



FINAL REPORT

**Traffic Study for
Highway 107 Phase 1 –
Burnside to Sackville**

Presented To:
Nova Scotia Department of Transportation and Infrastructure Renewal

February 2011

Project No. DA10095

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Executive Summary

The construction of a new highway from Burnside to Sackville has been considered for more than 20 years. A section of Highway 107 from the Burnside Drive / Akerley Boulevard intersection in Dartmouth to Highway 102 in Bedford is considered to be warranted since existing traffic volumes on Magazine Hill are over 40,000 vehicles per day.

A study completed for Nova Scotia Department of Transportation and Infrastructure Renewal (NSTIR) and Halifax Regional Municipality (HRM) during 2008 developed a three phased approach for the implementation of Highway 107 as a freeway from the current end of Highway 107 at the north end of Akerley Boulevard to Highway 102. Phase 1 of the implementation plan includes construction of a direct connection from Burnside Drive at Akerley Boulevard to Duke Street in Bedford, using the existing Glendale Avenue / Duke Street interchange to access Highway 102. Since Phase 1 is expected to open for traffic within the next five years, NSTIR and HRM have commissioned this traffic study to evaluate impacts of traffic changes on all Burnside Drive, Duke Street, Glendale Avenue, and Glendale Drive intersections, as well as affected weaving and merging movements on Highway 101 and Highway 102.

Study Objectives - The primary objectives of the traffic study are

- To investigate the traffic impacts on the existing road network associated with the completion of a new four lane controlled access connection between the intersection of Burnside Drive and Akerley Boulevard and the intersection Duke Street and Rocky Lake Drive intersection; and
- To identify road network improvements required to mitigate any identified deficiencies for projected 2016 and 2026 volumes.

Volume Growth Rate - Extensive regression analysis completed using historical traffic volume data for Highway 101 and 102, the Bedford By-Pass and Magazine Hill indicated annual traffic volume increases that ranged between 0.8 % to 1.6%. Since development in the study area during the next 15 years is expected to generally result in traffic volume increases on study area roads similar the historic trend over the past ten years, an annual growth rate of 1.5% has been used to project 2016 and 2026 volumes.

Highway 107 Trip Diversion Candidates - The existing design hourly volumes that could possibly use Highway 107 Phase 1 Study Corridor are either from traffic now using Magazine Hill or traffic that is now using Highway 102 to the Trunk 2 interchange at Waverley and then Highway 118 to access the Burnside area.

Projected 2010 volumes on Magazine Hill include 4375 vehicles per hour (vph) during the AM peak and 4760 vph during the PM peak. The majority of Magazine Hill traffic is to / from the Bedford By-Pass which accounts for 70% of the AM peak trips and 62% of the PM peak trips. Review of turning movement counts at Windmill Road intersections with Akerley Boulevard and Wright Avenue reveals that about 40% of Magazine Hill AM peak traffic and about 50% of the PM peak traffic enters / exits the Burnside area at those two intersections. The remaining 60% of AM peak hour traffic and 50% of PM peak hour traffic from Magazine Hill continues southbound on Windmill Road towards the Harbour Bridges, Highway 111, and Downtown Dartmouth.

Traffic volume projections from data included in a 2008 Waverley traffic study indicate that 480 vph of the Highway 102 northbound exit traffic continue to the Highway 118 interchange and Miller Lake area during a 2010 weekday AM peak hour. It is understood that a significant portion of these trips originate from residents of the Sackville, Highway 101 and Hammonds Plains areas who work in the Burnside or east Dartmouth areas and use Highway 102 and Highway 118 to avoid congestion on Magazine Hill and at Windmill Road intersections.

Trip Diversion to Highway 107 - Evaluation of traffic volumes at over thirty study area intersections and local knowledge of the area, have been used to redistribute trips from Magazine Hill and the Waverley interchange area to the proposed Highway 107 Phase 1. The following summarize trip diversion to Highway 107:

- Traffic diverted to Highway 107 reduced Magazine Hill volumes by 27% during the 2016 AM peak hour and 29% during the PM peak hour.
- Projected 2016 two-way peak hour volumes on Highway 107 Phase 1 include approximately 1800 vph during the AM peak hour and 1600 vehicles during the PM peak hour.
- The 2016 two-way AM peak hour volumes on Highway 107 include approximately 5% from Dartmouth Road, 70% from Bedford By-Pass and 25% from other locations, such as Highway 102 at the Waverley interchange.
- The 2016 two-way PM peak hour volumes on Highway 107 include approximately 5% from Dartmouth Road, 85% from Bedford By-Pass and 10% from other locations, such as Highway 102 at the Waverley interchange.

Turning Lane Warrant Analysis - Analysis of projected 2010 AM and PM peak hour traffic volumes indicated that left and right turn auxiliary lanes are required at most Glendale Drive STOP controlled intersections for the existing traffic volumes.

Signal Warrant Analysis - Signal warrant analyses of STOP controlled Glendale Drive intersections indicate the following:

- Signals will not be warranted at any intersections by 2016 without Highway 107.
- Signals won't be warranted at any intersection during 2016 with added Highway 107 trips, however, the Smokey Drive and Magee Drive intersections should be monitored.
- Signals are expected to be warranted at the Glendale Drive / Smokey Drive intersection during 2026; the Pinehill Drive and Magee Drive intersections should continue to be monitored.

Crosswalk Evaluation - The evaluation of pedestrian crossings on Glendale Avenue and Duke Street using counted pedestrian volumes to estimate 'equivalent adult units', and projected 2016 volumes that include added Highway 107 trips, indicate the following:

- Pedestrian crosswalks will not be warranted at the Old Beaver Bank Road, Rankin Drive, or Mann Street intersections.
- While analysis indicates that a crosswalk is not warranted at the Chandler Drive intersection on Glendale Drive, the existing RA-5 signs should be retained pending review by HRM.
- High counted pedestrian volumes and high peak hour volumes on Glendale Drive indicate the need for pedestrian traffic signals at the Raymond Drive crossing area. This crosswalk should be re-evaluated after Highway 107 is open to traffic.
- Analysis indicates that the existing RA-5 signs with actuated amber beacons are the appropriate crossing protection at the Pinehill Drive and Magee Drive intersections on Glendale Drive.

Level of Service Analysis Conclusions - A level of service Synchro 6 analysis completed for study area intersections indicates the following:

- With provision of the recommended intersection improvements, all study area intersections, with the exception of the Burnside Drive / Highway 111 eastbound ramp intersection which has existing poor performance, will provide satisfactory performance for through street movements during 2016 with Highway 107, Phase 1.
- While the Beaver Bank By-Pass can be expected to divert traffic from Beaver Bank Road, and may also divert some trips from Glendale Drive over the next 10 to 15 years, the existing two lane cross section of Glendale Drive will be approaching capacity by 2026. Plans should be prepared for widening Glendale Drive to a four lane street with appropriate auxiliary lanes.
- While Duke Street intersections and the Highway 102 ramp intersections are expected to provide satisfactory levels of performance for 2016 volumes with Highway 107, Phase 1, additional capacity provided by future Highway 107 phases with direct connections to Highway 102 will be required to provide satisfactory performance for projected 2026 volumes.
- Traffic diverted from Burnside Drive to Highway 107 and Highway 118 by construction of Highway 107 from Burnside Drive extension to the existing Highway 107 east of Akerley Boulevard will reduce Burnside Drive volumes which could improve levels of performance at all Burnside Drive intersections, including the Highway 111 ramp intersections.

Summary Weaving Analysis - Weaving analyses completed for two ramp locations using 2010 to 2026 AM and PM peak hour volumes indicate the following:

- While the Highway 102 northbound weave area between the Highway 101 eastbound ramp to Highway 102 northbound and the Highway 102 northbound exit to Highway 101 westbound, now operates with poor level of performance during PM peak hours, and will continue to have poor performance during 2016 and 2026, the addition of traffic diverted to Highway 107 is not expected to have any significant impact on the weave performance.
- The Highway 101 westbound weave area between the Highway 102 southbound exit to Highway 101 westbound and the Highway 101 westbound exit to Sackville Drive will continue to provide satisfactory levels of performance to 2026 with added Highway 107 trips.

Summary of Roundabout Performance Evaluation - The ARCADY analyses indicate the following for the four intersections that were evaluated:

- **Burnside Drive / Akerley Boulevard** (Table 6-7) - While a roundabout will provide LOS A for all approaches for 2016 AM and PM peak hours and 2026 PM peak hours, the Highway 107 southbound approach will have reduced performance with LOS D during 2026 AM peak hours. The completion of additional Highway 107 phases in the Burnside area should alleviate this problem.
- **Duke Street / Rocky Lake Road** (Table 6-8) - A roundabout will provide LOS A for all approaches for 2016 and 2026 peak hours that include Highway 107 trips.
- **Duke Street / Highway 102 Northbound Ramps** (Table 6-9) - While a roundabout will provide LOS A for all approaches during 2016 and 2026 AM peak hours, the Duke Street westbound approach is projected to operate with LOS D during the 2016 PM peak hour and LOS F during the 2026 PM peak hour.
- **Glendale Avenue / Highway 102 Southbound Ramps** (Table 6-10) - While a roundabout will provide LOS A for all approaches for 2016 AM and PM peak hours and 2026 AM peak hours, the Highway 107 southbound approach will have reduced performance with LOS D during 2026 AM peak hours.

Summary of Recommendations -

- A. *Intersection Improvements without Highway 107*** - The following improvements, which will be required on Glendale Drive by 2016 without Highway 107, should be designed and implemented during the next five years:
- Reconstruct the Beaver Bank Road / Glendale Drive intersection to include two northbound through lanes and dual southbound left turn lanes;
 - Construct left turn lanes and warranted right turn lanes at all intersections that do not now have left turn lanes;
 - Upgrade the Glendale Drive / McDougall Avenue intersection traffic signals to include signal phases for Glendale Drive left turn movements;
- B. *Glendale Drive Crosswalks*** - HRM should continue to monitor pedestrian crossings on Glendale Drive and ensure that appropriate signs and signal devices are maintained.
- C. *Glendale Drive Intersection Traffic Control*** - HRM should continue to monitor the Smokey Drive, Pinehill Drive, and Magee Drive intersections with regard to warrants for installation of traffic signals. While signal warrant analysis did not indicate the need for signals at these intersections prior to 2016, the warrant analyses for 2016 and 2026 with Highway 107 and poor side street levels of performance indicate the need to monitor the intersections.
- D. *Intersection Improvements with Highway 107*** - The following intersection improvements on Glendale Avenue and Duke Street will be required as part of the Highway 107, Phase 1, project:
- A westbound right turn lane is required on Glendale Avenue at the Cobequid Road intersection. The traffic signals must also be converted to provide split phases on Cobequid Road approaches to permit dual left turns for the southbound approach.
 - Either construct a roundabout illustrated on Figure 6-3 at the Glendale Avenue / Highway 102 southbound ramps, or upgrade the existing intersection to include an eastbound right turn lane on Glendale Avenue, and dual left turn lanes for the southbound exit ramp and Glendale Avenue westbound approaches.
 - Either construct a roundabout illustrated on Figure 6-3 at the Duke Street / Highway 102 northbound ramps, or upgrade the existing intersection to include a northbound right turn lane and right turn channel.
 - Widen the section of Duke Street from Damascus Drive to Rocky Lake Drive to four lanes and add a left turn lane at Mann Street.
- E. *Additional Highway 107 Phases*** - Since roundabout or intersection reconstruction at the Highway 102 interchange ramps are not expected to continue to provide satisfactory levels of performance with projected 2026 volumes, NSTIR should plan to construct additional Highway 107 phases to provide direct access to Highway 102 before 2026.

Conclusions -

- A. With provision of recommended improvements, all study area intersections with the exception of the Burnside Drive / Highway 111 eastbound ramp intersection will provide satisfactory performance for through street movements during 2016 with Highway 107, Phase 1.
- B. While the Beaver Bank By-Pass may divert some trips from Glendale Drive over the next 10 to 15 years, the existing two lane cross section of Glendale Drive will be approaching capacity by 2026. Plans should be prepared for widening Glendale Drive to a four lane street with appropriate auxiliary lanes.
- C. Duke Street will provide a temporary connection to Highway 102 for Highway 107, Phase 1 to accommodate projected 2016 volumes. However, the additional capacity of future Highway 107 phases with direct connections to Highway 102 will be required to provide satisfactory performance for projected 2026 volumes.
- D. Construction of the future phase of Highway 107 from Burnside Drive extension to meet existing Highway 107 east of Akerley Boulevard will divert traffic to Highway 118 and Highway 107 east of Highway 118. This will reduce Burnside Drive volumes which could improve levels of performance at all Burnside Drive intersections, including the Highway 111 ramp intersections.

1.0 Introduction

1.1 Background

The construction of a highway from Burnside to Sackville to provide an alternate route to Trunk 7 over Magazine Hill has been considered for more than 20 years. The construction of a section of Highway 107 from the Burnside Drive / Akerley Boulevard intersection to Highway 102 is considered to be warranted since existing traffic volumes on Magazine Hill are over 40,000 vehicles per day.

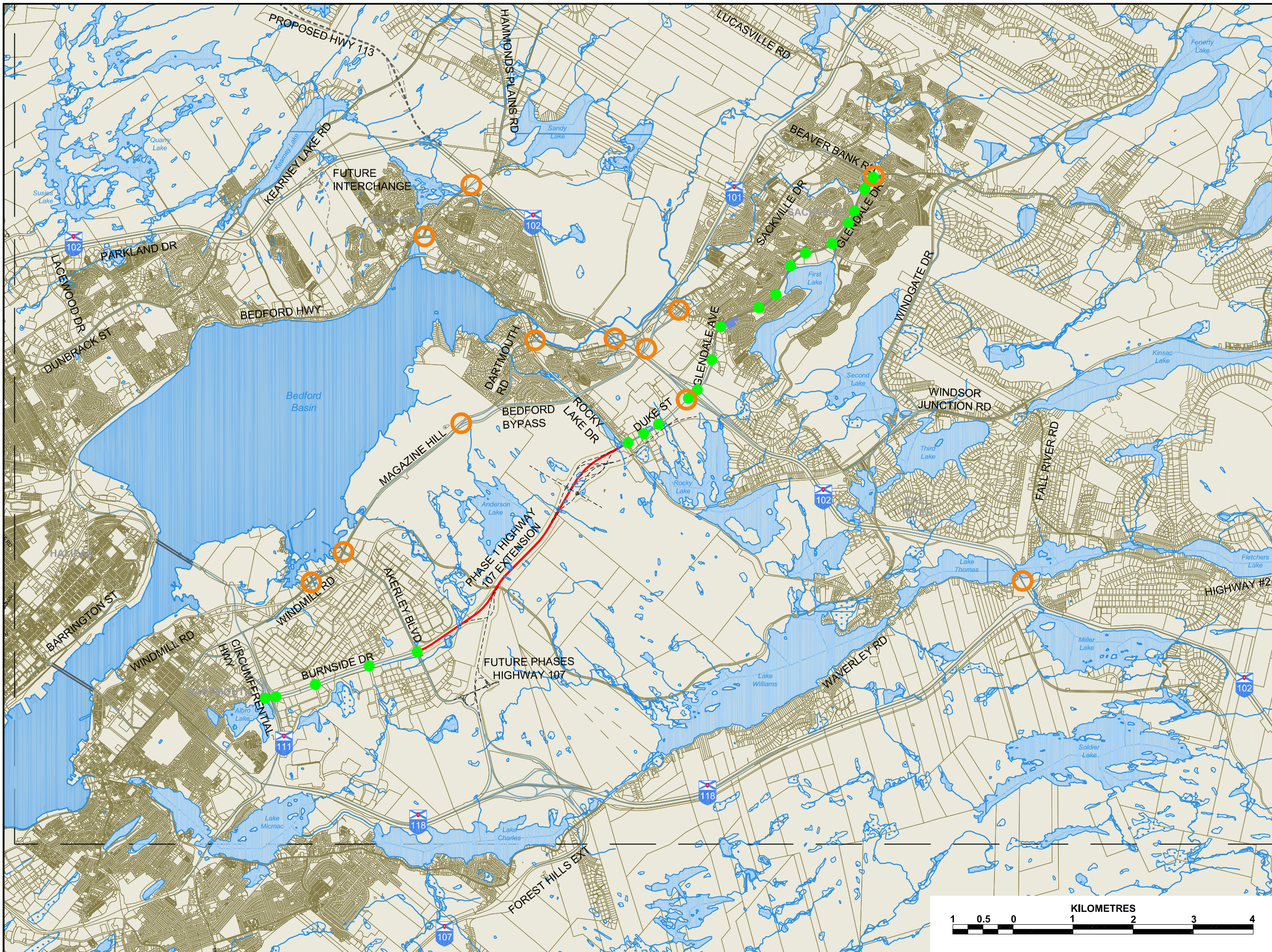
Nova Scotia Department of Transportation and Infrastructure Renewal (NSTIR) and Halifax Regional Municipality (HRM) retained Stantec during 2008 to complete a long range transportation needs study of Bayers Road and Highway 102, as well as the proposed section of Highway 107 from Burnside to Sackville. The study developed a three phased approach for the implementation of Highway 107 as a freeway from the current end of Highway 107 at the north end of Akerley Boulevard to Highway 102. Phase 1 of the implementation plan (Figure 1-1) includes construction of a direct connection from Burnside Drive at Akerley Boulevard to Duke Street in Bedford, using the existing Glendale Avenue / Duke Street interchange to access Highway 102.

Since Phase 1 is expected to open for traffic within the next five years, NSTIR and HRM have commissioned a traffic study to evaluate impacts of traffic changes on all Burnside Drive, Duke Street, Glendale Avenue, and Glendale Drive intersections, as well as affected weaving and merging movements on Highway 101 and Highway 102.

1.2 Project Objectives

The primary objectives of the traffic study are:

- (a) to investigate the traffic impacts on the existing road network associated with the completion of a new four lane controlled access connection between the Burnside Drive / Akerley Boulevard intersection and the Duke Street / Rocky Lake Drive intersection (Phase 1); and
- (b) to identify road network improvements required to mitigate any identified deficiencies for projected 2016 and 2026 volumes.



