TH 61 at CSAH 9
Intersection Control Evaluation

Final Report | October 2, 2018

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MINNESOTA DEPARTMENT OF TRANSPORTATION

INTERSECTION CONTROL EVALUATION

for

S.P. 3804-61
TH 61 and CSAH 9

In Two Harbors, Lake County

Program: Safety Capacity **Funding:** Trunk Highway

Projected Letting Date: Estimated Letting 2022

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.

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1.0 Introduction

The Minnesota Department of Transportation (MnDOT) has a programmed year 2022 resurfacing project which could incorporate safety improvements at the Trunk Highway 61 (TH 61) and CSAH 9 intersection in Two Harbors, MN (see **Figure 1**: Project Location). Lake County has expressed concerns about the safety of the intersection to MnDOT, supporting the need to conduct an Intersection Control Evaluation (ICE) at this location to identify the appropriate intersection improvements and/or intersection control device.

1.1 Purpose and Need

Over the past ten years, the TH 61 and CSAH 9 intersection has experienced a noteworthy crash history. While the observed intersection crash rate is similar to the statewide average for a rural through/stop low-volume/high-speed intersection, the crash type of the reported crashes is noticeable. A concerning concentration of right-angle crashes, which is typically the most severe crash type, accounted for 6 of the 7 total crashes at the intersection. Over the past ten years, none of the reported crashes at the intersection resulted in a fatality or involved an incapacitating injury (Type A).

Major infrastructure projects, such as grade separated interchanges or corridor expansion projects, are not programmed for this corridor within the foreseeable future. MnDOT is taking a proactive approach at evaluating and implementing cost-effective safety improvements that can begin to address deficiencies in the near and long-term. Understanding the nature of the intersection safety problem and the need to address potential future traffic operations deficiencies, MnDOT desires an intersection improvement solution that accomplishes the following goals:

- Reduce the frequency of injury crashes
- Maintain the intersection level of service into the future; and
- Retain east/west connectivity

To support MnDOT and Lake County in identifying the appropriate intersection and traffic control improvements that meet the above stated goals, this ICE accomplishes the following:

- Documents the existing geometric, traffic operations, and safety characteristics
- Documents existing year 2018 and horizon year 2040 traffic forecasts based upon study area historical traffic volumes and expected population growth
- Develops and evaluates high-level conceptual alternatives that will improve intersection safety characteristics to a varying degree
- Conducts a traffic operations and safety analysis of each alternative
- Develops a matrix comparing preliminary cost estimates, right of way, and other factors to help determine the most optimal intersection lane geometrics and appropriate level of traffic control
- Identifies preferred intersection alternatives

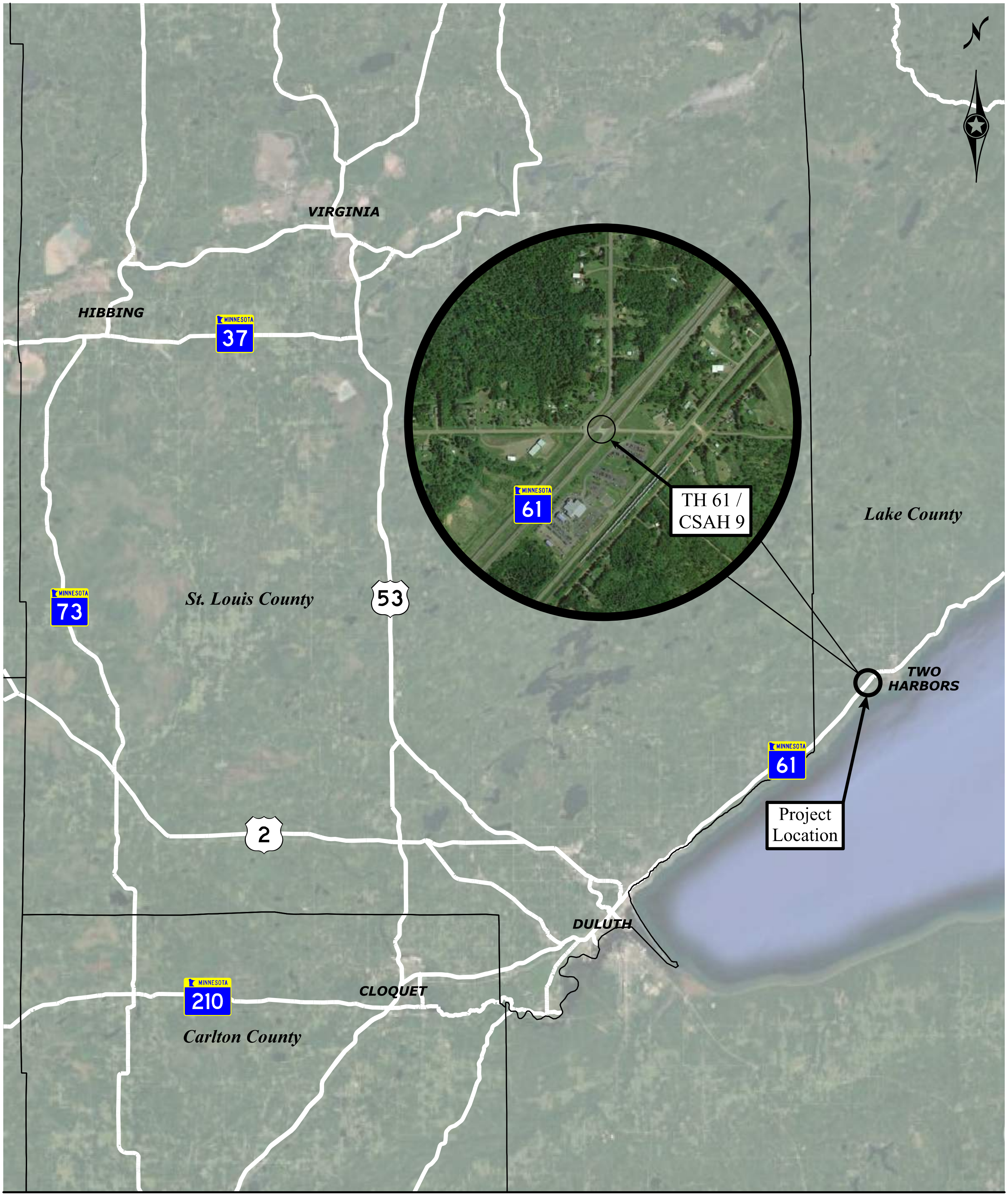
1.2 Description of Location

The proposed roadway geometric and traffic control revisions are located at the intersection of TH 61 and CSAH 9, just south of the city limits of Two Harbors, MN. The immediate surrounding area is low-density residential and commercial, with driveways near the intersection along the east and west intersection legs. The immediate surrounding commercial properties include two car dealerships, a small motel, and a bar and grill. The estimated year 2017 population of Two Harbors is 3,517.

1.3 Elements of Evaluation

The following elements are included in this ICE:

- Existing Conditions (Section 2.0)
- Forecast Conditions (Section 3.0)
- Preliminary Alternatives Analysis (Section 4.0)
- Preferred Alternatives Analysis (Section 5.0)
- Recommendations (Section 6.0)



TH 61 & CSAH 9 ICE - Two Harbors

Figure 1
Project Location

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2.0 Existing Conditions

The following sections document the existing conditions analysis completed for the TH 61 / CSAH 9 intersection.

2.1 Existing Roadway and Traffic Control Characteristics

The existing roadway characteristics are summarized below:

- **TH 61:** TH 61 serves as a principal arterial roadway consisting of a divided four-lane cross-section with shoulders and turn lanes at major intersections. No pedestrian or bicycle facilities exist on TH 61. The posted speed limit on TH 61 transitions from 65 miles per hour (mph) to 55 mph at CSAH 9.
- **CSAH 9 (Stanley Road):** CSAH 9 serves as a minor collector roadway consisting of an undivided two-lane cross-section with a posted speed limit of 50 mph. No pedestrian or bicycle facilities exist on CSAH 9.
- **CSAH 10:** CSAH 10 serves as a minor collector roadway consisting of an undivided two-lane cross-section with a posted speed limit of 45 mph. No pedestrian or bicycle facilities exist on CSAH 10.

Currently, the TH 61 / CSAH 9 intersection is controlled by stop signs on the CSAH 9 approaches as well as yield signs on either side of the median. The intersection of CSAH 9 and CSAH 10 is immediately west of the study intersection and was included in parts of the analysis. Key existing intersection characteristics, including lane geometrics and traffic control, are illustrated in **Figure 2**. The existing traffic volumes, as well as a depiction of vehicle routings through the two intersections, are illustrated in **Figure 3**. There are currently no crosswalk markings provided at the intersection. It should be noted that with the immediate surrounding commercial properties including two car dealerships and a small motel there may a high number of motorists unfamiliar with the area and the intersection.

To determine the estimated seasonal variation along TH 61, daily and monthly traffic data collected at the Weigh-In-Motion (WIM) Station 30 (TH 61, located approximately 9 miles south of the TH 61 / CSAH 9 intersection) was reviewed. The average daily traffic data by month, obtained from WIM Station 30 is plotted in **Figure 4**. The figure also indicates the average annual daily traffic (AADT) and the monthly adjustment factors. Depending on the month in which traffic data is collected, the adjustment factors are used to either increase or decrease the collected volumes to arrive at an average normalized level. As shown, data collected in April is approximately 18% less than the average annual volume. The traffic volume documented in **Figure 3** is based on data collection in April 2018 and adjusted by the monthly factor 1.22 to simulate the annual average (nominal traffic volume).

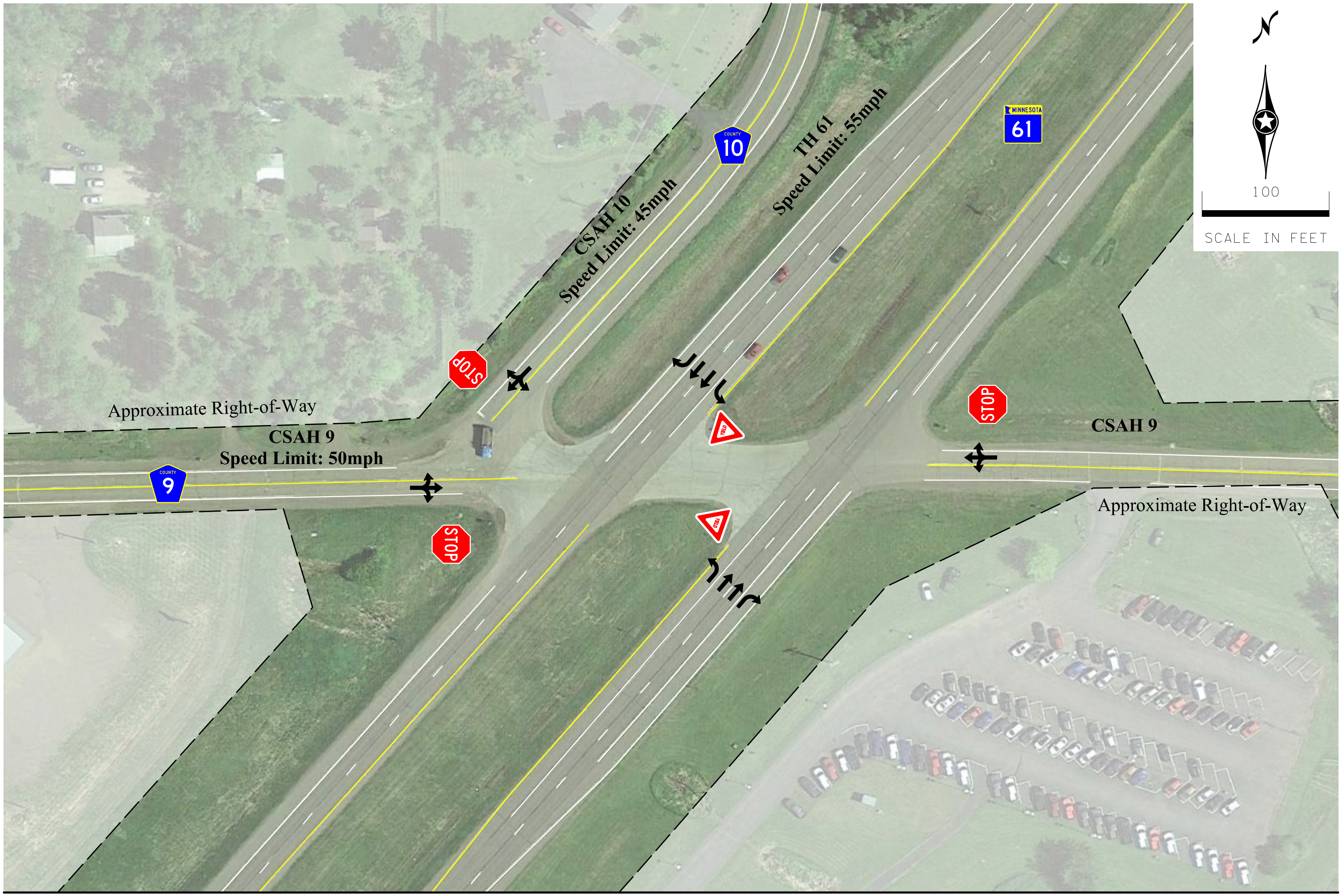

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Figure 2
Existing Geometric Conditions

