] In the 1995 PHP, gross domestic product (GDP) was also included as an independent variable in the previous 1995 PHP forecasts, but is not used in the 1997 PHP forecasts for three reasons:

- GDP forecasts are only produced for 5 years and the planning period is 25 years
- GDP is forecast for the Province as a whole while traffic is often specific to the economy or population of a region.
- In the past, when calibrated against historical data, GDP did not significantly improve the fit of the forecast model.

4.2 Select a Permanent Count Station

At the PHP level, only permanent count stations with 6 years of record or more are used to correlate population growth with traffic growth. Short counts are not used since the year to year variation is usually too high to correlate traffic with population in any meaningful way.

From Kamloops to Alberta, there are three permanent counter stations:

> 21-001 Monte Creek East of Kamloops 1965-1995
> 22-001 E.of Sicamous Since 1986 (short count only prior to 1986)
> 37-001 E of Golden since 1993

P21-001 has about 30 years of record and is used to correlate traffic with population.

4.3 Characterise Traffic Generation

Traffic generation on a section of highway is usually related to population growth in a defined area or zone served by the highway. Transportation models allow for many zones to be considered but in the absence of a calibrated Provincial model, traffic growth is characterized using a limited number of zones, in order to be manageable. For example, two zones can be defined; one influencing non-local traffic and the other local traffic:

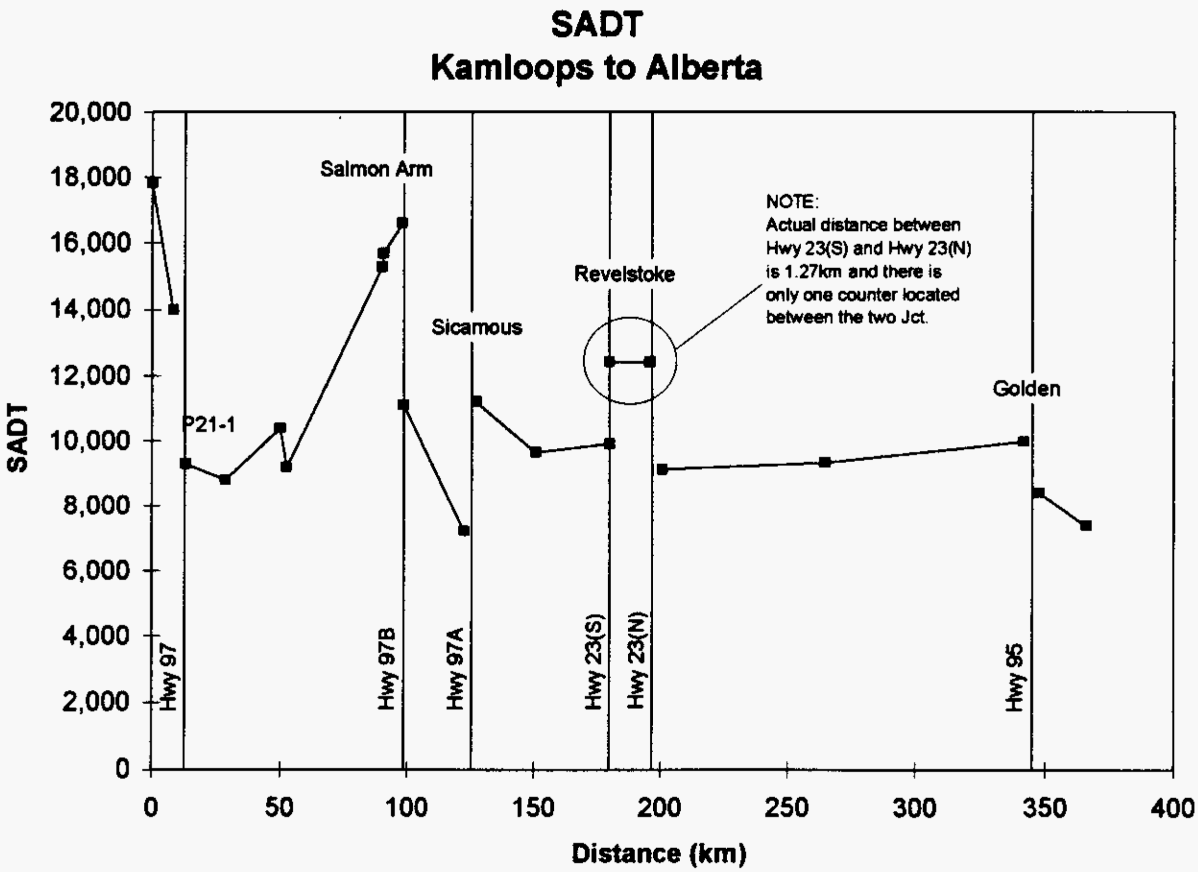
Non-Local Traffic

Non-Local traffic is defined here as through traffic with origin or destination outside the urban area (the Highway Classification Manual defines Urban areas as having population >5,000). Counter P21-1 is located at Monte Creek east of Kamloops and by this definition, reflects non-local traffic. As an inter-Provincial corridor, non-local traffic volumes on Highway 1 are strongly related to population growth in the Province as a whole so in this case, the population of BC is used as the independent variable correlated to traffic at this counter location. Historical and forecast population for local Health Areas are (will be) included as appendix B.

Local Traffic

The local traffic component of a traffic count is defined here as traffic with origin or destination in the urban center where the counter is located. Since P21-1 lies outside of the Kamloops urban area, then it has no local traffic component.

Exhibit 4.1


SADT
Kamloops to Alberta
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
SADT
0
50
100
150
200
250
300
350
400
Distance (km)
Salmon Arm
Sicamous
Revelstoke
Golden
P21-1
Hwy 97
Hwy 97B
Hwy 97A
Hwy 23(S)
Hwy 23(N)
Hwy 95
NOTE:
Actual distance between Hwy 23(S) and Hwy 23(N) is 1.27km and there is only one counter located between the two Jct.

Year	21-1	Population
1971	4,275	2,250,200
1976	5,557	2,545,000
1977	6,147	2,581,200
1978	6,546	2,625,800
1979	6,746	2,675,000
1980	7,388	2,755,500
1981	7,934	2,836,500
1982	7,775	2,886,300
1983	6,657	2,919,600
1984	6,270	2,960,600
1985	6,375	2,990,000
1986	7,156	3,020,400
1987	7,822	3,064,600
1988	8,053	3,128,200
1989	8,556	3,209,200
1990	8,566	3,300,100
1991	8,042	3,379,800
1992	8,479	3,476,871
1993	9,131	3,574,603
1994	9,748	3,669,634

4.4 Historical Population and Traffic Statistics

Historical population data are available for 1971 and 1976 through to 1994. The counter data goes back further but there is no matching population record so it is not used.

4.5 Correlate Historical Traffic and Population

A linear regression using population as the independent variable and AADT as the dependent variable may be done using any spreadsheet software. The results for this regression are:

	Regression Output:
Constant	-2120
Std Err of AADT Estimate	600
Coeff. of Correlation R^2	0.80
No. of Observations	20
Degrees of Freedom	18
Population Coefficient	0.00317
Std Err of Coef.	0.00037

The regression formula for projecting AADT at counter P21-1 uses only the BC population as the independent variable and is:

$$AADT = .00317 \times \text{BC Population} - 2,120$$

4.6 Forecast Future Traffic

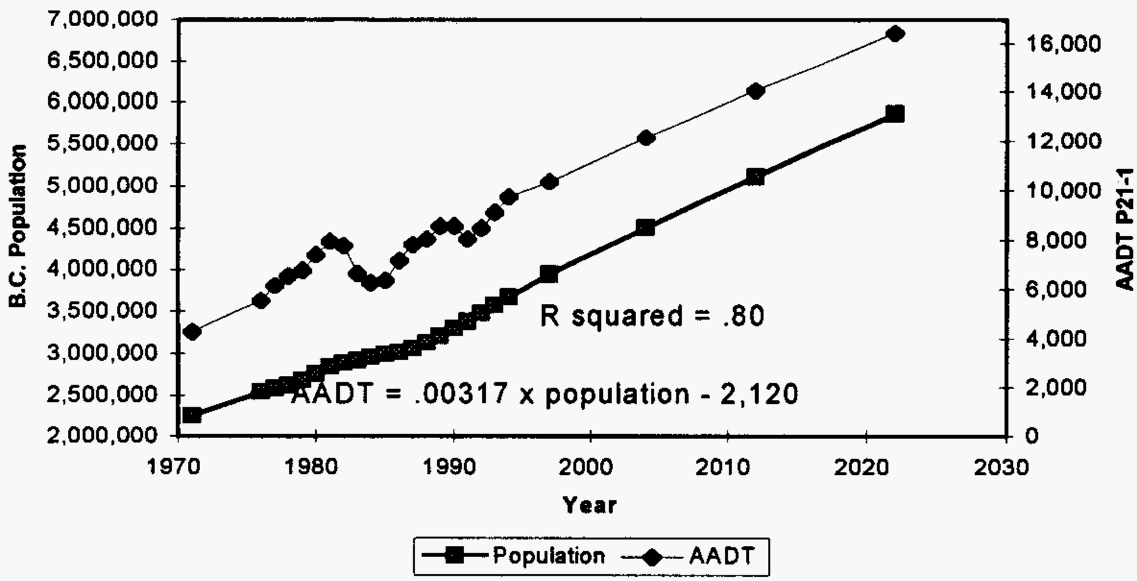
Using this regression formula the planning volumes at P21-1 are shown here.

	Year	BC Population	P21-1 AADT	Growth
Data Year	1994	3,669,534	9,748	1.000
Base Year[10]	1997	3,945,233	10,380	1.065
Short Term Horizon	2002	4,338,970	11,635	1.194
Medium Term	2012	5,109,720	14,069	1.443
Long Term	2022	5,860,999	16,450	1.688

Annual traffic growth from the base year to the 25 year horizon averages 2.3% linear (or 1.86% compound) growth. The historical and projected traffic and AADT are illustrated below.

Exhibit 4.2

B.C. Population and AADT on TCH



[10] The forecast 1997 base year SADT may be quite different from the last observed year (1994) since the forecast is following a long term trend while any individual historic year can vary widely from the long term trend.

Typical problems encountered with this method are:

Short Time Series

It is desirable to have about 10 years of record to establish a reasonable correlation between population and traffic. The minimum used is 6 years. A short time series usually gives a poor correlation.

Poor Correlation:

Where population density or traffic volume is low or the historical time series is short, the correlation between traffic and population may be poor (a cutoff of R^2 = .60 is used as a minimum). If the correlation is poor, then future traffic is simply estimated to grow in the same proportion as future population, without regard to the historical correlation. In other words if the characteristic population grows at 2% then the traffic also grows at 2%.

4.7 Translate to the Local area

As an example, project the traffic in Revelstoke. Relevant counter data includes:

Counter Number	Location	SADT	AADT
	Permanent Counts		
P22-1	0.2 km east of Gorge Creek Bridge at Craigellachie historical site. West of Revelstoke	9,645	5,255
P37-1	2.5 km east of route 95, east of Golden	8,407	4,147
P21-1	4.7 km west of Route 97, Monte Creek, East of Kamloops	13,987	9,748
	Short Counts		
38-001	west end of the Columbia River Bridge, in Revelstoke	12,400	6,200*
38-004	4.0 km east or route 23, east of Revelstoke	8,800	4,400*

* AADT for the short counts is estimated as .50 x SADT based on the permanent count data from P22-1 and P37-1

Non-local Traffic

Non-local traffic in Revelstoke is assumed to be 4,400 AADT or 8,800 SADT from counter 38-004 which measures traffic outside of Revelstoke to the east. It is assumed to grow at the rate defined by counter P21-1:

	Year	AADT	Growth
Data Year	1994	4400	1.000
Base Year[11]	1997	4686	1.065
Short Term Horizon	2004	5474	1.244
Medium Term	2012	6349	1.443
Long Term	2022	7427	1.688

Local Traffic

Total traffic on Highway 1 in Revelstoke is estimated to be 6,200 AADT from counter 38-001. Subtracting the non-local component 4,400 leaves a local component of 1,800 AADT. Local traffic is assumed to grow in proportion to the local Revelstoke population (Local Health Area 19):

	Year	Population Revelstoke	Local AADT
Data Year	1994	8,862	1,800
Base Year	1997	9,029	1,834
Short Term Horizon	2004	9,401	1,909
Medium Term	2012	9,471	1,924
Long Term	2022	9023	1,833

Total traffic in Revelstoke is the sum of local and non-local:

	Year	AADT
Data Year	1994	6,200
Base Year[12]	1997	6,520
Short Term Horizon	2004	7,383
Medium Term	2012	8,273
Long Term	2022	9,260

[11] The forecast 1997 base year SADT may be quite different from the last observed year (1994) since the forecast is following a long term trend while any individual historic year can vary widely from the long term trend.

[12] same note

4.8 Design Hour Volume

The capacity needed to provide a given level of service, is estimated using the design hour volume (DHV). At the corridor planning level, the normal approach is to take peak hour traffic counts and use these as the DHV for level of service analysis. At the PHP level this is not possible, so DHV is estimated using three formulas:

Type of Traffic	DHV
Urban	= 30 + .09 x AADT
Rural	= 100 + .11 x AADT
Recreational	= 250 + .13 x AADT

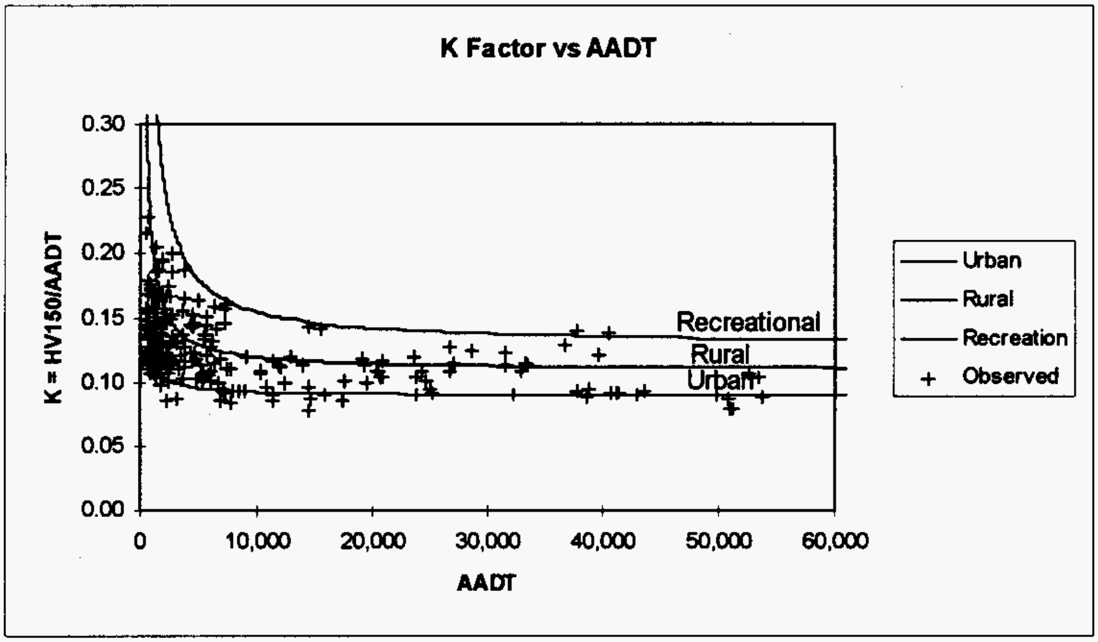
In Revelstoke for example, if peak hour counts were not available, then an estimate of DHV could be made using these formulae. Even though Revelstoke is classified as "urban" (population >5,000) most of the traffic is rural or through traffic.

Using the equation for estimating DHV for rural traffic (DHV = 100 + .11 AADT) gives the following DHV's:

Horizon	Year	AADT	DHV
Data Year	1994	6,200	782
Base Year	1997	6,519	817
Short Term Horizon	2004	7,383	912
Medium Term	2012	8,274	1,010
Long Term	2022	9,258	1,118

The general formulae are derived from approximately 300 permanent count stations with an AADT over 500 in BC for 1993 shown below.

Exhibit 4.3



The urban, rural and recreational lines are defined subjectively in relation to the observed data. The observed data above is the 150th highest volume of the year (HV150) for each count station and represents the normal daily peaks during the peak season, rather than the 30th hour volume.[13]

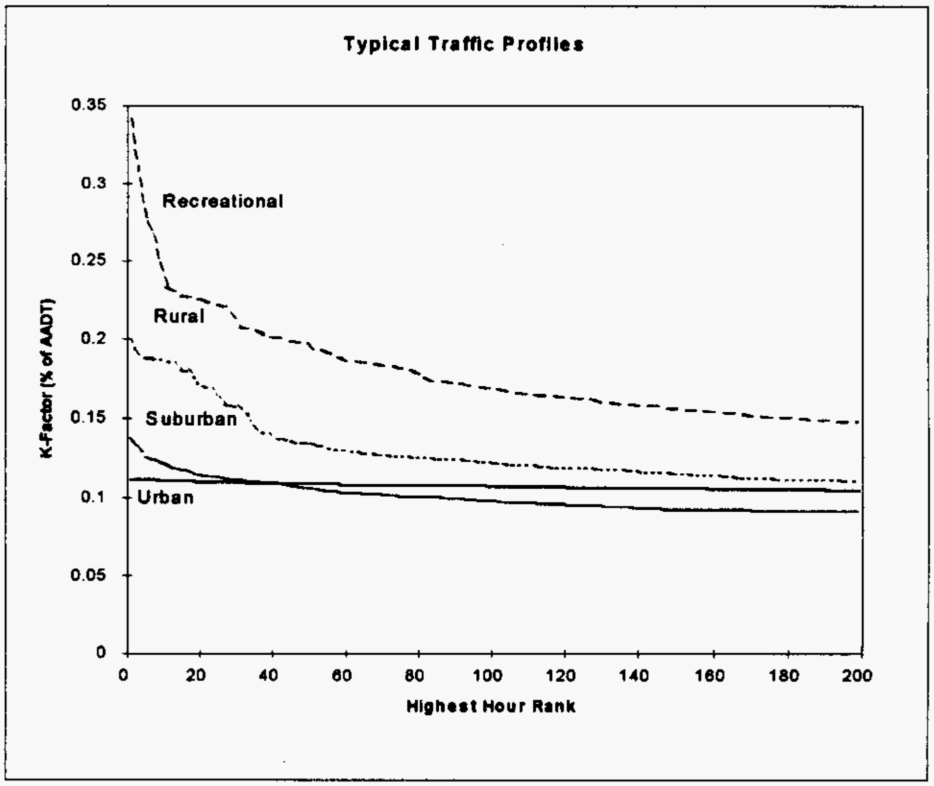
These DHV formulae are consistent with the 1995 PHP but allow for some variation in the K factor (=DHV/AADT) over the planning period as AADT increases. This is because growth in AADT is often the result of increased travel during off peak hours or seasons rather than peak periods which means DHV does not grow as fast as AADT. The assumption that DHV grows at the same rate as AADT would tend to overstate future capacity requirements.

For information purposes, some typical counter profiles are shown below:

	Recreational	Rural	Suburban	Urban
Counter	P15-3	P21-1	P17-4	P15-2
Highway	Hwy 99	Hwy 1	Rte 1	Hwy 1
Location	North of Squamish	at Hwy 97 Monte Creek	Bradner Rdin Matsqui	2nd Narrows Bridge
K factor (150 HV)	.16	.12	.09	.10
AADT	8,063	13,988	61,348	112,030
DHV	1,370	1,679	5,521	11,203

Exhibit 4.4

The 200 highest hours from these count stations are profiled here



[13] ADI Limited "Design Hour Volumes and Level of Service for the Provincial Highway Plan" Prepared for BC MoTH, Systems Planning, Highway Planning Branch, February 1995.

5. Benefit Cost Analysis

5.1 Introduction

The financial and customer service accounts for multiple account evaluation come from benefit cost analysis. The *costs* are the financial account and the *benefits* are the customer service account.

In benefit cost analysis, the costs represent the incremental increase in capital and maintenance costs to the infrastructure providers while the benefits are the incremental reductions in time, accident and vehicle operating costs experienced by the highway user as a result of the proposed project. Benefits and costs are discounted over the life of the project to a single present value. Who pays and who benefits are not considered. Cost shared amounts for example, should not be subtracted from costs.

The two economic performance measures most commonly used from B/C analysis for selecting projects are B/C and NPV.

Measure	Definition
Benefit Cost Ratio (B/C ratio)	Present Value of Benefits/Present Value of Costs
Net Present Value (NPV)	Present Value of Benefits - Present Value of Costs

Under conditions of fixed budget, the objective is to select the combination of projects which give the maximum Net Present Value for the budget available. This is usually, but not always the same projects which would be selected by descending order of B/C ratio. Generally the B/C ratio should be expressed to no more than 1 decimal place since they are rarely more accurate and usually less than this.

The MicroBencost model is the present standard for benefit cost analysis in the Ministry. It is supported by Transport Canada, the U.S. FHWA and is widely used in other Provinces. The model is presently in U.S. units but a metric version is nearing completion. Data requirements are similar to most benefit cost models.

An interim default file for B.C. will be supplied for use with the MicroBencost model. The general principle is to use default data where better data is not available or where most of the inputs do not change between the base and proposed case. The data inputs and defaults are defined in more detail below.

