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BRITISH COLUMBIA | Ministry of Transportation and Infrastructure

216 Street Interchange
Diamond vs. Parclo Option Evaluation

PARSONS

SW1200SWE
JULY 2015

TABLE OF CONTENTS

1.0 INTRODUCTION

As part of the study to determine the most appropriate configuration for the new full movement connection at 216 Street and Highway 1, a detailed evaluation of two shortlisted options has been completed. The two options considered were a Diamond interchange and a Parclo B2 / Diamond Hybrid interchange.

The purpose of this interim report is to summarize the option evaluation process and provide a comparison of the two options being considered.

Additional project information is available in the 216 Street Interchange Project Background Report, the 216 Street Interchange Design Criteria summary sheets, and the 216 Street Interchange Option Generation and Preliminary Evaluation reports.

2.0 OPTIONS

As a part of a previous report, six distinct interchange concepts were developed and a high level screening process was undertaken with a diamond interchange concept being selected as the preferred option. More recently, a new option hybrid option with a Parclo B2 configuration on the north side of Highway 1 and a diamond configuration on the south side of Highway 1 is being considered. This analysis will evaluate and compare two options. These options are:

- *Option 2: Provide a Diamond interchange*

  This option, shown in ***Figure 1***, would provide a directional on/off ramp in each quadrant as well as a connecting overpass between them.

  At the off-ramp terminal intersections at 216 Street, it is assumed signalization would be provided along with auxiliary turning lanes; to be confirmed through forthcoming traffic analysis. For comparative purposes, it is assumed that the ramp terminal intersections would be spaced approximately 150 m apart.

- *Option 8: Provide a Hybrid Parclo B2 / Diamond interchange*

  This option, shown in ***Figure 2***, would provide a loop off-ramp and a directional on-ramp in the northwest quadrant of the interchange, and a directional on/off ramp in the south quadrants, with a connecting overpass between the ramp terminal junctions. It is assumed that the ramp terminal intersections will be signalized to facilitate left-turn movements.

SCALE 0 80m

QUALITY CONTROL _____ DATE _____

DRAWN _____ DATE 11/1/13

Rev	Date	REVISIONS	Initials

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TRANS CANADA HIGHWAY No. 1
CONCEPT DESIGN

216 STREET - OPTION 2

FIGURE

1

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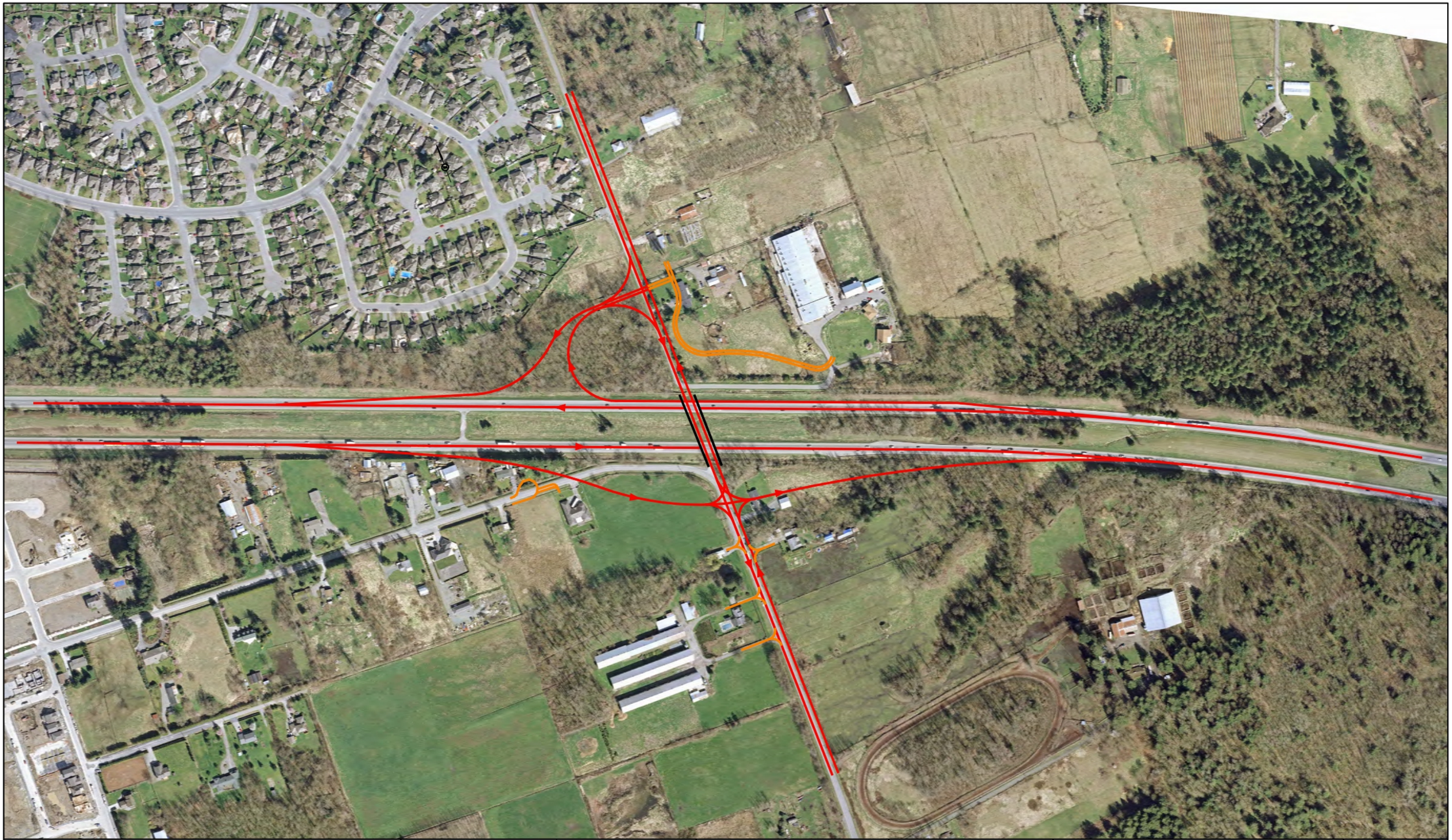

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QUALITY CONTROL _____ DATE _____

DRAWN _____ DATE 29/06/15

Rev	Date	REVISIONS	Initials

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TRANS CANADA HIGHWAY No. 1
CONCEPT DESIGN

216 STREET - OPTION 8 OPTIMIZED

FIGURE 2

3.0 EVALUATION CRITERIA

In order to compare and contrast the relative merits and drawbacks of each option, a set of high level evaluation criteria was developed based on Multiple Account Evaluations prepared for similar Ministry transportation planning studies. The criteria are a combination of quantitative and qualitative measures to assist in selecting a preferred alternative through a comparison to the base case (do nothing) scenario. For consistency with business case development, a 25 year project horizon will be assumed for those quantitative related criteria.

The descriptions below include a summary of the criterion characteristics and rationale, as well as a range of evaluation output.

In keeping with the Ministry's Multiple Account Evaluation categories, the evaluation criteria have been grouped into the respective Customer Service, Socio-Community, Financial, and Environmental accounts. The Economic account is not proposed at this level of analysis.

3.1 Customer Service Account

3.1.1 TRAFFIC LEVEL OF SERVICE AND MOBILITY PROVIDED

Using the PARAMICS traffic operations model (micro-simulation) and each option's proposed geometric and operational modifications, an assessment of the performance of each option in terms of travel delay and level of service will be conducted.

Evaluation Output:

This quantitative assessment will take into consideration the following comparative performance statistics as extracted from the AM and PM peak models which cover the Highway 1 corridor between 160 Street and 232 Street as well as the municipal road network from the Fraser River to Highway 10:

- *Network Travel Time Savings (all vehicles, all delay throughout the network– the AM and PM peak period savings will be factored up to an equivalent annual amount). A higher value of savings is preferred;*
- *Interchange Utilization (volumes crossing the highway at the subject interchange as well as at other interchanges between 176 and 232 Streets –*

indicates potential relief at adjacent interchanges). A higher volume of interchange utilization is preferred as this indicates adjacent network relief;

- *Level of Service at Key Signalized Intersections (volumes extracted from the traffic operations model will be run through the Synchro signal optimization program to assess changes in volume to capacity ratios and delay). LoS D or better with a volume to capacity ratio of 0.85 or less is desired;*

3.1.2 RELATIVE SAFETY PERFORMANCE

Although there is no existing interchange to provide a baseline safety performance comparison, this criterion is based on a subjective assessment of key option characteristics such as the number of conflict points (merge or weave areas, signalized intersections, etc) and the effect on the safety of non-motorized travel modes.

Evaluation Output: *Mild / Moderate / Significant positive or negative safety performance*

3.1.3 VEHICLE OPERATING COSTS

Vehicle operating costs are derived from vehicle kilometres travelled as extracted from the PARAMICS traffic operations model. The model will take into account traffic redistribution and rerouting within the Langley network.

Evaluation Output: *Network Vehicle Kilometres Travelled (by vehicle type), Vehicle Operating Costs (expressed as a present dollar value).*

3.2 Socio-Community Account

3.2.1 RESIDENTIAL PROPERTY IMPACTS

This criterion will consider the additional right-of-way required and quantify the number of individual residential properties impacted (full or partial impacts).

Evaluation Output: *# of Residential Properties Impacted*

3.2.2 BUSINESS / INSTITUTIONAL PROPERTY IMPACTS

This criterion will consider the additional right-of-way required and quantify the number of individual business / institutional properties impacted (full or partial impacts).

Evaluation Output: *# of Business / Institutional Properties Impacted*

3.2.3 ALR IMPACTS

This quantitative criterion will consider the total area of land within the Agricultural Land Reserve which would be impacted.

Evaluation Output: *ALR Area Required*

3.2.4 NOISE IMPACTS

This qualitative criterion will consider the potential effects of noise on adjacent residents and businesses. This criterion will be measured by proximity to higher volume traffic.

Evaluation Output: *Low / Medium / High Noise Impacts*

3.2.5 VISUAL IMPACTS

This criterion will consider the visual intrusion of the option in terms of its proximity to residents and businesses. The qualitative evaluation will determine whether each option would have low, medium or high visual impacts.

Evaluation Output: *Low / Medium / High Visual Impacts*

3.2.6 EFFECT ON NON-MOTORIZED TRAVEL MODES

The effect on pedestrian and cyclist safety will be qualitatively evaluated based on changes in geometry, traffic speed, and ease of roadway crossing.

Evaluation Output: *Low / Moderate / Significant Positive or Negative Effect on Non-Motorized Travel Modes*

3.3 Environmental Account

3.3.1 GHG IMPACTS

Using the Vehicle Kilometres Travelled (VKT) output from the traffic operations model, the total fuel consumed and associated Greenhouse Gas emissions (C02e) can be estimated for each option. Lower emission values are desired.

Evaluation Output: GHG Emissions (CO2e)

3.3.2 TERRESTRIAL IMPACTS

The relative severity of impacts to the terrestrial environment within the construction limits of each option in comparison to the base case (existing conditions) will be noted.

The qualitative evaluation will determine whether each option would have neutral, low, medium or high terrestrial impacts.

Evaluation Output: Neutral / Low / Medium / High Terrestrial Impacts

3.3.3 AQUATIC IMPACTS

The relative severity of impacts to the aquatic environment within in the construction limits of each option in comparison to the base case (existing conditions) will be noted.

