Intersection Control Evaluation

Lookout Drive at Howard Drive

in North Mankato, Nicollet County, Minnesota

Mankato/North Mankato Area Planning Organization

SRF Consulting Group, Inc. | Engineers Planners Designers

February 2018

SRF No. 10279

Intersection Control Evaluation

Lookout Drive at
Howard Drive

Proposed Letting Date: TBD

Report Certification:

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Adrian S. Potter — Print Name

42785 — Reg. No.

Adrian S. Potter — Signature

2/15/2018 — Date

Approved:

City of North Mankato
City Engineer

3/8/2018 — Date

Nicollet County
Public Works Director

3-7-18 — Date

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Introduction

This report contains the intersection control evaluation results for the Lookout Drive (CSAH 13) at Howard Drive intersection in North Mankato, Nicollet County, Minnesota (see Figure 1). The purpose of the evaluation was to analyze the intersection control alternatives for the intersection to identify the long-term preferred intersection control. The following intersection control alternatives were considered applicable and are analyzed within this report:

- All-Way Stop Control
- Roundabout Control
- Traffic Signal Control

A detailed warrants analysis, operational analysis, safety analysis, and planning-level cost analysis were performed to determine the preferred intersection control alternative. In addition to these analyses, other factors considered for this evaluation that were applicable to determining the long-term preferred intersection control included:

- Right-of-Way Considerations
- Transportation System Considerations
- Pedestrian and Bicycle Considerations
- Local Acceptance

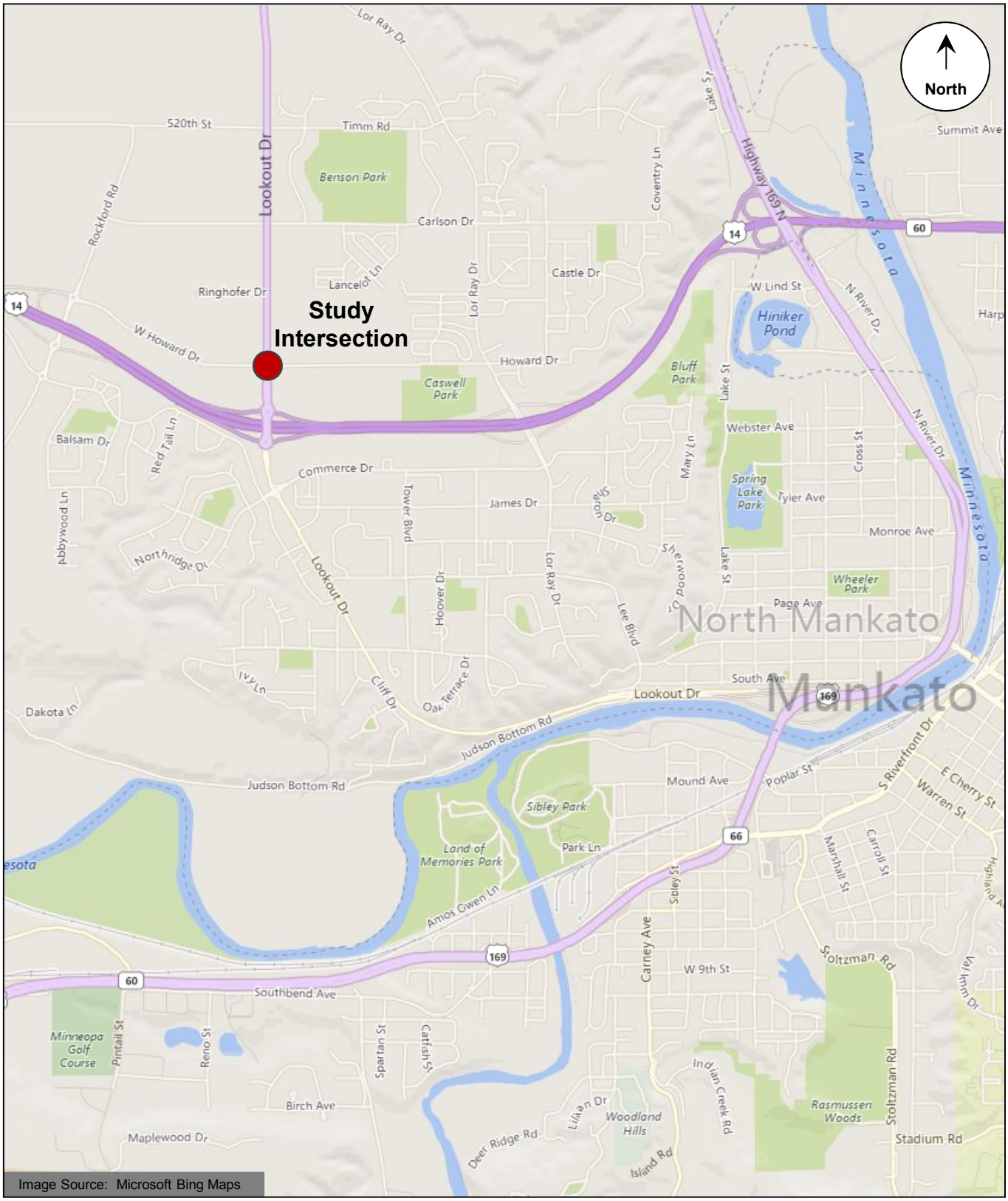

Image Source: Microsoft Bing Maps

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Study Intersection

Figure 1

Intersection Control Evaluation
Lookout Drive at Howard Drive
North Mankato, Nicollet County, Minnesota

10279
September 2017

Existing Intersection Characteristics

Existing Conditions

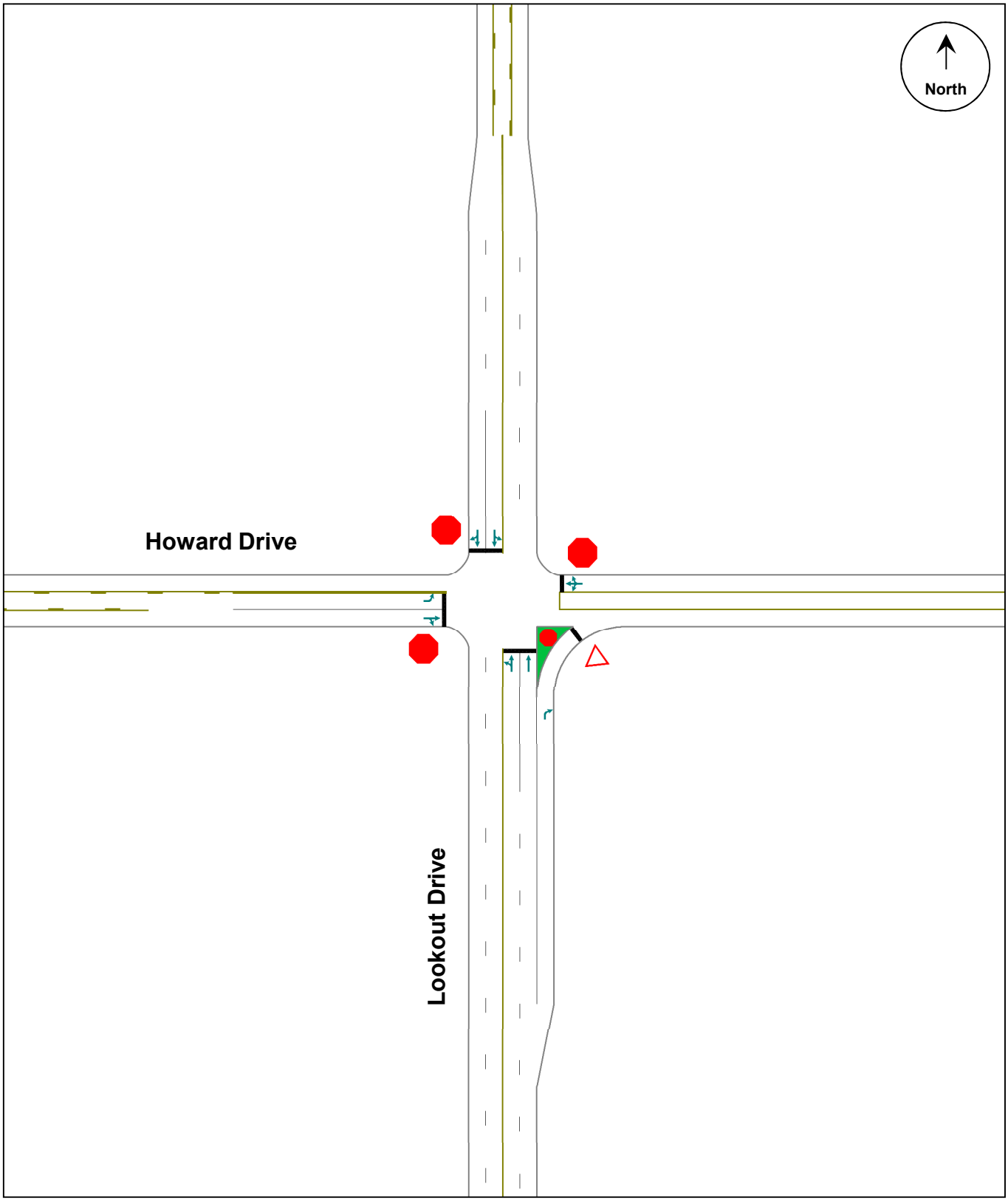
The study intersection is located in the City of North Mankato, Nicollet County as shown in Figure 1. Lookout Drive (CSAH 13) is a four-lane roadway south of the study intersection and transitions to a three-lane roadway immediately north of the intersection. Lookout Drive is functionally classified as a minor arterial. Lookout Drive has a posted speed limit of 45 mph. West of the intersection, Howard Drive is a three-lane roadway and is functionally classified as a local road, while to the east Howard Drive is a two-lane roadway that is functionally classified as a major collector. Howard Drive has a posted speed limit of 30 mph. The intersection of Lookout Drive and Howard Drive is currently all-way stop controlled. There are sidewalks/trails on both sides of Howard Drive and Lookout Drive, except for the north side of Lookout Drive west of the study intersection. There are marked pedestrian crossings on all four legs of the intersection. The adjacent area has primarily industrial land uses. The existing lane configurations for the Lookout Drive at Howard Drive intersection are listed in Table 1 below and are shown in Figure 2.

Table 1. Existing Conditions

Approach	Configuration
Northbound Lookout Drive	One shared thru/left-turn lane, one thru lane, and one channelized right-turn lane
Southbound Lookout Drive	One shared thru/left-turn lane and one shared thru/right-turn lane
Eastbound Howard Drive	One left-turn lane and one shared thru/right-turn lane
Westbound Howard Drive	One shared lane (all movements)

Crash History

Crash data was obtained from the Minnesota Crash Mapping Analysis Tool (MnCMAT) database for a five-year period from 2011 to 2015. There were three recorded crashes at the study intersection during the analysis period. Detailed crash data is provided in the Appendix. This results in a crash rate of 0.19 crashes per million entering vehicles, which is below the statewide average of 0.35 for all-way stop controlled intersections and well below the critical crash rate of 0.76 (0.995 level of confidence) for this intersection.