Data Requirements:

- Project data
- Economic data
- Vehicle operating cost
- Traffic
- Value of time
- Accident
- Agency Costs

5.2 Economic Data

The economic data include:

Currrent Year	Benefits and costs over the analysis period are discounted to the current year specified in the model.
Horizon Year	This is the last year of the analysis period. For the PHP analysis, the planning period is 25 years so the horizon year is 2022. A 25 year planning period is consistent with the South Coast Systems Plan and the Okanagan Valley Transportation Plan. For a project completed in 1999 for example, then the horizon year is 2024.
Discount Rate	8% - This is the time value of money. It excludes inflation. Typically the interest rate = inflation + discount rate.
Year benefits begin	If for example, construction is completed in 1997 then benefits begin in 1998.
Analysis Period	Period over which benefits are measured, for example: (25 year planning period - 1 year of construction) = 24 year analysis period

5.3 Project Data

These inputs to the model describe project geometry and are used by the model to calculate default accident rates and default speeds using the Highway Capacity Manual procedures. As a general principle, these inputs are not critical if the analyst overrides the default speeds and accident rates with more reliable data or observed values. The inputs below are shown as "user input" which *must* be supplied by the analyst and default or optional data which *may* be supplied by the user.

construction period	default is 1 year
environment	user input (urban or rural)
length	user input - length of
lane width	default
median width	default
# of lanes	user input
lateral clearance	default
speed limit	default
specific grades	optional user input
curve radius	optional user input
capacity override	default
design speed	default
running speed	default
surface deterioration	default
% no passing	default
auxiliary lanes	not specifically analyzed

5.4 Vehicle Operating Costs

Unless there is a change in the length of an alignment, VOC usually makes up less than 5% of the change in user benefits between base and proposed case. The changes are not necessarily positive since projects often result in higher speeds leading to greater fuel consumption. In the analysis of the TCH the important factor will be to capture any changes in travel distance resulting from improved alignments. A 1% reduction in the length of an alignment can easily increase project benefits by 10%. While a 1% reduction is small it represents 1% of a very large accumulation in user costs (accident and time as well as VOC) over the life of a project and as a result, shows up as a large benefit.

MicroBencost calculates vehicle operating costs as a function of traffic and highway conditions. Components accounted for in the cost calculations include:

- Fuel
- Oil
- Tires
- Maintenance
- Use related depreciation

The variables used to predict consumption rates of each VOC component typically include:

- speed
- grade
- curvature
- number of speed change cycles
- number of stop cycles
- surface condition
- temperature

The general algorithm for estimating Vehicle Operating Cost (VOC) is:

VOC = AADT x distance x consumption rate x unit price

All of the variables are default values with the exception of unit prices. These are under review by BCTFA and MoTH, along with other default inputs but the following data are suitable in the interim for use in B.C.

Vehicle Description	Fuel Cost ($/US.gal)	Oil Cost ($/qrt)	Tire Cost ($/veh)	Maint & Rep Cost ($/1000 mi)	Deprec Cost ($/veh)
Small pass	$2.27	$1.72	$240	$30	$12,000
Med/large pass	$2.27	$1.72	$300	$40	$17,000
Pickup/van	$2.27	$1.72	$400	$50	$20,000
Buses	$1.50	$0.91	$5,600	$250	$100,000
2-Axle Single Unit	$2.27	$1.72	$2,400	$300	$25,000
3-Axle Single Unit	$2.09	$3.40	$5,000	$350	$70,000
2-S2 Semi's	$2.09	$3.40	$7,000	$315	$100,000
3-S2 Semi's	$2.09	$3.40	$9,000	$315	$130,000
3-S3 Semi's	$2.09	$3.40	$11,000	$315	$160,000
A,B or C Train Doubles	$2.09	$3.40	$15,000	$315	$150,000
Other					

Tire cost is for all tires on a vehicle including semi-trailers and full trailers, if applicable. For trucks, this is not only the cost of new tires but also includes 1.5 recaps for 2-axle single-unit trucks and 2.5 recaps for all other truck types.

5.5 TRAFFIC

5.5.1 Vehicle Classification

Default vehicle splits, which can be overwritten by the analyst, are available for the following vehicle types:

Passenger Vehicles:

Typical default values are shown here. There is no separate provision for Recreational Vehicles in the Benefit Cost model. If RV's are an issue they can be added in as single unit trucks rather than ignore them. The value of time and vehicle parameters for single unit trucks should be changed accordingly. It is recommended that the working group responsible for standardizing benefit cost add an RV category this category to the BC default values.

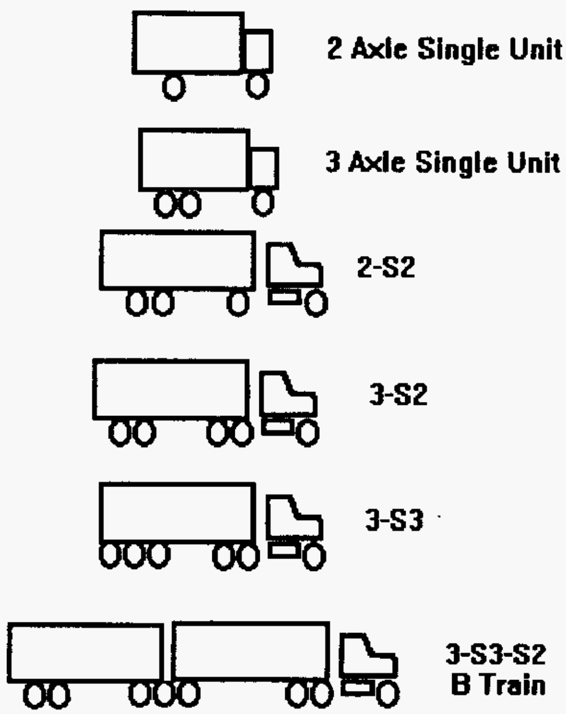
Vehicle	% of Fleet	Occupancy
Small Pass	17.4	1.3
Med/large Pass	50.8	1.3
Pickup/van	31.8	1.3
Bus	1.0	20

Trucks:

The analyst should have reasonable estimates for traffic growth and % trucks, in particular an estimate of 3-S2 or larger trucks is desirable since these have the greatest impact on vehicle operating costs and capacity (the default is 10%). Theses default truck configurations are supplied with the BC default data. For most applications, the analyst does not need to classify the configuration. The overall % trucks is adequate. The BC defaults assume trucks are split:

2-Axle	7%
3-Axle	3%
2-S2	5%
2-S3	40%
3-S3	20%
3-S3-S2	25%

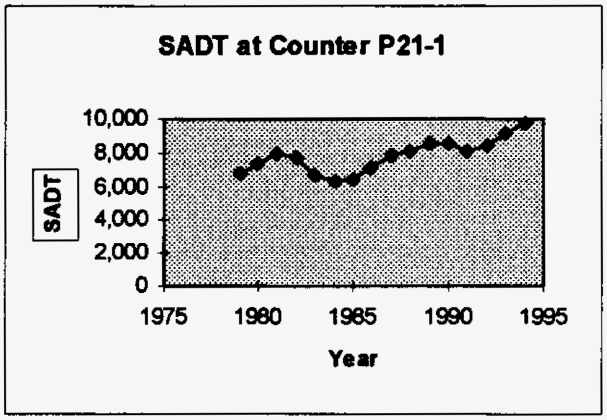
Other configurations may also be added if desired.



5.5.2 *Traffic Growth*

Traffic growth must be specified by the analyst . It can be given as:

1. the base year traffic and an annual growth rate;
2. a base, intermediate, and horizon year traffic; or
3. as traffic volumes given for each year of the analysis period.



In the absence of structures traffic forecast, the first approach is most commonly used by planners. This approach has a tendency to overstate traffic in later years of the analysis period since it is a compound growth rate. The second approach is preferred since it assumes a straight linear growth which is usually closer to the truth. Traffic normally grows linearly or in a sigmoidal curve with slow growth initially, followed by e period of rapid growth as activity centers develop; followed by slow growth as the traffic patterns mature.

5.5.3 *Traffic Profiles*

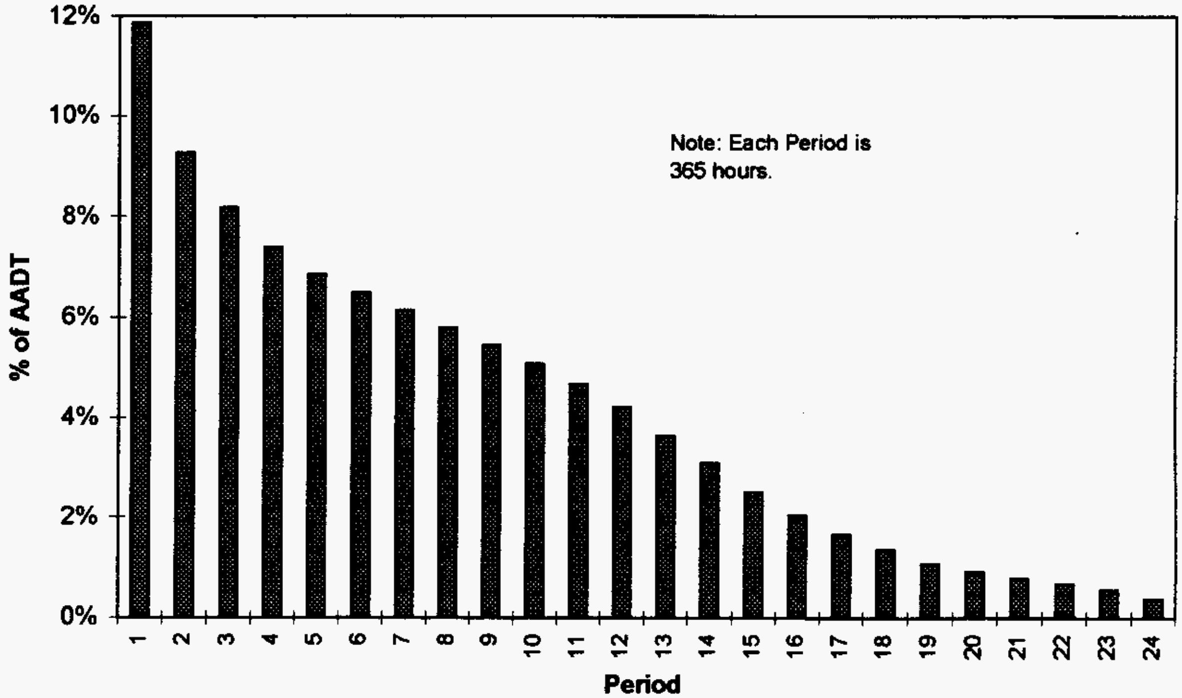
Traffic profiles are the hourly traffic pattern over the average day or year. They characterize the variation in traffic flow over time to account for peak period congestion which increases the time and VOC cost per vehicle. The profile is entered as a histogram with 24 intervals and can either represent the average daily traffic pattern or the annual distribution. The profile for counter P21-1 at Monte Creek is illustrated here in an annual distribution. Default profiles are also available in the model if no profile is specified.

When traffic peaking is a concern, the annual traffic profile is usually the preferred approach. Converting the 8,760 hour/year profile from a permanent counter to a smaller number of intervals (up to 24) can be done by:

1. ranking the hour counts in descending order
2. divide them into 24 groups of 365 hours each
3. average the hourly traffic for each group.
4. convert the average to a % of AADT
5. enter the % of AADT into the model for each interval

The summation of the traffic over the 24 intervals $= \sum_{1}^{24} \%AADT_n \times 365$ should equal the total annual traffic. Some minor adjustment is usually necessary. The analyst may also use variable duration groups

Annual Traffic Profile - Monte Creek



Traffic Interval	% of AADT	Traffic Interval	% of AADT
1	11.88%	13	3.66%
2	9.25%	14	3.09%
3	8.17%	15	2.50%
4	7.39%	16	2.04%
5	6.86%	17	1.66%
6	6.49%	18	1.35%
7	6.14%	19	1.08%
8	5.81%	20	0.90%
9	5.45%	21	0.76%
10	5.09%	22	0.64%
11	4.68%	23	0.53%
12	4.23%	24	0.36%
			100.00%

5.5.4 Speed/Flow Relationships

Time savings typically make up 60% of project benefits. They are measured as the difference in travel time between the existing base case highway and the proposed case option. The best way to measure the travel speed for the *base case* is to drive the analysis section in the typical peak period and in the off-peak periods and modify the default speed/volume curves in the model to agree with the observed speeds and volumes. Speeds for the *proposed case* cannot be measured directly. The recommended way is to use the default HCM calculations in the model or to measure speeds on a comparable highway at a different location. If the HCM calculations are used, TAC recommends using level terrain for all generalized terrain calculations since the HCM overstates the impact of terrain type on capacity[14]. For modeling purposes, specify 0% grade for generalized sections, and use the actual grade on specific grades which are long enough to reduce trucks to crawl speed[15].

Length of Grade for trucks to Slow to Crawl Speed

Grade	Length (km)
3%	1.3
4%	1.2
5%	0.9
6%	0.75
7%	0.65
8%	0.5
8%	0.4

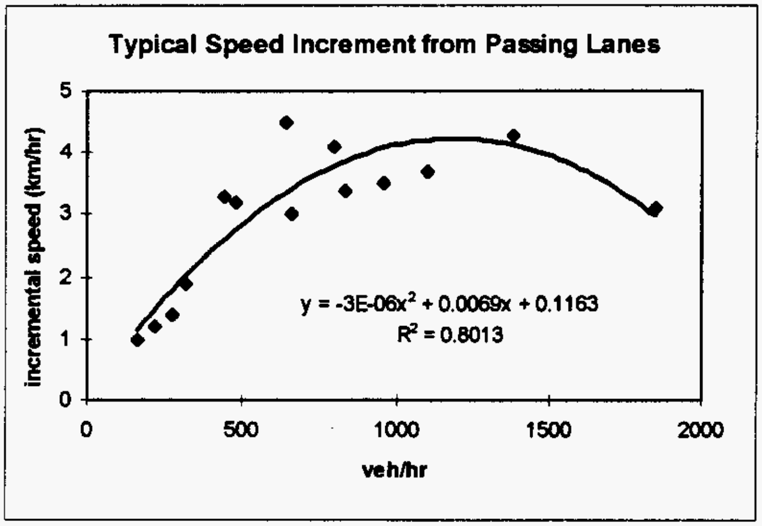
5.5.5 Passing Lanes or Short 4 Lane Sections

Passing/climbing/descending lanes will likely be one of the interim options considered for the TCH. The impact of passing lanes varies depending on volume, vehicle mix and grades and it is difficult to make a single generalization for use in benefit cost. The general approach is to estimate the impact of passing lanes using traffic simulation models, then input the speeds into a benefit cost model.

The TRARR model is used in various Provinces for this purpose and has been refined over the years to include better speed prediction, particularly for downhill operation. Properly calibrated, it remains the best tool for evaluating passing lane options. It has been used for Monte Creek to Revelstoke and in Revelstoke National Park. The outputs from TRARR include the estimates of changes in travel speed which are a required input for benefit costs analysis. Some typical speed increments are shown below:

[14] Krumins, I. "Two-Lane Highway Cpacity and Level of Service Research Project: Phase III Final Report" Prepared for the Transportation Associatin of Canada, Ottawa, 1991

[15] "Highway Engineering Design Manual" prepared by Highway Engineering Branch, MoTH , Victoria ,BC, 1994



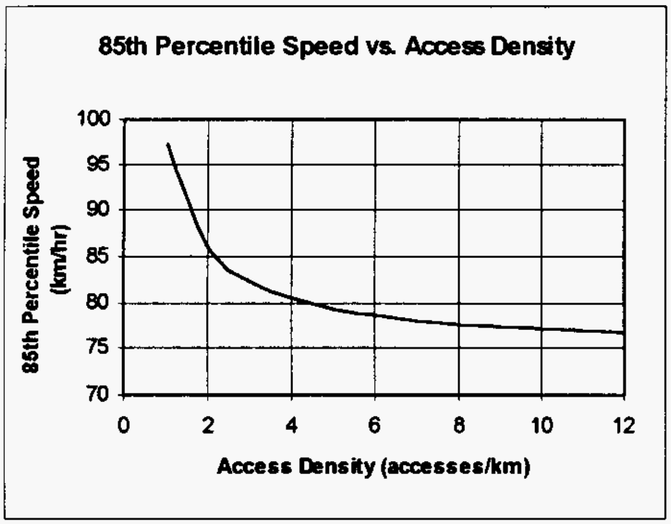
Depending on traffic volume, the typical increases in travel speed in the treated direction range from 1 to 4 km/hr over the passing lane plus its effective downstream distance. If the treated section is a short 4 lane section, then the benefits apply to both directions.

If a TRARR simulation is not possible, this chart (taken from other TRARR simulations) could be used as a guide to evaluate passing lanes in MicroBencost by using it to modify the speed volume curve. The proposed case speed/volume curve for MicroBencost would be the base case plus these incremental speeds. These incremental speeds could be applied to the same passing lane + effective downstream distance where the downstream distance is estimated as the lesser of the distance to the next passing lane or:

Downstream Distance = 10 km - AADT/1,500

This accounts for platoons which reform more rapidly as traffic volume increases.

5.5.6 Access



The impact of access on operating speeds is of interest where an improvement includes frontage roads or median barriers. Traffic normally slows down in response to accesses whether or not there is traffic on them. Field studies by the Texas Transportation Institute[16] calculated a relationship between the 85th percentile operating speed and access density for tangent roadways:

$V^{85} = 74.91 + 22.29/AD$

where AD = access density in approaches/km

AD is assumed to represent the access on both side for undivided highways and the right side only on divided highways.

[16] Fitzpatrick,K.et al, "Design Speed, Operating Speed and Posted Speed, Relationships", ITE Journal, February, 1997.

5.5.7 Summary of Traffic Inputs

Traffic data inputs may be grouped as default or required data:

> Default data is supplied by the model and may be replaced by better observed data if it is available and likely to make a difference to the analysis. The default values usually make little difference to the analysis unless they are likely to change between the base and proposed case.
>
> Required data must be entered by the analyst. Default vehicle classification data is supplied by the model but it is recommended that some vehicle classification data be collected since this will have a large influence on highway performance in mountainous terrain.

The required and default data are summarized below:

Vehicle Classification	
car	default (3 types)
SU truck	default (2 types)
MU truck	default (2 types)
Bus	default
RV	No separate class
AADT	required
Traffic Growth	required
Traffic profiles	
no. intervals	up to 24
interval volume	default
interval duration	default
by Hwy type	default
by rural/urban	default
Speed/Volume Default Curves	
by Hwy type	default
by terrain	default (percent grade)
by avg.hwy.speed	default (design speed)
Directional split	
peak interval	default (for each interval)
by rural/urban	default

5.5.8 Value of Time

The recommended value of time are:

$10.00 *per person hour* for passenger vehicles and buses.
$25.00/hr for Single Unit Trucks
$28.00/hr for Multiple Unit Trucks

These do not include the value of time for cargo

Values of time in MicroBencost are not differentiated by trip purpose since this varies considerably by time of day, day of week, and other categorizations. To correctly take into account the variations by time of day and day of week, it would be necessary to determine the percent of work/non-work, number of passengers by type, etc. by hour of day and day of week *and* to make calculations in the program for each subcategory. If this distinction is required, it should be calculated outside the model and input as a single average value.

Adjustments to Time Value for Congestion

MicroBencost allows adjustments to the value of time for congestion. These adjustments are applied uniformly to all vehicle types. The adjustments can be categorized by volume/capacity ratio and rural or urban areas. It is recommended that these adjustments be kept to the default value of 1.0. As facilities reach capacity, delay increases exponentially. Adding a congestion multiplier compounds this effect and exaggerates benefits beyond reasonable limits.

Adjustments to Time Value for Stopping/Stopped Time

MicroBencost allows adjustments for stopping and stopped time at intersections, which is applied uniformly to all vehicle types. The default value of 1.5 is recommended.

Adjustments for Discomfort

A separate discomfort cost is used for pavement roughness. It is recommended that the default roughness values be used as an interim measure. The defaults are constant over the planning period. Introducing roughness as a cost tends to distort user benefits depending on when the overlay is done in the base case.

5.6 Accident Costs

Accident Cost savings are determined by the unit costs of accidents and the accident rates and severities before and after the improvement.

5.6.1 Unit Costs

	1996
Fatal	$4,168,964
Injury	$97,076
PDO	6,012

Unit costs by accident severity are comprehensive costs recommended in 1991 by Miller[17] and updated to September 1996 based on Consumer Price Index (CPI). Fatal Accident costs are about 30% higher than those used prior to 1997. The lower value was 1 standard deviation below the statistical value of life generated by Miller. The higher value represents the median value and a move toward full cost accounting in transportation.

[17] Dr.T.Miller, Crash Costs in British Columbia" Contract 034535, correspondence with Ross Harris, Planning Services Branch, 1992

5.6.2 Base Case Accident Rates

Accident rates are expressed as accidents/million vehicle km (a/mvk) for highway sections and should include intersection accident rates unless there is a need to analyze intersections separately. If intersections need to be analyzed separately, as in the case of an interchange project, then intersection accident rates may also be specified in the MicroBencost model as accidents/million vehicles (a/mv).

