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Memorandum

To/Attention	Joe Murphy, County of Brant	**Date**	May 16, 2017
From	Jessica Deslippe, IBI Group	**Project No**	103485
cc	Joe Murphy, County of Brant Scott Johnston, IBI Group Don Drackley, IBI Group Matt Colwill, IBI Group		
Subject	**Microsimulation Analysis for an Elongated Roundabout at Silver Street and Grand River Street North**		

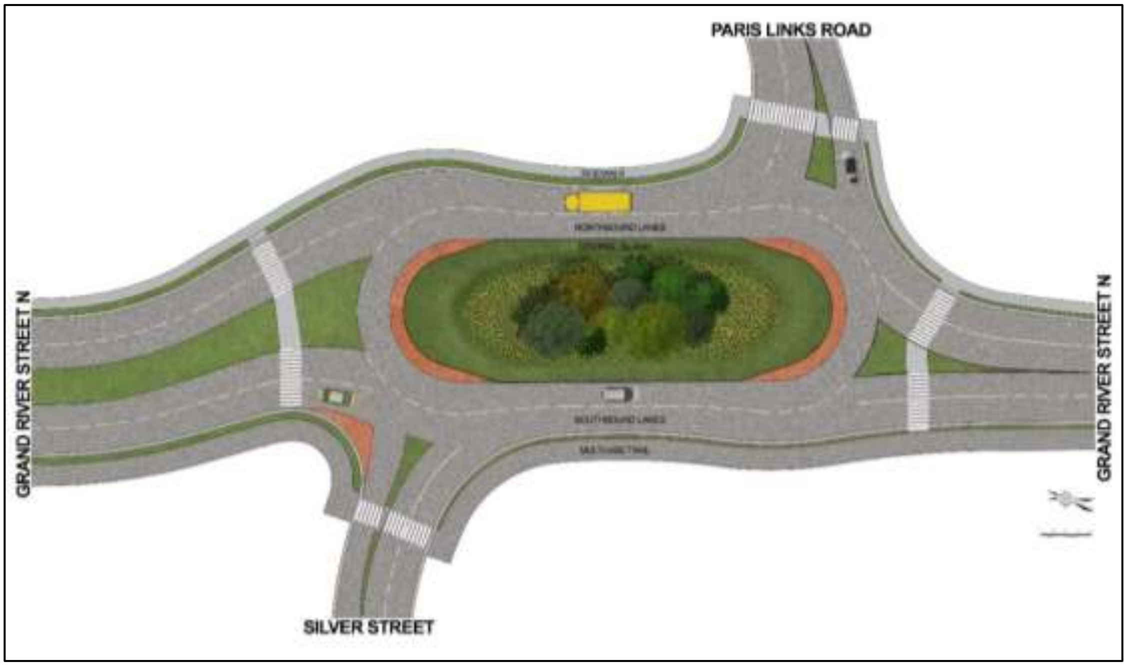
Introduction

IBI Group is currently developing the Grand River Street North Corridor Transportation Study. Through this study, it was identified that changes are required at the intersection of Grand River Street North and Silver Street due to future planned developments along Paris Links Road. The forecasted increase in traffic along Paris Links Road will exceed the operational capacity at the intersection with Grand River Street North.

The initial option identified was to realign Paris Links Road to Silver Street to form a standard four-legged intersection. Key considerations for this option are the significant property impacts along Paris Links Road, and the need to reroute the existing east leg of the Silver Street and Grand River Street North intersection.

An alternative plan, consisting of an elongated roundabout, was developed to help address some of the challenges associated with the realignment option. Perhaps most importantly, a roundabout at this location would significantly reduce property impacts associated with the realignment of Paris Links Road. A concept illustration of this somewhat unique roundabout option is shown in Exhibit 1. It involves a modification to a standard double roundabout design.

