Highway 1 (North Vancouver to Surrey) Monitoring and Evaluation Program

Phase II HOV Evaluation & TMP Baseline

Consulting Engineers (IBI Group) Submit Report to Ministry of Transportation and Highways on behalf of BC Transportation Financing Authority

Background

In June, 1999 Harry Lali, minister responsible for the BC Transportation Financing Authority announced the province's proposed plan to fight traffic congestion on Highway 1 in Greater Vancouver using intelligent traffic system technology. This technology includes video monitoring, Internet traveller information systems and telecommunication networks. "The Traffic Management Program is aimed at achieving travel time savings, increased reliability, reduced accident rates and lower air emission," said Lali.

The ICBC-funded Freeway Service Patrol pilot initiative is the first visible step in the Traffic Management Program. In this pilot initiative vehicles patrol the Highway 1 HOV corridor from Grandview to Cape Horn, recovering disabled vehicles in order to minimize the risk of secondary incidents and restore freeway capacity as quickly as possible.

Following is the IBI Group report's Executive Summary. Study findings are a positive reflection on the joint efforts to date in the Highway 1 corridor of the Ministry of Transportation and Highways, BC Transportation Financing Authority, Insurance Corporation of British Columbia and the Royal Canadian Mounted Police. This baseline report illustrates the "synergy of services" of the proposed Traffic Management Program.

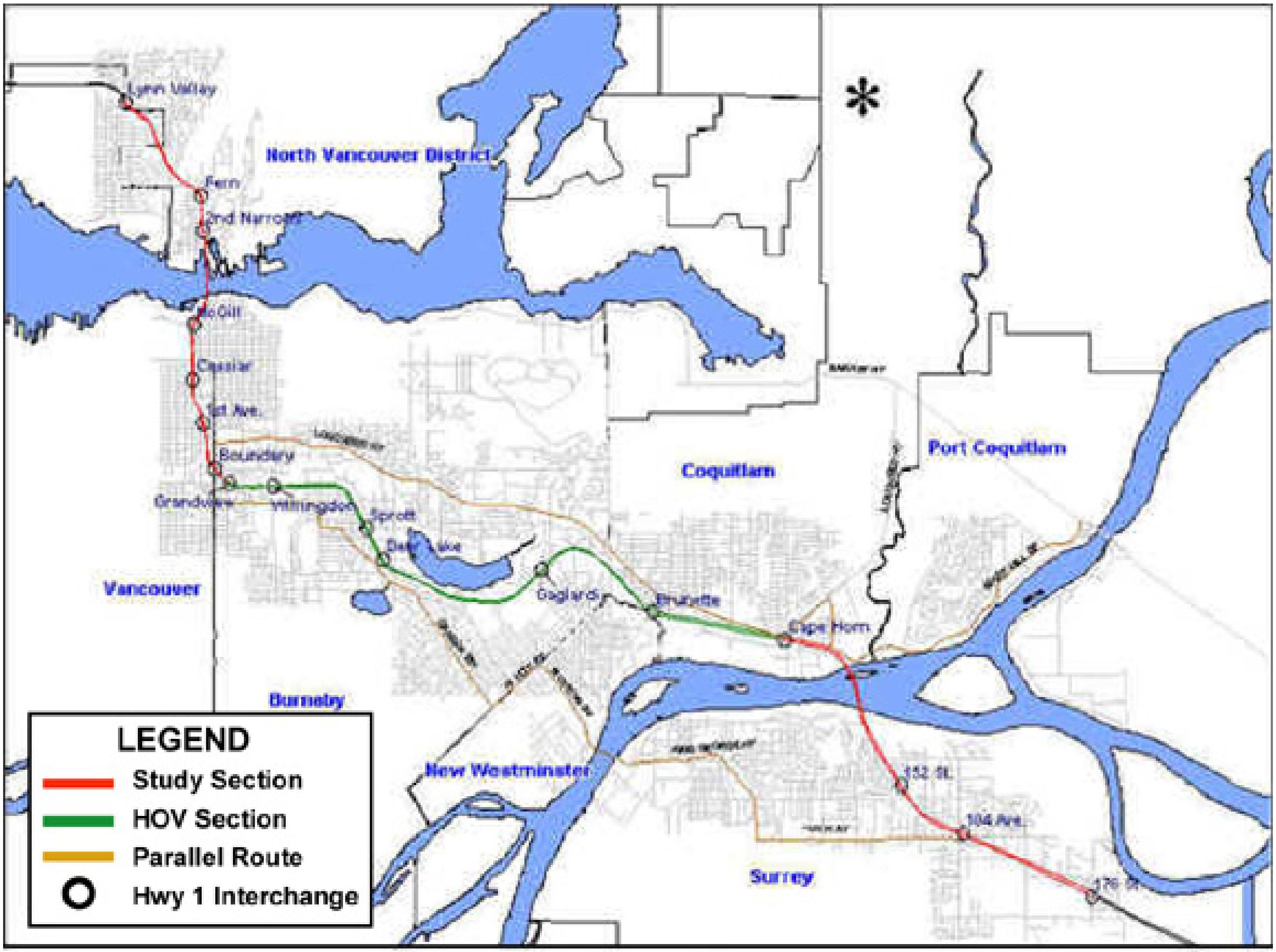

EXHIBIT ES-1
TCH MONITORING AND EVALUATION PROGRAM
PHASE II STUDY AREA

· Top

Key Findings

1. Person throughput in the central portion of the HOV section has increased by approximately 40% (or 4500 persons) in the morning (6:00 AM to 9:00 AM) westbound peak direction, and 72% (or 6700 persons) in the evening (3:00 PM to 6:00 PM) peak direction.
2. Overall traffic volumes in the central portion of the HOV section have increased by approximately 55% in the peak hour directions, and about 15% in the off-peak hour directions.
3. HOV lane peak hour volumes are about 1100 vph east of Kensington Avenue in the AM westbound peak direction, and about 1250 vph east of Sprott Street in the PM eastbound peak direction.

