McTAVISH ROAD INTERCHANGE – A ROUNDABOUT SOLUTION

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Abstract:

The McTavish Interchange project near Victoria BC replaces an at-grade, signalized intersection on Highway 17 with a full movement, grade-separated interchange. The busy Highway 17 corridor, with peak hour volumes currently exceeding 3,500 vehicles (both directions), connects the Provincial capital to the Victoria International Airport, the Swartz Bay ferry terminal, and the communities of the Saanich peninsula.

The project directly or indirectly addresses all modes of transportation by improving safety and reducing travel time for motorists on Highway 17, improving service to the international airport and ferry terminal, accommodating Rapid Bus service on the interchange ramps, expanding local transit operations by incorporating a 6-bay transit exchange and 200 stall park & ride lot, and providing specific measures to promote and safeguard pedestrians and cyclists. The interchange configuration features multi-lane modern roundabouts at the ramp terminals to efficiently distribute traffic and to maintain effective connections to the local road network. Another, smaller and single lane roundabout is used to accommodate movements in and out of the transit exchange and park & ride area.

The creative use of roundabouts offered operational and connectivity advantages that were otherwise unavailable with more common signalized intersection solutions, and reflects the BC Ministry of Transportation and Infrastructure's policy to consider roundabouts *"as the first option for intersection designs"*. Through analysis, (SIDRA and VISSIM), the multi-lane roundabouts were confirmed capable of accommodating peak hour volumes exceeding 2,600 vehicles, (corresponding to 4,900 vph on Highway 17) at the 2035 forecast horizon.

With the added benefits of idling reduction and greater transit usage, the McTavish Interchange project not only results in a safer environment for the traveling public, but also results in more efficient energy use, better air quality, and reduced greenhouse gas emissions. Total project cost is estimated at approximately $28 million, cost-shared by the Government of British Columbia, Government of Canada, BC Transit and the Victoria Airport Authority.

Visit the project website at
http://www.th.gov.bc.ca/highwayprojects/hwy_17_McTavish_Interchange/index.htm

PROJECT BACKGROUND

Highway 17 (locally known as the Patricia Bay Highway) serves as a gateway to the Capital Region and to the whole of Vancouver Island by virtue of its service to the BC Ferries terminal at Swartz Bay and to the Victoria International Airport. As the primary north south corridor on the Saanich Peninsula, Highway 17 also serves an important role for travel within the Capital Regional District.

Over the last few decades the Ministry of Transportation and Infrastructure (BC MoT) has worked collaboratively with municipalities and other interested agencies on a range of transportation studies, culminating in the recently completed ***Highway 17 Corridor Planning Strategy*** *(Urban Systems, March 2007).* This *Corridor Strategy* was developed to guide the investment and implementation of long-term corridor improvements with the support of local municipalities and other stakeholders. The key planning principles used to shape the ultimate *Corridor Strategy*, and also relevant to the McTavish Interchange project included:

- The corridor should be a four-lane highway with a posted speed of 90 km/hr;
- All major roadways crossing and intersecting with the Highway should connect to the highway with grade-separated interchanges;
- Provide effective connections to the Victoria International Airport; and
- Promote regional goals for direct, express bus services along the corridor and support infrastructure needs as part of the interchange concepts;

The *Corridor Planning Strategy* highlighted the fundamental features of the long-term plan and, in particular, identified the preferred interchange locations within the study area. McTavish Road had previously been identified in the ***Vision for Highway 17*** document *(Earth Tech, October 2001)* as a candidate location for an interchange, and this earlier conclusion was confirmed in the *Corridor Strategy*. The McTavish Road intersection location is identified within the context of the greater Saanich Peninsula in ***Figure 1***, and illustrated in greater detail in ***Figure 2***.

As part of the federal stimulus program, this project required an aggressive schedule for all work components. The project was announced at the Conceptual design stage in April, 2009 and is currently in construction with an anticipated construction completion date prior to the March 31, 2011 funding deadline. A comprehensive construction staging strategy and tendering strategy was required to meet this aggressive schedule. In all, 4 separate Major Works Contracts were tendered by the Province of BC, including pre-purchase of steel girders for the two structures. Additionally, other preparatory works were completed by Day Labour (hired equipment) under the direction of BC MoT representatives.

FIGURE 1 – Project Location

FIGURE 2 – Project Area

PROJECT OBJECTIVES

The principal objectives for this project reflect the priorities of the various funding partners. Each objective could be supported by each funding partner, however the relative importance of each objective was a topic of much discussion throughout the project's evolution. The principal objectives are briefly discussed below.

- ***Replace Signalized Intersection***
  Of primary importance to the BC MoT, replacing the signalized intersection with an interchange will improving safety, efficiency and reliability of Highway 17 corridor by eliminating the congestion associated with the existing at-grade intersection.

- ***Improve Connections to/from Victoria International Airport***
  The Victoria International Airport was the 9th busiest in Canada in 2009 (behind Winnipeg and ahead of Kelowna). The airport serviced 1.53 million passengers and accommodated 91,200 itinerant aircraft movements. With continued growth anticipated for the airport operations, ensuring reliable and efficient connections between the airport and greater Victoria was of primary importance to the Victoria Airport Authority.

- ***Maintain ALL Connections to Local Road Network***
  This objective was the subject of considerable discussion throughout the project, and ultimately became one of the determinants for selection of the preferred interchange configuration. Maintaining all connections to the local road network is deemed invaluable for facilitating emergency response service, for local transit service, and for cross-highway connectivity of active transportation corridors. These connections were of primary importance to the local municipalities and BC Transit.