For sections or intersections, it is preferable to use the actual accident rate for the base case if the sample size is large enough. Large enough is a matter of degree but statisticians consider a sample size less than 25 to be "small". A sample size less than 25 should not be used to establish a rate. If there are less than 25 accidents recorded for an analysis section or intersection, then the options in order of preference are:

1. Use a longer period of record
2. Use a longer section of road
3. Use the TAC default rates[18] (appendix B) by facility type

A longer period of record or section of road can be used as long as it is representative of the current conditions at the analysis section. A longer period of record may overstate the accident rate for PDO accidents since the minimum reporting level was raised from $400 to $1,000 on January 1, 1991.

5.6.3 Base Case Accident Severity

For benefit cost analysis, accident severity is the proportion of fatal, injury and property damage only (PDO) accidents. In statistics, the sample size required to estimate the proportion increases as the proportion diminishes or as the required accuracy increases. The formula for calculating the required sample size is:

$$N = [t^2_{95\%} \times P \times (1-P)]/d^2$$

where:

- $N =$ sample size required to estimate the proportion
- $t_{95\%} =$ the t statistic for (N-1) degrees of freedom and the 95% confidence interval ($t_{95\%} = 1.960$ for large samples)
- $P =$ assumed population proportion expressed as a decimal typically .01 for fatal accidents
- $d =$ Desired precision. The precision is in the same units as the proportion.

[18] Hauer E., Persaud B., "Safety Analysis of Roadway Geometric and Ancillary Features" Transportation Association of Canada, Dec., 1996.

If for example the estimated proportion of fatal accidents is .01 and the desired precision is +/- .005 then required sample size (fatal + injury + PDO) is :

$$N = [1.960^2 \times .01 \times (1-.01)] / .005^2 = 1{,}521 \text{ accidents}$$

The total number of accidents (fatal + injury + PDO) required to estimate proportions at the 95% confidence interval for example are shown here.

	Fatal	Injury	PDO
Estimated Proportion	0.01	0.33	0.66

Error	Required Sample Size		
0.005	1521	33975	34482
0.01	380	8494	8621
0.05	15	340	345
0.1	4	85	86

The following guidelines apply for estimating base case accident proportions for benefit cost analysis:

- Use the Provincial default values for estimating proportion of fatal accidents. Sample sizes at any single location are generally not large enough.
- Use observed data for estimating proportions for injury and for PDO accidents if there are more than 50 total accidents in the sample. This will give an error of about +/-13% on the injury and PDO accidents.
- If the sample size is <50 use Provincial averages for the proportion (see table below) or use judgement in the case of low volume rural roads where obvious safety problems exist.

Accidents by Known Highway Class and Severity

BC Provincial Averages For Highway Sections Excluding Intersections 1991-1995

	Fatal		Injury		PDO		Total	
Urban Freeway	22	**0.4%**	2456	**43.9%**	3122	**55.7%**	5600	9.2%
Urban Expressway (Multilane)	89	**1.0%**	3706	**41.4%**	5166	**57.6%**	8961	14.6%
Urban Conventional (2 lane)	49	**1.0%**	1792	**37.5%**	2933	**61.5%**	4774	7.8%
Rural Freeway	85	**1.4%**	2529	**41.0%**	3554	**57.6%**	6168	10.1%
Rural Expressway (Multilane)	39	**2.0%**	878	**43.9%**	1085	**54.1%**	2002	3.3%
Rural Conventional (2 Lanes)	699	**2.1%**	12079	**35.9%**	20854	**62.0%**	33632	55.0%
Total	983	1.6%	23440	38.3%	36714	60.1%	61137	100.0%

	Fatal		Injury		PDO		Total	
Freeway	107	0.9%	4985	42.4%	6676	56.7%	11768	19.3%
Multilane Undivided	128	1.2%	4584	41.8%	6251	57.0%	10963	17.9%
2 Lane	748	2.0%	13871	36.1%	23787	61.9%	38406	62.8%
Total	983	1.6%	23440	38.3%	36714	60.1%	61137	100.0%

	Fatal		Injury		PDO		Total	
Urban	160	0.8%	7954	41.1%	11221	58.1%	19335	31.6%
Rural	823	2.0%	15486	37.0%	25493	61.0%	41802	68.4%
Total	983	1.6%	23440	38.3%	36714	60.1%	61137	100.0%

5.6.4 *Proposed Case Accident Rate*

Algorithms for estimating the accident rate for the proposed case are contained in appendix B and C taken from TAC[19]. Appendix B contains formulas for generalized highway improvements where the entire highway classification is changed. The algorithms in Appendix C can be used to estimate accidents for site specific improvements such as curve straightening, lane widening, shoulder paving etc.

The algorithms in appendix B compare favorably with the BC Provincial averages below:

	All Accidents (a/mvk)	Section Accidents	Intersection Accidents[a] (a/mv)
Urban Freeway	1.0	0.5	n/a
Urban Expressway (Multilane)	1.5	0.5	0.7
Urban Conventional (2 lane)	1.4	0.5	0.6
Rural Freeway	0.6	0.4	0.7
Rural Expressway (Multilane)	1.2	0.5	0.5
Rural Conventional (2 Lanes)	0.7	0.5	0.5

[a] Intersection accidents are only calculated for major roads not local access. They are expressed as number of accidents per million main road vehicles.

5.6.5 *Proposed Case Accident Severity*

In order of preference, the options for estimating the distribution of fatal, injury and PDO accidents for the proposed case include:

1. The reduction factors in appendix A or B when they are given separately by accident severity
2. For spot improvements use the same severity as the base case proportions
3. For changes in highway or intersection service class use the Provincial averages by highway or intersection class.

5.6.6 *Intersections*

When intersections or interchanges need to be analyzed separately, such as for an interchange project, then intersection accident rates are needed. These are usually expressed as accidents/million vehicles (a/mv) where the number of vehicles is the sum of the main road and side road vehicles entering the intersection.

[19] Hauer E., Persaud B., "Safety Analysis of Roadway Geometric and Ancillary Features" Transportation Association of Canada, Dec., 1996.

Intersection accidents are more complex than section accidents and there are no simple quantitative relationships to predict the effects of specific intersection improvements. Accident rates will vary depending on :

- minor road volumes
- Major Road Volumes
- left turn protection
- sight distance at the intersection
- environmental conditions

Default accident rates are provided in MicroBencost but some additional research which may provide more accurate estimates or current estimates of intersection accident rates are given in appendix B from the TAC recommendations.

5.6.7 Reporting the Benefit Cost Results

The results of the benefit cost analysis can be kept simple but should include:

1. List of major assumptions which differentiate the base case from the proposed case.
2. Summary of results
3. Interpretation of the results - what accounts for the benefits in each category
4. Digital Files from the benefit cost model

An example of items 1 to 3 is presented in appendix D.

6.0 Multiple Account Evaluation

6.1 Introduction

Multiple account evaluation (exhibit 6.1) is a multi-criteria decision matrix tool to:

- provide a balanced view to decision makers--understanding the inevitable trade-offs which are required in any decision
- compare options within a project
- draw comparisons with other projects
- facilitate comparison with other program needs (such as health, education and social services)

MAE is most effective at the systems, reconnaissance or corridor level study where a broad range of corridor options are examined.

6.2 System Level Options

For the TCH corridor, options exist at both the *system level* and at the *corridor level*. It is not intended here to evaluate the broader system level options, which include for example:

1. Improve the TCH
2. Transfer truck traffic to rail
3. Improve the viability of highway 3 as an alternative to highway 1
4. Transportation Demand Management

The intention is to outline an evaluation framework for corridor level options associated with the first system level option of upgrading the TCH.

6.3 MAE Accounts

Five accounts typically used in the multiple account evaluation (MAE) are:

- Financial
- Customer service
- Social/Community
- Economic Development
- Environmental

A sixth account, infrastructure stewardship, may also be used in cases where the difference between options is due to deferred maintenance practices or the ability of an option to perform well if assumed future parameters change beyond expectation (e.g. demand) and whether the option could be modified later without great expense.

The most important accounts for the TCH will be the financial, customer service and environmental accounts.

Exhibit 6.1
Typical Multiple Account Evaluation

OPTION / ACCOUNT	Base Case	1 Passing Lanes then 4 lanes	2 Pass.Ln. converted to 4 lanes	3 Staged 4 Lane Sections	4 Bypass Option: Existing Route	4 Bypass Option: Bypass Route
FINANCIAL (millions $)	millions $1997					
Capital Cost (PV)	$1	$120	$130	$125	$1	$200
Annual Maintenance	$0	$1	$1	$1	$0	$1
Resurfacing (PV)	$5	$7	$7	$8	$5	$6
Life Cycle Cost (PV)	$9	$132	$142	$138	$223	
Incremental Cost		$123	$133	$129	$214	
CUSTOMER SERVICE	millions $1997					
Time (PV)	$273	$218	$218	$218	$100	$119
Accident (PV)	$146	$102	$102	$102	$38	$64
Vehicle Operating (PV)	$730	$715	$715	$723	$276	$319
Total	$1,149	$1,036	$1,036	$1,043	$917	
Incremental Benefit	$0	$113	$113	$106	$232	
Annual Closures (hrs)	80	80	80	60	60	20
ECONOMIC INDICATORS						
NPV		($10)	($20)	($23)	$18	
B/C Ratio		0.9	0.8	0.8	1.1	
SOCIAL/COMMUNITY						
Average Daily Traffic (noise, pollution)	8000	8000	8000	8000	3000	5000
Residences Impacted	166	166	166	166	166	5
Business/institutional	71	71	71	71	71	0
Business Takings	0	1	1	I	0	0
Residential Takings	0	6	6	7	0	2
Commmunity Severance	⊙	●	●	●	○	○
Community Plans	⊙	○	○	○	●	●
Business Impact (equity)	⊙	○	○	○	●	⊙
Visual Impact	⊙	⊙	⊙	⊙	⊙	●
ECONOMIC DEVELOPMENT						
Provincial Output		($9)	($18)	($21)	$16	
Jobs		-11	-21	-25	19	
ENVIRONMENTAL						
Land Requirements	0.0	5.0	7.0	7.0	0.0	20
Fuel (million litres)	1,825	1,900	1,900	2,000	800	1,000
CO (million kg)	456	475	475	500	200	250
Site Rehabilitation	○	○	○	○	○	○
Wildlife	○	⊙	⊙	⊙	○	●
Water Pollution	○	⊙	⊙	⊙	○	●
Special Areas	none	none	none	none	none	historic site

KEY

○ Good
⊙ Fair
● Poor

PV=Present Value
NPV = Net Present Value

6.4 Financial Account

This is the cost to the infrastructure provider(s) of each option. It is expressed as a life cycle cost which is the present value of capital costs (class D estimates), periodic rehabilitation costs and annual operating costs discounted at 8% over a 25 year planning period to 1997 dollars. The financial costs are standard outputs from the MicroBencost model and can be used directly in the MAE chart. Financial costs do not differentiate between who pays. Cost shared amounts with other agencies for example should not be excluded from the project cost. The evaluation frameworks are presented in Chapter 6.

Region	$/2-Lane-km	$/4-Lane-km
1 and 6	$9,100	$12,100
2 and 3	$7,800	$10,400
4 and 5	$8,400	$11,400

These are the maintenance costs used for 1995 capital programming[20], for winter class A highways.
Costs are likely to be twice as high in extreme winter maintenance areas.

Resurfacing costs were assumed to be $60,000/2 Lane-km for hot mix resurfacing with 15 years between resurfacings. Pavements resurfaced near the end of the planning period are assigned a salvage value equal to:

$$\text{Salvage value of resurfacing} = \text{Resurfacing cost} \times n/10$$

where n is the number of years remaining to the end of the planning period. For example, n=2 for a highway resurfaced in 2020 and a planning period ending in 2022.

Salvage values of other components are discussed in chapter 7.

6.5 Customer Service Account

This is the cost to highway users and includes dollar values for:

- Time
- Accident
- Vehicle operating costs

These are standard outputs from the MicroBencost model. The values from the model may be entered directly into the MAE table in the same way as the financial costs.

Highway closures on the TCH during avalanche conditions, landslides, traffic accidents or other causes are a regular occurrence. If reliability is to be a distinguishing feature between options, then the customer service account should show this as a separate item. The dollar

[20] Lyall P. O'Sullivan S., "Benefit/Cost Analysis for the Five Year Capital Program" Prepared by ADI Limited for Ministry of Transportation and Highways, Program Planning, Victoria B.C., December, 1995

cost of closures is difficult to estimate since it varies depending on the decision to wait, divert or postpone a trip which in turn depends on the duration and location of the closure. The best option is usually to simply identify the annual duration of closures.

6.6 Social/Community Account

This documents external effects of highway projects on the communities and social values.

Noise, Visual and Pollution Impacts:

- Exposure - The number of residences and number of businesses adjacent to the highway quantifies how many will be directly influenced by noise, visual impact and pollution. This can be done with a drive-by survey.
- Magnitude - Changes in AADT indicate the magnitude and direction of the impacts for each option.

Community Displacement

This is measured as the number of property takings associated with each option. These are typically assessed in the planning stages of a project and can be quantified for example:

Total takings	46
Business takings	4
Residential takings	42
Partial takings	27
Special Purpose takings	Golf course

Community Severance Effect

Constructing a new transportation right of way through an existing community can limit access to pedestrian or local vehicle traffic to major generators and attractors in the community. Qualitatively, a bypass reduces community severance by reducing through traffic volume. Improving the existing route through town generally increases the barrier effect of the route. This can be summarized on an MAE chart as:

- good - reduces barrier effects
- fair - little or no change
- poor - increases barrier effects

Consistency with Community Plans

This is rated by comparing options to Official Community Plans, Major Street Network Plans and Regional Growth Strategies where they exist. Consistency is evaluated qualitatively, based on the location, role, and impact of proposed transportation works relative to where they were envisioned in the plans. This can be summarized on an MAE chart as:

- good - project agrees with community plans
- fair - project is not addressed in the community plan
- poor - project is not consistent with community plans

Equity

This highlights changes which benefit one group possibly at the expense of another. A bypass for example benefits residents of the bypassed community and through traffic at the expense of local businesses who depend on through traffic for business. If the issue is to be addressed in the economic development account, then it should not be repeated here. The MAE chart can summarize this by identifying the major impact group(s) and whether the impact is:

- good - positive impact
- fair - neutral
- poor - negative impact

Visual Impacts

This may include for example:

Obstruction	More desirable views are blocked by structures with no aesthetic value.
Intrusion	This is a broader concept than visual obstruction. It relates to the perceived loss of amenity by people located close to a road and its traffic. It includes loss of privacy, night time glare from street and vehicle lights and the changed character of the landscape (i.e. from natural to modified).
Overshadowing	A structure, such as an embankment or overhead bridge, reduces the amount of direct sunlight on an occupied property. This impact is not likely to be of importance in the TCH corridor and can be excluded.

For presentation in the MAE chart, impacts may be given as:

- good - improves visual qualities (i.e. by removing undesirable structures)
- fair - little or no change
- poor - visual impact is negative

6.7 Economic Development Account

This account documents the real income and employment benefits of alternatives to the Provincial economy. Income and jobs generated during highway construction for example are a benefit to a regional economy but not to a Provincial economy. From a Provincial perspective, the jobs created in one region are considered a loss to the other regions so there is no net gain from the construction.

Economic development benefits are generated when a highway improvement project results in lower out-of-pocket costs for transportation and health care due to lower time, accident and vehicle operating costs to the highway users. "Out-of-pocket" costs are the portion of highway user costs for which there is a market. Property damage, health care and lost productivity resulting from an accident for example are a real cost to the economy. Pain and suffering though, are not a cost to the economy, even though people demonstrate a willingness to pay to avoid pain and suffering. The reason is that there is no market associated with pain and suffering.

A rough estimate of the savings in out-of-pocket costs over a 25 year planning period can be calculated directly from the customer service accounts as:

> Out-of-pocket cost savings
> = Total time cost savings x (% trucks x truck value of time)/(% trucks x truck value of time + % cars x car value of time)
> + Total accident cost savings x 35%
> + Total vehicle operating cost savings x 100%

The rationale for these proportions is explained in table 6.1

To apply the formula, asume for example, a project with 10% trucks and typical values of time shows the following comprehensive benefits:

> Time savings \$1.0 million
> Accident Savings \$2.0 million
> Vehicle Operating Costs Savings \$0.5 million

Then the out-of-pocket costs savings are:

> *= \$1.0 million x (10% trucks x \$28/hr)/(10% trucks x \$28/hr + 90% cars x \$10/hr)*
> *+ \$2.0 million x 35%*
> *+ \$0.5 million x 100%*
> *= \$1.4 million*

Table 6.1
Rational for Out-of-Pocket Proportion of User costs

User Cost	Out-of-Pocket Proportion
Time	This is the portion of the traffic stream for which travel time savings can be translated directly into additional marketable productivity. This is approximated as the value of time savings to trucks. The equation represents the lower bound of the estimate since it excludes some cars which also fall into this category.
Accident	Accident costs in benefit cost analysis are "comprehensive" costs which means they include non-market costs for pain and suffering as well as market costs for property damage, health care, lost production etc. The market cost or "out-of-pocket" cost of accidents is about 35% of the total based on the typical composition of comprehensive accident costs[21]: 3.4% Medical and rehabilitation 13.8% Wages and household Production 0.3% Emergency services 0.7% Workplace 2.3% Administrative and legal 0.6% Travel delay 11.5% Property damage 2.3% Other 65.1% Pain, suffering and lost quality of life 100%
Vehicle Operating Costs	100% of the savings in vehicle operating cost savings are considered as savings in "out-of-pocket costs". Commercial vehicles are able to translate 100% of vehicle cost savings directly into increased productivity or lower cost of production. For non-commercial traffic there are savings in the variable portion of vehicle operation (fuel, maintenance, use-related depreciation) in the short run and savings in fixed costs (ownership, insurance etc.) in the long run.

The Provincial economic benefits (discounted total for the planning period) are calculated from the out-of-pocket costs as:

Economic development benefits
= Out-of-pocket cost savings x economic multiplier
= \$1.4 million x 1.68 = \$2.35 million

[21] National Safety Council "Accident Facts, 1996 Edition" Itasca, Illinois.

Industry	Multiplier
Agriculture and related services	1.74
Logging and forestry	1.94
Food and Beverage	1.78
Other Manufacturing	1.74
Construction	1.49
Wholesale and retail trade	1.39
Average	*1.68*

The *economic multiplier* accounts for the indirect benefits when the out-of-pocket cost savings are re-spent several times on other goods or services. These multipliers are calculated periodically for each industry in the Provincial economy by BC Stats using a provincial input/output model[22]. The savings from highway improvements are eventually passed on to all consumers in the form of lower tax burdens for health care and lower prices (hence greater demand) for those goods for which rely more heavily on highway transportation. Some of the industries which intuitively depend on highway transportation are identified here. For planning purposes, the average of these industries, 1.68, is used.

Regional or local economic benefits are more difficult to estimate. The major impact group includes businesses that rely on drive-by traffic (gas stations, restaurants, hotels). Qualitatively, the impact may be negative if the option is a community bypass and positive if the existing alignment is improved. Quantitatively, the impact is the number of businesses on the affected route.

Improvement	Qualitative impact	Quantitative
Community Bypass	negative	# of businesses
Improve existing route through town	positive	# of businesses

If better information is not available, a crude estimate of the rate at which jobs are created from the economic development benefits is the Provincial gross domestic product divided by Provincial employment. Gross domestic Product is the value of all goods and services produced in the province.

Provincial Employment 1.73 million
Provincial Gross Domestic Product $99.9 billion
GDP/job = $76,800/job

Using this estimate, the number of permanent jobs created by economic development is:

jobs = Economic development benefits/(pwf x $76,800)

where pwf = 10.675 is the present worth factor of a 25 year stream of benefits at an 8% discount rate and the economic development benefits are given as the total for the 25 year planning period.

[22] Horne, Gary and Powell, Charlotte, "Provincial Econmic Multipliers and How to Use Them", Draft, Prepared for the Analysis and Evaluation Branch, Treasury Board Staff, Ministry of Finance and Corporate Relations, November 1996.

6.8 Environmental

This account helps document the nature, degree and mitigation of the major environmental impacts. Monetization of these impacts is possible using unit costs[23] presented in appendix E. Monetized environmental costs have not yet been formally adopted by the Ministry but it would be consistent with the policy of full cost accounting for transportation projects. Monetized environmental costs have the potential to change the outcome of project evaluations, particularly where they involve new routes or environmentally sensitive areas.

In the interim, non-dollar measures are used but monetized environmental costs should be considered on a project by project basis.

Impact	Measure
Land Requirements	The requirements are quantified in hectares by land use, to the extent that different land uses can be defined. For example: • Wetland • Agricultural • Forest • Park/Protected Area • Developed land • Total
Noise	This is already included in the Social/Community Account as traffic volume and number of residences/businesses impacted.
Energy Consumption	Fuel Consumption is calculated by MicroBencost.
Emissions	Emissions of CO are calculated by MicroBencost.
Visual	Included in the Social/Community Account
Site Rehabilitation	Cleanup of contaminated sites prior to construction. Not expected to be an issue in the TCH -Kamloops to Alberta
Wildlife	Wildlife impacts include roadkill of migratory animals and habitat fragmentation related to new roads. In general, animals grow accustomed to transportation routes and tend to stay away from them. However, new routes are notorious for initial high rates of roadkill.
Water Pollution	Water quality impacts can all be measured quantitatively after the fact using accepted quantity, chemical and observation techniques. Predicting the impact prior to implementing a project is more problematic. The measure of impact is more likely to be the degree of avoidance and mitigation measures required in advance of a project.

