

Highway 97 / Stickle Road Safety Review FINAL REPORT



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1. Introduction

1.1. Background

The intersection of Highway 97 at Stickle Road north of Vernon (LKI Segment 1120, km 5.03) has been the subject of numerous safety assessments, analyses, and intersection improvement studies over the past several years. These studies by the Ministry of Transportation and Infrastructure (MoTI) identified this as a collision prone intersection and there is consideration to implement safety improvements. A functional design (Binnie, May 2016) was prepared based on a restricted movement unsignalized improvement option; however, prior to progressing to the detailed design stage, MoTI has requested that an independent safety review be undertaken to consider both a signalization option, and an improvement option of restricting left turns and through movements from Stickle Road onto Highway 97.

The two improvement options are described in greater detail as follows:

1. A signalized intersection, including improved auxiliary acceleration and deceleration lanes for right turn movements, and deceleration and increased storage for left turn movements off of Highway 97.
2. An unsignalized intersection with full movements on Highway 97 but prohibits left turns from Stickle Road onto Highway 97, as well as prohibits eastbound/westbound Stickle Road through movements across Highway 97. This option also provides improved auxiliary acceleration and deceleration lanes on Highway 97 for right turn movements, and deceleration lanes and increased storage for left turn movements off of Highway 97. Together with this configuration, a southwards extension of the eastside Frontage Road to 20th Street has been proposed. This 20th Street connection will provide an alternate route for the existing westbound left-out movement from Stickle Road onto Highway 97 southbound. The role and function of this new connection is included as part of this review.

1.2. Context

The existing Highway 97 / Stickle Road intersection, shown in *Figure 1*, has the following features:

- A full-movement unsignalized intersection with a two-way stop control on the east-west minor approaches
- The highway within the vicinity of Stickle Road is divided by a raised median, with a combination of open shoulder drainage and asphalt curb and gutter
- A median truck weigh scale for Highway 97 northbound and southbound traffic is located approximately 830 m north of Stickle Road (measured from the centerline of Stickle to the start of the northbound taper to the truck weigh scale).
- The 27 Street interchange is located approximately 560 m to the south (measured from the centerline of Stickle to the gore point of the 27 Street northbound on-ramp), with no median barrier beyond the left turn lane.
- The highway has an annual average daily traffic volume (AADT) of approximately 26,000 veh/day, with northbound and southbound through volumes in the order of 1,000 to 1,500 veh/hr depending on the direction and peak period. These highway through volumes represent approximately 95% of the total volume entering the intersection.
- The summer average daily traffic volumes (SADT) is approximately 50% greater than the AADT.
- The posted speed is 90 km/h; however, the recorded 85th percentile operating speed is 99 km/h

- The east leg of Stickle Road links Highway 97 with Pleasant Valley Road, a 2-lane, 60 km/h rural undivided minor arterial running parallel to Highway 97 and extending from Greenhow Road in the north to Silver Star Road in Vernon to the south
- There is an existing at-grade rail crossing on Stickle Rd approximately 35m west of Highway 97 which is without gates or other warning system.

Land uses adjacent to the Highway 97 / Stickle Road intersection include the Silver Star RV and Camping Park on the west (servicing both camping and RV tourists as well as a small number of permanent mobile home residents), and numerous light industrial and commercial businesses along a Frontage Road to the east. South of the Stickle Road intersection and between Highway 97 and Pleasant Valley Road is a 10.5 hectare parcel known as Anderson Ranch where a residential development of 345 single family lots has been proposed.

Figure 1. Highway 97 / Stickle Road Intersection Layout and Features



2. Document Review and Findings

In addition to a site visit undertaken in July 2016, a comprehensive review was done of previous relevant project reports, namely:

- Option Evaluation and Business Case - Highway 97/ Stickle Road Intersection Improvements (Urban Systems January 2015)
- Traffic and Safety Analysis for Highway 97 Intersections at Stickle Road & Highland Road (McElhanney, September 2013)
- Stickle Road - Protected-T Option Review (Binnie, May 2015)
- Stickle Road and 20th Street Extension Traffic Analysis Memo (Binnie, October 2015)
- Highway 97 Stickle Road Intersection Improvements Functional Design (Binnie, May 2016)
- Open House Boards, May 29, 2015 and April 26, 2016 (MoTI)

For the purposes of the study, the following MoTI and other documents were referenced:

- TAC Geometric Design Guide
- BC Supplement to TAC Geometric Design Guide
- Signing and Pavement Marking manuals
- TAC Canadian Guide for In-Service Safety Reviews
- BC MoTI Road Safety Audit Guidelines
- TAC Canadian Road Safety Audit Guide
- Transport Canada Grade Crossing Standards
- Collision Prediction Models for BC
- Collision Modification Factors for BC

Key findings from the previous projects are provided below.

2.1. Traffic Assessment

i. Traffic Operational Performance

Intersection capacity analysis for the existing and future (year 2040) traffic conditions was performed by R. F. Binnie and Associates. Traffic volume counts were conducted on April 7, 2015 by TransTech. As Highway 97 and Stickle Road traffic volumes are highly seasonal, a 'summer condition' adjustment factor was also applied to the April 2015 data. Based on a review of data from the Ministry's permanent count station on Highway 97A near Armstrong, it was found that on average traffic was approximately 49% higher in August than in April in 2014. To capture this summer demand, a factor of 49% was applied to the April 2015 TransTech traffic volumes. Traffic volumes for the future 2040 summer volume scenario were estimated by applying a 2% growth rate to the 2015 summer traffic volumes. As a result, intersection Level of Service (LOS) reporting for both the 2015 and 2040 horizon years reflect summer volumes and the current two-way stop control (TWSC) condition. Traffic volumes for the summer 2015 condition at the Highway 97 / Stickle Road intersection are shown in *Figure 2*. The results of the intersection capacity analysis are shown in *Table 1*.

Table 1. Highway 97 / Stickle Road 2015 and 2040 Summer Intersection Performance (TWSC)

2015 Existing Summer Traffic Operations											
Intersection	Turning Movement	AM Peak Hour					PM Peak Hour				
		Volume	LOS	Delay (s)	V/C Ratio	95% Q (m)	Volume	LOS	Delay (s)	V/C Ratio	95% Q (m)
Hwy 97 / Stickle Road (TWSC)	EBL	1	F	100.0	0.30	8.5	0	C	20.1	0.06	1.4
	EBT	1					0				
	EBR	13					13				
	WBL	18	F	695.9	1.32	24.5	28	F	Error	11.10	Error
	WBT	0					0				
	WBR	82					C				
	NBL	7	C	16.5	0.02	0.6	15	C	17.8	0.05	1.4
	NBT	1,153	A	-	0.35	-	1,784	A	0.0	0.55	-
	NBR	228	A	-	0.15	-	186	A	0.0	0.12	-
	SBL	74	B	12.2	0.14	3.8	128	C	24.5	0.43	16.7
	SBT	1,705	A	-	0.55	-	1,784	A	0.0	0.57	-
	SBR	3	A	-	0.00	-	3	A	0.0	0.00	-
	Int. LOS			A					F		

2040 Summer Traffic Operations											
Intersection	Turning Movement	AM Peak Hour					PM Peak Hour				
		Volume	LOS	Delay (s)	V/C Ratio	95% Q (m)	Volume	LOS	Delay (s)	V/C Ratio	95% Q (m)
Hwy 97 / Stickle Road (TWSC)	EBL	2	F	Error	27.64	Error	0	F	53.7	0.24	6.9
	EBT	2					0				
	EBR	21					21				
	WBL	30	F	Error	Error	Error	46	F	Error	Error	Error
	WBT	0					0				
	WBR	134					225				
	NBL	11	E	38.6	0.59	27.3	25	F	669.9	2.28	171.2
	NBT	1,891	E	42.3	0.11	2.9	25	F	57.2	0.28	8.5
	NBR	374	A	-	0.58	-	2,926	A	0.0	0.90	-
	NBR	374	A	-	0.24	-	305	A	0.0	0.20	-
	SBL	121	D	27.3	0.45	17.9	210	F	594.0	2.11	155.2
	SBT	2,796	A	-	0.89	-	2,926	A	0.0	0.94	-
	SBR	5	A	-	0.00	-	5	A	0.0	0.00	-
Int. LOS		F					F				