Exhibit 1: Elongated Roundabout Concept

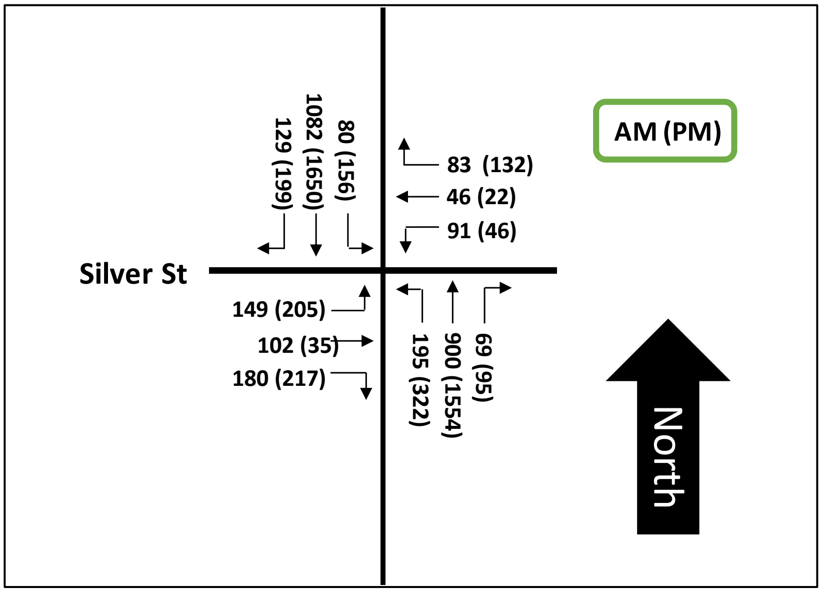


Due to the non-traditional geometry associated with elongated roundabouts, some further study of traffic operations and geometries was requested by the County. This memo is intended to investigate how an elongated roundabout would operate relative to a more conventional intersection control option.

Microsimulation Analysis

Traffic operations during the a.m. and p.m. peak periods were analysed using the microsimulation tool Vissim 7. The initial traffic volumes used in the analysis represent the Future Total Volumes from the Grand River Street North Corridor Transportation Study, which account for traffic diversions and conceptual lane configurations resulting from the realignment of Paris Links Road. The volumes are presented in Exhibit 2.

Exhibit 2: Future Total Volumes



Three separate scenarios were analysed:

- **Scenario 1** – 2031 Future Conditions Option 1 – with signalization and re-alignment of Paris Links Road;
- **Scenario 2** – 2031 Future Conditions Option 2 – with a traditional 2-lane roundabout including re-alignment of Paris Links Road; and
- **Scenario 3** – 2031 Future Conditions Option 2 – with an elongated 2-lane roundabout as per the alternative concept developed for the Corridor Transportation Study.

The first scenario allows for a comparison of the operations of a signalized intersection to a roundabout given the forecast traffic volumes. The second scenario is for the purposes of calibration only, in that it assumes a familiar geometry, for which roundabout operations can be more accurately predicted. The third scenario illustrates the expected operations of the elongated geometry, and it can be compared to the first two scenarios in terms of resulting capacity and delay.

Calibration

A two-stage calibration process was undertaken: observational and volumetric.

The observational calibration examined how the simulation model operates as a whole, and concentrated on driver behaviour and programming discrepancies. At each intersection, the behaviour of vehicles, and the interactions between conflicting traffic streams were observed through animation in the model. Elements of the model, including but not limited to, conflict zones, reduced speed zones, and vehicular routing decision start and end points, were adjusted to reflect typical driver behaviour, which is representative of the Highway Capacity Manual (HCM) 2010’s gap acceptance behaviour. The volumetric calibration used the GEH statistic to verify that the throughput of traffic in Vissim matched the input volumes (i.e., the Future Total Volumes).

Specific changes made as a result of the calibration process include the following:

- Locations and sizes of conflict zones were adjusted such that the decisions made by vehicles entering the roundabout are representative of HCM 2010 gap acceptance behaviour;
- Reduced speed zones were added to the approaching legs and to the circulatory roadway within the roundabout to reflect typical speeds of North American drivers traversing a roundabout[1]; and
- Vehicle routings were adjusted to avoid drivers blocking lanes due to last minute merges prior to entering the roundabout, and to prevent vehicles from changing lanes within the roundabout circulatory roadway. This reflects typical roundabout design, where there is signage provided well in advance of the roundabout denoting which lane to occupy, and pavement markings indicate that lane changes within the circulatory roadway are not permitted.