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Existing Conditions

Figure 2

Intersection Control Evaluation
Lookout Drive at Howard Drive
North Mankato, Nicollet County, Minnesota

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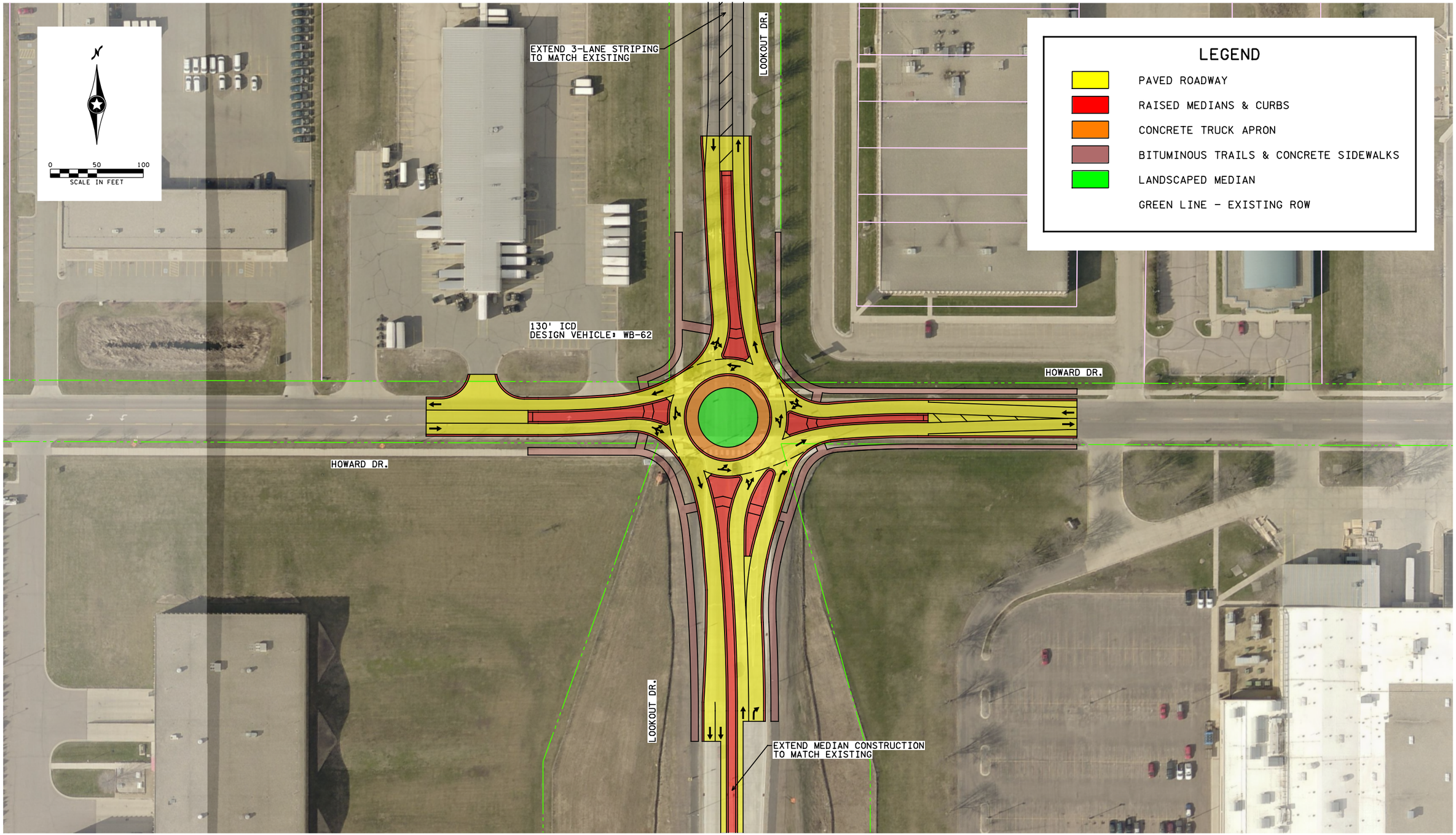
Future Conditions

Based on discussions with City and County staff in the summer of 2017, no short-term improvements to Lookout Drive, Howard Drive, or the study intersection are planned. For the alternatives analysis, the existing lane configurations under all-way stop control (listed in Table 1 and shown in Figure 2) were assumed to be the same for the traffic signal control alternative. The lane configurations for the roundabout control alternative are listed in Table 2 below and are shown in Figure 3.

Table 2. Proposed Lane Configurations for Roundabout Control Alternative

Approach	Configuration
Northbound Lookout Drive	One shared thru/left-turn lane and one right-turn bypass lane
Southbound Lookout Drive	One shared lane (all movements)
Eastbound Howard Drive	One shared lane (all movements)
Westbound Howard Drive	One shared lane (all movements)

Please note that the roundabout concept layout shown in Figure 3 would need to be refined during final design to determine how to best incorporate the adjacent driveway accesses along the west leg and still promote proper traffic operations and safety at the intersection.



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Roundabout Control Alternative

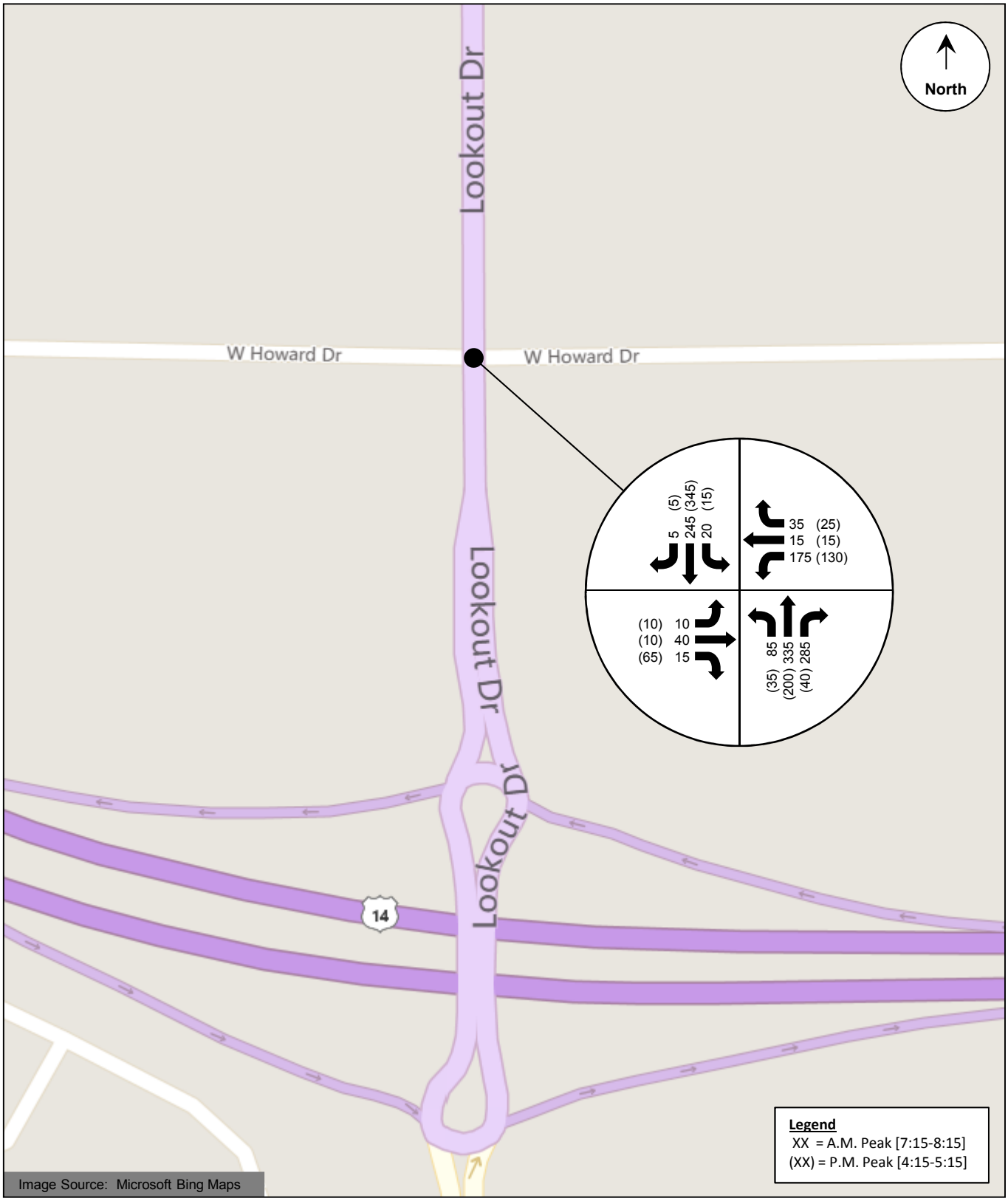
Intersection Control Evaluation

Lookout Drive at Howard Drive

Figure 3

Traffic Volumes

Hourly traffic volumes including the existing a.m. and p.m. peak hour were collected in April 2017 by SRF prior to the conclusion of the spring term at Minnesota State University and are shown in Figure 4. Pedestrian and bicycle volumes were also collected. Growth rates from the MAPO 2045 Transportation Plan (1.2% for the east and west legs, and 1.0% for the north and south legs) were used as the basis for traffic forecasts. The growth rates for the north and south legs were adjusted to 2.0% and 1.5%, respectively, based on significant proposed housing development north of the study intersection in the vicinity of Lookout Drive and Timm Road. These growth rates were used to determine Forecasted Year 2037 peak hour turning movement volumes, which are shown in Figure 5.



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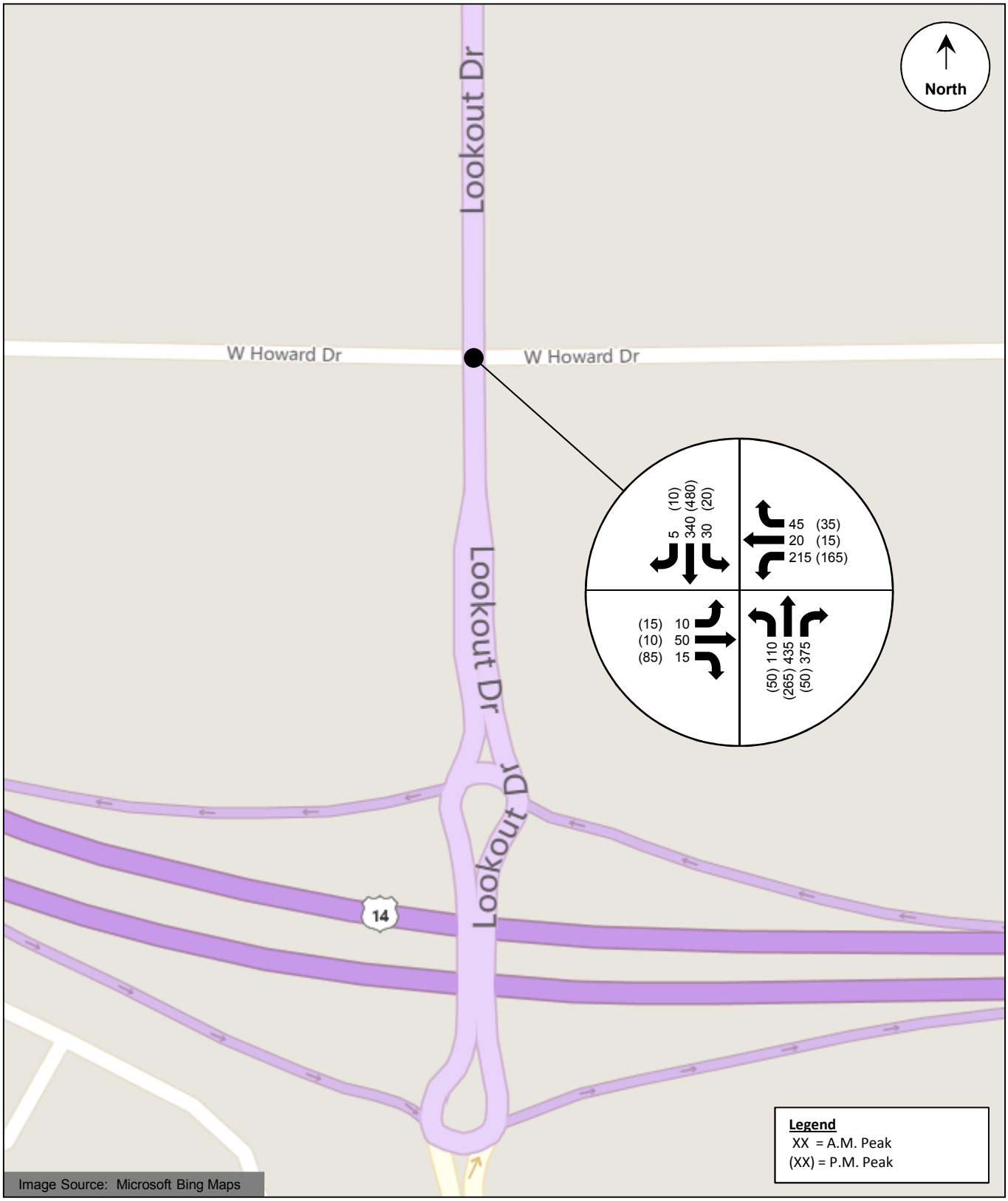
Existing Year 2017 Volumes