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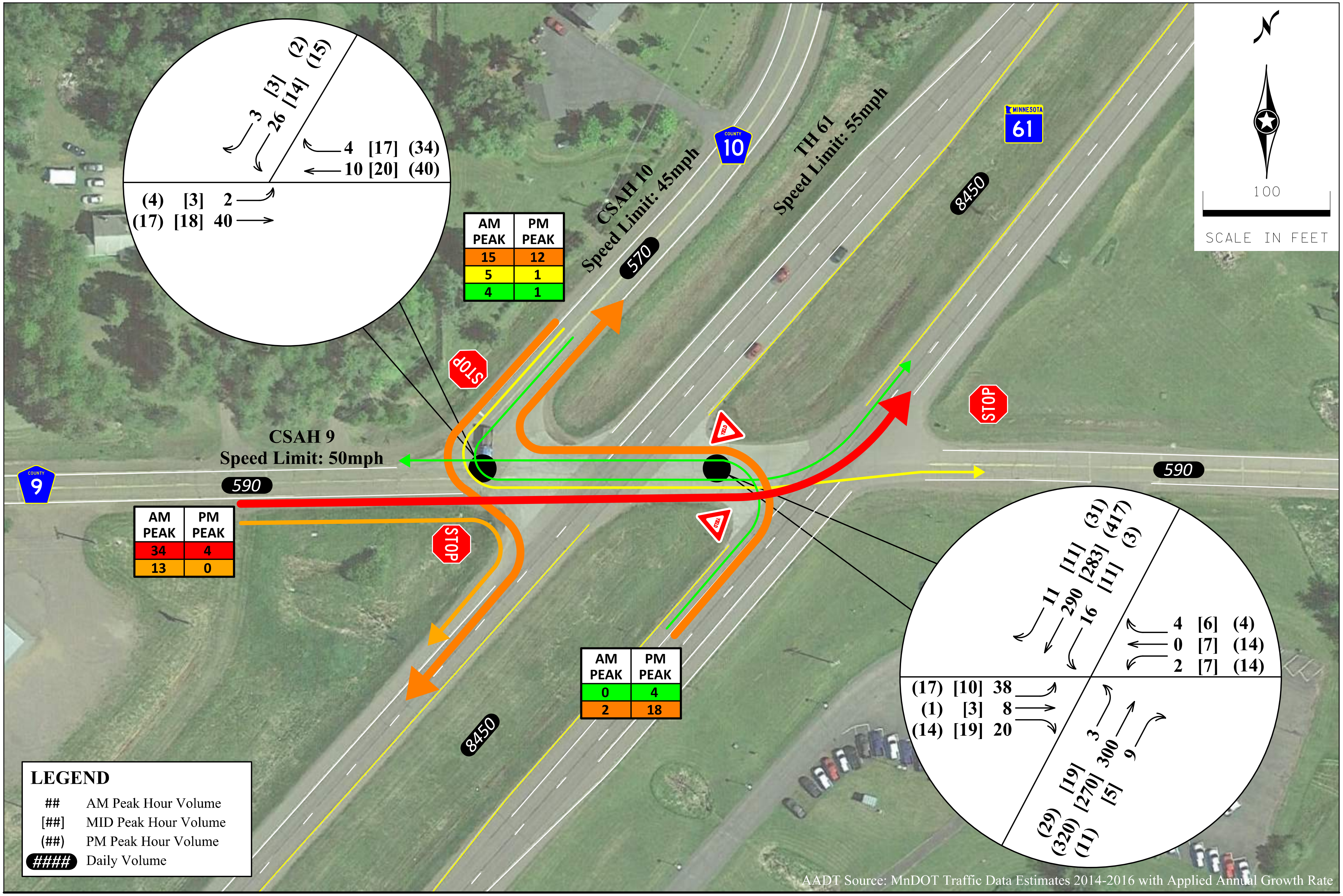

TH 61 & CSAH 9 ICE - Two Harbors

Figure 3

2018 Existing Nominal Traffic Volumes and Vehicle Routing

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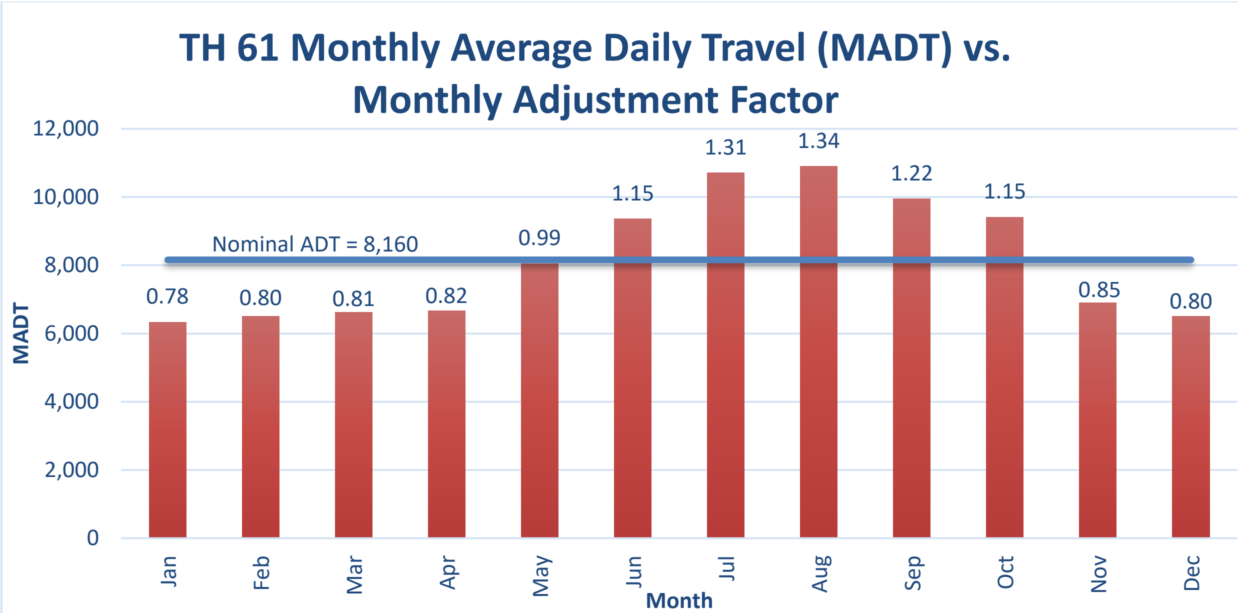


Figure 4. Study Area Monthly ADT and Annual Average (Nominal ADT)

2.2 Right of Way

Approximate right of way and parcel property mapping information was provided by MnDOT. The purpose of documenting approximate right of way is to estimate the cross-sectional width available for infrastructure-related improvements. To the extent feasible, future design alternatives and conceptual layouts were developed within the right of way to minimize environmental, land acquisition, and access impacts. However, where this is not possible, the comparison of the right of way needs between each alternative may serve as a useful decision factor.

2.3 Existing Crash Experience

Historical crash data from the most recent 10 years of data available, 2006 through 2015, was obtained from MnDOT's MnCMAT platform. Detailed police reports of relevant crashes were reviewed to ensure data accuracy. Based on the crash data provided, there were seven reported crashes at the TH 61 / CSAH 9 intersection during the analysis period (see **Figure 6**: Existing Crash Diagram). The crashes are classified into the following types:

- 6 of 7 Crashes (86%) – Right Angle
- 1 of 7 Crashes (14%) – Rear End

A key factor in the safety analysis is the intersection crash rate. The crash rate for any intersection is defined as the number of crashes occurring per million entering vehicles (MEV). **Table 1** summarizes the observed intersection crash rate compared to the statewide average for similar traffic control types.

Crash occurrence is somewhat random by nature. Identifying every intersection with a crash rate above the statewide average value in an analysis would produce a large amount of data that may not be statistically relevant with respect to safety deficiencies. The critical crash rate identifies those locations that have a crash rate higher than similar facilities by a statistically significant amount. The critical crash rate is calculated by adjusting the systemwide average based on the amount of exposure and a statistical constant indicating level of confidence[1]. At locations where the observed crash rate exceeds the critical crash rate, it is 99 percent certain that an intersection design deficiency exists, or there are hazardous characteristics present at the location. Critical severity rate and critical K/A rate (combination of Type K (Fatal) and Type A (Incapacitating Injury) crashes) in **Table 1** are also based on the same statistical method but with lower confidence level of 80% as a more conservative cut-off for significance.

It should be noted that while the observed intersection crash rate (0.23 crashes/MEV) is similar to the statewide average for a rural through/stop low-volume/high-speed intersection (0.27 crashes/MEV) and much lower than the corresponding critical crash rate (0.53 crashes/MEV), the unique characteristics of these crashes present an opportunity for crash reduction if an alternative exists to effectively mitigate these particular right-angle crashes.

[1] MnDOT Traffic Safety Fundamentals Handbook, August 2015.

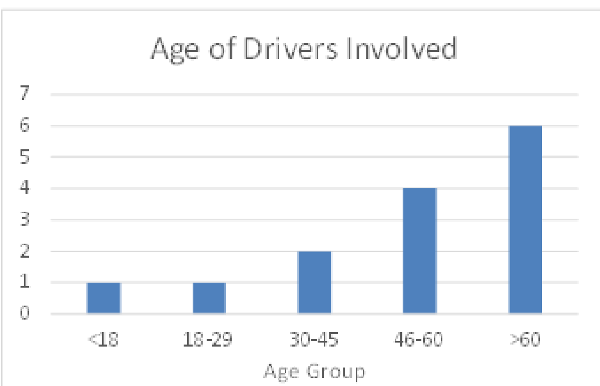
Table 1. Crash Rate Summary (2006– 2015)

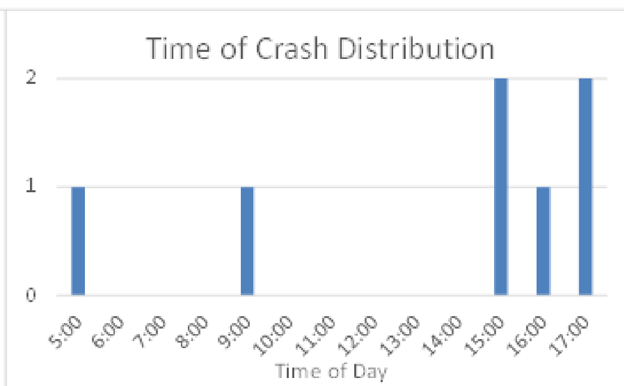
Key Characteristics		Summary of Intersection Crash Rates			
Intersection	TH 61 & CSAH 9	Rate Category (per MEV)	Crash Rate	Severity Rate[3]	K/A Rate
Traffic Control	Rural Through-Stop	Intersection	0.23	0.45	0.00
Total Crashes[1]	7	State Average[4]	0.27	0.43	1.14
Total Entering Volume[2]	30,922,226	Critical[5]	0.53	0.60	5.22
K/A Crashes	0	Issue?	NO	NO	NO

[1] Crash Data obtained from MnCMAT and detailed police crash reports.
[2] AADT obtained from MnDOT Traffic Data Map
[3] Severity rate factors: 5 for Fatal Crashes, 4 for A type, 3 for B type, 2 for C type, and 1 for Property Damage Crashes
[4] MnDOT's 2015 Green Sheets were used to determine the State average crash rate.
[5] Critical crash rate is a statistically adjusted crash rate to account for random nature of crashes - 99% confidence level assumed for critical crash rate and 80% confidence level assumed for critical severity and critical K/A rate.

Reviews of detailed police reports revealed that six out of the seven crashes were right-angle. All right-angle crashes involved side-street (CSAH 9) crossing vehicles and mainline (TH 61) through vehicles on the far-side of the 2-stage crossing. It is likely that these side street vehicle drivers underestimated the need to exam conflicting traffic again at the second stage of the crossing and/or the skewed angle of approach made viewing oncoming motorists more difficult.

Furthermore, drivers involved in crashes are heavily skewed towards older age, and most crashes happened around the PM peak hour (the highest peak), as shown by the breakdown below:

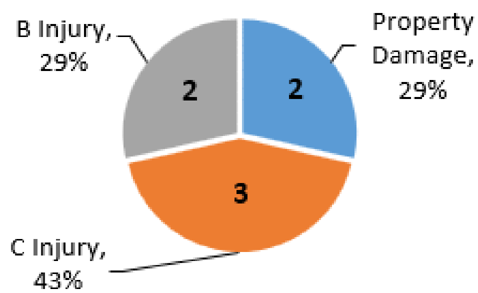




There may be a correlation between the intersection skew and two-stage crossing that caused challenges for elderly drivers choosing appropriate traffic gaps during the time of day with highest traffic volumes.