[23] Bein P.,Johnson,C.J., Litman,T. "Monetization of Environmental Impacts of Roads", Planning Services Branch, Ministry of Transportation and Highways, Victoria B.C. July 1995.

Special Areas	The MAE should report special areas, their importance and whether the impact is positive, negative or neutral. Special areas may include sites of cultural, spiritual, historic, aesthetic, archaeological, special ecological, botanical, geological, scientific or recreational importance. The importance of special sites is specific to each case and can only be evaluated by people who have experience and knowledge of it. If they have not been previously identified, special sites are often identified through public consultation.

For the purpose of summarizing complex environmental impacts on a one page MAE table, a simple presentation is needed. For example:

Good	Low impact due to direct effects. Mitigation of impacts feasible and cost effective
Fair	Medium impacts due to direct effects. Mitigation of impacts is possible and should be considered
Poor	High impacts due to direct effects. Mitigation opportunities are limited

6.9 Presenting the MAE Results

The MAE results are summarized in a single chart similar to exhibit 6.1. Monetary impacts are presented as dollars, quantifiable impacts as numbers and qualitative impacts as symbols. For each impact shown in the chart, there is normally an accompanying text supporting the rating given in the chart.

7. Option Analysis Framework for Benefit Cost

7.1 Corridor Level Options

The cost of upgrading the TCH means the corridor is likely to be done in stages rather than as one project. Conceptually there are several options leading to the ultimate development. The ultimate development is the plan beyond which no further highway improvements are anticipated.

Option	*Description*
Base Case	Do the minimum to maintain and operate the highway
Option 1. Staged improvements which are not part of the ultimate option	Passing lanes for example built in stage 1, which are abandoned in stage 2, may be less costly to build today but the investment is lost when the second stage is implemented.
Option 2. Staged improvements incorporated as part of the ultimate development option	Some or all of the improvement made today will form a part of the ultimate plan. If passing lanes for example were constructed in stage 1, so as to be part of an ultimate 4 lane concept in stage 2, then the cost of the four laning at the beginning of stage 2 is reduced accordingly
Option 3. Build the ultimate option in stages (short 4 lane sections)	If the ultimate plan is a 4 lane highway, then this option would be to build short 4 lane sections in stages.
Option 4 Build a bypass route	Most likely a combination of a new alignment combined with improvements to the existing route.
Option 5 Build a new route Abandon the old	This might apply to Kicking Horse Pass where a new alignment is built and the old alignment is abandoned.

7.2 Base Case

The base case usually represents the "do-minimum" scenario. This generally includes normal maintenance, periodic resurfacing costs plus some allowance for capital replacement such as bridges or major structures which must be done if the route is to remain functional. There is usually no change, other than traffic growth, which would affect highway user costs.

7.3 Staged Improvements Which are not Part of the Ultimate Option

Climbing lanes for example, which do not get used in the ultimate design, may be less costly to build in the first stage but the investment is lost when the second stage is implemented.

Benefit cost models cannot analyze multiple stages in a single model run. The internal algorithms do not allow basic highway parameters to change more than once in the analysis period. The general approach is to handle each stage as a separate project and then add the results from each stage together as one project.

The important points in modeling the benefits and costs are:

- Both stages have a common base year (1997) and a common base case which is the existing road with no improvements.
- The construction value of the passing lane in phase 1 has no salvage value at the end of phase 1 because it is no longer used and it is not sold.
- Salvage value of the land can be included at the end of the 1st stage but the same number must be added as a cost at the start of the second phase and recovered again as salvage value in year 25.
- Construction of the 4 lane section must start before or in the last year of the benefit period of the passing lane, if the 4 lane section is to open in the next year.

For example, a passing lane commissioned in 1999 and replaced by a 4 lane section in 2009 would be analyzed two stages.

Stage 1

	Base case	Proposed case
Base Year	1997	1997
Construction begins	nil	1998
Year Benefits begin	1999	1999
Horizon year	2008	2008
Maintenance cost	$30,000/yr	$30,000/yr
Resurfacing cost	$120,000 in year 2002	none
Capital Cost	nil	$3 million
Salvage Values		
construction	nil	nil
property	nil	default

Stage 2

	Base Case	Proposed Case
Base Year	1997	1997
Construction Begins	nil	2007
Year Benefits begin	2009	2009
Horizon year	2022	2022
Maintenance cost	$30,000/yr	$50,000/yr
Resurfacing cost	$120,000 in year 2017	$200,000 in 2023

Capital Cost	$1.0 million bridge repairs in 2015	Stage 2 design + construction + stage 1 property cost
Salvage Values construction property	 nil nil	 default 1997 value

7.4 Staged Improvements Incorporated as Part of the Ultimate Development Option

This would be similar to a case where initial passing lanes are constructed so that they can be incorporated into the ultimate 4 lane design. The approach to the analysis is similar except for the capital cost of the stage 1 passing lane and the four lane section in stage 2. Most likely the cost of the initial passing lane will be higher and the cost of the ultimate 4 lane section will be lower. The salvage value of the passing lane is still zero since its value is captured as the reduced capital cost for the 4 lane section.

7.5 Build the Ultimate Plan in Stages

If the ultimate improvement is built in stages, for example short 4 lane sections, then benefits of each stage begin in the year it is commissioned and continue to the end of the 25 year planning period (year 2022) and the default salvage values are used. A separate analysis is done for each stage and the present values for all stages are added together to get the total benefits and total costs.

7.6 Bypass

For analysis purposes, a bypass is any new alignment constructed without removing the old alignment from service. MicroBencost can analyze both routes simultaneously or independently. Regardless of the approach, the key is to include agency and user costs associated with both the old and the new alignment since both will remain in service. On the TCH traffic can be split logically between the two routes based on available origin destination data.

7.7 Build a New Route and Abandon the Old

The ultimate route is built in one stage on a new alignment and the old one is abandoned. Since the old alignment does not remain in service, this does not have to be treated as a bypass problem. It can be analyzed as if the existing route were being upgraded. The base case assumes the characteristics of the old alignment as if it were to continue in service. The proposed case is analyzed with the alignment, capacity and maintenance cost characteristics of the new route. The benefits begin in the year the new alignment is commissioned and continue to the end of the 25 year planning period (year 2022). Default salvage values are used. The restoration cost of the abandoned route can be included in the initial project cost as a separate item with no salvage value. If the abandoned ROW is sold, the proceeds can be used to offset the cost of the property for the new alignment. If the old alignment is transferred to recreational use, the benefits associated with this transfer should be shown in the social account and the costs in the financial account.

7.8 Property Purchase

Conceptually there are two options for meeting future land requirements:

1. Land Banking for future use
2. Buy as required

The practical argument for buying land in the first stage of construction for use in the second stage is usually the difficulty associated with coming back a second time to expropriate additional land for the second stage.

The economic argument for buying land now for a need in the future is similar to any other highway project. The objective is to maximize the net present value of the investment. This occurs when the first year rate of return exceeds the discount rate. In the case of property, when the annual increase (less inflation) in property value exceeds the 8% discount rate, and is expected to continue to do so until the land is needed for construction, then it should be purchased. When the choice is vacant land now or developed land later, then the rate of increase is likely much greater than 8%/year and the decision to purchase now is justified. There is little value to a house or business purchased later for use as a highway.

When the first stage of a project includes purchasing land needed for the second stage, then the first stage should not be presented as a stand alone project. The cost of the additional land would otherwise distort the cost of the first stage. The approach is similar to the analysis used in section 6.3 where the present value of costs and benefits of the two stages are added together and presented as a single project.

The salvage value of the land at the end of the planning period should not be increased to market values. Unless the highway is closed and the land sold, the salvage value remains as the value of the land continuing in its use as a highway. The default calculation done in MicroBencost yields a salvage value close to the original purchase price.

Appendix A
Population Forecasts by Health Area and Municipal Populations

INSERT MAP OF LOCAL HEALTH AREAS

A.1 Population Forecasts by Health District

		1971	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	Fernie	11,022	14,545	14,998	15,373	15,755	16,429	17,275	18,773	18,905	18,349
2	Cranbrook	15,334	18,395	19,174	19,855	20,788	21,302	21,789	22,507	22,508	22,697
3	Kimberley	9,308	9,103	8,966	8,958	9,035	9,249	9,460	9,629	9,441	9,466
4	Windermere	5,129	5,740	5,791	5,869	6,017	6,390	6,809	6,925	6,993	6,767
5	Creston	9,063	10,378	10,530	10,461	10,423	10,534	10,580	10,575	10,611	10,545
6	Kootenay Lake	2,901	2,578	2,752	2,924	2,853	2,998	3,155	3,263	3,223	3,240
7	Nelson	19,080	21,091	21,165	21,183	21,284	21,772	22,190	22,402	22,776	22,492
9	Castlegar	10,967	11,794	11,967	11,998	12,194	12,582	12,877	12,688	12,654	12,426
10	Arrow Lakes	4,087	4,639	4,571	4,654	4,700	4,756	4,953	5,019	5,027	5,006
11	Trail	23,638	22,754	22,613	22,688	22,727	22,864	23,636	23,163	22,544	22,199
12	Grand Forks	5,821	6,617	6,691	6,748	6,830	7,015	7,345	7,447	7,534	7,493
13	Kettle Valley	2,789	3,256	3,213	3,240	3,311	3,322	3,262	3,429	3,382	3,405
14	Southern Okanagan	9,975	12,427	12,909	12,968	13,177	13,675	14,311	14,659	14,823	14,559
15	Penticton	21,407	25,484	25,735	25,845	26,225	26,891	28,128	28,978	29,549	30,170
16	Keremeos	2,851	3,305	3,259	3,267	3,351	3,413	3,642	3,660	3,639	3,622
17	Princeton	3,738	4,768	4,759	4,901	4,859	4,859	4,879	4,990	4,939	4,929
18	Golden	6,677	6,403	6,405	6,360	6,379	6,513	6,601	6,885	6,728	6,778
19	Revelstoke	9,242	9,485	9,460	9,493	9,753	10,034	10,150	10,791	10,496	10,170
20	Salmon Arm	15,541	20,694	21,264	22,222	22,777	23,341	24,574	26,773	26,895	26,387
21	Armstrong-Spallumcheen	4,057	5,799	6,010	6,168	6,393	6,657	7,103	7,393	7,382	7,338
22	Vernon	27,329	37,608	38,893	40,135	40,925	41,856	43,453	44,303	44,452	44,884
23	Central Okanagan	51,584	73,346	75,696	76,850	79,009	83,233	87,856	89,574	90,600	91,896
24	Kamloops	56,909	71,971	74,005	74,905	75,724	77,917	81,378	82,274	81,926	81,693
26	North Thompson	3,506	4,874	5,106	5,232	5,179	5,265	5,299	5,217	5,102	5,160
27	Cariboo - Chilcotin	23,023	31,635	32,470	33,903	34,254	35,714	37,388	38,515	38,979	39,442
28	Quesnel	17,168	21,448	21,846	22,385	22,669	23,309	23,627	24,147	24,288	24,441
29	Lillooet	3,799	4,073	4,113	4,138	4,198	4,251	4,492	4,582	4,642	4,646
30	South Cariboo	8,361	8,398	8,376	8,239	8,055	8,076	8,307	8,617	8,514	8,532
31	Merritt	9,254	9,530	9,776	9,915	9,876	9,813	10,070	10,005	9,965	9,824
32	Hope	6,637	7,368	7,448	7,366	7,317	7,438	7,753	7,768	7,722	7,704
33	Chilliwack	36,206	41,078	42,316	43,353	43,054	44,401	46,032	46,417	46,427	46,683
34	Abbotsford	32,331	42,373	44,412	47,324	49,419	53,028	56,994	60,369	62,815	65,298
35	Langley	27,469	48,227	51,493	54,733	56,571	59,084	61,645	63,413	65,619	68,540
36	Surrey	112,451	133,369	137,468	143,972	149,717	159,150	166,294	173,058	181,182	189,842
37	Delta	47,271	66,488	67,687	69,530	72,247	75,360	77,132	78,715	80,273	80,882
38	Richmond	64,263	82,860	85,459	89,352	92,017	97,053	99,699	102,017	104,731	107,832
39	Vancouver	444,991	430,027	426,080	425,449	429,054	435,666	436,532	441,260	443,728	448,708
40	New Westminster	44,061	39,583	38,853	38,762	38,833	39,491	39,823	39,497	39,775	40,718
41	Burnaby	129,746	136,184	135,742	135,932	139,331	140,799	141,619	142,762	144,770	148,148
42	Maple Ridge	28,227	35,375	36,286	36,940	38,042	39,034	39,857	40,396	42,083	43,091
43	Coquitlam	87,101	95,214	96,004	97,836	100,153	104,863	108,272	108,942	112,360	116,485
44	North Vancouver	93,198	99,093	99,388	100,049	101,417	103,274	103,406	103,950	104,298	105,555
45	West Vancouver	38,775	40,270	39,873	39,914	39,995	40,630	40,650	40,902	41,355	41,817
46	Sechelt	9,948	12,901	13,708	14,049	14,530	15,285	16,010	16,628	16,996	17,182
47	Powell River	19,026	19,875	19,333	18,990	19,122	19,338	19,611	19,606	19,380	19,179
48	Howe Sound	9,685	12,206	13,022	13,466	13,731	14,329	15,077	15,198	14,958	15,329
49	Central Coast	4,326	4,300	4,152	4,138	4,038	3,870	3,135	3,131	3,154	3,207
50	Queen Charlotte	4,472	5,671	5,523	5,493	5,563	5,625	5,795	5,859	5,789	5,663
52	Prince Rupert	18,426	17,642	17,680	17,851	18,051	18,427	18,953	19,126	19,173	19,163
54	Smithers	10,396	11,334	11,619	12,094	12,547	13,315	14,597	14,788	14,703	14,899
55/93	Burns Lake/Eutsuk Lake	5,988	7,463	7,636	7,730	7,907	8,245	8,370	8,438	8,166	7,886
56	Nechako	11,221	14,764	15,002	15,372	15,751	16,102	16,504	16,787	16,972	16,624
57	Prince George	66,110	81,904	86,417	87,848	89,598	90,419	92,119	93,642	93,402	93,766
59	Peace River South	21,759	20,615	20,633	20,594	21,131	22,507	23,822	23,974	25,086	27,278
60	Peace River North	19,546	21,009	21,901	22,570	24,013	25,823	27,986	27,992	27,694	26,853
61	Greater Victoria	158,336	168,880	169,889	171,799	173,305	175,681	177,015	177,571	178,543	179,899
62	Sooke	24,420	32,334	32,910	33,797	34,956	35,572	36,367	37,395	38,526	39,488
63	Saanich	23,144	29,662	29,815	30,869	31,955	33,756	35,731	36,748	37,978	39,385
64	Gulf Islands	4,672	6,608	6,861	6,963	7,198	7,605	8,208	8,641	8,905	9,092
65	Cowichan	23,645	29,664	30,818	31,953	32,604	33,495	35,472	36,343	36,365	36,359
66	Lake Cowichan	6,024	5,806	5,775	5,779	5,743	5,879	5,829	5,831	5,674	5,565
67	Ladysmith	10,275	13,039	13,007	12,935	12,727	12,842	13,059	13,223	13,183	13,136
68	Nanaimo	40,938	50,012	50,416	51,217	51,146	53,144	59,431	60,548	60,890	61,897
69	Qualicum	8,521	13,974	14,934	15,345	16,297	17,576	20,316	21,158	21,596	22,153
70	Alberni	32,593	33,084	33,153	33,214	32,917	33,172	33,524	33,329	32,839	32,575
71	Courtenay	25,114	30,237	31,360	32,226	33,063	33,998	36,278	37,569	37,947	38,501
72	Campbell River	19,263	24,084	24,831	25,725	26,583	27,700	29,346	29,771	29,928	30,316
75	Mission	13,001	18,609	20,235	21,002	21,757	22,707	24,070	24,386	24,632	25,149
76	Agassiz - Harrison	4,518	4,484	4,579	4,668	4,678	4,729	4,893	5,073	5,248	5,326
77	Summerland	5,947	7,027	7,039	7,003	7,231	7,516	7,962	8,185	8,254	8,302
78	Enderby	3,610	4,831	4,972	5,044	5,155	5,304	5,466	5,639	5,589	5,542
80	Kitimat	14,135	14,110	13,787	14,157	14,177	14,410	15,106	15,269	14,697	14,238
81	Fort Nelson	3,945	4,531	4,631	4,698	5,104	5,395	5,348	5,478	5,456	5,457
84	Vancouver Island West	4,249	4,512	4,569	4,744	4,910	4,966	5,063	4,884	4,618	4,445
85	Vancouver Island North	10,708	12,853	13,036	13,700	14,073	14,502	15,135	15,726	15,925	16,079
87	Stikine	1,744	1,588	1,798	2,055	2,034	1,950	2,010	2,151	2,339	2,084
88	Terrace	22,007	23,817	22,957	23,046	23,161	24,648	26,028	27,086	26,871	26,315
92	Nisga'a	1,632	1,337	1,571	1,692	1,760	1,744	1,939	1,856	1,842	1,734
94	Telegraph Creek	569	586	609	585	597	623	628	622	627	675
	British Columbia	2,250,200	2,545,000	2,581,200	2,625,800	2,675,000	2,755,500	2,836,500	2,886,300	2,919,600	2,960,600