4. Average Vehicle Occupancy (AVO) in the central portion of Highway 1 has increased about 5% to 6% in both peak period directions.
5. The overall peak direction High Occupancy Vehicle (HOV) versus Single Occupant Vehicle (SOV) split is between 25% to 30% HOV and 70% to 75% SOV.
6. Average Vehicle Occupancy on TCH at the Port Mann Bridge has increased approximately 3.3 to 6.2%, while the Pattullo Bridge AVOs have decreased approximately 2.5 to 3.6%.
7. Travel time savings are about 20 minutes (64%) for HOV, and 12 minutes (36%) for GP traffic in the afternoon eastbound peak hour direction; as well as 7 minutes (44%) for HOV, and 2 minutes (11%) for GP traffic in the morning westbound peak hour direction.
8. HOV lane travel time reliability has increased by 24% in the morning westbound peak hour direction, and 13% in the afternoon eastbound peak hour direction.
9. In the peak hour direction, "Per Lane Efficiency" has increased 31% in the morning and 106% in the afternoon.
10. Levels of Service (LOS) for the GP lanes have improved generally from LOS F to E and D.
11. HOV rule compliance is 85-95%.
12. Freeway Service Patrols (FSP) deal with approximately 300 incidents per month (10 per day).
13. A reduction in average incident time duration of approximately 50% compared to Phase I, and 43% compared to locations without FSP is observed.
14. The total annual cost of delay due to incidents in the FSP section has decreased about 40%, from $46 Million before to $28 Million after the HOV and FSP improvement projects.
15. Potential capacity, currently lost due to incident impacts (to be regained by TMP) is between 10% to 15% in the peak periods, which at a 1.4% growth rate could defer infrastructure expenditures by as much as 10 years.
16. ICBC crash claims have decreased about 25%, and the cost of claims has decreased about 48% or about $4.6 Million, after HOV and FSP improvements.
17. Almost all of the Stakeholder respondents, especially the RCMP, find the FSP to be a clear asset in incident response and clearance.
18. The Highway 1 Motorist Surveys taken after HOV-FSP implementation indicate that:

    - About 28% of the HOV are new carpools, while 72% were already carpooling.
    - About 60% of the HOV were previously on the TCH, while 40% switched from the parallel routes.
    - About 17% of the HOV were new carpools formed by SOV on the TCH, while 11% were new carpools formed by SOV from the parallel routes; and, about 43% of the HOV were old carpools already on the TCH, while 29% were old carpools formerly on the parallel routes.
    - About 93% of the SOV were already on the TCH, while 7% switched from the parallel routes.
    - Approximately 52% of motorists often see the FSP vehicles responding to incidents.
    - Approximately 10% of all respondents have been helped by, or know someone who has been helped by the FSP.
    - Approximately 89% of HOV and 74% of SOV motorists believe that the designated number of occupants for the HOV lanes should be 2 or more persons (existing rule).
    - Approximately 30% of the SOV said they would be encouraged to become HOV

users if their hours of work permitted it, while 20% require a "good rideshare opportunity" to become HOV users.
- More than 85% of HOV and 70% of SOV motorists are satisfied with the HOV and FSP operations.

Recommendations

It is recommended that:

1. ICBC look at continuing the FSP initiative, and together with BCTFA/MoTH consider expediting the evolution of FSP into the proposed TMP coordinated Roadside Assistance/Emergency Service Patrols.
2. The ICBC Crash Claims Contravention project team consider following up the use of the Highway 1 HOV-FSP section as a prototype for calibrating MV104 trend data and for "piloting" the transition to the proposed new and more comprehensive "consolidated" Police MV104/ICBC claims database.
3. Consideration be given to extension of the HOV lanes along the TCH corridor, through the Cassiar Tunnel and possibly over the Second Narrows Bridge, as well as across the Port Mann Bridge, in order to extend the advantages, generate new carpools, and maximize the use of available capacity.
4. The safety analysis of the HOV-FSP section be updated using a complete sample of data from Police, ICBC, and MoTH databases (when the 1999 data is available). Also, additional pre-TMP accident data should be collected using the FSP as an additional source of incident data collection within the HOV portion of the Highway 1.
5. Further accident data analysis and research of experience in other jurisdictions be conducted to estimate more accurately the relative impact of the accident increasing/reducing factors involved in the TCH-HOV-TMP project.
6. Consideration be given to periodic monitoring of the HOV lanes to determine if the improved travel time and trip time reliability, safety and satisfaction incentives are maintained, and to measure the effectiveness of future improvements.
7. A follow-up (Phase III) of this study and report be included as part of the TMP "pilot" project.
8. The scope and timing of the TMP pilot project deployment be coordinated closely with other improvements along the corridor, such that a few fundamental data surveys are made as part of each project.

· Top

Introduction

Improving traffic management measures by encouraging higher occupant modes of travel through

High Occupancy Vehicle (HOV) facilities, and through the deployment of Intelligent Transportation System (ITS) applications, represent two ways of efficiently accommodating increasing travel demands on existing highways.

The Ministry of Transportation and Highways (MoTH) has several major projects underway, targeted at improving person travel accessibility, encouraging more efficient usage of roadway infrastructure, improving travel safety, and improving air quality.