2.3.1 Crash Severity

Although the number of reported crashes would not be considered statistically significant, it is worth investigating the severity of reported crashes. At the TH 61 / CSAH 9 intersection, five out of the seven reported crashes resulted in injury, while two were property damage only crashes. The reported crash severity types are illustrated to the right:



Crashes are categorized into five (5) types:

- Fatal (Type K)
- Incapacitating Injury (Type A)
- Non-Incapacitating Injury (Type B)
- Possible Injury (Type C)
- Property Damage Only (Type PDO)

Crash severity quantifies how severe the crashes are at a specific location. The purpose for analyzing this statistic is to identify locations that experience a low crash rate but have a high percentage of injury or fatal crashes. Conversely, locations which have high crash rates and a large proportion of property damage crashes may not warrant as much priority when deficiencies are being addressed. It should be noted that the observed intersection crash severity rate (0.45) is above the statewide average for a rural through/stop intersection (0.43), but less than the critical rate (0.60). The observed intersection K/A rate (0.00) is lower than the statewide average for a rural through/stop intersection (1.14) and the corresponding critical K/A rate (5.22) as no fatalities or Type A crashes were reported.

The reported crashes are summarized by severity and type in **Figure 5**.

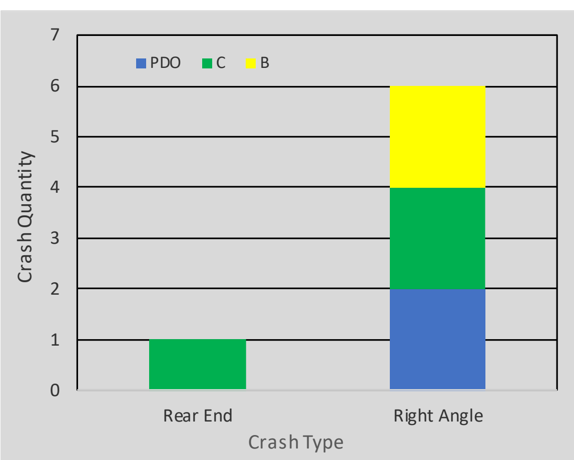


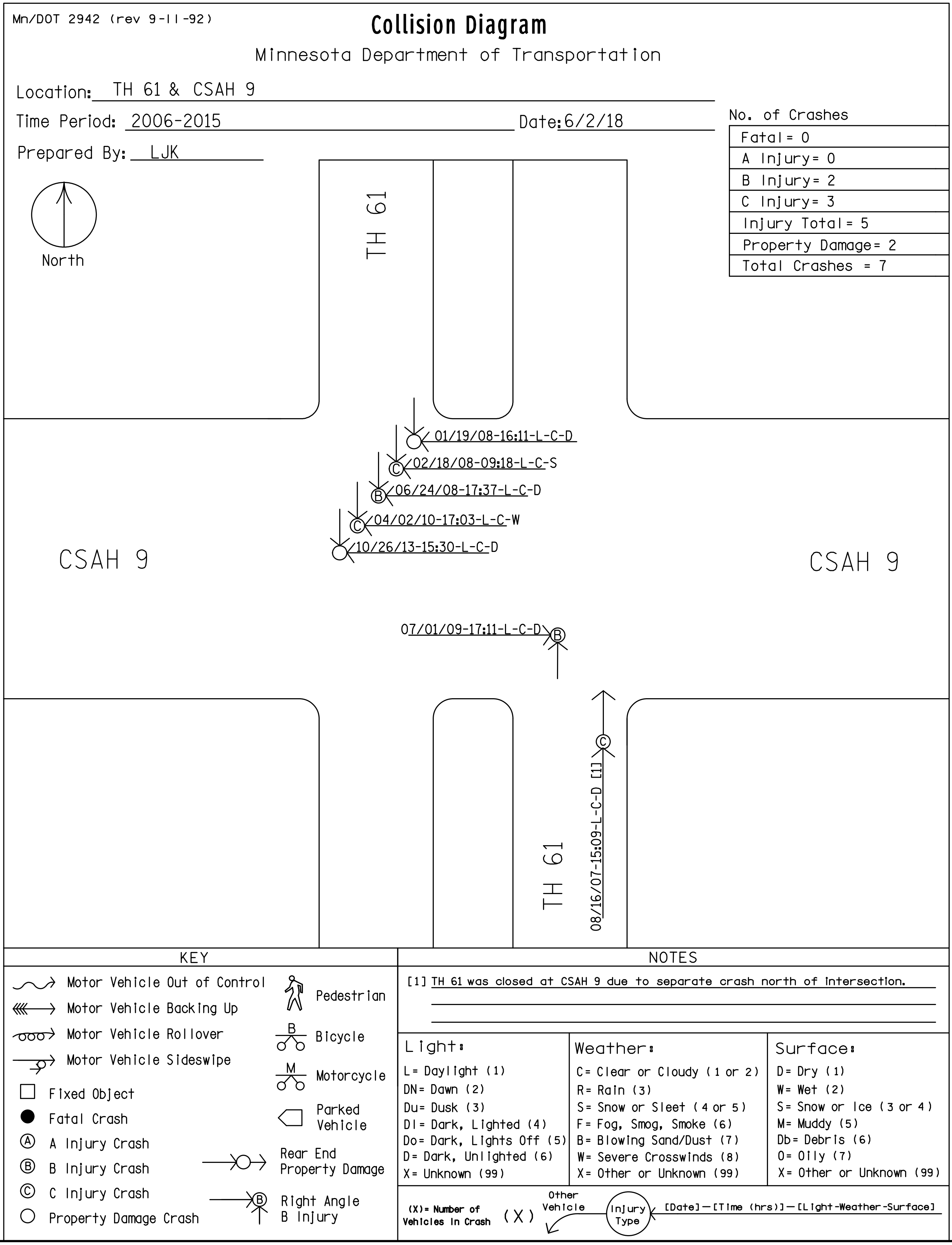
Figure 5. Existing Crashes by Severity and Type

2.3.2 Crash Analysis Conclusions

Based on the analysis of the existing intersection characteristics and crash experience, the following preliminary conclusions are made:

- The TH 61 / CSAH 9 intersection has experienced only seven crashes over the past ten years. Out of these crashes there were zero fatalities and five possible injuries. The overall intersection crash rate is below the average state rate[2] and the critical crash rate.
- The most common type of crash was right-angle, accounting for six of the seven crashes (86 percent). This is greatly over represented at this location compared to typical rural expressway intersections (statewide average right-angle related crash representation is 30 percent).
- Of the crashes, a majority occurred in clear conditions in dry weather. Therefore, weather does not appear to be significant factor.
- A thorough review of the contributing factors was completed. The evaluation does not conclude on a single cause contributing to the excessive right-angle crashes; however, the skewed approach angles and the 2-stage crossing are suspected to play a contributing role, especially among the elderly driving population.
- While a single factor does not appear to be the source of the safety deficiency, a combination of several characteristics may be contributing to the high rate of right angle related crashes, including:
  - **Traffic volume level** – Most right angle-related crashes occurred during the PM peak period for traffic volume level (between 3 and 6 PM). This may be leading to motorists accepting less than ideal traffic gaps or taking greater chances.
  - **The center median interaction –** In order to cross the divided highway, motorists are trying to fit within the median to make eastbound/westbound movements and left turns onto TH 61. This median only has adequate space for one or two motorists at a time. Motorists are required to look over their shoulder (negative angle) when crossing the far side approach.
  - **Motorist Age** – As noted in the data, a notable number of drivers involved in crashes at this location are over the age of 60. Reduced ability to thoroughly exam over their shoulder (negative angle) can limit stopped motorists from being able to clearly discern which lane the approaching motorist is traveling in, their actual travel speed, and acceptable gaps.
  - **High speed roadway** – The high-speed approach may be a factor with elderly motorists not being able to select an acceptable traffic gap. Furthermore, MnDOT is currently re-evaluating the speed zones along TH 61 as they transition from 65 mph just south of the intersection to 55 mph just north of the intersection.

[2] MnDOT 2015 Green Sheet



TH 61 & CSAH 9 ICE - Two Harbors

Figure 6
Existing Crash Diagram

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3.0 Forecast Traffic Volumes

Increases in vehicle traffic resulting from regional infrastructure, regional connectivity, and demographic changes will influence the long-term operation of the TH 61 / CSAH 9 intersection. This ICE studied intersection geometric and traffic control needs based upon the forecast year 2040 design horizon. It should be noted that based on MnDOT direction, 2018 was selected as the initial forecast year (or current year) even with a potential project construction year of 2022.

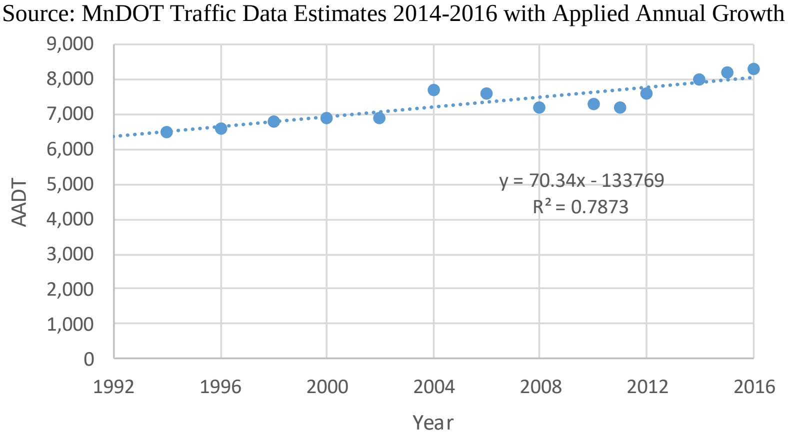
3.1 AADT and Traffic Forecasts

A review of historical average annual daily traffic (AADT) volumes along TH 61 within the study area indicates increasing traffic over a 20-year period (see **Figure 7**). A regression analysis was completed based upon the historical growth trend. Consequently, an annual growth rate of 0.9 percent per year was applied to existing traffic volumes to provide a conservative estimate of future conditions. **Table 2** illustrates the existing and forecast year 2040 AADT.

Table 2. Existing and Forecast Year 2040 Average Annual Daily Traffic

Roadway	AADT	
	2018	2040
TH 61 (NB Approach)	8450	10400
TH 61 (SB Approach)	8450	10400
CSAH 9 (WB Approach)	590	700
CSAH 9 (EB Approach)	590	700

Source: MnDOT Traffic Data Estimates 2014-2016 with Applied Annual Growth Rate

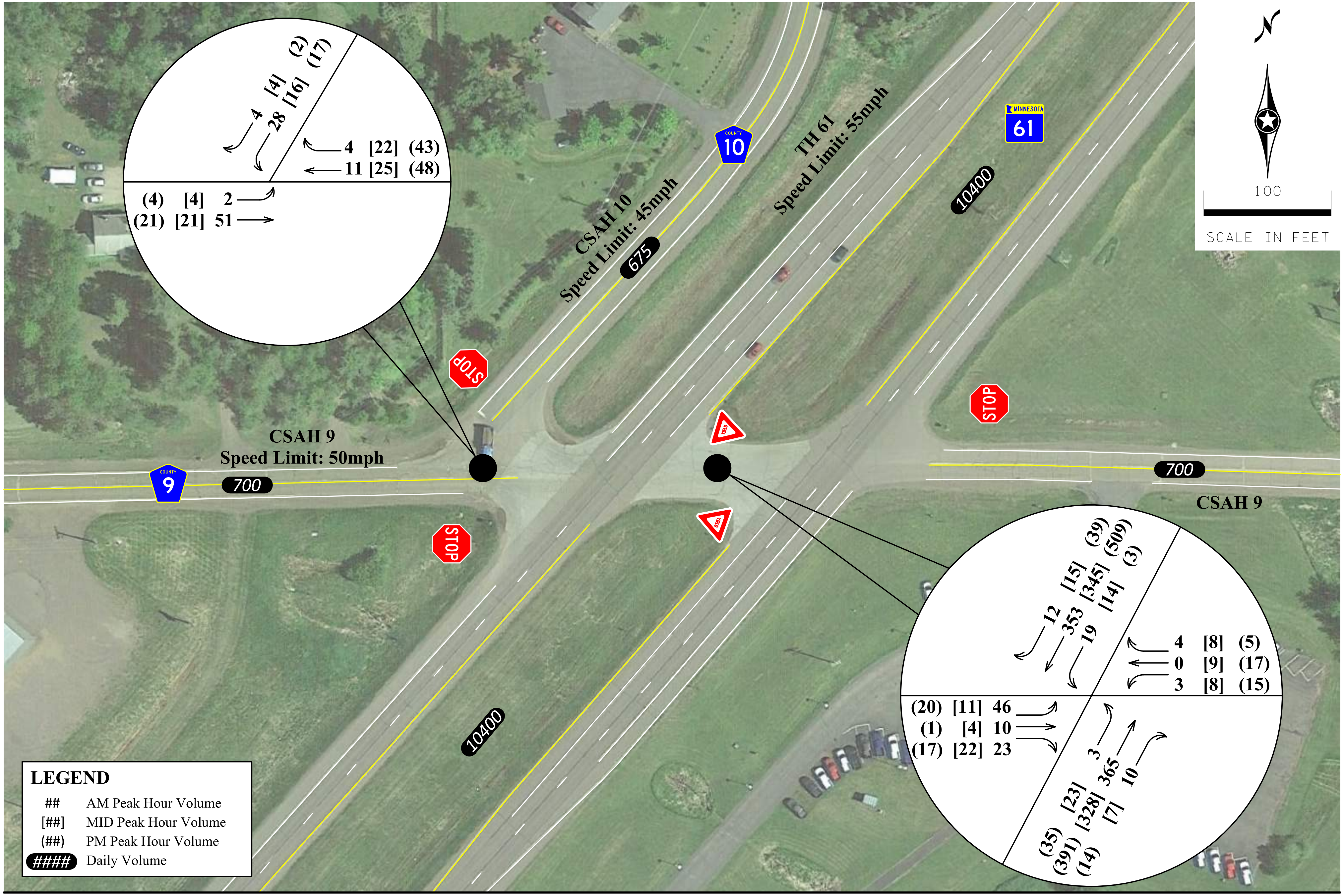


Source: MnDOT Traffic Forecasting & Analysis

Figure 7. TH 61 Historical AADT

3.2 Forecast Peak Hour Traffic Volumes

Forecast a.m., midday, and p.m. peak hour intersection turning movement volumes were developed with the 0.9 percent per year growth rate. The resultant forecasted year 2040 traffic volumes are shown in **Figure 8**. It should be noted that at the time of this ICE there are no known planned developments or programmed infrastructure improvements in the vicinity that could influence future traffic volumes at the study intersection.