		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	Fernie	18,010	17,422	16,752	16,062	16,100	16,096	16,023	15,668	15,625	15,580
2	Cranbrook	22,427	22,091	21,836	21,791	22,068	22,457	22,392	22,856	23,497	24,201
3	Kimberley	9,332	8,990	8,564	8,403	8,524	8,592	8,502	8,487	8,629	8,595
4	Windermere	6,817	6,725	6,923	7,019	7,061	7,077	6,974	7,315	7,734	8,184
5	Creston	10,534	10,546	10,313	10,270	10,278	10,599	10,630	10,954	11,328	11,772
6	Kootenay Lake	3,263	3,224	3,172	3,189	3,197	3,248	3,236	3,334	3,460	3,628
7	Nelson	21,730	20,840	20,792	20,685	21,045	21,570	21,940	22,948	23,083	23,598
9	Castlegar	12,302	12,014	11,576	11,560	11,677	11,810	12,147	12,385	12,653	13,084
10	Arrow Lakes	4,873	4,698	4,571	4,456	4,415	4,476	4,604	4,724	4,965	5,121
11	Trail	21,787	21,089	20,556	20,395	20,627	20,793	20,893	20,942	21,074	20,955
12	Grand Forks	7,385	7,271	7,245	7,337	7,437	7,744	7,951	8,222	8,615	9,019
13	Kettle Valley	3,320	3,221	3,198	3,139	3,223	3,180	3,257	3,284	3,431	3,645
14	Southern Okanagan	14,315	14,231	14,259	14,446	14,390	15,181	15,765	16,304	17,008	17,667
15	Penticton	29,886	30,335	31,056	31,420	32,229	33,159	34,336	35,974	37,697	39,195
16	Keremeos	3,629	3,622	3,607	3,757	3,771	3,790	3,958	4,142	4,392	4,653
17	Princeton	4,894	4,892	4,758	4,745	4,782	4,713	4,701	4,719	4,894	4,878
18	Golden	6,931	6,913	6,996	7,276	7,206	7,155	7,044	7,085	7,212	7,388
19	Revelstoke	9,667	9,366	8,950	8,632	8,570	8,599	8,619	8,677	8,762	8,866
20	Salmon Arm	25,948	25,417	25,234	25,353	25,697	26,368	27,212	28,455	29,901	31,778
21	Armstrong-Spallumcheen	7,303	7,298	7,433	7,458	7,551	7,804	8,149	8,480	8,805	9,064
22	Vernon	44,963	44,570	45,154	45,998	46,715	48,159	49,538	52,049	54,489	56,259
23	Central Okanagan	91,988	93,426	95,715	98,565	102,826	109,160	115,097	123,241	130,081	134,692
24	Kamloops	80,421	79,556	80,290	80,918	81,938	83,745	85,107	87,271	90,211	93,173
26	North Thompson	5,090	4,919	4,873	4,665	4,535	4,598	4,571	4,461	4,613	4,666
27	Cariboo - Chilcotin	38,966	38,520	38,702	38,302	38,167	38,681	39,044	39,785	40,941	41,888
28	Quesnel	24,513	24,358	24,555	24,394	24,104	24,260	23,980	23,671	24,147	24,778
29	Lillooet	4,729	4,744	4,622	4,528	4,594	4,637	4,567	4,678	4,822	4,881
30	South Cariboo	8,112	7,906	7,572	7,376	7,312	7,264	7,333	7,538	7,733	8,125
31	Merritt	9,904	10,100	10,134	10,071	10,104	10,186	10,428	10,720	11,033	11,225
32	Hope	7,770	7,480	7,400	7,504	7,652	7,908	7,996	8,001	8,313	8,531
33	Chilliwack	46,764	47,394	48,392	49,750	51,297	54,359	56,559	59,418	62,369	65,093
34	Abbotsford	67,302	69,295	72,129	75,921	80,513	86,158	89,743	94,446	98,091	101,761
35	Langley	70,977	73,348	76,490	80,075	84,037	87,067	88,845	92,396	96,034	100,521
36	Surrey	196,809	204,753	217,404	229,388	243,596	258,883	269,480	282,455	291,523	299,623
37	Delta	81,759	83,175	84,289	86,035	88,372	90,140	92,034	93,366	95,141	96,166
38	Richmond	110,986	113,875	116,531	119,289	121,836	126,148	130,305	132,712	136,345	139,601
39	Vancouver	455,516	460,941	465,083	472,588	479,972	485,230	491,636	498,501	507,291	517,118
40	New Westminster	41,627	41,761	41,501	42,422	43,777	43,769	44,852	47,007	46,086	47,855
41	Burnaby	150,178	152,606	153,439	156,369	159,016	161,010	163,476	167,935	170,968	173,535
42	Maple Ridge	44,235	46,043	49,072	52,510	56,025	59,367	61,595	64,219	66,849	68,944
43	Coquitlam	118,461	120,864	123,833	128,838	134,207	138,633	143,999	150,311	156,471	162,376
44	North Vancouver	107,183	109,501	110,700	112,780	115,114	115,873	117,448	120,245	122,156	123,080
45	West Vancouver	42,376	42,819	42,921	43,493	44,310	44,983	45,518	46,295	47,071	47,785
46	Sechelt	17,398	17,496	17,816	18,516	19,350	20,603	21,435	22,519	23,712	24,714
47	Powell River	18,960	18,773	18,497	18,694	18,958	19,230	19,420	19,484	19,703	20,033
48	Howe Sound	15,350	15,905	16,576	17,375	19,008	20,069	20,501	21,481	22,472	23,974
49	Central Coast	3,250	3,290	3,370	3,423	3,529	3,676	3,643	3,804	3,835	3,916
50	Queen Charlotte	5,687	5,710	5,621	5,439	5,373	5,500	5,471	5,493	5,675	5,792
52	Prince Rupert	18,790	18,285	18,436	18,597	18,853	18,863	18,989	19,174	19,382	19,354
54	Smithers	14,925	14,847	14,978	14,994	15,029	15,399	15,943	16,344	16,663	16,989
55/93	Burns Lake/Eutsuk Lake	7,937	8,102	7,953	7,950	7,652	7,854	7,287	7,313	7,447	7,732
56	Nechako	16,452	16,044	16,085	16,069	16,184	16,199	16,228	16,338	16,548	16,901
57	Prince George	93,489	92,940	92,321	91,836	92,214	92,755	93,376	93,952	96,503	97,882
59	Peace River South	28,304	28,036	28,003	27,484	27,839	28,202	28,756	28,730	28,857	28,902
60	Peace River North	26,218	26,100	25,660	25,490	25,539	25,823	26,111	25,976	26,448	27,061
61	Greater Victoria	182,247	183,959	186,898	189,436	192,677	195,994	198,430	201,033	202,574	205,502
62	Sooke	40,329	41,260	42,039	42,964	44,612	45,207	45,746	47,160	48,475	49,726
63	Saanich	40,520	42,018	43,084	45,073	47,131	49,915	52,560	54,392	55,730	57,925
64	Gulf Islands	9,304	9,366	9,519	9,953	10,376	11,064	11,705	12,122	12,749	13,030
65	Cowichan	36,480	36,495	37,076	37,990	39,474	41,578	43,231	44,854	47,043	48,953
66	Lake Cowichan	5,388	5,332	5,259	5,177	5,212	5,229	5,324	5,637	5,855	6,199
67	Ladysmith	13,026	12,972	12,992	13,115	13,218	13,520	13,889	14,220	14,826	15,661
68	Nanaimo	62,291	62,864	63,607	65,404	68,130	71,684	76,176	79,335	82,601	85,681
69	Qualicum	22,523	22,950	23,299	24,150	25,358	27,367	28,853	30,855	33,040	35,195
70	Alberni	32,136	31,544	31,529	31,471	31,634	32,066	32,132	32,168	32,970	33,231
71	Courtenay	39,006	39,064	39,357	40,554	42,044	43,665	45,818	47,982	50,817	54,135
72	Campbell River	30,442	30,783	31,498	32,322	33,272	34,614	35,386	35,975	37,215	38,129
75	Mission	25,744	26,330	26,824	27,841	28,822	30,095	30,988	32,456	33,686	34,743
76	Agassiz - Harrison	5,308	5,473	5,505	5,410	5,554	6,002	6,122	6,393	6,771	7,259
77	Summerland	8,349	8,412	8,651	8,900	8,990	9,396	9,881	10,502	10,764	11,405
78	Enderby	5,499	5,450	5,450	5,379	5,331	5,450	5,852	6,314	6,594	6,985
80	Kitimat	14,032	13,461	13,281	13,084	13,092	13,186	13,423	13,406	13,522	13,622
81	Fort Nelson	5,476	5,486	5,409	5,269	5,089	5,054	5,311	5,453	5,517	5,612
84	Vancouver Island West	4,323	4,163	3,966	4,037	3,978	4,113	4,088	4,355	4,390	4,341
85	Vancouver Island North	15,864	15,571	15,123	14,996	14,788	14,666	14,300	14,230	14,497	14,825
87	Stikine	2,106	2,100	2,059	1,992	1,984	1,978	2,088	1,442	1,316	1,372
88	Terrace	25,541	25,289	26,002	26,388	26,779	27,397	27,506	27,842	28,535	29,170
92	Nisga'a	1,648	1,659	1,590	1,587	1,598	1,582	1,651	1,733	1,618	1,590
94	Telegraph Creek	676	712	675	669	662	676	696	723	710	737
	British Columbia	2,990,000	3,020,400	3,064,600	3,128,200	3,209,200	3,300,100	3,379,800	3,476,868	3,574,601	3,670,825

		1995	1996	1997	1998	1999	2000	2001	2002	2003
1	Fernie	16,155	16,810	16,449	16,575	16,696	16,810	16,900	16,982	17,053
2	Cranbrook	25,002	25,516	25,655	25,813	25,955	26,088	26,153	26,228	26,308
3	Kimberley	8,772	8,760	8,856	8,873	8,892	8,913	8,783	8,683	8,606
4	Windermere	8,678	9,048	9,059	9,158	9,243	9,316	9,398	9,475	9,549
5	Creston	11,933	12,190	12,149	12,222	12,272	12,299	12,341	12,380	12,422
6	Kootenay Lake	3,721	3,830	3,834	3,878	3,912	3,942	3,978	4,013	4,046
7	Nelson	23,891	24,369	25,224	25,806	26,268	26,621	27,088	27,559	28,023
9	Castlegar	13,157	13,467	13,450	13,527	13,598	13,659	13,726	13,792	13,858
10	Arrow Lakes	5,232	5,393	5,452	5,531	5,597	5,649	5,715	5,763	5,803
11	Trail	20,907	21,003	21,064	21,105	21,145	21,236	21,341	21,441	21,536
12	Grand Forks	9,054	9,170	9,099	9,105	9,108	9,142	9,180	9,221	9,260
13	Kettle Valley	3,781	3,861	3,877	3,910	3,940	3,992	4,050	4,098	4,135
14	Southern Okanagan	18,027	18,306	18,799	19,145	19,482	19,795	20,097	20,406	20,724
15	Penticton	39,353	39,740	42,062	43,367	44,646	45,865	47,054	48,186	49,249
16	Keremeos	4,869	4,942	4,934	4,914	4,896	4,918	4,946	4,982	5,025
17	Princeton	4,980	5,073	5,013	5,007	4,997	4,985	4,972	4,968	4,966
18	Golden	7,611	7,781	7,634	7,628	7,632	7,644	7,667	7,694	7,728
19	Revelstoke	8,994	9,178	9,029	9,070	9,175	9,268	9,328	9,365	9,388
20	Salmon Arm	33,382	34,643	35,371	36,094	36,722	37,442	38,187	38,971	39,770
21	Armstrong-Spallumcheen	9,364	9,546	9,910	10,169	10,431	10,688	10,940	11,200	11,453
22	Vernon	57,703	59,265	61,335	63,005	64,654	66,289	67,906	69,530	71,122
23	Central Okanagan	138,010	141,673	148,292	153,246	158,112	162,838	167,517	172,195	176,817
24	Kamloops	96,039	99,050	101,010	103,044	105,095	107,231	109,392	111,615	113,834
26	North Thompson	4,922	5,046	5,018	5,036	5,045	5,050	5,051	5,059	5,074
27	Cariboo - Chilcotin	43,668	45,044	45,864	46,824	47,982	48,707	49,014	49,324	49,640
28	Quesnel	25,495	26,395	26,027	26,175	26,333	26,489	26,671	26,851	27,028
29	Lillooet	4,975	5,062	5,226	5,296	5,366	5,433	5,501	5,560	5,612
30	South Cariboo	8,430	8,678	8,483	8,484	8,473	8,453	8,435	8,405	8,373
31	Merritt	11,717	11,951	12,073	12,207	12,339	12,471	12,604	12,723	12,837
32	Hope	8,810	8,923	9,096	9,198	9,294	9,388	9,488	9,589	9,687
33	Chilliwack	66,974	68,774	71,297	73,143	74,665	75,942	77,077	78,202	79,310
34	Abbotsford	105,224	107,850	112,412	115,324	117,743	119,947	122,110	124,257	126,368
35	Langley	103,928	107,277	109,196	111,954	114,528	116,937	119,371	121,786	124,160
36	Surrey	310,947	319,702	335,040	346,448	357,783	369,289	381,181	393,215	405,233
37	Delta	97,336	98,469	99,094	99,919	100,733	101,556	102,376	103,197	104,005
38	Richmond	143,683	148,311	150,443	153,455	156,252	158,672	160,941	163,222	165,481
39	Vancouver	528,471	543,084	546,589	553,685	560,686	567,681	574,338	581,040	587,661
40	New Westminster	47,292	48,759	50,873	52,596	54,308	55,856	57,327	58,817	60,302
41	Burnaby	176,032	178,922	182,400	185,767	189,869	194,513	199,842	205,420	211,138
42	Maple Ridge	70,908	73,069	75,972	78,272	80,492	82,531	84,468	86,441	88,421
43	Coquitlam	169,192	175,307	184,047	191,611	198,914	206,404	214,117	222,123	230,296
44	North Vancouver	123,598	125,341	126,583	128,002	129,377	130,819	132,263	133,726	135,187
45	West Vancouver	48,001	48,602	49,124	49,574	50,170	50,760	51,364	51,977	52,586
46	Sechelt	25,511	26,416	27,456	28,288	29,136	29,977	30,883	31,808	32,733
47	Powell River	20,312	20,951	20,638	20,678	20,674	20,624	20,568	20,513	20,457
48	Howe Sound	25,383	26,569	28,096	29,237	30,361	31,486	32,677	33,854	35,022
49	Central Coast	4,049	4,150	4,093	4,114	4,126	4,143	4,156	4,171	4,178
50	Queen Charlotte	5,965	6,165	5,979	5,934	5,957	5,978	6,000	6,022	6,044
52	Prince Rupert	19,568	19,828	20,038	20,231	20,428	20,622	20,810	20,990	21,160
54	Smithers	17,525	18,070	18,381	18,678	18,952	19,220	19,485	19,746	19,996
55/93	Burns Lake/Eutsuk Lake	7,970	8,275	8,255	8,382	8,505	8,628	8,750	8,869	8,986
56	Nechako	17,415	17,771	17,963	18,216	18,442	18,673	18,901	19,139	19,374
57	Prince George	100,127	102,551	103,535	104,969	106,452	107,986	109,566	111,129	112,672
59	Peace River South	29,443	29,957	30,179	30,469	30,403	30,510	30,671	30,868	31,098
60	Peace River North	27,715	28,387	28,979	29,407	29,802	30,190	30,565	30,930	31,292
61	Greater Victoria	207,387	208,515	211,742	213,485	215,055	216,608	218,126	219,649	221,144
62	Sooke	50,343	51,242	53,433	55,078	56,657	58,275	59,879	61,675	63,642
63	Saanich	59,105	60,599	62,255	63,485	64,537	65,512	66,452	67,323	68,122
64	Gulf Islands	13,784	14,221	14,435	14,684	14,900	15,114	15,323	15,537	15,755
65	Cowichan	50,411	51,574	53,662	54,998	56,156	57,298	58,431	59,520	60,565
66	Lake Cowichan	6,536	6,702	6,639	6,637	6,640	6,642	6,643	6,650	6,657
67	Ladysmith	16,263	16,573	17,245	17,707	18,116	18,515	18,910	19,312	19,717
68	Nanaimo	87,956	89,821	93,224	95,817	98,344	100,837	103,319	105,762	108,145
69	Qualicum	36,903	37,983	39,740	40,914	42,048	43,156	44,248	45,309	46,325
70	Alberni	33,677	34,271	34,125	34,184	34,191	34,193	34,182	34,160	34,127
71	Courtenay	57,033	58,909	61,097	62,476	63,698	64,903	66,084	67,320	68,588
72	Campbell River	39,538	40,753	41,334	42,026	42,660	43,286	43,929	44,535	45,109
75	Mission	35,557	36,195	38,067	39,575	40,990	42,612	44,861	47,176	49,540
76	Agassiz - Harrison	7,511	7,605	8,077	8,230	8,365	8,475	8,585	8,682	8,772
77	Summerland	11,528	11,643	12,291	12,630	12,960	13,273	13,577	13,879	14,180
78	Enderby	7,273	7,464	7,535	7,619	7,691	7,761	7,826	7,889	7,955
80	Kitimat	13,652	14,011	13,826	13,881	13,953	14,022	14,090	14,151	14,211
81	Fort Nelson	5,950	6,231	6,416	6,532	6,650	6,766	6,884	7,007	7,126
84	Vancouver Island West	4,396	4,508	4,309	4,263	4,213	4,157	4,080	4,006	3,939
85	Vancouver Island North	15,069	15,441	14,975	14,834	14,772	14,729	14,734	14,749	14,777
87	Stikine	1,508	1,645	1,582	1,643	1,689	1,739	1,796	1,854	1,916
88	Terrace	29,882	30,531	30,761	31,119	31,480	31,832	32,198	32,540	32,869
92	Nisga'a	1,643	1,672	1,693	1,711	1,730	1,751	1,774	1,792	1,809
94	Telegraph Creek	753	761	764	783	799	812	800	773	729
	British Columbia	3,762,859	3,855,140	3,945,233	4,026,076	4,104,352	4,181,833	4,259,961	4,338,970	4,417,805

		2004	2005	2006	2007	2008	2009	2010	2011	2012
1	Fernie	17,114	17,183	17,255	17,323	17,384	17,436	17,464	17,470	17,457
2	Cranbrook	26,389	26,469	26,543	26,615	26,678	26,736	26,784	26,824	26,856
3	Kimberley	8,549	8,500	8,452	8,407	8,364	8,323	8,293	8,268	8,250
4	Windermere	9,625	9,709	9,798	9,892	9,987	10,080	10,165	10,232	10,288
5	Creston	12,458	12,491	12,522	12,549	12,576	12,608	12,646	12,691	12,737
6	Kootenay Lake	4,080	4,115	4,150	4,185	4,217	4,251	4,287	4,325	4,362
7	Nelson	28,488	28,945	29,392	29,836	30,290	30,754	31,260	31,805	32,376
9	Castlegar	13,918	13,962	13,995	14,020	14,036	14,048	14,066	14,091	14,125
10	Arrow Lakes	5,836	5,871	5,908	5,953	6,000	6,041	6,081	6,119	6,158
11	Trail	21,621	21,685	21,742	21,789	21,836	21,886	21,954	22,042	22,149
12	Grand Forks	9,301	9,341	9,382	9,418	9,454	9,490	9,529	9,566	9,600
13	Kettle Valley	4,163	4,189	4,215	4,244	4,274	4,302	4,330	4,358	4,382
14	Southern Okanagan	21,039	21,343	21,640	21,926	22,214	22,505	22,813	23,133	23,464
15	Penticton	50,256	51,228	52,157	53,039	53,899	54,740	55,573	56,402	57,223
16	Keremeos	5,072	5,118	5,166	5,214	5,261	5,309	5,356	5,406	5,458
17	Princeton	4,957	4,915	4,853	4,775	4,689	4,594	4,532	4,500	4,490
18	Golden	7,767	7,818	7,871	7,931	7,993	8,064	8,136	8,206	8,260
19	Revelstoke	9,401	9,411	9,422	9,435	9,445	9,456	9,463	9,469	9,471
20	Salmon Arm	40,581	41,353	42,093	42,798	43,484	44,156	44,820	45,485	46,151
21	Armstrong-Spallumcheen	11,709	11,955	12,197	12,425	12,649	12,869	13,084	13,297	13,508
22	Vernon	72,695	74,218	75,675	77,070	78,441	79,785	81,090	82,369	83,638
23	Central Okanagan	181,414	185,960	190,407	194,753	199,085	203,399	207,682	211,953	216,235
24	Kamloops	116,035	118,077	119,973	121,756	123,486	125,195	127,005	128,908	130,897
26	North Thompson	5,093	5,112	5,131	5,151	5,169	5,189	5,202	5,215	5,224
27	Cariboo - Chilcotin	49,951	50,235	50,500	50,747	50,982	51,212	51,464	51,728	52,003
28	Quesnel	27,205	27,375	27,539	27,697	27,850	27,995	28,136	28,273	28,402
29	Lillooet	5,657	5,709	5,767	5,824	5,884	5,949	6,011	6,074	6,141
30	South Cariboo	8,336	8,303	8,265	8,231	8,196	8,159	8,120	8,074	8,025
31	Merritt	12,954	13,063	13,176	13,280	13,386	13,487	13,583	13,683	13,775
32	Hope	9,778	9,869	9,957	10,043	10,134	10,225	10,311	10,402	10,496
33	Chilliwack	80,400	81,456	82,475	83,475	84,474	85,476	86,505	87,553	88,627
34	Abbotsford	128,473	130,572	132,653	134,722	136,809	138,917	141,062	143,237	145,458
35	Langley	126,513	128,859	131,191	133,507	135,834	138,167	140,498	142,843	145,206
36	Surrey	417,295	429,332	441,252	453,033	464,858	476,710	488,552	500,433	512,396
37	Delta	104,806	105,592	106,368	107,117	107,847	108,554	109,249	109,930	110,595
38	Richmond	167,727	169,957	172,155	174,318	176,469	178,600	180,698	182,776	184,830
39	Vancouver	594,187	600,505	606,584	612,417	618,079	623,585	628,982	634,223	639,386
40	New Westminster	61,784	63,236	64,644	66,012	67,372	68,726	70,079	71,434	72,807
41	Burnaby	217,003	222,920	228,807	234,642	240,524	246,428	252,295	258,163	264,057
42	Maple Ridge	90,409	92,392	94,351	96,289	98,239	100,189	102,141	104,098	106,063
43	Coquitlam	238,653	247,074	255,494	263,881	272,366	280,928	289,537	298,225	307,014
44	North Vancouver	136,656	138,140	139,629	141,111	142,607	144,122	145,633	147,153	148,684
45	West Vancouver	53,188	53,767	54,313	54,832	55,351	55,872	56,425	57,007	57,622
46	Sechelt	33,666	34,599	35,517	36,423	37,341	38,263	39,197	40,144	41,108
47	Powell River	20,404	20,349	20,297	20,249	20,196	20,143	20,091	20,046	20,001
48	Howe Sound	36,191	37,374	38,555	39,741	40,947	42,167	43,399	44,645	45,909
49	Central Coast	4,181	4,187	4,190	4,189	4,183	4,179	4,175	4,165	4,156
50	Queen Charlotte	6,068	6,094	6,120	6,149	6,180	6,210	6,236	6,260	6,288
52	Prince Rupert	21,329	21,497	21,665	21,831	22,000	22,164	22,322	22,476	22,625
54	Smithers	20,244	20,492	20,734	20,975	21,209	21,443	21,683	21,919	22,149
55/93	Burns Lake/Eutsuk Lake	9,101	9,211	9,319	9,428	9,533	9,636	9,734	9,831	9,925
56	Nechako	19,601	19,801	19,980	20,137	20,278	20,409	20,556	20,720	20,898
57	Prince George	114,204	115,744	117,281	118,809	120,334	121,847	123,336	124,809	126,263
59	Peace River South	31,353	31,602	31,848	32,095	32,338	32,581	32,819	33,055	33,293
60	Peace River North	31,646	32,000	32,342	32,681	33,019	33,347	33,659	33,959	34,257
61	Greater Victoria	222,603	224,030	225,415	226,755	228,082	229,389	230,618	231,796	232,944
62	Sooke	65,772	68,029	70,380	72,792	75,284	77,837	80,360	82,867	85,380
63	Saanich	68,870	69,608	70,321	71,010	71,685	72,341	72,965	73,567	74,146
64	Gulf Islands	15,981	16,216	16,454	16,689	16,928	17,166	17,395	17,618	17,839
65	Cowichan	61,590	62,640	63,695	64,745	65,799	66,845	67,854	68,831	69,784
66	Lake Cowichan	6,671	6,676	6,683	6,685	6,686	6,690	6,694	6,704	6,716
67	Ladysmith	20,121	20,537	20,956	21,370	21,788	22,204	22,609	23,006	23,396
68	Nanaimo	110,495	112,832	115,135	117,397	119,675	121,955	124,232	126,521	128,825
69	Qualicum	47,313	48,285	49,226	50,124	51,013	51,885	52,740	53,587	54,432
70	Alberni	34,085	34,035	33,976	33,914	33,847	33,778	33,708	33,635	33,558
71	Courtenay	69,878	71,161	72,427	73,663	74,888	76,097	77,272	78,420	79,542
72	Campbell River	45,670	46,243	46,826	47,416	48,023	48,642	49,273	49,918	50,581
75	Mission	51,975	54,495	57,070	59,680	62,373	65,133	67,945	70,823	73,774
76	Agassiz - Harrison	8,855	8,944	9,029	9,110	9,192	9,273	9,359	9,439	9,527
77	Summerland	14,474	14,756	15,026	15,282	15,532	15,777	16,031	16,287	16,545
78	Enderby	8,019	8,079	8,137	8,192	8,252	8,311	8,367	8,423	8,487
80	Kitimat	14,275	14,351	14,441	14,543	14,647	14,758	14,864	14,969	15,071
81	Fort Nelson	7,249	7,372	7,498	7,621	7,747	7,872	7,999	8,118	8,240
84	Vancouver Island West	3,880	3,819	3,763	3,709	3,648	3,588	3,530	3,471	3,411
85	Vancouver Island North	14,814	14,855	14,900	14,950	15,000	15,042	15,081	15,119	15,153
87	Stikine	1,981	2,050	2,120	2,198	2,278	2,355	2,436	2,515	2,592
88	Terrace	33,184	33,499	33,812	34,132	34,460	34,789	35,122	35,462	35,811
92	Nisga'a	1,829	1,854	1,878	1,903	1,932	1,961	1,987	2,014	2,036
94	Telegraph Creek	681	649	632	628	635	649	663	676	692
	British Columbia	4,496,789	4,575,289	4,652,707	4,728,897	4,805,124	4,881,243	4,957,187	5,033,258	5,109,720