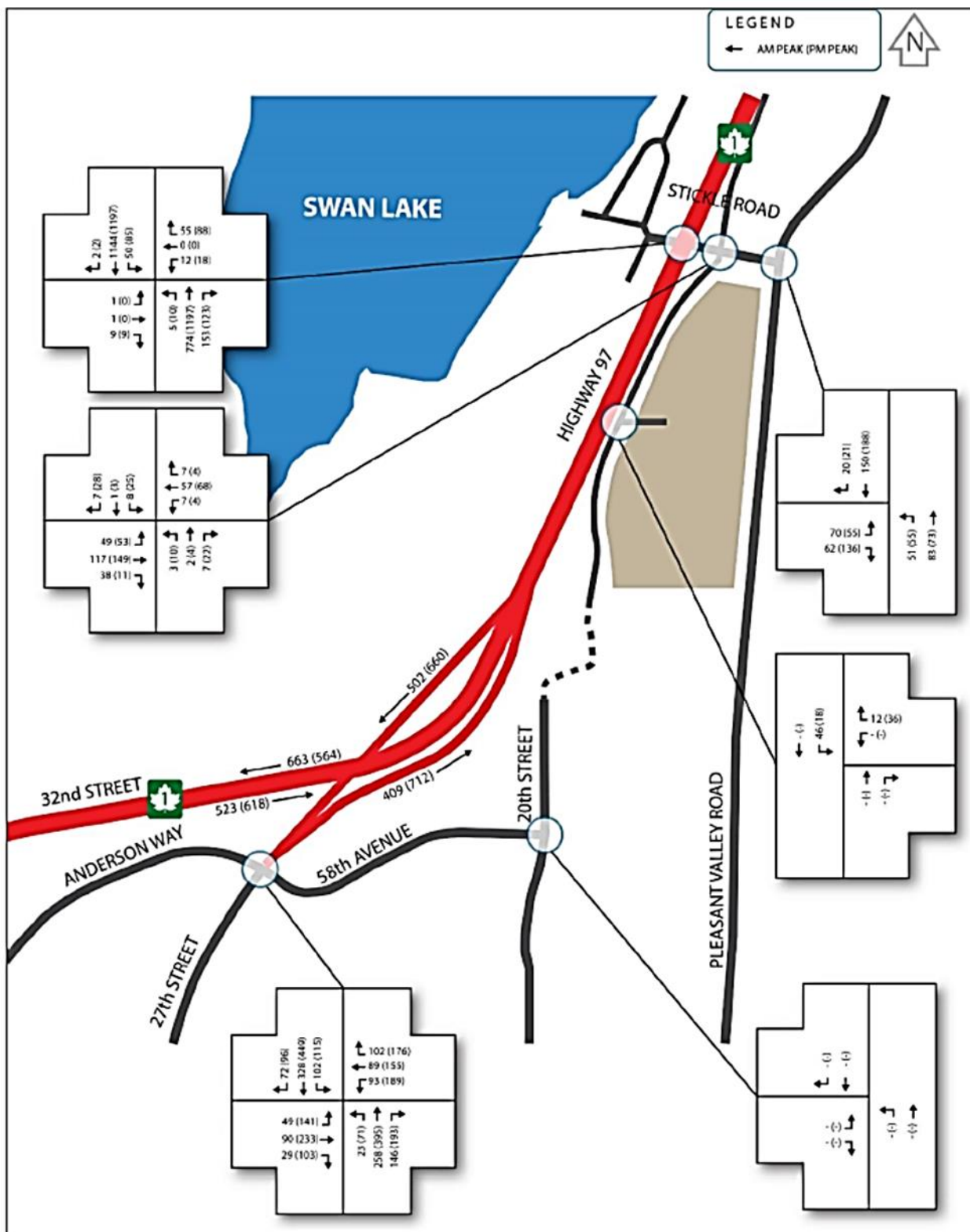
2015 Existing Spring Traffic Operations											
Intersection	Turning Movement	AM Peak Hour					PM Peak Hour				
		Volume	LOS	Delay (s)	V/C Ratio	95% Q (m)	Volume	LOS	Delay (s)	V/C Ratio	95% Q (m)
Hwy 97 / Stickle Road (TWSC)	EBL	1	D	27.1	0.07	1.8	0	B	14.0	0.02	0.6
	EBT	1					0				
	EBR	9					9				
	WBL	12	F	68.7	0.19	5.1	19	F	368.7	0.87	20.9
	WBT	0					0				
	WBR	55					92				
	NBL	5	B	11.5	0.01	0.2	10	B	12.0	0.02	0.5
	NBT	774	A	-	0.24	-	1,197	A	-	0.37	-
	NBR	153	A	-	0.10	-	125	A	-	0.08	-
	SBL	50	A	9.7	0.07	1.7	86	B	12.8	0.17	4.8
	SBT	1,144	A	-	0.37	-	1,197	A	-	0.38	-
	SBR	2	A	-	0.00	-	2	A	-	0.00	-
	Int. LOS			A					A		

2040 Spring Traffic Operations											
Intersection	Turning Movement	AM Peak Hour					PM Peak Hour				
		Volume	LOS	Delay (s)	V/C Ratio	95% Q (m)	Volume	LOS	Delay (s)	V/C Ratio	95% Q (m)
Hwy 97 / Stickle Road (TWSC)	EBL	2	F	432.2	0.95	21.3	0	C	22.8	0.07	1.9
	EBT	2					0				
	EBR	15					15				
	WBL	20	F	Error	3.03	Error	31	F	Error	27.82	Error
	WBT	0					0				
	WBR	90					151				
	NBL	8	C	16.7	0.24	7.5	16	F	50.3	0.70	37.0
	NBT	1,269	A	-	0.39	-	1,963	C	20.5	0.07	1.8
	NBR	251	A	-	0.16	-	205	A	-	0.13	-
	SBL	82	B	13.4	0.17	4.9	141	D	34.1	0.56	25.5
	SBT	1,876	A	-	0.60	-	1,963	A	-	0.63	-
	SBR	3	A	-	0.00	-	3	A	-	0.00	-
	Int. LOS	F					F				

Source: R. F. Binnie and Associates

Note: Eastbound (EB) and westbound (WB) movements relate to Stickle Rd, while northbound (NB) and southbound (SB) relate to Highway 97. LOS F results are highlighted in red; summer conditions reported.

Figure 2. Highway 97 / Stickle Road Summer 2015 AM (PM) Traffic Volumes



Source: Stickle Road and 20th Street Extension Traffic Analysis Memo – DRAFT Rev. 2 (Binnie October 14 2015)

Based on the traffic analysis conducted it was determined that under the summer 2015 existing condition the westbound through and left-turn movements currently fail (LOS F) during both the AM and PM peak hours. The eastbound movement also fails during the 2015 summer AM peak hour. The northbound left turn movement is LOS C for both 2015 summer AM and PM periods, while the southbound left turn is LOS B/C (2015 summer AM peak/PM peak respectively). Overall the intersection operates at LOS A during the AM peak and LOS F during the 2015 summer PM peak.

In the 2040 horizon year, it is expected that both eastbound and westbound movements will fail during summer AM and PM peak hours. The northbound and southbound left-turn movements also fail (LOS F) during the 2040 summer PM peak. Although turning movement volumes from Stickle Road are relatively low, even for the 2040 horizon, vehicle delay is significant due to the lack of available gaps in north-south Highway 97 traffic. Overall the intersection operates at LOS F during both 2040 summer AM and PM peak periods.

ii. Queueing

A traffic operational performance analysis was done for the Highway 97 / Stickle Road intersection if it were to be signalized (Binnie, May 2015). The analysis was done for the years 2014, 2024, 2029 and 2039, and the results of that analysis are provided in [Table 2](#). It is evident from the analysis that delays and queuing occur for the westbound left turn and through (WBL/T) movements from Stickle Road to Highway 97. This is due to the amount of green time required to accommodate the high traffic volumes on the highway relative to the side road volumes. Queuing for the westbound left turn and through movements is expected to impact performance at the Stickle Road/Frontage Road intersection.

The diversion scenarios presented in [Table 2](#) refer to diversion to the signalized intersection at Stickle Road from Pleasant Valley given the improved access to the highway under a signalization option. This also explains why the higher diversion percentages result in increased delay and reduced LOS for the intersection overall (this is not always the case for individual movements due to timing plan optimization).

Under a traffic signal scenario where approximately 50% of traffic currently using Pleasant Valley Road divert to the Highway 97/Stickle Road intersection, westbound queues on Stickle Road are expected to block access to the Frontage Road by 2024 during the PM peak. During the 2029 period (assuming a 50% diversion to the Highway 97/Stickle Road intersection), northbound queuing remains modest at approximately 100 m.

By 2039 however, analysis shows significant queuing on the highway even under a no diversion scenario, where northbound traffic backs up to the 27 Street on-ramp. This not only introduces significant delays and idling on the highway, but also increases the risk of rear-end collisions on the on-ramp approaching Highway 97 due to accelerating on-ramp vehicles encountering the back of a traffic queue immediately after the 27 Street on-ramp left-hand curve. These queues are reflected in [Figure 3](#) for the best case, no diversion scenario. The 50% diversion scenario analyses show significantly longer queues on both Highway 97 and 27 Street northbound as well as on Stickle Road westbound, as highlighted by the shaded cells in the table.

Table 2. Highway 97 / Stickle Road Signalized Intersection Performance – Summer Conditions

2014 Traffic Operations													
Intersection	Turning Movement	No Traffic Diversion				PM Peak Hour 50% Traffic Diversion				100% Traffic Diversion			
		LOS	Delay (s)	V/C Ratio	95% Q (m)	LOS	Delay (s)	V/C Ratio	95% Q (m)	LOS	Delay (s)	V/C Ratio	95% Q (m)
Highway 97 at Stickle Road (Full Signal)	EBL/T/R	A	0.2	0.01	-	A	0.3	0.01	-	A	0.3	0.01	-
	WBL/T	C	21.1	0.16	17.7	C	24.1	0.51	27.9	D	48.5	0.73	44.9
	WBR	A	1.3	0.06	-	A	1.3	0.06	-	A	1.4	0.06	-
	NBL	B	10.4	0.02	4.2	B	13.9	0.03	5.1	A	5.1	0.03	4.3
	NBT	A	7.4	0.67	48.5	A	9.3	0.73	54.1	B	14.1	0.86	71.4
	NBR	A	3.2	0.08	-	A	3.5	0.09	-	A	3.9	0.11	-
	SBL	B	12.9	0.22	19.1	B	18.6	0.26	20.8	B	19.3	0.32	23.4
	SBT	A	2.7	0.55	28.5	A	5.5	0.64	41.8	A	6.3	0.75	44.8
	SBR	A	-	-	-	A	1.9	-	-	A	1.4	-	-
Int. LOS		B (13.6 s)				B (18.3 s)				B (19.1 s)			
2024 Traffic Operations													
Highway 97 at Stickle Road (Full Signal)	EBL/T/R	A	0.3	0.01	-	A	0.3	0.01	-	A	0.3	0.01	-
	WBL/T	C	29.9	0.24	18.8	D	50.8	0.82	58.9	F	86.5	1.02	91.6
	WBR	A	1.3	0.07	-	A	1.5	0.07	-	A	2.6	0.07	-
	NBL	B	10.7	0.04	5.2	C	24.0	0.05	5.4	B	15.8	0.06	7.0
	NBT	A	9.3	0.81	58.9	B	12.9	0.88	90.0	B	19.9	0.92	120.7
	NBR	A	3.8	0.10	-	A	4.6	0.11	-	A	5.2	0.11	-
	SBL	C	20.4	0.36	23.6	C	27.4	0.49	35.1	D	37.1	0.51	28.5
	SBT	A	4.6	0.71	45.3	A	6.4	0.79	48.0	A	8.5	0.83	67.9
	SBR	-	-	-	-	A	2.7	-	3.2	-	-	-	-
Int. LOS		B (18.2 s)				C (24.8 s)				C (28.4 s)			
2029 Traffic Operations													
Highway 97 at Stickle Road (Full Signal)	EBL/T/R	A	0.2	0.02	-	A	0.2	0.02	-	A	0.3	0.02	-
	WBL/T	C	34.3	0.34	25.4	E	67.7	1.25	67.8	F	124.5	1.55	152.1
	WBR	A	1.3	0.08	-	A	1.4	0.08	-	A	6.7	0.08	18.0
	NBL	C	33.1	0.05	8.1	C	23.0	0.07	4.8	C	23.3	0.07	5.6
	NBT	B	15.0	0.89	101.1	B	15.7	0.94	97.9	C	33.1	0.95	125.2
	NBR	A	5.4	0.11	-	A	5.7	0.12	36.0	C	21.6	0.12	49.4
	SBL	C	26.5	0.45	26.8	D	38.9	0.60	57.3	D	46.6	0.65	34.9
	SBT	A	7.4	0.78	57.0	A	6.9	0.83	2.0	A	7.2	0.87	65.6
	SBR	A	2.4	-	-	A	2.3	-	-	-	-	-	-
Int. LOS		C (26.0 s)				C (29.0 s)				D (40.6 s)			
2039 Traffic Operations													
Highway 97 at Stickle Road (Full Signal)	EBL/T/R	A	0.2	0.02	-	A	0.2	0.02	-	A	0.2	0.02	-
	WBL/T	D	49.3	0.51	26.4	E	68.0	1.19	114.0	F	107.6	1.94	1060.3
	WBR	A	1.5	0.09	-	A	4.6	0.09	-	B	10.9	0.09	-
	NBL	F	93.6	0.07	6.3	F	234.3	0.07	59.3	F	336.0	0.07	59.9
	NBT	F	120.9	1.09	613.5	F	234.7	1.14	1476.8	F	323.8	1.14	2066.4
	NBR	F	110.1	0.13	180.9	F	221.9	0.14	217.6	F	307.3	0.14	198.0
	SBL	D	46.3	0.81	36.8	D	52.3	0.84	37.9	D	52.8	0.84	40.5
	SBT	A	8.6	0.97	81.7	B	14.2	1.02	112.3	B	12.5	1.02	96.8
	SBR	A	6.1	-	2.4	A	5.1	-	-	A	2.7	-	-
Int. LOS		F (83.0 s)				F (154.9 s)				F (236.9 s)			