TH 61 & CSAH 9 ICE - Two Harbors

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Figure 8
Forecasted Year 2040 Traffic Volumes

4.0 Preliminary Alternatives Analysis

To address existing intersection crash severity issues and to preserve traffic mobility, a preliminary alternatives analysis was completed. The goals of the preliminary alternatives analysis are to identify engineering considerations, expected traffic operations and safety impacts, as well as select preferred alternatives. Key elements of the preliminary alternatives analysis include:

- Identification of preliminary alternatives
- Analysis of potential safety benefits
- Assessment of traffic operations for each alternative
- Selection of preferred alternatives

4.1 Traffic Control Devices

Several forms of traffic control and geometric improvements were considered at a high-level for implementation at the TH 61 / CSAH 9 intersection: signalization, roundabout, a traditional through/stop-controlled intersection with an alignment improvement, and various configurations of reduced-conflict intersection (RCI) design. The following summary provides the high-level pros and cons of the preliminary traffic control alternatives:

- A traffic signal would require intersection retrofit and the installation of the signal system. It is expected to increase the overall crash frequency (increase in specific crash types such as rear-end). A traffic signal system may reduce right-angle crashes, but it will not eliminate these crash occurrences. If a traffic signal system is not warranted by traffic demands, it will cause extra traffic delay compared to stop sign controls. The true cost of a signal system involves a minimum of initial construction, ongoing maintenance, and electricity.
- Traditional stop-controlled intersection with geometric changes would require full intersection reconstruction. Cost and safety improvements will vary depending on proposed changes to the existing infrastructure and right of way acquisition. A modified traditional intersection is not expected to provide any operational benefit, but with the right geometric and operational changes, may achieve some safety improvement.
- Reduced-conflict intersections (RCI) would require reconfiguration of left turn and through lanes on side-street and addition of U-turn lanes at mainline medians. Additional stop/yield controls are required at the U-turns while mainline turn lanes at the original intersection will need to be reconstructed. RCI bears increased travel time for left-turn and through maneuvers from the side street, and requires public education, but will effectively reduce right-angle crashes and may improve operation efficiency.
- A roundabout would require full intersection reconstruction with higher initial construction cost. Right of way acquisition may be necessary. Overall, a roundabout is expected to provide high intersection safety performance (minimizes the potential for severe crashes) and with optimal lane configurations provides efficient traffic operations with the low motorist delay during all time periods of the day.

4.2 Signal Warrant Analysis

A signal warrant analysis was completed for the TH 61 / CSAH 9 intersection under existing and forecasted year 2040 traffic volumes. The warrant analysis was conducted in accordance with the *Minnesota Manual on Uniform Traffic Control Devices* (MnMUTCD)[3]. The following signal warrants were considered:

- W1 – Eight-Hour Vehicular Volume
- W2 – Four-Hour Vehicular Volume
- W3 – Peak Hour
- W4 – Pedestrian Volume
- W5 – School Crossing
- W6 – Coordinated Signal System
- W7 – Crash Experience
- W8 – Roadway Network
- W9 – Intersection Near a Grade Crossing

Warrant 1, Warrant 2, and Warrant 3 were reviewed under existing and forecasted traffic volumes. Warrant 7 was reviewed using historical crash data. The remaining traffic signal warrants are not applicable at the TH 61 / CSAH 9 intersection, or minimum warrant standards are not met. **Table 3** presents a summary of the MnMUTCD signal warrant analysis results. The right-turn volumes on the minor street approaches were not included in the warrant analysis based upon recommended procedures documented in MnDOT Technical Memorandum 13-05-T-02[4]. The detailed signal warrant analysis results are included in **Appendix A**.

Table 3. Signal Warrant Analysis Summary

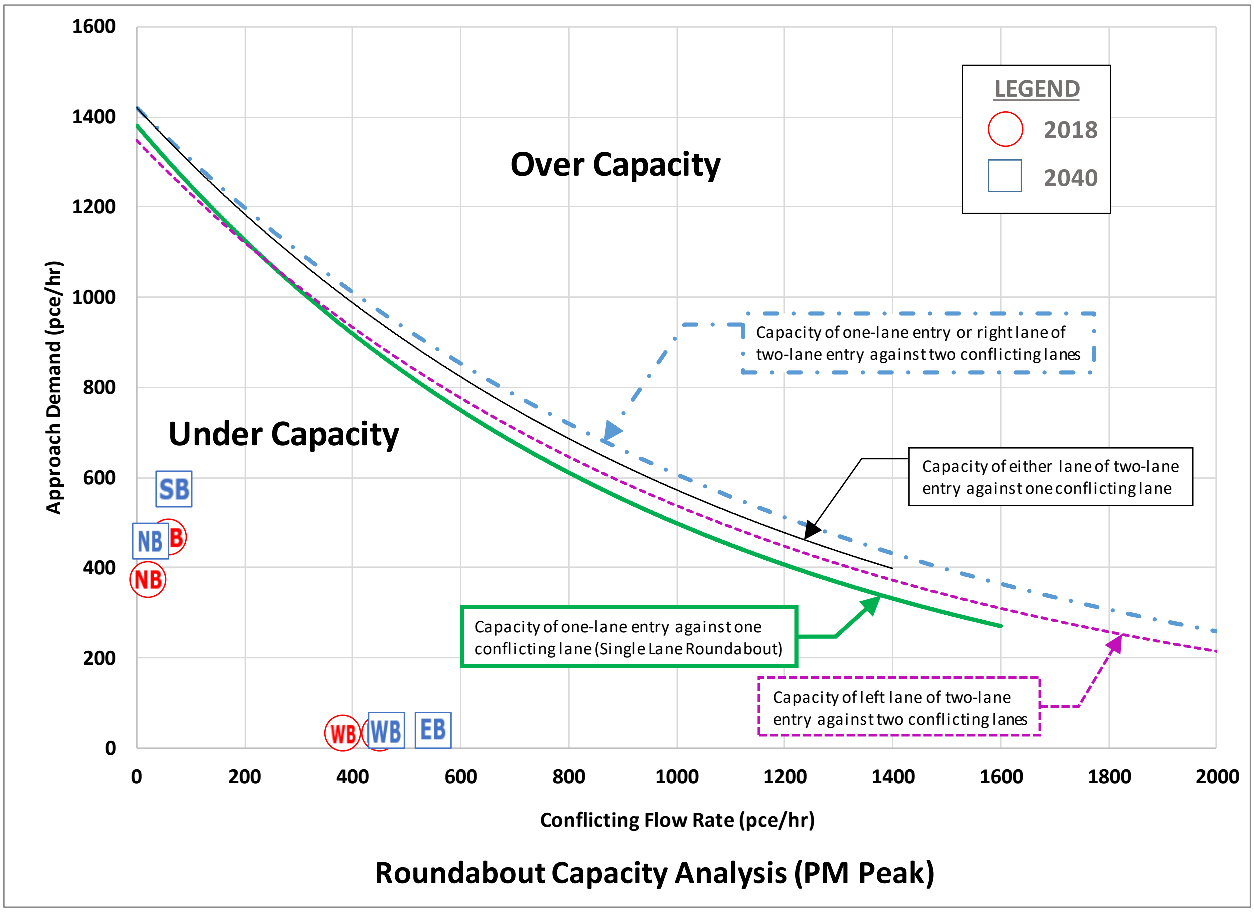
Scenario	Warrant 1 - Eight-Hour Vehicular Volume				Warrant 2 - Four-Hour Vehicular Volume		Warrant 3 - Peak Hour		Warrant 7 - Crash Experience	
	1A (Hours Met)	1B (Hours Met)	1C (Hours Met)	Warrant Met?	Hours Met	Warrant Met?	3B (Hours Met)	Warrant Met?	(Relevant Crash)	Warrant Met?
Existing Conditions	0	0	0	No	0	No	0	No	3	No
Year 2040 Conditions	0	1	0	No	0	No	0	No	3	No

Results of the signal warrant analysis indicate that no signal warrants are met under existing or 2040 conditions. Therefore, a traffic signal system was not considered any further in the ICE.

[3] Minnesota Manual on Uniform Traffic Control Devices, February 2015
[4] Technical Memorandum 13-05-T-02, MnDOT Engineering Services, Intersection Control Evaluation, 2013

4.3 Roundabout Capacity Analysis

A planning-level roundabout capacity analysis was completed for the TH 61 / CSAH 9 intersection under existing year 2018 and forecasted year 2040 traffic volumes. The analysis was conducted in accordance with the *Highway Capacity Manual* (HCM)[5]. The purpose of the analysis was to determine whether a roundabout would be a suitable alternative for the intersection under forecasted year 2040 traffic volumes. Results of the planning-level roundabout capacity analysis under 2018 and 2040 PM peak hour volumes, shown in **Figure 9,** indicate that a single-lane roundabout is expected to accommodate forecasted year 2018 and 2040 traffic volumes. The detailed roundabout capacity analysis results are included in **Appendix B**.



Source: Highway Capacity Manual, 6th Edition, Chapter 22 Roundabouts

Figure 9. Planning Level Roundabout Capacity Analysis

[5] Highway Capacity Manual, 6th Edition, Transportation Research Board

4.4 Preliminary Intersection Alternatives

Six alternatives in addition to the no build alternative were identified for preliminary evaluation:

- **No-Build**: A continuation of the existing intersection geometry and through-stop control.
- **Alternative 1 – Traditional Intersection w/ Realignment**: Re-alignment of CSAH 9 and CSAH 10 to provide perpendicular intersection with TH 61. In addition, the CSAH 9 and CSAH 10 alignments would create a new through road, which then 'T' into TH 61 to create a traditional intersection. New stop signs will be on the new through road to prevent repetitive stopping to/from TH 61.
- **Alternatives 2-4 – Reduced Conflict Intersections (RCI)**:
    - **Alternative 2 – Reduced Conflict Intersections (RCI)**: Re-routed CSAH 9 left and through movements to right-turn and U-turn. The existing roadway alignment will generally be maintained.
    - **Alternative 3 – RCI w/ Re-alignment**: Re-routed CSAH 9 left and through movements to right-turn and U-turn. It also re-aligns CSAH 9 and CSAH 10 to form a new through road with perpendicular side-street access (similar to Alternative 1). New stop signs will be on the new through road to prevent repetitive stopping to/from TH 61.
    - **Alternative 4 – RCI w/ Offset T**: Re-routed TH 61 left and CSAH 9 left and through movements to right-turn and U-turn. It perpendicularly and individually connects CSAH 9 (west and east legs) and CSAH 10 with TH 61. The existing connection between CSAH 9 and CSAH 10 will be downgraded to driveway with improved access angle.
- **Alternatives 5-6 – Roundabouts**:
    - **Alternative 5 – 2x1 Roundabout**: Full reconstruction of a 2-by-1 roundabout with 2-lanes maintained along TH 61. CSAH 9 and CSAH 10 are connected to form a new through road and they share one leg of the roundabout for TH 61 access. New stop signs will be on the new through road to prevent repetitive stopping to/from TH 61.
    - **Alternative 6 – 2x1 Roundabout with U-turn**: Full reconstruction of a 2-by-1 three-leg roundabout with 2-lanes maintained along TH 61. CSAH 10 will be re-aligned and 'T' into CSAH 9 that 'T' into TH 61 for a right-in-right-out access. A U-turn lane is added south of that access to accommodate left turn and through movements from/to CSAH 9 (west leg). A direct left turn from northbound TH 61 to CSAH 9 is allowed.

These alternatives are expected to experience low and similar traffic delay due to the low volume in both existing and forecast years. Therefore, detailed traffic operation analysis is only performed for the selected preferred alternatives (Section 5). However, detailed safety analysis is documented below for preliminary alternative comparison.

4.5 Safety Analysis

A goal of improving the TH 61 / CSAH 9 intersection is to reduce the frequency of severe crashes. A detailed safety analysis was completed to help understand the anticipated level of improvement with each preliminary alternative. The safety analysis includes investigating the change in crash types and/or the elimination in certain types of crashes and computing a monetary annual crash cost for each preliminary alternative.