- ***Incorporate Transit and Active Transportation Objectives***
  BC Transit's Master Plan for service throughout the Saanich Peninsula identified the need to accommodate 'Rapid Bus' service on Highway 17, and to provide a 200 stall park & ride lot and a 6 stall transit exchange on the west side of Highway 17 at the McTavish Interchange. These enhanced transit services and facilities will replace the existing, smaller park and ride lot and promote a greater shift toward transit use.

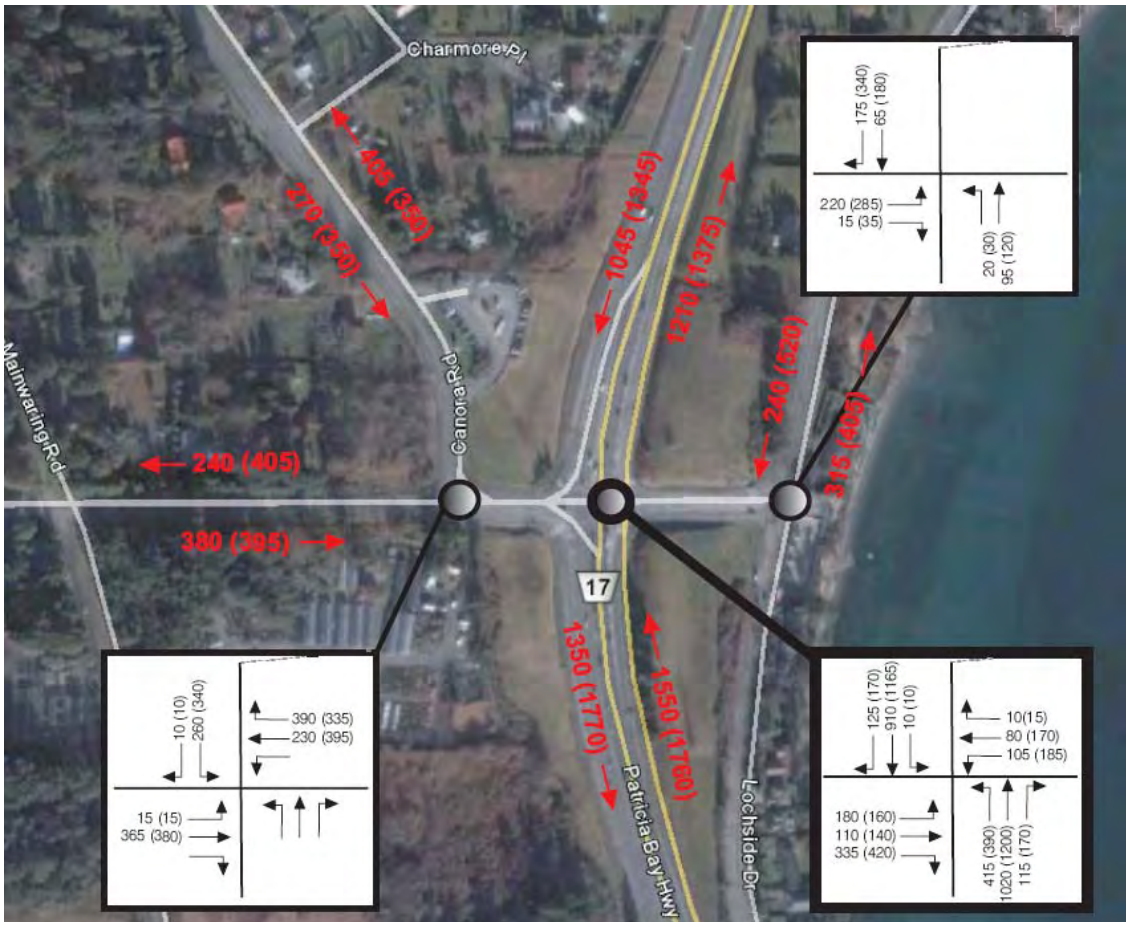
  The regional Lochside Trail recreational corridor extends the entire length of the peninsula and provides an excellent environment for commuter and recreational cyclists. Preserving this corridor was a fundamental project objective, and providing a safe and convenient connection between the Lochside Trail and the East Saanich Road cycling corridor was of primary importance to local cycling groups, residents and the affected municipalities.

TRAFFIC DATA

Existing Highway 17 traffic data was obtained from available BC MoT sources and supplemented by traffic counts conducted over two consecutive days in April 2009. The traffic count locations included the intersections of McTavish Road /Canora Road and McTaivsh Road / Lochside Drive.

Base (2009) traffic volumes for the project area were then established by combining the traffic data described above, performing balancing between intersections and manually adjusting traffic volumes for consistency with other traffic count data previously collected (McElhanney, 2005 and MoT Highway 17 Permanent Count Stations Data, 2008). The resulting base traffic volumes for 2009 are illustrated in ***Figure 3***.