This model was also compared with measures of effectiveness (MOE) from Synchro 9's HCM 2010 report for a standard multi-lane roundabout, namely delay and Level of Service (LOS). These MOEs are not directly comparable to those produced by Vissim, as the two models are fundamentally different in how they assess operations. However, the operations observed in the Vissim simulation are similar to HCM predictions.

Traffic Operations

The results of the traffic analysis for the a.m. peak period are presented in Exhibit 3. It should be noted that results from scenario 2 (a traditional 2-lane roundabout including re-alignment of Paris Links Road) are not presented. Geometrically, a traditional 2-lane roundabout will require significant property impacts, and is not recommended to be built. The model was created solely for the purposes of calibrating scenario 3, the elongated roundabout.

Exhibit 3: Traffic Analysis Results - 2031 Future Volumes, a.m. Peak Period

		Signalized Intersection			Elongated Roundabout		
Movement	Volumes	LOS	Delay	Average Queue (m)	LOS	Delay	Average Queue (m)
EBL	149	D	41	12	C	35	9
EBT	102	C	25	8	C	35	9
EBR	180	B	14	8	B	11	9
EB Approach	431	C	26	10	C	26	9
WBL	91	D	38	12	C	31	3
WBT	46	D	38	12	C	28	3
WBR	83	C	30	13	B	13	3
WB Approach	220	D	36	13	C	24	3
NBL	195	C	28	8	C	25	14
NBT	900	A	10	7	B	15	14
NBR	69	A	10	8	B	12	14

[1] L, Rodegerdts., J, Bansen., C, Tiesler., J, Knudsen., E, Myers., M, Johnson., M, Moule., B, Persaud., C, Lyon., S, Hallmark., H, Isebrands., B, Crown., B, Guichet., and A, O'Brien. NCHRP Report 672: Roundabouts: An Informational Guide. *Second Edition*. Transportation Research Board of the National Academies, Washington, D.C., 2010.

NB Approach	1164	B	14	8	B	17	14
SBL	80	C	22	2	B	17	6
SBT	1082	B	18	18	B	12	6
SBR	129	B	15	19	B	11	6
SB Approach	1291	B	18	18	B	13	6

During the a.m. peak period, both the signalized and elongated roundabout scenarios are operating well, with the following notable observations:

- All movements in the elongated roundabout scenario are operating with a LOS of C or better;
- All movements in the signalized scenario are operating with a LOS of D or better;
- The elongated roundabout is generally experiencing lower delay than the signalized intersection, with the exception of the northbound through and right-turn movements; and
- Average queue lengths do not exceed storage.

The results of the traffic analysis for the p.m. peak period are presented in Exhibit 4.

Exhibit 4: Traffic Analysis Results - 2031 Future Volumes, p.m. Peak Period

		Signalized Intersection			Elongated Roundabout		
Movement	Volumes	LOS	Delay	Average Queue (m)	LOS	Delay	Average Queue (m)
EBL	205	D	47	18	F	92	34
EBT	35	C	31	5	E	80	34
EBR	217	B	12	6	C	27	34
EB Approach	457	C	30	12	E	61	34
WBL	46	D	38	9	D	52	5
WBT	22	D	36	9	D	46	5
WBR	132	C	23	10	C	25	5
WB Approach	200	C	29	10	C	35	5
NBL	322	F	97	115	F	183	427
NBT	1554	C	34	81	F	149	427
NBR	95	C	31	81	F	133	427
NB Approach	1971	D	45	87	F	154	427
SBL	156	F	290	194	F	165	457
SBT	1650	F	93	214	F	153	457
SBR	199	F	89	215	F	150	457
SB Approach	2005	F	108	213	F	154	457

During the p.m. peak period, both the signalized intersection and elongated roundabout scenarios are expected to operate over-capacity, with significant queuing along Grand River Street North, and numerous movements experiencing a LOS of F. This is a worst case scenario as the volumes used are conservative estimates of both background growth, and all proposed future developments. It is expected that in the long term, the Green Lane extension / Paris bypass proposed in the County's Transportation Master Plan will provide relief to the growing congestion occurring on Grand River Street North and South through Paris, prior to either the signalized intersection or roundabout reaching capacity. In particular, the proposed bypass will divert northbound and southbound through movements, and a high percentage of heavy vehicle traffic. This diversion will be especially beneficial for the roundabout scenario, as high volumes of through movements and heavy vehicles have a particularly detrimental impact on cross-street entering capacity and north/south left-turn capacity.