Anticipated future traditional intersection crashes were estimated utilizing crash reduction factors (i.e. intersection skew correction) in the *Crash Modification Factors Clearinghouse*[6]. Anticipated future RCI crashes were estimated utilizing *A Study of the Traffic Safety at Reduced Conflict Intersections in Minnesota*[7]. This study revealed significant reductions in right-angle crashes and increases in rear-end and sideswipe crashes upon conversion of traditional intersections to RCIs. Anticipated future roundabout crashes were estimated utilizing *A Study of the Traffic Safety at Single-Lane Roundabouts in Minnesota*[8]. This study revealed significant reductions in severe crashes upon conversion of traditional intersections to roundabout control. **Table 4** summarizes the safety analysis while detailed results are included in **Appendix C**.

Table 4. Safety Analysis Summary

	ALT 0	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6
	No-Build	Traditional Intersection w/ Realignment	Reduced Conflict Intersection (RCI)			Roundabout	
			RCI	RCI w/ Realignment	RCI w/ Offset T	2x1	2x1 w/ U-Turn
Observed/Estimated Crash Rate (Crashes/MEV)	0.23	0.18	0.11	0.11	0.11	0.76	0.76
Observed/Estimated Injury Crashes (Percent of Total Crashes)	71.4%	72.3%	35.2%	35.2%	35.2%	18.5%	18.5%
2042 Estimated Crash Cost (2018 Dollars)	$82,134	$63,912	$20,420	$20,420	$20,420	$80,182	$80,493

Key conclusions of the safety analysis include the following:

- Alternative 1 – Traditional Intersection w/ Realignment allows moderate crash reduction due to the correction of skewed crossing. However, since most majority of the right-angle crashes are due to the two-stage crossing, the crash reduction is not significant.
- Alternative 2-4 – Reduced Conflict Intersections (RCI) significantly reduced far-side right-angle crashes by re-routing the side-street left/through movements to right-turn and U-turn. Since right-angle is the prevailing crash type at this location, the overall intersection crash cost of these alternatives is significantly improved. Additional features (re-alignment of CSAH 9 and CSAH 10 or offset T connections) among RCI alternatives do not noticeably contribute to the crash cost calculation.

[6] FHWA Crash Modification Factors Clearinghouse.
[7] A Study of the Traffic Safety at Reduced Conflict Intersections in Minnesota, MnDOT. May 23, 2017
[8] A Study of the Traffic Safety at Roundabouts in Minnesota, MnDOT. October 30, 2017

- Alternative 5 – 2x1 Roundabout provides a similar crash cost compared to the No Build condition. Although the crash severity is significantly reduced, the crash rate is expected to be much higher compared to other alternatives and No Build conditions.
- Alternative 6 – 2x1 Roundabout with U-turn inherits most of safety benefits of Alternative 5. Due to the existence of the right-in-right-out intersection and direct northbound left turn lane south of the roundabout, the crash cost of this alternative is slightly higher than that of Alternative 5.

Overall, Alternative 2-4 RCIs are expected to experience the most crash cost reduction from the No Build condition.

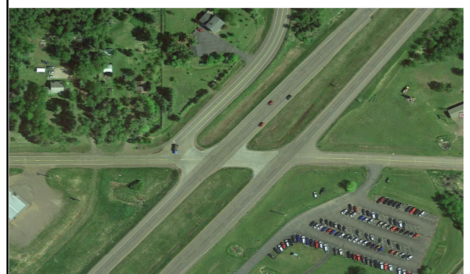
4.6 Preliminary Comparison Matrix

A comparison matrix summarizing the key decision factors with respect to project goals is provided in **Table 5**. The key decision factors include:

- **Pros and Cons** – Qualitative assessment of key advantages and disadvantages of the preliminary intersection alternatives
- **Safety Evaluation** – Assessment of expected impact on motorist safety and to the degree to which the existing safety deficiency is improved
- **Operation Evaluation** – Documentation of anticipated future traffic operations

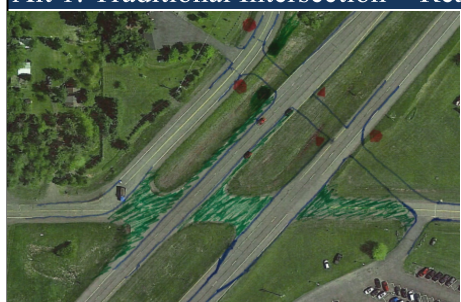
Table 5. Preliminary Alternatives Screening

No Build



Description	Pros and Cons	Safety Evaluation	Operation Evaluation
The "No Build" scenario carries the current geometry and traffic control (thru-stop) under the forecast year traffic volume.	**Pros:** 1. No construction cost 2. No need to educate the public for new traffic control **Cons:** 1. No improvement to the known safety concerns 2. No improvement to the skewed side street access 3. No Improvement to the close spacing of intersections 4. Potential R/W acquisition needed. Further review is needed.	**(Fully or partially) Addressed known safety issues:** None **Unaddressed known safety issues:** 1. Right angle crashes between side street thru and mainline (6 of the 7 total crashes). 6 of the 6 occurred on the far side of the intersection. 2. Right-angle crashes may due in part to the intersection skew **Potential new safety issues:** None Estimated **Crash Rate / Injury Rate: 0.23 / 71.4%** **Estimated 2040 Crash Cost (2018 Dollars): $82,134**	No operation issue identified - intersection expected to operate at LOS A or B with 2040 traffic demand.

Alt 1: Traditional Intersection + Realignment



Description	Pros and Cons	Safety Evaluation	Operation Evaluation
This alternative re-aligns CSAH 9 and 10 to create a new thru road, which then T into TH 61 to create a traditional intersection. New stop signs will be on the new thru road to prevent excessive stopping to/from TH 61. CSAH 9 east of the intersection is also re-aligned.	**Pros:** 1. Minimal construction cost 2. No need to educate the public for new traffic control 3. Some improvement to right angle crashes due to the perpendicular access **Cons:** 1. No improvement to other known safety concerns. 2. Would realign the CSAH 10 intersection in close proximity to an existing residential driveway. 3. Does not fully address the far side right angle crash occurrences	**(Fully or partially) Addressed known safety issues:** 1. Some right-angle crashes due to the intersection skew may be reduced **Unaddressed known safety issues:** 1. Right angle crashes between side street thru and mainline especially on the far side of intersection are not fully addressed with traditional intersection design **Potential new safety issues:** None **Crash Rate / Injury Rate: 0.18 / 72.3%** **Estimated 2040 Crash Cost (2018 Dollars): $63,912**	No operation issue identified - intersection LOS is expected to be similar to No Build.

Alt 2: Reduced Conflict Intersection (RCI)

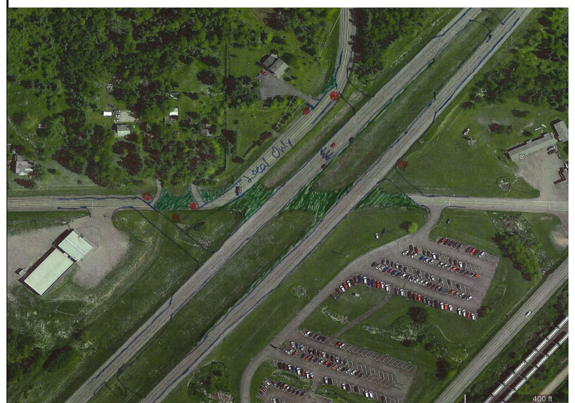
Description	Pros and Cons	Safety Evaluation	Operation Evaluation
This alternative creates an RCI intersection that re-routes CSAH 9 left and thru movements to right-turn and U-turn. The existing roadway alignment will generally be maintained.	**Pros:** 1. Only requires median construction, no R/W 2. Reduces severity of crashes and specifically addresses the far side right angle crashes **Cons:** 1. No improvement to the skewed side street access 2. No Improvement to the close spacing of frontage road intersections 3. Diverts motorist (adds motorist travel time for certain movements) and may have negative public perception 4. Side-swipe crashes may increase due to the re-route 5. The westbound roadway profile is much higher than the eastbound direction, which may cause grade challenges at the U-turn locations.	**Highlight:** RCI decreases right-angle crashes, the prevailing crash type currently at this intersection, while increase the changes of other crash types. **(Fully or partially) Addressed known safety issues:** 1. Right angle crashes between side street thru and mainline especially on the far side of intersection are expected to be specifically addressed **Unaddressed known safety issues:** 1. Some right-angle crashes due to the intersection skew **Potential new safety issues:** Increase of sideswipe and rear/end related crashes associated with lane changes associated with U-turn Expected C**rash Rate / Injury Rate: 0.11 / 35.2%** **Estimated 2040 Crash Cost (2018 Dollars): $20,420**	No operation issue identified - intersection LOS is expected to be similar to No Build. Re-route is expected to have minimal impact to overall traffic operation due to the minimum number of traffic being affected, though specific movements will have a longer travel time.

Alt 3: RCI + Realignment

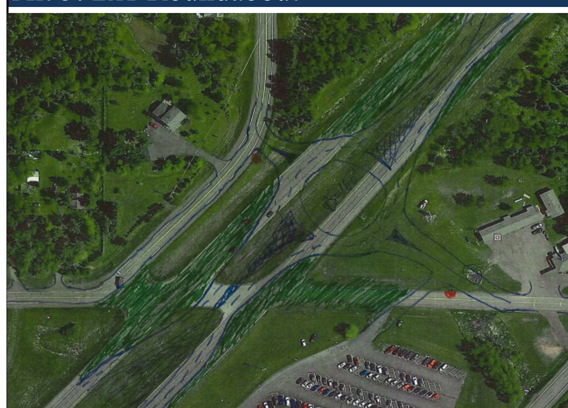
Description	Pros and Cons	Safety Evaluation	Operation Evaluation
This alternative creates an RCI intersection that re-routes side street left and thru movements to right-turn and U-turn. It also re-aligns CSAH 9 & 10 to form a new thru road with perpendicular side-street access (similar to Alt 1). New stop signs will be on the new thru road to prevent excessive stopping to/from TH 61.	Pros: 1. Only requires median construction, no R/W 2. Reduces severity of crashes and specifically addresses the far side right angle crashes 3. Reduces conflicts with the realigned frontage road access. 4. Addresses the skewed left turn movement alignment Cons: 1. Places primary frontage road access in close proximity to a residential driveway 2. Diverts motorist (adds motorist travel time for certain movements) and may have negative public perception 3. Side-swipe crashes may increase due to the re-route 4. The westbound roadway profile is much higher than the eastbound direction, which may cause grade challenges at the U-turn locations.	**Highlight:** RCI decreases right-angle crashes, the prevailing crash type currently at this intersection, while increase the changes of other crash types. **(Fully or partially) Addressed known safety issues:** 1. Right angle crashes between side street thru and mainline especially on the far side of intersection are expected to be specifically addressed **Unaddressed known safety issues:** 1. None **Potential new safety issues:** Increase of sideswipe and rear/end related crashes associated with lane changes associated with U-turn Expected C**rash Rate / Injury Rate: 0.11 / 35.2%** **Estimated 2040 Crash Cost (2018 Dollars): $20,420**	No operation issue identified - intersection LOS is expected to be similar to No Build. Re-route is expected to have minimal impact to overall traffic operation due to the minimum number of traffic being affected, though specific movements will have a longer travel time.

Table 5. Preliminary Alternatives Screening Cont'd

Alt 4: RCI + Offset T

	Description	Pros and Cons	Safety Evaluation	Operation Evaluation
	This alternative creates an RCI intersection that re-routes mainline left and side street left and thru movements to right-turn and U-turn. It perpendicularly and individually connects CSAH 9 (west and east legs) and CSAH 10 with TH 61. The existing connection between CSAH 9 & 10 will be downgraded to driveway with improved access angle.	**Pros:** 1. Significant improvement to existing right angle crashes - mainline left re-route may be additional safety improvement compared to Alt 3 2. Eliminate close spacing between intersections, and reduces frontage road related conflicts. **Cons:** 1. Need to educate the public for new traffic control 2. Side-swipe crashes may increase due to the re-route 3. Adds an additional right-in/right-out access to TH 61 4. Increases left turn travel time for all left turn movements. Overall might be most negatively perceived alternative by the community. 5. Side-swipe crashes may increase due to the re-route 6. The westbound roadway profile is much higher than the eastbound direction, which may cause grade challenges at the U-turn locations.	**Highlight:** RCI decreases right-angle crashes, the prevailing crash type currently at this intersection, while increase the changes of other crash types. Re-routing of the mainline left (to U-turn), even with no recorded crash history at this site, may be a proactive safety improvement due to the right-angle crashes reduction benefit by RCI. **(Fully or partially) Addressed known safety issues:** 1. Right angle crashes between side street thru and mainline especially on the far side of intersection 2. Some right-angle crashes due to the intersection skew **Unaddressed known safety issues:** None **Potential new safety issues:** Increase of sideswipe and rear/end related crashes associated with lane changes associated with U-turn and addition of right-in/out access on TH 61 **Crash Rate / Injury Rate: 0.11 / 35.2%** **Estimated 2040 Crash Cost (2018 Dollars): $20,420**	No operation issue identified - intersection LOS is expected to be similar to No Build. Re-route is expected to have minimal impact to overall traffic operation. However, all left turn movements will experience an increased travel time.