The qualitative evaluation will determine whether each option would have neutral, low, medium or high aquatic impacts.

Evaluation Output: Neutral / Low / Medium / High Aquatic Impacts

3.3.4 ARCHAEOLOGICAL / HISTORICAL IMPACTS

For each option, archaeologically or historically significant impacts due to the potential construction of each option will be noted.

The qualitative evaluation will determine whether each option would have neutral, low, medium or high impacts.

Evaluation Output: *Neutral / Low / Medium / High Archaeological and Historical Impacts*

3.3.5 SPECIAL CONSTRUCTABILITY CONSIDERATIONS

Existing constraints may affect the constructability of certain options. These constraints can include geotechnical mitigation / preload requirements, major utility conflicts / relocations requiring third party review, and special stormwater management requirements. The number and severity of these considerations will be noted and evaluated accordingly.

Evaluation Output: *Low / Medium / High Special Constructability Considerations*

3.4 Financial Account

3.4.1 CAPITAL COST

The relative construction cost of each option will be assessed at a high level using a conceptual single line sketch and typical unit costs referenced from the Ministry's Construction and Rehabilitation Cost Guide, the Wolski method, and previous experience. The costs are dependent on the extent of physical modifications, the complexity of the modifications (including geotechnical, utilities, drainage, and environmental compensation features), and right-of-way requirements. Property costs will be highlighted separately.

Evaluation Output: *Total Construction Cost (Including Contingencies)*

3.4.2 MAINTENANCE AND REHABILITATION COST

Consideration for annual maintenance and rehabilitation costs will be based on standard lane-kilometre costs and scheduled rehabilitation for major roadways. The cost will be expressed as a 25 year present value ($2015).

Evaluation Output: *Maintenance and Rehabilitation Cost (25 Year Present Value)*

3.4.3 SALVAGE VALUE

The salvage value of the proposed infrastructure at the end of the 25 year business case period will be reported using applicable discount rates.

Evaluation Output: *Salvage Value (25 Year Present Value)*

3.4.4 BENEFIT COST RATIO AND NET PRESENT VALUE

This calculation takes into consideration the 25 year present value of the benefits (travel time savings, operating cost savings) accrued to each option and the associated implementation costs (capital, maintenance and rehabilitation, and salvage value).

Evaluation Output: *B/C Ratio, NPV (25 Year Benefits - Costs)*

4.0 OPTION EVALUATION

Using the evaluation criteria in Section 3.0, the three shortlisted options were evaluated in detail by applying the evaluation criteria described in the previous section. As noted, some of the criteria will be evaluated in a quantitative manner whereas others will be evaluated qualitatively. Quantitative factors include performance metrics extracted from the PARAMICS traffic operations model, Synchro intersection capacity analysis, as well as objective measures such as cost estimates using the Wolski methodology or the amount of property required in hectares.

For the evaluation criteria involving qualitative assessments, a descriptive assessment has been provided in relation to the base case conditions. The descriptive assessments include the use of indicators ranging from neutral, low, medium, to high impacts (or in some instances, benefits). As a means to more definitely score the qualitative related criteria, the following ranking scale has also been applied:

○ indicates an option with a significant negative impact, has strong incompatibility, or that fails to meet project objectives.

◔ indicates an option with a moderate negative impact, incompatibility or somewhat falls short of project objectives.

◑ indicates an option that is relatively neutral in its impacts or partially meets project objectives.

◕ indicates an option with moderate improvements, good compatibility, or mostly achieves project objectives.

● indicates an option with significant improvements, strong compatibility, or fully achieves project objectives.

A comprehensive explanation of the evaluation results for each criterion is provided as in the following subsections. A summary table, ***Table 4.14,*** is provided at the end of this section.

4.1 Customer Service Account

4.1.1 TRAFFIC LEVEL OF SERVICE AND MOBILITY PROVIDED

Using the traffic operations model and each option's proposed geometric and operational modifications, an assessment of the performance of each option in terms of travel delay and level of service was conducted.

Network Travel Time Savings

Network travel time represents the cumulative travel time of each vehicle travelling through the study network during the simulation period. Total network travel time for each option is depicted in the summary table below along with the relative travel time savings as compared to the base case in each time frame, 2015 and 2045.

Table 4.1a: 2015 AM Network Travel Times (hours)

Base	Option 2		Option 8	
	Absolute	Change	Absolute	Change
7,061	6,840	-221	6,803	-258

As shown in the table above, Option 8 has the highest travel time savings (258 hours) during the AM peak period.

Table 4.1b: 2015 PM Network Travel Times (hours)

Base	Option 2		Option 8	
	Absolute	Change	Absolute	Change
8,368	8,166	-202	8,172	-196

As shown in the table above, Options 2 has the highest travel time savings (202 hours) during the PM peak period.

Table 4.1c: 2045 AM Network Travel Times (hours)

Base	Option 2		Option 8	
	Absolute	Change	Absolute	Change
13,478	12,243	-1,235	12,081	-1,397

In the table above, Option 8 has the highest travel time savings (1,397 hours) during the AM peak period.

Table 4.1d: 2045 PM Network Travel Times (hours)

Base	Option 2		Option 8	
	Absolute	Change	Absolute	Change
17,851	15,790	-2,061	15,608	-2,243

In the table above, Option 8 again has the highest travel time savings (2,243 hours) during the PM peak period.

The total AM and PM travel time savings were factored to annual values, based on an assumption of 250 work days per year. In the absence of a weekend model, additional savings equivalent to the average of the AM and PM periods was included (just one period per day) to reflect the potential savings for the 100 weekend days per year. The annual travel time savings for each option for the 2045 planning horizon is summarized in ***Table 4.2*** below.

Table 4.2: 2045 Annual Travel Time Savings (Thousand Hours)

Base	Option 2	Option 8
-	989	1,092

Option 8 displays a slightly higher annual savings than Option 2.

Interchange Utilization

The utilization of the 216 Street is an important measure of potential relief to adjacent interchanges along the Highway 1 corridor in Langley. ***Table 4.3*** summarizes the forecast AM and PM peak traffic volumes entering the 216 Street level of the interchange in the year 2045. The volumes were extracted directly from the traffic operations model.

Table 4.3: 2045 Interchange Utilization (two-way vehicles per hour)

Time Period	Base	Option 2	Option 8
AM Peak	0	2,800	2,770
PM Peak	0	3,130	3,180

As shown in the table above, Option 2 and Option 8 have virtually the same utilization in the AM and PM peak hours. Both have a high volume utilization which is desirable as this indicates additional relief is provided to the adjacent network and likely at the other interchanges along Highway 1 in Langley.

Level of Service

Table 4.4 summarizes the Level of Service analysis conducted using the Synchro intersection capacity analysis programs and year 2045 forecast travel demands at the interchange ramp terminals.

In contrast to the previous high-level estimates in the option screening assessment, the turning movement volumes for this more detailed option evaluation were extracted from the traffic operations model rather than utilizing the more coarse static turning movements from the macro-level regional travel demand model (Emme) outputs. Because the traffic operations model is sensitive to the effects of inefficient traffic operations and any related congestion on the network, particularly at the adjacent 200 Street Interchange, the results below are considered more representative of expected network traffic distribution.

Level of Service is graded on a scale of A to F with F representing high delays and significant congestion, while A represents low delays and no congestion. The volume to capacity ratio is a measure of capacity utilization, with a maximum of 0.85 considered desirable during peak hours in urban areas.

Table 4.4: Interchange Terminal Level of Service Analysis (2045)

Option	Terminal	AM Peak			PM Peak		
		v/c Ratio	Average Delay (sec/veh)	LoS	v/c Ratio	Average Delay (sec/veh)	LoS
2	North	***0.97***	36.5	D	***1.02***	44.2	D
	South	***0.93***	23.8	C	***1.01***	32.2	C
8	North	***0.94***	24.5	C	***1.01***	43.2	D
	South	***0.89***	17.2	B	***0.98***	33.4	C

As shown, both Options 2 and 8 show high volume to capacity ratios during the AM and PM peak hours in 2045 at both the north and south ramp terminal locations. Additional turning lanes or channelized lanes would be needed to mitigate the high volume to capacity ratios at the ramp terminals for both options by 2045. Option 8 is predicted to perform slightly better in the AM peak hour in 2045 but in the PM peak hour both options have the same performance.

4.1.2 RELATIVE SAFETY PERFORMANCE

As there is no existing interchange or connections with Highway 1 in the vicinity of 216 Street in which to compare safety performance, this evaluation is based on how each interchange option addresses speed transitions, intersection conflicts, and driver expectations.

Option 2

This option has a "diamond" configuration which is familiar to many drivers and poses no unique challenges. As the 216 Street structure will pass over the Highway 1 mainline, the profile of the on / off ramps will encourage deceleration on the highway exit ramps and acceleration on the highway entrance ramps which are desirable characteristics for minimizing merging and loss of control collisions. At the ramp terminal intersections at 216 Street, traffic entering Highway 1 east from 216 Street north or Highway 1 west from 216 Street south will be required to make a left turn across opposing traffic, increasing the risk of 90 degree collisions.

Evaluation: Moderate safety performance

Option 8

This hybrid option is configured as a Parclo B2 configuration north of the highway and a Diamond configuration south of the highway, which is less common than the diamond configuration, but still prevalent enough not to pose any unique challenges to drivers. As the 216 Street structure will pass over the Highway 1 mainline, the vertical profile of the on / off ramps will encourage deceleration on the highway exit ramps and acceleration on the entrance ramps, however, the high speed westbound traffic exiting the mainline will be required to slow for a loop ramp which can result in an increased risk of rear end or loss of control collisions. At the ramp terminals, traffic entering Highway 1 west from 216 Street south will be required to make a left hand turn across opposing traffic, increasing the risk of 90 degree collisions.

Evaluation: Neutral to Low safety performance

4.1.3 VEHICLE OPERATING COSTS

Vehicle operating costs are derived from vehicle kilometres travelled which has been extracted from the traffic operations model. The traffic operations model accounts for traffic redistribution and rerouting within the Langley network based on simulated traffic operations and areas of possible delay.

The total AM and PM vehicle kilometres travelled were factored to annual values, based on an assumption of 250 work days per year. In the absence of a weekend model, additional savings equivalent to the average of the AM and PM periods was included (just one period per day) to reflect the potential savings for the 100 weekend days per year. ***Table 4.7*** summarizes the annual difference in vehicle kilometres travelled (VKT) for each option for the 2045 planning horizon.

Table 4.7: 2045 Annual Vehicle Kilometres Travelled (Millions of VKT)

Base	Option 2		Option 8	
	Absolute	Change	Absolute	Change
418	423	+5	424	+6

From the table above, Option 2 and Option 8 have virtually the same increase in VKT. This increase in VKT is likely due to some vehicles using the 216 Street interchange in lieu of a shorter, direct route, which is more congested. Lower VKT is desirable as this measure is tied to vehicle operating costs and greenhouse gas emissions.

As indicated in the table on the previous page, all of the options result in an approximate 1.2% to 1.4% increase in vehicle kilometres travelled which, for the purposes of this study, would likely reflect a similar amount in vehicle operating costs and emissions.

4.2 Socio-Community Account

4.2.1 RESIDENTIAL PROPERTY IMPACTS

Residential property impacts have been estimated based on the single line option sketches with respect to existing right-of-way and adjacent property lines. A full or partial property take was determined according to whether any structure / building impacts are likely and whether the property could remain functional following construction. Impact mitigation will be refined in more detail as part of the interchange

functional design. Minimizing the total number of properties impacted and the number that is fully impacted is desired.