Figure 4

Intersection Control Evaluation
Lookout Drive at Howard Drive
North Mankato, Nicollet County, Minnesota



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Forecasted Year 2037 Volumes

Figure 5

Intersection Control Evaluation
Lookout Drive at Howard Drive
North Mankato, Nicollet County, Minnesota

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Analysis of Alternatives

The analysis of the all-way stop control, traffic signal control, and roundabout control alternatives included a warrants analysis, operational analysis, planning-level crash analysis, and a planning-level cost analysis. Existing Year 2017 and Forecasted Year 2037 volumes with proposed lane configurations discussed previously were used for the analysis.

Warrants Analysis

A warrants analysis was performed for the traffic signal control alternative as outlined in the February 2015 *Minnesota Manual on Uniform Traffic Control Devices* (MN MUTCD). The signal warrants analysis was based on the assumptions shown in Table 3.

Table 3. Warrants Analysis Assumptions

Approach	Geometry	Speed
Northbound Major Street (Lookout Drive)	2 or more approach lanes	45 mph
Southbound Major Street (Lookout Drive)	2 or more approach lanes	45 mph
Eastbound Minor Street (Howard Drive)	1 approach lane	30 mph
Westbound Minor Street (Howard Drive)	1 approach lane	30 mph

Northbound right-turns were excluded from the analysis because of the channelized right-turn lane with a long storage length. Minor street right-turns were included in the analysis because of the shared eastbound thru/right-turn lane and the shared westbound lane. The eastbound approach was considered a one lane approach because of the low left-turn volume. Table 4 provides a summary of the results of the warrants analysis. The detailed warrants analysis can be found in the Appendix.

Table 4. Warrants Analysis Results

MN MUTCD Warrant	Hours Required	Existing Year 2017 Volumes		Forecasted Year 2037 Volumes	
		Hours Met	Warrant Met	Hours Met	Warrant Met
Warrant 1A: Minimum Vehicular Volume	8	3	No	6	No
Warrant 1B: Interruption of Continuous Traffic	8	0	No	5	No
Warrant 1C: Combination of Warrants	8	2	No	7	No
Warrant 2: Four-Hour Volume	4	2	No	5	Yes
Warrant 3B: Peak-Hour Volume	1	0	No	2	Yes
Multi-way Stop Applications Condition C	8	7	No	8	Yes

Warrants 4-9 were investigated but were determined to be not applicable. Results of the warrants analysis indicate that Existing Year 2017 volumes do not satisfy any MN MUTCD traffic signal warrants, while Forecasted Year 2037 volumes satisfy the MN MUTCD warrant requirements for traffic signal Warrants 2 and 3B. The intersection meets multi-way stop warrants with Forecasted Year 2037 volumes.

Operational Analysis

An initial planning-level analysis was performed for the roundabout control alternative based on methods found in the *Highway Capacity Manual, Sixth Edition* (Transportation Research Board, 2016). The analysis involved testing the theoretical capacity of a single-lane roundabout against the Forecasted Year 2037 entering and circulating volumes. As shown in Chart 1, the Forecasted Year 2037 volumes do not exceed the theoretical capacity of a single-lane roundabout. Therefore, a single lane roundabout was selected for further analysis. A separate northbound right-turn bypass lane was included because of the existing south leg roadway configuration and the high northbound right-turn volume.

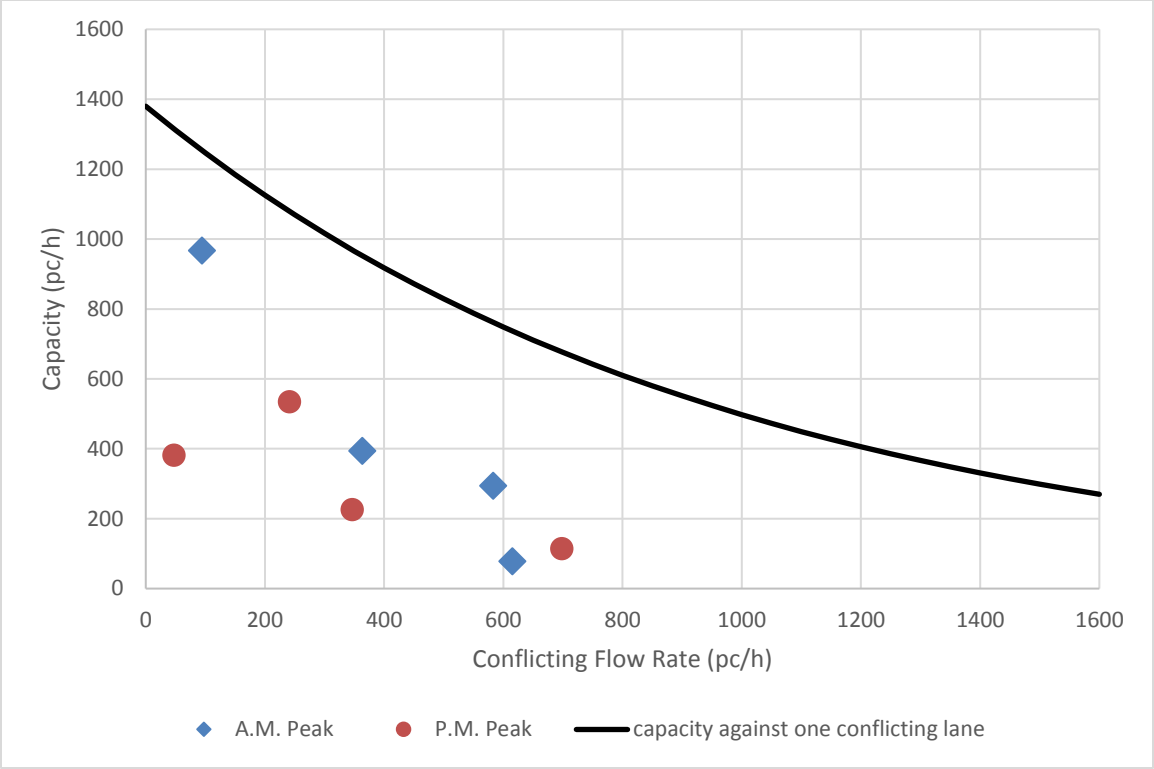


Chart 1. Single-Lane Roundabout Entry Lane Capacity (Forecasted Year 2037 volumes)

Operational analysis of the roundabout control alternative was performed using Highway Capacity Software (HCS). HCS is based on methodologies found in the *Highway Capacity Manual, 6th Edition* (HCM). It is important to note that HCS only reports "stop" or "control" delay. Therefore, to determine the total delay, "geometric" delay, or delay due to vehicle deceleration and acceleration through an intersection, must be added to the "stop" or "control" delay.

The detailed operational analysis of all-way stop control and traffic signal control was performed using methods outlined in the HCM using Synchro/SimTraffic. Synchro/ SimTraffic can calculate various measures of effectiveness such as control delay, queuing, and total travel time impacts. SimTraffic results are reported for the analysis.

The operational analysis identified a Level of Service (LOS), which indicates how well an intersection is operating based on average delay per vehicle. Intersections are given a ranking from LOS A to LOS F. LOS A indicates the best traffic operation and LOS F indicates an intersection where demand exceeds capacity. LOS A through LOS D are generally considered acceptable.

Table 5 and Table 6 provide a summary of the operational analysis for Existing Year 2017 and Forecasted Year 2037 conditions, respectively. Detailed operational analysis results can be found in the Appendix.

Table 5. Existing Year 2017 Operational Analysis Results

Alternative	Analysis Tool	A.M. Peak		P.M. Peak	
		Delay (1) (sec/veh)	LOS	Delay (1) (sec/veh)	LOS
All-Way Stop Control	Synchro/SimTraffic	4/5	A/A	3/4	A/A
Traffic Signal Control	Synchro/SimTraffic	5/9	A/A	4/8	A/A
Roundabout Control	HCS	6/7	A/A	6/7	A/A

(1) Control/stop delay is reported. Overall results are followed by the worst approach results.

Table 6. Forecasted Year 2037 Operational Analysis Results

Alternative	Analysis Tool (Variation)	A.M. Peak		P.M. Peak	
		Delay (1) (sec/veh)	LOS	Delay (1) (sec/veh)	LOS
All-Way Stop Control	Synchro/SimTraffic	6/9	A/A	4/5	A/A
Traffic Signal Control	Synchro/SimTraffic	6/11	A/B	5/8	A/A
Roundabout Control	HCS	8/10	A/A	7/9	A/A

(1) Control/stop delay is reported. Overall results are followed by the worst approach results.

Results of the operational analysis indicate that under the existing all-way stop control, the intersection operates with an acceptable level of service, and would continue to do so under Forecasted Year 2037 conditions. The traffic signal control and roundabout control alternatives would operate with acceptable levels of service under Forecasted Year 2037 conditions.

Safety Analysis

A crash analysis was performed to determine the projected crashes per year for Existing Year 2017 and Forecasted Year 2037 conditions for the study intersection. Crash rates from the MnDOT Green Sheets (2011 to 2015 data) were used for the crash analysis of the alternatives. According to *NCHRP Report 672 Roundabouts: An Informational Guide, Second Edition* (Transportation Research Board, 2010), the conversion of an all-way stop controlled intersection to a roundabout has an insignificant impact on the crash rate. Therefore, the crash rate for all-way stop control was used for the roundabout control alternative. A summary of the crash analysis is shown in Table 7.

Table 7. Crash Analysis Results

Alternative	Intersection AADT (2017)	Intersection AADT (2037)	Crash Rate	Projected Crashes/Year (2017)	Projected Crashes/Year (2037)
All-Way Stop Control	8,700	11,500	0.35	2	2
Traffic Signal Control			0.52	2	3
Roundabout Control			0.35	2	2

Based on the results of the crash analysis, the all-way stop control and roundabout control alternatives are anticipated to have slightly less crashes than the traffic signal control alternative.