FIGURE 3 – 2009 AM (PM) Base Traffic Volumes



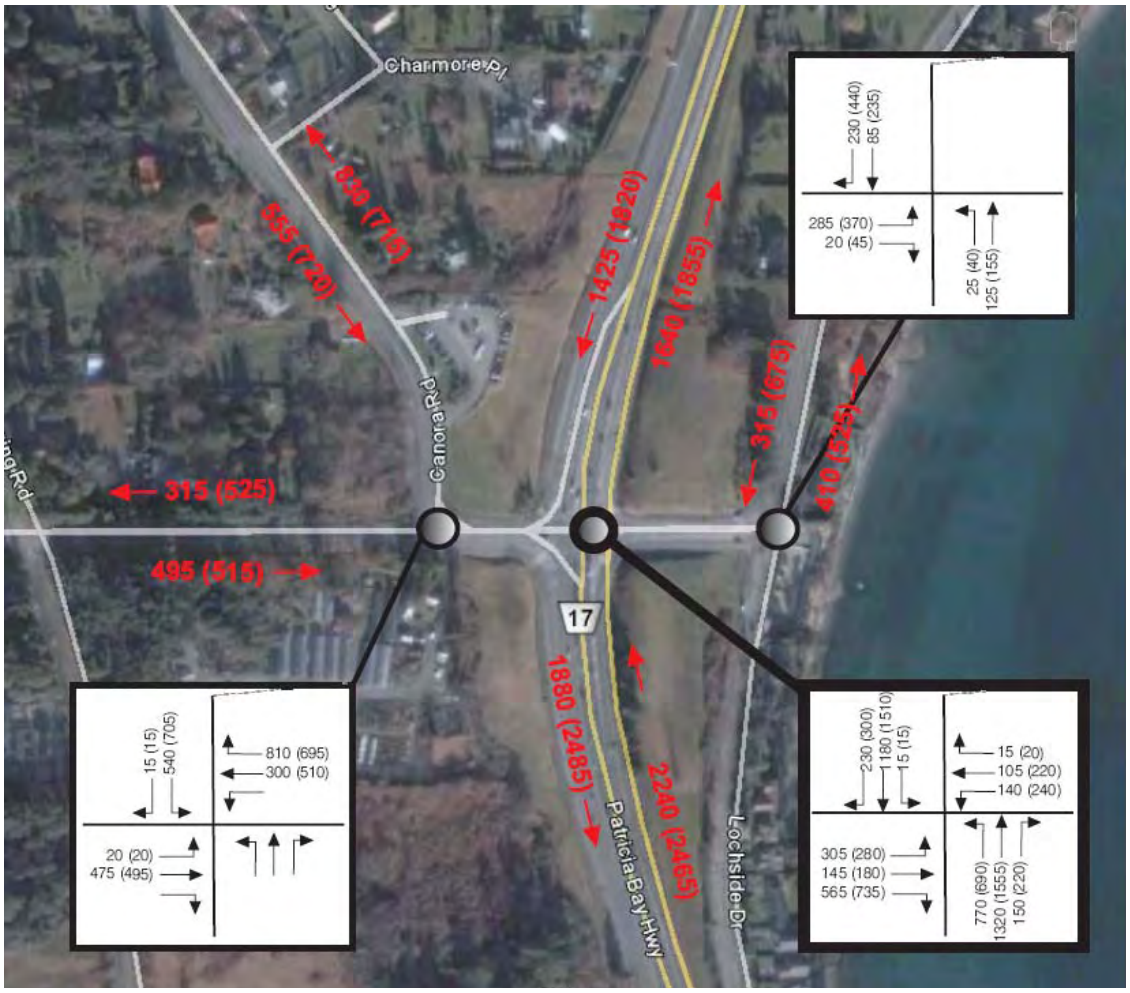
Information regarding forecast traffic volumes was obtained from the Capital Regional District's (CRD's) recently prepared TransCAD model. This model includes the 2006 and 2036 horizon years for both the AM and PM peak hours. The CRD model indicated annual compound growth rates ranging from

approximately 0.3%/yr to 0.8%/yr. To remain slightly conservative, an average base growth rate of 1.0% was assumed for this project and applied to the Highway 17 corridor and surrounding network.

As part of its Master Plan, the Victoria Airport Authority (VAA) has identified an expected growth rate of 3.0%/year for airport related traffic. Although the CRD's model indicates a lower growth relative to this area, this model is noted to be regionally focused and does not necessarily account for detailed site specific growth. Therefore, to be conservative, and to remain consistent with VAA's anticipated growth, a 3%/year compound growth rate was applied to airport related traffic volumes. It was assumed that as much as 90% of the traffic utilizing Canora Road is originating from, or is destined to the airport.

The resulting forecast traffic volumes for the 2035 design horizon (being 25 years beyond a 2010 opening for the interchange) are illustrated in ***Figure 4***.

FIGURE 4 – 2035 AM (PM) Forecast Traffic Volumes



INTERCHANGE CONFIGURATION OPTIONS

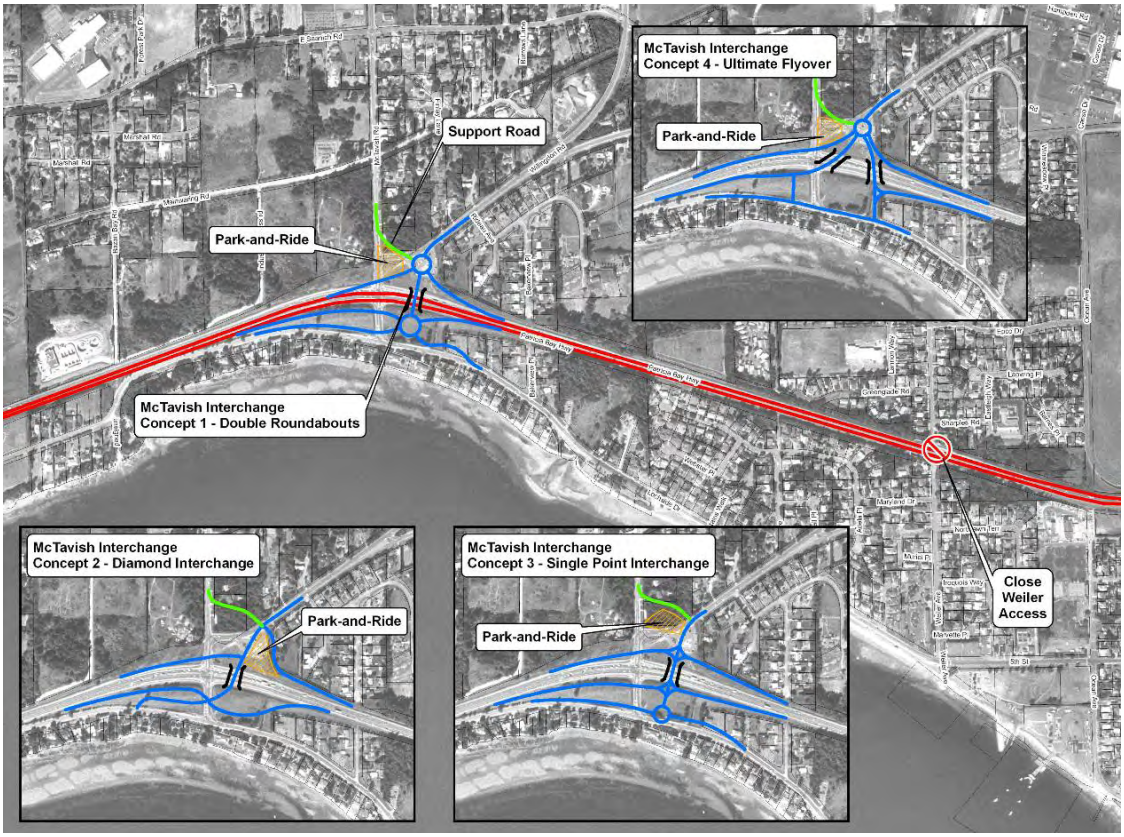
Since 2001 the BC MoT worked with local municipalities and the Victoria Airport Authority (VAA) on the development of options for the McTavish Road Interchange. An initial 'preferred' concept, illustrated in ***Figure 5***, was selected by the stakeholders based on a high level review of ten or more alternative concepts.