The v/c ratio, also referred to as the degree of saturation, represents the sufficiency of an intersection to accommodate the vehicular demand. A v/c ratio less than 0.85 generally indicates that adequate capacity is available and vehicles are not expected to experience significant queues and delays. As the v/c ratio approaches 1.0, traffic flow may become unstable, and delay and queuing conditions may occur. Once the demand exceeds the capacity (a v/c ratio greater than 1.0), traffic flow is unstable and excessive delay and queuing is expected. Under these conditions, vehicles may require more than one signal cycle to pass through the intersection.

Table 2 also illustrates how vehicle performance is not linearly proportional to increasing time, particularly when demand approaches or exceeds capacity. For example, the increase in delay and queuing between the 2029 and 2039 horizon years significantly exceeds the increase in delay and queuing between the 2014 and 2024 period. This is because by the 2039 horizon, demand at the Highway 97/Stickle Road intersection exceeds capacity and so any additional traffic volume results in queuing and associated delays

Figure 3. Highway 97 / Stickle Road Queuing for a Signalized Intersection (2039)



Source: Hwy 97 Stickle Road Intersection Queue Length Concept Drawings (Binnie, May 2015)

iii. Signal Warrant Assessments

Signal warrant assessments are used to determine the appropriateness of traffic signal installation at candidate locations. MoTI Electrical and Traffic Engineering Design Guidelines (April 2013) clearly state that ‘*an engineering study shall be conducted to determine if the installation of a traffic signal will improve the overall safety and/or operation of the intersection. If these requirements are not met, a traffic signal should not be put into operation nor continued to operate, if already installed*’ (Section 402.3). The rationale for this is that if a signal is installed at a location where it is not warranted, it may result in a decrease in traffic performance and/or safety.

MoTI and TAC signal warrant assessments were done for the study intersection to determine if indeed a signal is warranted at this location (McElhanney, 2013). The MoTI warrant assessment takes several factors into account, and the results of the assessment for each factor are provided in [Table 3](#). As seen, none of the warrant criteria are satisfied.

Table 3. MoTI Signal Warrant Assessment Results at the Highway 97 / Stickle Road Intersection

MoTI Warrants	Warrant Satisfied (Yes/No)
1) Minimum Vehicular Volume	No
2) Interruption of Continuous Traffic	No
3) Progressive Movement	No
4) Accident Experience	No
5) System Warrant	No
6) Combination Warrant	No
7) Four Hour Volume	No
8) Peak Hour Delay	No
9) Peak Hour Volume	No

Source: *Traffic and Safety Analysis for Highway 97 Intersections at Stickle Rd and Highland Rd*

For the TAC warrant, a Warrant Score of 100 points, and a traffic volume exceeding 75 vehicles for a six-hour period for one leg of the intersection, indicates that a signal may be warranted. The score at this intersection is 68 points, and the side road volume is less than 75 vehicles, indicating a signal is not warranted at this intersection. Right turn volumes are excluded from the warrant analysis since right turn vehicles are able to slip by the westbound through and left turn vehicles. This approach is consistent with Ministry signal warrant analysis guidelines.

iv. Adjacent At-Grade Rail Crossing

A review of Transport Canada’s Grade Crossing Standards (July 2014) Section 9 Warning Systems Specification indicates that for a public grade crossing within 60 m of an adjacent signalized intersection, a warning system with gates is required (for rail design speed is 25 km/hr or greater). For non-signalized intersections, this distance is reduced to 30 m. As the distance between the Highway 97/Stickle Rd intersection and the at-grade rail crossing is 35 m, the introduction of a traffic signal at Highway 97/Stickle Rd will trigger the need for a warning system with gates at the adjacent rail crossing.

v. 20th Street Connection

A traffic analysis was done for the 20th Street connection to examine the impact on the Frontage Road / Stickle Road intersection if restricted left turn movements were implemented at the Highway 97 / Stickle Road intersection (*Stickle Road and 20th Street Extension Traffic Analysis Memo, Binnie, October 2015*). A two-lane north- and southbound connection was assumed in the Binnie analysis. The Highway 97/Stickle Road intersection involved:

- Right in, right out movements to/from Highway 97 and Stickle Road permitted
- Left turn movements into Stickle Road from Highway 97 permitted
- Left out movements from Stickle Road onto Highway 97 prohibited
- Eastbound and westbound through movements on Stickle Road prohibited

The study was done for the years 2015 and 2039, and concluded that the existing two-way-stop-controlled intersection at Stickle Road and Highway 97 Frontage Road is expected to operate acceptably for the horizon year study scenarios based on the most probable traffic diversion and anticipated future trip generations. The intersection continues to operate at an acceptable level even under the “worst-case” scenario, which includes both turn restrictions on Highway 97 and traffic diverting from 27 Street to the 20th Street connection to access the commercial develops on 58 Avenue. (Note the extension of 20th Street is only being considered under a restricted left turn from Stickle Road to Highway 97 scenario, i.e. eastbound and westbound left turns and through movements prohibited).

The 20th Street connection extends the Highway 97 Frontage Road southwards to 20th Street in Vernon (refer to *Figure 1*).

2.2. Safety Assessment

A safety performance assessment was undertaken and included in the report, *Highway 97 / Stickle Road Intersection Improvements, Option Evaluation and Business Case, Urban Systems, January 2015*. Based on 10 years of collision data, the key safety performance indicators and corresponding provincial benchmarks are shown in *Table 4*.

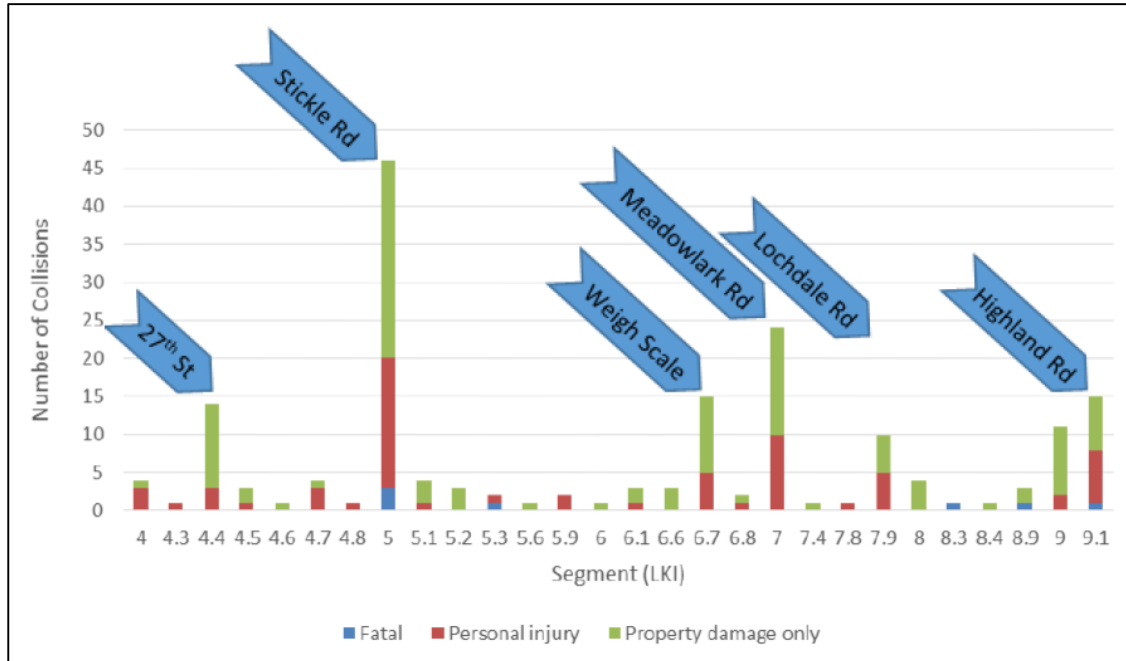
Table 4. Highway 97 / Stickle Road Intersection Safety Performance Indicators (2003 – 2012)

Performance Indicator	Highway 97 / Stickle Road	Provincial Average
Collision Rate (collisions / million veh km)	2.65	0.47
Critical Collision Rate (collisions / million veh km)	0.89	n/a
Severity Index	10.18	5.52

Source: *Highway 97/Stickle Rd Intersection Improvements, Option Evaluation and Business Case (Urban Systems, Jan 2015)*

The safety performance indicators show that both the collision rate and severity index are significantly higher than their respective provincial averages at this intersection when compared to similar facilities. In addition, the data shows a predominant spike in collisions at this intersection relative to other intersections in the near vicinity, as seen in *Figure 4*.