Studies have determined that the installation of a roundabout can improve overall safety of an intersection when compared to other forms of intersection control. Roundabouts typically have fewer conflict points than conventional intersections and the geometry of a roundabout induces lower speeds for vehicles approaching and traversing an intersection. With lower speeds, the severity of the crashes is decreased. A roundabout virtually eliminates right-angle and left-turn head-on crashes. Studies have shown the frequency of injury crashes is reduced more than property damage only crashes.

At a roundabout, drivers must be aware of traffic traveling around the circle when merging on or off the roundabout. Conversely, drivers at a traditional intersection must be aware of vehicles at all approaches and the movements they are making. This issue is most prevalent at stop-controlled intersections where there is not a traffic signal to control vehicle movements.

Planning-Level Cost Analysis

Capital Costs

The intersection is currently all-way stop controlled, therefore with the "no build" alternative there would be no cost to continue with this type of intersection control. The traffic signal control alternative can utilize the existing geometric conditions, therefore the cost for this alternative would only be the cost of installing a traffic signal system, along with ADA improvements. The roundabout control alternative would require substantial reconstruction at and leading up to the intersection, which results in a much higher construction cost than the traffic signal control alternative.

Operation and Maintenance Costs

Traffic signals typically have higher operation and maintenance costs than roundabouts because of the electricity required to operate the signal and routine maintenance required to keep the signal in operation. Operation and maintenance costs associated with a roundabout can vary depending on the amount of illumination required or landscaping alternatives used for the center island. All-way stop control operation and maintenance costs are only the ongoing costs of maintaining the stop signs and pavement markings.

A cost analysis summary is shown in Table 8. Detailed cost analysis results can be found in the Appendix.

Table 8. Cost Analysis Summary

Alternative	Capital Costs (1)	Operation/Maintenance Costs (annual)
All-Way Stop Control	$0	< $200
Traffic Signal Control	$300,000	$4,000-$6,000
Roundabout Control	$1,260,000	$500-$1,000

(1) Does not include engineering or right-of-way costs.

Alternatives Assessment

Right-of-Way Considerations

The roadway geometry for the all-way stop control and traffic signal control alternatives would use existing conditions and therefore no additional right-of-way would be required. Construction of a roundabout at the study intersection would require additional right-of-way in all four quadrants of the intersection.

Transportation System Considerations

There are several roundabouts immediately south of the intersection at the TH 14 interchange and immediately west of the intersection along County Road 41. Roundabout control was also recommended for the Lor Ray Drive and Howard Drive intersection east of the subject intersection. The roundabout would require closure of one of the UPS facility driveways. No significant queues are expected with any of the alternatives.

Pedestrian and Bicycle Considerations

As previously mentioned, there are currently sidewalks/trails on both sides of Howard Drive and Lookout Drive, except for the north side of Lookout Drive to the west of the study intersection. There are marked pedestrian crossings on all four legs of the intersection. Pedestrian accommodations can be provided regardless of the selected intersection control.

The design of a roundabout allows pedestrians to cross one direction of traffic at a time with a refuge space in the middle of each leg of the roundabout, and these short crossing distances and reduced travel speeds of vehicle traffic improve pedestrian safety. However, their route is slightly longer since they are kept to the outside of the inscribed circle.

The design of a traffic signal can create a safe environment for pedestrian crossings with the use of pedestrian signal phasing. This phasing allows pedestrians to safely cross an intersection while vehicular movements are served. Although signalized intersections can provide indications showing pedestrian right-of-way, potential conflicts can come from red-light running through vehicles and permissive turning traffic.

The all-way stop alternative provides a safety benefit for pedestrians by having all vehicular movements stop; however, there are safety concerns for pedestrians where all road users expect other road users to stop. Most vehicle-pedestrian collisions at all-way stop controlled intersections are a result of either vehicles not stopping when pedestrians assume they are, or pedestrians not paying attention to vehicles approaching the intersection.

Local Acceptance

Drivers are familiar with traveling through all-way stop controlled and signalized intersections since there are many intersections in the area under these types of traffic control. Drivers are also familiar with traveling through roundabout controlled intersections since there are many existing roundabouts throughout the greater Mankato area.

Conclusions and Recommendations

The following conclusions are provided for this intersection control evaluation for the Lookout Drive (CSAH 13) at Howard Drive intersection in North Mankato, Nicollet County, Minnesota:

- *Warrants Analysis*
  Results of the warrants analysis indicate that Existing Year 2017 volumes do not satisfy any MN MUTCD traffic signal warrants, while Forecasted Year 2037 volumes satisfy the MN MUTCD warrant requirements for traffic signal Warrants 2 and 3B.

- *Operational Analysis*
  Results of the operational analysis indicate that under the existing all-way stop control, the intersection operates with an acceptable level of service, and would continue to do so under Forecasted Year 2037 conditions. The traffic signal control and roundabout control alternatives would also operate with acceptable levels of service under forecasted conditions.

- *Safety Analysis*
  Based on the results of the crash analysis, the all-way stop control and roundabout control alternatives are anticipated to have slightly less crashes than the traffic signal control alternative. Roundabouts typically have fewer conflict points than conventional intersections and the geometry of a roundabout induces lower speeds for vehicles approaching and traversing an intersection. With lower speeds, the severity of the crashes is decreased.

- *Planning-Level Cost Analysis*
  There would be no cost to continue with the existing all-way stop control. The traffic signal control alternative can utilize the existing geometric conditions, therefore the cost for this alternative would only be the cost of installing a traffic signal system, along with ADA improvements, which would be approximately $300,000. The roundabout control alternative would require substantial reconstruction at and leading up to the intersection, which would cost approximately $1,260,000. Traffic signals typically have higher operation and maintenance costs because of the electricity required to operate the signal and routine maintenance required to keep the signal in operation. Operation and maintenance costs associated with a roundabout can vary depending on the amount of illumination required or landscaping alternatives used for the center island. Stop control operation and maintenance costs are only the ongoing costs of maintaining the stop signs and pavement markings.

- *Right-of-Way Considerations*
  The roadway geometry for the all-way stop and traffic signal control alternatives would use existing conditions and therefore no additional right-of-way would be required. Construction of a roundabout at the study intersection would require additional right-of-way in all four quadrants of the intersection.

- *Transportation System Considerations*
  There are several roundabouts immediately south of the intersection at the TH 14 interchange and immediately west of the intersection along County Road 41. No significant queues are expected with any of the alternatives.

- *Pedestrian and Bicycle Considerations*
  The design of signalized intersections can take pedestrian crossings and safety into consideration with the use of pedestrian signal phasing. The design of a roundabout allows pedestrians to cross one direction of traffic at a time on each leg of the roundabout. Their route is slightly longer since they are kept to the outside of the inscribed circle. All-way stop control provides a safety benefit for pedestrians by having all vehicular movements stop; however, most vehicle-pedestrian collisions at all-way stop controlled intersections are a result of either vehicles not stopping when pedestrians assume they are, or pedestrians not paying attention to vehicles approaching the intersection.

- *Local Acceptance*
  Drivers are familiar with traveling through all-way stop controlled and signalized intersections since there are many intersections in the area under these types of traffic control. Drivers are also familiar with traveling through roundabout controlled intersections since there are many existing roundabouts throughout the greater Mankato area.

A decision matrix was developed to help evaluate the key factors and is provided on the following page. Based on the results of this Intersection Control Evaluation, the all-way stop control, traffic signal control, and roundabout control alternatives are all viable options for the Lookout Drive at Howard Drive intersection. All alternatives have acceptable operations under forecasted conditions. The "no build" all-way stop alternative does not require any capital improvements. The traffic signal control alternative has comparable operations to the all-way stop control alternative. However, it has a significant capital cost. Therefore a traffic signal is not practical at this intersection. Compared to a traffic signal, a roundabout would have more consistent off-peak operations throughout the day when traffic volumes are lower. However, the existing dual northbound and southbound thru lanes provide better operations under all-way stop control than would be provided by a single-lane roundabout, without the additional capital costs. Therefore, maintaining the existing all-way stop control is recommended since this type of control would have no capital cost, require no right-of way, and have low delay.

A roundabout should be considered at this location in the future if safety issues develop or traffic volumes increase more than what was forecasted. A roundabout would match the control type used at adjacent intersections. If a roundabout is desired in the future, the roundabout concept layout shown in Figure 3 of this report would need to be refined during final design to determine how to best incorporate the adjacent driveway accesses along the west leg and still promote proper traffic operations and safety at the intersection.

Alternatives Decision Matrix: Lookout Drive at Howard Drive

Factor		All-Way Stop Control	Traffic Signal Control	Roundabout Control	Recommended Alternative(s) Based on Factor
Warrants Analysis	2017	• AWSC warrant not met	• Existing Year 2017 volumes do not meet traffic signal control warrants	N/A	**Roundabout Control**
	2037	• AWSC warrant met	• Forecasted Year 2037 volumes meet traffic signal control warrants	N/A	**All-Way Stop Control** **Traffic Signal Control** **Roundabout Control**
Operational Analysis	2017	• Acceptable LOS	• Acceptable LOS	• Acceptable LOS • Consistent off-peak operations	**All-Way Stop Control** **Traffic Signal Control** **Roundabout Control**
	2037	• Acceptable LOS	• Acceptable LOS	• Acceptable LOS • Consistent off-peak operations	
Safety Analysis	Pro(s):	• Least number of crashes expected • Lower vehicle speeds through intersection	• Signal indications show vehicle right-of-way	• Least number of crashes expected • Lower vehicle speeds through intersection	**All-Way Stop Control** **Roundabout Control**
	Con(s):	• Drivers decide right-of-way	• Slightly more crashes expected than all-way stop/roundabout	• Drivers select acceptable gaps	
Cost Analysis	Pro(s):	• No capital cost • Low operation/maintenance costs	• Lower capital costs ($300,000) than roundabout control	• Lower operation/maintenance costs than traffic signal control	**All-Way Stop Control**
	Con(s):	none	• Higher operation/maintenance costs than roundabout control	• Higher capital costs ($1,260,000) than traffic signal control • Requires substantial reconstruction	
Right-of-Way	Pro(s):	N/A (existing control)	• No ROW impacts expected	none	**All-Way Stop Control** **Traffic Signal Control**
	Con(s):		none	• Requires additional ROW in all four quadrants	
Transportation System Considerations	Pro(s):	• Existing control	• Nearest signal is south of TH 14 interchange	• Matches adjacent intersections at TH 14 interchange	**Roundabout Control**
	Con(s):	• Majority of adjacent intersections are roundabouts	• Majority of adjacent intersections are roundabouts	none	
Pedestrian and Bicycle Considerations	Pro(s):	• All vehicular movements stop	• Pedestrian pushbuttons and signal phasing	• Pedestrian Refuge islands • Lower vehicle speeds thru intersection	**Traffic Signal Control**
	Con(s):	• Expecting vehicles to yield to pedestrians can lead to a false sense of security	• Pedestrian signal phasing can lead to a false sense of security	• Longer route • No pedestrian phase	
Local Acceptance	Pro(s):	N/A (existing control)	• Familiar to drivers	• Familiar to drivers • Positive public feedback	**All-Way Stop Control** **Roundabout Control**
	Con(s):		none	none	