HOV Project: a BCTFA-funded $62 million widening of the Trans Canada Highway (TCH) from 4 to 6 lanes to provide 2 HOV lanes, over a distance of 16 km from Grandview Highway in Burnaby to Lougheed Highway (Cape Horn) Interchange in Coquitlam. The HOV Project on Highway 1 opened October 28, 1998, and included the following physical components:

- Six laning with provision of median HOV lanes;
- Various ramp improvements,
- Additional lighting;
- Continuous median barrier;
- Wider median shoulders where possible.

FSP Project: an ICBC-funded ($1.6 million over 3 years) deployment of Freeway Service Patrols (FSP) started on January 4, 1999 as a forerunner or "precursor" to the proposed TMP coordinated Roadside Assistance/Emergency Service Patrols. This service is designed to assist motorists by detecting, responding to, and clearing, traffic incidents more quickly. The service includes a tow truck and a push truck with appropriate equipment, as well as a temporary Traffic Management Centre (trailer with radio and CCTV), to provide the following services:

- CTV monitoring for quick detection and response;
- Tow or push disabled vehicles:
- Provide jump starts, gas, water, and minor repairs:
- Remove debris and clean up spills;
- Transport motorists and pedestrians from the Freeway;
- Record or log all incidents.

TMP Pilot Project: a BCTFA-funded $25 million initiative, over 4 years, as the first phase of a long-range plan aimed at managing traffic congestion, encouraging more efficient use of roadway infrastructure, improving travel safety, and improving air quality along a 34 km stretch of Highway 1. Subject to further review and clarification, this pilot program includes the section of Highway 1, between Lynn Valley Road in North Vancouver and 160 Street in Surrey, and will include the application of ITS technologies with interagency coordination. The TMP demonstration "pilot" project will deploy two key transportation user service applications on Highway 1, i.e. Incident Management and Traveler Information. The current project scope involves interagency coordination through a Traffic Management Centre to manage the following components:

- Fibre optic communications backbone,
- Coordinated Roadside Assistance/Emergency Service Patrols,
- Digital cameras and automatic incident detection systems;
- Toll-free motorist cell-phone incident reporting system;
- Internet and Radio/TV traffic information programming;
- Supporting hardware and software systems, etc.

Other Related Projects (not part of Phase II Study): include the following recently completed or proposed near-term future projects:

- Lougheed westbound on-ramp near Coleman Avenue (with ramp signal control) - opened Dec. 15, 1999;
- Lougheed westbound on-ramp at Cape Horn I/C - closed Dec. 15, 1999;
- Mary Hill Bypass westbound on-ramp at Cape Horn I/C - proposed;
- Port Mann Bridge 5-laning and HOV lane extension - proposed.

The HOV, FSP, and TMP initiatives are intended to increase the operational lifecycle of this critical urban section of the TCH corridor by optimizing person throughput, providing Incident Management and Traveler Information services, thus reducing delays, improving safety, and minimizing impacts to the environment.

As part of its program evaluation mandate, MoTH retained IBI Group in August of 1997 (prior to the construction of the HOV lanes) to develop and implement Phase I of a staged monitoring and evaluation methodology for evaluating the incremental benefits of the HOV lanes and the TMP pilot project as it unfolds.

IBI Group carried out the first phase of that program which included the collection and analysis of related traffic data to establish a "before" baseline prior to implementation of the HOV and TMP projects. Data for the Phase I "before" study was collected in September/October 1997.

Two years later (one year after the opening of the HOV lanes October 28, 1999), IBI Group carried out Phase II of the TCH Monitoring and Evaluation Program data collection. This report presents the analyses and findings of this Phase II "after" study. In addition to the evaluation of the HOV lanes, this report evaluates and documents the benefits of the ICBC-funded FSP deployment starting January 4, 1999. Also, the Phase II study is intended to provide a secondary baseline for measuring the benefits of further evolution of the FSP and the initiation of other TMP components described above.

Study Cost and Objectives

The overall BCTFA-funded "Before/After" (Phase I & II) TCH-HOV Evaluation & TMP Baseline study cost approximately $1/2 Million, but over ¾ of that is reusable survey data, such as traffic counts, travel times, vehicle occupancy, incident frequency, etc.

This Phase II report reveals that HOV and FSP objectives have been achieved, and that MOEs and baselines for the TMP are reliable. The report also reveals more general and aggregate improvements resulting from the array of improvements along the Highway 1 sections between North Vancouver and Surrey. Attributing these benefits to specific improvements is however difficult because the contributing factors are so numerous and overlapping.

The HOV-FSP Section covers the 16 km of TCH between Grandview Highway and Cape Horn, while the TMP section lies within the 34 km stretch of the TCH between the Lynn Valley Road overpass in North Vancouver and 160 Street overpass in Surrey. The Study Section (Lynn Valley Road to 176 Street) is shown in ES-1 (at the beginning of this Executive Summary). The Study Corridor includes parallel arterial roadways that provide alternate routes for Highway 1 traffic in these sections.

The primary objectives of the Phase II Monitoring and Evaluation Program were defined as follows:

- Review HOV and TMP Measures of Effectiveness (MOEs) identified in Phase I and confirm the application of the developed methodology for a quantitative evaluation of the MOEs for both "before" and "after" surveys.
- Coordinate and conduct data collection activities for the "after" HOV conditions, the "after" FSP conditions, and the "before" TMP conditions.
- Analyze all the data collected and compare before and after statistics to document HOV and FSP/CCTV benefits, and any background changes affecting the TMP second baseline travel patterns.

· Top

HOV Monitoring & Evaluation

By providing higher travel speed and lower travel time variability, the HOV facility is expected to encourage a modal shift to higher occupancy vehicles, resulting in an increase in the person carrying throughput of the highway, optimization of travel speeds, more reliable travel times and a reduction in energy consumption and vehicle emissions due to reduced delays and congestion.