- Option 2 potentially requires three full residential property takes and up to 10 partial takes (to be confirmed through functional design).
- Option 8 potentially requires four full residential property takes and up to nine partial takes to accommodate the northwest quadrant loop ramp and the south side on / off ramps (to be confirmed through functional design).

The number of fully impacted properties and partially impacted properties is summarized in ***Table 4.8*** below:

Table 4.8: Residential Property Impacts

	Option 2	Option 8
Partial	10	9
Full	3	4
Total	13	13

4.2.2 BUSINESS / INSTITUTIONAL PROPERTY IMPACTS

Each of Options 2, and 8 have no direct impacts to the current agricultural businesses in the northeast or southwest quadrant. Current access points can be modified to maintain vehicle movements in all options. As such, there are no significant business / institutional property impacts for any option.

4.2.3 ALR IMPACTS

Agricultural Land Reserve land is located on the east side of the 216 Street right-of-way. Reducing the area of ALR impacted is desirable. The following impacts are noted for the two options:

- Option 2 requires 2.17 hectares of ALR for the construction of on / off ramps, road widening and relocation of east/west roadway.
- Option 8 requires the same area of ALR, 2.17 hectares, for construction of an on ramp, road widening and road relocation of the east/west roadway.

4.2.4 NOISE IMPACTS

This qualitative criterion is evaluated based on the proximity of the interchange ramp terminals to sensitive residential uses, and the effect of traffic control devices on stopping / starting noises.

Option 2

Option 2 locates the interchange ramp terminals away from residential uses; however, the two new signalized intersections will create additional stop / start traffic noise. The overall rating is a low to moderate impact compared to existing (base) conditions.

Evaluation: Low to Moderate Noise Impacts

Option 8

Option 8 positions a loop ramp in the northwest quadrant immediately adjacent to an established residential area. This would result in traffic being brought close to homes and the removal of some of the existing vegetation which serves as a noise screen from the Highway 1 mainline. The overall rating would therefore be a moderate impact compared to existing (base) conditions.

Evaluation: Moderate Noise Impacts

4.2.5 VISUAL IMPACTS

This qualitative criterion is evaluated based on the proximity of the interchange terminals to sensitive residential uses, and the effect of lighting spillover.

Option 2

Option 2 locates the interchange ramp terminals away from residential uses; however, the two new signalized intersections will create additional lighting spillover.

Evaluation: Neutral to Low impact compared to existing (base) conditions

Option 8

Option 8 positions a loop ramp in the northwest quadrant immediately adjacent to an established residential area. This infrastructure would result in lighting being brought close to homes and the removal of some of the existing vegetation which serves as a visual screen from the Highway 1 mainline.

Evaluation: Moderate impact compared to the existing (base) conditions

4.2.6 EFFECT ON NON-MOTORIZED TRAVEL MODES

As pedestrian and bicycle traffic is currently low in the area, the evaluation of the effect of each option on non-motorized travel modes is focused on the opportunities for providing a multi-use pathway along the corridor as envisioned in the Township of Langley Cycling Plan, as well as any features that would introduce conflicts with on-road or off-road active travellers.

Option 2

The interchange configuration in Option 2 will provide for a continuous pathway across the highway, however special intersection treatments will be required to reduce turning conflicts where the multi-use pathway crosses. Right and left-hook collisions are a potential hazard from vehicle traffic.

Evaluation: Neutral to Moderate improvement for non-motorized travel

Option 8

Option 8 provides an opportunity to place the multi-use path on the east side of the roadway which would eliminate all conflicts with vehicle traffic north of the interchange and across the highway.

Evaluation: Moderate to Significant Improvement for non-motorized travel

4.3 Environmental Account

4.3.1 GHG IMPACTS

By assuming Greenhouse Gas (GHG) emissions are proportional to Vehicle Kilometres Travelled (VKT) output from the traffic operations model, the modelled increase in VKT results in a:

- 1.2% increase in GHG for Option 2
- 1.4% increase in GHG for Option 8

Lower increases (or decreases) are desirable. Due to the uncertainty in depicting absolute values for vehicle emissions due to the lack of fuel consumption information for the future vehicle fleet in Metro Vancouver, only the relative change as a percentage is provided between each option and the base conditions.

4.3.2 TERRESTRIAL IMPACTS

The relative severity of impacts to the terrestrial environment is proportional to the amount of area consumed by the new interchange and overpass, especially with respect to any ecologically sensitive areas. Reducing the amount of area impacted, and avoiding known sensitive areas is considered desirable. The following impacts to the terrestrial area for each option are summarized below:

- Option 2 requires 3.36 hectares of area, most of which lies within existing developed lots. Therefore, the terrestrial impact is considered low.
- Option 8 requires 5.35 hectares of area, including a wooded area in the northwest quadrant. As such, the terrestrial impact is considered moderate.

4.3.3 AQUATIC IMPACTS

The relative severity of impacts to the aquatic environment is determined by the impact on streams and watercourses within the study area, particularly those which are fish bearing. There is one primary fish bearing stream in the southeast quadrant of the interchange study area. All of the options avoid significant impacts to this stream and therefore are all evaluated similarly as with low aquatic impacts (assuming best practices in construction management and mitigation techniques).

4.3.4 ARCHAEOLOGICAL / HISTORICAL IMPACTS

No significant archaeological or heritage sites were noted within the interchange study area, and therefore all options are evaluated as having neutral impacts.

4.3.5 SPECIAL CONSTRUCTABILITY CONSIDERATIONS

There are no significant utilities in the interchange study area that would be impacted by the interchange construction in any option. Similarly, each option involves similar construction techniques with no complicated structural components and no significant geotechnical issues anticipated.

4.4 Financial Account

4.4.1 CAPITAL COST

The capital costs for each improvement option have been estimated using the "Wolski" Elemental Parametric methodology. These estimates have been developed based on single line sketches for each option and the previously submitted design criteria sheets. The capital costs are summarized in ***Table 4.9*** and included costs for the following categories:

- Project Management
- Engineering (Preliminary and Detailed Design)
- Grade Construction
- Structures
- Paving Construction
- Operational Construction (signs, pavement marking, etc)
- Utility Construction
- Resident Engineering
- Contingency (30%)
- Management Reserve

Table 4.9: Capital Cost Estimates ($M*)

	Base Case	Option 2	Option 8
Project Management	-	2.1	2.4
Engineering		3.2	3.5
Grade Construction		10.3	11.2
Structural Construction		11.1	11.9
Paving Construction		1.0	1.2
Operational Construction		1.5	1.8
Utility Construction		0.4	0.4
Resident Engineering		2.1	2.4
Contingency (30%)		9.5	10.4
Management Reserve		2.1	2.3
Total		**43.3**	**47.5**

** Costs have been rounded up to the nearest 0.1 million*

It can be seen from the above table, that Option 8 has the highest estimated capital cost.

For property costs, the amount of the impacted area was estimated for each option based on the existing right-of-way and adjacent property lines. Agricultural property (within the ALR) was assumed to cost $500,000 per hectare, while other property was assumed to cost $2,500,000 per hectare. These costs are based on recent high level estimates for projects around Metro Vancouver. ***Table 4.10*** summarizes the property costs.

Table 4.10: Property Cost Estimates ($M)

Land Use	Option 2		Option 8	
	Area	Cost	Area	Cost
Residential	1.19	3.0	3.18	8.0
Agricultural	2.17	1.1	2.17	1.1
Total	**3.36**	**4.1**	**5.35**	**9.1**

4.4.2 MAINTENANCE AND REHABILITATION COST

Using an annual discount rate of 6% and assumed annual maintenance and rehabilitation costs of $3.8 / lane-m and $130 / lane-m respectively, the 25 year present value of these costs were calculated for each option. It is assumed that rehabilitation occurs in year 15 of operation. ***Table 4.11*** summarizes the maintenance and rehabilitation costs expressed in millions of 2015 dollars.

Table 4.11: Maintenance and Rehabilitation Cost Estimates ($2015 M)

	Base Case	Option 2	Option 8
Total	-	0.33	0.4

4.4.3 SALVAGE VALUE

The salvage value of the proposed infrastructure at the end of the 25 year business case period is reported in ***Table 4.12*** based on an annual discount rate of 6%. The salvage costs are based on the following assumptions:

- Structures: 50 year life
- Roadways: 25 year life (after rehab)
- Property: 100% value retained

Table 4.12: Salvage Value Cost Estimates ($2015 M)

	Base Case	Option 2	Option 8
Total	-	2.6	2.8

4.4.4 BENEFIT COST RATIO AND NET PRESENT VALUE

This calculation takes into consideration the 25 year present value of the quantifiable benefits of each option (travel time savings) and the associated costs for each option (capital, property, maintenance and rehabilitation, and salvage value).

The value of travel time savings accrued for each year of benefits in the analysis period has been interpolated between the period from 2017 (following construction when benefits will start to accrue) through 2040. Vehicle operating costs have not been included in the calculation, but due to the earlier assumption, vehicle operating costs may increase for each option and therefore will slightly reduce the overall benefits.

The B/C ratios and NPVs for each option are presented in ***Table 4.13*** below:

Table 4.13: Benefit Cost Ratio and Net Present Value ($2015 M)

	Option 2	Option 8
B/C Ratio	2.21	2.03
NPV	$57.7	$58.7

4.5 Evaluation Summary

Table 4:14: Evaluation Summary

Criterion/Option	Option 2: Diamond	Option 8: Parclo B2 / Diamond Hybrid
Customer Service Account		
2045 Network Travel Time Savings (annual veh-hr)	989 K	1092 K **(highest savings)**
Interchange Utilization (volume on 216 Street overpass)	AM 2045: 2,800 vph PM 2045: 3,130 vph	AM 2045: 2,770 vph PM 2045: 3,180 vph
Intersection Level of Service (see ***Table 4.4*** for details)	Adequate LOS at both ramp terminals (LOS C/D in peak hours), High v/c ratio at both terminals (>0.90 during AM peak hour and >1.0 during the PM peak hour)	Good LOS at both terminals during both peak hours, High v/c ratio at both terminals (0.90 during AM peak hour and 1.0 during the PM peak hour) **(slightly better performance)**
Relative Safety Performance	Diamond overpass encourages deceleration on highway exit, acceleration on highway entry. Risk of 90 degree collisions due to left turning movements at ramp terminal intersections. Moderate safety performance	High speed westbound traffic from rural freeway must exit on loop ramp, risk of 90 degree collisions due to left turning movements at ramp terminal intersections, creates weaving section on cross street. Neutral safety performance
2045 Annual VKT	423 M **(slightly lower total and increase over base)**	424 M
Socio-Community Account		
Residential Property Impacts	Full Impacts: 3 Partial Impacts: 10 potential Minimizes the number of fully impacted properties	Full Impacts: 4 Partial Impacts: 9 potential
Business / Institutional Property Impacts	No direct impacts, access to agricultural businesses in southwest and northeast quadrants can be maintained. No impacts	No direct impacts, access to agricultural businesses in southwest and northeast quadrants can be maintained No impacts
ALR Impacts	2.17 ha	2.17 ha