Appendix

- 2011-2015 Crash History
- Existing Year 2017 Warrants Analysis
- Forecasted Year 2037 Warrants Analysis
- Existing Year 2017 Detailed Operational Analysis
    - All-Way Stop Control
    - Traffic Signal Control
    - Roundabout Control
- Forecasted Year 2037 Detailed Operational Analysis
    - All-Way Stop Control
    - Traffic Signal Control
    - Roundabout Control
- Detailed Cost Analysis

2011-2015 Crash History

Crash Detail Report

Lookout Drive at Howard Drive

Report Version 1.0 March 2010

Crash ID: 110110165 **Date:** 01/10/2011 **Time:** 1600
County: NICOLLET **City:** NORTH MANKATO

Sys: 04-CSAH
Route: 52000013 000+00.220

Severity: PROPERTY DAMAGE
Road Type: OTHER
Road Char: STRAIGHT AND LEVEL
Crash Type: COLL W/MV IN TRANSPORT
Surf Cond: ICE/PACKED SNOW
Light Cond: DAYLIGHT
Weather 1: SNOW
Weather 2: NOT SPECIFIED

First Event: ON ROADWAY
To Junction: INTERSECTION-RELATED
Traffic Device: STOP SIGN 4-WAY
Speed Limit: 45
Diagram: REAR END
Officer:
Reliability: CONFIDENT
# of Vehicles: 2.00

	Unit 1	Unit 2	Unit 3
Trav Dir:	N	S	
Veh Act:	BACKING	STOPPED TRAFFIC	
Veh Type:	SPORT UNTILITY VEHICLE	SPORT UNTILITY VEHICLE	
Age:	25	35	
Gender:	F	M	
Cond:	NORMAL	NORMAL	
Cont Fact 1	SKIDDING	NO IMPROPER DRIVING	
Cont Fact 2	UNSAFE BACKING	NOT SPECIFIED	

Crash ID: 110630060 **Date:** 01/31/2011 **Time:** 0115
County: NICOLLET **City:** NORTH MANKATO

Sys: 05-MSAS
Route: 28550255 000+00.000

Severity: PROPERTY DAMAGE
Road Type: NOT SPECIFIED
Road Char: NOT SPECIFIED
Crash Type: COLL W/MV IN TRANSPORT
Surf Cond: ICE/PACKED SNOW
Light Cond: DAYLIGHT
Weather 1: SNOW
Weather 2: NOT SPECIFIED

First Event: NOT SPECIFIED
To Junction: NOT SPECIFIED
Traffic Device: STOP SIGN 4-WAY
Speed Limit: 30
Diagram: RIGHT ANGLE
Officer:
Reliability: CONFIDENT
# of Vehicles: 2.00

	Unit 1	Unit 2	Unit 3
Trav Dir:	W	N	
Veh Act:	STRAIGHT AHEAD	STRAIGHT AHEAD	
Veh Type:	SPORT UNTILITY VEHICLE	PICKUP TRUCK	
Age:	57	44	
Gender:	M	M	
Cond:	NOT SPECIFIED	NOT SPECIFIED	
Cont Fact 1	NOT SPECIFIED	NOT SPECIFIED	
Cont Fact 2	NOT SPECIFIED	NOT SPECIFIED	

Crash ID:	113340064	**Date:**	11/30/2011	**Time:**	1150
County:	NICOLLET	**City:**	NORTH MANKATO		

Sys:	04-CSAH	
Route:	52000013	000+00.220

Severity:	PROPERTY DAMAGE	**First Event:**	ON ROADWAY
Road Type:	4_6 LANES UNDIV 2_WAY	**To Junction:**	4-LEGGED INTERSECTION
Road Char:	STRAIGHT AND GRADE	**Traffic Device:**	STOP SIGN 4-WAY
Crash Type:	COLL W/MV IN TRANSPORT	**Speed Limit:**	45
Surf Cond:	DRY	**Diagram:**	REAR END
Light Cond:	DAYLIGHT	**Officer:**	
Weather 1:	CLEAR	**Reliability:**	CONFIDENT
Weather 2:	NOT SPECIFIED	**# of Vehicles:**	2.00

	Unit 1	Unit 2	Unit 3
Trav Dir:	N	N	
Veh Act:	STOPPED TRAFFIC	BIKE SLOWING/STOPPING/STARTI	
Veh Type:	SPORT UNTILITY VEHICLE	PASSENGER CAR	
Age:	43	59	
Gender:	F	M	
Cond:	NORMAL	NORMAL	
Cont Fact 1	NO IMPROPER DRIVING	OTHER HUMAN FACTOR	
Cont Fact 2	NOT SPECIFIED	NOT SPECIFIED	

Selection Filter:

WORK AREA: CONST_DIST_CODE('7') - FILTER: CRASH_YEAR('2011','2012','2013','2014','2015') - SPATIAL FILTER APPLIED

Analyst:

Luke James

Notes:

Existing Year 2017 Warrants Analysis

WARRANTS ANALYSIS

Existing Year 2017

Lookout Drive at Howard Drive
Intersection Control Evaluation
City of North Mankato, Nicollet County

Background Information

		Speed (mph)	Lanes	Approach	
Location :	City of North Mankato, Nicollet County	45	2 or more	Major Approach 1:	Northbound Lookout Drive
Date:	5/24/2017	45	2 or more	Major Approach 3:	Southbound Lookout Drive
Analysis Prepared By:	Luke James	30	1	Minor Approach 2:	Eastbound Howard Drive
Population Less than 10,000:	No	30	1	Minor Approach 4:	Westbound Howard Drive
Seventy Percent Factor Used:	Yes				

Warrants Analysis: Warrants 1A, 1B and 1C

Hour	Major Approach 1	Major Approach 3	Total 1 + 3	Warrant Met 420	Warrant Met 630	Minor Approach 2	Minor Approach 4	Largest Minor App.	Warrant Met 105	Warrant Met 53	Met Same Hours Condition A	Met Same Hours Condition B	Combination A	Combination B	MWSA (C) 210	MWSA (C) 140
6 - 7 AM	130	98	228			10	15	15							X	
7 - 8 AM	305	244	549	X		56	179	179	X	X	X		X	X	X	X
8 - 9 AM	359	178	537	X		73	120	120	X	X	X		X	X	X	X
9 - 10 AM	135	108	243			47	53	53		X					X	
10 - 11 AM	117	114	231			38	34	38							X	
11 - 12 AM	169	207	376			59	105	105	X	X			X		X	X
12 - 1 PM	238	229	467	X		71	79	79		X					X	X
1 - 2 PM	212	131	343			40	54	54		X					X	
2 - 3 PM	189	162	351			58	65	65		X					X	
3 - 4 PM	185	204	389			60	238	238	X	X			X		X	X
4 - 5 PM	218	272	490	X		103	162	162	X	X	X		X		X	X
5 - 6 PM	200	283	483	X		83	96	96		X			X		X	X
6 - 7 PM	110	103	213			45	41	45							X	
7 - 8 PM	71	52	123			21	54	54		X						
8 - 9 PM	55	38	93			21	21	21								
9 - 10 PM	38	29	67			13	15	15								
10 - 11 PM	26	22	48			12	4	12								
											3	0	6	2	7	

Warrant Summary

Warrant and Description		Hours Met	Hours Required	Met/Not Met
MWSA (C):	Multiway Stop Applications Condition C	7	8	Not Met
Warrant 1A:	Minimum Vehicular Volume	3	8	Not Met
Warrant 1B:	Interruption of Continuous Traffic	0	8	Not Met
Warrant 1C:	Combination of Warrants	2	8	Not Met
Warrant 2:	Four-Hour Vehicular Volume	2	4	Not Met
Warrant 3B:	Peak Hour	0	1	Not Met

SRF Consulting Group, Inc.

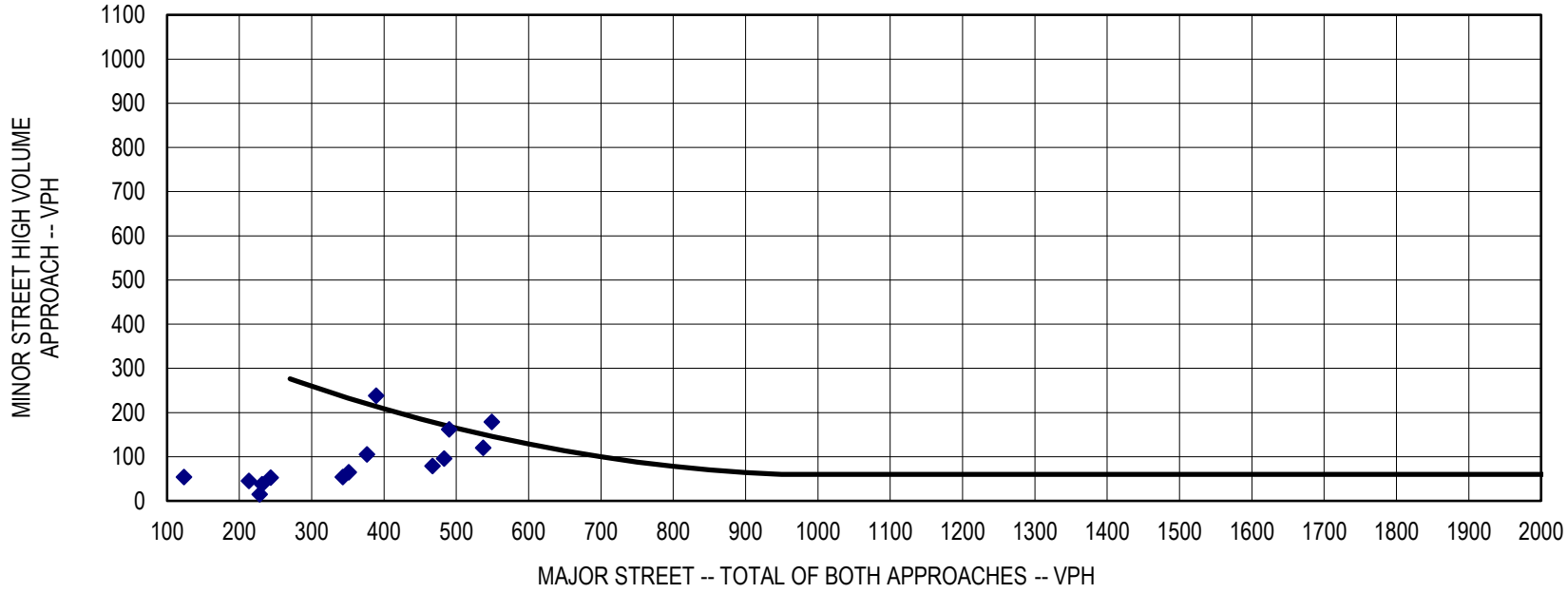
WARRANTS ANALYSIS

Existing Year 2017

Lookout Drive at Howard Drive
Intersection Control Evaluation
City of North Mankato, Nicollet County

Warrants Analysis: Warrant 2

WARRANT 2 - FOUR-HOUR VEHICULAR VOLUME



Number of Hours Satisfying Requirements:	2

Notes:
1. 80 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACH WITH TWO OR MORE LANES AND 60 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACHING WITH ONE LANE.
2. INTERSECTION IS EITHER (1) WITHIN A COMMUNITY LESS THAN 10,000 POPULATION OR (2) HAS SPEEDS ABOVE 40 MPH ON MAJOR STREET.