FIGURE 5 – Initial 'Preferred' Concept – BC MoT

A subsequent ***Concept Development and Evaluation Study*** *(McElhanney, May 2007)* identified and evaluated additional interchange configurations for McTavish Road based on forecast 2026 traffic demands and a 90 km/h, four lane expressway standard for Highway 17. The McElhanney work produced the four interchange concepts illustrated in ***Figure 6***. Of these, Concept 4 was ultimately selected as the "preferred" concept, and additional effort was invested to develop a staged implementation strategy for this concept.

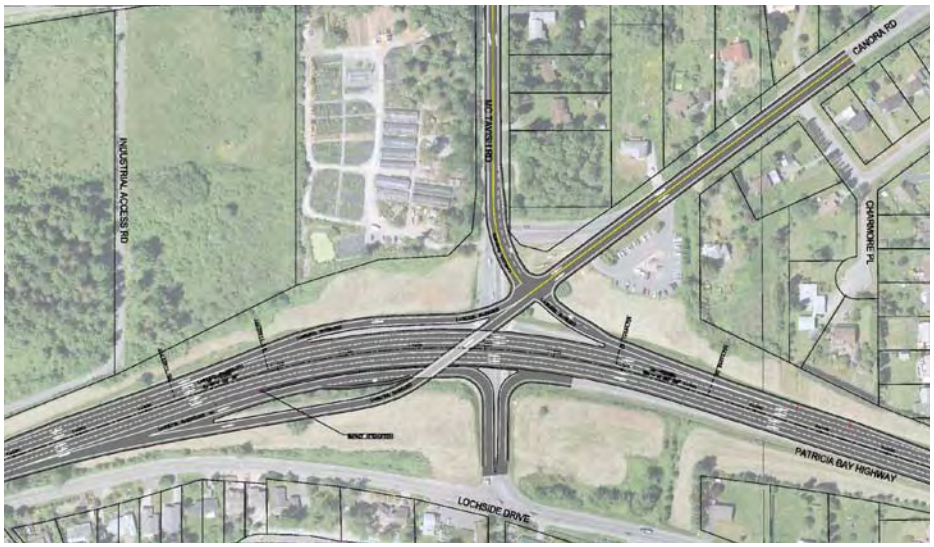
Subsequent scrutiny of Concept 4 revealed a variety of concerns for BC MoT. The estimated construction cost was at the upper end of affordability at that time, and the concept was considered to have inherent safety and operational issues. Consequently, MoT initiated another options development exercise with Urban Systems based on a revised set of project objectives. Of primary significance was a relaxing of the requirement to accommodate **all** movements at the interchange.

FIGURE 6 – Concept Development and Evaluation Study



Of the three new concepts developed by Urban Systems, a flyover option with directional ramps (illustrated in ***Figure 7***) was initially preferred because it met the ***primary*** project objectives while keeping the anticipated costs within range of the available budget.

FIGURE 7 – FLYOVER OPTION



McElhanney

URBANSYSTEMS.

However, stakeholder feedback from BC Transit, VAA and the neighbouring municipalities suggested that an interchange concept that did not accommodate all movements would not be supported. This feedback required that the project objectives be again revisited.

A review of all previous concepts revealed that they shared one common characteristic; each was based on the highway remaining in it's existing location, and at it's existing elevation. Understandably, this was a natural assumption in order to limit construction costs, but it automatically disadvantaged the cross-road profile. The proximity of Highway 17 and Lochside Drive necessitated relatively steep grades between the two roadways to ensure sufficient vertical clearance at the highway crossing. Additionally, the convergence of McTavish Road and Canora Road on the west side of the highway increases the number of movements that need to be accommodated in close proximity to the highway. It was suggested that this complication could be simplified by removing the McTavish connection to Highway 17, and re-directing McTavish traffic along East Saanich Road to Willingdon Road (at the roundabout) before returning to the highway intersection.

This strategy gave rise to yet another preferred concept that reversed the orientation of the crossing roadways and removed the McTavish connection, resulting in the "Tight Diamond" concept illustrated in ***Figure 8.*** To respect constructability and traffic management objectives, this Tight Diamond option consumed the majority of the available right-of-way on the west side of the highway, which required that the transit exchange and park & ride lot be located in different quadrants on the east side of the highway .