Criterion/Option	Option 2: Diamond	Option 8: Parclo B2 / Diamond Hybrid
Noise Impacts	Interchange terminals away from residential uses, will create additional stop / start traffic noise Low to Moderate Impacts	Loop in northwest quadrant adjacent to established residential area Moderate Impacts
Visual Impacts	Interchange terminals away from residential uses, some lighting spillover Neutral to Low Impacts	Loop in northwest quadrant will require removal of treed buffer area adjacent to established residential area Moderate Impacts
Effect on Non-Motorized Travel Modes	Multi-use pathway on either side will require intersection treatment to reduce turning conflicts Neutral to Moderate Improvement	Opportunity for multi-use path on east side which would avoid all traffic conflict Moderate to Significant Improvement
Environmental Account		
GHG Impacts	1.2% increase in GHGs over base case **(slightly lower increase)**	1.4% increase in GHGs over base case
Terrestrial Impacts	3.36 ha of area required Low Impacts	5.35 ha of area required including wooded area in northwest quadrant Moderate Impacts
Aquatic Impacts	Minimal to low impact to creek crossing southeast quadrant Low Impacts	Minimal to low impact to creek crossing southeast quadrant Low Impacts
Archaeological / Historical Impacts	Low Impacts	Low Impacts
Special Constructability Considerations	No significant constraints, conflicts, or issues	No significant constraints, conflicts, or issues

Criterion/Option	Option 2: Diamond	Option 8: Parclo B2 / Diamond Hybrid
Financial Account		
Capital Cost	**$43.3 M**	**$47.5 M**
Capital Cost ($2015)	$39.7 M	$43.6 M
Property Cost ($2015)	$4.1 M	$9.1 M
Maintenance and Rehabilitation Cost ($2015)	$0.3 M	$0.4 M
Salvage Value ($2015)	$2.6 M	$2.8 M
Net Present Value ($2015)	$57.7 M	$58.7 M
Overall Benefit Cost Ratio	**2.21**	**2.03**

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216th Street Interchange Option Evaluation

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TABLE OF CONTENTS

1.0 INTRODUCTION

As part of the study to determine the most appropriate configuration for the new full movement connection at 216 Street and Highway 1, a detailed evaluation of three shortlisted options has been completed.

The purpose of this interim report is to summarize the option evaluation process and identify a recommended option to advance to functional design.

Additional project information is available in the 216 Street Interchange Project Background Report, the 216 Street Interchange Design Criteria summary sheets, and the 216 Street Interchange Option Generation and Preliminary Evaluation reports.

2.0 SHORTLISTED OPTIONS

As a part of a previous report, six distinct interchange concepts were developed and a high level screening process was undertaken to shortlist three concepts. The screening process was based on the following criteria:

- Traffic Level of Service (based on terminal intersection performance);
- Sensitive Area Impacts (disruption to natural land and water features);
- Property Impacts (number and type of properties and area required);
- Agricultural Land Reserve Impacts (impacts to east side of 216 Street);
- Cost (estimated based on high level relative construction and mitigation requirements).

The resulting three shortlisted options are described as follows:

- *Option 2: Provide a Diamond interchange*

  This option, shown in ***Figure 1***, would provide a directional on/off ramp in each quadrant as well as a connecting overpass between them.

  At the off-ramp terminal intersections at 216 Street, it is assumed signalization would be provided along with auxiliary turning lanes; to be confirmed through forthcoming traffic analysis. For comparative purposes, it is assumed that the ramp terminal intersections would be spaced approximately 150 m apart.

- *Option 4: Provide a Folded Cloverleaf interchange (Parclo A-B)*

  This option, shown in ***Figure 2***, would provide a loop off-ramp and a directional on-ramp in the northwest quadrant of the interchange, as well as a loop on-ramp and a directional off-ramp in the southwest quadrant of the interchange.

  It is assumed that the on and off-ramp terminal intersections will be signalized to facilitate left-turn movements.

- *Option 6: Provide a Diamond interchange with Roundabouts*

  This option, shown in ***Figure 3***, would provide a directional on/off ramp in each quadrant as well as a connecting overpass between them.

  At the off-ramp terminal intersections at 216 Street, modern multi-lane roundabouts would be provided. This may potentially eliminate the need for supplemental left-turn lanes and reduce the overpass structure width from six lanes to four.

1

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QUALITY CONTROL _____ DATE _____
DRAWN _____ DATE 11/1/13

Rev	Date	REVISIONS	Initials

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TRANS CANADA HIGHWAY No. 1
CONCEPT DESIGN

216 STREET - OPTION 2

FIGURE
1

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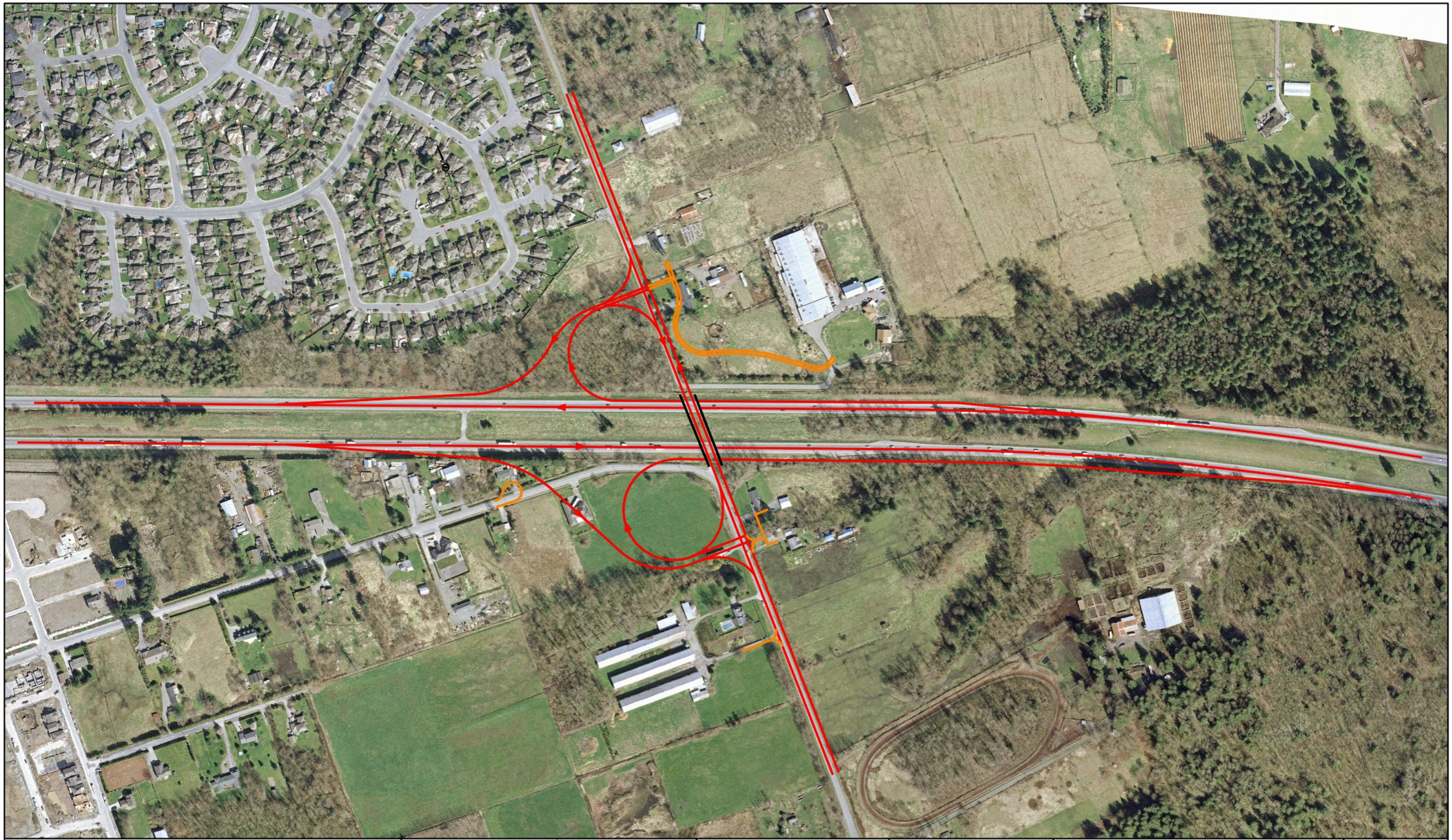

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Rev	Date	REVISIONS	Initials

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TRANS CANADA HIGHWAY No. 1
CONCEPT DESIGN

216 STREET - OPTION 4

FIGURE
2

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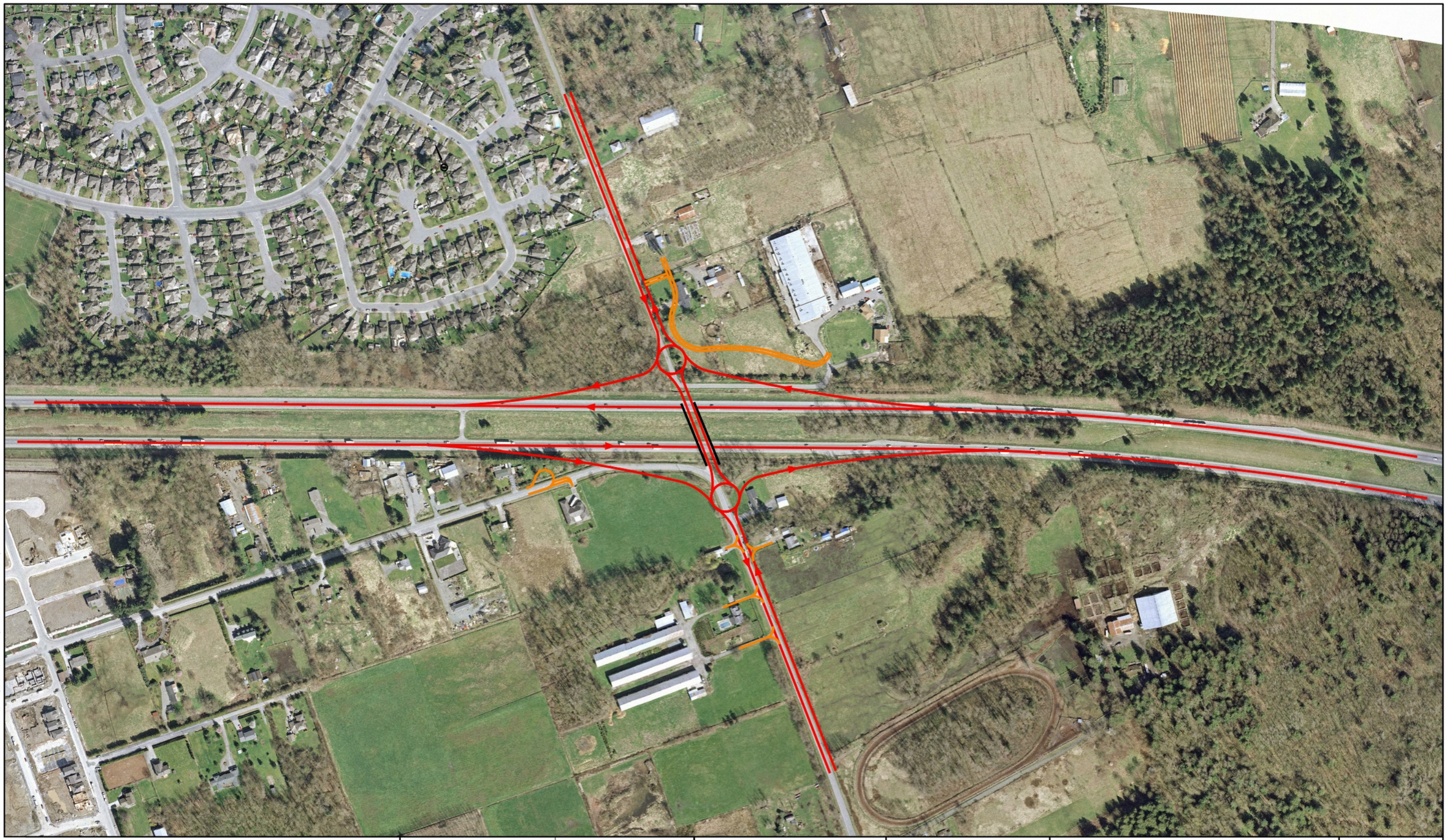

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Rev	Date	REVISIONS	Initials

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TRANS CANADA HIGHWAY No. 1
CONCEPT DESIGN

216 STREET - OPTION 6

FIGURE
3

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3.0 EVALUATION CRITERIA

In order to compare and contrast the relative merits and drawbacks of each option, a set of high level evaluation criteria was developed based on Multiple Account Evaluations prepared for similar Ministry transportation planning studies. The criteria are a combination of quantitative and qualitative measures to assist in selecting a preferred alternative through a comparison to the base case (do nothing) scenario. For consistency with business case development, a 25 year project horizon will be assumed for those quantitative related criteria.