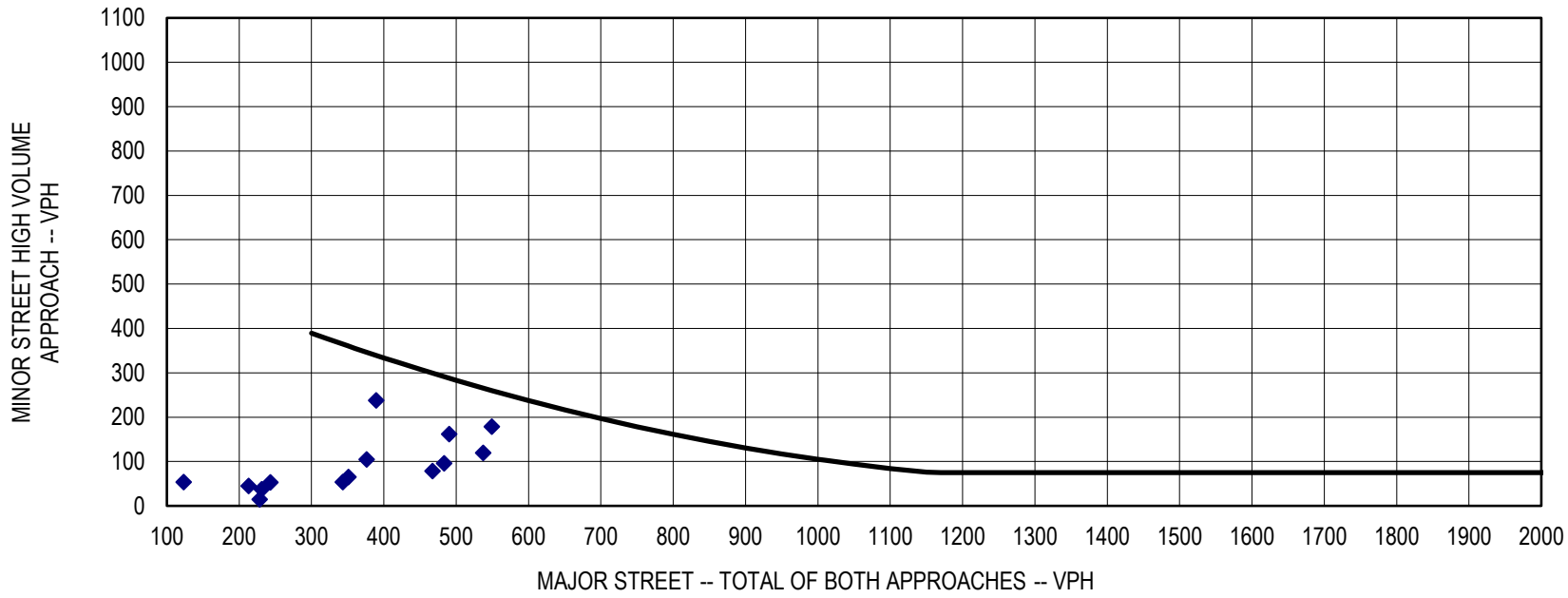
SRF Consulting Group, Inc.

WARRANTS ANALYSIS

Existing Year 2017

Lookout Drive at Howard Drive
Intersection Control Evaluation
City of North Mankato, Nicollet County

Warrants Analysis: Warrant 3



Number of Hours Satisfying Requirements:	0

Notes:
1. 100 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACH WITH TWO OR MORE LANES AND 75 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACHING WITH ONE LANE.
2. INTERSECTION IS EITHER (1) WITHIN A COMMUNITY LESS THAN 10,000 POPULATION OR (2) HAS SPEEDS ABOVE 40 MPH ON MAJOR STREET.

Forecasted Year 2037 Warrants Analysis

WARRANTS ANALYSIS

Forecasted Year 2037

Lookout Drive at Howard Drive
Intersection Control Evaluation
City of North Mankato, Nicollet County

Background Information

		Speed (mph)	Lanes	Approach	
Location :	City of North Mankato, Nicollet County	45	2 or more	Major Approach 1:	Northbound Lookout Drive
Date:	7/12/2017	45	2 or more	Major Approach 3:	Southbound Lookout Drive
Analysis Prepared By:	Luke James	30	1	Minor Approach 2:	Eastbound Howard Drive
Population Less than 10,000:	No	30	1	Minor Approach 4:	Westbound Howard Drive
Seventy Percent Factor Used:	Yes				

Warrants Analysis: Warrants 1A, 1B, and 1C

Hour	Major Approach 1	Major Approach 3	Total 1 + 3	Warrant Met 420	Warrant Met 630	Minor Approach 2	Minor Approach 4	Largest Minor App.	Warrant Met 105	Warrant Met 53	Met Same Hours Condition A	Met Same Hours Condition B	Combination A	Combination B	MWSA (C) 210	MWSA (C) 140
6 - 7 AM	169	137	306			12	18	18							X	
7 - 8 AM	397	342	739	X	X	69	221	221	X	X	X	X	X	X	X	X
8 - 9 AM	466	249	715	X	X	91	148	148	X	X	X	X	X	X	X	X
9 - 10 AM	176	151	327			58	66	66		X					X	
10 - 11 AM	151	160	311			47	42	47							X	
11 - 12 AM	219	289	508	X		73	130	130	X	X	X		X	X	X	X
12 - 1 PM	309	321	630	X	X	88	98	98		X		X	X	X	X	X
1 - 2 PM	276	183	459	X		50	66	66		X					X	
2 - 3 PM	245	226	471	X		72	80	80		X					X	X
3 - 4 PM	241	286	527	X		74	295	295	X	X	X		X	X	X	X
4 - 5 PM	283	381	664	X	X	127	201	201	X	X	X	X	X	X	X	X
5 - 6 PM	260	396	656	X	X	102	118	118	X	X	X	X	X	X	X	X
6 - 7 PM	142	144	286			55	50	55		X					X	
7 - 8 PM	92	73	165			25	67	67		X						
8 - 9 PM	72	53	125			25	25	25								
9 - 10 PM	49	40	89			16	19	19								
10 - 11 PM	34	31	65			15	4	15								
											6	5	7	7	8	

Warrant Summary

	Warrant and Description	Hours Met	Hours Required	Met/Not Met
MWSA (C):	Multiway Stop Applications Condition C	8	8	Met - Multiway Stop Applications
Warrant 1A:	Minimum Vehicular Volume	6	8	Not Met
Warrant 1B:	Interruption of Continuous Traffic	5	8	Not Met
Warrant 1C:	Combination of Warrants	7	8	Not Met
Warrant 2:	Four-Hour Vehicular Volume	5	4	Met - Warrant 2 Satisfied
Warrant 3B:	Peak Hour	2	1	Met - Warrant 3B Satisfied

SRF Consulting Group, Inc.

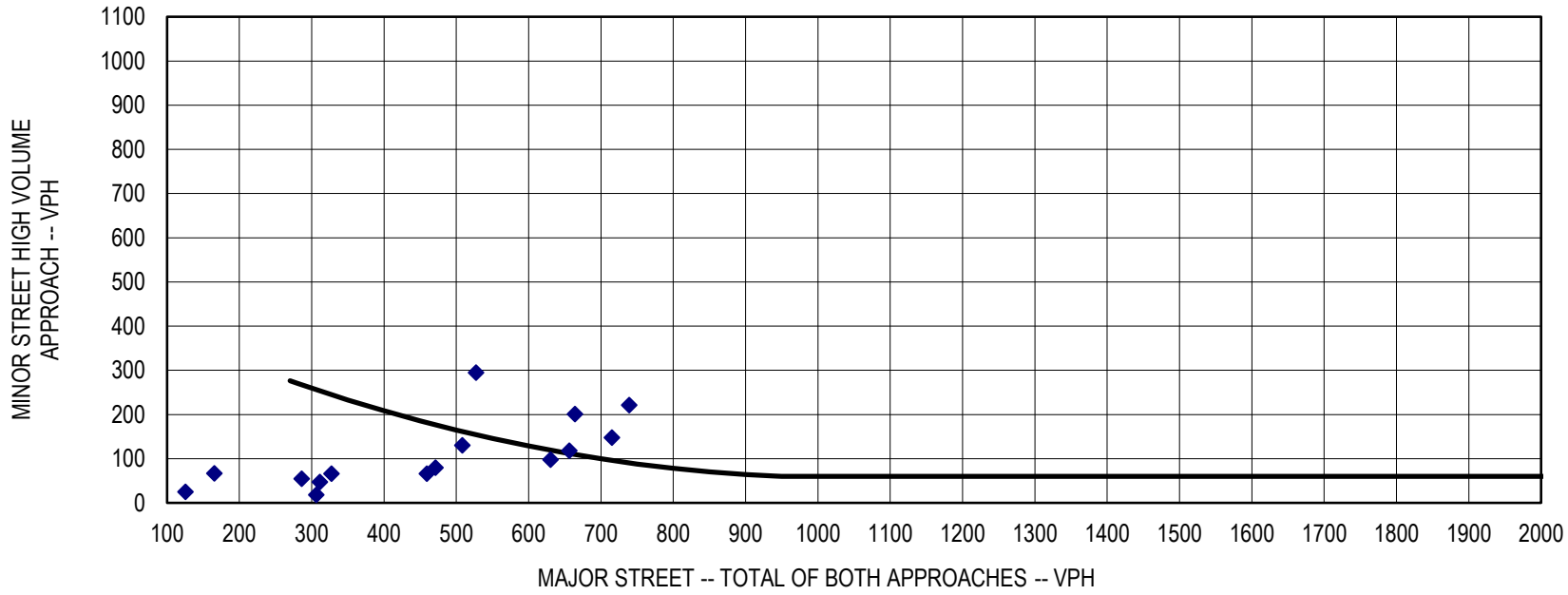
WARRANTS ANALYSIS

Forecasted Year 2037

Lookout Drive at Howard Drive
Intersection Control Evaluation
City of North Mankato, Nicollet County

Warrants Analysis: Warrant 2

WARRANT 2 - FOUR-HOUR VEHICULAR VOLUME



Number of Hours Satisfying Requirements:	5

Notes:
1. 80 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACH WITH TWO OR MORE LANES AND 60 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACHING WITH ONE LANE.
2. INTERSECTION IS EITHER (1) WITHIN A COMMUNITY LESS THAN 10,000 POPULATION OR (2) HAS SPEEDS ABOVE 40 MPH ON MAJOR STREET.

SRF Consulting Group, Inc.