In order to evaluate these expected benefits, eight objectives were defined:

1. Increase Person Movement Throughput;
2. Provide Travel Time Savings;

3. Improve Trip Travel Time Reliability;
4. Increase Per-Lane Efficiency;
5. Minimize Negative Impacts on General Purpose (GP) Lanes;
6. Maintain Safety;
7. Obtain Compliance
8. Acquire Public and Stakeholder Acceptance & Satisfaction

For each of these objectives, measures of effectiveness (MOEs) were defined. These MOEs dictated the traffic data requirements to measure the degree of achievement of each of the objectives. The evaluation relative to each of the objectives is described below.

HOV Objective 1
Increase Person Movement Throughput

The new HOV lanes have significantly increased the person movement throughput along the HOV section of TCH and its parallel routes during the peak periods. The key MOEs for measuring increases in person throughput are before and after Average Vehicle Occupancy comparisons, and before and after comparisons of HOV market share.

Overall traffic volumes in the central portion of the HOV section have increased by approximately 55% in the peak hour directions, and about 15% in the off-peak hour directions.

Average Vehicle Occupancy (AVO)

Peak direction AVOs have increased by approximately 2.5% to 4.4% along the Centre screenline (TCH, Lougheed Highway, and Canada Way) near the Gaglardi interchange, and between 5.3% and 9.4% across the King Edward Screenline (TCH and Lougheed Highway) near Brunette. Increases in AVO across the screenlines have been significant on the TCH, without significant decreases on the parallel routes, confirming that the HOV lanes have induced the generation of new carpools. Exhibit ES-2 provides a summary of before and after AVOs.

• Top

Exhibit ES-2 - Before & After AVO Changes by Screenline

WESTBOUND AM PEAK PERIOD	September 1997 AVO	September 1999 AVO	% Difference
Centre Screenline: Lougheed, TCH, Canada Way (West of King Edward)	1.14	1.19	+4.4%
King Edward Screenline: Lougheed, TCH (east of **Brunette**)	1.13	1.19	+5.3 %
Fraser River Screenline: Pattullo Bridge, Port Mann Bridge	1.16	1.19	+2.6%
Second Narrows Screenline: Second Narrows Bridge only	1.11	1.13	+ 1.9%

EASTBOUND PM PEAK PERIOD	September 1997 AVO	September 1999 AVO	% Difference
Centre Screenline: Lougheed, TCH, Canada Way (West of King Edward)	1.24	1.27	+ 2.4 %
King Edward Screenline: Lougheed, TCH (east of **Brunette**)	1.17	1.28	+9.4%
Fraser River Screenline: Pattullo Bridge, Port Mann Bridge	1.20	1.23	+2.5 %
Second Narrows Screenline: Second Narrows Bridge only	1.20	1.23	+2.9 %

Some diversions in existing HOVs have been observed across the Fraser River screenline (Pattullo Bridge and Port Mann Bridge), where the TCH/Port Mann Bridge AVOs have increased significantly (approximately 3.3 to 6.2%), while the Pattullo Bridge AVOs have decreased significantly (approximately 2.5 to 3.6%).

Person Throughput

In general AVOs are the best measure of person throughput because they are normalized by the before and after number of vehicles. Raw person throughput data can also be used to measure the degree to which this objective is achieved, but are not as reliable since traffic volume variations can significantly sway results. Using the AVOs and the available short count data collected during September of 1997 and 1999, changes in person throughput along Highway 1 near Gaglardi interchange (central and representative portion of the HOV section) are summarized in Exhibit ES-3.

Exhibit ES-3 - Before & After Person Throughput at the Central Portion of the HOV Section

HIGHWAY AT GAGLARDI INTERCHANGE (CENTRAL PORTION OF HOV SECTION)			
Peak Period / Direction **Person Throughput**	**Before**	**After**	**% Change**
AM Period (6:00 –9:00) **Westbound**	11,200	15,700	40%
PM Period (3:00- 6:00) **Eastbound**	9,200	15,900	72%

Review of the person volume data indicates that total person movement throughput along the Highway 1 HOV Section has increased by approximately 40% in the AM westbound peak direction, and 72% in the PM eastbound peak direction. When interpreted with the overall AVO increase observations across all screenlines, it can be confirmed that the increase in person throughput is due to an increase in higher occupant modes, and not just an increase in traffic volumes. The increase in person throughput beyond normal growth can be accounted for by attraction of SOVs and HOVs from parallel routes (such as Lougheed Highway and Canada Way / Pattullo Bridge), and by satisfaction of latent demand (where more people are able to make the trip they want when they want, etc).

· Top

HOV Market Share

Significant increases in HOV market share have been observed primarily in the peak direction. Specifically, the percentage of people in the HOVs has increased between 9% and 12% across the King Edward screenline, 2% to 4% across the Centre screenline, and 3% to 5% across the Fraser

River screenline during the AM and PM peak directions. Exhibit ES-4 provides a tabulation of before and after HOV market share percentages.