LEGEND

- Study Intersection
- Areas Reviewed for Trip Diversion to Highway 107, Phase 1
- Highway 107 Extension Phase 1
- Highway 107 Extension Future Phases

NORTH

DRAWN: BMW
CHECKED: GOB

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2.0 Traffic Volume Data

2.1 Historical Count Data

Review of AADT Volumes and Growth Trends - NSTIR has historical Annual Average Daily Traffic (AADT) volume data from the previous 20 to 30 years available for several arterial roads in the study area. While growth trends were observed to be generally consistent from 1980 to about 2000, some areas have exhibited erratic or lower than expected growth during the past ten years. Linear regression (Appendix A, Tables A-1 to A-6) using either the past 30 years of volume history, or ten years where appropriate, has been completed for six locations where sufficient historical count data were available. Projected 2010, 2016 and 2026 AADT volumes for these locations are included in Table 2-1.

Since future traffic volume increases are expected to be similar to the historic trend over the past ten years calculated for study area roads (Table 2-1), an annual traffic volume growth rate of 1.5% has been selected for use in this study.

Location	Table / Figure	Projected 2010 AADT ²	Annual AADT Growth ³	Annual Percent Growth ⁴	Projected 2016 AADT ⁵	Projected 2026 AADT ⁵
Highway 101 - Bedford By-Pass to Beaver Bank Road	A-1	32,000	325	1.0	34000	37,000
Highway 102 - Hammonds Plains Road to Trunk 1 / Highway 101	A-2	44,000	330	0.8	46000	49,000
Highway 102 - Trunk 1 / Highway 101 to Duke St. / Glendale Avenue	A-3	29,000	440	1.5	32000	36,000
Highway 102 - Duke St. / Glendale Avenue to Trunk 2 Waverley	A-4	25,000	335	1.3	27000	30,000
Bedford By-Pass	A-5	26,000	400	1.6	28000	32,000
Trunk 7 (Magazine Hill)	A-6	38,000	450	1.1	41000	45,000

NOTES: 1. AADT is the Annual Average Daily Traffic which is an estimate of the total volume for a year divided by 365.
 2. AADT volumes projected from the regression analyses
 3. Annual AADT volume increase as 'vehicles per day per year' established from regression analyses
 4. Annual percentage increase in AADT is based on the annual AADT growth and the projected 2010 AADT
 5. Projected 2016 and 2026 AADTs calculated by adding 10 and 20 years of annual AADT growth to the projected 2010 AADT

Review of Hourly Volumes on Study Area Roads - Seven day 24 hour machine counts are available for the six locations where AADT volumes have been reviewed. Tabulated hourly volumes and graphical displays of average weekday volumes are included in Appendix A, Tables A-7 to A-12. Average weekday volumes for the count periods, as well as average weekday AM and PM peak hour volumes, are summarized in Table 2-2.

The graphical displays for Highway 101 (Figure A-7), Highway 102 between Hammonds Plains and Highway 101 interchange (Figure A-8), Bedford By-Pass (Figure A-11) and Magazine Hill (Figure A-12) illustrate the pronounced 'spikes' in AM and PM peak hours typical of a road with high commuter volumes.

Table 2-2 - Summary of Average Weekday and Peak Hour Volumes					
Location	Table / Figure	Count Dates	Average Weekday Volume ²	AM Peak Hour Volume ³	PM Peak Hour Volume ³
Highway 101 - Bedford By-Pass to Beaver Bank Road	A-7	Nov. 9-16, 2009	38,300	3,550	3,625
Highway 102 - Hammonds Plains Road to Trunk 1 / Highway 101	A-8	Sep. & Oct. 2009	48,000	3,875	4,600
Highway 102 - Trunk 1 / Highway 101 to Duke St. / Glendale Avenue	A-9	Sep. 16-22, 2008	32,300	2,490	2,845
Highway 102 - Duke St. / Glendale Avenue to Trunk 2 Waverley	A-10	Sep. 10-17, 2007	27,000	1,940	2,480
Bedford By-Pass	A-11	Oct. 22-29, 2009	29,650	3,035	2,845
Trunk 7 (Magazine Hill) ¹	A-12	Jun. 16-22, 2008	46,400	4,250	4,135
NOTES: 1. Data in Tables A-7 to A-11 was obtained from NSTIR and data in Table A-12 was obtained from HRM. 2. Weekday volumes are two-way vehicle per day. 3. Peak hour volumes are two-way vehicles per hour.					

Review of Interchange Ramp Volumes - NSTIR obtained machine traffic counts on ramps at the Highway 102 / Highway 101 interchange during the first week of October 2006 and at the Highway 102 / Glendale Avenue interchange during the last week of September 2006. Since counts obtained at that time of year in an area with high commuter volumes can be expected to include some of the higher peak hourly volumes of the year, the ramp volumes for the peak days of the week have been considered as reasonable estimations of 2006 design hourly volumes (DHVs).

The estimated 2006 DHVs for the Highway 102 northbound exit ramps and the southbound access ramps at the Highway 102 / Highway 101 interchange are tabulated in Table A-13 and are shown graphically in Figure A-13. The northbound exit ramp to Highway 101 westbound and the southbound access ramp from Highway 101 eastbound to Highway 102 southbound have the highest ramp volumes at the interchange with 2006 daily volumes of from 11,000 to 11,700.

The estimated 2006 DHVs for the Highway 102 southbound exit ramps and the northbound access ramps at the Highway 102 / Highway 101 interchange are tabulated in Table A-14 and are shown graphically in Figure A-14.

The estimated 2006 DHVs for the four ramps at the Highway 102 / Glendale Avenue interchange are tabulated in Table A-15 and are shown graphically in Figure A-15. As was the case with the Highway 101 interchange, the highest volumes at this interchange are the southern ramps which have 2006 daily volumes of 5,800 to 6,600 vehicles.

2.2 Manual Turning Movement Counts

Manual Counts in the Burnside - Duke - Glendale Corridor - Manual turning movements were obtained at study area intersections during the later half of September and early October 2009. Counts obtained at the 23 intersections on Burnside Drive, Duke Street, Glendale Avenue, and Glendale Drive (Table 2-3) are tabulated in Tables B-1 to B-23 with peak hours indicated by shaded areas.. Counts were obtained from 7:00 AM to 9:00 AM and 4:00 PM to 6:00 PM at signalized intersections, as well as 11:00 AM to 1:00 PM at STOP controlled intersections.

Table 2-3 - Burnside - Duke - Glendale Corridor Manual Turning Movement Counts			
Intersection	Traffic Control	Date Counted	Table Number
1. SB Exit Ramp - Burnside Drive / Highway 111	Signalized	Sep. 22, 2009	B-1
2. NB Exit Ramp - Burnside Drive / Highway 111	Signalized	Sep. 22, 2009	B-2
3. Burnside Drive / Commodore Drive	Signalized	Oct. 9, 2009	B-3
4. Burnside Drive / Wright Avenue	Signalized	Set. 24, 2009	B-4
5. Burnside Drive / Akerley Boulevard	Signalized	Sep. 30, 2009	B-5
6. Duke Street / Rocky Lake Drive	STOP	Sep. 18, 2009	B-6
7. Duke Street / Mann Street	STOP	Sep. 18, 2009	B-7
8. Duke Street / Damascus Drive	Signalized	Sep. 18, 2009	B-8
9. NB Exit Ramp - Duke Street / Highway 102	Signalized	Sep. 24, 2009	B-9
10. SB Exit Ramp - Glendale Ave. / Highway 102	Signalized	Sep. 24, 2009	B-10
11. Glendale Avenue / Estates Blvd. / Temple Ter.	Signalized	Sep. 22, 2009	B-11
12. Glendale Avenue / Cobequid Road	Signalized	Sep. 22, 2009	B-12
13. Glendale Drive / Magee Drive	STOP	Sep. 22, 2009	B-13
14. Glendale Drive / Chandler Drive	STOP	Sep. 22, 2009	B-14
15. Glendale Drive / Pinehill Drive	STOP	Sep. 17, 2009	B-15
16. Glendale Drive / McDougall Ave / Stadium	Signalized	Sep. 17, 2009	B-16
17. Glendale Drive / Raymond Drive	STOP	Sep. 24, 2009	B-17
18. Glendale Drive / Metropolitan Avenue	Signalized	Sep. 24, 2009	B-18
19. Glendale Drive / Riverside Drive	Signalized	Sep. 23, 2009	B-19
20. Glendale Drive / Rankin Drive	STOP	Sep. 23, 2009	B-20
21. Glendale Drive / Smokey Drive	STOP	Sep. 16, 2009	B-21
22. Glendale Drive / Old Beaver Bank Road	STOP	Sep. 16, 2009	B-22
23. Glendale Drive / Beaver Bank Road	Signalized	Sep. 16, 2009	B-23

Projected 2010 Design Hourly Volumes - Counts obtained during late September and early October in an area with high commuter volumes can be expected to include some of the higher peak hourly volumes of the year. AM and PM peak hour volumes from the 2009 counts which have been increased by 2.0 % have been considered as reasonable estimations of 2010 design hourly volumes (DHVs) for this study. AM and PM peak hour volumes for the Glendale - Duke corridor from Beaver Bank Road to Rocky Lake Road are show diagrammatically on Figures C-1A and C-1B. Peak hour volumes for the Burnside Drive corridor are included on Figure C-2.

Projected 2016 Background Design Hourly Volumes - Projected 2016 AM and PM peak hour volumes without Highway 107 have been developed using the 2010 volumes (Figures C-1 and C-2) and a 1.5% annual volume growth rate.

Projected 2016 AM and PM peak hour volumes without Highway 107 for the Glendale - Duke corridor from Beaver Bank Road to Rocky Lake Road are show diagrammatically on Figures C-3A and C-3B. Projected 2016 peak hour volumes for the Burnside Drive corridor are included on Figure C-4.

Other Manual Turning Movement Counts - The turning movement counts included in Table 2-3 provide background data for studying the impacts of Highway 107 Phase 1 which will complete a missing link in the Burnside - Duke - Glendale corridor. However, count data from several other intersections in or near the study area have been accumulated to provide background information needed to evaluate the origin and destinations of trips that will divert from existing roads to use Highway 107 Phase 1. These volumes will be discussed further in *Section 4.0 - Traffic Volume Projections for Highway 107 Phase 1*.

Table 2-4 - Other Study Area Manual Turning Movement Counts			
Intersection	Data Source	Date Counted	Table Number
24. Windmill Road / Wright Avenue / Bancroft Drive	HRM	Oct. 2009	B-24
25. Windmill Road / Akerley Boulevard	HRM	Oct. 2009	B-25
26. Trunk 7 / Bedford By-Pass / Dartmouth Road	Study Count	Oct. 14, 2009	B-26
27. Bedford By-Pass / Highway 101	Study Count	Oct. 15, 2009	B-27
28. Cobequid Road / Memory Lane / Legacy Court	HRM	July 2006	B-28
29. Sackville Drive / Cobequid Road	HRM	May 2009	B-29
30. Bedford Highway / Dartmouth Road	HRM	Nov. 2008	B-30
31. Bedford Highway / Hammonds Plains Road	HRM	May 2009	B-31
32. Hammonds Plains Road / Highway 102 NB Ramps	ARTM	Nov. 27, 2009	B-32
33. Hammonds Plains Road / Highway 102 SB Ramps	ARTM	Nov. 27, 2009	B-33
34. Trunk 2 / Highway 102 NB Ramps / Perrin Drive	CBCL Report ¹	2008	B-34
NOTE: 1. Waverley - Fall River - Wellington Transportation Study, CBCL Limited, 2008			

3.0 Review of Existing and Future Land Use

3.1 Known Future Development Overall (Figure 3-1)

It is important when planning for new highways to understand the potential impact from the development of lands for residential and commercial purposes. Figure 3-1 provides an indication of developments that may occur by 2016 as well as by study horizon 2026.

The majority of development that would affect traffic volumes on Highway 107 is expected to occur in Bedford (Rocky Lake/Sackville Business Park), Sackville along Highway 101 (McCabe Lake/Glen Arbour/Sunset Ridge), Hammonds Plains Road (Sandy Lake), or the proposed Highway 113 (Bedford West).

Within the actual study area there are a few future developments which are intended to be primarily of a commercial nature. At the Duke Street interchange with Highway 102 there is continued development intended to unfold over the next ten to twenty years for commercial lands known as Bedford Commons (38/39) and Sackville Business Park (36/37). It should be noted that the owner of the Bedford Commons lands is interested in developing a portion of the lands for residential purpose (39), however, this has not been supported by HRM.

Burnside Industrial Park is at the eastern end of the proposed Highway 107 extension. Both immediately within the study area and just beyond are significant lands that are being developed by the Municipality for light industrial purposes. The lands immediately adjoining the Highway 107 extension (45) are not anticipated to be developed until after 2016 because of the existing lands within Burnside (43) and since access is not included in the proposed Highway 107 Phase 1. It should also be noted that Dartmouth Crossing is planning to develop a portion of its lands for residential purposes which was recently approved for rezoning by HRM (44).

3.2 Possible Development - Detailed Study Area (Figures 3-2 and 3-3)

The development of any new highway can lead to enhancing the development potential of lands that adjoin the new road. In understanding the development potential of existing lands that adjoin Highway 107 extension, the Halifax Regional Municipal Plan, Halifax Regional Subdivision Bylaw and the relevant Municipal Land Use Bylaws were referenced. The study area has three Land Use Bylaws which guide development in the area:

- Bedford Land Use Bylaw
- Dartmouth Land Use Bylaw; and
- Planning Districts 14 & 17, Shubenacadie Lakes

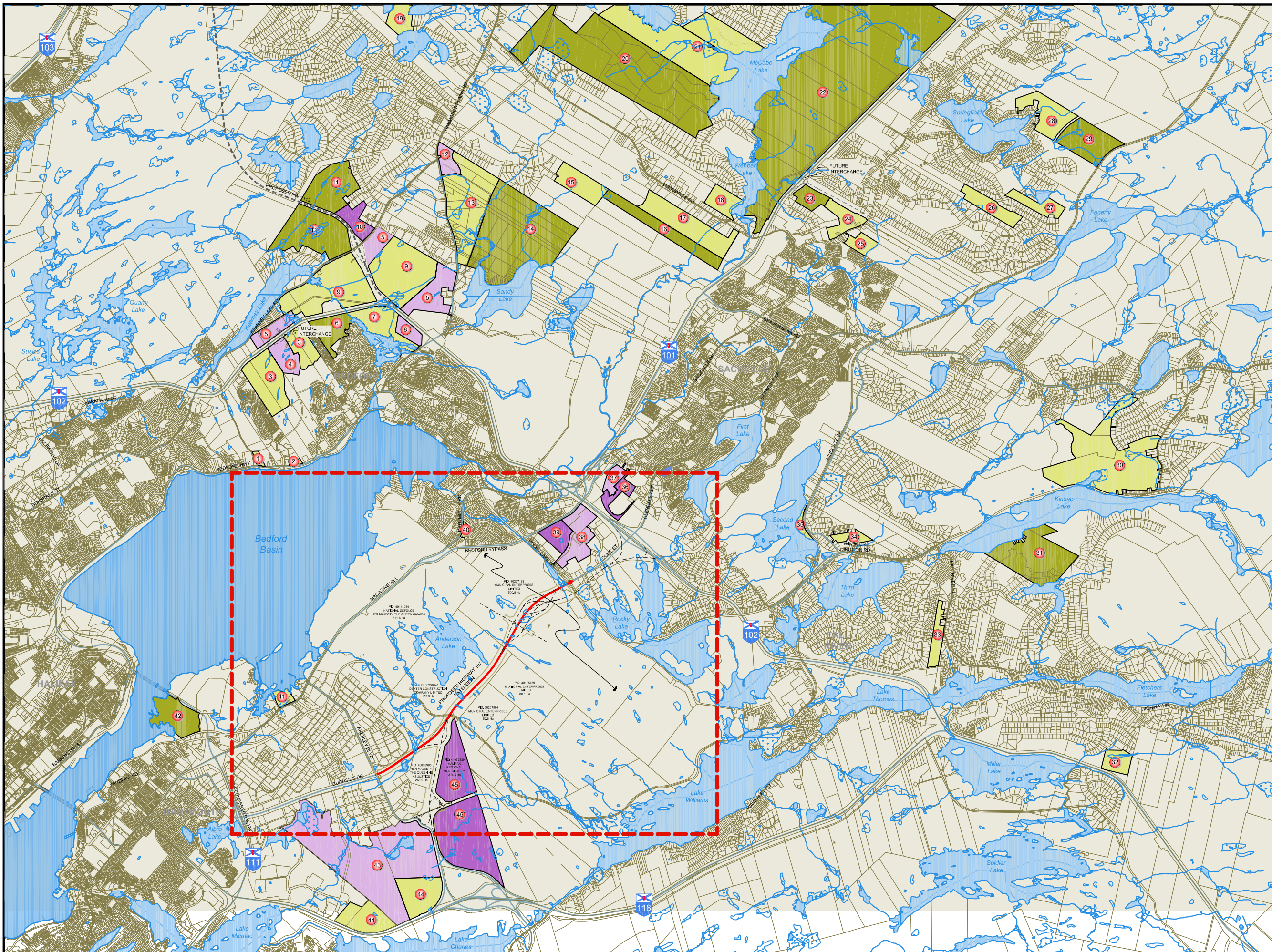
The Land Use Bylaw areas and the relevant zoning are indicated on Figure 3-2. A significant portion of these lands are zoned Urban Reserve consistent with the Regional Plan (Figure 3-3) indicating that these lands have been reserved for future development beyond the anticipated lifetime of the Regional Plan (being twenty five years). Lands to the north of Anderson Lake are either zoned R-7 (Rural Estate) or I-3 (Light Industrial). The I-3 zoned lands relate to the Dexter Quarry located along Rocky Lake Drive which is anticipated to continue its operation well beyond a twenty five year lifespan. For these reasons it is extremely unlikely any change in land use will occur. Other additional lands are owned by the National Defense where there are unknown locations of munitions that must be cleared prior to any development in those areas.

There are R-7 (Rural Estate) zoned lands also located adjacent to the proposed Highway 107 Extension north of Anderson Lake (Figure 3-2). These lands are located outside of the service boundary area and currently have no immediate frontage to a public road. This limits the ability to subdivide the lands further. Currently the Land Use Bylaw enables the number of uses that are not very intensive, such as single and two unit dwellings or forestry/agricultural uses that are subject to meeting a number of regulatory criteria e.g. on-site servicing/road access. The current zone and provisions of the Land Use Bylaw are not expected to lead to any significant development as a result of Highway 107, Phase 1. However, the Regional Plan, as indicated below, could enable greater residential development than the Land Use Bylaw Provisions.