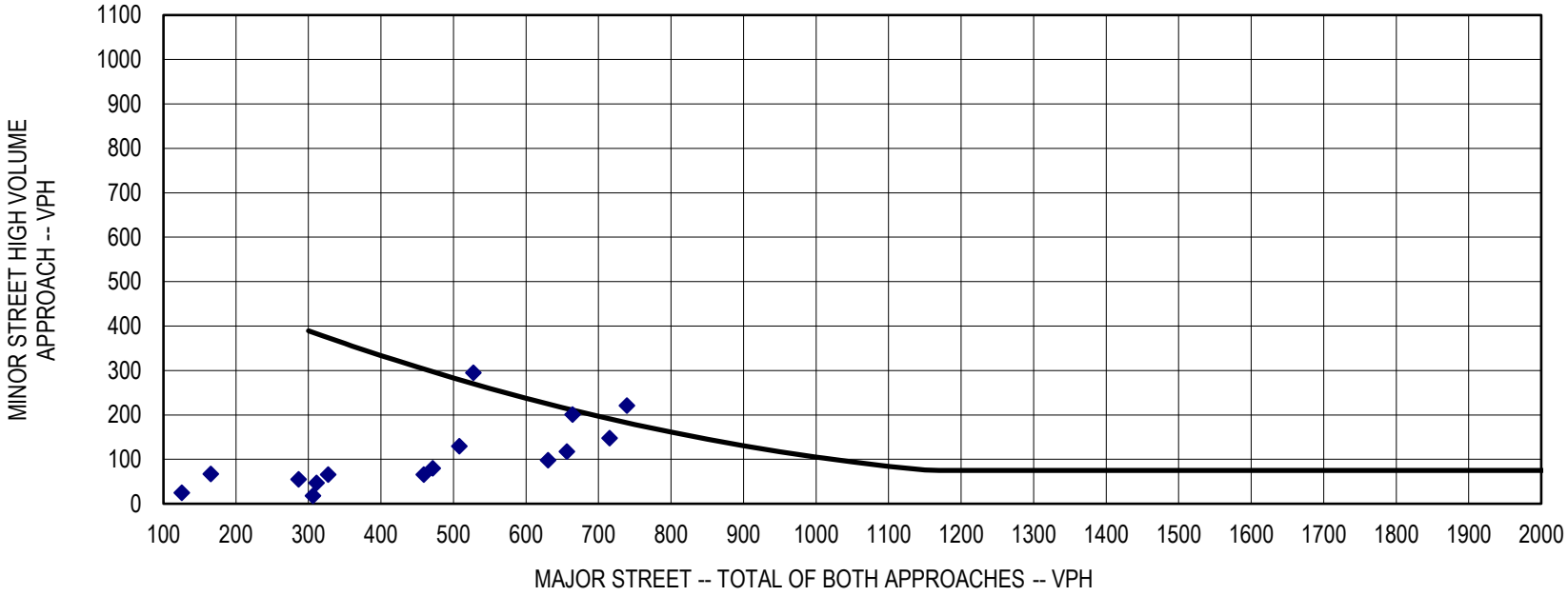
WARRANTS ANALYSIS

Forecasted Year 2037

Lookout Drive at Howard Drive
Intersection Control Evaluation
City of North Mankato, Nicollet County

Warrants Analysis: Warrant 3

WARRANT 3 - PEAK HOUR



Number of Hours Satisfying Requirements:	2

Notes:
1. 100 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACH WITH TWO OR MORE LANES AND 75 VPH APPLIES AS THE LOWER THRESHOLD VOLUME FOR A MINOR STREET APPROACHING WITH ONE LANE.
2. INTERSECTION IS EITHER (1) WITHIN A COMMUNITY LESS THAN 10,000 POPULATION OR (2) HAS SPEEDS ABOVE 40 MPH ON MAJOR STREET.

Existing Year 2017 Detailed Operational Analysis

All-Way Stop Control

1: Lookout Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.3	0.0	0.3
Denied Del/Veh (s)	0.7	0.2	1.4	0.0	0.8
Total Delay (hr)	0.1	0.5	1.7	0.7	2.9
Total Del/Veh (s)	7.5	7.4	8.8	8.7	8.4
Stop Delay (hr)	0.1	0.3	0.5	0.3	1.2
Stop Del/Veh (s)	4.8	4.7	2.8	3.6	3.5
Total Stops	67	224	425	270	986
Stop/Veh	1.00	1.00	0.62	1.00	0.79

Intersection: 1: Lookout Drive & Howard Drive

Movement	EB	EB	WB	NB	NB	NB	SB	SB
Directions Served	L	TR	LTR	LT	T	R	LT	TR
Maximum Queue (ft)	42	67	112	119	80	91	87	88
Average Queue (ft)	9	31	54	61	38	16	44	40
95th Queue (ft)	34	58	88	99	64	65	71	69
Link Distance (ft)		960	960	966	966		238	238
Upstream Blk Time (%)								
Queuing Penalty (veh)								
Storage Bay Dist (ft)	250					250		
Storage Blk Time (%)								
Queuing Penalty (veh)								

1: Lookout Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.1	0.0	0.1
Denied Del/Veh (s)	0.5	0.2	0.7	0.0	0.3
Total Delay (hr)	0.1	0.3	0.7	0.9	2.0
Total Del/Veh (s)	4.5	6.6	8.5	9.0	8.0
Stop Delay (hr)	0.1	0.2	0.2	0.4	0.8
Stop Del/Veh (s)	3.4	4.0	2.7	3.5	3.3
Total Stops	82	173	232	374	861
Stop/Veh	1.00	1.00	0.84	1.00	0.95

Intersection: 1: Lookout Drive & Howard Drive

Movement	EB	EB	WB	NB	NB	NB	SB	SB
Directions Served	L	TR	LTR	LT	T	R	LT	TR
Maximum Queue (ft)	31	62	92	88	70	11	99	101
Average Queue (ft)	7	33	48	45	23	0	49	46
95th Queue (ft)	29	55	76	73	53	8	81	76
Link Distance (ft)		960	960	966	966		238	238
Upstream Blk Time (%)								
Queuing Penalty (veh)								
Storage Bay Dist (ft)	250					250		
Storage Blk Time (%)								
Queuing Penalty (veh)								

Existing Year 2017 Detailed Operational Analysis

Traffic Signal Control

1: Lookout Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.3	0.0	0.3
Denied Del/Veh (s)	0.7	0.2	1.4	0.0	0.9
Total Delay (hr)	0.2	0.8	1.8	0.5	3.2
Total Del/Veh (s)	10.2	12.0	8.7	6.6	8.9
Stop Delay (hr)	0.1	0.6	0.8	0.3	1.8
Stop Del/Veh (s)	8.0	8.9	3.7	4.0	4.9
Total Stops	45	157	220	100	522
Stop/Veh	0.69	0.68	0.30	0.37	0.40

Intersection: 1: Lookout Drive & Howard Drive

Movement	EB	EB	WB	NB	NB	NB	SB	SB
Directions Served	L	TR	LTR	LT	T	R	LT	TR
Maximum Queue (ft)	36	76	150	203	140	65	88	95
Average Queue (ft)	8	31	76	82	29	4	43	24
95th Queue (ft)	31	65	131	145	85	30	75	64
Link Distance (ft)		960	960	966	966		238	238
Upstream Blk Time (%)								
Queuing Penalty (veh)								
Storage Bay Dist (ft)	250					250		
Storage Blk Time (%)								
Queuing Penalty (veh)								

1: Lookout Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.1	0.0	0.1
Denied Del/Veh (s)	0.5	0.2	0.7	0.0	0.3
Total Delay (hr)	0.1	0.5	0.6	0.6	1.9
Total Del/Veh (s)	5.6	10.5	7.6	6.0	7.4
Stop Delay (hr)	0.1	0.4	0.3	0.3	1.1
Stop Del/Veh (s)	4.6	7.7	3.8	3.3	4.4
Total Stops	51	118	105	125	399
Stop/Veh	0.70	0.66	0.35	0.34	0.44

Intersection: 1: Lookout Drive & Howard Drive

Movement	EB	EB	WB	NB	NB	SB	SB
Directions Served	L	TR	LTR	LT	T	LT	TR
Maximum Queue (ft)	35	69	126	104	48	108	97
Average Queue (ft)	6	28	62	49	10	49	29
95th Queue (ft)	27	57	105	90	39	89	69
Link Distance (ft)		960	960	966	966	238	238
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (ft)	250						
Storage Blk Time (%)							
Queuing Penalty (veh)							

Existing Year 2017 Detailed Operational Analysis

Roundabout Control

HCS7 Roundabouts Report

General Information

Analyst	Luke James
Agency or Co.	SRF Consulting Group, Inc.
Date Performed	7/6/2017
Analysis Year	2017
Time Period	A.M. Peak
Project Description	10279

Site Information

Intersection	Lookout Drive at Howard Drive
E/W Street Name	Howard Drive
N/S Street Name	Lookout Drive
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	MAPO

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LT				LTR	
Volume (V), veh/h	0	10	40	15	0	175	15	35	0	85	335	285	0	20	245	5
Percent Heavy Vehicles, %	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Flow Rate (v_{PCE}), pc/h	0	10	42	16	0	184	16	37	0	89	352	299	0	21	257	5
Right-Turn Bypass	None				None				Yielding				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	0				0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)		4.9763			4.9763			4.9763	4.9763		4.9763	
Follow-Up Headway (s)		2.6087			2.6087			2.6087	2.6087		2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		68			237			441	299		283	
Entry Volume veh/h		65			226			420	285		270	
Circulating Flow (v_c), pc/h	462			451			73			289		
Exiting Flow (v_{ex}), pc/h	63			110			399			457		
Capacity (c_{pce}), pc/h		861			871			1281	1294		1028	
Capacity (c), veh/h		820			830			1220	1232		979	
v/c Ratio (x)		0.08			0.27			0.34	0.23		0.28	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		5.2			7.3			6.2	5.0		6.4	
Lane LOS		A			A			A	A		A	
95% Queue, veh		0.3			1.1			1.6	0.9		1.1	
Approach Delay, s/veh	5.2			7.3			5.7			6.4		
Approach LOS	A			A			A			A		
Intersection Delay, s/veh | LOS	6.1						A					

HCS7 Roundabouts Report

General Information

Analyst	Luke James
Agency or Co.	SRF Consulting Group, Inc.
Date Performed	7/6/2017
Analysis Year	2017
Time Period	P.M. Peak
Project Description	10279

Site Information

Intersection	Lookout Drive at Howard Drive
E/W Street Name	Howard Drive
N/S Street Name	Lookout Drive
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	MAPO

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LT				LTR	
Volume (V), veh/h	0	10	10	65	0	130	15	25	0	35	200	40	0	15	345	5
Percent Heavy Vehicles, %	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Flow Rate (v_{PCE}), pc/h	0	10	10	68	0	136	16	26	0	37	210	42	0	16	362	5
Right-Turn Bypass	None				None				Yielding				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	0				0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)		4.9763			4.9763			4.9763	4.9763		4.9763	
Follow-Up Headway (s)		2.6087			2.6087			2.6087	2.6087		2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		88			178			247	42		383	
Entry Volume veh/h		84			170			235	40		365	
Circulating Flow (v_c), pc/h	514			257			36			189		
Exiting Flow (v_{ex}), pc/h	26			58			246			566		
Capacity (c_{pce}), pc/h		817			1062			1330	1344		1138	
Capacity (c), veh/h		778			1011			1267	1280		1084	
v/c Ratio (x)		0.11			0.17			0.19	0.03		0.34	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		5.7			5.1			4.4	3.1		6.7	
Lane LOS		A			A			A	A		A	
95% Queue, veh		0.4			0.6			0.7	0.1		1.5	
Approach Delay, s/veh	5.7			5.1			4.2			6.7		
Approach LOS	A			A			A			A		
Intersection Delay, s/veh | LOS	5.5						A					

Forecasted Year 2037 Detailed Operational Analysis

All-Way Stop Control

1: Lookout Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.4	0.0	0.4
Denied Del/Veh (s)	0.6	0.3	1.4	0.0	0.8
Total Delay (hr)	0.2	0.9	3.1	1.2	5.3
Total Del/Veh (s)	8.2	11.5	12.2	10.9	11.6
Stop Delay (hr)	0.1	0.7	1.4	0.6	2.8
Stop Del/Veh (s)	5.6	8.7	5.5	5.6	6.1
Total Stops	75	276	581	391	1323
Stop/Veh	1.00	0.99	0.64	1.00	0.80