To provide a more realistic estimate of how each scenario will operate over the long-term, the northbound and southbound through movements were reduced incrementally until the model showed the intersection operating at, or near, its theoretical capacity. This approach still represents a conservative estimate, as no other traffic volumes were adjusted, and all movements show significant growth from existing conditions. A 30% reduction in through traffic volumes was required to achieve the desired conditions. The results of the traffic analysis for the p.m. peak period with reduced northbound and southbound through volumes are presented in Exhibit 5.

Exhibit 5: Traffic Analysis Results – Reduced 2031 Future Volumes, p.m. Peak Period

		Signalized Intersection			Elongated Roundabout		
Movement	Volumes	LOS	Delay	Average Queue (m)	LOS	Delay	Average Queue (m)
EBL	205	D	44	17	D	40	11
EBT	35	C	28	5	D	38	11
EBR	217	B	11	6	B	15	11
EB Approach	457	C	27	11	C	28	11
WBL	46	D	39	8	D	39	3
WBT	22	C	33	8	C	35	3
WBR	132	B	20	9	B	20	3
WB Approach	200	C	27	9	C	27	3
NBL	322	D	45	25	D	44	41
NBT	1088	B	11	9	C	27	41
NBR	95	A	9	10	C	21	41
NB Approach	1505	B	19	13	C	31	41
SBL	156	C	34	8	E	64	100
SBT	1143	B	19	22	D	54	100
SBR	181	B	18	23	D	51	100
SB Approach	1510	C	21	21	D	55	100

With the reduced volumes, traffic operations from Silver Street and Paris Links Road are comparable between the signalized intersection and elongated roundabout scenarios, with LOS C predicted for both approaches. The elongated roundabout scenario has higher delay on Grand River Street North, although the southbound approach with has the highest delay is still operating with a LOS of D. Overall, both scenarios will operate fairly well if the bypass is built, with the signalized intersection scenario showing improved operations for movements along Grand River Street.

Although the signalized intersection scenario appears to offer an operational advantage during the p.m. peak period, the elongated roundabout, like most roundabouts, offers the advantage of reduced stops, and generally less delay, during the off-peak periods. As discussed in the following sections, there are additional considerations, beyond basic operational performance, that will need to be considered in selecting the preferred mode of intersection control for the junction.

Additional Considerations

Properly designed roundabouts can be safer and more comfortable for both pedestrians and vehicles, when compared with traditional signalized intersections, and they can also offer traffic calming and aesthetic benefits. The sections below discuss design considerations that should be further developed and evaluated in a future Municipal Class EA process.