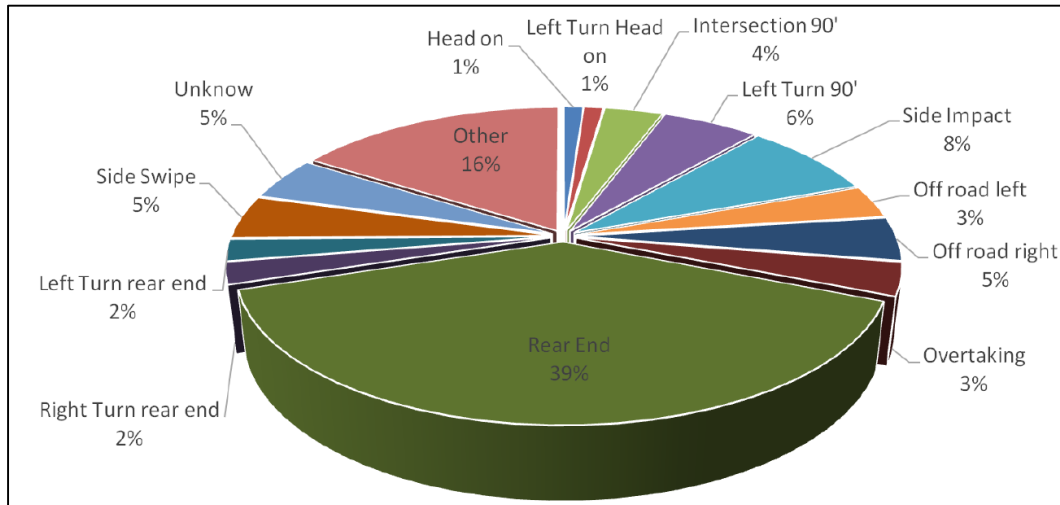
Figure 4. Spatial Distribution of Collisions (2003-2012)



Source: *Highway 97/Stickle Rd Intersection Improvements, Option Evaluation and Business Case (Urban Systems, Jan 2015)*

A summary of the primary collision types is shown in *Figure 5*, demonstrating that rear-end collisions, including left and right turn rear-enders account for approximately 43% of all collision types at this intersection. This is a significant finding particularly for a unsignalized intersection that is free-flow for the dominant highway movements (i.e. two-way stop control for minor approaches only).

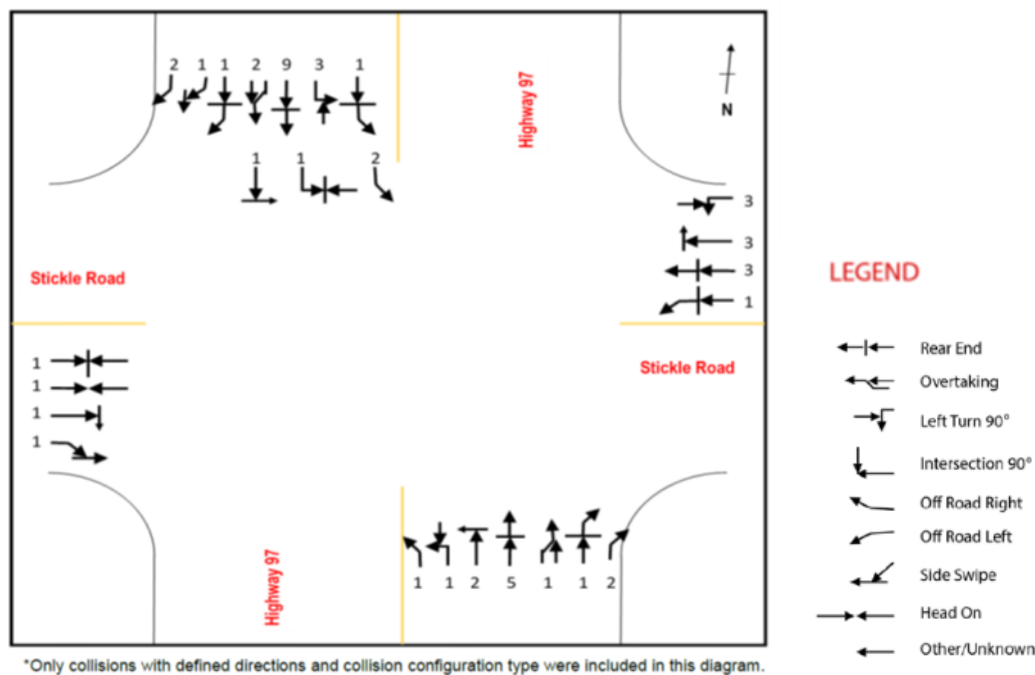
Figure 5. Highway 97 / Stickle Collision Types (2003-2012)



Source: Highway 97/Stickle Rd Intersection Improvements, Option Evaluation and Business Case (Urban Systems, Jan 2015)

The types of collisions that are occurring at the intersection and the directions that vehicles are travelling are reflected in a collision diagram shown in Figure 6. The diagram highlights the occurrence of rear-end type collisions, which appear to be more frequent in the southbound direction. This is supported by the findings of the traffic capacity analysis where traffic exiting Stickle Road likely accepts minimal gaps in Highway 97 north-south traffic to complete the westbound left-out (from Stickle Road onto Highway 97 southbound) turning movement, surprising inattentive highway motorists. In addition, the lack of acceleration and deceleration lanes for entering and exiting traffic likely further contributes to rear-end type collisions, as well as the restricted sight lines at the east leg of Stickle Road.

Figure 6. Collision Diagram at Stickle Road and Highway 97 Intersection



Note: of the three fatalities recorded at Highway 97/Stickle Road between 2003 and 2012, two involved pedestrians. As a result, these are not shown on the collision diagram. The third fatal involved a motorcycle travelling north making a right turn and a truck with camper travelling east with driver inattentive and failing to yield right of way listed as contributing factors.

Further analysis of 10-year collision data (2003-2012) reveals that:

- Over this 10-year period, there were a total of 3 fatal, 18 injury, and 29 property damage only collisions for a total of 50 collisions. This equates to an average of 5 collisions per year.
- Fatal type collisions account for 6%, injury type collisions account for 36%, while property damage only account for 58% of all collisions.
- The average collision severity at Highway 97/Stickle Road is 10.2, which is higher than the Provincial Average of 7.3 for similar intersections (non-signalized RAU4).
- Approximately 84% of collisions occur during daylight hours, which indicates that a proportionate number of collisions occur at night given that traffic during daylight hours account for approximately 85% of daily volumes. This suggests that collisions are not more likely to occur at night.
- Driver inattentive is the number one contributing factor at 20%, followed failing to yield at 12%, followed by poor road conditions (ice, snow, slush) and improper turning, both at 8%. Other contributing factors include ability impaired by alcohol, driver error, driving too fast, and fatigue.

In future, as traffic volumes and corridor congestion increases, headways in highway traffic will reduce, and driver frustration will increase as delays become longer on Stickle Road. It is therefore reasonable to anticipate that these factors may lead to an increase in the frequency and severity of collisions at the Highway 97 / Stickle Road intersection if no improvements are made.

2.3. Collision Modification Factors and Prediction Modelling

In road safety engineering practice, Collision Modification Factors (CMFs) have been developed by researchers and engineering professionals to allow for an improvement in the accuracy of safety improvement assessments. The Collision Modification Factors for British Columbia (2008) safety engineering manual published by the Ministry of Transportation and Infrastructure states the followings:

To evaluate the safety associated with highway improvement projects, the overall safety effect of the improvements is based on the anticipated change (i.e., increase or decrease) in the frequency and/or severity of collisions. The change in safety performance is calculated using what is commonly known in the literature as collision modification factors (CMFs).

A CMF is defined simply as a multiplicative factor used to reflect the expected change in safety performance associated with the corresponding change in highway design and/or the traffic control feature.

Option 1: Traffic Signal

The CMF Clearinghouse database (www.cmfclearinghouse.org) provides CMFs for a large array of geometric and intersection control scenarios. CMFs for installing a traffic signal on a highway with a major road speed limit at least 40 mph (64 km/hr) are provided, and include a CMF of 2.43 for rear-end type collisions. This represents a projected increase in rear-end type collisions of 243% when a traffic signal is installed on a high-speed roadway. Installation of a traffic signal is expected to reduce angle type collisions by 67%, and reduce all collision types by 5% (CMFs for every individual collision type are not provided).

Option 2: Restricted Movements

A review of the Highway Safety Manual (AASHTO 2014 Table 14-25) shows that CMFs have been developed for the geometric modification that restricts left turns and through movements from the minor road approach to a highway intersection (consistent with Option 2 Restricted Movements). These CMFs suggest that rear-end type collisions are reduced by 16%, angle type collisions are reduced by 36%, and that collisions of all types are reduced by 20% relative to the existing unsignalized full-movement condition.

CMFs for both the Traffic Signal and Restricted Movements options are summarized in [Table 5](#).

Table 5. Projected Collisions Based on Collision Modification Factors (CMFs)

Collision Type	Number of Hwy 97/Stickle Rd Collisions Under Existing Condition (2003-2012)	Option 1: Traffic Signal		Option 2: Restricted Movements	
		CMF ¹	Projected 10-yr Collision Frequency	CMF ²	Projected 10-yr Collision Frequency
Rear-end	17	2.43	41	0.84	14
Angle	14	0.33	5	0.64	9
All ³	50	0.95	48	0.8	40

¹CMF Clearinghouse

²Highway Safety Manual

³Includes overtaking, side-swipe, head-on, and other collision types in addition to rear-end and angle types

CMFs available through widely accepted highway safety engineering publications suggest that the installation of traffic signals on roadways where the posted speed exceeds 40 mph (64 km/hr) can provide an overall 5% reduction in crashes, however the frequency of rear-end type collisions can increase substantially. In comparison, the restricted movement configuration (left turn and through movements from minor road prohibited) can result in an overall 20% reduction in crashes.

As a check to the appropriateness of CMFs used in the analysis, a Collision Prediction Model (CPM) was developed based on the Ministry's 2008 methodology (Collision Prediction Models for British Columbia, 2008). Analysis based on the Ministry's CPM methodology confirmed that the Traffic Signal option is expected to increase collisions compared to the unsignalized full movement (existing) condition, particularly for severe type collisions, while the Restricted Movements option is expected to reduce collisions relative to the unsignalized full movement condition.

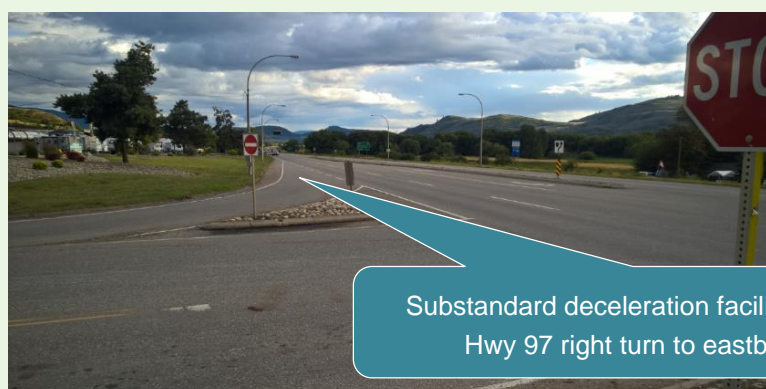
3. Site Safety Review

A number of potential safety issues at the Highway 97 / Stickle Road intersection were identified during a site visit on July 15, 2016. Descriptions and mitigation measures for each are provided here.