Exhibit ES-4 - Before & After HOV Market Share Changes by Screenline

WESTBOUND AM PEAK PERIOD	% of People in HOVs		% Difference
	September 1997	September 1999	
Centre Screenline: Lougheed, TCH, Canada Way (near **Gaglardi**)	27 %	29 %	+2%
King Edward Screenline: Lougheed, TCH (east of **Brunette**)	20 %	29 %	+9%
Fraser River Screenline: Pattullo Bridge, Port Mann Bridge	25 %	30 %	+5%
Second Narrows Screenline: Second Narrows Bridge only	17 %	21 %	+4%

EASTBOUND PM PEAK PERIOD	% of People in HOVs		% Difference
	September 1997	September 1999	
Centre Screenline: Lougheed, TCH, Canada Way (near **Gaglardi**)	34 %	38 %	+4%
King Edward Screenline: Lougheed, TCH (east of **Brunette**)	27 %	39 %	+12%
Fraser River Screenline: Pattullo Bridge, Port Mann Bridge	31 %	34 %	+3%
Second Narrows Screenline: Second Narrows Bridge only	29 %	33 %	+4%

HOV Objective 2
Provide Travel Time Savings

The new HOV lanes provide significant travel time savings to HOVs relative to Phase I conditions prior to the construction of the HOV lanes, and relative to adjacent current GP traffic (Phase II). In the AM peak period westbound, HOVs save 7.3 minutes compared to travel times in Phase I, and 5.6 minutes compared to the GP traffic currently in the lanes next to them. In the PM peak period eastbound, HOVs save 20.3 minutes compared to travel times in Phase I, and 8.7 minutes compared to the GP traffic currently next to them. All of the savings were found to be statistically significant at the 95% level.

Exhibit ES-5 provides a tabulation of travel time comparisons travel times along the HOV/FSP corridor parallel routes. It can be observed that the Highway 1 travel times are consistently lower than the parallel routes, predominantly due to the arterial nature of those routes. It is interesting to note that the parallel route travel times are lower in the peak direction, than in the off-peak, illustrating the benefits of signal coordination.

Exhibit ES-5 - HOV/FSP Corridor Phase II Travel Time and Speed Comparison

· Top

HOV Objective 3:
Improve Trip Time Reliability

Variances in average speeds along the HOV lanes were also observed to be significantly lower when compared to Phase I variances, and when compared to current GP variances in average speed. In the westbound AM peak direction, HOV trip time reliability has increased by 27% and 24% relative to previous (Phase I) conditions, and current (Phase II) GP conditions, respectively. In the eastbound PM peak direction, HOV trip time reliability has increased by 13% and 17% relative to Phase I conditions, and current GP conditions, respectively. All of the differences were found to be statistically significant at the 95% level.

HOV Objective 4:
Increase Per Lane Efficiency

An increase in the efficiency of the HOV section has been observed, as measured by increased person throughput and increased operating speeds (averaged for all three lanes). In the peak directions, the per lane efficiency has increased by 31% for the westbound AM peak period, and an astounding 106% for the PM peak period eastbound, clearly showing the efficiency improvements when capacity is utilized to its potential with higher occupant modes of travel.

HOV Objective 5:
Minimize Negative Impacts on GP Lanes

The new HOV lanes have not adversely affected the GP lane operations, as measured in terms of average GP speeds and levels of service. Average GP speeds have increased in all periods and directions as a result of the additional capacity and the absorption of existing HOVs by the new lanes. Although not an objective to improve conditions for GP traffic, some of the GP travel times savings were also observed to be statistically significant. LOS were also observed to improve for the GP lanes, increasing from LOS F to E and D in the peak directions.

HOV Objective 6:
Maintain Safety

The assessment of safety impacts to the HOV/FSP section was based on comparisons of crash claims data, as obtained from ICBC's claims database, for the periods before, during and after construction of the HOV lanes. It was initially intended to use MoTH's Highway Accident System (HAS) which is based on the ICBC's Traffic Accident System (TAS) and Police MV104 accident database; however, this data was not available at the time of this project.

Comparisons of the claims data indicate a noticeable increase in the number of accident related claims during the construction period, but a dramatic decrease in the frequency of claims and total associated claim costs after the construction of the HOV facility and the FSP service. Specifically, when compared to the total number of annualized claims prior to construction of the HOV lanes, claims increased by 22% during construction, but decreased (from the pre-construction phase) by 25% in the year subsequent to the HOV and FSP operations. In terms of cost of claims, the costs increased by approximately $400,000 during construction of the HOV lanes, but decreased by $ 4.6 million from before construction, expressed on an annual basis.

Although claims data is not a comprehensive source of safety data, the general reduction in accident claims tentatively confirms that safety has been maintained along the Highway 1 HOV and FSP section since the construction of the HOV lanes and deployment of the FSP.

HOV Objective 7:
Obtain Compliance

HOV lane compliance rates were observed to be satisfactory in all periods and directions, ranging between 90 to 95%, except near the east terminus of the eastbound HOV lanes where AM compliance rates of 85% were observed. The proximity of the measurements to the terminus of the lanes suggests that during peak conditions, GP traffic may enter the HOV lanes close to its terminus. Nevertheless, most agencies including MoTH target a minimum compliance rate of 85%. The TCH HOV lanes clearly achieve this.

Comparison of 2+ HOV compliance data six months after the HOV lanes opened, versus one year after, indicates consistency in the results, with compliance rates increasing between 6 to 11% near the Gaglardi interchange, and decreasing by 3 to 8% near the Cape Horn terminus of the HOV lanes

Analysis of all HOV-related offences (including 2+ non-compliance) since the opening of the lanes indicates that the frequency of offences has not increased or decreased. However, the allocation of enforcement resources has been optimized by starting out with higher levels of enhanced enforcement and accordingly reducing the effort to the required amount of enforcement to maintain standards.

HOV Objective 8: Acquire Public Acceptance and Satisfaction

Information, observation, and opinion seeking surveys were distributed to TCH motorists, as well as to a selected sample of stakeholders, to document acceptance and satisfaction with the HOV lanes. Based on responses from approximately 566 motorists on Highway 1 (with an appropriate 30% to 70% HOV and SOV split), public acceptance and satisfaction was observed to be very high (stakeholders even higher).

Exhibit ES-6 below summarizes the critical attributes of the full sample of HOV respondents, broken down by whether they are newly formed or existing, and whether they were already on the TCH or switched from parallel routes.