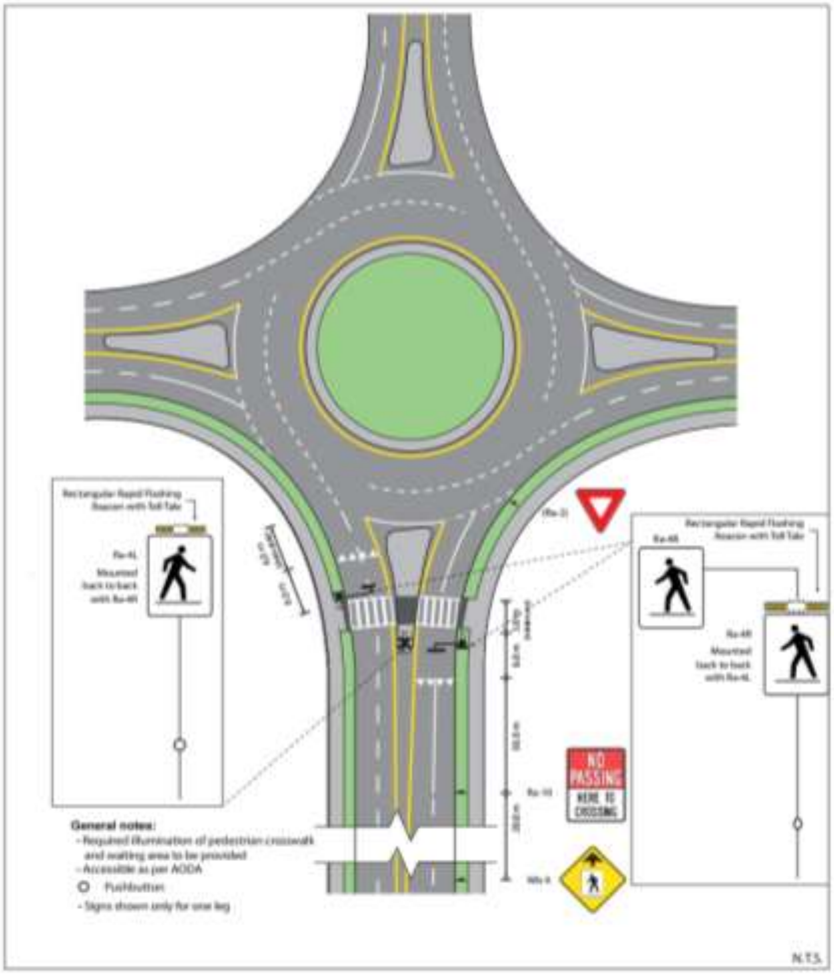
Pedestrians

The main factors that increase pedestrian safety at roundabouts include:

- Lower vehicle operating speeds can reduce the severity of collisions;
- The number of conflict points (potential collision locations) are reduced from 16, at signalized intersections, to 8;
- Splitter islands provide refuge to pedestrians and allow them to cross one direction of traffic at a time; and
- Pedestrian crosswalks are typically located at least one vehicle length back from the merge point, reducing the number of potential conflicts that a driver must pay attention to at one time (e.g., a driver looking left for gaps in circulating traffic may not notice a pedestrian approaching from the right if the crosswalk is at the merge point).

While roundabouts have been shown to offer significant vehicular safety performance advantages over signalized intersections, there are additional design improvements that can be incorporated to further increase pedestrian safety. One example is to install a Level 2 Pedestrian Crossover (Ontario Traffic Manual (OTM) Book 15 – Pedestrian Crossing Treatments), which incorporates, at a minimum, warning and regulatory signage, and pavement markings. The Type B version (illustrated in Exhibit 6) is supplemented with rectangular rapid flashing beacons (RRFB) that draw additional attention to the crosswalk when activated.

Exhibit 6: Level 2 Pedestrian Crossover Type B – Double-Lane Roundabout (Source: OTM Book 15)



The additional traffic controls increase the visibility of pedestrians (especially important for visually impaired pedestrians) and reduce the perceived risk of the roundabout, increasing pedestrian comfort. These enhancements are recommended to be considered as part of future design iteration, since there are two significant pedestrian generators with vulnerable users in close proximity to the intersection: Paris District High School, and Telfer Place Retirement Residence. However, it may not be necessary to implement full measures at all crossings. Pedestrian desire lines should be evaluated to ensure the approaches with the highest pedestrian traffic (e.g., high pedestrian traffic on the east leg as students travel between Paris District High School and the McDonald's just south of Scott Avenue) receive the full treatment with RRFBs, while the other approaches may not require more than ground-mounted signs and pavement markings.

As discussed in the Grand River Street North Corridor Transportation Study report, it is also recommended to consider a controlled pedestrian crossing at Alexander Avenue to accommodate students crossing east-west. This would reduce the number of pedestrians crossing at the roundabout, and reduce the number of pedestrians potentially crossing mid-block.