To better accommodate BC Transit's objectives for a combined transit facility on the west side of Highway 17, a competing concept incorporating roundabouts into a conventional diamond interchange configuration was developed. This 'Roundabout' option also reverted back to an orientation wherein the side road crosses over the highway. This configuration was made possible by realigning and raising Lochside Drive, which overcame previous issues with steep grades on the overpass. The original 'Roundabout' option is illustrated in ***Figure 9***.

The 'Roundabout' option is also consistent with the BC MoT "Roundabouts First" Policy, which was developed in support of BC's Climate Action Program of 2007. This policy requires that:

- *"Roundabouts shall be considered as the first option for intersection designs where 4-way stop control or signals are supported by traffic analysis."*
- *"If an intersection treatment other than a roundabout is recommended, the project documentation should include a reason why a roundabout solution was not selected for that location."*

FIGURE 8 – Tight Diamond Option

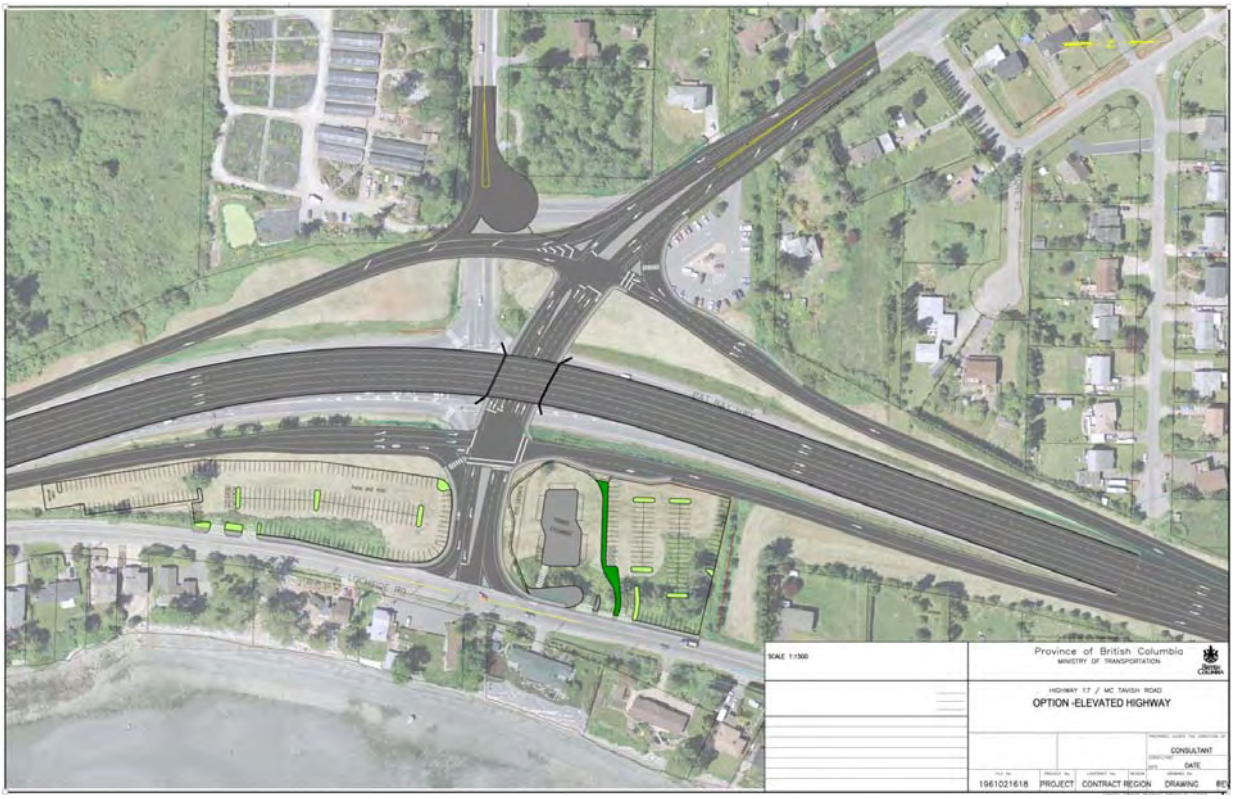
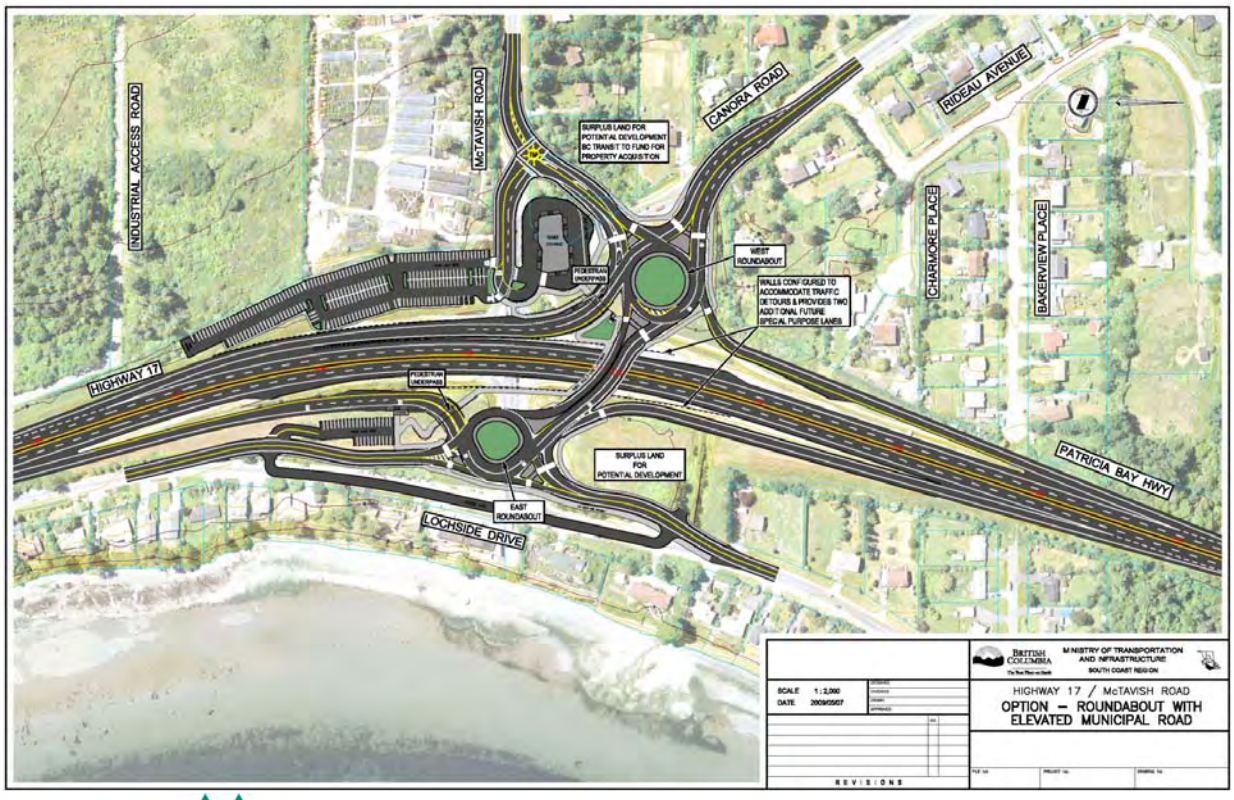