· Top

Exhibit ES-6 - Existing & New HOVs versus TCH & Route Switching HOVs

TCH Sample of HOV Users	Already on Highway 1	Switched from Parallel Routes	Totals
Existing HOVs (i.e. already carpooling prior to HOV lanes)	43%	29%	72%
New HOVs (i.e. carpooling after HOV lanes)	17%	11%	28%
Totals	60%	40%	100%

Of the sample of all HOV users, the surveys indicate that:

- About 28% of the are new carpools, while 72% were already carpooling.
- About 60% of were already on the TCH, while 40% switched from the parallel routes.
- About 17% of the HOVs were new carpools formed by SOVs on the TCH, while 11% were new carpools formed by SOVs on the parallel routes.
- About 43% of the HOVs were carpools already existing on the TCH, while 29% were carpools already on the parallel routes.

Results were consistent irrespective of the respondents' mode of travel and confirm that for most of the acceptance and satisfaction accounts used (relating to HOV benefits and safety), more than 70% of SOVs and 85% of HOVs are satisfied. Also, approximately 89% of HOV and 74% of SOV motorists believe that the designated number of occupants for the HOV lanes should be 2 or more persons (existing rule).

Primary issues raised by the respondents related to HOV expansion and improvements across the Port Mann Bridge, as well as the need for additional enforcement. Only 23% of the SOVs indicated a desire to limit the HOV lanes to peak periods only.

Summary of HOV Benefits

All of the HOV project objectives have been achieved, with expected benefits attained:

1. Person movement throughput has increased significantly through the formation of new carpools, as opposed to merely diversion of existing HOV traffic from other parallel facilities
2. HOVs experience significant travel time savings in both peak periods and directions
3. Trip times are significantly more reliable for HOV traffic
4. Per lane efficiency during the peak directions has significantly increased due to the movement of more persons at optimum average speeds
5. GP lanes have not been adversely affected but operate better now due to the added capacity
6. Safety has not been compromised, with the total frequency and cost of claims decreasing
7. Compliance is above the desired 85% minimum for all directions and time periods
8. More than 70% of the SOVs and 85% of the HOVs view the HOV lanes as a benefit to their transportation system and are satisfied with its benefits.

· Top

TMP Monitoring & Evaluation

The TMP is intended to increase the efficiency and operational lifecycle of this critical urban section of the Highway 1 corridor by providing Incident Management and Traveler Information services, and thus improving vehicle throughput, reducing delays due to incidents, and reducing accidents.

Similar to the HOV evaluation, a set of objectives was defined to evaluate the benefits expected from the TMP as well as interim benefits associated with the FSP. The objectives identified were:

1. Reduce/Manage Recurrent Congestion
2. Reduce/Manage Non-Recurrent Congestion
3. Improve Safety
4. Optimize Efficient Use of Capacity
5. Acquire Public Acceptance & Satisfaction

Using the MOE's and data requirements identified for the TMP evaluation objectives, a second baseline of data were collected and analyzed for the TMP to reflect pre-and post-HOV conditions. Where applicable, the FSP benefits were evaluated as part of the TMP objectives of reduced non-recurrent congestion and improved safety. Relevant before and after comparisons were made in an attempt to differentiate the changes due to HOV, FSP and TMP,

TMP Objective 1:
Reduce/Manage Recurrent Congestion

Recurrent congestion is due to regular, daily high levels of traffic relative to capacity, which regularly create traffic congestion and delays. The primary MOE for measuring the reduction in recurring congestion is average speeds and travel times along the entire length of the Study section. Exhibit ES-7 below tabulates before and after travel time estimates, providing a breakdown by the key study sections. Differences between Phase I and II travel times within the North Vancouver and Surrey sections were observed to be negligible; this was expected since no major improvements were implemented in these sections since Phase I. The results do indicate an "end to end" (Lynn Valley Road to 176 Street) travel time saving of 13.8 minutes for the eastbound PM peak period, confirming that the benefits of the HOV and FSP improvements are significant and extend well beyond the boundaries of the HOV / FSP section.

Exhibit ES-7- Before and After Comparisons of Study Section Travel Times

Travel Time Comparisons (Minutes)	AM Peak Direction (WB)			PM Peak Direction (EB)		
	Before	After	Savings	Before	After	Savings
North Vancouver & Vancouver Section: Lynn Valley to Grandview Highway	15.7	17.1	**-1.4**	8.7	8.2	**0.5**
Vancouver Coquitlam HOV & FSP Section	16.7	14.9	**1.8**	32	20.3	**11.7**
Coquitlam & Surrey Section: Cape Horn to 176 Street	8.2	7.4	**0.8**	8.8	7.2	**1.6**
Lynn Valley to 176 Street **Total Study Section**	**40.6**	**39.4**	**1.2**	**49.5**	**35.7**	**13.8**

This second baseline of travel time data for evaluating the TMP complements the Phase I baseline well, is statistically reliable, and will permit separating the effects of the HOV and "precursor" FSP improvements from other forthcoming TMP improvements. Phase III "after" evaluation of TMP should reflect more significant savings along this length of the Study section due to improved traffic management and traveler information services. Collection of Phase III travel time data will be more efficient, if volume and speed data are extractable from an Automatic Incident Detection (AID) system.

· Top

TMP Objective 2:
Reduce/Manage Non-Recurrent Congestion

Non-recurrent congestion results from random traffic incidents, such as accidents and stalls, which reduce available capacity by blocking lanes and/or shoulders and therefore delay the flow of traffic.

Non-recurrent congestion can be reduced and managed by reducing the overall duration of incidents, by detecting, responding, and clearing incidents faster. The primary MOE for this objective is reduced incident durations. A supporting MOE, which is a function of incident duration, is reduced delay due to incident blockages.

