

INTERSECTION CONTROL STUDY

FINAL REPORT

MAPLE GROVE ROAD (R.R. 38) AND FOUNTAIN
STREET NORTH (R.R. 17)

CITY OF CAMBRIDGE

PREPARED FOR:

THE REGION OF WATERLOO

February 2007
06407.800



We therefore recommend that a roundabout be installed at the intersection when deemed practical by the Region. The interim layout for the roundabout with two-lane entries, as shown in Figure 3, should provide good safety performance throughout its life cycle, and low average delays for several years past the 2018 horizon year.

Yours truly,

OURSTON ROUNDABOUTS CANADA

(A Member of The Sernas Group Inc.)

A handwritten signature in black ink, appearing to read 'P. Weber', written in a cursive style.

Philip Weber, P.Eng.
Project Manager

/pw

1.0 INTRODUCTION

1.1 BACKGROUND

This Intersection Control Study is for Maple Grove Road and Fountain Street North in the City of Cambridge. The site context is shown in Figure 1.

Figure 1
Intersection Site Context

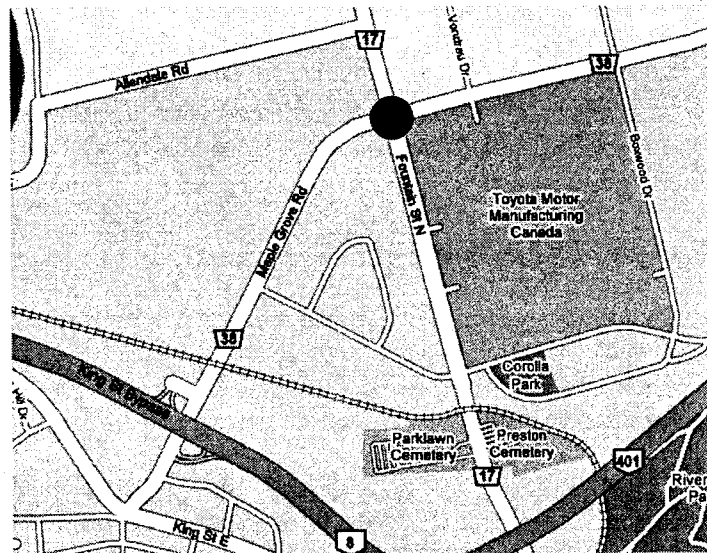


Image: Google Maps

The intersection is currently signalized. Maple Grove Road and Fountain Street have urban cross sections and a posted speed limit of 70 km/h. There is a Loblaws distribution centre on the northeast corner and a Toyota manufacturing plant on the southwest corner. A private residence is on the northwest corner with an access driveway onto Fountain Street approximately 45 metres north of the southbound stop bar. The southwest corner, where there is a channelized right turn lane, is currently vacant. There are no sidewalks or bicycle lanes in the vicinity, although pedestrian signals and crosswalks are provided.

The study is being carried out to investigate the feasibility of a roundabout because of forecast traffic growth that will warrant widening of the intersection. The quantitative criteria used to compare traffic signals and a roundabout include:

- Safety performance for all users.
- Operational performance for motorists.
- Estimated capital (construction plus property) costs.
- Life cycle costs (including injury crash and operating costs).

Also discussed are qualitative criteria such as fuel consumption and vehicle emissions, effects on pedestrians, bicyclists, transit and emergency services, speed control, compatibility with adjacent land use, accesses and corridor travel times, and aesthetics.

2.0 PERFORMANCE EVALUATION

2.1 ANALYSIS INPUTS

Peak hour traffic forecasts for the 2018 horizon year were provided by the Region. We assumed 5 percent trucks on all approaches. We also ran the capacity analysis with 9 percent trucks as a check.

2.2 SAFETY PERFORMANCE

2.2.1 Traffic Signal Injury Collisions

The Region has provided collision documentation at the subject intersection for the last 5 years. The injury collisions are summarized in Table 1.