		2013	2014	2015	2016	2017	2018	2019	2020	2021
1	Fernie	17,421	17,369	17,300	17,217	17,119	17,013	16,898	16,773	16,642
2	Cranbrook	26,876	26,885	26,884	26,876	26,855	26,816	26,760	26,692	26,611
3	Kimberley	8,235	8,221	8,210	8,197	8,183	8,166	8,144	8,114	8,074
4	Windermere	10,333	10,372	10,405	10,431	10,456	10,478	10,500	10,524	10,552
5	Creston	12,788	12,842	12,896	12,952	13,010	13,066	13,119	13,169	13,217
6	Kootenay Lake	4,397	4,434	4,472	4,507	4,540	4,570	4,600	4,630	4,660
7	Nelson	32,968	33,569	34,178	34,790	35,394	35,987	36,560	37,106	37,616
9	Castlegar	14,165	14,208	14,255	14,300	14,345	14,389	14,431	14,469	14,502
10	Arrow Lakes	6,195	6,231	6,265	6,294	6,320	6,345	6,369	6,392	6,417
11	Trail	22,269	22,399	22,534	22,672	22,811	22,947	23,073	23,186	23,286
12	Grand Forks	9,631	9,662	9,691	9,717	9,739	9,764	9,786	9,801	9,816
13	Kettle Valley	4,400	4,415	4,432	4,449	4,460	4,473	4,484	4,490	4,491
14	Southern Okanagan	23,799	24,127	24,455	24,782	25,100	25,408	25,700	25,972	26,226
15	Penticton	58,032	58,815	59,582	60,339	61,086	61,822	62,537	63,230	63,911
16	Keremeos	5,510	5,559	5,609	5,657	5,704	5,755	5,810	5,868	5,926
17	Princeton	4,497	4,515	4,540	4,570	4,601	4,627	4,644	4,649	4,635
18	Golden	8,355	8,433	8,510	8,590	8,670	8,746	8,819	8,887	8,955
19	Revelstoke	9,468	9,462	9,454	9,443	9,424	9,399	9,370	9,338	9,297
20	Salmon Arm	46,816	47,469	48,125	48,792	49,466	50,154	50,859	51,578	52,322
21	Armstrong-Spallumcheen	13,713	13,913	14,111	14,307	14,503	14,703	14,904	15,105	15,308
22	Vernon	84,885	86,103	87,300	88,491	89,683	90,875	92,075	93,282	94,500
23	Central Okanagan	220,496	224,693	228,878	233,080	237,297	241,529	245,777	250,052	254,348
24	Kamloops	132,948	135,022	137,117	139,240	141,368	143,480	145,564	147,599	149,568
26	North Thompson	5,227	5,228	5,229	5,230	5,227	5,223	5,215	5,203	5,191
27	Cariboo - Chilcotin	52,285	52,562	52,834	53,095	53,348	53,582	53,788	53,963	54,107
28	Quesnel	28,521	28,633	28,737	28,830	28,914	28,988	29,051	29,104	29,145
29	Lillooet	6,204	6,269	6,329	6,392	6,451	6,514	6,574	6,631	6,685
30	South Cariboo	7,970	7,913	7,853	7,785	7,713	7,641	7,567	7,486	7,402
31	Merritt	13,868	13,956	14,046	14,137	14,231	14,319	14,413	14,507	14,608
32	Hope	10,589	10,685	10,786	10,885	10,985	11,087	11,191	11,301	11,415
33	Chilliwack	89,715	90,813	91,922	93,042	94,168	95,300	96,433	97,561	98,685
34	Abbotsford	147,709	149,959	152,218	154,490	156,771	159,058	161,333	163,587	165,813
35	Langley	147,555	149,872	152,170	154,465	156,745	159,009	161,255	163,475	165,661
36	Surrey	524,353	536,212	548,058	559,958	571,891	583,848	595,835	607,829	619,819
37	Delta	111,234	111,840	112,417	112,966	113,489	113,982	114,438	114,860	115,241
38	Richmond	186,847	188,807	190,727	192,621	194,482	196,311	198,099	199,846	201,554
39	Vancouver	644,432	649,327	654,103	658,782	663,375	667,875	672,286	676,611	680,837
40	New Westminster	74,182	75,545	76,913	78,291	79,679	81,076	82,476	83,883	85,289
41	Burnaby	269,930	275,735	281,541	287,389	293,274	299,189	305,146	311,143	317,180
42	Maple Ridge	108,031	109,977	111,925	113,876	115,826	117,770	119,718	121,655	123,580
43	Coquitlam	315,832	324,615	333,441	342,342	351,305	360,315	369,373	378,473	387,606
44	North Vancouver	150,224	151,759	153,307	154,868	156,444	158,030	159,623	161,219	162,813
45	West Vancouver	58,250	58,873	59,500	60,130	60,755	61,368	61,964	62,534	63,071
46	Sechelt	42,081	43,045	44,012	44,987	45,967	46,948	47,933	48,923	49,914
47	Powell River	19,963	19,924	19,883	19,838	19,785	19,727	19,663	19,592	19,511
48	Howe Sound	47,183	48,467	49,764	51,074	52,399	53,738	55,091	56,454	57,828
49	Central Coast	4,142	4,128	4,114	4,094	4,070	4,045	4,006	3,964	3,921
50	Queen Charlotte	6,318	6,342	6,364	6,384	6,402	6,423	6,436	6,451	6,461
52	Prince Rupert	22,767	22,903	23,040	23,174	23,303	23,425	23,545	23,660	23,772
54	Smithers	22,372	22,586	22,790	22,985	23,158	23,322	23,460	23,576	23,671
55/93	Burns Lake/Eutsuk Lake	10,019	10,108	10,195	10,281	10,367	10,452	10,538	10,624	10,709
56	Nechako	21,078	21,262	21,452	21,639	21,823	21,997	22,158	22,306	22,425
57	Prince George	127,695	129,098	130,475	131,843	133,209	134,568	135,930	137,289	138,649
59	Peace River South	33,527	33,755	33,975	34,186	34,390	34,586	34,778	34,956	35,125
60	Peace River North	34,559	34,875	35,204	35,557	35,945	36,368	36,842	37,371	37,974
61	Greater Victoria	234,057	235,135	236,200	237,273	238,362	239,472	240,611	241,780	242,986
62	Sooke	87,893	90,387	92,896	95,449	98,057	100,732	103,482	106,317	109,259
63	Saanich	74,691	75,189	75,655	76,090	76,498	76,868	77,202	77,494	77,737
64	Gulf Islands	18,057	18,261	18,460	18,655	18,846	19,041	19,232	19,425	19,621
65	Cowichan	70,705	71,585	72,436	73,265	74,073	74,866	75,640	76,399	77,147
66	Lake Cowichan	6,729	6,743	6,755	6,767	6,781	6,794	6,805	6,813	6,822
67	Ladysmith	23,779	24,156	24,527	24,894	25,258	25,624	25,990	26,359	26,730
68	Nanaimo	131,139	133,437	135,741	138,072	140,425	142,805	145,218	147,659	150,134
69	Qualicum	55,264	56,069	56,868	57,671	58,482	59,299	60,123	60,957	61,801
70	Alberni	33,481	33,409	33,336	33,265	33,194	33,127	33,058	32,988	32,923
71	Courtenay	80,633	81,683	82,709	83,713	84,696	85,664	86,613	87,543	88,460
72	Campbell River	51,252	51,922	52,598	53,276	53,953	54,634	55,315	55,987	56,653
75	Mission	76,772	79,796	82,866	86,005	89,207	92,465	95,789	99,170	102,608
76	Agassiz - Harrison	9,622	9,710	9,804	9,897	9,991	10,079	10,168	10,252	10,334
77	Summerland	16,800	17,057	17,306	17,553	17,795	18,026	18,252	18,466	18,663
78	Enderby	8,547	8,607	8,665	8,723	8,779	8,836	8,891	8,950	9,009
80	Kitimat	15,166	15,257	15,339	15,423	15,496	15,568	15,633	15,696	15,749
81	Fort Nelson	8,364	8,495	8,621	8,750	8,885	9,021	9,162	9,307	9,456
84	Vancouver Island West	3,358	3,316	3,277	3,249	3,229	3,226	3,229	3,248	3,288
85	Vancouver Island North	15,182	15,203	15,221	15,227	15,228	15,222	15,211	15,195	15,169
87	Stikine	2,665	2,737	2,810	2,882	2,954	3,028	3,112	3,199	3,290
88	Terrace	36,162	36,518	36,879	37,237	37,592	37,944	38,287	38,624	38,945
92	Nisga'a	2,062	2,086	2,118	2,146	2,171	2,198	2,217	2,229	2,249
94	Telegraph Creek	711	729	742	756	772	785	803	819	834
	British Columbia	5,185,950	5,261,276	5,336,356	5,411,547	5,486,749	5,561,920	5,636,984	5,711,819	5,786,409

NOTES:
- All figures are asof July 1st of the year stated.
- 1976, 1981, and 1986 figures include estimates of the net census undercount and non-permanent residents.
- 1991 figures include estimates of the net census undercount.
- Reference date for projection data is July 1.
- 1996 to 2021 projections are from P.E.O.P.L.E. ProjectionSeries 21.
-LastUpdated: April 1996

A.2 Municipal Population Statistics

Road sections with populations greater than 5,000 are considered as "urban" classification

Regional District and Municipality	Area Type	1996 Population
Alberni-Clayoquot		34,271
Port Alberni	C *	19,377
Tofino	DM	1,396
Ucluelet	VL	1,733
Bulkley-Nechako		44,116
Burns Lake	VL *	2,126
Fort St. James	DM	2,209
Fraser Lake	VL	1,426
Granisle	VL	676
Houston	DM	3,936
Smithers	T *	5,794
Telkwa	VL *	1,328
Vanderhoof	DM	4,470
Capital		334,577
Central Saanich	DM	15,611
Colwood	C	14,672
Esquimalt	DM	17,992
Highlands	DM *	1,285
Langford	DM *	17,878
Metchosin	DM	4,835
North Saanich	DM	10,990
Oak Bay	DM	18,243
Saanich	DM *	106,318
Sidney	T	11,184
Victoria	C	77,772
View Royal	T *	6,748
Cariboo		71,439
Quesnel	C *	8,588
Williams Lake	C	11,398
100 Mile House	DM	2,075
Central Coast		4,150
Central Fraser Valley ++		-
City of Abbotsford	C *	-
Abbotsford	DM *	-
Matsqui	DM *	-

Regional District and Municipality	Area Type	1996 Population
Central Kootenay		59,249
Castlegar	C	7,257
Creston	T *	4,843
Kaslo	VL	996
Nakusp	VL *	1,813
Nelson	C *	9,607
New Denver	VL	604
Salmo	VL	1,227
Silverton	VL	277
Slocan	VL	328
Central Okanagan		141,673
Kelowna	C	93,403
Lake Country	DM *	8,848
Peachland	DM	4,619
Columbia-Shuswap		51,602
Golden	T	4,107
Revelstoke	C	8,507
Salmon Arm	DM	15,034
Sicamous	DM	3,082
Comox-Strathcona		104,170
Campbell River	DM	30,672
Comox	T *	11,857
Courtenay	C *	18,420
Cumberland	VL	2,683
Gold River	VL	2,279
Sayward	VL	444
Tahsis	VL	1,224
Zeballos	VL	276
Cowichan Valley		74,849
Duncan	C	5,330
Ladysmith	T	6,362
Lake Cowichan	VL	3,116
North Cowichan	DM	26,326
Dewdney-Alouette ++		-
Maple Ridge	DM	-
Mission	DM	-

Regional District and Municipality	Area Type	1996 Population
Pitt Meadows	DM *	-
East Kootenay		60,134
Cranbrook	C	18,780
Elkford	DM	3,456
Fernie	C *	5,155
Invermere	DM	2,721
Kimberley	C	6,908
Radium Hot Springs	VL	556
Sparwood	DM	4,250
Fort Nelson-Liard		6,081
Fort Nelson	T	4,484
Fraser-Cheam/Fraser Valley	++ #	229,409
Chilliwack	DM	62,582
City of Abbotsford	C *	107,410
Harrison Hot Springs	VL	1,060
Hope	DM *	7,032
Kent	DM	5,231
Mission	DM	31,677
Fraser-Fort George		102,551
Mackenzie	DM	6,146
Mcbride	VL *	764
Prince George	C	77,996
Valemount	VL	1,295
Greater Vancouver ++	1	1,866,781
Anmore	VL	863
Belcarra	VL *	642
Burnaby	C	178,922
City of Langley	C	23,485
Coquitlam	C	103,995
Delta	DM	97,936
Langley	DM	83,173
Lions Bay	VL	1,417
Maple Ridge	DM	58,342
New Westminster	C	48,759

Regional District and Municipality	Area Type	1996 Population
North Vancouver	C	41,918
North Vancouver	DM	83,302
Pitt Meadows	DM	14,445
Port Coquitlam	C	47,780
Port Moody	C *	21,200
Richmond	C	148,311
Surrey	C	300,581
Vancouver	C	535,699
West Vancouver	DM	42,252
White Rock	C	18,044
Kitimat-Stikine	*	46,450
Hazelton	VL	384
Kitimat	DM	12,077
New Hazelton	DM	826
Stewart	DM	1,033
Terrace	C	13,372
Kootenay-Boundary		34,034
Fruitvale	VL	2,196
Grand Forks	C	4,184
Greenwood	C	831
Midway	VL	663
Montrose	VL	1,269
Rossland	C *	3,768
Trail	C *	8,005
Warfield	VL	1,750
Mount Waddington		15,441
Alert Bay	VL	697
Port Alice	VL	1,626
Port Hardy	DM	5,470
Port McNeill	T	3,014
Nanaimo		127,469
Nanaimo	C	72,812
Parksville	C *	9,576
Qualicum Beach	T	6,874
North Okanagan		76,275
Armstrong	C	4,069

Regional District and Municipality	Area Type	1996 Population
Coldstream	DM	9,518
Enderby	C	3,012
Lumby	VL	1,901
Spallumcheen	DM	5,477
Vernon	C *	34,059
Okanagan-Similkameen		79,704
Keremeos	VL	1,101
Oliver	T	4,490
Osoyoos	T	4,135
Penticton	C	32,218
Princeton	T *	3,036
Summerland	DM	11,150
Peace River		58,344
Chetwynd	DM	3,271
Dawson Creek	C	11,730
Fort St. John	C	15,191
Hudson's Hope	DM	1,115
Pouce Coupe	VL	960
Taylor	DM	1,066
Tumbler Ridge	DM	3,817
Powell River		21,286
Powell River	DM	14,143
Sechelt Ind Gov Dist	IGD •	26
Skeena-Queen Charlotte	*	26,518
Masset	VL	1,493

Regional District and Municipality	Area Type	1996 Population
Port Clements	VL	577
Port Edward	DM	835
Prince Rupert	C	17,681
Squamish-Lillooet		31,631
Lillooet	VL	2,058
Pemberton	VL	811
Squamish	DM	14,284
Whistler	DM	7,348
Stikine		1,795
Sunshine Coast		26,416
Gibsons	T *	3,937
Sechelt	DM	7,745
Sechelt Ind Gov Dist	IGD •	772
Thompson-Nicola		124,725
Ashcroft	VL	2,128
Cache Creek	VL	1,212
Chase	VL	2,466
Clinton	VL	740
Kamloops	C	79,566
Logan Lake	DM	2,530
Lytton	VL	366
Merritt	C *	7,805
British Columbia		3,855,140

Sources: Population Section, BC Stats Ministry of Finance and Corporate Relations Government of British Columbia November , 1996

All figures correspond to municipal boudaries as of July 1 of the year stated.

C = City, T = Town, VL = Village, DM = District Municipality , IGD = Iindian Government District

* Denotes a boudary change between 1991 and 1996

** Sechelt Indian Government District is split between Sunshine Coast and Powell River Regional Districts.

Dewdney-Alouette and Central Fraser Valley Regional Districts have been eliminated and apportioned to the Fraser Valley and Greater Vancouver Regional Districts.

The Fraser-Cheam Regional District was renamed the Fraser Valley Regional District after its amalgamation with the Central Fraser Valley and a portion of Dewdney-Alouette.

Appendix B
TAC Default Rates[24] by Facility Type

The accidents rates recommended in the TAC document for use in Microbencost are drawn from research in several Provinces and States, relying heavily on BC and Ontario data. They are presented here as accidents per km per year but must be converted to an accident rate of accidents per 100 million vehicle miles for use in Microbencost. The conversion formula is:

accidents/100 million veh-miles = 160.9 x accidents/(km-year) x 1,000,000/(365 x AADT)

Accident rates are given separately for intersections and sections since Microbencost allows the accident rates to be entered this way if desired.

B.1 Highway Sections

B.1.1 Two Lane Rural Roads.

The recommended model for estimating accidents that do not occur at intersections is:

$$\text{Accidents/(km-year)} = A \times (AADT)^b$$

	All Accidents				Fatal and Injury Accidents			
Lane Width (m)	>6.1	<6.1	>6.1	<6.1	>6.1	<6.1	>6.1	<6.1
Shoulder Width (m)	<1.8	<1.8	>1.8	>1.8	<1.8	<1.8	>1.8	>1.8
b	0.733	0.892	0.733	0.892	0.783	0.971	0.783	0.971
A	0.00287	0.00096	0.00250	0.00069	0.00067	0.00018	0.00054	0.00012

The equivalent accidents per 100 million vehicle miles for use in Microbencost is shown below.