Observation		
Item	Safety Concern	Potential Mitigation Measure
1	Southbound Acceleration Lane An acceleration lane is not provided in the southbound direction on Highway 97 for the eastbound right turn from Stickle Road. Vehicles entering Highway 97 southbound directly into the southbound through movement from the stop position, introducing a risk of rear end type collisions as entering vehicles may not be able to reach highway speeds within available gaps.	Auxiliary Lanes A southbound acceleration lane should be provided in accordance with BC Supplement to TAC to reduce the risk of rear end type collisions in the southbound direction.




Observation		
Item	Safety Concern	Potential Mitigation Measure
2	Northbound Deceleration Lane The northbound right turn facility from Highway 97 at Stickle Road is a direct taper (i.e. no parallel deceleration lane segment). As a result, there is a risk of northbound rear-end type collisions on the approach to the Stickle Road intersection as well as a risk of northbound right-turning vehicles taking the turn at inappropriately high speeds and crossing the centreline on Stickle Road, resulting in a collision on Stickle Road.	Auxiliary Lanes Provide deceleration lane geometry in accordance with the requirements of the BC Supplement to TAC Figure 710.H Rural Arterial Intersection layout (i.e. 100 m parallel deceleration lane). A northbound deceleration lane will reduce the risk of northbound rear end type collisions, and collisions related to excessive turning speeds to Stickle Road.



Observation		
Item	Safety Concern	Potential Mitigation Measure
3	<p>Northbound Acceleration Lane</p> <p>There is currently no northbound acceleration lane for westbound right turn movements from Stickle Road. Traffic entering a 90 km/h facility is subject to a yield condition and, therefore enters the highway at a low speed, raising the risk of rear end collisions by inattentive motorists. Similar to the southbound direction, this introduces a risk of rear end type collisions as entering vehicles may not be able to reach highway speeds within available gaps.</p>	<p>Auxiliary Lanes</p> <p>Provide acceleration lane geometry in accordance with the requirements of the BC Supplement to TAC Figure 710.L (i.e. 210 m parallel acceleration lane). A northbound acceleration lane will reduce the risk of rear end type collisions in the northbound direction.</p>



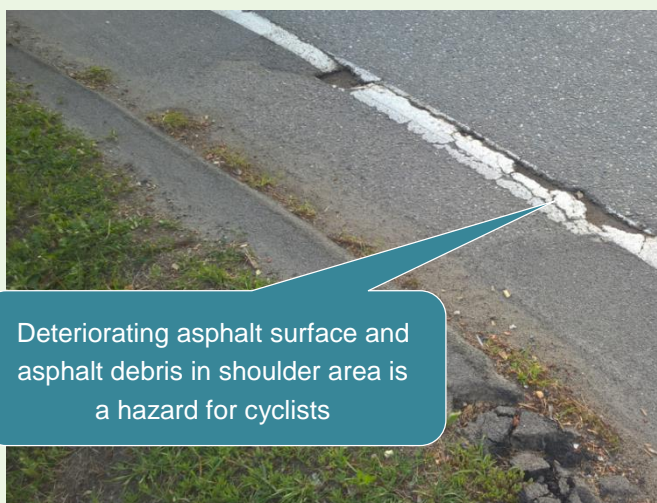
Observation		
Item	Safety Concern	Potential Mitigation Measure
4	<p>Left-out Movement from Stickle Road</p> <p>Evidence of tire skid marks in the Highway 97 northbound fast lane supports documented reports of rear-end and intersection 90 degree type collisions at the Highway 97 / Stickle Road intersection. During the night-time component of the safety review, brake lights on Highway 97 north- and southbound vehicles were observed when vehicles were entering from Stickle Road. This is further evidence of the regular conflict between highway movements and left-out movements from Stickle Road where entering vehicles have insufficient gaps to reach highway speeds increasing the risk of rear-end and left-turn 90° type collisions.</p>	<p>Prohibited Left Turns</p> <p>Although it is not conclusive which vehicle movement conflict resulted in the skid marks, previous collision analysis (McElhanney September 2013 and Urban Systems January 2015) does conclude that rear-end collisions account for 43% of total collisions. Restricting left-out movements from Stickle Road (along and providing acceleration/deceleration lanes) is expected to improve overall intersection safety relative to both the existing condition and signalization option.</p>



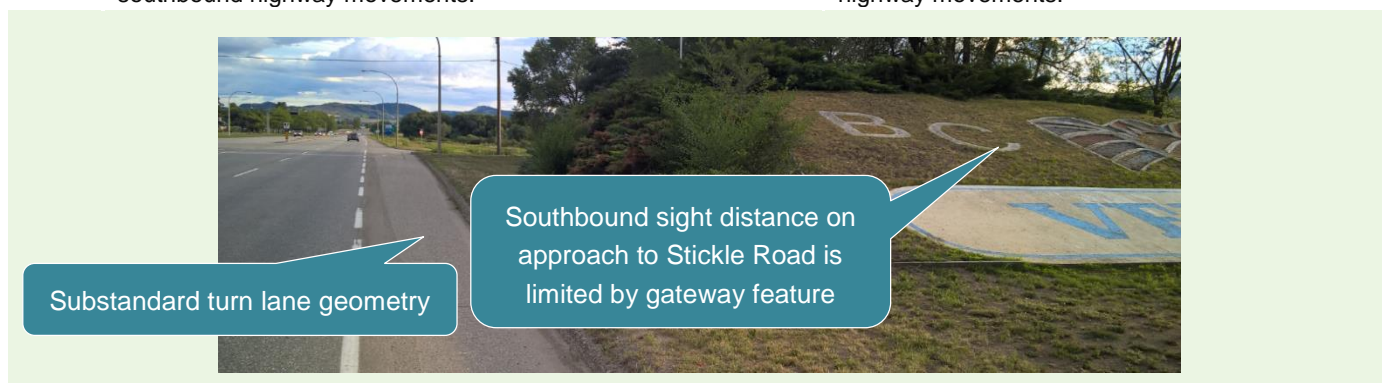
Observation		
Item	Safety Concern	Potential Mitigation Measure
5	<p>Intersection Spacing</p> <p>The spacing between the Frontage Road and the Highway 97 intersection on Stickle Road is approximately 40 m. This results in limited sight distance and perception/reaction time between vehicles exiting at the Frontage Road and northbound right turning vehicles from Highway 97 entering Stickle Road eastbound. Reduced perception/reaction time increases collision risk. Due to the current deficiency in the northbound auxiliary lane (Item 2), this problem is compounded as vehicles leaving Highway 97 to travel eastbound on Stickle are more likely to do so at relatively high speeds.</p>	<p>Sight Distance</p> <p>Provide northbound right turn deceleration laning in accordance with BC Supplement to TAC, and maximize spacing between the Highway 97 and Frontage Road intersections to reduced turning speed of exiting vehicles and provide greater separation between conflicting vehicle movements. W-6 warning signage (intersection ahead) for northbound right turning traffic could also be considered.</p>



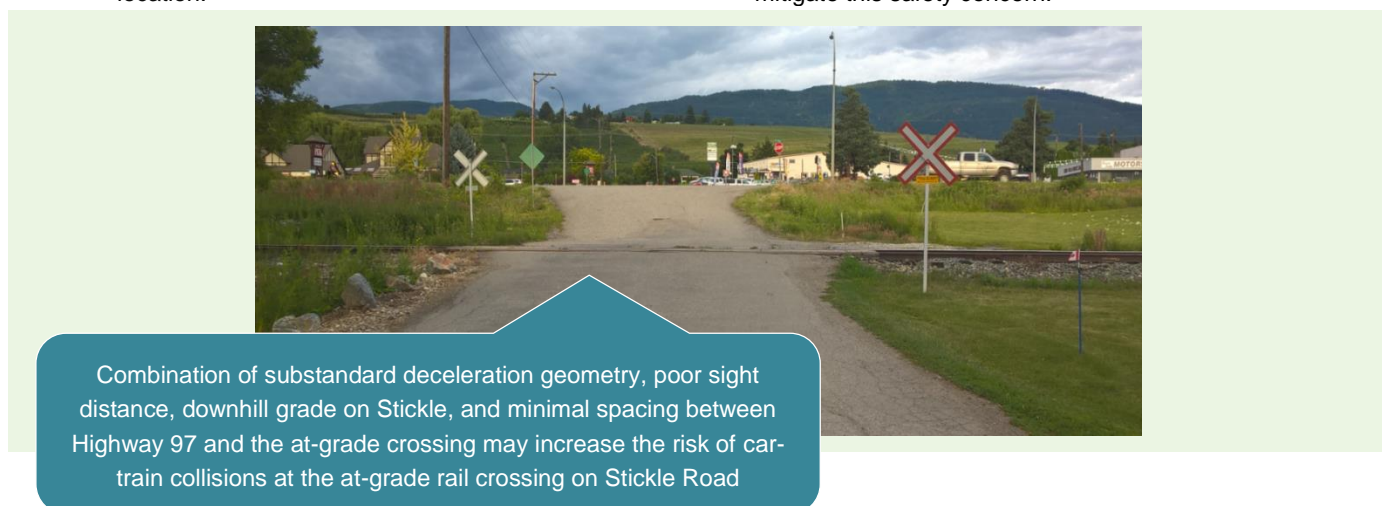
Observation		
Item	Safety Concern	Potential Mitigation Measure
6	<p>Deteriorating Asphalt Surface and Curb</p> <p>Deteriorating asphalt and asphalt curb was observed along the shoulder of the northbound right turn lane. This is considered a hazard for cyclists as it presents unexpected obstacles/uneven surface within the cycling travel portion of the roadway.</p>	<p>Pedestrians / Cyclists</p> <p>Deteriorating asphalt surface should be repaired and asphalt debris removed from shoulders to create a hazard free and even riding surface for cyclists.</p>