Table 1
5-Year Injury Collision Summary

| Impact Type | No. | Comments |
|------------------|-----|---|
| Angle | 2 | 2 clear and dry |
| Rear End | 4 | 1 clear and ice, 1 snow and slush, 2 rain and wet |
| Turning Movement | 7 | 5 clear and dry, 1 clear and wet, 1 snow and ice |
| Fixed Object | 1 | 1 clear and dry |
| Other | 1 | 1 clear and dry |

The current injury collision frequency at Maple Grove/Fountain is 3.0 crashes per year. About half of them are from turning movements, likely either from motorists turning right on red in front of oncoming through traffic, or motorists trying to clear on a left turn. It can be expected that the left turn collision pattern would abate somewhat with the future lane configurations because protected only left turn phasing would be required with the dual left turn lanes. However we did not have sufficient data to investigate this method of predicting future crash performance.

Instead, data from the Region on injury crash rates at illuminated, signalized intersections were utilized. For the 5-year time period between 2000 and 2004, for an entering AADT of 20,000 vehicles per day or greater, the following rates per million vehicles entering (MVE) applied:

- For four-way intersections, 0.00074 fatal crashes and 0.22 non-fatal injury crashes.

Through the Region's permanent count stations, it has been established that the average ratio of hourly traffic to AADT is 0.068 for the AM peak hour and 0.087 for the PM peak hour. Assuming the same ratios apply in 2018, the entering AADT would be 50,000 vehicles per day. (This averages the separate AADT's obtained by dividing the AM and PM peak hour forecasts report by their respective ratios.) Accordingly, the predicted 2018 injury collision frequency under traffic signal control is 4.03 per year.

2.2.2 Roundabout Injury Collisions

We used two methods to predict injury collision frequency under roundabout control.

We assumed a cost of \$3,000 per year for annual traffic signal maintenance, and that in 20 years it would cost \$100,000 to do a complete re-build (mast arms, signal heads, etc). A cost of \$400 per year for maintenance was assumed for the existing street lighting for the future traffic signal alternative. A capital cost of \$20,000 and \$1,500 per year for maintenance was used for additional street lighting for the roundabout alternative.⁴

In terms of total capital, injury and life cycle costs, the preferred alternative is a roundabout by a margin of \$1.385 million. A roundabout would also result in lower delays than traffic signals, and have advantages in terms of environmental factors, conditions for pedestrians and bicyclists, and speed control.

3.2 SUMMARY EVALUATION

Table 5 summarizes our findings in terms of the quantitative criteria of safety performance, operational performance, construction costs, and 20-year life cycle costs.

Table 5
Summary of Operational, Safety and Cost Evaluation

| Evaluation Criteria | Traffic Signals | Roundabout |
|-------------------------------|-----------------|----------------|
| Annual Injury Crashes by 2020 | 4.03 | 1.66 |
| Traffic Operations by 2020 | LOS 'D' | LOS 'B' to 'C' |
| Total Capital Costs | \$2,299,000 | \$1,484,000 |
| Capital plus Life Cycle Costs | \$3,400,000 | \$2,015,000 |

Table 6 summarizes qualitative comments associated with traffic signals and roundabouts, namely education and public acceptance, speed control, effects on pedestrians and persons with disabilities, effects on heavy vehicles and emergency services, and land use and environmental factors.

Table 6
Summary of Subjective Comments

| Evaluation Criteria | Comments | |
|---|---|--|
| | Traffic Signals | Roundabouts |
| Speed Control | Traffic speeds controlled during peak times. | Potential to control traffic speeds at all times through good design. |
| Pedestrians and Persons with Disabilities | May require push-button actuation. Audible signals possible. | Shorter crossing distances, and splitter islands provide refuge. Audible signals possible on individual legs. |
| Bicyclists | Status quo. | Slower motor vehicle speeds good for bicyclists. |
| Emergency Services, Maintenance, Transit | Pre-emption equipment may be required. | Comparable to traffic signals. No pre-emption equipment required. |

⁴ Street lighting costs supplied by the Region of Waterloo, January 25, 2007.

4.0 CONCLUSION

Based on the foregoing safety and operational analyses, and costing exercise, for the Intersection Control Study at Maple Grove Road and Fountain Street North, the preferred alternative is a roundabout by a margin of \$1.385 million.