Alt 5: 2x1 Roundabout

	Description	Pros and Cons	Safety Evaluation	Operation Evaluation
	This alternative constructs 2x1 roundabout with 2-lanes maintained along TH 61. CSAH 9 and 10 are connected to form a new thru road and they share one leg of the roundabout for TH 61 access. New stop signs will be on the new thru road to prevent excessive stopping to/from TH 61.	**Pros:** 1. Significant improvement to existing right angle crashes 2. Eliminate close spacing between intersections and realigns frontage road access to further reduce motorist conflicts. **Cons:** 1. High construction cost 2. 2x1 RAB historically have a higher crash frequency and will likely increase crashes at this intersection, despite the reduction in crash severity 3. R/W acquisition may be needed. Further evaluation is needed.	**Highlight:** Even though the MnDOT Roundabout study is the best available data for crash rate estimation, due to the low cross-street volumes at this site, the realistic crash rate/cost for this alternative may potentially be lower than observed statewide average for 2x1 RAB's. **(Fully or partially) Addressed known safety issues:** 1. RAB specifically addresses the right angle crashes between side street thru and mainline especially on the far side of intersection 2. Some right-angle crashes due to the intersection skew, as RAB corrects this. **Unaddressed known safety issues:** None **Potential new safety issues:** Increase of property damage crashes related to multilane RAB is expected **Expected Crash Rate / Injury Rate: 0.76 / 18.5%** **Estimated 2040 Crash Cost (2018 Dollars): $80,182**	Single Lane RAB is expected to provide sufficient capacity; therefore, a 2x1 RAB will not have any operational issues - intersection LOS is expected to be better than No Build.

Alt 6: Roundabout + U-turn

	Description	Pros and Cons	Safety Evaluation	Operation Evaluation
	This alternative constructs 2x1 three leg roundabout with 2-lanes maintained along TH 61. CSAH 10 will be re-aligned and T into CSAH 9 that T into TH 61 for a right-in-right-out access. A U-turn lane is added south of that access to accommodate left turn and thru movements from/to CSAH 9 (west leg). A direct left turn from northbound TH 61 to CSAH 9 is allowed.	**Pros:** 1. Improvement to existing right angle crashes 2. Eliminate close spacing between intersections 3. Provide more direct accesses compared to Alt 5: Roundabout **Cons:** 1. High construction cost 2. Need to educate the public for new traffic control 3. 2x1 RAB historically have a higher crash frequency and will likely increase crashes at this intersection, despite the reduction in crash severity 4. R/W acquisition may be needed. Further evaluation is needed. 5. May have slightly higher number of crashes than Alt 5, due to the additional access (though RCI design) maintained at CSAH 9	**Highlight:** Even though the MnDOT Roundabout study is the best available data for crash rate estimation, due to the low cross-street volumes at this site, the realistic crash rate/cost for this alternative may potentially be lower than observed statewide average for 2x1 RAB's. **(Fully or partially) Addressed known safety issues:** 1. RAB specifically addresses the right angle crashes between side street thru and mainline especially on the far side of intersection 2. Any crashes related to the intersection skew, as RAB corrects this. **Unaddressed known safety issues:** None **Potential new safety issues:** Increase of property damage crashes related to multilane RAB is expected Expected **Crash Rate / Injury Rate: 0.76/ 18.5%** **Estimated 2040 Crash Cost (2018 Dollars): $80,493**	Single Lane RAB is expected to provide sufficient capacity; therefore, a 2x1 RAB will not have any operational issues - intersection LOS is expected to be better than No Build. Re-route is expected to have minimal impact to overall traffic operation due to the minimum number of traffic being affected.

4.7 Preferred Alternatives Selection

Based on the preliminary alternatives analysis, design considerations evaluated in the comparison matrix, and discussion with MnDOT the following alternatives were selected for detailed evaluation:

- **Alternative Traditional Intersection w/ Realignment** (Preliminary Alternative 1: Traditional Intersection w/ Realignment) was selected for further evaluation due to its familiarity and expectation of the public, and potential for safety benefit concluded by the preliminary analysis.
- **Alternative Reduced Conflict Intersection (RCI)** (Preliminary Alternative 2: RCI) was also selected for further analysis due to its significant safety benefit, reduced construction cost, and relatively minimal impact to left and through movement re-circulation compared to the other RCI alternatives.

5.0 Preferred Alternatives

The goal of the preferred alternatives analysis is to evaluate in greater detail the selected traffic control device and geometric configurations, and to present the key decision-making factors that aid in developing the study recommendations. Key elements of the preferred alternatives analysis include:

- Development of conceptual layouts
- Development of construction cost estimates
- Conducting a benefit/cost analysis
- Select a recommended alternative

5.1 Conceptual Layouts

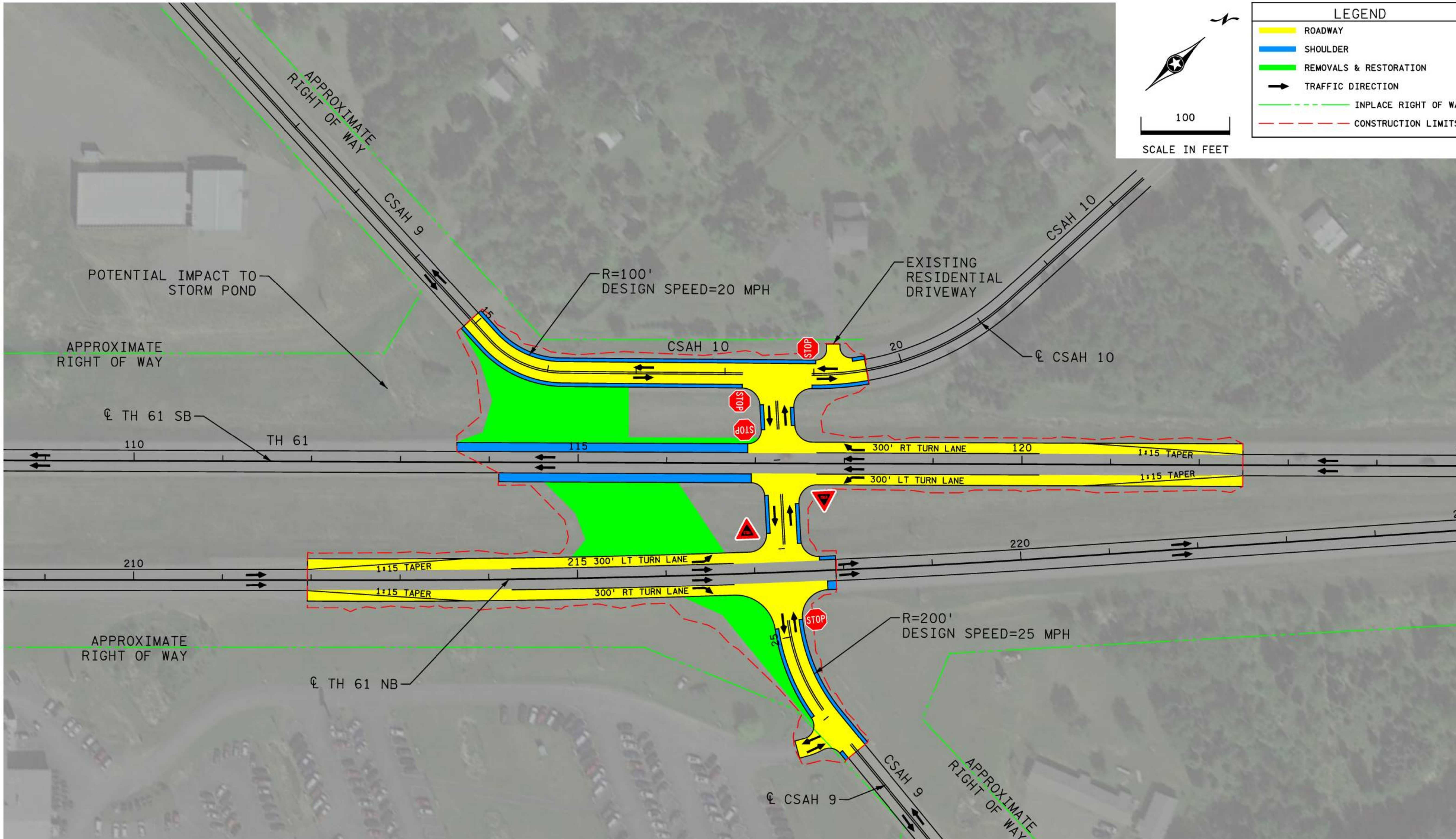
Conceptual layouts were developed for Alternative 1: Traditional Intersection w/ Realignment and Alternative 2: Reduced Conflict Intersection (RCI) and are shown in **Figure 10** and **Figure 11** respectively.

5.1.1 Design Assumptions

The conceptual layouts were preliminarily engineered in accordance with the requirements and guidelines specified in the *MnDOT Road Design Manual*[9]. In developing the conceptual layouts, a number of design considerations were made:

- Design Vehicle: WB-62
    - AutoTURN truck turning templates were evaluated for the WB-62 design vehicle overall and SU-40 design vehicle at the U-Turns of RCI
- Design Speed on TH 61: 65 mph
- Design Speed on CSAH 9: 50 mph
- Design Speed on CSAH 10: 45 mph
- Turn lane taper rates are 1:15
    - 12-foot-wide turn lanes on all approaches
    - In general, 300-foot-long storage length plus 180-foot taper, except locations where shorter or longer turn lanes improve the overall intersection design and operation
- Both alternatives were assumed to be implemented through retrofit construction

[9] MnDOT Road Design Manual

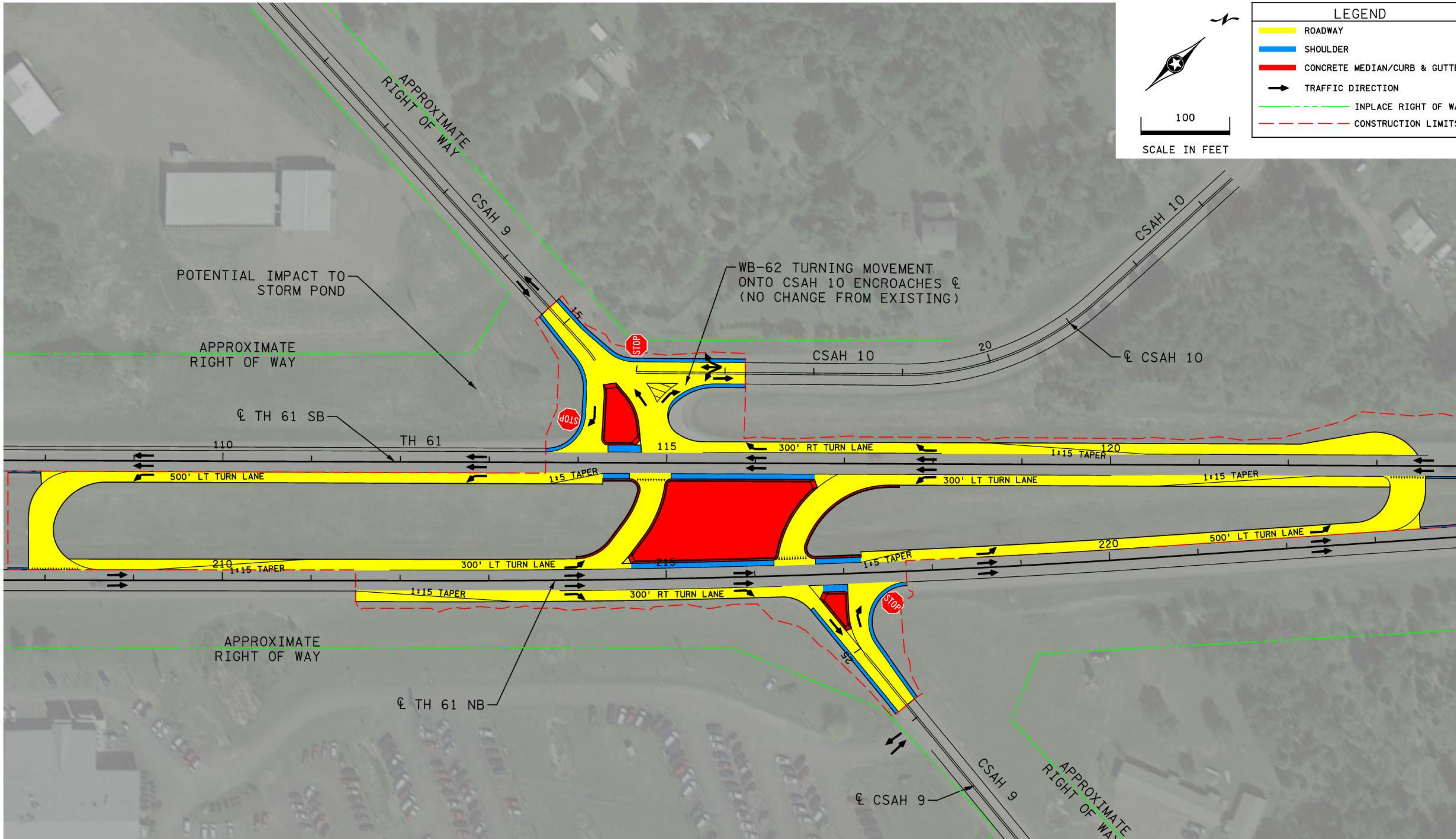


TH 61 & CSAH 9 ICE - Two Harbors

ALLIANT ENGINEERING

Figure 10

Alternative: Traditional Intersection Conceptual Layout



TH 61 & CSAH 9 ICE - Two Harbors

Figure 11
Alternative: Reduced Conflict Intersection (RCI) Conceptual Layout

ALLIANT ENGINEERING

5.2 Traffic Operations Analysis

A detailed traffic operations analysis was conducted to evaluate the operational performance of the two preferred alternatives under existing (2018) and forecasted year 2040 traffic volumes at TH 61 / CSAH 9 intersection.