Design Considerations

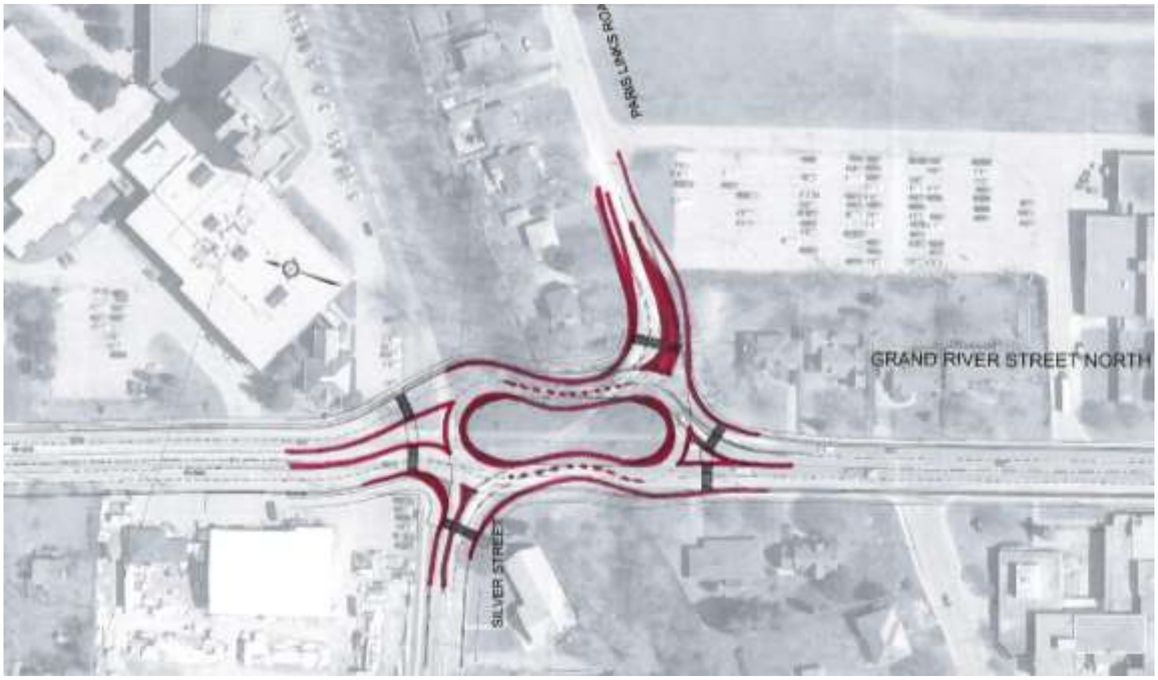
Roundabouts experience better safety performance than signalized intersections for two main reasons: they reduce vehicle operating speeds, and they reduce the number of conflict points between users. The oval shape, and property constraints of the proposed elongated roundabout pose some challenges to maintaining slower circulating speeds. However, proper design considerations can ensure that the elongated roundabout operates as efficiently and safely as a traditional roundabout.

Below are some recommendations that should be further developed and evaluated in the future Municipal Class EA process to improve the safety and functionality of the elongated roundabout (illustrated in Exhibit 7):

- Increasing the deflection of the entry lanes reduces vehicle speeds. This reduces the potential for, and severity of, collisions, by decreasing the relative speed between entering and circulating vehicles. The increased deflection also increases the capacity of the roundabout, as downstream drivers are more confident entering the roundabout when the circulating flow is travelling at similar, constant speeds, which improves gap identification;
- Increasing deflection at the exits limits exit speeds, reducing the risk for collisions involving a pedestrian;
- Increasing curvature along the “straightaway” sections of the roundabout circulatory roadway to maintain lower operating speeds in the circulating flow of traffic; and
- Implementing a two-phase design to balance capacity with demand (i.e., not overbuild for early horizon volumes). The final roundabout will be designed for the 2031 future traffic volumes shown in Exhibit 2. However, the first-phase design should include entry widths and circulatory roadway appropriate for lower volumes. These can be accomplished with larger splitter and centre islands, which can be reduced during phase two, when the additional capacity is warranted. This will reduce the exposure of pedestrians, and encourage lower operating speeds, increasing overall safety of the roundabout.