A roundabout would also have advantages in terms of environmental factors, conditions for pedestrians and bicyclists, and speed control. Further, a roundabout would result in lower delays than traffic signals, and yield property damage crash savings in addition to injury crash savings. However, both are difficult to quantify and are thus not included in the comparison of life cycle costs.

We therefore recommend that a roundabout be installed at the intersection when deemed practical by the Region. The interim layout for the roundabout with two-lane entries, as shown in Figure 3, should provide good safety performance throughout its life cycle, and low average delays for several years past the 2018 horizon year.

HCM Signalized Intersection Capacity Analysis
 Maple Grove Road / Fountain Street

2/13/2007



| Movement | SBL | EBL | EBR | WBL | WBR | NBL | NBE | NBR | SBL | EBL | SBR | |
|------------------------|-------|------|------|-------|-------|------|------|------|-------|-------|------|------|
| Lane Configurations | ↔↔ | ↕↕ | ↗ | ↖ | ↕↕ | ↔↔ | ↕↕ | ↗ | ↔↔ | ↕↕ | ↗ | |
| Ideal Flow (vphpl) | 1775 | 1900 | 1750 | 1775 | 1775 | 1900 | 1775 | 1900 | 1750 | 1775 | 1900 | 1750 |
| Total Lost time (s) | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| Lane Util. Factor | 0.97 | 0.95 | 1.00 | 1.00 | 0.95 | 0.97 | 0.95 | 1.00 | 0.97 | 0.95 | 1.00 | |
| Frt | 1.00 | 1.00 | 0.85 | 1.00 | 0.94 | 1.00 | 1.00 | 0.85 | 1.00 | 1.00 | 0.85 | |
| Flt Protected | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 | |
| Satd. Flow (prot) | 2968 | 3275 | 1350 | 1530 | 2876 | 2968 | 3275 | 1350 | 2968 | 3275 | 1350 | |
| Flt Permitted | 0.95 | 1.00 | 1.00 | 0.40 | 1.00 | 0.95 | 1.00 | 1.00 | 0.95 | 1.00 | 1.00 | |
| Satd. Flow (perm) | 2968 | 3275 | 1350 | 645 | 2876 | 2968 | 3275 | 1350 | 2968 | 3275 | 1350 | |
| Volume (vph) | 265 | 361 | 185 | 223 | 562 | 374 | 74 | 173 | 67 | 399 | 263 | 254 |
| Peak-hour factor, PHF | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Adj. Flow (vph) | 265 | 361 | 185 | 223 | 562 | 374 | 74 | 173 | 67 | 399 | 263 | 254 |
| RTOR Reduction (vph) | 0 | 0 | 132 | 0 | 104 | 0 | 0 | 0 | 48 | 0 | 0 | 157 |
| Lane Group Flow (vph) | 265 | 361 | 53 | 223 | 832 | 0 | 74 | 173 | 19 | 399 | 263 | 97 |
| Turn Type | Prot | | Perm | pm+pt | | Prot | | Perm | Prot | | Perm | |
| Protected Phases | 7 | 4 | | 3 | 8 | 5 | 2 | | 1 | 6 | | |
| Permitted Phases | | | 4 | 8 | | | | 2 | | | 6 | |
| Actuated Green, G (s) | 9.0 | 29.4 | 29.4 | 47.6 | 33.0 | 4.0 | 28.9 | 28.9 | 15.1 | 40.0 | 40.0 | |
| Effective Green, g (s) | 11.0 | 31.4 | 31.4 | 49.6 | 35.0 | 6.0 | 30.9 | 30.9 | 17.1 | 42.0 | 42.0 | |
| Actuated g/C Ratio | 0.10 | 0.29 | 0.29 | 0.45 | 0.32 | 0.05 | 0.28 | 0.28 | 0.16 | 0.38 | 0.38 | |
| Clearance Time (s) | 6.0 | 6.0 | 6.0 | 4.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | |
| Vehicle Extension (s) | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | |
| Lane Grp Cap (vph) | 297 | 935 | 385 | 408 | 915 | 162 | 920 | 379 | 461 | 1250 | 515 | |
| v/s Ratio Prot | c0.09 | 0.11 | | c0.07 | c0.29 | 0.02 | 0.05 | | c0.13 | c0.08 | | |
| v/s Ratio Perm | | | 0.04 | 0.17 | | | | 0.01 | | | 0.07 | |
| v/c Ratio | 0.89 | 0.39 | 0.14 | 0.55 | 0.91 | 0.46 | 0.19 | 0.05 | 0.87 | 0.21 | 0.19 | |
| Uniform Delay, d1 | 48.9 | 31.6 | 29.2 | 19.9 | 36.0 | 50.4 | 30.0 | 28.8 | 45.3 | 22.9 | 22.6 | |
| Progression Factor | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | |
| Incremental Delay, d2 | 26.7 | 0.3 | 0.2 | 1.5 | 12.6 | 2.0 | 0.5 | 0.2 | 15.5 | 0.4 | 0.8 | |
| Delay (s) | 75.6 | 31.8 | 29.4 | 21.4 | 48.6 | 52.5 | 30.5 | 29.1 | 60.8 | 23.2 | 23.5 | |
| Level of Service | E | C | C | C | D | D | C | C | E | C | C | |
| Approach Delay (s) | | 45.6 | | | 43.4 | | 35.4 | | | | 39.7 | |
| Approach LOS | | D | | | D | | D | | | | D | |