FIGURE 9 – Roundabout Option



The defining characteristics of the competing options are summarized in ***Table A***.

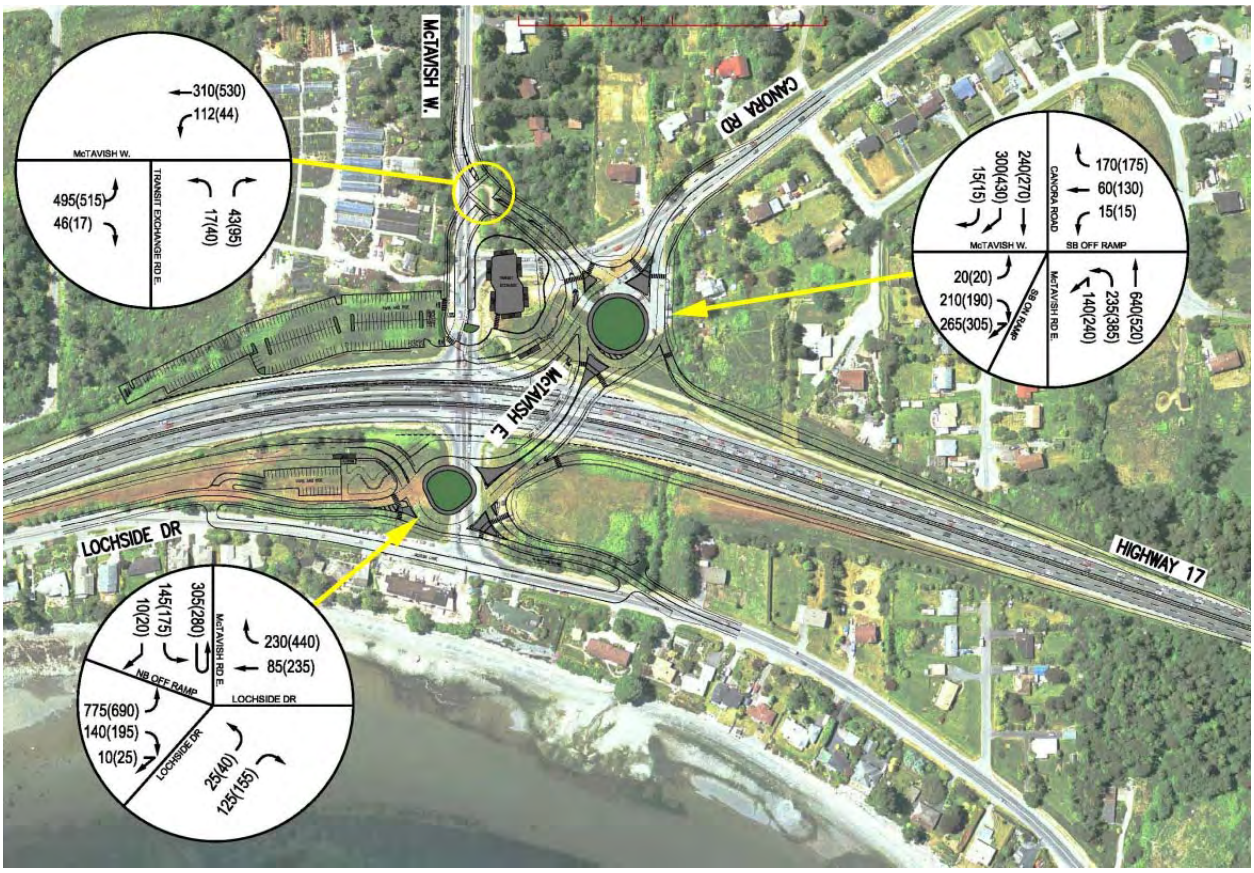
TABLE A – OPTION CHARACTERISTICS

ACCOUNT	TIGHT DIAMOND OPTION	ROUNDABOUT OPTION	COMMENTS
Intersection Type at Ramp Ends	Signalized	Roundabouts	Roundabouts preferred by BC MoT and local Municipalities. Signals preferred by BC Transit.
Orientation	Elevated Highway	Elevated Cross Road	
Transit Exchange Location	East of Highway	West of Highway	Location west of highway preferred by BC Transit. For tight diamond option, the transit exchange and park & ride lot would be in separate quadrants.
McTavish Connection	Partial	Full	Full connection preferred by most stakeholders
Surplus Land	Less (none)	More	NE quadrant available for sale and development with Roundabout Option
Property Acquisition Requirements	No	Yes	Realignment of McTavish in Roundabout Option requires acquisition of property (funded by BC Transit)