[24] Hauer E., Persaud B., "Safety Analysis of Roadway Geometric and Ancillary Features" Transportation Association of Canada Dec., 1996

Accidents/100mvm
2 lane Rural Highways
Travelled Way >6.1m, Shoulder Width <1.8 m

AADT	total	Fatality	Injury	PDO
1000	174	3.26	65.4	105.7
2000	145	2.71	54.3	87.8
3000	130	2.43	48.7	78.8
4000	120	2.25	45.1	73.0
5000	113	2.12	42.5	68.8
6000	108	2.02	40.5	65.5
7000	104	1.94	38.9	62.9
8000	100	1.87	37.5	60.7
9000	97	1.81	36.4	58.8
10000	94	1.76	35.3	57.1
11000	92	1.72	34.5	55.7
12000	90	1.68	33.7	54.4
13000	88	1.64	33.0	53.3
14000	86	1.61	32.3	52.2
15000	85	1.58	31.7	51.3
16000	83	1.55	31.2	50.4
17000	82	1.53	30.7	49.6
18000	81	1.51	30.2	48.8
19000	79	1.48	29.8	48.1
20000	78	1.46	29.4	47.5
21000	77	1.45	29.0	46.9
22000	76	1.43	28.6	46.3
23000	75	1.41	28.3	45.8
24000	75	1.40	28.0	45.2
25000	74	1.38	27.7	44.7

Accidents/100mvm
2 lane Rural Highways
Travelled Way <6.1m, Shoulder Width <1.8 m

AADT	total	Fatality	Injury	PDO
1000	200.1	3.74	75.0	121.3
2000	166.3	3.11	62.4	100.8
3000	149.2	2.79	56.0	90.5
4000	138.2	2.58	51.8	83.8
5000	130.2	2.43	48.8	78.9
6000	124.0	2.32	46.5	75.2
7000	119.0	2.23	44.6	72.2
8000	114.8	2.15	43.1	69.6
9000	111.3	2.08	41.7	67.5
10000	108.2	2.02	40.6	65.6
11000	105.5	1.97	39.6	64.0
12000	103.1	1.93	38.6	62.5
13000	100.9	1.89	37.8	61.2
14000	98.9	1.85	37.1	60.0
15000	97.1	1.82	36.4	58.9
16000	95.4	1.78	35.8	57.9
17000	93.9	1.76	35.2	56.9
18000	92.5	1.73	34.7	56.1
19000	91.2	1.70	34.2	55.3
20000	89.9	1.68	33.7	54.5
21000	88.8	1.66	33.3	53.8
22000	87.7	1.64	32.9	53.1
23000	86.6	1.62	32.5	52.5
24000	85.6	1.60	32.1	51.9
25000	84.7	1.58	31.8	51.4

Accidents/100mvm
2 lane Rural Highways
Travelled Way >6.1m, Shoulder Width >1.8 m

AADT	total	Fatal	Injury	PDO
1000	201	3.75	75.3	121.7
2000	186	3.48	69.8	112.9
3000	178	3.33	66.9	108.1
4000	173	3.23	64.8	104.8
5000	169	3.15	63.3	102.3
6000	165	3.09	62.0	100.3
7000	163	3.04	61.0	98.6
8000	160	3.00	60.1	97.2
9000	158	2.96	59.4	96.0
10000	157	2.93	58.7	94.9
11000	155	2.90	58.1	93.9
12000	153	2.87	57.6	93.1
13000	152	2.85	57.1	92.3
14000	151	2.82	56.6	91.5
15000	150	2.80	56.2	90.8
16000	149	2.78	55.8	90.2
17000	148	2.76	55.4	89.6
18000	147	2.75	55.1	89.1
19000	146	2.73	54.8	88.6
20000	145	2.72	54.5	88.1
21000	144	2.70	54.2	87.6
22000	144	2.69	53.9	87.2
23000	143	2.68	53.7	86.7
24000	142	2.66	53.4	86.3
25000	142	2.65	53.2	86.0

Accidents/100mvm
2 lane Rural Highways
Travelled Way <6.1m, Shoulder Width >1.8 m

AADT	total	Fatality	Injury	PDO
1000	144.3	2.70	54.1	87.5
2000	133.9	2.50	50.2	81.2
3000	128.1	2.40	48.1	77.7
4000	124.2	2.32	46.6	75.3
5000	121.3	2.27	45.5	73.5
6000	118.9	2.22	44.6	72.1
7000	116.9	2.19	43.8	70.9
8000	115.3	2.16	43.2	69.9
9000	113.8	2.13	42.7	69.0
10000	112.5	2.10	42.2	68.2
11000	111.4	2.08	41.8	67.5
12000	110.3	2.06	41.4	66.9
13000	109.4	2.05	41.0	66.3
14000	108.5	2.03	40.7	65.8
15000	107.7	2.01	40.4	65.3
16000	106.9	2.00	40.1	64.8
17000	106.2	1.99	39.8	64.4
18000	105.6	1.97	39.6	64.0
19000	105.0	1.96	39.4	63.6
20000	104.4	1.95	39.1	63.3
21000	103.8	1.94	38.9	63.0
22000	103.3	1.93	38.7	62.6
23000	102.8	1.92	38.6	62.3
24000	102.4	1.91	38.4	62.1
25000	101.9	1.91	38.2	61.8

B.1.2 Two Lane Urban Roads.

The recommended model for estimating accidents that do not occur at intersections is:

$$\text{Accidents/(km-year)} = 0.00369(\text{AADT})^{0.72}$$

The equivalent accidents per 100 million vehicle miles for use in Microbencost is shown here.

AADT	total	Fatality	Injury	PDO
1,000	235.2	1.65	90.0	143.5
2,000	193.7	1.36	74.1	118.2
3,000	172.9	1.21	66.2	105.5
4,000	159.5	1.12	61.1	97.4
5,000	149.9	1.05	57.4	91.5
6,000	142.4	1.00	54.5	86.9
7,000	136.4	0.95	52.2	83.2
8,000	131.4	0.92	50.3	80.2
9,000	127.1	0.89	48.7	77.6
10,000	123.4	0.86	47.2	75.3
11,000	120.2	0.84	46.0	73.3
12,000	117.3	0.82	44.9	71.6
13,000	114.7	0.80	43.9	70.0
14,000	112.3	0.79	43.0	68.5
15,000	110.2	0.77	42.2	67.2
16,000	108.2	0.76	41.4	66.0
17,000	106.4	0.74	40.7	64.9
18,000	104.7	0.73	40.1	63.9
19,000	103.1	0.72	39.5	62.9
20,000	101.6	0.71	38.9	62.0
21,000	100.3	0.70	38.4	61.2
22,000	99.0	0.69	37.9	60.4
23,000	97.7	0.68	37.4	59.7
24,000	96.6	0.68	37.0	58.9
25,000	95.5	0.67	36.6	58.3
26,000	94.4	0.66	36.2	57.6
27,000	93.5	0.65	35.8	57.0
28,000	92.5	0.65	35.4	56.5
29,000	91.6	0.64	35.1	55.9
30,000	90.7	0.64	34.7	55.4
31,000	89.9	0.63	34.4	54.9
32,000	89.1	0.62	34.1	54.4
33,000	88.3	0.62	33.8	53.9
34,000	87.6	0.61	33.5	53.5
35,000	86.9	0.61	33.3	53.0

B.1.3 Multilane Roads Without Full Access Control

These geneally represent the expressway classification. Below about 18,000 AADT there are more accidents on highways with a median barrier than without due to an increase in collisions with the median barrier. The recommended model for estimating accidents that do not occur at intersections is:

Accidents/km/yr = $a(AADT)^b$

Accident Type	Area Type	Divided or Undivided	a	b
Total	Urban	D or U	0.0000524	1.146
Total	Rural	D	0.0084885	0.618
Total	Rural	U	0.0000560	1.129
Fatal + Injury	Urban	D or U	0.0001045	0.980
Fatal + Injury	Rural	D	0.0013000	0.687
Fatal + Injury	Rural	U	0.0000078	1.219

Multilane Roads without Full Access Control

(Excluding Intersection Accidentss)

a/100mvm

AADT	total	Fatality	Injury	PDO
1,000	267.4	3.58	125.2	138.6
2,000	205.2	2.75	96.1	106.4
3,000	175.8	2.36	82.3	91.1
4,000	157.5	2.11	73.7	81.6
5,000	144.6	1.94	67.7	75.0
6,000	134.9	1.81	63.1	69.9
7,000	127.2	1.70	59.5	65.9
8,000	120.8	1.62	56.6	62.6
9,000	115.5	1.55	54.1	59.9
10,000	111.0	1.49	52.0	57.5
11,000	107.0	1.43	50.1	55.5
12,000	103.5	1.39	48.5	53.7
13,000	100.4	1.35	47.0	52.0
14,000	97.6	1.31	45.7	50.6
15,000	95.0	1.27	44.5	49.3
16,000	92.7	1.24	43.4	48.1
17,000	90.6	1.21	42.4	47.0
18,000	88.6	1.19	41.5	46.0
19,000	86.8	1.16	40.7	45.0
20,000	85.2	1.14	39.9	44.1
21,000	83.6	1.12	39.1	43.3
22,000	82.1	1.10	38.4	42.6
23,000	80.7	1.08	37.8	41.8
24,000	79.4	1.06	37.2	41.2
25,000	78.2	1.05	36.6	40.5
26,000	77.0	1.03	36.1	39.9
27,000	75.9	1.02	35.5	39.4
28,000	74.9	1.00	35.1	38.8
29,000	73.9	0.99	34.6	38.3
30,000	72.9	0.98	34.1	37.8
31,000	72.0	0.97	33.7	37.3
32,000	71.2	0.95	33.3	36.9
33,000	70.3	0.94	32.9	36.5
34,000	69.5	0.93	32.6	36.0
35,000	68.8	0.92	32.2	35.6
36,000	68.0	0.91	31.8	35.3
37,000	67.3	0.90	31.5	34.9
38,000	66.6	0.89	31.2	34.5
39,000	66.0	0.88	30.9	34.2
40,000	65.3	0.88	30.6	33.9
41,000	64.7	0.87	30.3	33.6
42,000	64.1	0.86	30.0	33.2
43,000	63.6	0.85	29.8	33.0
44,000	63.0	0.84	29.5	32.7
45,000	62.5	0.84	29.2	32.4
46,000	61.9	0.83	29.0	32.1
47,000	61.4	0.82	28.8	31.8
48,000	60.9	0.82	28.5	31.6
49,000	60.5	0.81	28.3	31.3
50,000	60.0	0.80	28.1	31.1

B.1.4 Freeways

These are generally a depressed median highway with full access control. The recommended model for estimating accidents that do not occur at interchanges is:

Accident Type	Lanes	a	b
Total	4	0.0000474	1.155
Total	>4	0.0000978	1.113
Fatal + Injury	4	0.0000206	1.136
Fatal + Injury	>4	0.0000122	1.212

$$\text{Accidents/km/yr} = a(\text{AADT})^b$$

The equivalent accidents per 100 million vehicle miles for use in Microbencost is shown below.

4 lane rural freeways with full access control

(excludes interchange accidents)

a/100mvm

AADT	total	Fatality	Injury	PDO
1,000	61.0	0.80	24.8	35.4
2,000	67.9	0.89	27.6	39.4
3,000	72.3	0.95	29.4	41.9
4,000	75.6	0.99	30.7	43.9
5,000	78.2	1.03	31.8	45.4
6,000	80.5	1.05	32.7	46.7
7,000	82.4	1.08	33.5	47.8
8,000	84.2	1.10	34.2	48.8
9,000	85.7	1.12	34.9	49.7
10,000	87.1	1.14	35.4	50.5
11,000	88.4	1.16	36.0	51.3
12,000	89.6	1.17	36.4	52.0
13,000	90.7	1.19	36.9	52.6
14,000	91.8	1.20	37.3	53.3
15,000	92.8	1.22	37.7	53.8
16,000	93.7	1.23	38.1	54.4
17,000	94.6	1.24	38.5	54.9
18,000	95.4	1.25	38.8	55.4
19,000	96.2	1.26	39.1	55.8
20,000	97.0	1.27	39.5	56.3
21,000	97.7	1.28	39.8	56.7
22,000	98.4	1.29	40.0	57.1
23,000	99.1	1.30	40.3	57.5
24,000	99.8	1.31	40.6	57.9
25,000	100.4	1.32	40.8	58.3
26,000	101.0	1.32	41.1	58.6
27,000	101.6	1.33	41.3	59.0
28,000	102.2	1.34	41.6	59.3
29,000	102.8	1.35	41.8	59.6
30,000	103.3	1.35	42.0	59.9
31,000	103.8	1.36	42.2	60.2
32,000	104.3	1.37	42.4	60.5
33,000	104.8	1.37	42.6	60.8
34,000	105.3	1.38	42.8	61.1
35,000	105.8	1.39	43.0	61.4
36,000	106.3	1.39	43.2	61.7
37,000	106.7	1.40	43.4	61.9
38,000	107.2	1.40	43.6	62.2
39,000	107.6	1.41	43.8	62.4
40,000	108.0	1.41	43.9	62.7
41,000	108.4	1.42	44.1	62.9
42,000	108.8	1.43	44.3	63.1
43,000	109.2	1.43	44.4	63.4
44,000	109.6	1.44	44.6	63.6
45,000	110.0	1.44	44.7	63.8
46,000	110.4	1.45	44.9	64.0
47,000	110.7	1.45	45.0	64.3
48,000	111.1	1.46	45.2	64.5
49,000	111.5	1.46	45.3	64.7
50,000	111.8	1.46	45.5	64.9

AADT	total	Fatality	Injury	PDO
1,000	61.0	0.23	26.5	34.2
2,000	67.9	0.26	29.5	38.1
3,000	72.3	0.27	31.4	40.6
4,000	75.6	0.29	32.9	42.4
5,000	78.2	0.30	34.0	43.9
6,000	80.5	0.31	35.0	45.2
7,000	82.4	0.31	35.8	46.3
8,000	84.2	0.32	36.6	47.2
9,000	85.7	0.33	37.3	48.1
10,000	87.1	0.33	37.9	48.9
11,000	88.4	0.34	38.4	49.6
12,000	89.6	0.34	39.0	50.3
13,000	90.7	0.34	39.5	50.9
14,000	91.8	0.35	39.9	51.5
15,000	92.8	0.35	40.3	52.1
16,000	93.7	0.36	40.7	52.6
17,000	94.6	0.36	41.1	53.1
18,000	95.4	0.36	41.5	53.6
19,000	96.2	0.37	41.8	54.0
20,000	97.0	0.37	42.2	54.4
21,000	97.7	0.37	42.5	54.9
22,000	98.4	0.37	42.8	55.3
23,000	99.1	0.38	43.1	55.6
24,000	99.8	0.38	43.4	56.0
25,000	100.4	0.38	43.7	56.4
26,000	101.0	0.38	43.9	56.7
27,000	101.6	0.39	44.2	57.0
28,000	102.2	0.39	44.4	57.4
29,000	102.8	0.39	44.7	57.7
30,000	103.3	0.39	44.9	58.0
31,000	103.8	0.39	45.1	58.3
32,000	104.3	0.40	45.4	58.6
33,000	104.8	0.40	45.6	58.8
34,000	105.3	0.40	45.8	59.1
35,000	105.8	0.40	46.0	59.4
36,000	106.3	0.40	46.2	59.6
37,000	106.7	0.41	46.4	59.9
38,000	107.2	0.41	46.6	60.1
39,000	107.6	0.41	46.8	60.4
40,000	108.0	0.41	47.0	60.6
41,000	108.4	0.41	47.1	60.9
42,000	108.8	0.41	47.3	61.1
43,000	109.2	0.42	47.5	61.3
44,000	109.6	0.42	47.7	61.5
45,000	110.0	0.42	47.8	61.7
46,000	110.4	0.42	48.0	62.0
47,000	110.7	0.42	48.1	62.2
48,000	111.1	0.42	48.3	62.4
49,000	111.5	0.42	48.5	62.6
50,000	111.8	0.42	48.6	62.8

4 lane urban freeways with full access control

(excludes interchange accidents)

a/100mvm

AADT	total	Fatality	Injury	PDO
1,000	94.1	1.23	38.3	54.6
2,000	101.8	1.33	41.4	59.1
3,000	106.6	1.40	43.3	61.8
4,000	110.1	1.44	44.8	63.9
5,000	112.9	1.48	45.9	65.5
6,000	115.2	1.51	46.9	66.9
7,000	117.3	1.54	47.7	68.0
8,000	119.1	1.56	48.4	69.1
9,000	120.6	1.58	49.1	70.0
10,000	122.1	1.60	49.7	70.8
11,000	123.4	1.62	50.2	71.6
12,000	124.6	1.63	50.7	72.3
13,000	125.8	1.65	51.1	73.0
14,000	126.8	1.66	51.6	73.6
15,000	127.8	1.67	52.0	74.2
16,000	128.8	1.69	52.4	74.7
17,000	129.6	1.70	52.7	75.2
18,000	130.5	1.71	53.1	75.7
19,000	131.3	1.72	53.4	76.2
20,000	132.0	1.73	53.7	76.6
21,000	132.8	1.74	54.0	77.0
22,000	133.5	1.75	54.3	77.4
23,000	134.1	1.76	54.6	77.8
24,000	134.8	1.77	54.8	78.2
25,000	135.4	1.77	55.1	78.6
26,000	136.0	1.78	55.3	78.9
27,000	136.6	1.79	55.6	79.3
28,000	137.2	1.80	55.8	79.6
29,000	137.7	1.80	56.0	79.9
30,000	138.2	1.81	56.2	80.2
31,000	138.7	1.82	56.4	80.5
32,000	139.2	1.82	56.6	80.8
33,000	139.7	1.83	56.8	81.1
34,000	140.2	1.84	57.0	81.3
35,000	140.7	1.84	57.2	81.6
36,000	141.1	1.85	57.4	81.9
37,000	141.5	1.85	57.6	82.1
38,000	142.0	1.86	57.7	82.4
39,000	142.4	1.87	57.9	82.6
40,000	142.8	1.87	58.1	82.9
41,000	143.2	1.88	58.2	83.1
42,000	143.6	1.88	58.4	83.3
43,000	144.0	1.89	58.6	83.5
44,000	144.3	1.89	58.7	83.7
45,000	144.7	1.90	58.9	84.0
46,000	145.1	1.90	59.0	84.2
47,000	145.4	1.91	59.1	84.4
48,000	145.8	1.91	59.3	84.6
49,000	146.1	1.91	59.4	84.8
50,000	146.4	1.92	59.6	85.0

Rural freeways with full access control and more than 4 Lanes

(excludes interchange accidents)

a/100mvm

Urban freeways with full access control and more than 4 Lanes

(excludes interchange accidents)

a/100mvm

AADT	total	Fatality	Injury	PDO
1,000	94.1	0.36	40.9	52.8
2,000	101.8	0.39	44.3	57.1
3,000	106.6	0.40	46.3	59.8
4,000	110.1	0.42	47.9	61.8
5,000	112.9	0.43	49.1	63.4
6,000	115.2	0.44	50.1	64.7
7,000	117.3	0.45	51.0	65.8
8,000	119.1	0.45	51.8	66.8
9,000	120.6	0.46	52.5	67.7
10,000	122.1	0.46	53.1	68.5
11,000	123.4	0.47	53.7	69.3
12,000	124.6	0.47	54.2	70.0
13,000	125.8	0.48	54.7	70.6
14,000	126.8	0.48	55.1	71.2
15,000	127.8	0.49	55.6	71.7
16,000	128.8	0.49	56.0	72.3
17,000	129.6	0.49	56.4	72.8
18,000	130.5	0.50	56.7	73.2
19,000	131.3	0.50	57.1	73.7
20,000	132.0	0.50	57.4	74.1
21,000	132.8	0.50	57.7	74.5
22,000	133.5	0.51	58.0	74.9
23,000	134.1	0.51	58.3	75.3
24,000	134.8	0.51	58.6	75.7
25,000	135.4	0.51	58.9	76.0
26,000	136.0	0.52	59.1	76.3
27,000	136.6	0.52	59.4	76.7
28,000	137.2	0.52	59.6	77.0
29,000	137.7	0.52	59.9	77.3
30,000	138.2	0.53	60.1	77.6
31,000	138.7	0.53	60.3	77.9
32,000	139.2	0.53	60.5	78.2
33,000	139.7	0.53	60.8	78.4
34,000	140.2	0.53	61.0	78.7
35,000	140.7	0.53	61.2	79.0
36,000	141.1	0.54	61.4	79.2
37,000	141.5	0.54	61.5	79.4
38,000	142.0	0.54	61.7	79.7
39,000	142.4	0.54	61.9	79.9
40,000	142.8	0.54	62.1	80.2
41,000	143.2	0.54	62.3	80.4
42,000	143.6	0.55	62.4	80.6
43,000	144.0	0.55	62.6	80.8
44,000	144.3	0.55	62.8	81.0
45,000	144.7	0.55	62.9	81.2
46,000	145.1	0.55	63.1	81.4
47,000	145.4	0.55	63.2	81.6
48,000	145.8	0.55	63.4	81.8
49,000	146.1	0.56	63.5	82.0
50,000	146.4	0.56	63.7	82.2

B.2 Highway Intersections

B.2.1 Rural Intersections

Intersection Type	Rate (accidents/yr)[a]	Severity
Rural Unsignalized Four leg intersection of undivided roads[25]	Accidents/year = $0.00204(AADT_{major\ road})^{0.42}(AADT_{minor\ road})^{0.51}$ For three legged intersections divide rate by 2.4 For divided roads multiply rate by 2.6 (These 2 adjustment factors were taken directly from TAC[24])	Fatal 0.017 Injury 0.342 PDO 0.641[26]
Rural Intersection, Signalized[27]	Accident/yr = $0.00703(AADT_{major\ road})^{0.51}(AADT_{minor\ road})^{0.29}$	Fatal 0.017 Injury 0.342 PDO 0.641[28]
Rural Interchange[29]	Accidents/yr = $0.04864 \times (AADT_{major\ road}/1{,}000)^{1.337}$	Fatal 0.012 Injury 0.370 PDO 0.619[30]

[a]For use in Microbencost, the above rates must be converted to accidents per million vehicles as:

a/mv = accidents/year x 1,000,000/(365 x (Major road AADT + Minor Road AADT)

[25] Belanger, C. Estimating of Safety for Four Legged Unsignalized Intersections. Transportation Research Record 1467, pp.23-29, 1995
[26] BC Provincial Average for rural arterials
[27] Webb, G.M. The Relation Between Accidents and Traffic Volumes at Signalized Intersections. ITE Proceedings, 1955, pp. 149-167
[28] BC Provincial Average for rural arterials
[29] Bonneson J.A et al, "interchange Versus At-Grade Intersection on Rural Expressways", Transportation Research Record No. 1395, Transportation Research Board, National Research Council, Washington D.C.,1993 (data was from Newbraska)
[30] BC Provincial Average for rural freeways

B.2.2 Urban Intersections, Unsignalized[31]

Yield Controlled

Major Street ADT	Minor Street ADT					
	100	300	500	700	900	1250
500	.31	.48	.62	.76	.90	1.20
1000	.34	.6	.75	.88	1.00	1.16
1500	.40	.68	.86	1.04	1.10	1.26
2000	.46	.71	.94	1.15	1.20	1.31
2500	.50	.75	.98	1.19	1.29	1.36
3000	.53	.77	.99	1.20	1.31	1.38
3500	.56	.79	1.01	1.22	1.33	1.4

Stop Controlled (4 leg, 2-way stop)

Major Street ADT	Minor Street ADT					
	100	300	500	700	900	1250
500	.12	.21	.27	.34	.40	.49
1000	.25	.31	.37	.41	.49	.61
1500	.34	.42	.49	.55	.72	.76
2000	.41	.52	.61	.70	.79	.90
2500	.49	.58	.69	.79	.89	1.04
3000	.52	.64	.80	.95	1.03	1.15
3500	.54	.70	.90	1.11	1.17	1.22

B.2.3 Urban Intersections, Signalized

The TAC report did not find any satisfactory research for predicting accidents at urban intersections. The default values in Microbencost are recommended as the interim values.