The Regional Plan has the lands designated to the north of Anderson Lake as Rural Commuter (Figure 3-3), however, any application to develop the lands would be by way of a public process and would require access to a public road. This designation enables the owners to apply for a Development Agreement under the Regional Plan Open Space provisions. There are two forms of Open Space developments that a development may proceed under, being:

- Hybrid – This enables the opportunity to develop the land based on a density of one unit per hectare subject to meeting a number of criteria.
- Classic – This enables the opportunity to develop the land based on one unit per acre subject to meeting a number of criteria. This form of development has not been as desirable to developers because of issues surrounding capital costs and marketability that has resulted in the Hybrid being the preferred form of Open Space development.

Since development to 2016 and 2026 is expected to generally result in traffic volume increases on study area roads similar to the historic trend over the past ten years, an annual growth rate of 1.5% (Section 2.1) has been used to project 2016 and 2026 volumes.



LEGEND

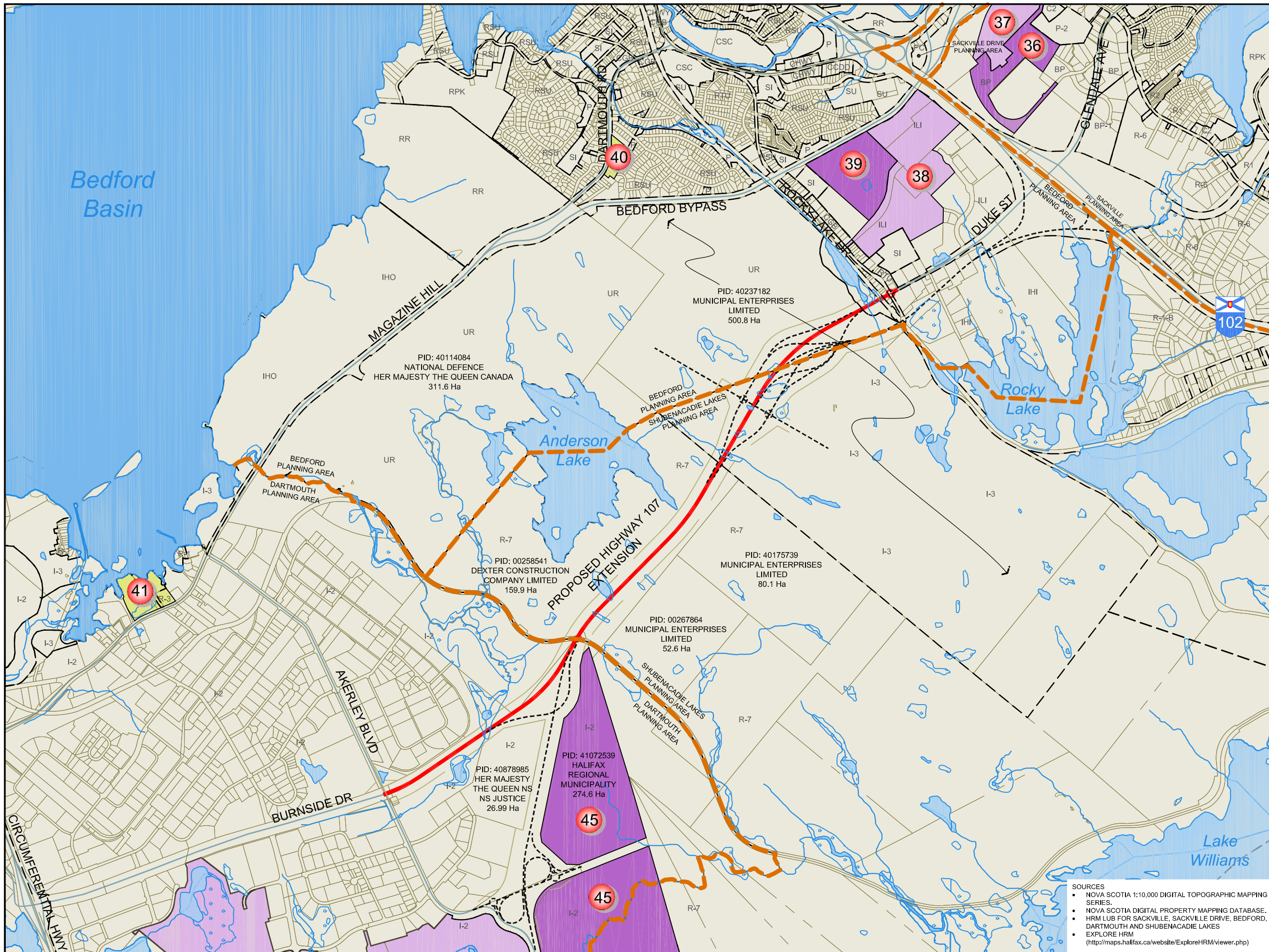
- DEVELOPMENT COMMERCIAL 2016
- DEVELOPMENT COMMERCIAL 2026
- DEVELOPMENT RESIDENTIAL 2016
- DEVELOPMENT RESIDENTIAL 2026
- HIGHWAY 107 EXTENSION PHASE 1
- HIGHWAY 107 EXTENSION FUTURE PHASES
- DETAILED STUDY AREA (SEE FIGURE 3-2)

NORTH

DRAWN: BMW
CHECKED: GOB

GENIVAR

1 SPECTACLE LAKE DRIVE
DARTMOUTH, NOVA SCOTIA
CANADA, B3B 1X7
PHONE: 902 835-9955 ~ FAX: 902 835-1645
WWW.GENIVAR.COM



LEGEND

	PLANNING BOUNDARIES
	ZONE BOUNDARIES
	DEVELOPMENT COMMERCIAL 2016
	DEVELOPMENT COMMERCIAL 2026
	DEVELOPMENT RESIDENTIAL 2016
	DEVELOPMENT RESIDENTIAL 2026
	HIGHWAY 107 EXTENSION PHASE 1
	HIGHWAY 107 EXTENSION FUTURE PHASES

BEDFORD PLAN AREA

CCDD	COMMERCIAL COMPREHENSIVE DEVELOPMENT DISTRICT
CGB	GENERAL BUSINESS DISTRICT
CHWY	HIGHWAY ORIENTED COMMERCIAL
CMC	MAIN STREET COMMERCIAL
CSC	SHOPPING CENTRE
FW	FLOOD WAY
IHI	HEAVY INDUSTRIAL
IHO	HARBOUR ORIENTED INDUSTRIAL
ILI	LIGHT INDUSTRIAL
P	PARK
RCDD	RESIDENTIAL COMPREHENSIVE DEVELOPMENT DISTRICT
RPK	REGIONAL PARK
RR	RESIDENTIAL RESERVE
RSU	SINGLE DWELLING UNITS
RTH	TOWNHOUSE
RTU-RTH	TOWNHOUSE TWO DWELLING UNIT
SI	INSTITUTIONAL
SU	UTILITIES

DARTMOUTH PLAN AREA

I-2	GENERAL INDUSTRIAL
I-3	HARBOUR ORIENTATED INDUSTRIAL
R-1	SINGLE FAMILY RESIDENTIAL
R-3	MULTIPLE FAMILY RESIDENTIAL (MEDIUM DENSITY)
R-7	RURAL ESTATE

SACKVILLE PLAN AREA

BP	BUSINESS PARK
BP-1	BUSINESS PARK 1
C-1	LOCAL BUSINESS
C-2	GENERAL BUSINESS
P-1	OPEN SPACE
P-2	COMMUNITY FACILITY
R-1	SINGLE FAMILY RESIDENTIAL
R-2	TWO FAMILY RESIDENTIAL
R-3	MULTIPLE FAMILY RESIDENTIAL (MEDIUM DENSITY)
R-6	RURAL RESIDENTIAL
RPK	REGIONAL PARK

SHUBENACADIE PLAN AREA

I-3	LIGHT INDUSTRIAL
6-1-B	SUBURBAN RESIDENTIAL
R-7	RURAL ESTATE

SACKVILLE DRIVE PLAN AREA

PC	PINEHILL COBEQUID
----	-------------------

NORTH

DRAWN: BMW
CHECKED: GOB

GENIVAR

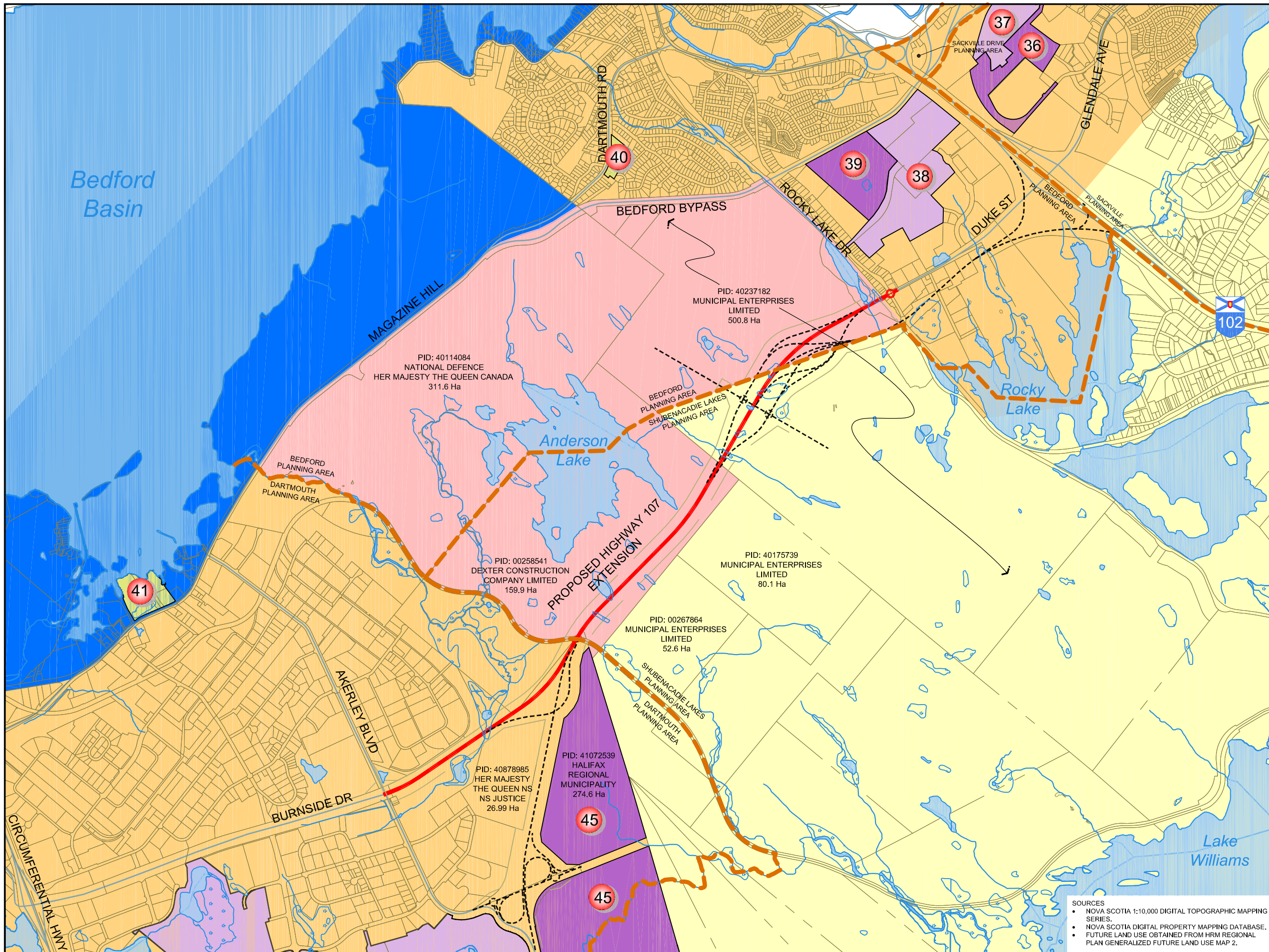
1 SPECTACLE LAKE DRIVE
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CANADA, B3B 1X7
PHONE: 902 835-9955 ~ FAX: 902 835-1645
WWW.GENIVAR.COM

DETAILED FUTURE DEVELOPMENT

FIGURE 3-2 JANUARY 2011

SOURCES

- NOVA SCOTIA 1:10,000 DIGITAL TOPOGRAPHIC MAPPING SERIES.
- NOVA SCOTIA DIGITAL PROPERTY MAPPING DATABASE.
- HRM LUB FOR SACKVILLE, SACKVILLE DRIVE, BEDFORD, DARTMOUTH AND SHUBENACADIE LAKES
- EXPLORE HRM (<http://maps.halifax.ca/website/ExploreHRM/viewer.php>)



LEGEND

- PLANNING BOUNDARIES
- DEVELOPMENT COMMERCIAL 2016
- DEVELOPMENT COMMERCIAL 2026
- DEVELOPMENT RESIDENTIAL 2016
- DEVELOPMENT RESIDENTIAL 2026
- HIGHWAY 107 EXTENSION PHASE 1
- HIGHWAY 107 EXTENSION FUTURE PHASES

HRM PRIMARY DESIGNATIONS
(REGIONAL MUNICIPAL PLANNING STRATEGY 2006)

- URBAN SETTLEMENT
- URBAN RESERVE
- HARBOUR
- RURAL COMMUTER

NORTH

DRAWN: BMW
CHECKED: GOB

GENIVAR

1 SPECTACLE LAKE DRIVE
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CANADA, B3B 1X7
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DETAILED STUDY AREA

FIGURE 3-3 JANUARY 2011

SOURCES

- NOVA SCOTIA 1:10,000 DIGITAL TOPOGRAPHIC MAPPING SERIES.
- NOVA SCOTIA DIGITAL PROPERTY MAPPING DATABASE.
- FUTURE LAND USE OBTAINED FROM HRM REGIONAL PLAN GENERALIZED FUTURE LAND USE MAP 2.

4.0 Traffic Volume Projections for Highway 107 Phase 1

4.1 Existing Design Hourly Volumes in the Study Corridor

The existing design hourly volumes that use, or could possibly use, the Highway 107 Phase 1 Study Corridor between Burnside and Bedford / Sackville, include the following:

- volumes now using Magazine Hill (Trunk 7) shown in Table 4-1; and
- traffic that is now using Highway 102 to the Trunk 2 interchange at Waverley (Table B-34, Appendix B) and then Highway 118 to access the Burnside area.

Movement	AM Peak Hour ¹	PM Peak Hour ¹
Dartmouth Road to Magazine Hill	870 ²	720
Bedford By-Pass to Magazine Hill ³	2500 ³	670
Total Southbound Magazine Hill	3370	1390
Magazine Hill to Dartmouth Road	430	1080
Magazine Hill to Bedford By-Pass	575	2290
Total Northbound Magazine Hill	1005	3370
Total Two-Way Magazine Hill Peak Hour Volumes	4375⁴	4760

NOTE: 1. Projected 2010 volumes in this table have been obtained from evaluation of volumes counted on October 14 and 15, 2009 (Tables B-26 and B-27, Appendix B) using a 1.5% annual growth rate for traffic volumes.
 2. These trips come from the Bedford Area including some from Hammond Plains Road and Rocky Lake Road.
 3. Projected 2010 volumes include 1330 vph from Highway 101 and 1170 vph from Sackville Drive (Table B-27).
 4. 30% of the AM peak hour two-way traffic on Magazine Hill uses Dartmouth Road and 70% uses the Bedford By-Pass.

Existing Volumes on Magazine Hill - Projected 2010 two-way DHVs on Magazine Hill (Trunk 7) between Burnside and Bedford summarized in Table 4-1, include 4375 vehicles per hour (vph) during the AM peak and 4760 vph during the PM peak. The majority of Magazine Hill traffic is to / from the Bedford By-Pass which accounts for 70% of the AM peak trips and 62% of the PM peak trips. Review of turning movement counts at Windmill Road intersections with Akerley Boulevard (Table B-25) and Wright Avenue (Table B-24) reveals that about 40% of Magazine Hill AM peak traffic and about 50% of the PM peak traffic enters / exits the Burnside area at those two intersections. The remaining 60% of AM peak hour traffic and 50% of PM peak hour traffic from Magazine Hill continues southbound on Windmill Road towards the Harbour Bridges, Highway 111, and Downtown Dartmouth.

Existing Volumes at the Highway 102 / Trunk 2 Exit at Waverley - Turning movement volumes included in the *Waverley - Fall River - Wellington Transportation Study* (CBCL Limited, 2008) indicate (Table B-34) that during the AM peak hour 468 vph (480 vph in 2010) of the Highway 102 northbound exit traffic continued to Perrin Drive to the Highway 118 interchange and Miller Lake area. It is understood that a significant portion of these trips originate from residents of the Sackville, Highway 101 and Hammonds Plains areas who work in the Burnside or east Dartmouth areas and use Highway 102 and Highway 118 to avoid congestion on Magazine Hill and at Windmill Road intersections.

Projected 2010 Volumes at Study Area Intersections - Projected 2010 AM and PM peak hourly volumes without Highway 107 Phase 1 for intersections in the Glendale-Duke-Burnside corridor are shown diagrammatically on Figures C-1 and C-2, Appendix C.

4.2 Projected 2016 Volumes with Highway 107 Phase 1

Projected 2016 Volumes Without Highway 107 - Projected 2016 AM and PM peak hourly volumes without Highway 107 Phase 1, prepared using 2010 volumes and a 1.5% annual growth rate, are shown diagrammatically on Figures C-3 and C-4 for intersections in the Glendale-Duke-Burnside corridor. Volumes on Magazine Hill are also summarized in Table 4-2 and volumes at the following strategic intersections shown diagrammatically on Figure 4-1:

- Windmill Road @ Akerley Boulevard
- Trunk 7 (Magazine Hill) @ Dartmouth Road / Bedford By-Pass
- Bedford By-Pass @ Highway 101 / Sackville connecting streets
- Akerley Boulevard @ Burnside Drive / Highway 107 Phase 1
- Rocky Lake Drive @ Highway 107 Phase 1 / Duke Street
- Highway 102 EXIT 4C Ramps @ Duke Street / Glendale Avenue.