OPERATIONAL ANALYSIS

The forecast traffic volumes for the 2035 design horizon were applied to each of the competing interchange configurations to determine their respective operational performance characteristics. The forecast traffic volumes were increased to include traffic generated by the transit facilities (60 vph in the AM and PM) for the transit exchange and 158 trips (AM) and 136 vph (PM) for the park & ride lot). These forecast volumes are overlain on the 'Roundabout' option in ***Figure 10*** for reference.

FIGURE 10 - 2035 AM (PM) Traffic Volumes



Operational performance of the 'Tight Diamond' option was analyzed using Synchro/Simtraffic (v.7) software. The software was also used to optimize the timings and splits for the signalized ramp intersections. Operational performance of the 'Roundabout' option was analyzed with SIDRA. Both of these software packages are ideal for assessing intersection operations, but do not provide operational performance for highway merge and diverge areas. Consequently VISSIM was used to provide LOS for highway operations. The VISSIM model also provided a network simulation, suitable for presentation purposes.

Analysis of the 'Tight Diamond' option, for both AM and PM peak periods, indicated that all traffic movements at both signalized intersections experiencing a LOS of 'C' or better, with overall intersection LOS 'B' or better. For the unsignalized intersection of Lochside Drive / Canora Road, HCM reporting from Synchro indicates LOS 'C' or better for all movements. These results and others are summarized in ***Table B***.

TABLE B – 2035 OPERATIONAL PERFORMANCE – TIGHT DIAMOND

MOVEMENT	TIME PERIOD	WEST RAMP INTERSECTION	EAST RAMP INTERSECTION	LOCHSIDE INTERSECTION
Overall Intersection Performance	2035 AM	LOS A	LOS B	LOS B
	2035 PM	LOS B	LOS B	LOS A
Worst Movement	2035 AM	SB Left LOS B (19.9 s)	WB Through LOS C (24.2 s)	EB Left LOS B (12.4 s)
	2035 PM	EB Through LOS C (25.5 s)	WB Through LOS C (24.0 s)	EB Left LOS C
From Airport to Victoria	2035 AM	EB Right LOS A	n/a	n/a
From Victoria to Airport	2035 PM	WB Through LOS A	NB Left LOS B (18.2 s)	n/a

Analysis of the "Roundabout" option showed very similar results, with all traffic movements at both roundabouts experiencing a LOS of C or better, with overall intersection LOS 'B' or better. These results and others are summarized in ***Table C***.

TABLE C – 2035 OPERATIONAL PERFORMANCE – ROUNDABOUT

MOVEMENT	TIME PERIOD	WEST RAMP INTERSECTION	EAST RAMP INTERSECTION
Overall Intersection Performance	2035 AM	LOS A	LOS B
	2035 PM	LOS B	LOS B
Worst Movement	2035 AM	McTavish EB LOS A (8.8 s)	NB Off-Ramp LOS B (12.4 s)
	2035 PM	McTavish EB LOS C (25.4 s)	NB Off-Ramp LOS B (20.5 s)
From Airport to Victoria	2035 AM	Canora SB LOS B	n/a
From Victoria to Airport	2035 PM	McTavish WB LOS A	NB Off-Ramp LOS C (20.5 s)

All three software packages (Synchro, SIDRA and VISSIM) will provide emissions data. However, results may not be directly comparable between different software packages due to varying methodology. Therefore, the tight diamond interchange was also analyzed with SIDRA to enable a fair comparison of emissions and fuel consumption characteristics between the two interchange concepts. These comparisons are summarized in ***Table D*** and ***Table E*** respectively. The environmental superiority of the roundabout concept is clearly evident in these results.

TABLE D – EMISSIONS COMPARISON

OPTION	TIME PERIOD	EMISSIONS (kg/hr)			
		CO_2	HC	CO	NO_x
Tight Diamond	2035 AM	972	1.67	76.5	2.33
	2035 PM	1,342	2.24	107	3.25
Roundabouts	2035 AM	637	1.03	37	1.10
	2035 PM	818	1.37	49.5	1.44
Difference	AM	-35%	-38%	-52%	-53%
	PM	-39%	-39%	-54%	-56%

TABLE E – FUEL CONSUMPTION COMPARISON

OPTION	TIME PERIOD	FUEL CONSUMPTION (l/hr)
Tight Diamond	2035 AM	325
	2035 PM	425
Roundabouts	2035 AM	255
	2035 PM	185
Difference	AM	-21%
	PM	-56%

OPTIONS ANALYSIS

The competing interchange configuration options were subjected to a comparative evaluation using a multiple account analysis methodology. The various 'accounts' considered community impacts, transit and active transportation objectives, operational performance characteristics, emissions and fuel consumption predictions, constructability issues, stakeholder support, and estimated project costs. Stakeholder support became an important determinant through this exercise, particularly as it related to maintaining all connections to the existing road network.

Table F provides a summary of the Multiple Account Evaluation results. The Roundabout option was deemed to produce equal or better outcomes for all accounts except 'constructability'. This lone exception was not considered significant so, overall, the Roundabout option was the clear favourite. Consequently the Roundabout option was recommended for advancement to detailed design and implementation, with the refinements listed below.