5.2.1 Analysis Software

The traffic operations analysis was performed using SimTraffic software. SimTraffic is a microscopic traffic simulation tools capable of modeling various arterial roadway segment and intersection configurations.

5.2.2 Level of Service

The term Level-of-Service (LOS), as taken from the HCM, refers to the ability of an intersection to process traffic volumes. It is defined as the delay to vehicles caused by the traffic control at the intersection. The results of this measure of effectiveness are typically presented in the form of a letter grade (A-F) that provides a qualitative indication of the operational effectiveness.

By definition, LOS A conditions represent high-quality operations and LOS F conditions represent very poor operations. The general relationship between delay and LOS are shown in **Table 6**. Although traffic simulation models arrive at the average seconds of delay per vehicle differently than HCM procedures, the thresholds presented are still applicable. The LOS C/D boundary is generally considered the acceptable threshold for operating conditions in greater Minnesota.

Table 6. LOS Definition

Level of Service	Description	Intersection Delay (Seconds / Vehicle)	
		Signalized Intersection	Un-Signalized Intersection
A	**Free Flow.** Low volumes and no delays.	0 - 10	0 - 10
B	**Stable Flow.** Speeds restricted by travel conditions, minor delays.	>10 - 20	>10 - 15
C	**Stable Flow.** Speeds and maneuverability closely controlled due to higher volumes.	>20 - 35	>15 - 25
D	**Stable Flow.** Speeds considerably affected by change in operating conditions. High density traffic restricts maneuverability, volume near capacity.	>35 - 55	>25 - 35
E	**Unstable Flow.** Low speeds, considerable delay, volume at or slightly over capacity.	>55 - 80	>35 - 50
F	**Forced Flow.** Very low speeds, volumes exceed capacity, long delays with stop and go traffic.	> 80	> 50

Source: Highway Capacity Manual, 2010 Edition, Transportation Research Board, Exhibit 18-4 for Signalized Intersections, Exhibit 19-1 for Unsignalized Intersections

5.2.3 Analysis Results

The traffic operations analysis was completed for the existing (2018) and forecasted year 2040 traffic volumes. The purpose of this analysis is to evaluate and compare the performance of each preferred alternative. In addition, the traffic operations analysis provides context to the need for intersection improvements based on intersection capacity. The key measures of effectiveness evaluated include overall intersection delay/LOS and individual movement delay/LOS. **Table 7** provides a summary of the traffic operations analysis for the AM, midday, and PM peak hours for existing and forecasted year 2040 traffic volumes. Detailed intersection operations analysis results are included in **Appendix D**.

Results of the traffic operations analysis indicate that the TH 61 / CSAH 9 intersection is expected to operate at an overall LOS A under both preferred alternatives for existing and forecast year 2040 traffic volumes. In addition, no significant queuing issues were observed in the traffic simulations.

The Traditional Intersection w/ Realignment alternative is expected to operate at the same intersection and movement LOS as the No Build condition due to their similar roadway geometry and traffic controls. Specifically, eastbound/westbound left and through movements from CSAH 9 may experience LOS C during peak hours due to the 2-stage crossing.

The RCI alternative is also expected to operate at intersection LOS A and a similar overall intersection delay, despite the re-circulation of the eastbound and westbound left and through movements. This is due to the overall very low traffic volume approaching TH 61 from CSAH 9. The re-routing of these through and left turn movements adds an estimated 17 seconds of travel time. This additional travel time does cause the delay for these movements to be generally higher than those under the Traditional Intersection alternative and the No Build condition. However, the differences are within a reasonable range, as shown in **Figure 12**, and all these movements are expected to operate at LOS D or better.

Table 7. Intersection Operations Analysis Summary

Existing Year 2018 - Measures of Effectiveness Summary

Scenario	AM Peak Hour		MID Peak Hour		PM Peak Hour	
	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)
Alternative 0 - Existing/No Build	A / C	2.7 / 24.1	A / B	2.3 / 14.4	A / C	2.9 / 18.8
Alternative 1 - Traditional Intersection w/ Realignment	A / C	2.7 / 24.1	A / B	2.3 / 14.4	A / C	2.9 / 18.8
Alternative 2 - Reduced Conflict Intersection (RCI)	A / C	3.3 / 24.4	A / C	2.7 / 24.3	A / D	3.2 / 25.1

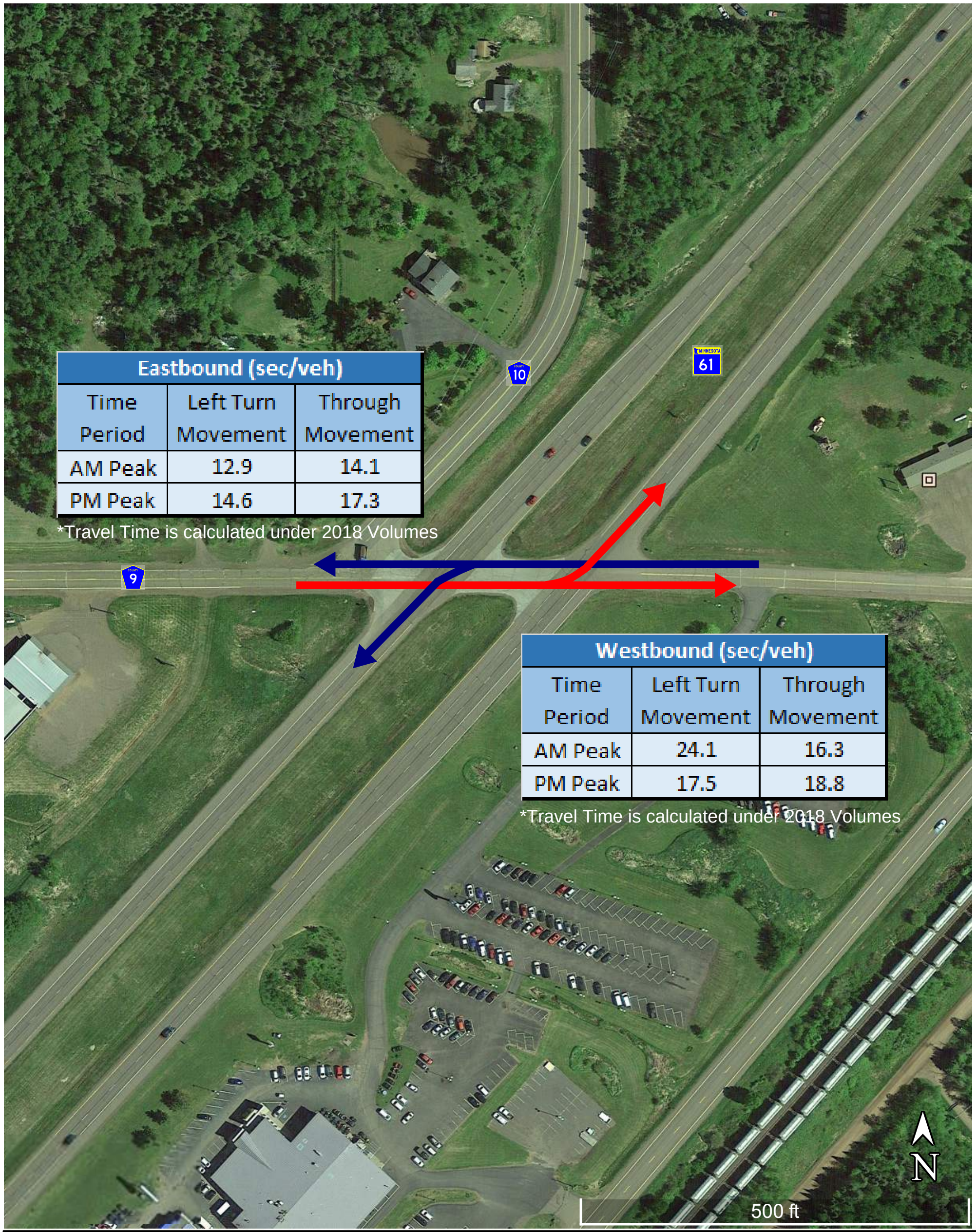
Overall Intersection LOS / Worst Approach LOS
Overall Intersection Delay / Worst Approach Delay

Year 2040 - Measures of Effectiveness Summary

Scenario	AM Peak Hour		MID Peak Hour		PM Peak Hour	
	LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)
Alternative 0 - Existing/No Build	A / C	3.0 / 16.5	A / C	2.5 / 16.1	A / C	3.1 / 21.5
Alternative 1 - Traditional Intersection w/ Realignment	A / C	3.0 / 16.5	A / C	2.5 / 16.1	A / C	3.1 / 21.5
Alternative 2 - Reduced Conflict Intersection (RCI)	A / C	3.4 / 24.3	A / C	2.8 / 24.2	A / D	3.2 / 26.1

Overall Intersection LOS / Worst Approach LOS
Overall Intersection Delay / Worst Approach Delay

No Build



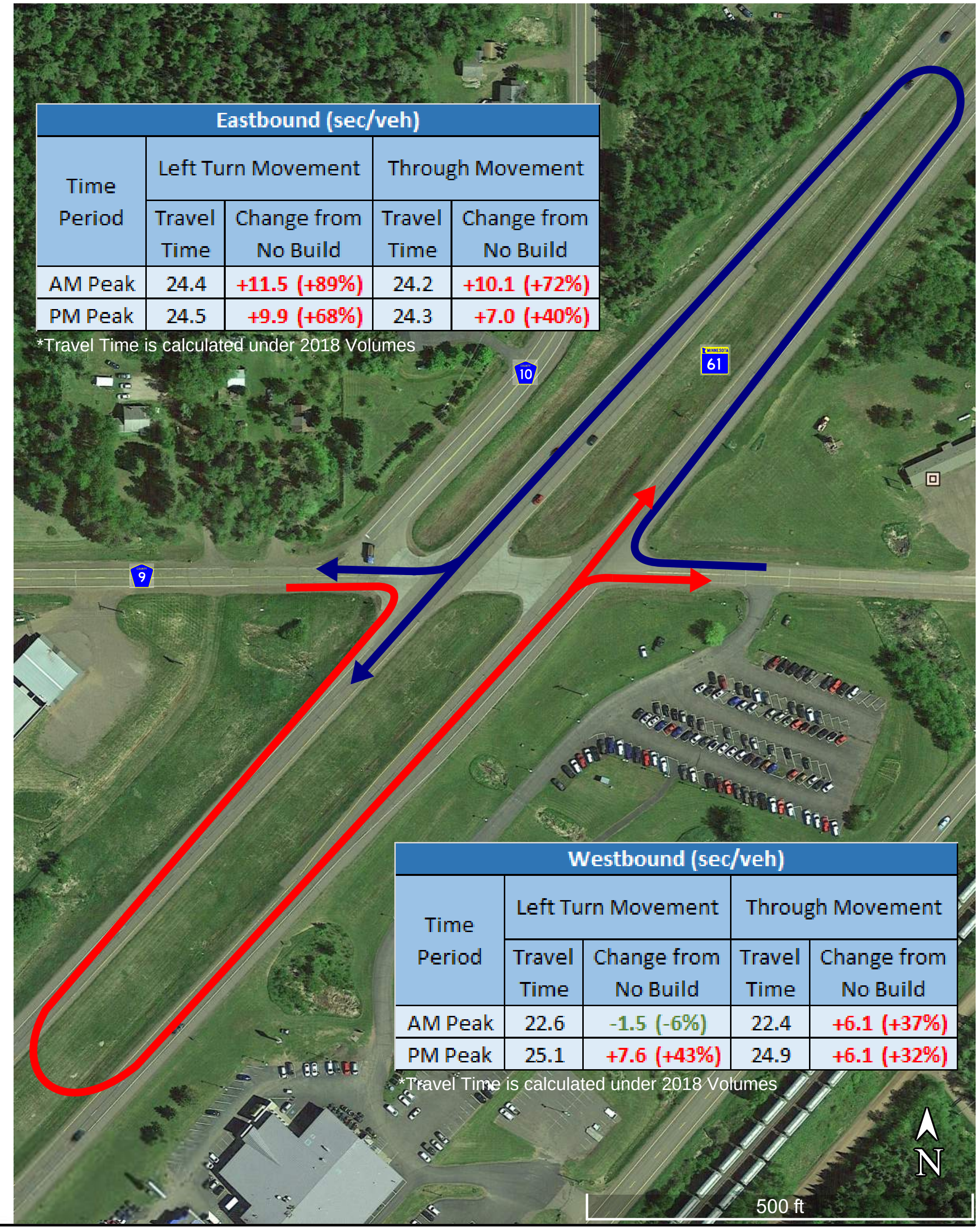
Eastbound (sec/veh)		
Time Period	Left Turn Movement	Through Movement
AM Peak	12.9	14.1
PM Peak	14.6	17.3

*Travel Time is calculated under 2018 Volumes

Westbound (sec/veh)		
Time Period	Left Turn Movement	Through Movement
AM Peak	24.1	16.3
PM Peak	17.5	18.8

*Travel Time is calculated under 2018 Volumes

Alternative RCI



Eastbound (sec/veh)				
Time Period	Left Turn Movement		Through Movement	
	Travel Time	Change from No Build	Travel Time	Change from No Build
AM Peak	24.4	+11.5 (+89%)	24.2	+10.1 (+72%)
PM Peak	24.5	+9.9 (+68%)	24.3	+7.0 (+40%)

*Travel Time is calculated under 2018 Volumes

Westbound (sec/veh)				
Time Period	Left Turn Movement		Through Movement	
	Travel Time	Change from No Build	Travel Time	Change from No Build
AM Peak	22.6	-1.5 (-6%)	22.4	+6.1 (+37%)
PM Peak	25.1	+7.6 (+43%)	24.9	+6.1 (+32%)

*Travel Time is calculated under 2018 Volumes

Figure 12
Side Street Left and Through Movement Travel Time Comparison at RCI Intersection

5.3 Construction Cost Estimates

Estimated construction costs were developed for the preferred intersection alternatives based upon the conceptual layouts. **Table 8** summarizes the construction cost estimates while detailed estimates are included in **Appendix E**. It should be noted that the cost estimates included a 30 percent contingency to account for risk or any unknowns that may not be identified without more detailed engineering. The cost estimates are also based on a high level conceptual layout, without supporting base mapping engineering detail to accurately account for actual construction limits, grading, drainage or other design considerations. Therefore, are used for purpose of relative comparison within the ICE study. Further preliminary engineering is necessary to refine the construction cost estimates suitable for project programming.