Projected 2016 Volumes With Highway 107 - As discussed in Section 4.1, candidate trips for diversion to Highway 107, Phase 1, are either existing trips using Magazine Hill or trips with destinations in Burnside or east Dartmouth that now use the Highway 102 exit at the Waverley interchange and Highway 118 to avoid congestion in the Magazine Hill / Windmill Road area.

Review of volumes with the HRM QRS II Transportation Planning Model confirmed that about 30% of Magazine Hill volumes use Dartmouth Road and 70% use the Bedford By-Pass as was determined from counted volumes in Section 4.1. The Model also indicated that a large percentage of Magazine Hill trips continue southbound on Windmill Road past the Akerley Boulevard and Wright Avenue intersections, as was also indicated by turning movement counts at those intersections.

Evaluation of traffic volumes at study area intersections and local knowledge of the area, have been used to redistribute trips from Magazine Hill and the Waverley interchange area to the proposed Highway 107 Phase 1. The following areas indicated by orange circles on Figure 1-1 have been reviewed when considering candidate trips for diverting to Highway 107:

- Trips from Hammonds Plains Road (Table B-31), Bedford Highway to Sunnyside, Rocky Lake Drive and Dartmouth Road that access Magazine Hill at Dartmouth Road ramps. Since only some of the Hammond Plains Road and Rocky Lake Road trips will have an advantage to using Highway 107, only a small percentage of the trips using Dartmouth Road trips are expected to divert to Highway 107.
- Trips entering Highway 102 northbound at the Hammonds Plains (Table B-31), Highway 101 (Table A-14) and Glendale Avenue (Table B-9) interchanges and the Waverley interchange and Highway 118 to access Burnside.
- Trips southbound on Beaver Bank Road (Table B-23) traveling to Highway 101, and other Highway 101 traffic, that use Bedford By-Pass (Table B-27). Since there is little advantage for trips from Highway 101 to divert from the Bedford By-Pass to Highway 107, it can be expected that most will continue to use Magazine Hill, however some trips from Beaver Bank Road are expected to divert to Glendale Drive to access Highway 107.
- Trips from the east end of Glendale Drive and Cobequid Road (Tables B-12 and B-29) that use the Sackville Drive approach to Bedford By-Pass (Table B-27);
- Traffic movements at the Trunk 7 (Magazine Hill)/ Dartmouth Road / Bedford By-Pass interchange (Table B-26);

- Traffic movements from the Bedford By-Pass to Highway 101 and Cobequid Road (Tables B-27 and B-28); and
- Traffic movements between Windmill Road and Akerley Boulevard (Table B-25) and Windmill Road and Wright Avenue (Table B-24).

The following details summarize trip diversion to Highway 107:

- Traffic diverted to Highway 107 reduced Magazine Hill volumes by 27% during the 2016 AM peak hour and 29% during the PM peak hour.
- Projected 2016 two-way peak hour volumes on Highway 107 Phase 1 include approximately 1800 vph during the AM peak hour and 1600 during the PM peak hour.
- The 2016 two-way AM peak hour volumes on Highway 107 include approximately 5% from Dartmouth Road, 70% from Bedford By-Pass and 25% from other locations, such as Highway 102 at the Waverley interchange.
- The 2016 two-way PM peak hour volumes on Highway 107 include approximately 5% from Dartmouth Road, 85% from Bedford By-Pass and 10% from other locations, such as Highway 102 at the Waverley interchange.

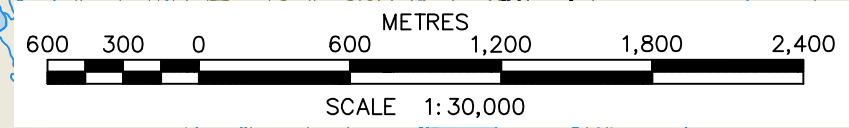
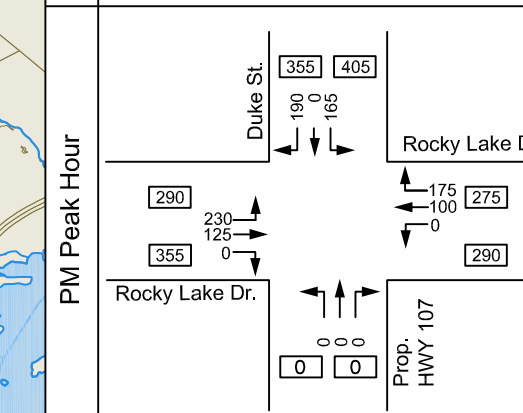
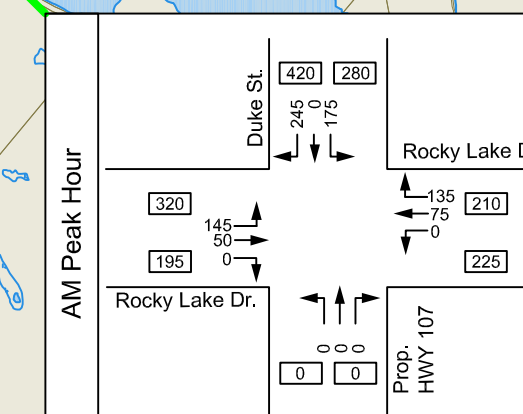
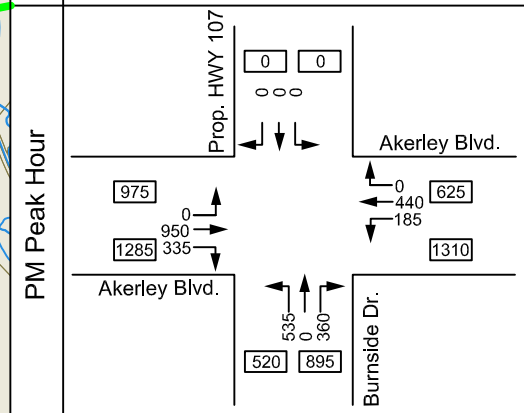
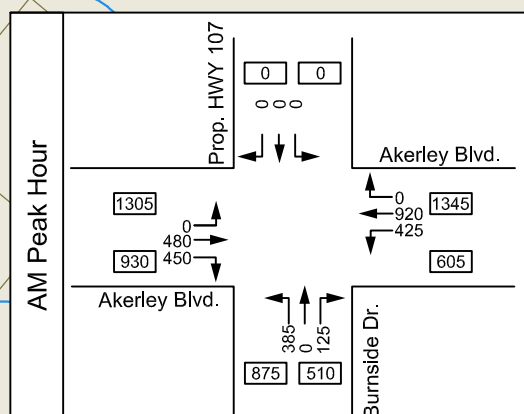
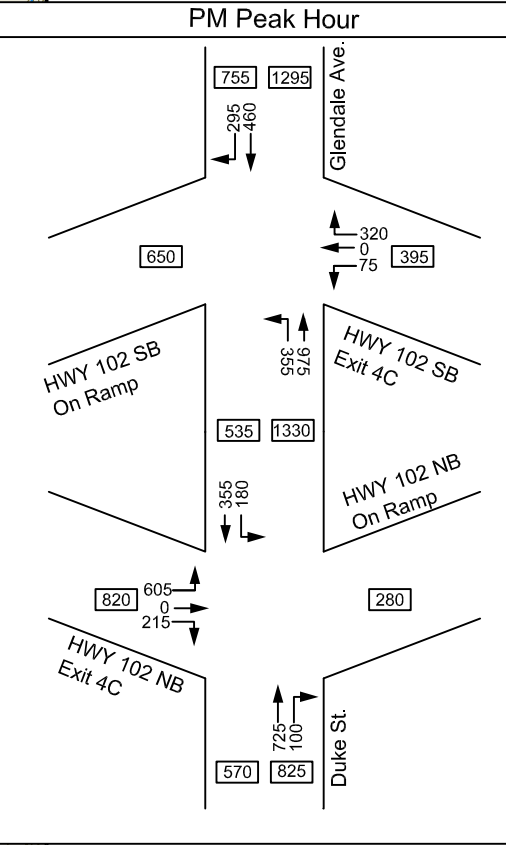
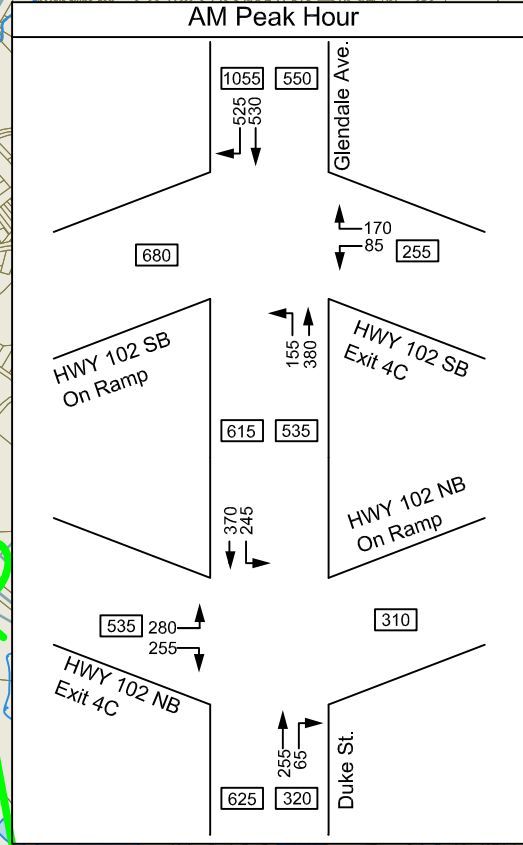
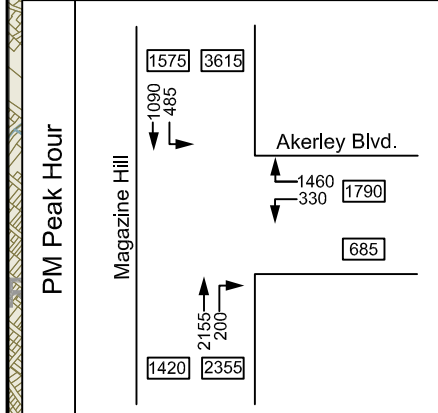
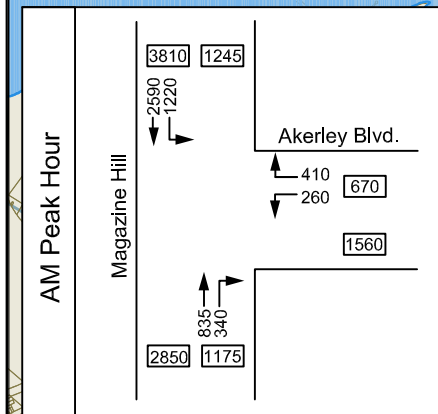
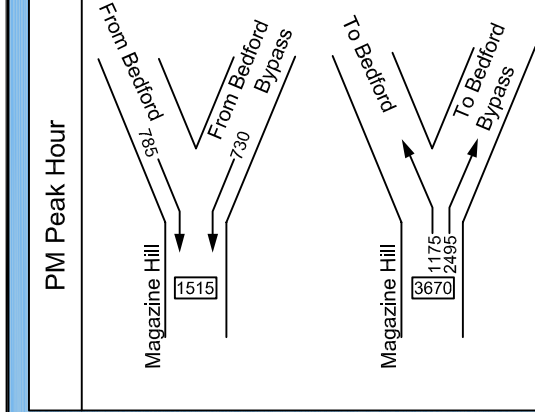
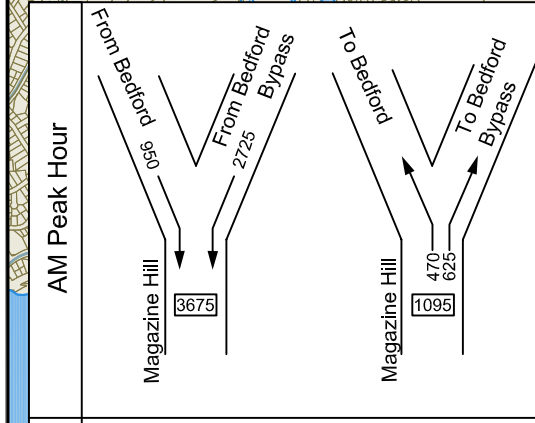
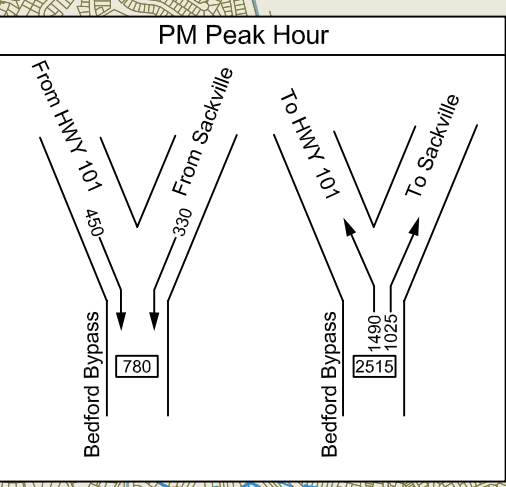
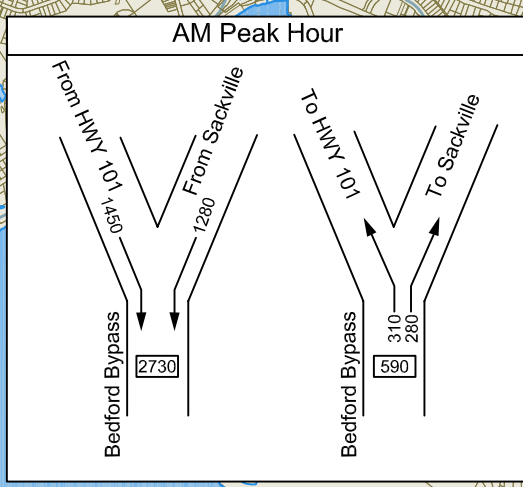
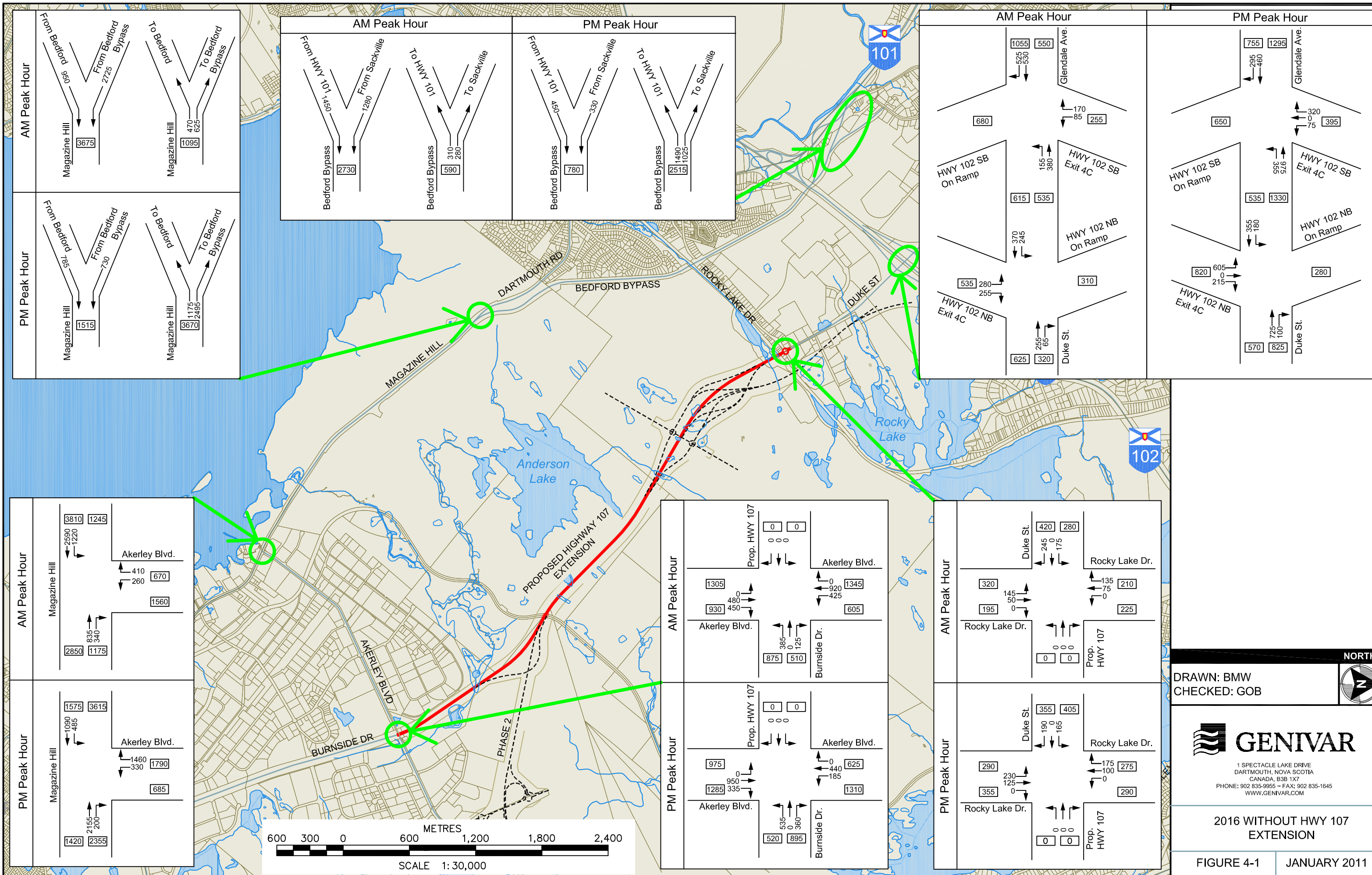
Projected 2016 peak hourly volumes with Highway 107 Phase 1 are shown diagrammatically on Figures C-5 and C-6 for intersections in the Glendale-Duke-Burnside corridor. Volumes on Magazine Hill are also summarized in Table 4-2 and volumes at strategic intersections are shown diagrammatically on Figure 4-2.