- Add a separate pedestrian / cyclist overpass to better address active transportation objectives
- Replace the "T" intersection at McTavish Road / transit access with a single lane roundabout
- Increase the east roundabout to 55 m ICD
- Optimize the roundabout approaches to control entry speed and deflection

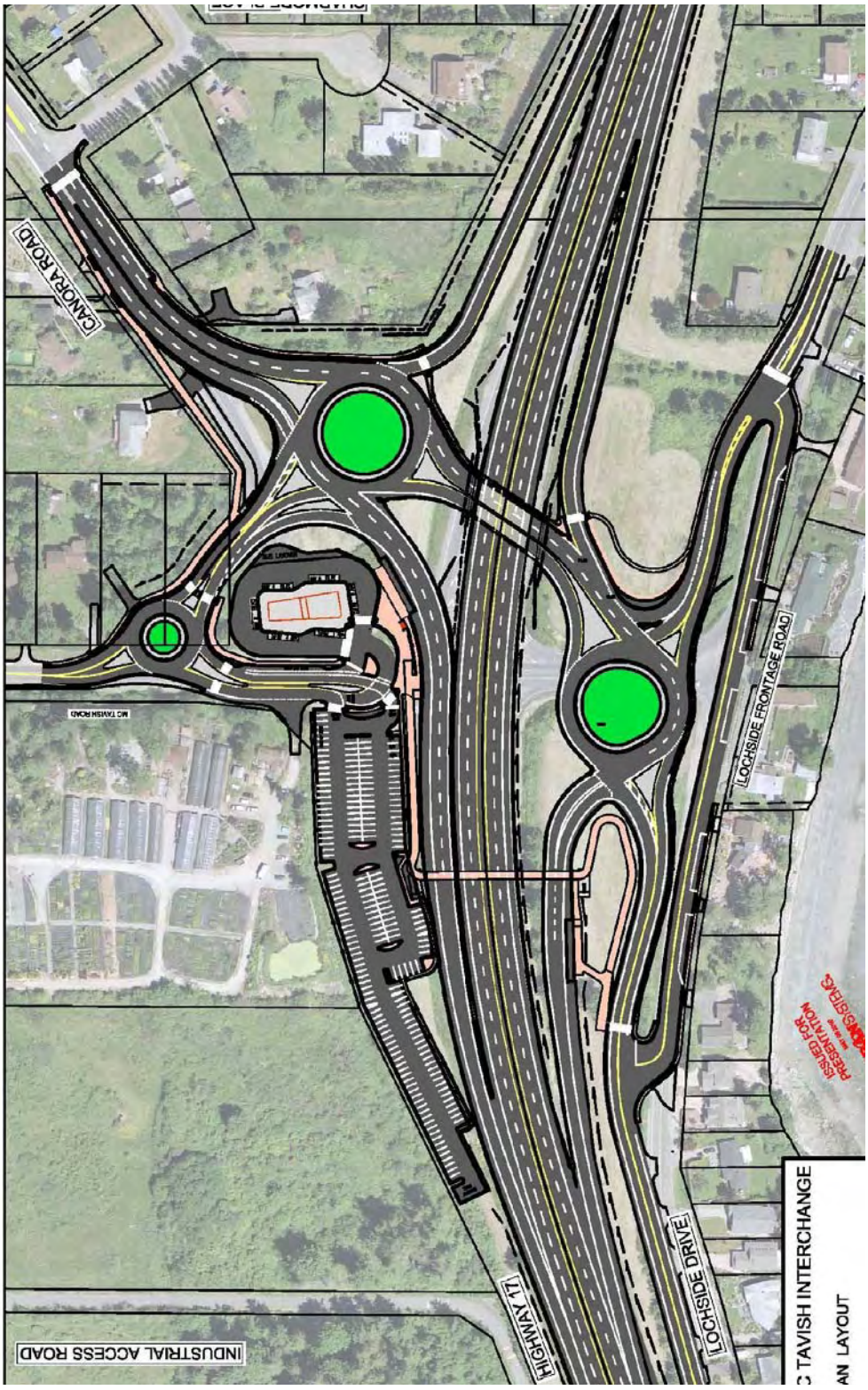
TABLE F – MULTIPLE ACCOUNT EVALUATION SUMMARY

ACCOUNT	TIGHT DIAMOND OPTION	ROUNDABOUT OPTION	COMMENTS
Community Impacts	🔴	🟢	Connectivity and noise benefits with Roundabout option
Transit / Active Transportation	O	O	Modal shift encouraged with both options.
Traffic Operations	O	O	Both operate well at design horizons
Emissions / Fuel Consumption	🔴	🟢	Substantial benefits for the Roundabout option
Constructability	🟢	🔴	Tight diamond option maintains all movements during construction
Stakeholder Support	🔴	🟢	Strong support for Roundabout Option from local municipalities
Cost	O	O	Both options in $24 million range

🔴 Less Desirable O Neutral 🟢 More Desirable

The refined Roundabout concept is illustrated in ***Figure 11***.

FIGURE 11 – Refined Roundabout Concept



CONCLUSIONS

The application of modern roundabouts in a conventional tight diamond interchange configuration offered significant advantages for the McTavish Road interchange project. In addition to respecting the BC MoT Policy of "Roundabouts First", the roundabout solution was deemed more effective than the familiar signalized intersection solution because:

- It maintained efficient connections to the existing road network and accommodated all existing movements;
- It provided robust operational performance at design horizon;
- It resulted in reduced carbon emissions and fuel consumption;
- It allowed an integrated transit facility to be located on the west side of Highway; and
- It created a gateway opportunity for the local municipalities and the Victoria Airport.

Given these outcomes, the innovative use of roundabouts in interchange design will undoubtedly be more popular for years to come.

With the added benefits of idling reduction and greater transit usage, the McTavish Interchange project not only results in a safer environment for the traveling public, but also results in more efficient energy use, better air quality, and reduced greenhouse gas emissions.