The descriptions below include a summary of the criterion characteristics and rationale, as well as a range of evaluation output.

In keeping with the Ministry's Multiple Account Evaluation categories, the evaluation criteria have been grouped into the respective Customer Service, Socio-Community, Financial, and Environmental accounts. The Economic account is not proposed at this level of analysis.

3.1 Customer Service Account

3.1.1 TRAFFIC LEVEL OF SERVICE AND MOBILITY PROVIDED

Using the PARAMICS traffic operations model (micro-simulation) and each option's proposed geometric and operational modifications, an assessment of the performance of each option in terms of travel delay and level of service will be conducted.

Evaluation Output:

This quantitative assessment will take into consideration the following comparative performance statistics as extracted from the AM and PM peak models which cover the Highway 1 corridor between 160 Street and 232 Street as well as the municipal road network from the Fraser River to Highway 10:

- *Network Travel Time Savings (all vehicles, all delay throughout the network– the AM and PM peak period savings will be factored up to an equivalent annual amount). A higher value of savings is preferred;*
- *Interchange Utilization (volumes crossing the highway at the subject interchange as well as at other interchanges between 176 and 232 Streets – indicates potential relief at adjacent interchanges). A higher volume of interchange utilization is preferred as this indicates adjacent network relief;*

- *Level of Service at Key Signalized Intersections (volumes extracted from the traffic operations model will be run through the Synchro signal optimization program to assess changes in volume to capacity ratios and delay). LoS D or better with a volume to capacity ratio of 0.85 or less is desired;*
- *Point to Point Travel Times (key directional bundles for 216 Street north and south, and for Highway 1 east and west between 176 Street and 232 Street). Lower travel times are desired.*
- *Highway link volume / capacity ratios (on highway links between 176 Street and 232 street – indicates impacts due to redistribution of traffic). Lower link volume / capacity ratios are desired.*

3.1.2 RELATIVE SAFETY PERFORMANCE

Although there is no existing interchange to provide a baseline safety performance comparison, this criterion is based on a subjective assessment of key option characteristics such as the number of conflict points (merge or weave areas, signalized intersections, etc) and the effect on the safety of non-motorized travel modes.

Evaluation Output: *Mild / Moderate / Significant positive or negative safety performance*

3.1.3 VEHICLE OPERATING COSTS

Vehicle operating costs are derived from vehicle kilometres travelled as extracted from the PARAMICS traffic operations model. The model will take into account traffic redistribution and rerouting within the Langley network.

Evaluation Output: *Network Vehicle Kilometres Travelled (by vehicle type), Vehicle Operating Costs (expressed as a present dollar value).*

3.2 Socio-Community Account

3.2.1 RESIDENTIAL PROPERTY IMPACTS

This criterion will consider the additional right-of-way required and quantify the number of individual residential properties impacted (full or partial impacts).

Evaluation Output: *# of Residential Properties Impacted*

3.2.2 BUSINESS / INSTITUTIONAL PROPERTY IMPACTS

This criterion will consider the additional right-of-way required and quantify the number of individual business / institutional properties impacted (full or partial impacts).

Evaluation Output: *# of Business / Institutional Properties Impacted*

3.2.3 ALR IMPACTS

This quantitative criterion will consider the total area of land within the Agricultural Land Reserve which would be impacted.

Evaluation Output: *ALR Area Required*

3.2.4 NOISE IMPACTS

This qualitative criterion will consider the potential effects of noise on adjacent residents and businesses. This criterion will be measured by proximity to higher volume traffic.

Evaluation Output: *Low / Medium / High Noise Impacts*

3.2.5 VISUAL IMPACTS

This criterion will consider the visual intrusion of the option in terms of its proximity to residents and businesses. The qualitative evaluation will determine whether each option would have low, medium or high visual impacts.

Evaluation Output: *Low / Medium / High Visual Impacts*

3.2.6 EFFECT ON NON-MOTORIZED TRAVEL MODES

The effect on pedestrian and cyclist safety will be qualitatively evaluated based on changes in geometry, traffic speed, and ease of roadway crossing.

Evaluation Output: *Low / Moderate / Significant Positive or Negative Effect on Non-Motorized Travel Modes*

3.3 Environmental Account

3.3.1 GHG IMPACTS

Using the Vehicle Kilometres Travelled (VKT) output from the traffic operations model, the total fuel consumed and associated Greenhouse Gas emissions (C02e) can be estimated for each option. Lower emission values are desired.

Evaluation Output: *GHG Emissions (CO2e)*

3.3.2 TERRESTRIAL IMPACTS

The relative severity of impacts to the terrestrial environment within the construction limits of each option in comparison to the base case (existing conditions) will be noted.

The qualitative evaluation will determine whether each option would have neutral, low, medium or high terrestrial impacts.

Evaluation Output: *Neutral / Low / Medium / High Terrestrial Impacts*

3.3.3 AQUATIC IMPACTS

The relative severity of impacts to the aquatic environment within in the construction limits of each option in comparison to the base case (existing conditions) will be noted.

The qualitative evaluation will determine whether each option would have neutral, low, medium or high aquatic impacts.

Evaluation Output: *Neutral / Low / Medium / High Aquatic Impacts*

3.3.4 ARCHAEOLOGICAL / HISTORICAL IMPACTS

For each option, archaeologically or historically significant impacts due to the potential construction of each option will be noted.

The qualitative evaluation will determine whether each option would have neutral, low, medium or high impacts.

Evaluation Output: *Neutral / Low / Medium / High Archaeological and Historical Impacts*

3.3.5 SPECIAL CONSTRUCTABILITY CONSIDERATIONS

Existing constraints may affect the constructability of certain options. These constraints can include geotechnical mitigation / preload requirements, major utility conflicts / relocations requiring third party review, and special stormwater management requirements. The number and severity of these considerations will be noted and evaluated accordingly.

Evaluation Output: *Low / Medium / High Special Constructability Considerations*

3.4 Financial Account

3.4.1 CAPITAL COST

The relative construction cost of each option will be assessed at a high level using a conceptual single line sketch and typical unit costs referenced from the Ministry's Construction and Rehabilitation Cost Guide, the Wolski method, and previous experience. The costs are dependent on the extent of physical modifications, the complexity of the modifications (including geotechnical, utilities, drainage, and environmental compensation features), and right-of-way requirements. Property costs will be highlighted separately.

Evaluation Output: *Total Construction Cost (Including Contingencies)*

3.4.2 MAINTENANCE AND REHABILITATION COST

Consideration for annual maintenance and rehabilitation costs will be based on standard lane-kilometre costs and scheduled rehabilitation for major roadways. The cost will be expressed as a 25 year present value ($2014).

Evaluation Output: *Maintenance and Rehabilitation Cost (25 Year Present Value)*

3.4.3 SALVAGE VALUE

The salvage value of the proposed infrastructure at the end of the 25 year business case period will be reported using applicable discount rates.

Evaluation Output: *Salvage Value (25 Year Present Value)*

3.4.4 BENEFIT COST RATIO AND NET PRESENT VALUE

This calculation takes into consideration the 25 year present value of the benefits (travel time savings, operating cost savings) accrued to each option and the associated implementation costs (capital, maintenance and rehabilitation, and salvage value).

Evaluation Output: *B/C Ratio, NPV (25 Year Benefits - Costs)*

4.0 OPTION EVALUATION

Using the evaluation criteria in Section 3.0, the three shortlisted options were evaluated in detail by applying the evaluation criteria described in the previous section. As noted, some of the criteria will be evaluated in a quantitative manner whereas others will be evaluated qualitatively. Quantitative factors include performance metrics extracted from the PARAMICS traffic operations model, Synchro intersection capacity analysis, or SIDRA traffic models (roundabout capacity analysis), as well as objective measures such as cost estimates using the Wolski methodology or the amount of property required in hectares.

For the evaluation criteria involving qualitative assessments, a descriptive assessment has been provided in relation to the base case conditions. The descriptive assessments include the use of indicators ranging from neutral, low, medium, to high impacts (or in some instances, benefits). As a means to more definitely score the qualitative related criteria, the following ranking scale has also been applied:

○ indicates an option with a significant negative impact, has strong incompatibility, or that fails to meet project objectives.

◔ indicates an option with a moderate negative impact, incompatibility or somewhat falls short of project objectives.

◑ indicates an option that is relatively neutral in its impacts or partially meets project objectives.

◕ indicates an option with moderate improvements, good compatibility, or mostly achieves project objectives.

● indicates an option with significant improvements, strong compatibility, or fully achieves project objectives.

A comprehensive explanation of the evaluation results for each criterion is provided as in the following subsections. A summary table, ***Table 4.14,*** is provided at the end of this section.

4.1 Customer Service Account

4.1.1 TRAFFIC LEVEL OF SERVICE AND MOBILITY PROVIDED

Using the traffic operations model and each option's proposed geometric and operational modifications, an assessment of the performance of each option in terms of travel delay and level of service was conducted.

Network Travel Time Savings

Network travel time represents the cumulative travel time of each vehicle travelling through the study network during the simulation period. Total network travel time for each option is depicted in the summary table below along with the relative travel time savings as compared to the base case in each time frame, 2012 and 2045.

Table 4.1a: 2012 AM Network Travel Times (hours)

Base	Option 2		Option 4		Option 6	
	Absolute	Change	Absolute	Change	Absolute	Change
7,061	6,840	-221	6,819	-242	6,811	-250

As shown in the table above, Option 6 has the highest travel time savings (250 hours) during the AM peak period.

Table 4.1b: 2012 PM Network Travel Times (hours)

Base	Option 2		Option 4		Option 6	
	Absolute	Change	Absolute	Change	Absolute	Change
8,368	8,166	-202	8,166	-202	8,238	-130

As shown in the table above, Options 2 and 4 have the highest travel time savings (202 hours) during the PM peak period.