Observation		
Item	Safety Concern	Potential Mitigation Measure
7	<p>Southbound Deceleration Lane and Landscaping</p> <p>The approach to the southbound right turn to Stickle Road westbound has a substandard design: deficient deceleration lane, taper, and lane width. In addition, the west leg of Stickle Road is hidden from southbound Highway 97 vehicles by the landscaped gateway feature entering Vernon. This results in several safety concerns, namely reduced roadside safety through the absence of a standard shoulder (greater risk of southbound right-turning vehicles hitting the asphalt curb), and a reduction in the available turning sight distance for westbound vehicles exiting Stickle Road which may result in conflict with southbound highway movements.</p>	<p>Auxiliary Lanes Sight Distance</p> <p>Provide deceleration lane geometry in accordance with the requirements of the BC Supplement to TAC Figure 710.H Rural Arterial Intersection layout (i.e. 100 m parallel deceleration lane) to improve roadside safety. The landscaped gateway feature should be modified to ensure that adequate intersection and departure sight distance is provided. Providing adequate sight distance from the west leg of Stickle will reduce the risk of collisions between exiting movements and highway movements.</p>



Observation		
Item	Safety Concern	Potential Mitigation Measure
8	<p>At-grade Rail Crossing on Stickle</p> <p>Substandard deceleration geometry for southbound right turning traffic, poor sight distance, minimal spacing between Highway 97 and the at-grade rail crossing, and the downhill grade approaching the at-grade rail crossing (>5%) could result in an increased risk of car-train collisions. Despite this potential risk, we are not aware of any documented vehicle-train incidents occurring at this location.</p>	<p>Rail Crossing</p> <p>At-grade rail crossing lights and bells could be considered in addition to the suggested improvements to the Highway 97 southbound deceleration geometry and sight triangles on the approach to Stickle Road (<i>Item 7</i>). Additional signage on Highway 97 warning motorists of the at-grade crossing should also be considered to improve safety at the at-grade crossing. Signalization is not expected to mitigate this safety concern.</p>



Observation		
Item	Safety Concern	Potential Mitigation Measure
9	<p>Sign Structure within Clear Zone</p> <p>Clear zone violation was observed with a highway sign's steel structure within the Highway 97 southbound clear zone 150m north of Stickle Road. Hazards within highway clear zone compromise roadside safety and could result in increased collision severity should an errant vehicle leave the roadway at this location.</p>	<p>Clear Zone</p> <p>Sign structure should be relocated outside of clear zone. Clear zone requirement for Highway 97 within the vicinity of Stickle Road is 6.0 m based on a 90 km/h posted speed with an AADT over 6000 veh/day (BC Supplement to TAC Table 620.C).</p>



Observation		
Item	Safety Concern	Potential Mitigation Measure
10	<p>Deteriorated Shoulder Gravels</p> <p>Deteriorated gravel shoulders could affect vehicle acceleration performance for the westbound Stickle Road to southbound Highway 97 movement and further contribute to rear-end type collisions by inattentive highway motorists. There is also no Highway 97 southbound acceleration lane at Stickle Road (<i>Item 1</i>). Insufficient asphalt width may lead to compromised vehicle performance (i.e. poor acceleration on gravel surface) which increases risk of conflict with highway movements.</p>	<p>Shoulders</p> <p>In addition to a southbound acceleration lane, consider channelized right turn lane with minimum 1.5 m paved shoulders to accommodate over-tracking of larger RV type vehicles exiting the RV Park.</p>



Observation		
Item	Safety Concern	Potential Mitigation Measure
11	<p>Southbound Shoulder on Approach to Stickle Road</p> <p>There is no formal shoulder adjacent to the Highway 97 southbound right turn lane on the approach to Stickle Road. This increases the risk of vehicles leaving the asphalt surface.</p>	<p>Shoulders</p> <p>Provide 1.5 m paved shoulders in accordance with BC Supplement to TAC (refer also to <i>Items 1</i> and <i>10</i>). Standard paved shoulders are a critical component of highway safety.</p>



Observation		
Item	Safety Concern	Potential Mitigation Measure
12	<p>CRB within Clear Zone at Visitor's Exit</p> <p>A single piece of concrete roadside barrier (CRB) is positioned within the clear zone of the Highway 97 southbound travel lanes. This presents a hazard within the highway clear zone. For roadside barriers to be an effective safety measure, they must be part of a system with a minimum length, and contain appropriate approach flares. Note: the location of the visitor's exit is considered acceptable as it is positioned north of the start of the taper for the southbound right turn.</p>	<p>Clear Zone</p> <p>This concrete barrier should be removed so that it does not present a hazard within the clear zone. Alternatively, a roadside barrier should be designed in accordance with the BC Supplement with appropriate barrier flares.</p>

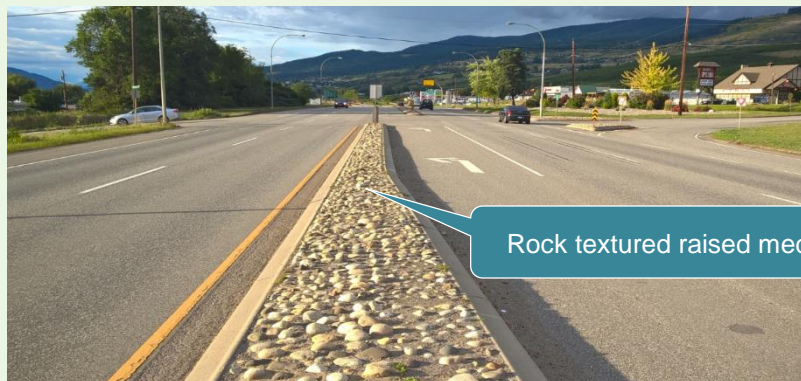


Observation		
Item	Safety Concern	Potential Mitigation Measure
13	Luminaire Poles within Clear Zone Luminaire poles within clear zone are potentially on non-frangible bases. This will increase the severity of a collision if struck by a vehicle.	Clear Zone Luminaire poles within clear zone should be checked to ensure that they are mounted on breakaway or frangible bases. Any poles mounted on non-frangible bases should be retrofitted with frangible bases.



Luminaire poles within clear zone potentially on non-frangible bases and should be checked and retrofitted to feature frangible bases if necessary

Observation		
Item	Safety Concern	Potential Mitigation Measure
14	Textured Raised Median The existing raised median does not prevent pedestrian crossings, however the rock textured surface presents a tripping hazard for pedestrians that use the raised median as a crossing refuge. Note: Section 180 of the BC Motor Vehicle Act states ' <i>when a pedestrian is crossing a highway at a point not in a crosswalk, the pedestrian must yield the right of way to a vehicle</i> ', and so pedestrians are permitted to cross Highway 97 at Stickle Road under this condition.	Pedestrians / Cyclists Consideration should also be given to better accommodating pedestrian/cyclists crossing movements within the Restricted Left option. This may include an informal pedestrian median refuge to improve pedestrian crossing safety. An informal refuge is suggested as pedestrian movements should not be encouraged at this location (due to high vehicle travel speeds). A formal pedestrian crossing is not proposed, however signage warning motorists of the presence of pedestrians is suggested. Note to designers: provide smooth median surface to mitigate median tripping hazard observed in existing condition.



Rock textured raised median

4. Problem Definition

There are several safety concerns at the study intersection, all contributing to a range of collision types. These include:

- Due to the highway traffic volumes and vehicle speeds at the study intersection, there are limited simultaneous north- and southbound gaps available for vehicles to enter the highway from Stickle Road, particularly for the left-out and through movements which cross multiple lanes. This leads to greater risk-taking by exiting motorists, who enter the highway when it is unsafe to do so, increasing the risk of collisions in the intersection, as well as rear-end collisions on the approaches to the intersection as motorists are forced to brake suddenly.
- During a site visit, the lack of available gaps in highway traffic was observed to be contributing to delays on Stickle Road westbound, with left turn queues extending past the Frontage Road intersection. Longer queues mean longer delays, resulting in greater risk taking as motorist frustration increases.
- The lack of deceleration lanes on the highway at Stickle Road means that motorists are slowing in the through travel lanes in order to turn off the highway, thereby raising the risk of rear-end collisions by inattentive highway motorists.
- The lack of acceleration lanes on the highway at Stickle Road means that motorists enter the through travel lanes on the highway from a stopped position, thereby raising the risk of rear-end and side swipe collisions with motorists on the highway approaching the intersection.
- The west leg of Stickle Road has limited sight distance for Highway 97 southbound motorists, obscured by a large mound of landscaping serving as a gateway feature to Vernon on the approach to the intersection. Combined with there being no southbound acceleration lane for vehicles exiting Stickle Road, the risk of rear-end collisions is increased as slow moving vehicles enter the through travel lane on the highway. Southbound motorists might also brake suddenly to turn right into the RV Park due to seeing the intersection late, further increasing the risk of rear-end collisions.
- Also during the site visit, pedestrians from the Silver Star RV and Camping site were observed crossing the highway at Stickle Road. With no pedestrian warning signs, motorists will be forced to slow unexpectedly on the highway, further raising the risk of rear-end collisions.

5. Option Evaluation

Two Highway 97/Stickle Road intersection improvement options have been identified for evaluation and are described as follows:

1. A signalized intersection, including improved auxiliary acceleration and deceleration lanes for right turn movements, and deceleration lane and increased storage for left turn movements off of Highway 97.
2. An unsignalized intersection with full movements on Highway 97 but prohibits left turns from Stickle Road onto Highway 97, as well as prohibits eastbound/westbound Stickle Road through movements across Highway 97. This option also provides improved auxiliary acceleration and deceleration lanes on Highway 97 for right turn movements, and deceleration lanes and increased storage for left turn movements off of Highway 97. Together with this configuration, a southwards extension of the eastside Frontage Road to 20th Street has been proposed. This 20th Street connection will provide an alternate route for the existing westbound left-out movement from Stickle Road onto Highway 97 southbound.

The two options are shown conceptually in *Figures 7* and *8*, and the 20th Street connection is described in *Section 5.1*. Other factors that have bearing on the evaluation are also discussed in subsequent sub-sections. The options are then evaluated considering the criteria described, in addition to other factors discussed in this report.