Table 4-2 - Projected Magazine Hill Peak Hour Volumes 2010 to 2026				
Movement	Projected Peak Hour Volumes			
	2010	2016 Without Highway 107	2016 With Highway 107	2026 With Highway 107
Projected AM Peak Hourly Volumes				
Dartmouth Road to Magazine Hill	870	950	880	1005
Bedford By-Pass to Magazine Hill	2500	2725	1735	1970
Total Southbound Magazine Hill	3370	3675	2615	2975
Magazine Hill to Dartmouth Road	430	470	445	510
Magazine Hill to Bedford By-Pass	575	625	410	470
Total Northbound Magazine Hill	1005	1095	855	980
AM Peak Hour Total Two-Way Magazine Hill	4375	4770	3470	3955
Percent Diverted to Highway 107 Phase 1 during 2016 AM peak Hour (1300 / 4770)			27%	
Projected PM Peak Hourly Volumes				
Dartmouth Road to Magazine Hill	720	785	760	865
Bedford By-Pass to Magazine Hill	670	730	335	375
Total Southbound Magazine Hill	1390	1515	1095	1240
Magazine Hill to Dartmouth Road	1080	1175	1115	1275
Magazine Hill to Bedford By-Pass	2290	2495	1485	1690
Total Northbound Magazine Hill	3370	3670	2600	2965
AM Peak Hour Total Two-Way Magazine Hill	4760	5185	3695	4205
Percent Diverted to Highway 107 Phase 1 during 2016 PM peak Hour (1490 / 5185)			29%	
NOTE: Volumes have been obtained from Table 4-1, and Figures 4-1, 4-2, and 4-3.				

Projected 2026 Volumes With Highway 107 - Projected 2026 volumes that include Highway 107 Phase 1 have been produced by adding an additional 1.5% annual traffic volume growth (15.0%) to projected 2016 volumes with Highway 107.

Projected 2026 peak hourly volumes with Highway 107 Phase 1 are shown diagrammatically on Figures C-7 and C-8 for intersections in the Glendale-Duke-Burnside corridor. Volumes on Magazine Hill are also summarized in Table 4-2 and volumes at strategic intersections are shown diagrammatically on Figure 4-3.

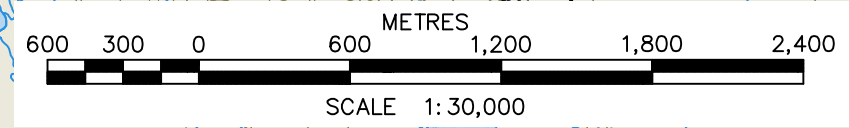
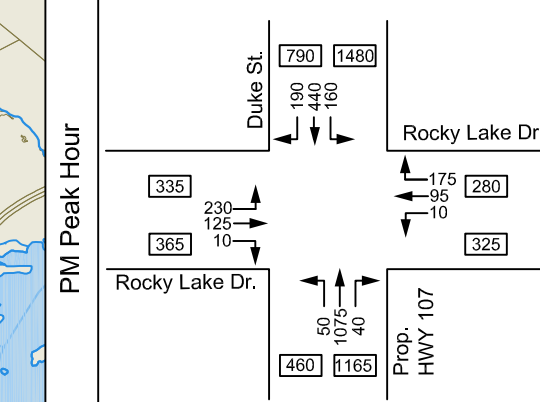
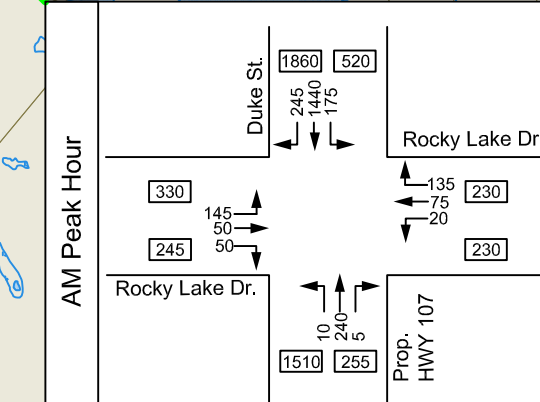
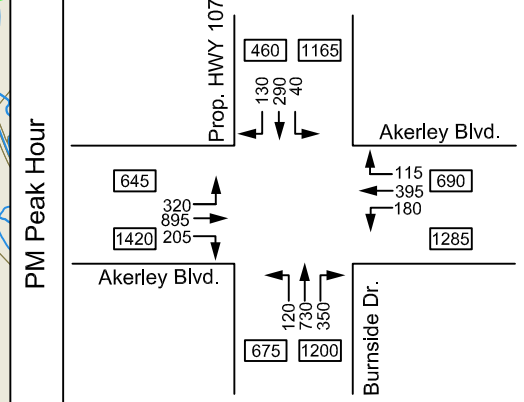
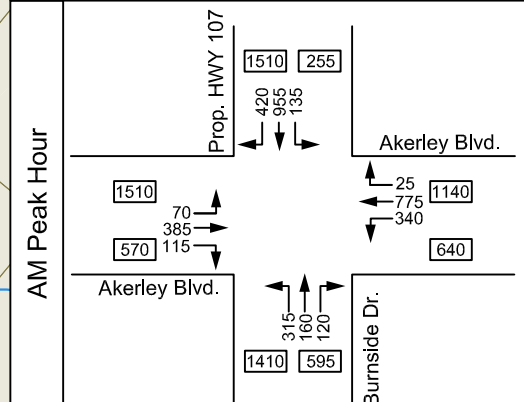
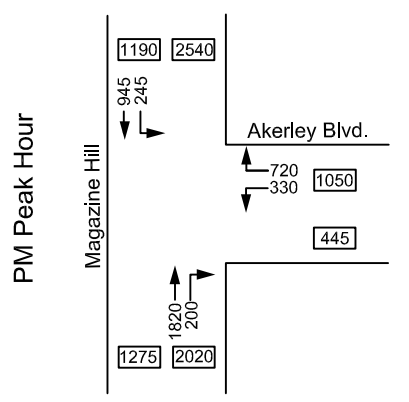
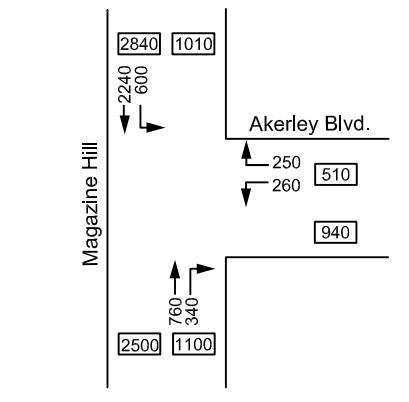
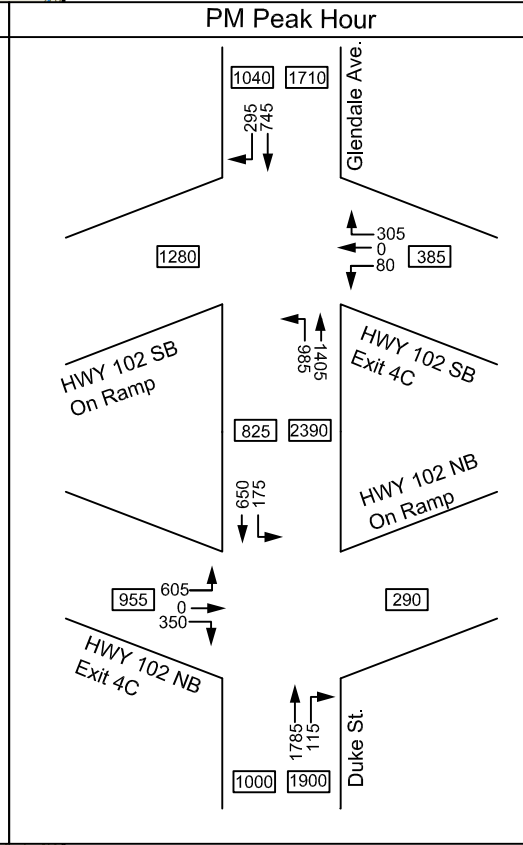
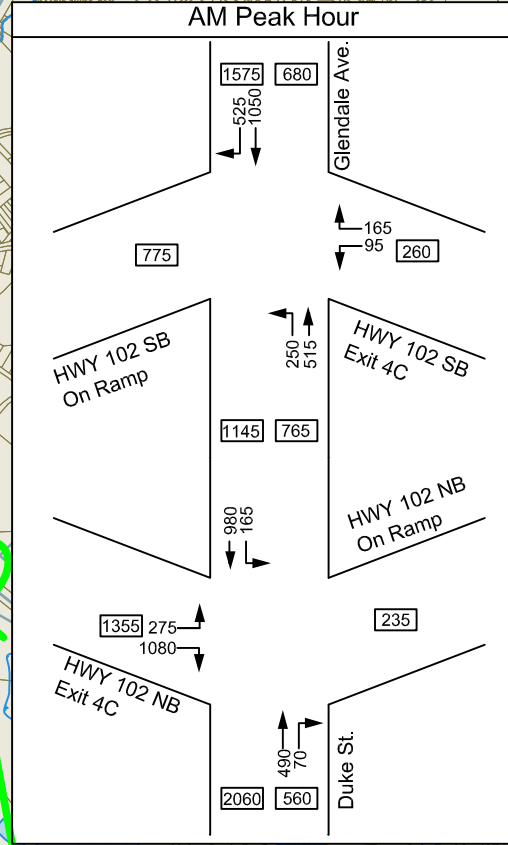
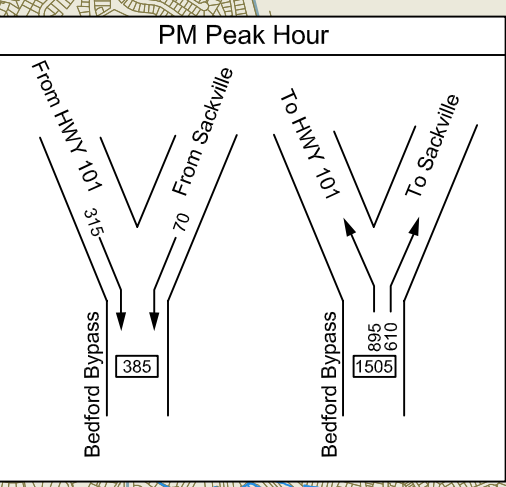
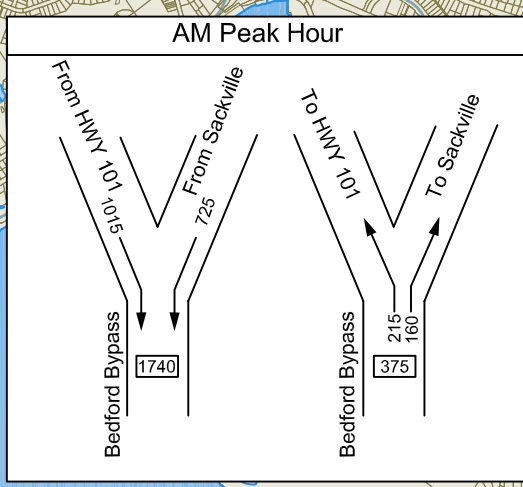
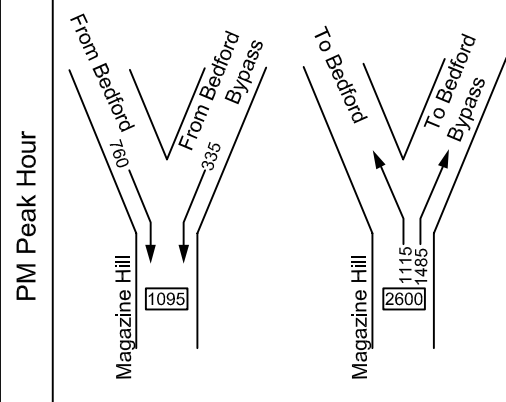
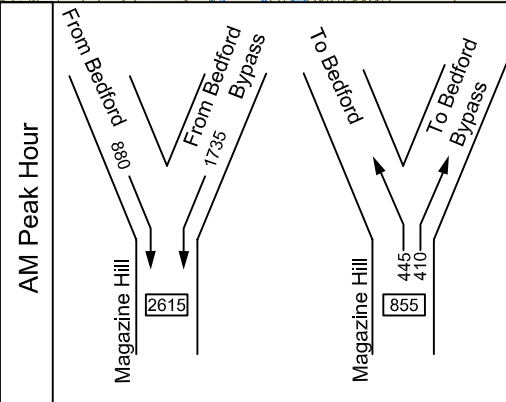
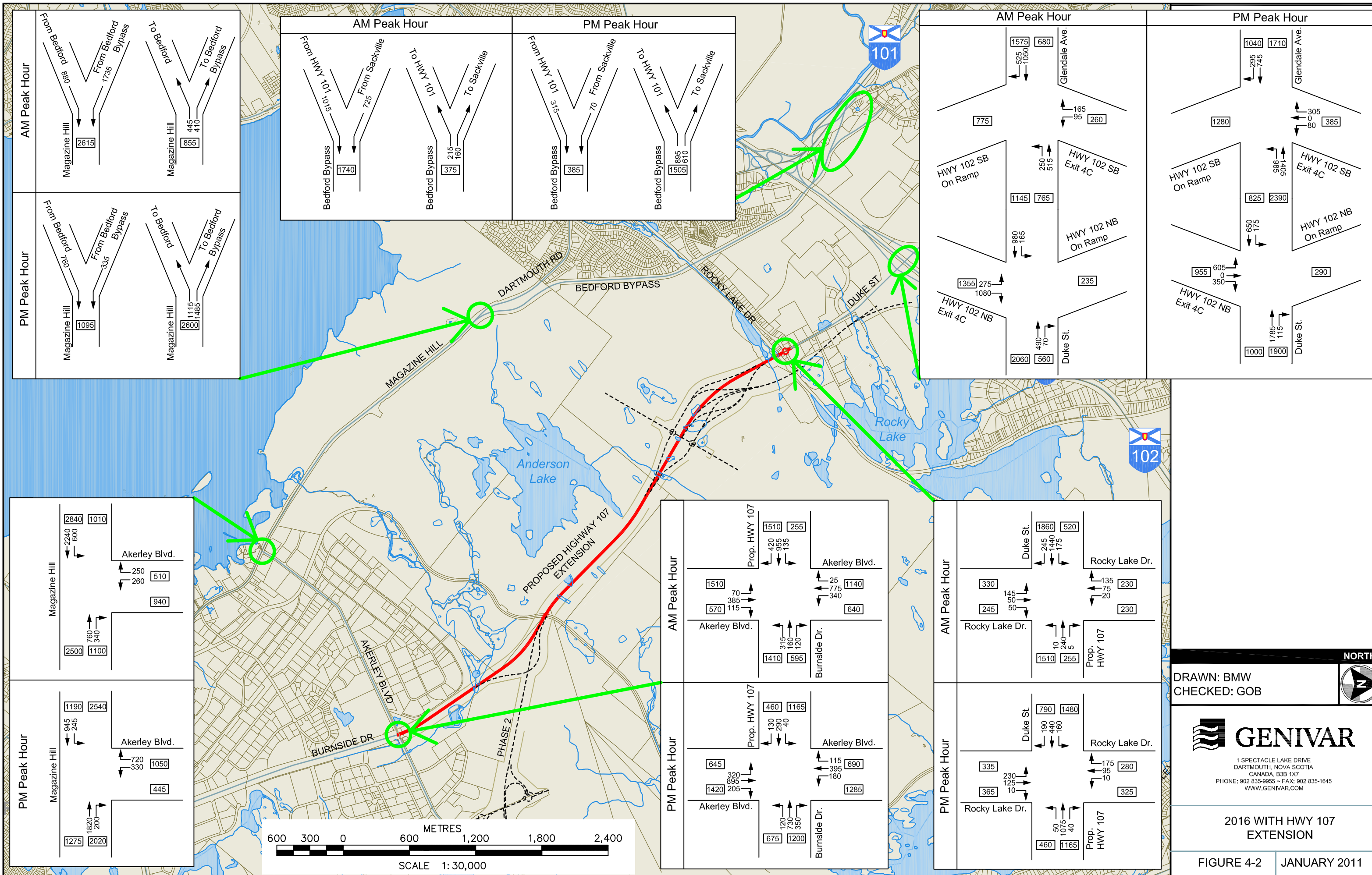
Projected 2026 two-way peak hour volumes on Highway 107 Phase 1 include approximately 2000 vph during the AM peak hour and 1800 vehicles during the PM peak hour.



DRAWN: BMW
CHECKED: GOB



2016 WITHOUT HWY 107
EXTENSION



DRAWN: BMW
CHECKED: GOB



2016 WITH HWY 107
EXTENSION

5.0 Warrant Evaluations

5.1 Left Turn Lane Warrants

Left turn movements on a two lane highway may cause both operational and safety problems. Operational problems result as a vehicle stopped waiting for an opportunity to turn across ‘heavy’ opposing traffic causes a queue of stopped vehicles to form. Safety problems result from rear end collisions when a stopped left turning vehicle is struck by an advancing vehicle, or from head-on or right angle collisions when a left turning vehicle is struck by an opposing vehicle.

The *Geometric Design Standards for Ontario Highways Manual* contains nomographs for left turn lane analysis for two lane streets. The analysis method, which is normally used by *GENIVAR Inc.* and *NSTIR* to evaluate need for left turn lanes, uses a series of nomographs that consider speed, advancing volumes, left turns as a percentage of advancing volumes, and opposing volumes. A point, based on ‘opposing’ and ‘advancing’ volumes, plotted to the right of the ‘warrant line’ of the appropriate ‘% left turns’ and ‘approach speed’ nomograph, indicates that a left turn lane is warranted for the conditions used in the analysis. Similarly, a point that is plotted to the left of the warrant line indicates that a left turn lane is not warranted.

The warrant for left turn lanes was evaluated at seven STOP sign controlled intersections in the Glendale - Duke corridor. The warrant nomographs are included in Figures D-1 to D-3, Appendix D, and results are summarized in Table 5-1. Since existing and projected 2016 peak hour volumes on Glendale Drive are very high, left turn lanes will be required at all Glendale Drive and Duke Street intersections for projected 2016 volumes without Highway 107. Also, review of the locations of the warrant points on the nomographs in Appendix D in relation to the ‘warrant line’ indicate that left turn lanes should be considered for all intersections on Glendale Drive for existing 2010 volumes.

Table 5-1 - Evaluation of Left Turning Lane Warrants for 2016 without Highway 107						
Intersection ¹		Advancing Volume ²	Opposing Volume ²	Percent Left Turns ²	Figure ³	Left Turn Lane Warranted? ⁴
Old Beaver Bank Rd.	AM	480	715	30	D-2	Yes
	PM	795	440	15	D-2	Yes
Smokey Drive	AM	720	460	5	D-1	Yes
	PM	545	885	35	D-3	Yes
Rankin Drive		475	965	5	D-1	Yes
Raymond Drive		415	855	5	D-1	Yes
Pinehill Drive	AM	475	1080	10	D-1	Yes
	PM	1300	620	5	D-1	Yes
Chandler Drive		540	1130	5	D-1	Yes
Magee Drive		Existing left turns lanes for both directions of travel				
Mann Street		465	280	10	D-1	Yes
NOTES: 1. The first seven intersections are on Glendale Drive between Beaver Bank Road and Cobequid Road. The Mann Street intersection is on Duke Street near Rocky Lake Drive. 2. Volumes used in this analysis are from Figure C-3, Appendix C. 3. Left turn warrant figures are in Appendix D. 4. Left turn lanes are warranted in accordance to the left turn warrant nonographs in Appendix D.						