Table 4.1c: 2045 AM Network Travel Times (hours)

Base	Option 2		Option 4		Option 6	
	Absolute	Change	Absolute	Change	Absolute	Change
13,478	12,243	-1,235	12,136	-1,342	12,267	-1,211

In the table above, Option 4 has the highest travel time savings (1,342 hours) during the AM peak period.

Table 4.1d: 2045 PM Network Travel Times (hours)

Base	Option 2		Option 4		Option 6	
	Absolute	Change	Absolute	Change	Absolute	Change
17,851	15,790	-2,061	15,704	-2,147	16,055	-1,796

In the table above, Option 4 again has the highest travel time savings (2,147 hours) during the PM peak period.

The total AM and PM travel time savings were factored to annual values, based on an assumption of 250 work days per year. In the absence of a weekend model, additional savings equivalent to the average of the AM and PM periods was included (just one period per day) to reflect the potential savings for the 100 weekend days per year. The annual travel time savings for each option for the 2045 planning horizon is summarized in ***Table 4.2*** below.

Table 4.2: 2045 Annual Travel Time Savings (Thousand Hours)

Base	Option 2	Option 4	Option 6
-	989	1047	902

Option 4 displays the highest annual savings, followed by Option 2 and Option 6.

Interchange Utilization

The utilization of the 216 Street is an important measure of potential relief to adjacent interchanges along the Highway 1 corridor in Langley. ***Table 4.3*** summarizes the forecast AM and PM peak two-way volumes crossing the new overpass in the year 2045. The volumes were extracted directly from the traffic operations model.

Table 4.3: 2045 Interchange Utilization (two-way vehicles per hour)

Time Period	Base	Option 2	Option 4	Option 6
AM Peak	0	2,060	1,975	1,895
PM Peak	0	2,320	2,370	2,175

As shown in the table above, Option 2 has the highest utilization in the AM peak, while Option 4 has the highest utilization in the PM peak. Higher volume utilization is more desirable as this indicates additional relief is provided to the adjacent network and likely at the other interchanges along Highway 1 in Langley.

Level of Service

Table 4.4 summarizes the Level of Service analysis conducted using the Synchro (or SIDRA) intersection capacity analysis programs and year 2045 forecast travel demands at the interchange ramp terminals.

In contrast to the previous high-level estimates in the option screening assessment, the turning movement volumes for this more detailed option evaluation were extracted from the traffic operations model rather than utilizing the more coarse static turning movements from the macro-level regional travel demand model (Emme) outputs. Because the traffic operations model is sensitive to the effects of inefficient traffic operations and any related congestion on the network, particularly at the adjacent 200 Street Interchange, the results below are considered more representative of expected network traffic distribution.

Level of Service is graded on a scale of A to F with F representing high delays and significant congestion, while A represents low delays and no congestion. The volume to capacity ratio is a measure of capacity utilization, with a maximum of 0.85 considered desirable during peak hours in urban areas.

Table 4.4: Interchange Terminal Level of Service Analysis (2045)

Option	Terminal	AM Peak			PM Peak		
		v/c Ratio	Average Delay (sec/veh)	LoS	v/c Ratio	Average Delay (sec/veh)	LoS
2	North	*0.93*	26.5	C	*0.94*	24.5	C
	South	0.56	10.5	B	0.71	14.2	B
4	North	0.65	10.5	B	0.78	13.0	B
	South	0.81	13.4	B	0.82	13.4	B
6	North	0.84	17.6	B	*1.03*	44.3	D
	South	0.57	8.2	A	0.71	10.3	B

As shown, the diamond configurations in Options 2 and 6 show poorer levels of service at the north interchange ramp terminal due to the heavy volume of westbound to southbound left-turning traffic. Additional turning lanes or channelized lanes would be needed to mitigate the high volume to capacity ratios at the north ramp terminal in Option 2 or Option 6. Option 4 has a slightly higher volume to capacity ratio at the south ramp terminal, but provides relatively low delays at both ramp terminals in both time periods. Option 2 would achieve improved performance (LoS B, v/c ratio < 0.80) if double westbound to southbound left-turn lanes were provided at the north ramp terminal intersection.

Point to Point Travel Times

The changes in point to point travel times as measured from the traffic operations model for 10 representative trip origins and destinations within the Langley area are summarized in ***Table 4.5***. The comparison is provided between travel times in the 2045 base scenario (no 216 Street interchange) and the travel times in each 2045 option scenario.

The 96 Avenue / 208 Street intersection was selected as a representative Walnut Grove neighbourhood trip start / end point while the 86 Avenue / 208 Street intersection was selected as a representative Willoughby neighbourhood trip start / end point. Highway 1 trips start / end west of 176 Street and east of 232 Street.

Table 4.5: Point to Point Travel Times Comparison 2045

	AM Peak - 2045				PM Peak - 2045			
	Base	Option 2	Option 4	Option 6	Base	Option 2	Option 4	Option 6
Trip 1 - 96 Ave /208 St to Hwy 1 West	10.5	-14%	-14%	-8%	15.2	-23%	-22%	-28%
Trip 2 - 96 Ave / 208 St to Hwy 1 East	12.1	-32%	-35%	-37%	18.9	-54%	-57%	-53%
Trip 3 - 86 Ave / 208 St to Hwy 1 West	16.1	-32%	-31%	-31%	16.6	-15%	-21%	-24%
Trip 4 - 86 Ave / 208 St to Hwy 1 East	12.1	-49%	-41%	-48%	15.4	-36%	-36%	-43%
Trip 5 - 96 Ave / 208 St to 86 Ave / 208 St	8.0	-51%	-51%	-50%	12.8	-65%	-65%	-64%
Trip 6 - 86 Ave / 208 St to 96 Ave / 208 St	3.8	8%	8%	-15%	5.0	-14%	-15%	-13%
Trip 7 - Hwy 1 West to 96 Ave / 208 St	11.3	-8%	-10%	-20%	13.4	-17%	-17%	-12%
Trip 8 - Hwy 1 West to 86 Ave / 208 St	22.3	-47%	-45%	-47%	26.0	-43%	-46%	-29%
Trip 9 - Hwy 1 East to 96 Ave / 208 St	21.3	-50%	-54%	-56%	12.3	-17%	-12%	-18%
Trip 10 - Hwy 1 East to 86 Ave / 208 St	35.3	-75%	-76%	-74%	24.9	-62%	-64%	-61%

As shown, almost all trip pairs indicate a reduction in travel times compared to the base case. For ease of comparison, the changes have therefore been evaluated as significant (>50% change), moderate (<50% to >10% change), or minor (<10% change).

For the AM Peak:

Option 2 has a significant reduction in travel time (>50%) for trips from Highway 1 east to Walnut Grove and Willoughby, and from Walnut Grove to Willoughby. There is also a minor reduction in travel time (<10%) for trips from Highway 1 west to Walnut Grove while the remainder of the trip pairs show moderate reduction in travel time (10% to 50% reduction).

Option 4 has a significant reduction in travel time (>50%) for trips from Highway 1 east to Walnut Grove and Willoughby, and from Walnut Grove to Willoughby. There is also a minor reduction in travel time (<10%) for trips from Highway west to Walnut Grove.

The remainder of the trip pairs show moderate reduction in travel time (10% to 50% reduction).

Option 6 has a significant reduction in travel time (>50%) for trips from Highway 1 east to Walnut Grove and Willoughby, and from Walnut Grove to Willoughby. There is also a minor reduction in travel time (<10%) for trips from Walnut Grove to Highway 1 west. The remainder of the trip pairs show moderate reduction in travel time (10% to 50% reduction).

For the PM Peak:

Option 2 has a significant reduction in travel time (>50%) for trips from Highway 1 east to Willoughby, from Walnut Grove to Highway 1 east, and from Walnut Grove to Willoughby. The remainder of the trip pairs show moderate reduction in travel time (10% to 50% reduction).

Option 4 has a significant reduction in travel time (>50%) for trips from Highway 1 east to Willoughby, from Walnut Grove to Highway 1 east, and from Walnut Grove to Willoughby. The remainder of the trip pairs show moderate reduction in travel time (10% to 50% reduction).

Option 6 has a significant reduction in travel time (>50%) for trips from Highway 1 east to Willoughby, from Walnut Grove to Highway 1 east, and from Walnut Grove to Willoughby. The remainder of the trip pairs show moderate reduction in travel time (10% to 50% reduction).

Highway Link v/c Ratios

The provision of a new interchange at 216 Street may also assist in reducing the volume to capacity ratios on the Highway 1 mainline by reducing the cross highway traffic that accesses the mainline. Lower volume to capacity ratios are desirable as this indicates travel demand has been reduced along the highway mainline.

Table 4.6: Highway 1 Link v/c Ratios* at 216 Street

Time Period	Base	Option 2	Option 4	Option 6
AM Peak	0.89 EB, 0.77 WB	0.87 EB, 0.72 WB	0.87 EB, 0.77 WB	0.86 EB, 0.76 WB
PM Peak	0.81 EB, 0.82 WB	0.90 EB, 0.83 WB	0.93 EB, 0.82 WB	0.87 EB, 0.85 WB

*assumes 1,800 vph capacity per lane

Option 2 has the lowest v/c ratio (0.72) of all options for the westbound direction in the AM peak. In the eastbound direction during the AM peak, all the options are similar with respect to the volume to capacity ratio.

Option 4 has the lowest v/c ratio (0.82) of all options for the westbound direction in the PM peak, however the other options have only slightly higher v/c ratios. In the eastbound direction, Option 6 has the lowest v/c ratio (0.87) of all options during the PM peak period.

As shown in the table above, the v/c ratios remain relatively high for this segment of Highway 1 assuming the existing two lanes per direction of travel. Separate studies are underway to determine additional laning requirements for the Highway 1 mainline.

4.1.2 RELATIVE SAFETY PERFORMANCE

As there is no existing interchange or connections with Highway 1 in the vicinity of 216 Street in which to compare safety performance, this evaluation is based on how each interchange option addresses speed transitions, intersection conflicts, and driver expectations.

Option 2

This option has a "diamond" configuration which is familiar to many drivers and poses no unique challenges. As the 216 Street structure will pass over the Highway 1 mainline, the profile of the on / off ramps will encourage deceleration on the highway exit ramps and acceleration on the highway entrance ramps which are desirable characteristics for minimizing merging and loss of control collisions. At the ramp terminal intersections at 216 Street, traffic entering Highway 1 east from 216 Street north or Highway 1 west from 216 Street south will be required to make a left turn across opposing traffic, increasing the risk of 90 degree collisions.

Evaluation: Moderate safety performance

Option 4

This option is configured as a Parclo A-B, or folded cloverleaf configuration, which is less common than the diamond configuration, but still prevalent enough not to pose any unique challenges to drivers. As the 216 Street structure will pass over the Highway 1 mainline, the vertical profile of the on / off ramps will encourage deceleration on the highway exit ramps and acceleration on the entrance ramps,

however, the high speed westbound traffic exiting the mainline will be required to slow for a loop ramp which can result in an increased risk of rear end or loss of control collisions. At the ramp terminals, traffic entering Highway 1 east or west from 216 Street south will be required to make a left hand turn across opposing traffic, increasing the risk of 90 degree collisions. Westbound to southbound and southbound to eastbound traffic movements also must weave across each other on the overpass structure, creating an increased risk of rear end and side swipe collisions.