A substantial database of incident data (such as type, location, time, direction, response time, lane blockages, and clearance times) was logged during Phase I and Phase II using the FSP traffic management centre, temporary CCTV installed specifically for this project, and the North Shore maintenance contractor. This data has been used to evaluate the FSP, in terms of this objective of managing and reducing non-recurrent congestion. Comparisons are made between Phase I incident data capturing the no FSP scenario, the Phase II data capturing the with FSP scenario for the HOV-FSP section, and the Phase II data without FSP scenario using data from other sections of the Study corridor. The data has also been used to establish a post-HOV and pre-TMP baseline of data for the TMP.

Incident Duration

A comparison of the Phase I and II incident duration data is provided in Exhibit ES-6 below.

Exhibit ES-8 - Incident Duration Comparisons

Incident Data Source	Coverage Area	Average Response Time (min)	Average Clearance Time (min)	Average Incident Duration (min)
Phase I (Visual Observations)	HOV/FSP Section	23.0	19.0	41.0
Phase II FSP Data Logs	HOV/FSP Section	7.1	13.8	21.0
Phase II CCTV & Video-taping	North Vancouver Section Surrey Section	23.7 3.4	38.9 13.4	61.5 14.8
	Average of Both Sections	10.3	22.0	29.3
Phase II North Shore Contractor	First Avenue to 2nd Narrows	19.7		19.7

Specific conclusions drawn include:

- **FSP Evaluation:**
  The FSP currently respond to approximately 300 incidents per month. In the HOV and FSP section of the corridor, the average incident duration has been reduced by approximately 50%, from 41 minutes to 21 minutes. This reduction is the result of a reduction in response times from 23 minutes down to 7 minutes, and a reduction in average incident clearance time from 19 minutes to 14 minutes, clearly reflecting the benefits of CCTV monitoring and FSP incident response, and clearance.

- **TMP Baseline:**
  Along the North Vancouver and Surrey sections of the study corridor where maintenance contractor service vehicles are present, but without FSP/CCTV, the average incident duration is 30 minutes. In both cases, the incident duration is comprised of approximately one-third response time and two-third clearance time. Along the HOV and FSP section of the corridor, the average duration of incidents is 21 minutes with FSP (Phase II), and 41 minutes without FSP (Phase I).

Delay Due to Incident Lane & Shoulder Blockage

The incident data were also used to estimate delays and costs resulting from lane and shoulder blockages. It is observed that incidents involving lane blockages comprised 18% of all incidents at an annualized user cost of $13.5 million, while the remaining 82% of incidents resulting in shoulder blockages cost users over $14.7 million. It was further determined that the average frequency and duration of lane and shoulder blockages, during the peak directions, results in a 15% reduction in capacity.

Incident user cost estimates were also used to further demonstrate FSP benefits. Linear regression techniques were used to determine a relationship between average incident duration and the cost of delays due to incidents. It was estimated that the reduction in incident durations from 41 minutes to 21 minutes translates to an approximate $ 18 million dollar reduction in user costs attributable to incident delays.

· Top

TMP Objective 3:
Improve Safety

Safety analysis of the TCH was limited to the analysis presented under the HOV safety objective. This analysis identified a significant decrease in the frequency of accident claims and associated costs since the opening of the HOV lanes.