5.2 Right Turn Lane Warrants

Operational problems may result at an intersection where a ‘high’ number of vehicles slow to make a right onto a street. The *Ohio Department of Transportation State Highway Access Management Manual* contains nomographs (Figures D-4 and D-5) for evaluating right turn lane warrants on two lane roads. The analysis is based on right turning and advancing volumes.

Right turn warrant evaluation has been completed for projected 2016 volumes without Highway 107 using nomograph in Figures D-4, Appendix D, and results are summarized in Table 5-2. Since Glendale Drive projected 2016 volumes without Highway 107 are high eastbound during the AM peak hour and westbound volumes during the PM peak hour, right turn lanes will be warranted at all Glendale Drive intersections except Chandler Drive and Magee Drive eastbound.

Since right turn volumes are very low at the Mann Street intersection on Duke Street, a right turn lane will not be warranted during 2016 without Highway 107. However, since volumes on Duke Street will increase significantly with the construction of Highway 107, a right turn evaluation was also completed for 2016 and 2026 with the added Highway 107 volumes (Figure D-5). While the low right turning volumes of 5 or 10 vehicles per hour do not warrant a right turn lane, construction of a right turn lane may be required if right turning volumes were to increase to 50 vehicles per hour during the PM peak hour.

Intersection ¹		Advancing Volume ²	Right Turning Volume ²	Figure ³	Right Turn Lane Warranted? ⁴
Old Beaver Bank Rd.	AM	715	50	D-4	Yes
	PM	440	40	D-4	No
Smokey Drive	AM	460	80	D-4	Yes
	PM	885	180	D-4	Yes
Rankin Drive	AM	430	30	D-4	No
	PM	965	60	D-4	Yes
Raymond Drive	AM	855	75	D-4	Yes
	PM	545	60	D-4	Yes
Pinehill Drive	AM	1080	60	D-4	Yes
	PM	620	55	D-4	Yes
Chandler Drive	AM	405	10	n/a	No
	PM	1130	20	D-4	No
Magee Drive WB	AM	420	35	D-4	No
	PM	1240	65	D-4	Yes
Magee Drive EB	AM	1005	15	D-4	No
	PM	515	20	D-4	No
Mann Street ⁵	AM	520 to 590	5	D-5	No
	PM	1480 to 1680	10	D-5	No

NOTES: 1. The first seven intersections are on Glendale Drive between Beaver Bank Road and Cobequid Road. The Mann Street intersection is on Duke Street near Rocky Lake Drive.
 2. Volumes for Glendale Drive intersections used in this analysis are from Figure C-3, Appendix C. Volumes for Mann Street intersection are from Figure C-5 (2016 with 107) and C-7 (2026 with 107)
 3. Right turn warrant figures are in Appendix D.
 4. Right turn lanes are warranted in accordance to the warrant nonographs in Appendix D.
 5. Analyses at Mann Street are for 2016 and 2026 volumes with Highway 107.

5.3 Traffic Signal Warrants

A signal warrant analysis is completed to determine if the installation of traffic signals at an intersection will provide a positive impact on total intersection operation. That is, the benefits in time saved and improved safety that will accrue to vehicles entering from a side street will exceed the impact that signals will have in time lost and potential additional collisions for vehicles approaching the intersection on the main street.

The *Canadian Traffic Signal Warrant Matrix Analysis (Transportation Association of Canada (TAC), 2005)* considers 100 warrant points as an indication that traffic signals will provide a positive impact. Signal warrant analysis uses vehicular and pedestrian volumes, and intersection, roadway and study area characteristics to calculate a warrant point value.

Signal warrant analyses have also been completed for projected 2016 volumes both without and with Highway 107, as well as for projected 2026 volumes with Highway 107. Signal warrant analysis sheets are included as Tables D-1 to D-24, Appendix D, on pages D-6 to D-29. Results are summarized in Table 5-3.

Intersection ¹	Analysis Results - 2016 Without Highway 107			Analysis Results - 2016 With Highway 107			Analysis Results - 2026 With Highway 107		
	Table ²	Points	Yes / No ³	Table ²	Points	Yes / No ³	Table ²	Points	Yes / No ³
Old Beaver Bank Rd.	D-1	55	No	D-9	64	No	D-17	76	No
Smokey Drive	D-2	78	No	D-10	91	Study	D-18	106	Yes
Rankin Drive	D-3	23	No	D-11	26	No	D-19	31	No
Raymond Drive	D-4	46	No	D-12	52	No	D-20	59	No
Pinehill Drive	D-5	65	No	D-13	73	No	D-21	83	Study
Chandler Drive	D-6	31	No	D-14	36	No	D-22	41	No
Magee Drive	D-7	71	No	D-15	81	Study	D-23	92	Study
Mann Street	D-8	10	No	D-16	39	No	D-24	49	No

NOTES: 1. The first seven intersections are on Glendale Drive between Beaver Bank Road and Cobequid Road. The Mann Street intersection is on Duke Street near Rocky Lake Drive.
 2. Signal warrant analyses are included in Appendix D, Pages D-6 to D-29.
 3. Are signals warranted by meeting 100 point requirement and minimum 75 vph on the side street approach?

Summary Signal Warrant Analysis - The signal warrant analysis indicates the following:

1. Signals will not be warranted at any of the intersections by 2016 without Highway 107.
2. While signals won't be warranted at any intersection during 2016 with added Highway 107 trips, the Glendale Drive intersections at Smokey Drive and Magee Drive should be re-evaluated.
3. Signals are expected to be warranted at the Glendale Drive / Smokey Drive intersection during 2026. The Glendale Drive intersections at Pinehill Drive and Magee Drive should be re-evaluated.

5.4 Evaluation of Pedestrian Crosswalks

The *Transportation Association of Canada (TAC)* has prepared the *Pedestrian Crossing Control Manual* (March 1998). The *Manual* provides operational guidelines for selecting the appropriate level of crosswalk protection in hierarchical form based on road width, pedestrian crossing volumes, and vehicle volumes. The methodology and appropriate tables and figures are included on Pages D-30 to 32, Appendix D.

Four types of pedestrian crossing control devices are considered:

1. **Unmarked crosswalks** - Pedestrians have the right-of-way at all intersections, thus marked crosswalks are not required at low volume intersections.
2. **Signed and marked crosswalks** are installed to draw a driver’s attention to a crossing location and to indicate to pedestrians that the location is a preferred place to cross the road.
3. **Special crosswalks** are pushbutton operated and are reserved where higher volumes and complex locations make it more difficult for drivers to realize that a pedestrian wishes to cross the road.
4. **Pedestrian signals** are pushbutton actuated half-signals that stop traffic to allow pedestrians to cross very busy arterial streets where normal crossing opportunities are infrequent.

Intersection ¹	Existing Crosswalk Treatment	Maximum Counted Pedestrian Volume	Adjusted Pedestrian Volume ²	Two-Way Volume ³	Crossing Opportunities ⁴	Warranted Crosswalk Treatment ⁵
Old Beaver Bank Rd.	None	10	15	1400	45	None
Smokey Drive	None	14	25	1500	38	RA-4 - Signs
Rankin Drive	None	5	10	1400	45	None
Raymond Drive	RA-3 - Signs	43	65	1400	45	Ped. Signals
Pinehill Drive	RA-5 - Lights	25	40	1700	25	RA-5 - Lights
Chandler Drive	RA-5 - Signs	8	15	1600	30	None
Magee Drive	RA-5 - Lights	36	55	1600	30	RA-5 - Lights
Mann Street	None	0	0	2400	Nil	None

NOTES: 1. The first seven intersections are on Glendale Drive between Beaver Bank Road and Cobequid Road. The Mann Street intersection is on Duke Street near Rocky Lake Drive.
 2. It was assumed that the pedestrian count included 50% children. The maximum count has been increased by 50% and rounded up to the nearest 5 to provide an estimate of 'equivalent adult units'.
 3. Since the maximum observed pedestrian volumes were generally during the AM peak period, projected 2016 two-way volumes with added Highway 107 traffic (Figure C-5A) have been used in this evaluation.
 4. Cross opportunities have been estimated using *Pedestrian Crossing Control Manual* Figure 9.
 5. Warranted crosswalk treatments have been selected using *Pedestrian Crossing Control Manual* Figure 13.

Summary Crosswalk Evaluation - The evaluation of pedestrian crossings on Glendale Drive and Duke Street (Table 5-4) using counted pedestrian volumes to estimate 'equivalent adult units', and projected 2016 volumes that include added Highway 107 trips, indicate the following:

1. Pedestrian crosswalks will not be warranted at the Old Beaver Bank Road and Rankin Drive intersections on Glendale Drive, or the Mann Street intersection on Duke Street.
2. While analysis indicates that a crosswalk is not warranted at the Chandler Drive intersection on Glendale Drive, the existing RA-5 signs should be retained pending further study by HRM.
3. High counted pedestrian volumes and high peak hour volumes on Glendale Drive indicate the need for pedestrian traffic signals at the Raymond Drive crossing area. This crosswalk should be re-evaluated after Highway 107 is open to traffic.
4. Analysis indicates that the existing RA-5 signs with actuated amber beacons are the appropriate crossing protection at the Pinehill Drive and Magee Drive intersections on Glendale Drive.

6.0 Performance Analysis

6.1 Intersection Level of Service Analysis

The level or quality of performance of an intersection in terms of traffic movement is determined by a level of service (LOS) analysis. LOS for intersections is defined in terms of delay, which is a measure of driver discomfort and frustration, fuel consumption, and increased travel time.

LOS	Signalized Intersections Control Delay (seconds per vehicle)	LOS Description	Two Way Stop Controlled (TWSC) Intersections Control Delay (seconds per vehicle)
A	less than 10.0	Very low delay; most vehicles do not stop (Excellent)	less than 10.0
B	between 10.0 and 20.0	Higher delay; more vehicles stop (Very Good)	between 10.0 and 15.0
C	between 20.0 and 35.0	Higher level of congestion; number of vehicles stopping is significant, although many still pass through intersection without stopping (Good)	between 15.0 and 25.0
D	between 35.0 and 55.0	Congestion becomes noticeable; vehicles must sometimes wait through more than one red light; many vehicles stop (Satisfactory)	between 25.0 and 35.0
E	between 55.0 and 80.0	Vehicles must often wait through more than one red light; considered by many agencies to be the limit of acceptable delay	between 35.0 and 50.0
F	greater than 80.0	This level is considered to be unacceptable to most drivers; occurs when arrival flow rates exceed the capacity of the intersection (Unacceptable)	greater than 50.0

LOS criteria (Table 6-1) are stated in terms of average control delay per vehicle which includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. Level of service analysis has been completed for all intersections using Synchro 6 software and analysis sheets are included in Appendix E. Analyses have been completed for projected 2016 volumes without Highway 107, and projected 2016 and 2026 volumes with Highway 107.

The following intersection improvements have been included in the intersection analysis process to improve intersection performance towards a level acceptable to HRM and NSTIR:

- Since Beaver Bank Road NB-T and SB-L movements at the Glendale Drive intersection were seen to have poor performance during 2016 PM peak hour without Highway 107 (Table F-1), two NB-T lanes and dual SB-L were used for all analyses.
- Since most Glendale Drive intersections do not have left turn lanes, and left turn movements resulted in unacceptable v/c ratios for Glendale Drive through movements at some intersections during the initial 2016 analysis without Highway 107, left turn lanes were included for all Glendale Drive intersections for all analyses.
- A westbound right turn lane was included on Glendale Drive at the McDougall Avenue intersection. Also, signal phases were added for Glendale Drive left turn movements (Table F-8).
- A westbound right turn lane was included on Glendale Avenue at the Cobequid Road intersection. The traffic signals were also converted to provide split phases on Cobequid Road approaches to allow the SB center through lane to operate as a through-left turn lane. The intersection improvements were included in 2016 and 2026 analyses with Highway 107 (Table F-12).

- An eastbound right turn lane was added to Glendale Avenue on the approach to the Highway 102 southbound ramps intersection, and lanes were also added to provide dual left turn lanes for SB and WB movements. The intersection improvements were included in 2016 and 2026 analyses with Highway 107 (Table F-14).
- A northbound right turn lane and right turn channel were added to the Highway 102 northbound exit ramp at Duke Street. The intersection improvements were included in 2016 and 2026 analyses with Highway 107 (Table F-15).
- The section of Duke Street from Damascus Drive to Rocky Lake Drive was widened to four lanes and a left turn lane was provided at Mann Street. Improvements were included in 2016 and 2026 analyses with Highway 107 (Table F-17).

Level of Service Analyses Conclusions - The level of service Synchro 6 analysis sheets (Appendix E) and the summaries provided in Appendix F and Table 6-2, indicate the following:

- With provision of the above recommended intersection improvements, all study area intersections, with the exception of the Burnside Drive / Highway 111 eastbound ramp intersection which has existing poor performance, will provide satisfactory performance for through street movements during 2016 with Highway 107, Phase 1.
- While the Beaver Bank By-Pass can be expected to divert traffic from Beaver Bank Road, and may also divert some trips from Glendale Drive over the next 10 to 15 years, the existing two lane cross section of Glendale Drive will be approaching capacity by 2026. Glendale Drive may have to be widened to a four lane street with appropriate auxiliary lanes beyond the study horizon.
- While Duke Street intersections and the Highway 102 ramp intersections are expected to provide satisfactory levels of performance for projected 2016 volumes with Highway 107, Phase 1, additional capacity, such as that provided by future Highway 107 phases with direct connections to Highway 102 will be required to provide satisfactory performance for projected 2026 volumes.
- Traffic diverted from Burnside Drive to Highway 107 and Highway 118 by construction of a section of Highway 107 from Burnside Drive extension to the existing section of Highway 107 east of Akerley Boulevard will reduce Burnside Drive volumes from Akerley Boulevard to Highway 111 which could improve levels of performance at all Burnside Drive intersections, including the Highway 111 ramp intersections.

Table 6-2 - Summary of Intersection Level of Service Analysis Tables in Appendix F					
Intersection	LOS Table	Year	LOS		LOS Summary
			AM	PM	
Glendale Drive / Beaver Bank Road	F-1	2016	B	D	2016 analyses without Highway 107 indicated the need for intersection improvements to overcome LOS deficiencies during the PM peak hour. With intersection improvements to provide two NB-T lanes and dual SB-L on Beaver Bank Road the intersection will provide satisfactory performance during both 2016 and 2026 with Highway 107, however, the WB-R will have a 0.96 v/c in 2026.
		2016 ¹	B	C	
		2016 W ³	B	C	
		2026 W ³	B	C	
Glendale Drive / Old Beaver Bank Road	F-2	2016	A	C	With addition of a WB left turn lane, Glendale Drive through lanes will have satisfactory performance with LOS A during both 2016 and 2026 with Highway 107. The Old Beaver Bank Road approach is projected to have poor LOS F during 2016 PM peak hours without Highway 107, and continued poor performance on that approach contributes to the poor overall intersection performance 2016 and 2026.
		2016 ²	A	C	
		2016 W ³	A	D	
		2026 W ³	A	F	
Glendale Drive / Smokey Drive	F-3	2016	E	C	With addition of an EB left turn lane, Glendale Drive through lanes will have satisfactory performance with LOS A during both 2016 and 2026 with Highway 107. The Smokey Drive approach has poor LOS F for all analyses which contributes to the poor overall intersection performance.
		2016 ²	E	C	
		2016 W ³	F	D	
		2026 W ³	F	F	
Glendale Drive / Rankin Drive	F-4	2016	A	C	With addition of an EB left turn lane, Glendale Drive through lanes will have satisfactory performance with LOS A during both 2016 and 2026 with Highway 107. The Rankin Drive approach has poor LOS D to F during AM peak hours and LOS F during PM peak hours for 2016 to 2026 analyses which contributes to the poor overall intersection performance during 2016 and 2026 PM peak hours.
		2016 ²	A	C	
		2016 W ³	A	N/A	
		2026 W ³	A	N/A	
Glendale Drive / Riverside Drive	F-5	2016	B	B	The existing signalized intersection will provide satisfactory overall performance for all analyses. However, the WB-L is projected to have poor LOS F during 2026 AM peak hours, and WB-TR and NB-LTR movements will have high v/c ratios of 0.98 and 0.94 respectively during 2026 PM peak hours.
		2016 W ³	B	C	
		2026 W ³	D	C	
Glendale Drive / Metropolitan Avenue	F-6	2016	B	C	The existing signalized intersection will provide satisfactory overall performance for all analyses. However, the WB-T movement is projected to have high v/c ratios of 0.87 during 2016 PM peak hours without Highway 107 and 0.99 and 1.00 during 2016 and 2026 PM peak hours with Highway 107.
		2016 W ³	B	C	
		2026 W ³	B	D	
Glendale Drive / Raymond Drive	F-7	2016	A	N/A	With addition of a WB left turn lane, Glendale Drive through lanes will have satisfactory performance with LOS A during both 2016 and 2026 with Highway 107. The Raymond Drive approach has poor LOS E to F during AM peak hours and LOS F during PM peak hours for 2016 to 2026 analyses which contributes to the poor overall intersection performance during 2016 and 2026 PM peak hours.
		2016 ²	A	N/A	
		2016 W ³	A	N/A	
		2026 W ³	B	N/A	
Glendale Drive / McDougall Avenue / Stadium	F-8	2016	B	C	With addition of a WB right turn lane, and Glendale Drive left turn lanes with left turn phases, the signalized intersection will provide satisfactory overall performance for all analyses. However, the EB-TR movement will have high v/c ratios of 0.87 and 0.98 during 2016 and 2026 AM peak hours with Highway 107, and the WB-T movement will have a v/c ratio of 0.91 during 2016 PM peak hours without Highway 107 and 0.99 and 1.13 during PM peak hours with Highway 107.
		2016 ^{2,4}	B	B	
		2016 W ³	B	C	
		2026 W ³	C	D	
Glendale Drive / Pinehill Drive	F-9	2016	N/A	A	With addition of a WB left turn lane, Glendale Drive through lanes will have satisfactory performance with LOS A during both 2016 and 2026 with Highway 107. The Pinehill Drive approach has poor LOS F during both AM and PM peak hours for all 2016 to 2026 analyses which contributes to the poor overall intersection performance during all AM peak hours and 2026 PM peak hours.
		2016 ²	N/A	A	
		2016 W ³	N/A	A	
		2026 W ³	N/A	E	
Glendale Drive / Chandler Drive	F-10	2016	A	A	With addition of an EB left turn lane, Glendale Drive through lanes, as well as the overall intersection, will have satisfactory performance with LOS A during both 2016 and 2026 with Highway 107. While the Chandler Drive approach is projected to have reduced levels of performance v/c ratios do not exceed 0.50 and the maximum 95% queue is about three vehicles during a 2026 AM peak hour.
		2016 ²	A	A	
		2016 W ³	A	A	
		2026 W ³	A	A	
Glendale Drive / Magee Drive	F-11	2016	A	A	With the existing Glendale Drive left turn lanes, Glendale Drive through lanes, as well as the overall intersection, will have satisfactory performance with LOS A during both 2016 and 2026 with Highway 107. Side street approaches have LOS E and F for all analyses, both without and with Highway 107.
		2016 W ³	A	A	
		2026 W ³	C	B	
Glendale Drive / Cobequid Road	F-12	2016	C	C	With addition of a westbound right turn lane on Glendale Avenue approach and conversion of signals to split phase on the Cobequid Road approaches to accommodate a southbound shared through-left turn lane, the intersection will provide satisfactory performance for all analyses.
		2016 W ^{3,5}	D	C	
		2026 W ³	D	D	