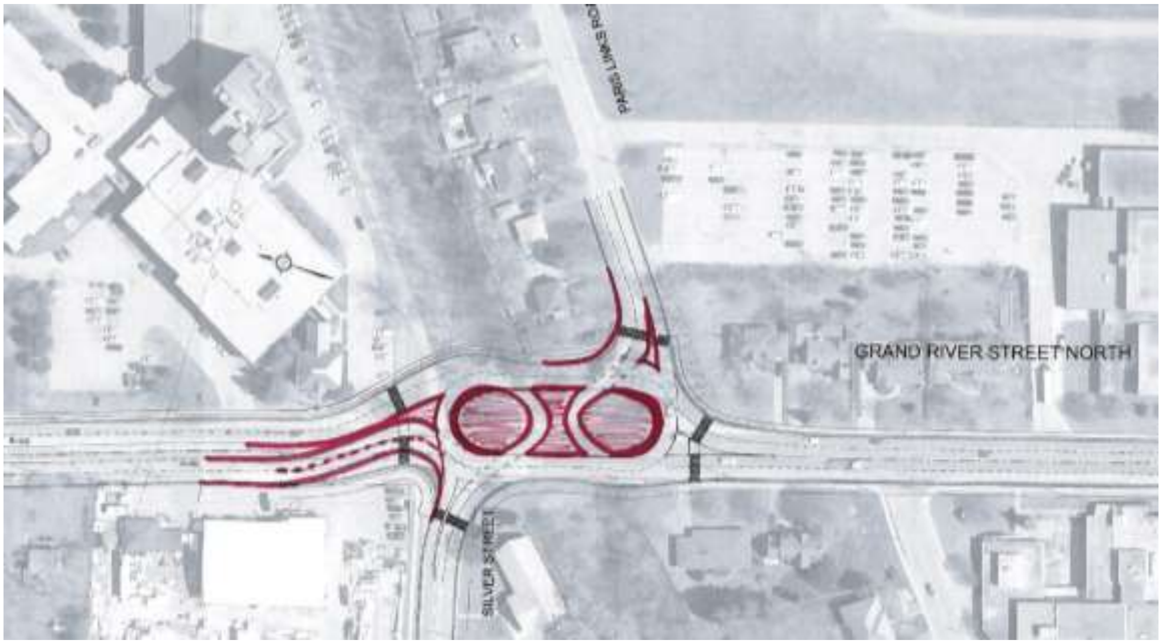
Joe Murphy, County of Brant – May 16, 2017

Exhibit 7: Design Concept for the Elongated Roundabout Showing Increase Deflection



The increased size of the elongated roundabout offers unique opportunities for landscaping (e.g. using the roundabout as a 'gateway' feature), or innovative lane configurations to improve operations. An example of a potential lane configuration is illustrated in Exhibit 8. This layout features two left-turn lanes that cut through the centre island of the roundabout to offer a more direct route for side street left-turn movements. This would reduce travel on the circulatory roadway for those left-turn movements, as well as reduce the conflict between circulating flow and entering flow at the approaches with the heaviest volumes (i.e., the northbound and southbound approaches). The concept presented is not meant to be an additional scenario to evaluate, but rather to illustrate the design flexibility and opportunity for innovation the elongated roundabout presents.

Exhibit 8: Alternative Design Concept for the Elongated Roundabout Showing Redirected Left-turns



Conclusions

In general, vehicles at a roundabout will experience less delay than at a signalized intersection, particularly side street movements and off-peak traffic. Conversely, signalized intersections are more efficient at handling high volumes of through traffic and dedicating right-of-way to low-volume side street movements. Based on the microsimulation analysis of the two proposed configurations of Grand River Street North and Silver Street / Paris Links Road (signalized intersection and elongated roundabout), the following can be concluded:

- Both scenarios will experience similar operations during the a.m. peak period, with all movements operating at a LOS D or better;
- Both scenarios will operate over capacity during the p.m. peak period, with numerous movements operating at a LOS F; and
- The proposed Green Lane extension / Paris bypass is expected to divert a significant amount of northbound and southbound through volume away from Grand River Street North and South. With an assumed 30% reduction in through traffic, both scenarios operate well, with the signalized scenario experiencing slightly better operations along Grand River Street during the p.m. peak.

The elongated roundabout offers additional advantages over a signalized intersection configuration, primarily through increased vehicular and pedestrian safety. The unique configuration of the proposed elongated roundabout is such that care must be taken in the future design iterations to ensure the potential safety benefits are realized. Some design considerations include:

- Implementing Level 2 – Type B pedestrian crossovers on key approaches;
- Increasing deflection of entry and exit lanes;
- Increasing curvature of circulating lanes; and
- Implementing a two-phase design to avoid overdesigning the intersection before traffic volumes warrant increase capacity.