Exhibit ES-9- Percent Difference in Claim Frequency by Project Phase

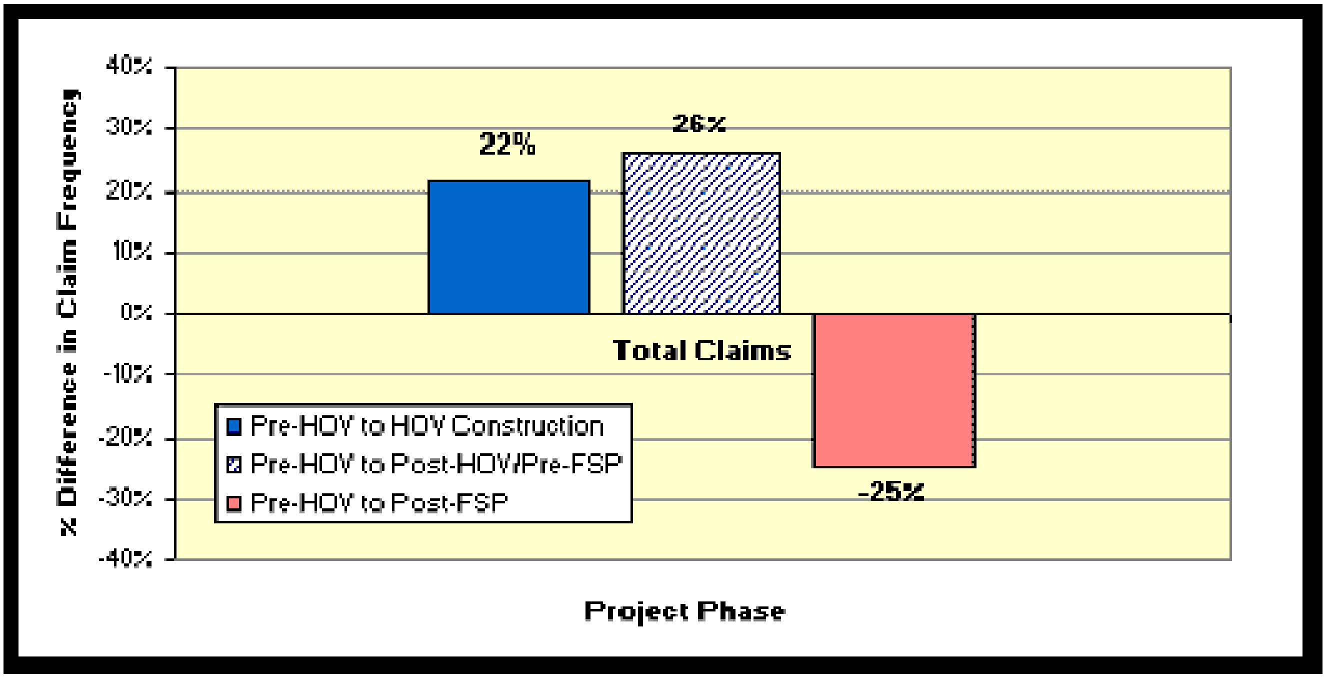

Exhibit ES-9 provides a summary of the increase and decrease in accident claim frequencies when comparing pre HOV lane conditions to post HOV and pre-FSP, and post-HOV and FSP conditions. An approximate 25% reduction in crashes is observed when comparing the safety performance of the Highway 1 study section before and after the HOV and FSP improvement projects.

Preliminary analysis by MoTH, of raw MV104 accident data obtained from the Police, indicates a 10% reduction in crashes when comparing the safety performance of the Highway 1 study section before and after the HOV and FSP improvement projects. However, temporary enhanced Police enforcement (paid by BCTFA) may have led to an increase in MV104 reporting after the HOV-FSP improvements (this following a few years of decreased reporting starting in 1996). The MV104 accident reports generally make up 25% to 30% of the ICBC claims data on crashes.

A portion of the above 10% to 25% crash reduction benefits may be attributable to improved incident response, management, and clearance by the FSP, but is difficult to separate from potential safety benefits of other improvements along the HOV and FSP segment. Exhibit ES-10 below provides a tabulated summary of potential safety impacts associated with changes in the HOV and FSP segment of Highway 1.

Exhibit ES-10 - Safety Impact Contributing Factors

Contributing Factors	Potential Safety Impact
Fsp	Positive
Continuous lighting	Positive
Traffic growth	Negative

Addition of Capacity through six Laning of Highway 1	Positive
Continuous median barrier	Positive
Provision of 3 meter left shoulder where possible	Positive
Less stop and go	Positive
HOV versus GP Speed Differential with weaving	Negative
Additional lane ends and merge conflicts	Negative

Prior to implementation, it was estimated that the ICBC Freeway Service Patrols and *4444 incident reporting system (CCTV detection was used instead of *4444) would improve safety by clearing incidents more quickly, and thereby reduce accidents by 5 – 12% (TMP Business Plan, by Delcan, 1995; and ICBC Review of Systems for Freeways, by Hamilton Associates, 1997). Although the 25% reduction in collision claims made to ICBC since the construction of the HOV lanes and the deployment of the FSP cannot be broken down, it does tentatively confirm that the safety benefits of recent improvements along the HOV and FSP sections of Highway 1 are substantial and may equal or exceed earlier estimates.

TMP Objective 4:
Efficient Use of Capacity

This objective is intended to demonstrate that the utilization of capacity between the mainline and the parallel routes is optimized, especially during non-recurrent (incident) congestion when traffic may divert to adjacent routes with spare capacity. The MOE proposed for this objective is total person throughput across key screenlines which reflect diversion impacts, such as across TCH, Lougheed Highway and Canada Way near the Gaglardi interchange. Baseline throughput data has been collected, for future comparisons after the deployment of the TMP pilot project.

· Top

TMP Objective 5:
Public Acceptance and Satisfaction

At this point, prior to the deployment of the TMP pilot project service applications, the public acceptance and satisfaction questions were limited to FSP and general questions on the impacts and benefits of responding to and clearing incidents faster. Survey results were based on a large sample of TCH users and a smaller sample of transportation agencies stakeholders. Approximately 60% of

TCH users, and 90% of the stakeholders often see the FSP respond to traffic incidents and agree that clearing incidents quickly minimizes congestion and leads to secondary benefits like improved air quality and lower fuel consumption. Almost all of the stakeholder respondents, especially the RCMP, find the FSP to be a clear asset in incident response and clearance.

All of the fundamental traffic data elements required to support the evaluation of the TMP pilot project have been collected for pre and post-HOV conditions consistent with the recommended study methodology and evaluation methodologies used for other similar evaluations. The following results have been derived during this secondary baseline of the TMP pilot project evaluation:

Summary of HOV Phase II TMP Baseline & Benefits

1. Statistically reliable travel time data has been collected to complement the same data collected in Phase I for the evaluation of reductions in recurrent congestion delays. Marginal differences were observed between Phase I and II, except in the PM peak eastbound direction where significant travel time savings were observed (13.8 minutes) primarily due to the benefits associated with the HOV and FSP sections.
2. The database of incident data has been expanded to include over 800 incidents. A reduction in average incident duration times of approximately 50% on sections patrolled by the FSP compared to Phase I, Total user cost of delay due to incident lane blockages has been reduced from $46M to $28M per year due to the FSP and overall improved operations with the HOV lanes. Potential capacity to be gained with TMP is between 10% to 15%, which at a 1.4% annual growth rate, could defer infrastructure expenditures by 10 years.
3. All collision data, available at the time of the study, was collected for establishing a second post-HOV and pre-TMP baseline for measuring improved safety. Claims data from ICBC was used to compare frequency of accidents before, during, and after construction of the HOV lanes, and after deployment of the FSP. The accident analysis indicated substantial crash claims reductions as a result of the HOV and FSP implementation programs.
4. Average speed, volume and occupancy data have been used to establish baseline throughput estimates across the west screenline of TCH, Canada Way, and Lougheed Highway at Gaglardi for throughput comparisons with the post TMP data.
5. Public acceptance and satisfaction with the FSP is high, with approximately 60% of the respondents aware of the FSP, and the benefits of short incident duration times due to improved traffic management.