[31] McGee, H.W., Blankskeship, M.R., "Guidelines for Converting stop to Yield Control at Intersections", National Cooperative Highway Research Program Report 320, Transportation Research Board, 1989

B.2.4 Railroad Crossings

Crossbuck

AADT Range	Fatal	Injury	PDO
0-1,999	2.00	22.8	36.9
2,000-3,999	0.89	10.1	16.4
4,000-7,999	0.44	5.1	8.2
8,000-15,999	0.38	4.3	7.0
16,000-23,999	0.24	2.7	4.4
24,000-35,999	0.17	2.0	3.2
36,000-57,999	0.13	1.5	2.4
58,000-75,999	0.10	1.2	1.9
76,000 +	0.09	1.1	1.7

Gate

AADT Range	Fatal	Injury	PDO
0-1,999	0.93	10.6	17.2
2,000-3,999	0.40	4.6	7.4
4,000-7,999	0.27	3.0	4.9
8,000-15,999	0.17	1.9	3.1
16,000-23,999	0.11	1.2	2.0
24,000-35,999	0.07	0.8	1.3
36,000-57,999	0.05	0.6	1.0
58,000-75,999	0.04	0.5	0.8
76,000 +	0.04	0.5	0.7

The TAC document pointed out that the RR grade crossing accidents for a gate controlled crossing were higher than for a crossbuck sign only. This has been corrected in later versions of the model. The correct defaults for the RR grade crossing accident rates are shown here.

Appendix C
TAC Default Accident Rates[32] for Site Specific Improvements

C.1 Introduction

This section presents accident reduction factors (ARFs) which are multipliers used to assess the safety impact of specific improvements including:

1) Lane widening and shoulder upgrading
2) Safety resurfacing
3) Installation of climbing lanes
4) Installation of passing lanes
5) Mitigation of collision with fixed roadside objects
6) Installation of roadway illumination
7) improvement of horizontal curvature
8) Measures to reduce intersection accidents
9) Installation of median barriers
10) Widening narrow bridges

The general algorithm is:

Proposed case accident rate
= Base case accident rate
x Target accident proportion
x Accident reduction factor

The *target accident proportion* is all accidents unless otherwise noted in the remarks accompanying each table. For left turn treatments for example, the target accidents are the proportion of left turn accidents at the intersection. Information on target accidents for BC is found in "1989-1993 Annual Accident Statistics on Numbered Highways"[33].

If multiple countermeasures at a site are used, they are not additive. Run-off-road (ROR) accidents on a curve for example can be addressed by curve straightening, shoulder widening and lane widening. The overall reduction for ROR accidents which could be expected is:

$$ARF = ARF_1 \times ARF_2 \times ARF_3$$

[32] Hauer E., Persaud B., "Safety Analysis of Roadway Geometric and Ancillary Features" Transportation Association of Canada, Dec., 1996
[33] "1989-1993 Annual Accident Statistics on Numbered Highways" Highway Safety Branch, B.C. Ministry of Transportation and Highways,

where:

ARF = overall reduction factor for ROR accidents due to all 3 countermeasures.
ARF_1= reduction factor for the largest countermeasure.
ARF_2= reduction factor for the next largest countermeasure.
ARF_3= reduction factor for the smallest countermeasure.

If for example three countermeasures were proposed with individual accident reduction factors of say 91% for curve straightening, 93% for lane widening and 95% for improving lateral clearance, then their combined effect is to reduce the accident rate to .84 of the base case rate.

$$ARF = .95 \times .93 \times .91 = .804$$

The accident reduction factors which follow are the summary of current research but should be interpreted as *guidelines in the absence of better information.*

C.2 Lane Widening And Shoulder Upgrading

Target Accident Reduction Factors For Lane And Shoulder Widening On 2 Lane Roads

Condition		Accident Reduction Factor Estimates			
Before	After	Pessimistic	Most Likely	Optimistic	Remarks
≤ 9 ft lanes, no shoulder	11 ft lanes, no shoulder	0.77	0.73	0.66	Same factors apply for paved and unpaved shoulders
≤ 9 ft lanes, no shoulder	11 ft lanes, 4 ft shoulder	0.60	0.52	0.40	
≤ 9 ft lanes, no shoulder	11 ft lanes, 6 ft shoulder	0.50	0.40	0.25	
11 ft lanes, no shoulder	11 ft lanes, 4 ft shoulder	0.71	0.65	0.57	
11 ft lanes, no shoulder	11 ft lanes, 6 ft shoulder	0.60	0.52	0.40	

C.3 Safety Resurfacing

	Accident Reduction Factor Estimates			
Condition	Pessimistic	Most Likely	Optimistic	Remarks
Fatal and Injury Accidents	1	0.9	0.85	Applies to wet pavement accidents
Property Damage Accidents	1	0.85	0.80	
All Accidents	1	0.85	0.80	

This reduction factor should be used with care since there is likely to be an increase in dry weather accidents associated with the higher speeds on the resurfaced pavement.

C.4 Passing or Climbing Lanes

The safety impact of auxiliary lanes is treated in three parts:

1. 2.0 km upstream of the treated section
2. The treated section
3. A downstream section over which platooning is reduced

C.4.1 Treated section

The following values from TAC were deduced from examination of both climbing and passing lane studies. Auxiliary lanes generally reduce accidents within the treated section due to the wider crossection and recovery area compared to the surrounding two-lane sections. The factors apply across all accident severities at the treated section.

Climbing Lanes

	Accident Reduction Factor Estimates			
Condition	Pessimistic	Most Likely	Optimistic	Remarks
Fatal and Injury Accidents	0.90	0.85	0.80	Applies to total accidents at target locations
All Accidents	0.95	0.90	0.85	

Passing Lanes

	Accident Reduction Factor Estimates			
Condition	Pessimistic	Most Likely	Optimistic	Remarks
Fatal and Injury Accidents	0.85	0.75	0.70	Applies to total accidents at target locations
All Accidents	0.90	0.80	0.75	

C.4.2 Upstream Section

Passing lanes are normally posted 2.0 km in advance of the treated section. This reduces the tendency of drivers to make risky overtaking maneuvers in this 2.0 km section. The normal rate of passing related accidents in BC is 2% to 4% of accidents[34]. For planning purposes a 2% accident reeducation is assumed in the 2.0 km section in advance of a passing lane.

C.4.3 Downstream Section

Auxiliary lanes provide some benefits downstream of the treated section[35] since platoons continue to be dispersed for some distance downstream depending on the traffic volume. Rear end type accidents, which are often attributed to following too close, make up about 10% of non-intersection accidents on rural 2 lane highways in B.C.[36] Including rear-end and overtaking accidents, about 12% of accidents are related to platooning. An Auxiliary lane typically reduces platooning by about 25% immediately downstream of the treated section, which suggests an overall accident reduction of 25% x 12 % = 3%. Assuming this drops to 0% over the effective downstream length of an auxiliary lane, then the average reduction over this effective downstream length is **1.5%.** Accident severity is assumed to be the same as the base case rate.

The effective downstream length is assumed to vary with AADT. At high volumes, platoons reform immediately downstream of the passing lane while at lower volumes, the effective distance can be several kilometers. The effective distance is estimated as the lesser of the distance to the next passing lane or:

Downstream Distance = 10 km - AADT/1,500

If the treated section is a short 4 lane section then the downstream distance can be applied in both directions.

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[34] Abdelwahab, Wahlid, "PASS - An Algorithm to Identify Passing-Related Accidents on Two-Lane Highways fromPolic Accidents Reports" Highway Safety Branch, B.C. MoTH report # MOTH-HS93-01, January, 1993

[35] Lyall P.D., Jaganathan R., Morrall J.F.,"Auxiliary Lane Warrants for Two-Lane Highways, Prepared by ADI Limited for BC MoTH, Systems Planning Br. Victoria, B.C., 1993

[36] "1989-1993 Annual Accident Statistics on Numbered Highways" Highway Safety Branch, BC MoTH, 1993

C.5 Mitigation Of Accidents With Fixed Roadside Objects.

This includes collisions with utility and sign poles, fences, culverts, bridge supports, ditches and trees.

Target Accident Reduction Factors For Fixed Object Accidents

	Accident Reduction Factor Estimates			
Condition	Pessimistic	Most Likely	Optimistic	Remarks
Fatal and Injury Accidents	0.80	0.60	0.50	Applies to fixed object accidents at target locations
Property Damage Only	1.10	1.0	0.90	

C.6 Installation Of Roadway Illumination

Target Accident Reduction Factors For Roadway Illumination

	Accident Reduction Factor Estimates			
Condition	Pessimistic	Most Likely	Optimistic	Remarks
Fatal and Injury Accidents	0.70	0.60	0.40	Applies to night accidents at target locations
Property Damage Only	0.95	0.85	0.65	

C.7 Horizontal Curve Improvements

This includes minor improvements such as widening and curve warning and delineation. Since these cover a variety of improvements, they should only be used for crude estimation purposes only.

Target Accident Reduction Factors For Minor Improvements To Horizontal Curves.

	Accident Reduction Factor Estimates			
Condition	Pessimistic	Most Likely	Optimistic	Remarks
All Accidents	0.90	0.75	0.60	Applies for crude estimation only

C.8 Measures To Reduce Intersection Accidents

Target Accident Reduction Factors For Intersection Improvements

	Accident Reduction Factor Estimates			
Condition/Measure	Pessimistic	Most Likely	Optimistic	Remarks
Left Turn Lanes - Signalized	0.90	0.80	0.65	For all severities, apply to left turn accidents
Left Turn Lanes - Unsignalized	0.70	0.50	0.40	For all severities, apply to left turn accidents
Traffic Control Signals (All Severities Combined)	0.65	0.50	0.25	Apply to right angle accidents
	2.00	1.60	1.40	Apply to rear end accidents
Illumination (All Severities Combined)	0.80	0.60	0.50	Apply to night accidents

C.9 Installation Of Median Barriers

Target Accident Reduction Factors For Installation Of Median Barriers

	Accident Reduction Factor Estimates			
Condition/Measure	Fatal	Injury	PDO	Remarks
Median Width < 12 ft Double Faced Beam Rail	0.25	0.98	1.28	Assumed to apply to median encroachment accidents. Factors have a high variability
Median Width < 12 ft Concrete Barrier	0.10	0.90	1.10	
Median Width > 12 ft Double Faced Beam Rail	0.15	0.95	1.30	
Median Width > 12 ft Concrete Barrier	0.15	N/A	N/A	

Caution: Median barriers virtually eliminate cross-median accidents. These are usually severe, but very few. The barriers increase the total accident frequency by as much as 30% on access controlled roads and 50% on non access controlled roads. Vehicles are presumably colliding with the median barrier, where previously they might swerve into the opposing lanes and recover without incident.

C.10 Widening And Other Improvements To Narrow Bridges.

Target Accidents Reduction Factors For Narrow Bridge Improvements

	Accident Reduction Factor Estimates			
Condition/Measure	Pessimistic	Most Likely	Optimistic	Remarks
Install Bridge and Approach Rail	0.55	0.40	.10	Accidents to side of bridge
	0.65	0.55	0.30	Accidents to end or approach
Widen Existing Bridge	0.75	0.64	0.55	Fatal accidents
	0.75	0.64	0.55	Injury accidents
	0.85	0.75	0.70	PDO accidents

Appendix D
Example Summary Report for the Benefit Cost Results

Monte Creek Interchange (Hwy 1/97)

Highway 97 is a two lane rural arterial connecting to the 2 lane Highway 1 east of Kamloops. The existing at grade stop controlled T intersection will be replaced by a grade separated loop interchange with free flow on the NBLT, NBRT, EBST,WBST and EBRT. The WBLT has very low volume and will be connected into a frontage road crossing under Highway 1. There is a 7% grade descending from south to north toward the interchange which is a concern for heavy trucks trying to stop for the signals in the down hill direction. The grade is preceded by a brake check. Trucks also roll over or lose their loads on the EBRT as they try to maintain speed for the approaching hill on Highway 97 SB.

The problem is modeled as a 3.38 km highway segment with an interchange commissioned in 2002.

Key Assumptions

Location	AADT
Highway 1 west of I/C	9,748
Highway 1 east of I/C	6,482
Highway 97	2,718
Intersection Volume	14,482

Traffic:

There are 5.8% trucks (from classification counts July 30, Aug 3, Aug 6/93).

Movement	% of Intersection Volume	Change in travel distance compared to base case (km)
NBRT	0.7%	-.722
NBLT	12.76%	-.323
EBST	36.6%	-.010
EBRT	13.8%	-.385
WBST	35.6%	-.010
WBLT	0.6%	+.746

Travel Distance.

The traffic splits and changes in travel distance due to the improved interchange flow are estimated here by turning movement.

Accident rate

The base case Highway 1 sample size is 94 accidents in 9 years over a 1.85 km section with an accident rate of 1.02 a/mvk. The proposed case Highway 1 section assumes this is reduced by 50% to 0.51 a/mvk, approaching that of a typical freeway rate (0.4 to 0.5 a/mvk). For analysis purposes, accidents on the Highway 97 approach are treated as intersection accidents. The sample includes 48 accidents at a base case rate of .84 acc/mv. The proposed case is assumed to reduce the accidents by 50% to 0.44 a/mv.

Accident Severity

The same accident severity is used for the base and proposed case section and intersection based on a sample of 142 accidents on the Hwy 1 and Hwy 97 approaches:

fatal	2.8%
injury	47.9%
PDO	49.3%

Project Costs

Costs are $24.4 million spread out over 4 years starting in 1999.

Summary of Results

Benefits	$ Millions
Travel Time Savings	6.5
Accident Cost Savings	16.0
Veh.Op.Cost Savings	1.8
Total Benefits	24.3
Costs	
a. Discounted Construction Costs	18.2
b. Discounted Salvage Value	2.7
c. Discounted Increase in Maintenance Costs	-0.15
Total Discounted Costs a-b+c	20.8
B/C Ratio	1.2
NPV	3.6
Carbon Monoxide reduction (million kg.)	0.26

Interpretation of Results

Time saving benefits result from

- removing the interrupted flow for the NB left and right turns
- decreasing the travel distance (via the new ramps) for all intersection movements except the WBLT.

Safety benefits result from the lower accident rate associated with removing the at grade intersection and with the improved geometric design of the approaches.

Vehicle operating costs are the largest component of benefits and result from reducing the travel distance around the ramps and from eliminating stop and go operation associated with a stop controlled T-intersection. Savings include fuel savings of 4 million litres over the 20 year planning period. Reduction in CO may be used in the environmental account of the MAE.

Appendix E
Environmental Costs Associated with Transportation[37]

Greenhouse gases. Automobiles produce several greenhouse gases, which are measured in terms of their CO_2 equivalents. Current precautionary estimates place global warming damage costs at $1,000/tonne of CO_2 equivalent. The shadow price of these emissions is the same no matter where they occur.

Particulate. Fine particulate matter (PM_{10}) is the most significant of local air pollutants. Particulates attributable to mobile sources cause a number of deaths comparable to traffic crash fatalities in the region. Current estimates of mean values of mortality costs for the Lower Fraser Valley range between $0.3 and $0.4 billion per year, assuming $3 million value of statistical life. The total mortality cost of fine particulate generated by vehicles is of the same order of magnitude as the mortality due to traffic accidents. The mortality cost per km depends on vehicle type, operating speed and emission control technology. For present and future vehicle technologies, diesel trucks and buses have the highest mortality rates per km driven. These vehicles are responsible for about half of the traffic related particulate in the Greater Vancouver Regional District at present. The statistics are not likely to improve in the future if vehicle travel keeps on increasing.

Ozone Depletion. Vehicles are major contributors to ozone depleting emissions through leaks and maintenance losses from automobile air conditioners. The shadow price of ozone depletion is high: preliminary estimates place it at $1,200 per kg of CFC equivalent for each 1% of global GDP experienced as damage from the "ozone hole" in 1995. There are indications that the 1995 damage might be two to four times higher than 1% GDP. In that case the annual damage from British Columbia light vehicles would about to $600 million to $1.2 billion. These costs accrue globally.

Ground Level Ozone. The economic costs of health, crop damage, material damage and visibility problems caused by smog are one order of magnitude smaller that the mortality and morbidity costs of fine particulate from traffic. While important for the sectors and communities affected, the preoccupation of major air quality management initiatives with these issues at the expense of more damaging pollution, is unjustified from scientific and administrative points of view.

[37] Bein,P.,Johnson,C.,Litman,T.,"Monetization of Environmental Impacts of Roads", Planning Services Branch, BC MoTH, Victoria ,BC, July 1995

Noise and Vibrations. Most of the existing estimates of noise costs are incorrect because they only consider a portion of the total damage costs. The density and sensitivity of the recipients to noise is as important a variable as traffic characteristics. The noise damage costs should therefore be expressed as costs per affected person. A shadow price of $1,000 to $1,500 per affected person per year is currently used in Scandinavian countries. This is likely a lower bound on the total damage cost of noise. Noise effect on wildlife is not known. Traffic induced vibrations do not likely cause building damage, but references disagree on the subject.

Land use Impacts. These impacts include the general impacts of low density urban expansion (urban sprawl) and specific damage to wildlife and greenspace that results from increased roads and automobile use. These can either be estimated based on a cost per hectare of land that is impacted or as a cost per vehicle-km. This cost most likely ranks higher than noise and below air pollution in terms of total cost. Indirect and cumulative impacts can be especially large if a project, such as a road capacity improvement, eliminates existing constraints to growth. In this case it can increase the speed and scale of development, causing significant indirect and cumulative land use impacts. If latent demand exists for development in an area, improved road access is almost certain to increase development and reduce external environmental benefits, even if land use management strategies are implemented.

Costs associated with converting various land uses to highways were presented in the report in $/ha/year:

Land Use	$/ha/year
Wetlands	$30,000
Pristine wildland/urban greenspace	$24,000
Second growth forest	$18,000
Pasture/Farmland	$12,000
Settlement/Road buffer	$6,000

Resources and Energy. Resource production and therefore consumption has external environmental and social costs. The best know of these are the externalities associated with energy consumption, which include environmental damage during production and processing spills, and various negative market impacts. These externalities are indicated by the general social support that has developed for energy conservation, recycling, and sustainable development. The indirect energy absorbed by transportation related activities, such as vehicle and fuel production and distribution, constitutes 20 to 45% of the energy consumed to propel vehicles. Personal vehicles use the most indirect energy and transit vehicles the least.

Waste Disposal. Automobiles use produces various wastes including used fluids, tires and junked vehicles. In the past many of these wastes were poorly managed, resulting in external costs. A variety of new programs and methods are now being used to reduce and internalize these costs, but these do not appear to be completely successful. A working value of $0.001 per km is recommended, although it grossly underestimates the total cost.

Water Pollution and Hydrologic Impacts. Roads and automobile use cause water pollution and hydrologic impacts (changes in surface and ground water flow such as increased flooding and reduced ground water recharge). We estimate this cost to average $0.01 to $0.02 per average automobile km, and recommend an intermediate working value of $0.015.

Barrier Effects. The barrier effect is the increased travel time discomfort and anger that roads and road traffic cause to pedestrians and bicyclists. Although methods for calculating the barrier costs to pedestrians and bicyclists are commonly used in Scandinavia, they are nearly unknown in North America. Based on the Scandinavian experience in Norwegian urban areas, the barrier costs are of the same order of magnitude as the total traffic noise damage costs to the communities. Road and transportation corridors also sever wildlife habitats and farming communities. Evaluation of these effects is ongoing in the Ministry of Transportation and Highways.

Impacts on Biodiversity. Through lost or degraded habitat and direct mortality of wildlife, transportation has a significant effect on the flora and fauna of British Columbia. While other chapters have accounted for reduced biodiversity through lost habitat and pollution, a model had been presented to calculate the cost on a site specific basis, of direct wildlife mortality resulting from traffic. This cost however, is a small fraction of the total value of biodiversity, which is not known and is not likely knowable. Based on the annual economic value of average habitat, the current total Canadian conserved nature area is worth as much as the national GDP.