Table 6-2 is continued on the next page

Table 6-2 (Continued) - Summary of Intersection Level of Service Analysis Tables in Appendix F					
Intersection	LOS Table	Year	LOS		LOS Summary
			AM	PM	
Glendale Drive / Estates Blvd. / Temple Ter.	F-13	2016	A	A	The existing signalized intersection will provide very good performance for all analyses both without and with Highway 107.
		2016 W ³	A	A	
		2026 W ³	A	A	
Glendale Avenue / SB Ramps Highway 102	F-14	2016	A	B	With addition of an eastbound right turn lane on Glendale Avenue, a southbound right turn lane on the Highway 102 exit ramp, and dual left turns for the southbound left from the exit ramp and the westbound left to the on ramp, the intersection will provide satisfactory performance during 2016 with Highway 107. However, the WB-L is projected to have a v/c ratio of 0.98 during 2026 PM peak hours.
		2016 W ^{3,6}	B	C	
		2026 W ³	B	D	
Duke Street / NB Ramps Highway 102	F-15	2016	A	B	With addition of a northbound right turn lane and right turn channel to the Highway 102 exit ramp, the intersection will provide satisfactory performance for all AM peak hour analyses. While the intersection achieves satisfactory LOS D during 2016 PM peak hours with Highway 107, EB-L, WB-TR, and NB-LT movements have high v/c ratios of 0.89 to 0.96. The intersection as configured cannot provide satisfactory performance during 2026 with Highway 107.
		2016 W ^{3,7}	A	D	
		2026 W ³	A	E	
Duke Street / Damascus Drive	F-16	2016	A	D	While the existing signalized intersection is projected to provide satisfactory performance for all 2016 and 2026 analyses, the eastbound through movements is projected to operate at LOS F with a v/c ratio of 1.08 during 2026 AM peak hours.
		2016 W ³	C	D	
		2026 W ³	D	C	
Duke Street / Mann Street	F-17	2016	A	A	With the addition of two Duke Street through lanes and a left turn lane for Mann Street, the Duke Street approaches will provide LOS A performance for both 2016 and 2026 with Highway 107. While the Mann Street approach is projected to have satisfactory performance during AM peak hours, it is expected to operate with LOS F during 2016 and 2026 PM peak hours, however, during 2016 the v/c ratio is only 0.44 and the 95% queue is about three vehicles.
		2016 W ^{3,8}	A	A	
		2026 W ³	A	A	
Duke Street / Rocky Lake Drive	F-18	2016	A	B	A signalized intersection is projected to provide satisfactory service during 2016 with Highway 107. While the intersection is projected to provide satisfactory overall performance during 2026, the EB-T movement is projected to have a v/c ratio of 0.86 during AM peak hours and WB-TR and NB-L movements are projected to have v/c ratios of 0.88 and 0.94, respectively, during PM peak hours.
		2016 W ³	B	C	
		2026 W ³	C	D	
Burnside Drive / Akerley Boulevard	F-19	2016	B	B	A signalized intersection is projected to provide satisfactory performance for 2016 analyses, however, the SB-T movement has a 0.91 v/c ratio during the AM peak and the EB-T movement has a 0.87 v/c ratio during the PM peak hour. While the intersection is projected to provide satisfactory overall performance during 2026, WB-L and SB-T have 1.03 and 0.99 v/c ratios during the AM peak hour and EB-L and EB-T have 0.96 and 1.00 v/c ratios during 2026 PM peak hours.
		2016 W ³	D	C	
		2026 W ³	D	C	
Burnside Drive / Wright Avenue	F-20	2016	B	C	The existing signalized intersection is projected to provide satisfactory performance for all 2016 and 2026 analyses.
		2016 W ³	B	C	
		2026 W ³	C	D	
Burnside Drive / Commodore Drive	F-21	2016	C	C	The existing signalized intersection is projected to provide satisfactory performance for all 2016 and 2026 analyses.
		2016 W ³	C	C	
		2026 W ³	D	C	
Burnside Drive / WB Ramps Highway 111	F-22	2016	B	A	The existing signalized intersection is projected to provide satisfactory performance for all 2016 and 2026 analyses, however, the WB-L movement from the Highway 111 exit ramp will continue to have poor LOS E and F. It is also noted that southbound queues at the Highway 111 eastbound exit ramp intersection can be expected to queue through this intersection during PM peak hours.
		2016 W ³	B	A	
		2026 W ³	C	A	
Burnside Drive / EB Ramps Highway 111	F-23	2016	D	F	This intersection is projected to operate at LOS F during 2016 without Highway 107, and will continue to have poor levels of performance during 2016 and 2026 with Highway 107.
		2016 W ³	F	F	
		2026 W ³	F	F	
<p>NOTE:</p> <ol style="list-style-type: none"> Analyses were completed for improved intersection with two NB-T lanes and dual SB-L was used for all analyses. Analyses were completed with added Glendale Drive left turn lanes. Analyses completed with Highway 107. A westbound right turn lane was added on Glendale Drive and left turn phases were included for existing traffic signals. A westbound right turn lane was added to Glendale Avenue approach and signals were converted to split phase on the Cobequid Road to permit dual left turns for the southbound approach. An eastbound right turn lane was added to Glendale Avenue; a southbound right turn lane was added to the Highway 102 exit ramp; dual left turns constructed for the southbound left from the exit ramp and the westbound left to the on ramp. A northbound right turn lane and right turn channel were added to the Highway 102 exit ramp. Duke Street was widened to four lanes between Damascus Drive and Rocky Lake Drive; a left turn lane was added on Duke Street for Mann Street. 					

6.2 Weaving Analysis

Weaving analysis (Appendix G) was completed for 2010 to 2026 AM and PM peak hour volumes for the following locations which are illustrated on Figure 6-1:

1. Highway 102 northbound weave area between the Highway 101 eastbound ramp to Highway 102 northbound and the Highway 102 northbound exit to Highway 101 westbound . Weaving volumes are included in Table 6-3 and results are summarized in Table 6-5.
2. Highway 101 westbound weave area between the Highway 102 southbound exit to Highway 101 westbound and the Highway 101 westbound exit to Sackville Drive. Weaving volumes are included in Table 6-4 and results are summarized in Table 6-5.



Figure 6-1 - Weave Analysis Locations

Scenario		Hwy 102 NB to Hwy 102 NB	Hwy 101 EB to Hwy 101 WB	Hwy 102 NB to Hwy 101 WB	Hwy 101 EB to Hwy 102 NB
2010 without Highway 107	AM	775	0	500	265
	PM	1035	0	1350	250
2016 without Highway 107	AM	845	0	545	290
	PM	1200	0	1400	275
2016 with Highway 107	AM	845	0	545	775
	PM	1200	0	1400	380
2026 with Highway 107	AM	960	0	620	865
	PM	1360	0	1585	430

Scenario		Bedford Highway to Hwy 101 WB	Hwy 102 SB to Sackville	Bedford Highway to Sackville	Hwy 102 SB to Hwy 101 WB
2010 without Highway 107	AM	375	30	405	125
	PM	1110	70	755	290
2016 without Highway 107	AM	410	35	440	135
	PM	1215	80	820	310
2016 with Highway 107	AM	425	50	425	195
	PM	1320	185	715	740
2026 with Highway 107	AM	480	55	485	225
	PM	1500	210	815	845

Year	AM or PM	Level of Service (LOS)	Weaving Segment Speed (S - km/h)	Weaving Segment Density (D - Pc/km/ln)
Highway 102 Northbound Weave - Analysis Location 1				
2010 without	AM	B	65.7	8.8
	PM	E	42.4	23.3
2016 without	AM	B	63.5	9.9
	PM	F	42.3	25.4
2016 with	AM	C	45.3	17.7
	PM	F	41.2	27.1
2026 with	AM	D	43.4	31.1
	PM	F	39.6	31.8
Highway 101 Westbound Weave - Analysis Location 2				
2010 without	AM	A	91.2	3.8
	PM	B	76.1	10.9
2016 without	Am	A	89.6	4.2
	PM	B	74.1	12.2
2016 with	AM	A	76.2	5.4
	PM	C	60.0	18.5
2026 with	AM	A	73.1	6.4
	PM	D	57.2	22.0
NOTE: Weaving analysis sheets are included in Appendix G, Page G-1 to G-17.				

Summary Weaving Analysis - The weaving analyses completed for 2010 to 2026 AM and PM peak hour volumes, indicate the following:

- While the Highway 102 northbound weave area (Location 1) between the Highway 101 eastbound ramp to Highway 102 northbound and the Highway 102 northbound exit to Highway 101 westbound, now operates with poor level of performance during PM peak hours, and will continue to have poor performance during 2016 and 2026, the addition of traffic diverted to Highway 107 is not expected to have any significant impact on the weave performance.
- The Highway 101 westbound weave area (Location 2) between the Highway 102 southbound exit to Highway 101 westbound and the Highway 101 westbound exit to Sackville Drive will continue to provide satisfactory levels of performance during 2016 and 2026 with added Highway 107 trips.

6.3 Evaluation of Roundabouts

Four intersections have been evaluated as roundabouts using *ARCADY 7* software. Analyses have been completed for projected 2016 and 2026 volumes that include trips diverted to Highway 107 Phase 1. Locations of concept drawings, roundabout parameters, and analysis result summaries are included in Table 6-6.

Table 6-6 - Details of Roundabout Analyses			
Intersection	Concept Drawing	Parameters	Analysis Summary
Burnside Drive / Highway 107 at Akerley Boulevard	Figure 6-2	Pages G-18 to G-20	Table 6-7
Duke Street / Highway 107 at Rocky Lake Drive	Figure 6-2	Pages G-21 to G-23	Table 6-8
Duke Street at Highway 102 Northbound Ramps	Figure 6-3	Pages G-24 to G-26	Table 6-9
Duke Street at Highway 102 Southbound Ramps	Figure 6-3	Pages G-27 to G-29	Table 6-10

NOTE: Roundabout analysis parameters are included in Appendix G, Pages 18 to 29.

Table 6-7 - Summary Roundabout Performance for Burnside Drive / Highway 107 at Akerley Boulevard									
Arm	Approach	AM Peak Hours				PM Peak Hours			
		Queue (Veh)	Delay (s)	RFC	LOS	Queue (Veh)	Delay (s)	RFC	LOS
Projected 2016 Volumes with Highway 107 Phase 1 (Figure 6-2)									
1	Akerley Blvd. WB	1.22	3.87	0.55	A	0.73	3.81	0.42	A
2	Highway 107 SB	2.98	9.84	0.75	A	0.21	2.23	0.17	A
3	Akerley Blvd. EB	0.47	3.64	0.32	A	1.41	4.14	0.58	A
4	Burnside Drive NB	0.31	2.34	0.24	A	1.19	5.00	0.54	A
Projected 2026 Volumes with Highway 107 Phase 1 (Figure 4-3)									
1	Akerley Blvd. WB	1.77	4.93	0.64	A	1.06	4.83	0.51	A
2	Highway 107 SB	10.69	32.72	0.92	D	0.26	2.41	0.20	A
3	Akerley Blvd. EB	0.66	4.48	0.39	A	2.07	5.41	0.67	A
4	Burnside Drive NB	0.38	2.53	0.27	A	1.93	7.20	0.66	A

NOTE: Roundabout concept is shown on Figure 6-2 and parameters are on Pages G-18 to G-20, Appendix G.

Rocky Lake Drive at Duke Street



Burnside Drive at Akerley Boulevard

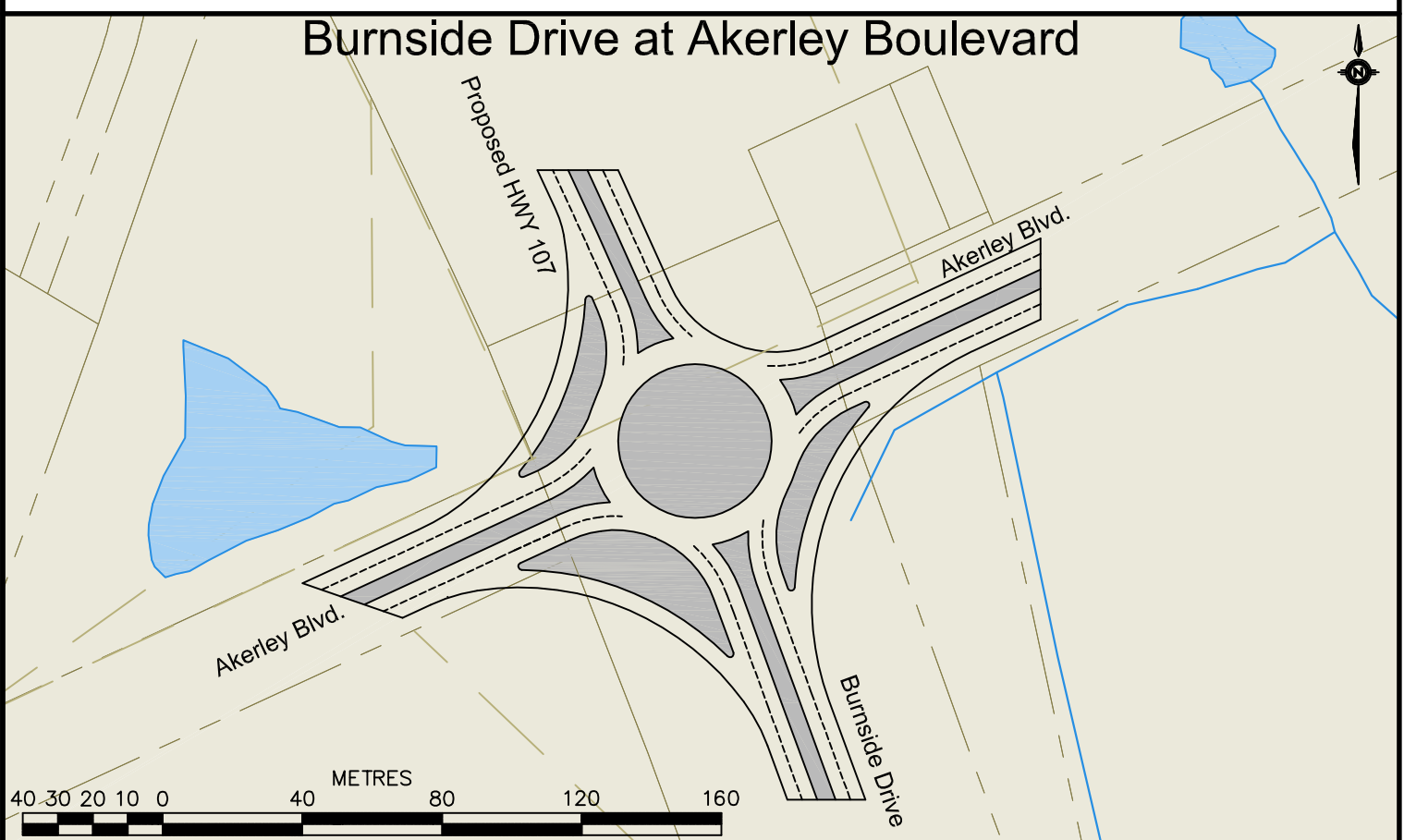


Table 6-8 - Summary Roundabout Performance for Duke Street / Highway 107 at Rocky Lake Drive

Arm	Approach	AM Peak Hours				PM Peak Hours			
		Queue (Veh)	Delay (s)	RFC	LOS	Queue (Veh)	Delay (s)	RFC	LOS
Projected 2016 Volumes with Highway 107 Phase 1 (Figure 4-2)									
1	Highway 107 WB	0.13	1.88	0.12	A	1.26	3.89	0.55	A
2	Rocky Lake Drive SB	0.15	2.33	0.13	A	0.31	3.97	0.23	A
3	Duke Street EB	2.15	4.78	0.68	A	0.36	2.10	0.26	A
4	Rocky Lake Drive NB	0.32	4.67	0.24	A	0.29	2.81	0.22	A
Projected 2026 Volumes with Highway 107 Phase 1 (Figure 4-3)									
1	Highway 107 WB	0.16	1.94	0.13	A	1.78	4.92	0.64	A
2	Rocky Lake Drive SB	0.17	2.43	0.14	A	0.42	4.73	0.29	A
3	Duke Street EB	3.37	6.66	0.77	A	0.43	2.22	0.30	A
4	Rocky Lake Drive NB	0.44	5.82	0.30	A	0.35	3.06	0.26	A

NOTE: Roundabout concept is shown on Figure 6-2 and parameters are on Pages G-21 to G-23, Appendix G.