| Intersection Summary | |
|-----------------------------------|---------------------------------|
| HCM Average Control Delay | 42.1 HCM Level of Service D |
| HCM Volume to Capacity ratio | 0.65 |
| Actuated Cycle Length (s) | 110.0 Sum of lost time (s) 12.0 |
| Intersection Capacity Utilization | 67.9% ICU Level of Service C |
| Analysis Period (min) | 15 |
| c Critical Lane Group | |



**ENGINEER'S ESTIMATE
FOUNTAIN STREET AND MAPLE GROVE ROAD
FUTURE TRAFFIC SIGNALS
SERNAS PROJECT NO. 06407**

February 9, 2007

| ITEM | DESCRIPTION | ESTIMATED AMOUNT |
|------|-------------------------|---------------------|
| 1 | SIGNALIZED INTERSECTION | \$ 1,468,243.75 |
| | LAYOUTS AND BONDS | \$ 75,000.00 |
| | LINE PAINTING | \$ 25,000.00 |
| | TRAFFIC SIGNAL SYSTEM | \$ 100,000.00 |
| | SUB-TOTAL | \$ 1,668,243.75 |
| | ADD: 6% G.S.T. | \$ 100,094.63 |
| | ESTIMATED TOTAL | \$ 1,768,338.38 |

| | |
|--------------|----|
| PREPARED BY: | CK |
| CHECKED BY: | PW |

NOTES:

1. This is a preliminary estimate and should be used for reference purposes only.
2. This estimate is based on conceptual design
3. No allowance has been made for any other works than those set out herein



SIGNALIZED INTERSECTION

| ITEM | DESCRIPTION | AVE. DEPTH | EST. QTY. | UNIT | UNIT RATE | ESTIMATED AMOUNT |
|------|---|---------------|--------------|----------------|--------------|---------------------|
| 1.11 | SWEEP, CLEAN AND FLUSH BASE ASPHALT | | 21,450 | m ² | 0.25 | 5,362.50 |
| 1.12 | APPLY TACK COAT TO BASE ASPHALT PRIOR TO PLACEMENT OF SURFACE ASPHALT | | 21,450 | m ² | 0.30 | 6,435.00 |
| 1.13 | SUPPLY, PLACE AND COMPACT HL-3 SURFACE ASPHALT - MINIMUM 75 mm DEPTH, INCL. ASPHALT CEMENT @ \$300 PER TONNE (AC PRICE BASED ON MTO PERFORMANCE GRADE ASPHALT CEMENT PRICE INDEX. UNIT RATE ADJUSTMENT TO BE BASED ON OHMPA / MTO PRICE INDEX AT TIME OF PLACEMENT, ALL HAULAGE CHARGES INCL. IN UNIT RATE PER m ²) | | 21,450 | m ² | 13.00 | 278,850.00 |