Figure 7. Option 1: Signalized Intersection Improvement

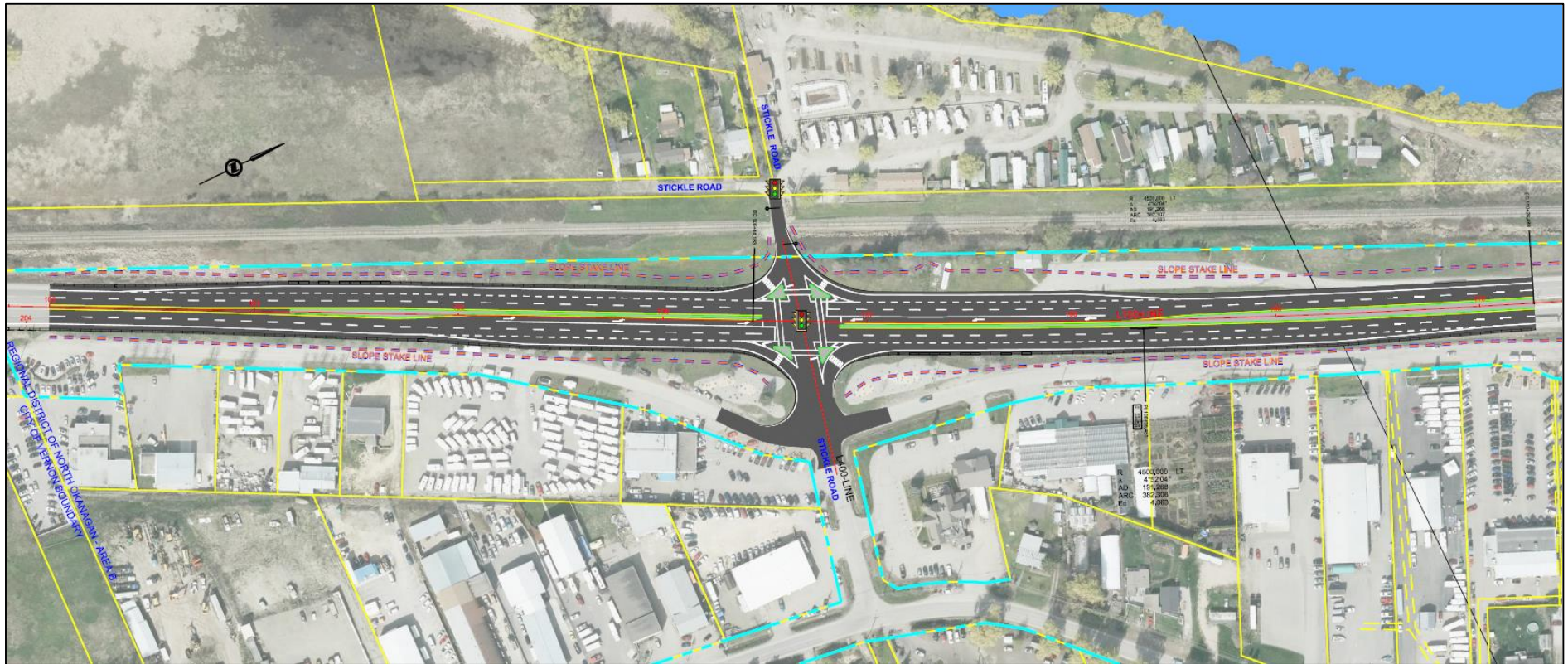
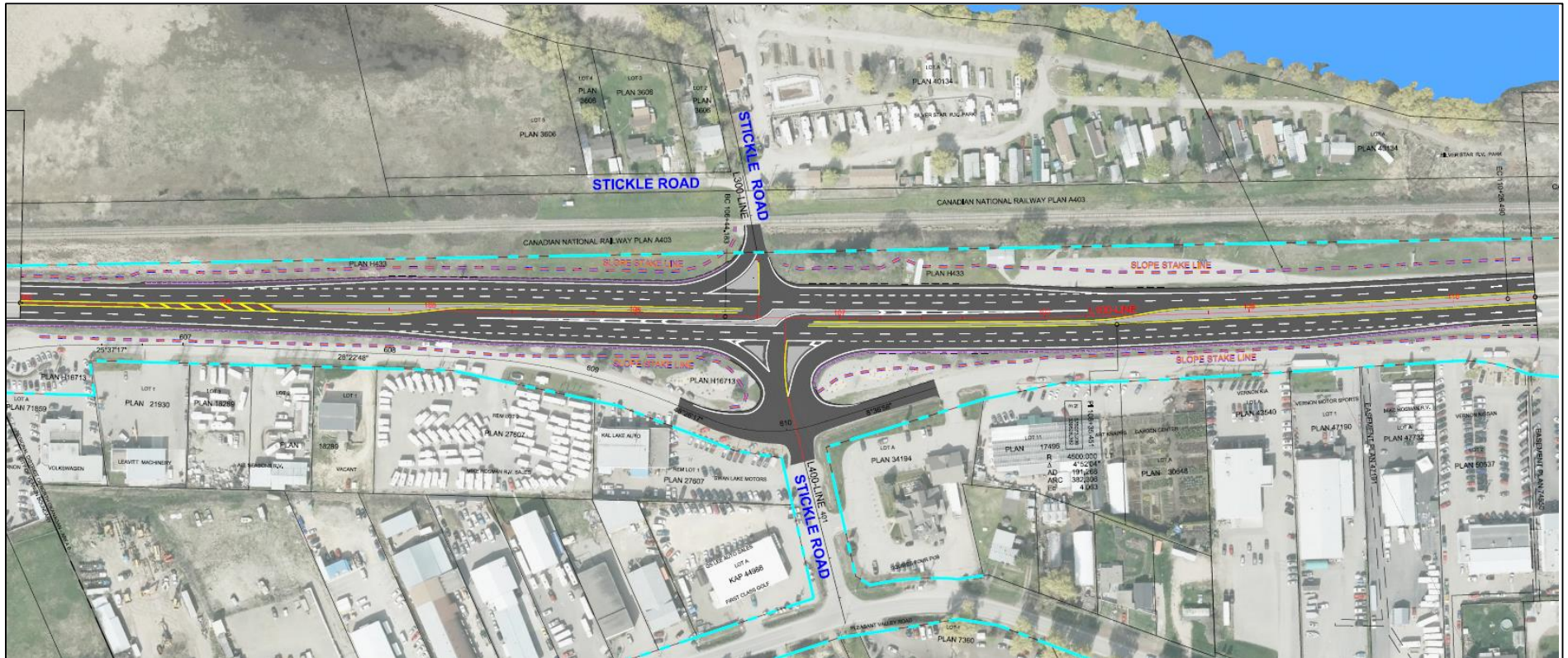


Figure 8. Option 2: Restricted Side Road Left Turn and Through Movement Intersection Improvement



5.1. 20th Street Connection

Due to the restriction of the existing westbound left turn movement at Highway 97/Stickle Road if Option 2 is implemented, and to reduce the impact of this movement restriction on Pleasant Valley Road, the City of Vernon and the Regional District of North Okanagan propose to extend the Frontage Road south to 20th Street as an alternative route. A one-way southbound connection is planned.

This proposed connection is supported; however, it is recommended that a two-way roadway be provided for the following reasons:

- There is a safety risk that inattentive drivers, having used this road in the southbound direction, will assume it also serves the northbound direction, thereby raising the risk of a collision with unsuspecting southbound drivers.
- The existing Frontage Road is two-way, and changing the cross section to one-way further south is confusing for motorists.
- The additional two-way link, together with Pleasant Valley Road, will provide highway redundancy in the event of a highway closure.
- The connection enables a reduction in local traffic demand on the highway between Vernon and Stickle Road.

Traffic analysis undertaken (Binnie, Oct 2015) at the Frontage Road and Stickle Road intersection demonstrates that even for a two- way roadway on the 20th Street connection, this intersection will operate at acceptable levels in future.

5.2. Intersection Conflict Points

A key indicator of the safety risk at an intersection is the number of conflict points within that intersection when taking into account all allowed turning movements. The greater the number of conflict points, the greater the risk of collisions assuming other factors are kept constant. The conflict points for both the full movement signalized intersection option and the restricted (prohibited) side road left out and through movement intersection option are shown in *Figure 9*, with the number of conflict points summarised in *Table 5*.

Figure 9. Conflict Points at Intersections

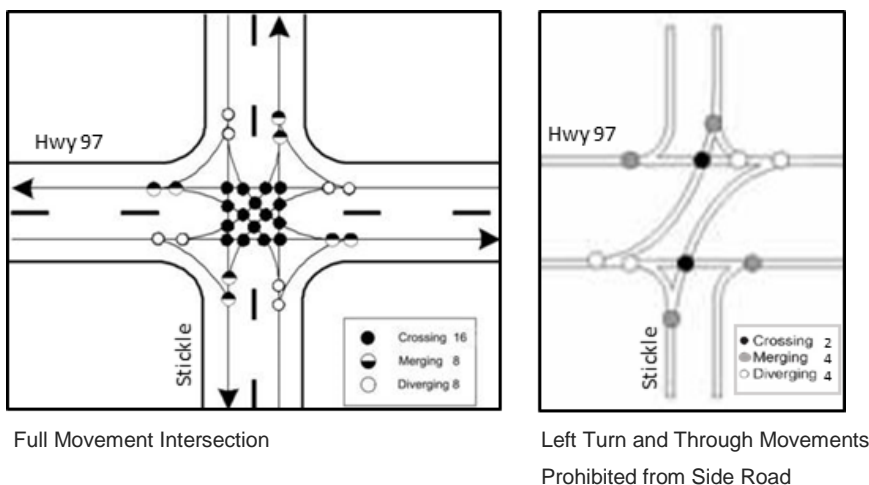


Table 6. Number of Intersection Conflict Points

Intersection Type	# of Conflicts
Full movement intersection (excluding lane change conflicts)	32
Restricted side road left turn and through movement intersection (excluding lane change conflicts)	10

Restricting turn movements at an intersection improves safety at that intersection due to the significantly reduced number of conflict points.

5.3. Signalized versus Unsignalized Intersections

Signalizing an intersection typically results in an increase in the number of collisions at that intersection, particularly rear-end incidents, but there is a decrease in collision severity. This is due to a number of factors:

- Inattentive drivers failing to pull off when the signal changes to green are rear-ended by the motorist behind them who expects that vehicle to proceed, or during congested periods when traffic is stop-and-go.
- Drivers incorrectly anticipating signal phases and entering the intersection when there is green signal for a conflicting movement. For example, a through vehicle proceeding when there is an opposing leading left turn signal phase.
- Drivers failing to stop at a red signal enter the intersection at high speed, resulting in severe collisions if another motorist enters the intersection.

In addition, signalizing an intersection that does not pass a warrant analysis can lead to more collisions, delays and driver disobedience, and also unnecessarily impedes traffic mobility and goods movement. These conditions also increase the use of alternate, inappropriate routes as motorist seek to avoid the intersection, which at this location would include Pleasant Valley Road and the 20th Street connection.