Table 6-9 - Summary Roundabout Performance for Duke Street at Highway 102 Northbound Ramps

Arm	Approach	AM Peak Hours				PM Peak Hours			
		Queue (Veh)	Delay (s)	RFC	LOS	Queue (Veh)	Delay (s)	RFC	LOS
Projected 2016 Volumes with Highway 107 Phase 1 (Figure 4-2)									
1	Duke Street WB	0.31	2.21	0.23	A	12.78	26.85	0.93	D
2	Duke Street EB	0.88	2.78	0.46	A	0.51	2.24	0.33	A
3	Hwy 102 NB Exit Ramp	0.21	2.65	0.17	A	0.49	2.87	0.33	A
Projected 2026 Volumes with Highway 107 Phase 1 (Figure 4-3)									
1	Duke Street WB	0.37	2.37	0.27	A	197.61	342.67	1.10	F
2	Duke Street EB	1.11	3.11	0.52	A	0.63	2.41	0.38	A
3	Hwy 102 NB Exit Ramp	0.27	2.94	0.21	A	0.63	3.28	0.38	A

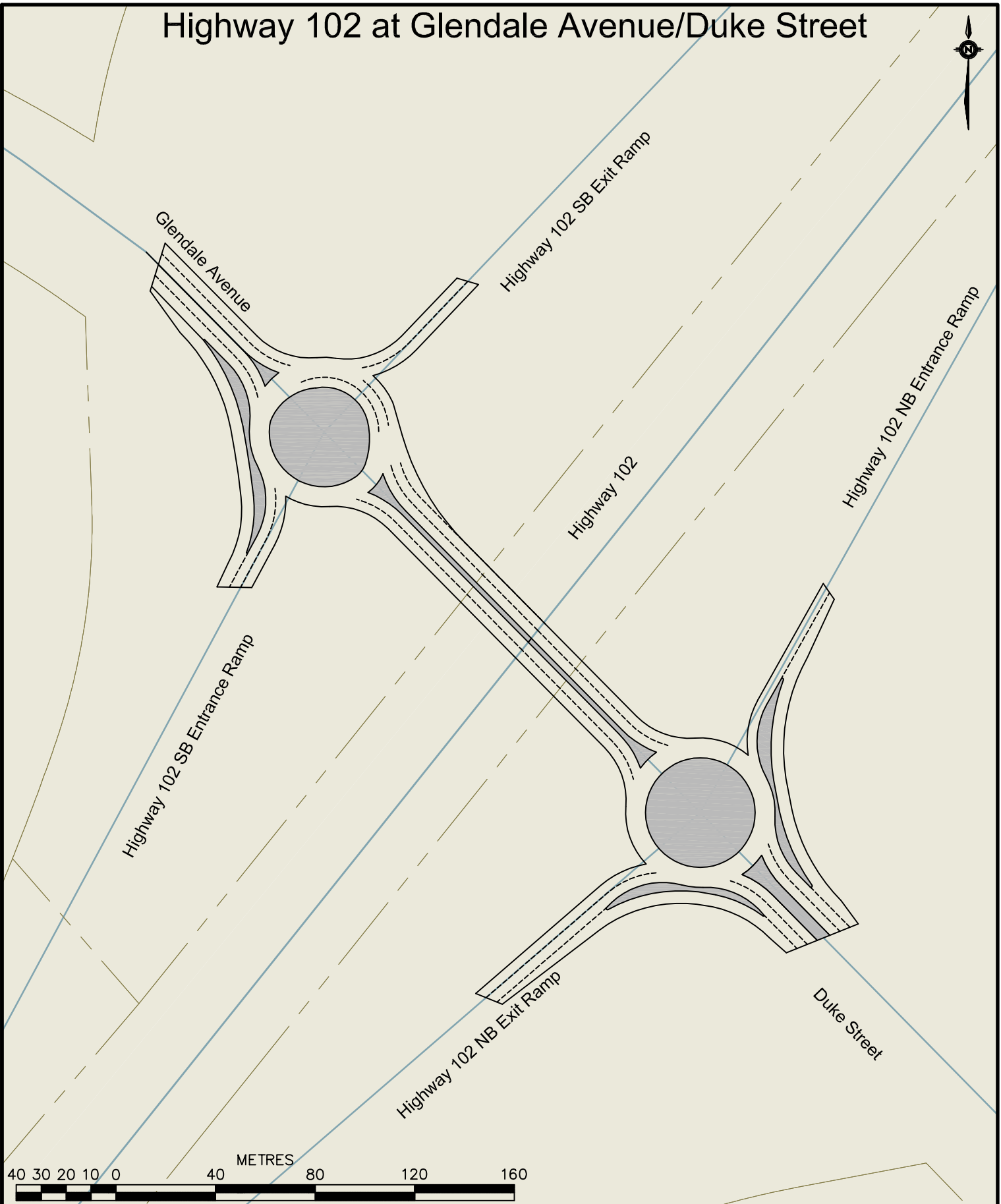
NOTE: Roundabout concept is shown on Figure 6-3 and parameters are on Pages G-24 to G-26, Appendix G.

Table 6-10 - Summary Roundabout Performance for Duke Street at Highway 102 Southbound Ramps

Arm	Approach	AM Peak Hours				PM Peak Hours			
		Queue (Veh)	Delay (s)	RFC	LOS	Queue (Veh)	Delay (s)	RFC	LOS
Projected 2016 Volumes with Highway 107 Phase 1 (Figure 4-2)									
1	Duke Street WB	0.31	1.46	0.23	A	2.72	4.12	0.73	A
2	Hwy 102 SB Exit Ramp	0.16	2.19	0.13	A	0.93	8.71	0.48	A
3	Glendale Avenue EB	0.93	3.15	0.48	A	0.79	3.78	0.44	A
Projected 2026 Volumes with Highway 107 Phase 1 (Figure 4-3)									
1	Duke Street WB	0.37	1.52	0.27	A	4.84	6.47	0.83	A
2	Hwy 102 SB Exit Ramp	0.19	2.34	0.16	A	3.08	25.88	0.76	D
3	Glendale Avenue EB	1.23	3.70	0.55	A	1.15	4.82	0.53	A

NOTE: Roundabout concept is shown on Figure 6-3 and parameters are on Pages G-27 to G-29, Appendix G.

Highway 102 at Glendale Avenue/Duke Street



Traffic Study for Highway 107
Phase 1 - Burnside to Sackville

FIGURE 6-3

Roundabout Concepts at Highway 102

JANUARY 2011

Summary of Roundabout Performance Evaluation - The ARCADY analyses indicate the following for the four intersections that were evaluated:

- **Burnside Drive / Akerley Boulevard** (Table 6-7) - While a roundabout will provide LOS A for all approaches for 2016 AM and PM peak hours and 2026 PM peak hours, the Highway 107 southbound approach will have reduced performance with LOS D during 2026 AM peak hours. The completion of additional Highway 107 phases in the Burnside area should alleviate this problem.
- **Duke Street / Rocky Lake Road** (Table 6-8) - A roundabout will provide LOS A for all approaches for 2016 and 2026 peak hours that include Highway 107 trips.
- **Duke Street / Highway 102 Northbound Ramps** (Table 6-9) - While a roundabout will provide LOS A for all approaches during 2016 and 2026 AM peak hours, the Duke Street westbound approach is projected to operate with LOS D during the 2016 PM peak hour and LOS F during the 2026 PM peak hour.
- **Glendale Avenue / Highway 102 Southbound Ramps** (Table 6-10) - While a roundabout will provide LOS A for all approaches for 2016 AM and PM peak hours and 2026 AM peak hours, the Highway 107 southbound approach will have reduced performance with LOS D during 2026 AM peak hours.

7.0 Summary, Conclusions and Recommendations

1. **Study Objectives** - The primary objectives of the traffic study are:
 - to investigate the traffic impacts on the existing road network associated with the completion of a new four lane controlled access connection between the Burnside Drive / Akerley Boulevard intersection and the Duke Street / Rocky Lake Drive intersection (Phase 1); and
 - to identify road network improvements required to mitigate any identified deficiencies for projected 2016 and 2026 volumes.
2. **Volume Growth Rate** - Since development to 2016 and 2026 is expected to generally result in traffic volume increases on study area roads similar the historic trend over the past ten years, an annual growth rate of 1.5% has been used to project 2016 and 2026 volumes.
3. **Highway 107 Trip Diversion Candidates** - The existing design hourly volumes that could possibly use Highway 107 Phase 1 Study Corridor include the following:
 - Projected 2010 volumes of 4375 vehicles per hour (vph) during the AM peak and 4760 vph during the PM peak now using Magazine Hill (Trunk 7); and
 - Traffic that is now using Highway 102 to the Trunk 2 interchange at Waverley and then Highway 118 to access the Burnside area.
4. **Trip Diversion to Highway 107** - The following summarize trip diversion to Highway 107:
 - Traffic diverted to Highway 107 reduced Magazine Hill volumes by 27% during the 2016 AM peak hour and 29% during the PM peak hour.
 - Projected 2016 two-way peak hour volumes on Highway 107 Phase 1 include approximately 1800 vph during the AM peak hour and 1600 vehicles during the PM peak hour.
 - The 2016 two-way AM peak hour volumes on Highway 107 include approximately 5% from Dartmouth Road, 70% from Bedford By-Pass and 25% from other locations, such as Highway 102 at the Waverley interchange.
 - The 2016 two-way PM peak hour volumes on Highway 107 include approximately 5% from Dartmouth Road, 85% from Bedford By-Pass and 10% from other locations, such as Highway 102 at the Waverley interchange.
5. **Left Turn Lane Warrant Analysis** - The warrant for left turn lanes was evaluated at seven STOP sign controlled intersections in the Glendale - Duke corridor. Since existing and projected 2016 peak hour volumes on Glendale Drive are very high, left turn lanes will be required at all Glendale Drive and Duke Street intersections for projected 2016 volumes without Highway 107. Also, review of the locations of the warrant points on the nomographs in Appendix D in relation to the 'warrant line' indicate that left turn lanes should be considered for all intersections on Glendale Drive for existing 2010 volumes.
6. **Right Turn Lane Warrant Analysis** - Right turn warrant evaluation has been completed for Glendale Drive intersections for projected 2016 volumes without Highway 107. Since Glendale Drive projected 2016 volumes without Highway 107 are high eastbound during the AM peak hour and westbound volumes during the PM peak hour, right turn lanes will be warranted at all Glendale Drive intersections except Chandler Drive and Magee Drive eastbound.

7. **Signal Warrant Analysis** - Signal warrant analyses of STOP controlled Glendale Drive intersections indicate the following:
 - Signals will not be warranted at any intersections by 2016 without Highway 107.
 - While signals won't be warranted at any intersection during 2016 with added Highway 107 trips, the Glendale Drive intersections at Smokey Drive and Magee Drive should be monitored.
 - Signals are expected to be warranted at the Glendale Drive / Smokey Drive intersection during 2026. The Glendale Drive intersections at Pinehill Drive and Magee Drive should continue to be monitored.

8. **Crosswalk Evaluation** - The evaluation of pedestrian crossings on Glendale Drive and Duke Street using counted pedestrian volumes to estimate 'equivalent adult units', and projected 2016 volumes that include added Highway 107 trips, indicate the following:
 - Pedestrian crosswalks will not be warranted at the Old Beaver Bank Road, Rankin Drive, or Mann Street intersections.
 - While analysis indicates that a crosswalk is not warranted at the Chandler Drive intersection on Glendale Drive, the existing RA-5 signs should be retained pending review by HRM.
 - High counted pedestrian volumes and high peak hour volumes on Glendale Drive indicate the need for pedestrian traffic signals at the Raymond Drive crossing area. This crosswalk should be re-evaluated after Highway 107 is open to traffic.
 - Analysis indicates that the existing RA-5 signs with actuated amber beacons are the appropriate crossing protection at the Pinehill Drive and Magee Drive intersections on Glendale Drive.

9. **Level of Service Analysis Conclusions** - The level of service Synchro 6 analysis completed for the 23 study area intersections indicates the following:
 - With provision of the recommended intersection improvements, all study area intersections, with the exception of the Burnside Drive / Highway 111 eastbound ramp intersection which has existing poor performance, will provide satisfactory performance for through street movements during 2016 with Highway 107, Phase 1.
 - While the Beaver Bank By-Pass can be expected to divert traffic from Beaver Bank Road, and may also divert some trips from Glendale Drive over the next 10 to 15 years, the existing two lane cross section of Glendale Drive will be approaching capacity by 2026. Plans should be prepared for widening Glendale Drive to a four lane street with appropriate auxiliary lanes.
 - While Duke Street intersections and the Highway 102 ramp intersections are expected to provide satisfactory levels of performance for projected 2016 volumes with Highway 107, Phase 1, additional capacity, such as that provided by future Highway 107 phases with direct connections to Highway 102 will be required to provide satisfactory performance for projected 2026 volumes.
 - Traffic diverted from Burnside Drive to Highway 107 and Highway 118 by construction of a section of Highway 107 from Burnside Drive extension to the existing section of Highway 107 east of Akerley Boulevard will reduce Burnside Drive volumes which could improve levels of performance at all Burnside Drive intersections, including the Highway 111 ramp intersections.

10. **Summary Weaving Analysis** - The weaving analyses completed for 2010 to 2026 AM and PM peak hour volumes, indicate the following:
- While the Highway 102 northbound weave area (Location 1) between the Highway 101 eastbound ramp to Highway 102 northbound and the Highway 102 northbound exit to Highway 101 westbound, now operates with poor level of performance during PM peak hours, and will continue to have poor performance during 2016 and 2026, the addition of traffic diverted to Highway 107 is not expected to have any significant impact on the weave performance.
 - The Highway 101 westbound weave area (Location 2) between the Highway 102 southbound exit to Highway 101 westbound and the Highway 101 westbound exit to Sackville Drive will continue to provide satisfactory levels of performance during 2016 and 2026 with added Highway 107 trips.
11. **Summary of Roundabout Performance Evaluation** - The ARCADY analyses indicate the following for the four intersections that were evaluated:
- **Burnside Drive /Akerley Boulevard** (Table 6-7) - While a roundabout will provide LOS A for all approaches for 2016 AM and PM peak hours and 2026 PM peak hours, the Highway 107 southbound approach will have reduced performance with LOS D during 2026 AM peak hours. The completion of additional Highway 107 phases in the Burnside area should alleviate this problem.
 - **Duke Street / Rocky Lake Road** (Table 6-8) - A roundabout will provide LOS A for all approaches for 2016 and 2026 peak hours that include Highway 107 trips.
 - **Duke Street / Highway 102 Northbound Ramps** (Table 6-9) - While a roundabout will provide LOS A for all approaches during 2016 and 2026 AM peak hours, the Duke Street westbound approach is projected to operate with LOS D during the 2016 PM peak hour and LOS F during the 2026 PM peak hour.
 - **Glendale Avenue / Highway 102 Southbound Ramps** (Table 6-10) - While a roundabout will provide LOS A for all approaches for 2016 AM and PM peak hours and 2026 AM peak hours, the Highway 107 southbound approach will have reduced performance with LOS D during 2026 AM peak hours.
12. **Summary of Recommendations** -
- A. Intersection Improvements without Highway 107** - The following improvements, which will be required on Glendale Drive by 2016 without Highway 107, should be designed and implemented during the next five years:
- Reconstruct the Beaver Bank Road / Glendale Drive intersection to include two northbound through lanes and dual southbound left turn lanes;
 - Construct left turn lanes and warranted right turn lanes at all intersections that do not now have left turn lanes;
 - Upgrade the Glendale Drive / McDougall Avenue intersection traffic signals to include signal phases for Glendale Drive left turn movements;
- B. Glendale Drive Crosswalks** - HRM should continue to monitor pedestrian crossings on Glendale Drive and ensure that appropriate signs and signal devices are maintained.
- C. Glendale Drive Intersection Traffic Control** - HRM should continue to monitor the Smokey Drive, Pinehill Drive, and Magee Drive intersections with regard to

warrants for installation of traffic signals. While signal warrant analysis did not indicate the need for signals at these intersections prior to 2016, the warrant analyses for 2016 and 2026 with Highway 107 and poor side street levels of performance indicate the need to monitor the intersections.

D. *Intersection Improvements with Highway 107* - The following intersection improvements on Glendale Avenue and Duke Street will be required as part of the Highway 107, Phase 1, project:

- A westbound right turn lane is required on Glendale Avenue at the Cobequid Road intersection. The traffic signals must also be converted to provide split phases on Cobequid Road to permit dual left turns for the southbound approach.
- Either construct a roundabout illustrated on Figure 6-3 at the Glendale Avenue / Highway 102 southbound ramps, or upgrade the existing intersection to include an eastbound right turn lane on Glendale Avenue, and dual left turn lanes for the southbound exit ramp and Glendale Avenue westbound approaches.
- Either construct a roundabout illustrated on Figure 6-3 at the Duke Street / Highway 102 northbound ramps, or upgrade the existing intersection to include a northbound right turn lane and right turn channel.
- Widen the section of Duke Street from Damascus Drive to Rocky Lake Drive to four lanes and add a left turn lane at Mann Street.

E. *Additional Highway 107 Phases* - Since roundabout or intersection reconstruction at the Highway 102 interchange ramps are not expected to continue to provide satisfactory levels of performance with projected 2026 volumes, NSTIR should plan to construct additional Highway 107 phases to provide direct access to Highway 102 before 2026.

13. ***Conclusions*** -

- A. With provision of recommended intersection improvements, all study area intersections with the exception of the Burnside Drive / Highway 111 eastbound ramp intersection will provide satisfactory performance for through street movements during 2016 with Highway 107, Phase 1.
- B. While the Beaver Bank By-Pass may divert some trips from Glendale Drive over the next 10 to 15 years, the existing two lane cross section of Glendale Drive will be approaching capacity by 2026. Plans should be prepared for widening Glendale Drive to a four lane street with appropriate auxiliary lanes.
- C. Duke Street will provide a temporary connection to Highway 102 for Highway 107, Phase 1 to accommodate projected 2016 volumes. However, the additional capacity of future Highway 107 phases with direct connections to Highway 102 will be required to provide satisfactory performance for projected 2026 volumes.
- E. Construction of the future phase of Highway 107 from Burnside Drive extension to meet existing Highway 107 east of Akerley Boulevard will divert traffic to Highway 118 and Highway 107 east of Highway 118. This will reduce Burnside Drive volumes which could improve levels of performance at all Burnside Drive intersections, including the Highway 111 ramp intersections.