SUB-TOTAL

ITEM

SIGNALIZED INTERSECTION

1,468,243.75



SIGNALIZED INTERSECTION

| ITEM | DESCRIPTION | AVE. DEPTH | EST. QTY. | UNIT | UNIT RATE | ESTIMATED AMOUNT |
|------------------|---|---------------|--------------|----------------|--------------|---------------------|
| 2.11 | SWEEP, CLEAN AND FLUSH BASE ASPHALT | | 17,970 | m ² | 0.25 | 4,492.50 |
| 2.12 | APPLY TACK COAT TO BASE ASPHALT PRIOR TO PLACEMENT OF SURFACE ASPHALT | | 17,970 | m ² | 0.30 | 5,391.00 |
| 2.13 | SUPPLY, PLACE AND COMPACT HL-3 SURFACE ASPHALT - MINIMUM 75 mm DEPTH, INCL. ASPHALT CEMENT @ \$300 PER TONNE (AC PRICE BASED ON MTO PERFORMANCE GRADE ASPHALT CEMENT PRICE INDEX. UNIT RATE ADJUSTMENT TO BE BASED ON OHMPA / MTO PRICE INDEX AT TIME OF PLACEMENT, ALL HAULAGE CHARGES INCL. IN UNIT RATE PER m ²) | | 17,970 | m ² | 13.00 | 233,610.00 |
| SUB-TOTAL | | | | | | |
| ITEM | SIGNALIZED INTERSECTION | | | | | 1,127,757.50 |



ROUNDBABOUT

| ITEM | DESCRIPTION | AVE. DEPTH | EST. QTY. | UNIT | UNIT RATE | ESTIMATED AMOUNT |
|------|--|---------------|--------------|----------------|--------------|---------------------|
| 1.1 | STRIP TOPSOIL FROM THE RIGHT OF WAY AND DISPOSE OFFSITE | | 8,000 | m ² | 8.00 | 64,000.00 |
| 1.2 | CUT TO FILL ROADWAY | | 2,500 | m ³ | 4.00 | 10,000.00 |
| 1.3 | REMOVE DISPOSE OFFSITE EXCESS MATERIAL INCL. EXISTING GRANULAR MATERIAL | | 2,500 | m ³ | 10.00 | 25,000.00 |
| 1.4 | COMPACT ROAD SUBGRADE | | 15,685 | m ² | 0.40 | 7,842.50 |
| 1.5 | SUPPLY, PLACE AND COMPACT GRANULAR 'B', 450 mm DEPTH AT CENTRELINE | | 15,685 | m ² | 11.00 | 215,668.75 |
| 1.6 | SUPPLY, PLACE AND COMPACT GRANULAR 'A' - MINIMUM 150 mm DEPTH | | 14,020 | m ² | 6.50 | 113,912.50 |
| 1.7 | SUPPLY AND INSTALL 100 mm DIA. PERFORATED SUBDRAINS, EXCLUDING CENTRE MEDIAN | | 1,850 | m | 11.00 | 20,350.00 |
| 1.8 | SUPPLY AND PLACE CONCRETE CURB: | | | | | |
| a) | FULL STAGE CURB AND GUTTER | | 1,850 | m | 45.00 | 83,250.00 |
| b) | DEPRESSED FULL STAGE CURB FOR ROUNDBABOUT AND REVERSED CURB FOR SPLITTER AND CENTRAL ISLAND | | 875 | m | 45.00 | 39,375.00 |
| 1.9 | SUPPLY AND INSTALL 150mm DEPTH CONCRETE ISLAND | | 550 | m ² | 45.00 | 24,750.00 |
| 1.10 | SUPPLY AND PLACE HL8 ASPHALT, INCL. ASPHALT CEMENT MINIMUM OF 100 mm DEPTH (2 LIFTS OF 50 mm) | | 14,020 | m ² | 13.50 | 189,270.00 |