Furthermore, at intersections where an unwarranted signal was installed, studies have shown that the subsequent removal of that signal may result in a 24% decrease in all collisions, a 53% decrease in collisions resulting in injury, a 24% decrease in right-angle crashes, and a 29% decrease in rear-end crashes (*NCHRP Report 500 / Volume 12: A Guide for Reducing Collisions at Signalized Intersections, Strategy A7, US Department of Transportation Federal Highway Administration*).

5.4. U-turns Associated with Restricted Movement Intersections

A key consideration when evaluating Option 2 is the accommodation of traffic rerouting due to the prohibited left turn movements at Stickle Road. This is aided on the east leg by the construction of the 20th Street connection, with Vernon being the primary travel destination for motorists using Stickle Road. On the west leg however, motorists exiting the RV Park and wanting to go northbound will have a significant detour, which could result in unsafe U-turns on the highway just south of the Stickle Road intersection, influenced by the length of the detour route. An example of a detour route is shown in [Figure 10](#), as well as the alternative whereby motorists use the parking lots with access on 58 Avenue to make a U-turn. It is however, noted that the volume of traffic wanting to go northbound from the RV Park is very low; estimated to be less than 10 vehicles per day based on peak period traffic counts, and one vehicle in the peak hour. This is consistent with the extensive shopping and other destinations in Vernon to the south.

Figure 10. Detour Options for Traffic Wanting to Travel Northbound from the RV Park
















5.5. Option Comparison

The two concept options are compared in [Table 6](#), summarizing all the safety and other elements discussed in this report.

Table 6. Comparison of Options

Factor	Option 1: Signalized Intersection	Option 2: Restricted Movement Intersection	Discussion
General Factors:			
Highway mobility is retained	●	●	The signal option requires Highway 97 traffic to stop to allow for movements from Stickle Rd, and so highway mobility (regional north-south movements) is reduced with the signal option.
Consistency with 2002 North Okanagan-Shuswap Corridor Management Plan	●	●	The North Okanagan Shuswap Corridor Management Plan (Urban Systems 2001) identifies a need to protect highway performance, and develop local road alternatives to the highway and a hierarchy within the road network. The Plan identifies Highway 97/Stickle Rd as a minor intersection with restricted movements.
Meets signal warrant assessment	●	N/A	Application of MoTI signal warrant criteria confirms that a traffic signal at Highway 97/Stickle Rd is not warranted.
Full movement options retained at Stickle Road	●	●	The signalized option at Highway 97/Stickle Rd provides a full-movement intersection (i.e. all movements are permitted with the signal).
Reduced GHG emissions	●	●	The signalized option results in increased Green House Gas (GHG) emissions as a result of Highway 97 movements stopping for Stickle Rd movements. It is noted that north-south movements on Highway 97 account for approximately 95% of the total traffic volume entering the intersection. The restricted movement option is considered neutral with respect to reducing GHG as there is no increase or decrease in vehicle emissions.
Key Safety Factors:			
Reduced number of intersection conflicts	●	●	The restricted movement option has 10 conflict points; the Highway 97/Stickle Rd intersection has 32 conflict points. The more conflict points, the greater the risk for conflict so the reduced number in the restricted intersection option is expected to increase safety.
Likely reduction in rear-end collisions	●	●	The highest number of crashes currently at this intersection are rear-end related. There is an increased risk of more high-speed rear-end crashes on the highway with the signalized option as high-speed vehicles will need to come to a full stop on the highway every time the signal turns to red for highway movements. A review of Collision Modification Factors (CMFs) indicates that installing a traffic signal on high-speed corridors can result in a 243% increase in rear-end type collisions.
Eliminates detours or possibility of unsafe U-turns	●	●	The restricted movements option increases the risk of highway U-turns and the need for detouring. This is mitigated on the east leg by the construction of the 20th Street connection. On the west leg however, motorists exiting the RV Park and wanting to go northbound will have a significant detour, which could result in unsafe U-turns on the highway south of the Stickle Road intersection. It is noted that the volume of traffic wanting to go northbound from the RV Park is very low (estimated to be less than 10 vehicles per day) and so the safety risk associated with potential U-turns is considered very low.
Reduces risk of vehicle queuing conflicts on highway	●	●	Based on a review of Collision Modification Factors (CMFs) the restricted movements option is expected to reduce the risk of right-angle type collisions by 36% without increasing the risk of queuing and rear-end type collisions on the highway (north-south movements will remain in a free-flow condition). Traffic signals on a high-speed facilities such as Highway 97 present an increased risk

of rear-end type collisions as a downstream 'stopped' condition on the highway may not meet the expectations of approaching motorists.

Intersection type better meets highway driver expectation			The Highway 97/Stickle intersection is located in a 90 km/hr speed zone (85th percentile operating speed is 99 km/h) and is downstream of the northbound acceleration lane from 27 th St. Stickle Rd is located in a rural environment with grade separation both to the north at Highway 97/97A and to the south at 27 th St with no other signals within this 5.5 km section of Highway 97. Traffic signals within high-speed corridors have been shown to significantly increase the risk of rear-end type collisions (CMF=2.43) as a stopped condition on the highway does not meet driver expectation. This is particular true with a traffic signal immediately downstream of an on-ramp acceleration lane and merge condition.
Design Factors:			
Sufficient turn lane storage provided			Both the signal and restricted movement options provide the required storage for turn lanes in accordance with the BC Supplement to TAC Geometric Design Guide.
Acceleration and deceleration lanes provided			Both the signal and restricted movement options provide improved acceleration and deceleration lanes in accordance with the BC Supplement to TAC Geometric Design Guide.
Improved intersection illumination			Both the signal and restricted movement options provide improved intersection lighting in accordance with Ministry illumination standards.
Accommodates pedestrian and cyclist crossing of highway			The signal option provides improved pedestrian crossing opportunities relative to the restricted movement option. It is noted that an informal pedestrian refugee can be incorporated into the restricted movement option to improve crossing safety relative to the existing unsignalized condition, however for comparative purposes this improvement is considered neutral.
Legend: Agree  Neutral  Disagree 			

Based on the comparison of options, Option 2, the restricted movements intersection, is preferred over Option 1, the signalized intersection, when considering the General Factors. Most importantly is the fact that a signal is not warranted at the Stickle Road intersection. The primary consequence of Option 2 is the elimination of the left turn and through movements on Stickle Road, which require detours, however demand for these movements is low.

Option 2 is also preferred over Option 1 when considering the Key Safety Factors, most notably the reduction in the risk of collisions at the intersection.

For the Design Factors, both options would be designed to meet the geometric requirements, but Option 2 does not allow for safe pedestrian and cyclist movements across the highway. While traffic counts showed these volumes are low, Option 2 partially accommodates these movements by providing a safe refuge on the centre median island, which will be designed with a flat surface versus the existing cobbled surface. This refuge allows for pedestrians and cyclists to only have to cross one direction of highway traffic at a time, and only when it is safe to do so.

In addition, the installation of a traffic signal at Highway 97/Stickle Road may require a warning system (gates, bells, lights) to be installed for the Stickle Road at-grade rail crossing located 35 m west of Highway 97. This warning system is contingent on there being sufficient storage length between the rail crossing and the traffic signal stop bar to accommodate the maximum vehicle queuing requirement for this side road traffic.

6. Conclusion

To improve safety at the Highway 97 / Stickle Road intersection, geometric and other improvements are warranted. It is evident that the current lack of auxiliary acceleration and deceleration lanes in both directions of the highway likely contribute to a high rate of rear-end and other types of collisions due to vehicles either slowing down to turn, or vehicles from Stickle Road entering the highway from a stop condition.

Of the improvement options considered, Option 1, the signalized intersection option is not supported for the following reasons:

- A signal is not warranted
- The introduction of traffic signals on high-speed corridors has been shown to increase rear-end collisions by 243% based on a review of Collision Modification Factors used in road safety analysis
- The signal is not consistent with the North Okanagan-Shuswap Corridor Management Plan
- In future, analysis shows that a signal will result in significant queuing of traffic on the highway, delaying traffic and further increasing the risk of collisions
- The introduction of a traffic signal will trigger the need for a warning system with gates at the adjacent rail crossing based on a review of Transport Canada Grade Crossing Standards (assumes public rail crossing with rail design speed 25 km/hr or greater)

Option 2, the restricted side road left turn and through movement intersection improvement option which prohibits left turns out of Stickle Road and east-west through movements, is supported for the following reasons:

- It maintains the free-flow north-south movement of traffic on Highway 97, which movements account for approximately 95% of the total traffic volume entering the intersection, thereby eliminating queuing and delay at this intersection
- It is consistent with North Okanagan-Shuswap Corridor Management Plan
- It increases safety at the intersection by significantly reducing the number of vehicle conflicts
- The restriction of the left turn movement from Stickle Road onto Highway 97 is accommodated by both the 20th Street connection, as well as Pleasant Valley Road network links

While the restricted left turn from the Silver Star RV Park is not directly accommodated and requires motorists to turn-around in Vernon to the south, existing traffic volumes doing this movement are low, and are not likely to increase. To prevent illegal U-turns on the highway by these vehicles, a median barrier on Highway 97 between the 27 Street interchange and Stickle Road is recommended.

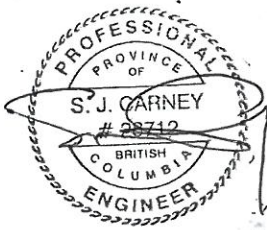
Pedestrians and cyclists are also not directly accommodated, however these volumes are also low, and provision of a flat surfaced refuge on the raised centre median at the intersection allows pedestrians and cyclists to only cross one direction of the highway at a time, enabling a safer crossing.

It is further recommended that the 20th Street connection be constructed as a two-lane roadway.

In summary, the recommended highway intersection improvements include:

- Restricted (prohibited) left turn movements from Stickle Road
- Restricted (prohibited) Stickle Road through movements
- Increased storage lengths for left turn movements on Highway 97
- Increased deceleration lanes for the left turn movements on Highway 97

- Addition of northbound and southbound acceleration lanes for right turn movements from Stickle Road onto Highway 97
- Addition of northbound and southbound deceleration lanes for right turn movements from Highway 97 into Stickle Road
- Addition of a median barrier on Highway 97 between the 27 Street interchange and Stickle Road
- Provision of a flat surfaced refuge on the raised centre median at the intersection to accommodate pedestrians and cyclists
- Improved illumination of the intersection



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