Intersection: 1: Lookout Drive & Howard Drive

Movement	EB	EB	WB	NB	NB	NB	SB	SB
Directions Served	L	TR	LTR	LT	T	R	LT	TR
Maximum Queue (ft)	36	71	163	235	195	138	136	108
Average Queue (ft)	8	33	75	92	52	32	57	50
95th Queue (ft)	31	60	129	171	117	107	97	86
Link Distance (ft)		960	960	966	966		238	238
Upstream Blk Time (%)								
Queuing Penalty (veh)								
Storage Bay Dist (ft)	250					250		
Storage Blk Time (%)					0			
Queuing Penalty (veh)					0			

1: Lookout Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.1	0.0	0.1
Denied Del/Veh (s)	0.5	0.2	0.6	0.0	0.3
Total Delay (hr)	0.2	0.5	1.0	1.5	3.0
Total Del/Veh (s)	5.3	7.8	9.7	10.2	9.1
Stop Delay (hr)	0.1	0.3	0.3	0.6	1.4
Stop Del/Veh (s)	4.2	5.2	3.5	4.4	4.2
Total Stops	107	210	305	515	1137
Stop/Veh	0.98	0.99	0.85	1.00	0.95

Intersection: 1: Lookout Drive & Howard Drive

Movement	EB	EB	WB	NB	NB	SB	SB
Directions Served	L	TR	LTR	LT	T	LT	TR
Maximum Queue (ft)	56	78	111	98	78	115	119
Average Queue (ft)	11	37	55	52	29	59	58
95th Queue (ft)	39	65	90	81	57	92	98
Link Distance (ft)		960	960	966	966	238	238
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (ft)	250						
Storage Blk Time (%)							
Queuing Penalty (veh)							

Forecasted Year 2037 Detailed Operational Analysis

Traffic Signal Control

1: Lookout Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.4	0.0	0.4
Denied Del/Veh (s)	0.8	0.3	1.4	0.0	0.9
Total Delay (hr)	0.2	1.2	3.0	0.8	5.2
Total Del/Veh (s)	10.9	14.7	11.4	7.8	11.1
Stop Delay (hr)	0.2	0.9	1.4	0.5	3.0
Stop Del/Veh (s)	8.7	11.1	5.4	4.8	6.3
Total Stops	45	206	338	158	747
Stop/Veh	0.66	0.73	0.36	0.41	0.44

Intersection: 1: Lookout Drive & Howard Drive

Movement	EB	EB	WB	NB	NB	NB	SB	SB
Directions Served	L	TR	LTR	LT	T	R	LT	TR
Maximum Queue (ft)	40	74	254	244	190	97	117	121
Average Queue (ft)	8	27	104	108	53	12	58	38
95th Queue (ft)	32	61	189	189	128	57	99	92
Link Distance (ft)		960	960	966	966		238	238
Upstream Blk Time (%)								
Queuing Penalty (veh)								
Storage Bay Dist (ft)	250					250		
Storage Blk Time (%)								
Queuing Penalty (veh)								

1: Lookout Drive & Howard Drive Performance by approach

Approach	EB	WB	NB	SB	All
Denied Delay (hr)	0.0	0.0	0.1	0.0	0.1
Denied Del/Veh (s)	0.7	0.2	0.7	0.0	0.3
Total Delay (hr)	0.2	0.6	1.0	1.1	2.9
Total Del/Veh (s)	6.0	10.4	9.6	7.4	8.5
Stop Delay (hr)	0.1	0.5	0.5	0.6	1.7
Stop Del/Veh (s)	4.9	7.5	5.1	4.1	5.1
Total Stops	67	136	153	204	560
Stop/Veh	0.63	0.63	0.41	0.39	0.46

Intersection: 1: Lookout Drive & Howard Drive

Movement	EB	EB	WB	NB	NB	SB	SB
Directions Served	L	TR	LTR	LT	T	LT	TR
Maximum Queue (ft)	47	81	150	140	92	123	110
Average Queue (ft)	10	34	68	66	21	62	50
95th Queue (ft)	36	66	122	120	60	105	97
Link Distance (ft)		960	960	966	966	238	238
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (ft)	250						
Storage Blk Time (%)							
Queuing Penalty (veh)							

Forecasted Year 2037 Detailed Operational Analysis

Roundabout Control

HCS7 Roundabouts Report

General Information

Analyst	Luke James
Agency or Co.	SRF Consulting Group, Inc.
Date Performed	7/13/2017
Analysis Year	2037
Time Period	A.M. Peak
Project Description	10279

Site Information

Intersection	Lookout Drive at Howard Drive
E/W Street Name	Howard Drive
N/S Street Name	Lookout Drive
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	MAPO

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LT				LTR	
Volume (V), veh/h	0	10	50	15	0	215	20	45	0	110	435	375	0	30	340	5
Percent Heavy Vehicles, %	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Flow Rate (v_{PCE}), pc/h	0	10	52	16	0	226	21	47	0	116	457	394	0	32	357	5
Right-Turn Bypass	None				None				Yielding				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	0				0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)		4.9763			4.9763			4.9763	4.9763		4.9763	
Follow-Up Headway (s)		2.6087			2.6087			2.6087	2.6087		2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		78			294			573	394		394	
Entry Volume veh/h		74			280			546	375		375	
Circulating Flow (v_c), pc/h	615			583			94			363		
Exiting Flow (v_{ex}), pc/h	84			142			514			599		
Capacity (c_{pce}), pc/h		737			761			1254	1267		953	
Capacity (c), veh/h		702			725			1194	1206		908	
v/c Ratio (x)		0.11			0.39			0.46	0.31		0.41	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		6.3			10.0			7.8	5.9		8.8	
Lane LOS		A			A			A	A		A	
95% Queue, veh		0.4			1.8			2.5	1.3		2.1	
Approach Delay, s/veh	6.3			10.0			7.0			8.8		
Approach LOS	A			A			A			A		
Intersection Delay, s/veh | LOS	7.9						A					

HCS7 Roundabouts Report

General Information

Analyst	Luke James
Agency or Co.	SRF Consulting Group, Inc.
Date Performed	7/13/2017
Analysis Year	2037
Time Period	P.M. Peak
Project Description	10279

Site Information

Intersection	Lookout Drive at Howard Drive
E/W Street Name	Howard Drive
N/S Street Name	Lookout Drive
Analysis Time Period (hrs)	0.25
Peak Hour Factor	1.00
Jurisdiction	MAPO

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LT				LTR	
Volume (V), veh/h	0	15	10	85	0	165	15	35	0	50	265	50	0	20	480	10
Percent Heavy Vehicles, %	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Flow Rate (v_{PCE}), pc/h	0	16	10	89	0	173	16	37	0	52	278	52	0	21	504	10
Right-Turn Bypass	None				None				Yielding				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	0				0				0				0			

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway (s)		4.9763			4.9763			4.9763	4.9763		4.9763	
Follow-Up Headway (s)		2.6087			2.6087			2.6087	2.6087		2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		115			226			330	52		535	
Entry Volume veh/h		110			215			314	50		510	
Circulating Flow (v_c), pc/h		698			346			47			241	
Exiting Flow (v_{ex}), pc/h		31			78			331			766	
Capacity (c_{pce}), pc/h		677			970			1315	1337		1079	
Capacity (c), veh/h		645			923			1253	1273		1028	
v/c Ratio (x)		0.17			0.23			0.25	0.04		0.50	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		7.6			6.2			5.1	3.1		9.4	
Lane LOS		A			A			A	A		A	
95% Queue, veh		0.6			0.9			1.0	0.1		2.8	
Approach Delay, s/veh	7.6			6.2			4.8			9.4		
Approach LOS	A			A			A			A		
Intersection Delay, s/veh | LOS	7.3						A					

Detailed Cost Analysis

SRF Consulting Group, Inc. | Engineers Planners Designers

Concept Cost Estimate (based upon 2017 bid price information)

Prepared By: SRF Consulting Group, Inc., Date 7/2017

						Lookout Drive at Howard Drive	
	ITEM DESCRIPTION		UNIT	UNIT PRICE	EST. QUANTITY	EST. AMOUNT
PAVING AND GRADING COSTS							
GrP 1	Excavation - common & subgrade		cu. yd.	$7.00	5,100	$35,700
GrP 2	Granular Subgrade (CV)		cu. yd.	$14.00	3,000	$42,000
GrP 3	County Road Pavement	(1)	sq. yd.	$32.00	6,060	$193,920
GrP 4	Concrete Median	(1)	sq. yd.	$40.00	1,590	$63,600
GrP 5	Walk / Trail	(1)	sq. yd.	$25.00	1,510	$37,750
GrP 6	ADA Pedestrian Curb Ramp		each	$800.00	18	$14,400
GrP 7	Concrete Curb and Gutter		lin. ft.	$12.00	5,250	$63,000
GrP 8	Removals - Pavement		sq. yd.	$2.50	9,770	$24,425
	SUBTOTAL PAVING AND GRADING COSTS:					**$474,795**
DRAINAGE, UTILITIES AND EROSION CONTROL						
Dr 1	Local Utilities - Sanitary Sewers		lin. ft.			
Dr 2	Local Utilities - Watermains		lin. ft.			
Dr 3	Water Quality Ponds		l.s.			
Dr 5	Drainage - urban (10-30%)		30%			$142,000
Dr 6	Turf Establishment & Erosion Control		10%			$47,000
Dr 7	Landscaping					
	SUBTOTAL DRAINAGE, UTILITIES AND EROSION CONTROL					**$189,000**
SIGNAL AND LIGHTING COSTS						
SGL 1	Signals (permanent)		each	$200,000		
SGL 2	At Grade Intersection Lighting (permanent - non signa		each	$10,000	12	$120,000
	SUBTOTAL SIGNAL AND LIGHTING COSTS:					**$120,000**
SIGNING & STRIPING COSTS						
SGN 1	Mainline Signing (C&D)		mile	$20,000	0.3	$6,000
SGN 2	Mainline Striping		mile	$10,000	0.3	$3,000
	SUBTOTAL SIGNING & STRIPING COSTS:					**$9,000**
	SUBTOTAL CONSTRUCTION COSTS:					**$792,795**
MISCELLANEOUS COSTS						
M 1	Mobilization		6%			$48,000
M 2	Non Quantified Minor Items (10% to 30%)		20%			$159,000
M 3	Temporary Pavement & Drainage		2%			$16,000
M 4	Traffic Control		4%			$32,000
	SUBTOTAL MISCELLANEOUS COSTS:					**$255,000**
	ESTIMATED TOTAL CONSTRUCTION COSTS without Contingency:					**$1,047,795**
1	Contingency or "risk" (10% to 30%)		20%			$210,000
	ESTIMATED TOTAL CONSTRUCTION COSTS PLUS CONTINGENCY:					**$1,257,795**

	OTHER PROJECT COSTS:				
	R/W ACQUISITIONS	Lump Sum			
	DESIGN ENG. & CONSTRUCTION ADMIN.	Lump Sum			
	SUBTOTAL OTHER PROJECT COSTS				
	TOTAL PROJECT COST (based upon 2016 bid price information)				**$1,257,795**

	INFLATION COST (CURRENT YR. TO YR. OF OPE	Years	3%		
	TOTAL PROJECT COST (OPENING YEAR DOLLARS)				**$1,257,795**

NOTE: (1) Includes aggregate base class 5.

MAJOR ITEMS NOT INCLUDED:
- Local utilities (sanitary sewer or watermain)
- Water quality ponds or other BMPs
- R/W acquisitions
- Engineering design fees
- Inflation