Evaluation: Neutral to Low safety performance

Option 6

Option 6 has a diamond configuration similar to Option 2 however, roundabouts are utilized at the two ramp terminal intersections. As the 216 Street structure will pass over the Highway 1 mainline, the vertical profile of the on / off ramps will encourage deceleration on the highway exit ramps and acceleration on the entrance ramps. The ramp terminal roundabouts will need to be multi-lane to accommodate the forecast volumes. Although research has shown that roundabouts tend to reduce collision severity due to controlled entry speeds and lower angle conflict potential, there is a potential counteracting safety effect when entry flows are highly imbalanced. Heavy volume on a main street movement couple with infrequent entries from a side street or ramp may result in failure to yield when entering the roundabout.

Evaluation: Moderate safety performance

4.1.3 VEHICLE OPERATING COSTS

Vehicle operating costs are derived from vehicle kilometres travelled which has been extracted from the traffic operations model. The traffic operations model accounts for traffic redistribution and rerouting within the Langley network based on simulated traffic operations and areas of possible delay.

The total AM and PM vehicle kilometres travelled were factored to annual values, based on an assumption of 250 work days per year. In the absence of a weekend model, additional savings equivalent to the average of the AM and PM periods was included (just one period per day) to reflect the potential savings for the 100 weekend days per year. ***Table 4.7*** summarizes the annual difference in vehicle kilometres travelled (VKT) for each option for the 2045 planning horizon.

Table 4.7: 2045 Annual Vehicle Kilometres Travelled (Millions of VKT)

Base	Option 2		Option 4		Option 6	
	Absolute	Change	Absolute	Change	Absolute	Change
418	423	+5	425	+7	424	+6

From the table above, Option 2 has the lowest increase in VKT and Option 4 has the highest increase in VKT. This increase in VKT is likely due to some vehicles using the 216 Street interchange in lieu of a shorter, direct route, which is more congested. Lower VKT is desirable as this measure is tied to vehicle operating costs and greenhouse gas emissions.

As indicated in the table on the previous page, all of the options result in an approximate 1.2% to 1.6% increase in vehicle kilometres travelled which, for the purposes of this study, would likely reflect a similar amount in vehicle operating costs and emissions.

4.2 Socio-Community Account

4.2.1 RESIDENTIAL PROPERTY IMPACTS

Residential property impacts have been estimated based on the single line option sketches with respect to existing right-of-way and adjacent property lines. A full or partial property take was determined according to whether any structure / building impacts are likely and whether the property could remain functional following construction. Impact mitigation will be refined in more detail as part of the interchange functional design. Minimizing the total number of properties impacted and the number that is fully impacted is desired.

- Option 2 potentially requires three full residential property takes and up to 10 partial takes (to be confirmed through functional design). The number of fully impacted properties is minimized in this option.
- Option 4 potentially requires six full residential property takes and up to seven partial takes to accommodate the southwest quadrant loop ramp. The number of fully impacted properties is the highest amongst the short listed options.
- Option 6 potentially requires three full residential property takes and up to 10 partial takes (to be confirmed through functional design). The number of fully impacted properties is minimized in this option.

The number of fully impacted properties and partially impacted properties is summarized in ***Table 4.8*** below:

Table 4.8: Residential Property Impacts

	Option 2	Option 4	Option 6
Partial	10	7	10
Full	3	6	3
Total	13	13	13

4.2.2 BUSINESS / INSTITUTIONAL PROPERTY IMPACTS

Each of Options 2, 4, and 6 have no direct impacts to the current agricultural businesses in the northeast or southwest quadrant. Current access points can be modified to maintain vehicle movements in al options. As such, there are no significant business / institutional property impacts for any option.

4.2.3 ALR IMPACTS

Agricultural Land Reserve land is located on the east side of the 216 Street right-of-way. Reducing the area of ALR impacted is desirable. The following impacts are noted for the three shortlisted options:

- Option 2 requires 1.53 hectares of ALR for the construction of on / off ramps and road widening
- Option 4 has the least amount of ALR impact, requiring 0.87 hectares for road widening.
- Option 6 requires 1.32 hectares for the construction of on / off ramps and road widening (slightly less than Option 2 due to the reduced need for left / right turn bays).

4.2.4 NOISE IMPACTS

This qualitative criterion is evaluated based on the proximity of the interchange ramp terminals to sensitive residential uses, and the effect of traffic control devices on stopping / starting noises.

Option 2

Option 2 locates the interchange ramp terminals away from residential uses; however, the two new signalized intersections will create additional stop / start traffic noise. The overall rating is a low to moderate impact compared to existing (base) conditions.

Evaluation: Low to Moderate Noise Impacts

Option 4

Option 4 positions a loop ramp in the northwest quadrant immediately adjacent to an established residential area. This would result in traffic being brought close to homes and the removal of some of the existing vegetation which serves as a noise screen from the Highway 1 mainline. The overall rating would therefore be a moderate impact compared to existing (base) conditions.

Evaluation: Moderate Noise Impacts

Option 6

Option 6 locates the interchange ramp terminals away from residential uses and avoids or at least minimizes the additional stop / start traffic noise associated with traffic signals through the use of roundabouts. The overall rating is a neutral to low impact as compared to existing (base) conditions.

Evaluation: Neutral to Low Impacts

4.2.5 VISUAL IMPACTS

This qualitative criterion is evaluated based on the proximity of the interchange terminals to sensitive residential uses, and the effect of lighting spillover.

Option 2

Option 2 locates the interchange ramp terminals away from residential uses; however, the two new signalized intersections will create additional lighting spillover.

Evaluation: Neutral to Low impact compared to existing (base) conditions

Option 4

Option 4 positions a loop ramp in the northwest quadrant immediately adjacent to an established residential area. This infrastructure would result in lighting being brought close to homes and the removal of some of the existing vegetation which serves as a visual screen from the Highway 1 mainline.

Evaluation: Moderate impact compared to the existing (base) conditions

Option 6

Option 6 locates the interchange ramp terminals away from residential uses.

Evaluation: Neutral to low impact compared to existing (base) conditions

4.2.6 EFFECT ON NON-MOTORIZED TRAVEL MODES

As pedestrian and bicycle traffic is currently low in the area, the evaluation of the effect of each option on non-motorized travel modes is focused on the opportunities for providing a multi-use pathway along the corridor as envisioned in the Township of Langley Cycling Plan, as well as any features that would introduce conflicts with on-road or off-road active travellers.

Option 2

The interchange configuration in Option 2 will provide for a continuous pathway across the highway, however special intersection treatments will be required to reduce turning conflicts where the multi-use pathway crosses. Right and left-hook collisions are a potential hazard from vehicle traffic.

Evaluation: Neutral to Moderate improvement for non-motorized travel

Option 4

Option 4 provides an opportunity to place the multi-use path on the east side of the roadway which would eliminate all conflicts with vehicle traffic through the interchange and across the highway.

Evaluation: Moderate to Significant Improvement for non-motorized travel

Option 6

Option 6 will provide for a continuous pathway across the highway and features roundabouts which slow vehicle entry speeds and provide pedestrian crossing priority without waiting for a traffic signal change. Multi-lane junctions can, however, be challenging for on-road cyclists.

Evaluation: Neutral to Moderate improvement for non-motorized travel

4.3 Environmental Account

4.3.1 GHG IMPACTS

By assuming Greenhouse Gas (GHG) emissions are proportional to Vehicle Kilometres Travelled (VKT) output from the traffic operations model, the modelled increase in VKT results in a:

- 1.2% increase in GHG for Option 2
- 1.6% increase in GHG for Option 4
- 1.4% increase in GHG for Option 6

Lower increases (or decreases) are desirable. Due to the uncertainty in depicting absolute values for vehicle emissions due to the lack of fuel consumption information for the future vehicle fleet in Metro Vancouver, only the relative change as a percentage is provided between each option and the base conditions.

4.3.2 TERRESTRIAL IMPACTS

The relative severity of impacts to the terrestrial environment is proportional to the amount of area consumed by the new interchange and overpass, especially with respect to any ecologically sensitive areas. Reducing the amount of area impacted, and avoiding known sensitive areas is considered desirable. The following impacts to the terrestrial area for each option are summarized below:

- Option 2 requires 2.72 hectares of area, most of which lies within existing developed lots. Therefore, the terrestrial impact is considered low.
- Option 4 requires 5.07 hectares of area, including a wooded area in the northwest quadrant. As such, the terrestrial impact is considered moderate.

- Option 6 requires 2.32 hectares of area, most of which lies within existing developed lots. Therefore, the terrestrial impact is considered low.

4.3.3 AQUATIC IMPACTS

The relative severity of impacts to the aquatic environment is determined by the impact on streams and watercourses within the study area, particularly those which are fish bearing. There is one primary fish bearing stream in the southeast quadrant of the interchange study area. All of the options avoid significant impacts to this stream and therefore are all evaluated similarly as with low aquatic impacts (assuming best practices in construction management and mitigation techniques).

4.3.4 ARCHAEOLOGICAL / HISTORICAL IMPACTS

No significant archaeological or heritage sites were noted within the interchange study area, and therefore all options are evaluated as having neutral impacts.

4.3.5 SPECIAL CONSTRUCTABILITY CONSIDERATIONS

There are no significant utilities in the interchange study area that would be impacted by the interchange construction in any option. Similarly, each option involves similar construction techniques with no complicated structural components and no significant geotechnical issues anticipated.

4.4 Financial Account

4.4.1 CAPITAL COST

The capital costs for each improvement option have been estimated using the "Wolski" Elemental Parametric methodology. These estimates have been developed based on single line sketches for each option and the previously submitted design criteria sheets. The capital costs are summarized in ***Table 4.9*** and included costs for the following categories:

- Project Management
- Engineering (Preliminary and Detailed Design)
- Grade Construction
- Structures

- Paving Construction
- Operational Construction (signs, pavement marking, etc)
- Utility Construction
- Resident Engineering
- Contingency (30%)
- Management Reserve

Table 4.9: Capital Cost Estimates ($M*)

	Base Case	Option 2	Option 4	Option 6
Project Management	-	2.1	2.3	1.9
Engineering		3.2	3.4	2.8
Grade Construction		10.3	11.2	9.5
Structural Construction		11.1	11.1	9.7
Paving Construction		1.0	1.1	0.8
Operational Construction		1.5	1.7	1.0
Utility Construction		0.4	0.5	0.3
Resident Engineering		2.1	2.3	1.9
Contingency (30%)		9.5	10.0	8.3
Management Reserve		2.1	2.2	1.8
Total		**43.3**	**45.8**	**38.0**

* *Costs have been rounded up to the nearest 0.1 million*

It can be seen from the above table, that Option 4 has the highest estimated capital cost and Option 6 the lowest. The structural cost for Option 6 is lower due to a narrower structure to connect the two terminals (no left-turning bays required). It is assumed that these capital outlays would be over a two year period following design and approvals.

For property costs, the amount of the impacted area was estimated for each option based on the existing right-of-way and adjacent property lines. Agricultural property (within the ALR) was assumed to cost $500,000 per hectare, while other property was assumed to cost $2,500,000 per hectare. These costs are based on recent high level estimates for projects around Metro Vancouver. ***Table 4.10*** summarizes the property costs.

Table 4.10: Property Cost Estimates ($M)

Land Use	Option 2		Option 4		Option 6	
	Area	Cost	Area	Cost	Area	Cost
Other (Commercial)	1.19	3.0	4.20	10.5	1.00	2.5
Agricultural	1.53	0.7	0.87	0.4	1.32	0.7
Total	2.72	3.7	5.07	10.9	2.32	3.2

4.4.2 MAINTENANCE AND REHABILITATION COST

Using an annual discount rate of 6% and assumed annual maintenance and rehabilitation costs of $3.8 / lane-m and $130 / lane-m respectively, the 25 year present value of these costs were calculated for each option. It is assumed that rehabilitation occurs in year 15 of operation. ***Table 4.11*** summarizes the maintenance and rehabilitation costs expressed in millions of 2014 dollars.

Table 4.11: Maintenance and Rehabilitation Cost Estimates ($2014 M)

	Base Case	Option 2	Option 4	Option 6
Total	-	0.33	0.33	0.33

4.4.3 SALVAGE VALUE

The salvage value of the proposed infrastructure at the end of the 25 year business case period is reported in ***Table 4.12*** based on an annual discount rate of 6%. The salvage costs are based on the following assumptions:

- Structures: 50 year life
- Roadways: 25 year life (after rehab)
- Property: 100% value retained

Table 4.12: Salvage Value Cost Estimates ($2014 M)

	Base Case	Option 2	Option 4	Option 6
Total	-	2.60	4.27	2.25

4.4.4 BENEFIT COST RATIO AND NET PRESENT VALUE

This calculation takes into consideration the 25 year present value of the quantifiable benefits of each option (travel time savings) and the associated costs for each option (capital, property, maintenance and rehabilitation, and salvage value).

The value of travel time savings accrued for each year of benefits in the analysis period has been interpolated between the period from 2016 (following construction when benefits will start to accrue) through 2039. Vehicle operating costs have not been included in the calculation, but due to the earlier assumption, vehicle operating costs may increase for each option and therefore will slightly reduce the overall benefits.

The B/C ratios and NPVs for each option are presented in ***Table 4.13*** below:

Table 4.13: Benefit Cost Ratio and Net Present Value ($2014 M)

	Option 2	Option 4	Option 6
B/C Ratio	2.69	2.46	2.81
NPV	69.2	68.9	64.5

Table 4:14: Evaluation Summary

Criterion/Option	Option 2: Diamond	Option 4: Parclo A-B	Option 6: Diamond with Roundabouts
Customer Service Account			
2045 Network Travel Time Savings (annual veh-hr)	989 K	1047 K **(highest savings)**	902 K
Interchange Utilization (volume on 216 Street overpass)	AM 2045: 2,060 vph **(highest utilization)** PM 2045: 2,320 vph	AM 2045: 1,975 vph PM 2045: 2,370 vph **(highest utilization)**	AM 2045: 1,895 vph PM 2045: 2,175 vph
Intersection Level of Service (see ***Table 4.4*** for details)	Good LOS at south ramp terminal (LOS B in peak hours), High v/c ratio at north terminal (>0.90 during both peak hours)	Good LOS and acceptable v/c at both terminals (LOS B during both peak hours)	Good LOS at south terminal (LOS B or better in peak hours), Poor LOS and high v/c ratio at north terminal (>1.00 in PM peak hour)
Point to Point Travel Times (see ***Table 4.5*** for details)	AM 2045: Significant reduction in travel time (>50%) for trips from Highway 1 east to Walnut Grove and Willoughby, and from Walnut Grove to Willoughby. Minor reduction in travel time (<10%) for trips from Highway west to Walnut Grove. Remainder of trip pairs show moderate reduction in travel time (10 to 50% reduction). PM 2045: Significant reduction in travel time (>50%) for trips from Highway 1 east to Willoughby, from Walnut Grove to Highway 1 east, and from Walnut Grove to Willoughby. Remainder of trip pairs show moderate reduction in travel time (10 to 50% reduction).	AM 2045: Significant reduction in travel time (>50%) for trips from Highway 1 east to Walnut Grove and Willoughby, and from Walnut Grove to Willoughby. Minor reduction in travel time (<10%) for trips from Highway west to Walnut Grove. Remainder of trip pairs show moderate reduction in travel time (10 to 50% reduction). PM 2045: Significant reduction in travel time (>50%) for trips from Highway 1 east to Willoughby, from Walnut Grove to Highway 1 east, and from Walnut Grove to Willoughby. Remainder of trip pairs show moderate reduction in travel time (10 to 50% reduction).	AM 2045: Significant reduction in travel time (>50%) for trips from Highway 1 east to Walnut Grove and Willoughby, and from Walnut Grove to Willoughby. Minor reduction in travel time (<10%) for trips from Walnut Grove to Highway 1 west. Remainder of trip pairs show moderate reduction in travel time (10 to 50% reduction). PM 2045: Significant reduction in travel time (>50%) for trips from Highway 1 east to Willoughby, from Walnut Grove to Highway 1 east, and from Walnut Grove to Willoughby. Remainder of trip pairs show moderate reduction in travel time (10 to 50% reduction).
Highway Link v/c ratios (at 216 Street, assumes 1,800 vphpl)	AM 2045: 0.87 EB, 0.72 WB **(lowest v/c ratio)** PM 2045: 0.90 EB, 0.83 WB	AM 2045: 0.87 EB, 0.77 WB PM 2045: 0.93 EB, 0.82 WB **(lowest v/c ratio)**	AM 2045: 0.86 EB **(lowest v/c ratio),** 0.76 WB PM 2045: 0.87 EB **(lowest v/c ratio),** 0.85 WB
Relative Safety Performance	Diamond overpass encourages deceleration on highway exit, acceleration on highway entry. Risk of 90 degree collisions due to left turning movements at ramp terminal intersections. Moderate safety performance	High speed westbound traffic from rural freeway must exit on loop ramp, risk of 90 degree collisions due to left turning movements at ramp terminal intersections, creates weaving section on cross street. Neutral safety performance	Reduced collision severity due to roundabouts at ramp terminal intersections, potential increase in collision frequency due to imbalanced traffic flows at roundabouts. Diamond interchange configuration overpass encourages deceleration on highway exit, acceleration on highway entry Moderate safety performance
2045 Annual VKT	423 M **(lowest total and lowest increase over base)**	425 M	424 M

Criterion/Option	Option 2: Diamond	Option 4: Parclo A-B	Option 6: Diamond with Roundabouts
Socio-Community Account			
Residential Property Impacts	Full Impacts: 3 Partial Impacts: 10 potential Minimizes the number of fully impacted properties	Full Impacts: 6 Partial Impacts: 7 potential Increased number of fully impacted properties.	Full Impacts: 3 Partial Impacts: 10 potential Minimizes the number of fully impacted properties
Business / Institutional Property Impacts	No direct impacts, access to agricultural businesses in southwest and northeast quadrants can be maintained. No impacts	No direct impacts, access to agricultural businesses in southwest and northeast quadrants can be maintained No impacts	No direct impacts, access to agricultural businesses in southwest and northeast quadrants can be maintained No impacts
ALR Impacts	1.53 ha	0.87 ha **(lowest area impacted)**	1.32 ha
Noise Impacts	Interchange terminals away from residential uses, will create additional stop / start traffic noise Low to Moderate Impacts	Loop in northwest quadrant adjacent to established residential area Moderate Impacts	Interchange terminals away from residential uses, roundabouts will limit stop / start traffic noise Neutral to Low Impacts
Visual Impacts	Interchange terminals away from residential uses, some lighting spillover Neutral to Low Impacts	Loop in northwest quadrant will require removal of treed buffer area adjacent to established residential area Moderate Impacts	Interchange terminals away from residential uses, some lighting spillover Neutral to Low Impacts
Effect on Non-Motorized Travel Modes	Multi-use pathway on either side will require intersection treatment to reduce turning conflicts Neutral to Moderate Improvement	Opportunity for multi-use path on east side which would avoid all traffic conflict Moderate to Significant Improvement	Benefits from reduced vehicle entry speeds and pedestrian priority, however, multi-lane junctions can be challenging for on-road cyclists Neutral to Moderate Improvement

Criterion/Option	Option 2: Diamond	Option 4: Parclo A-B	Option 6: Diamond with Roundabouts
Environmental Account			
GHG Impacts	1.2% increase in GHGs over base case **(lowest increase)**	1.6% increase in GHGs over base case	1.4% increase in GHGs over base case
Terrestrial Impacts	2.72 ha of area required Low Impacts	5.07 ha of area required including wooded area in northwest quadrant Moderate Impacts	2.32 ha of area required **(smallest area required)** Low Impacts
Aquatic Impacts	Minimal to low impact to creek crossing southeast quadrant Low Impacts	Minimal to low impact to creek crossing southeast quadrant Low Impacts	Minimal to low impact to creek crossing southeast quadrant Low Impacts
Archaeological / Historical Impacts	Low Impacts	Low Impacts	Low Impacts
Special Constructability Considerations	No significant constraints, conflicts, or issues	No significant constraints, conflicts, or issues	No significant constraints, conflicts, or issues
Financial Account			
Capital Cost	**$43.3 M**	**$45.8 M**	**$38.0 M**
Capital Cost ($2014)	$39.7 M	$42.0 M	$34.8 M
Property Cost ($2014)	$3.4 M	$10.0 M	$2.9 M
Maintenance and Rehabilitation Cost ($2014)	$0.3 M	$0.3 M	$0.3 M
Salvage Value ($2014)	$2.6 M	$4.3 M	$2.2 M
Net Present Value ($2014)	$69.2 M	$68.3 M	$64.2 M
Overall Benefit Cost Ratio	**2.69**	**2.42**	**2.79**

5.0 RECOMMENDED OPTION

By assigning a cumulative score to each option based on the individual scores received in each category, the highest scoring option is Option 2 (Diamond Interchange). This Option also has the highest Net Present Value.

Although Option 6 was found to have the lowest capital cost, there were several capacity and operational issues with the roundabout configurations that preclude its recommendation as a preferred option, as described below:

- The southbound movement entering the north terminal would operate with a volume in excess of capacity. This is a primary movement exiting the east Walnut Grove area and would require over 1,400 vehicles in the 2045 PM per hour to yield to circulating traffic made up of Highway 1 westbound to 216 Street southbound off-ramp traffic (500 vehicles per hour) and the 216 Street northbound to Highway 1 westbound traffic (275 vehicles per hour). Even if a channelized slip lane were provided to separate southbound right-turns from entering the roundabout, volumes would exceed 90% of capacity which is not desirable for good roundabout level of service.
- There are potential safety and operational issues associated with imbalanced entry flows. At a diamond interchange such as proposed in Option 6, there would be no traffic entering the north terminal from the west approach, or the south terminal from the east approach. This implies that the northbound and southbound movements respectively would become accustomed to entering the north and south roundabouts without having to yield to traffic already circulating in the roundabout. This creates an occasional conflict risk when legal u-turns occur within the roundabouts and the dominant movements are forced to yield unexpectedly. A similar conflict risk can occur in off-peak hours when turning movements to/from Highway 1 are less frequent and north-south movements dominate. The occasional vehicle turning left to or from the Highway 1 ramps may be challenged to receive right-of-way from the higher volume, multi-lane north-south traffic. Similar issues can be observed at roundabouts at the Highway 99 / 8 Avenue interchange in South Surrey and at the Mount Lehman Road / South Fraser Way intersection in Abbotsford.

It is recommended that Option 2 be considered for future implementation and taken to functional design such that the further detail can be added in terms of implementation costs, right-of-way requirements, and identification of conflicts. Any carry forward issues can also be identified more clearly through the functional design process.