Table 8. Construction Cost Estimate Summary

	Alternative: Traditional Intersection w/ Realignment	Alternative: Reduced Conflict Intersection (RCI)
Construction Cost Estimate (2018 Dollars)	$962,300	$1,526,200

5.4 Benefit/Cost Analysis

An economic benefit/cost analysis was completed in accordance with the MnDOT Office of Investment Management, Benefit/Cost Analysis for Transportation Projects procedures, and assumes a 20-year analysis period (Year 2022 to 2042) with construction expenditures assumed to occur in the year 2022. The benefit/cost ratio is a comparison between the estimated traffic operations and safety benefit for the preferred intersection alternatives, the estimated 20-year construction cost and any expected operational and maintenance cost over this period (e.g., lighting, street signs). The highest benefit/cost ratio represents the most economical solution. Benefit/cost ratios less than 1.0 might not be considered an economically viable alternative. To more accurately reflect the implementation plan for the preferred intersection alternatives, the year 2022 construction costs were adjusted (discount rate of 1.3 percent) to account for the expected present worth value when the expenditures are expected to be made (for purposes of analysis, assumed to be year 2022). At the end of the analysis period (year 2042) there is remaining capital value with each infrastructure component, which is also accounted for in the total cost. The 20-year traffic operations and safety benefit are influenced by this decision and reflected in the benefit/cost ratio. The economic benefit/cost analyses for the preferred intersection alternatives are summarized in **Table 9** and provided in detail in **Appendix F**.

Table 9. Benefit/Cost Analysis Summary

	Alternative 1: Traditional Intersection w/ Realignment	Alternative 2: Reduced Conflict Intersection (RCI)
Total Traffic Operation Benefit	$ -	$ (144,264)
Total Safety Benefit	$ 259,305	$ 958,699
Total Cost[1]	$ 815,140	$ 1,290,182
Benefit to Cost Ratio	**0.32**	**0.63**

[1] Total cost is a 20 year estimate (2022-2042) that includes the discounted construction cost plus professional fees minus the remaining capital value at the end of the analysis period.

The monetary benefit of the project is quantified in terms of reduced (or increased) vehicle hours traveled (VHT) or less delay (or added delay) at the intersection and the reduced number and/or severity of estimated crashes over the analysis period between the existing conditions and the proposed alternatives as previously presented. The monetary costs include construction costs contingency, and professional services fees. Remaining capital values of the roadway features at the end of the analysis period are also subtracted from the total cost of the project.

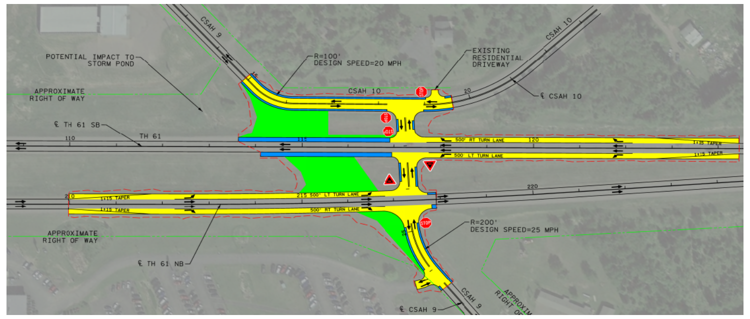
5.5 Alternatives Evaluation Summary

A comparison matrix summarizing the key decision factors with respect to project goals is provided in **Table 10**. The key decision factors include:

- **Pros and Cons** – Qualitative assessment of key advantages and disadvantages of the preferred intersection alternatives
- **Safety Evaluation** – Assessment of expected impact on motorist safety and to the degree to which the existing safety deficiency is improved
- **Operation Evaluation** – Documentation of anticipated future traffic operations
- **Design Considerations** – Qualitative assessment of issues, considerations, and impacts
- **Construction Cost Estimate** – Order of magnitude construction cost
- **Right of Way** – Qualitative assessment of property and right of way impacts

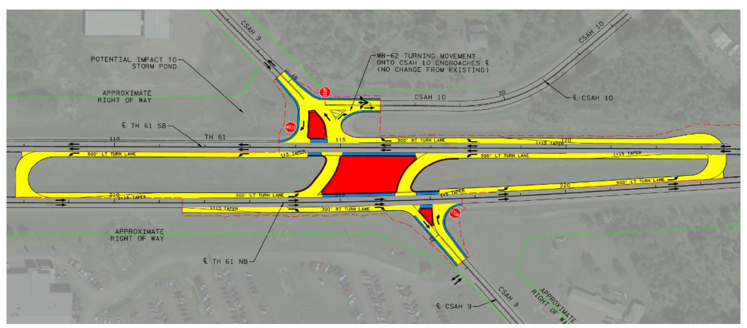
Table 10. Final Alternatives Evaluation Matrix

Alternative: Traditional Intersection w/ Realignment



Description	Pros and Cons	Safety Evaluation	Traffic Operation Evaluation	Design Consideration	Construction Cost Estimate	Right of Way
This alternative creates a traditional intersection with TH 61 are eliminates the existing skewed angles of approach. In addition, it re-aligns CSAH 9 and 10 to create a new thru road, which then T into TH 61 to create a traditional intersection. New stop signs will be on the new thru road to prevent repetitive stopping to/from TH 61. CSAH 9 east of the intersection is also re-aligned.	Pros: 1. Higher construction cost 2. Familiar traffic control device and intersection design that likley meets public expectations 3. Some improvement to right angle crashes due to the perpendicular access Cons: 1. No improvement to other known safety concerns. 2. Would realign the CSAH 10 intersection in close proximity to an existing residential driveway. 3. Expensive investment that does not fully address the far side right angle crash occurrences 4. May not be economically justified due to the low B/C ratio.	**Crash Types:** Most common crash types include right angle, rear-ends, and single-vehicle run off road. **Average Crash Rate:** 0.18 crashes/MEV **Crash Severity:** Injury related crashes represent approximately 72.3% of total reported intersection crashes. **Fatal and Serious Injury Crash** The existing K/A rate 0. This analysis assumes it will remain at 0. However, the design does not provide design characteristics that historically address K/A crashes at rural high speed intersections. Therefore, the potential for K/A crashes is possible and the liklihood of it occuring is inevitable. **Expected Change:** Some potential right-angle crashes due to the intersection skew may be reduced. Right angle crashes between side street thru and mainline especially on the far side of intersection are not fully addressed with traditional intersection design.	**Key Conclusions:** - PM peak period is the highest peak - Traffic operation is expected to be the same as No Build - All movements operate at LOS C or above - No significant queuing is observed **2040 Traffic Operation:** PM peak (Traditional Intersection): 3.1s/A PM peak (No Build): 3.1s/A **Low volume intersection with no traffic delays or congestion expected.**	- Design speed of TH 61 is 65mph. - Retrofit CSAH 9 & 10 connection and their connection with TH 61. - New stop signs on CSAH 10 (no stop signs for motorists turning off TH 61 to prevent potential for multiple motorists to queue into TH 61). - Position the CSAH 10 / TH 61 connecting road such that vehicle headlights do not interfere with the adjacent housing west of TH 61. - Intersection street lighting should be provided. - Reconstructed CSAH roads will have 12' lanes + 4' shoulders per current State Aid Standards - New curve on CSAH 9, tying into northbound TH 61 is designed as 25 mph curve due to close proximity to intersection. This allows the intersection to be located further from the existing driveway on CSAH 10 - Areas of pavement removal assumed to be regraded to drain, maintaining current drainage patterns	**Construction Cost plus Contingency:** $962,300 **Engineering/Admin Cost (17%):** $163,000 **Total Cost:** $1,125,300	No right-of way acquisition expected.

Alternative: Reduced Conflict Intersection (RCI)



Description	Pros and Cons	Safety Evaluation	Operation Evaluation	Design Consideration	Construction Cost Estimate	Right of Way
This alternative creates an RCI intersection with TH 61 that re-routes CSAH 9 left and thru movements to right-turn and U-turn. The existing CSAH 9 and CSAH 10 roadway alignments will generally be maintained.	Pros: 1. Only requires median construction, and minimal approach roadway construction. No Right-of-way acquisition is necessary 2. Reduces severity of crashes and specifically addresses the far side right angle crashes Cons: 1. Does not fully address the skewed side street approaches; however, can be minimized through providing perpendicular alignment of the right turn movements 2. No Improvement to the close spacing of frontage road intersections 3. Diverts motorist (adds motorist travel time for certain movements) and may have negative public perception 4. Side-swipe crashes may increase due to the re-route	**Crash Types:** Most common crash types include side-swipes, rear-ends, right angle, and single-vehicle run off road. **Average Crash Rate:** 0.11 crashes/MEV **Crash Severity:** Injury related crashes represent approximately only 35.2% of total reported intersection crashes. The K/A rate remains as 0 from No Build. **Expected Change:** Right angle crashes between side street thru and mainline especially on the far side of intersection are expected to be specifically addressed. Some right-angle crashes due to the intersection skew are not fully addressed.	**Key Conclusions:** - PM peak period is the highest peak - Overall traffic operation is slightly better than No Build, despite the additional travel time for left & thru movements of CSAH 9 due to the re-route - All movements operate at LOS C or above, except the westbound left/thru movement (LOS D due to re-route) - No significant queuing is observed **2040 Traffic Operation:** PM peak (RCI): 3.2s/A PM peak (No Build): 3.1s/A **Travel time for "left turn" and "through" movements are expected to be increased by approximatley 12-20seconds over the traditional intersection design.**	- Design speed of TH 61 is 65mph. - Retrofit TH 61 left turn lanes and CSAH 9 approaches. - Use Yield signs at U-turns - The specific locations of the median U-turns will need to consider the roadway profile of the two directions of TH 61 to ensure an acceptable grade in the median and motorist visibility. If grades on the northern U-turn becomes too unacceptable, it is necessary to position this U-turn closer to the main intersection. - The northern U-turn lane radius may not accommodate WB-62 design vehicle due to the narrow median width. - The northbound and southbound left turn lanes from TH 61 should be laterally separated to provide a more neutral offset (improved sight line), while still accommodating the ability to make a U-turn. - Intersection street lighting should be provided. - Right turn movements from CSAH 9 should be realigned and brought perpendicular to TH 61. - The separation between CSAH 10 and TH 61 should be maximized, and concrete channelization islands provided to clarify the intended vehicle movements and vehicle paths. - Storm pond near CSAH 9 may be affected due to realignment of the roadway - geometry appears to be outside of the pond but grading may slightly affect it	**Construction Cost plus Contingency:** $1,526,200 **Engineering/Admin Cost (17%):** $260,000 **Total Cost:** $1,786,200	No right-of way acquisition expected.

6.0 Recommendations

The selection of the recommended alternative for the TH 61 / CSAH 9 intersection is made based upon discussions with MnDOT District 1, results of the intersection operations and safety analyses, results of the benefit/cost analysis, and consideration of the key decision factors evaluated in the evaluation matrix. Based on the information presented in this ICE, the Reduced Conflict Intersection (RCI) is the recommended alternative (see **Figure 11**). Key conclusions of the ICE leading to this recommendation include:

- The RCI alternative is expected to significantly reduce the far-side right-angle crashes by re-routing the side-street left/through movements to right-turn and U-turn movements. Since right-angles are the prevailing crash type at this location, an overall safety benefit is expected to be achieved. Even though the B/C ratio of this alternative is only 0.63, it is twice that of the traditional intersection re-alignment alternative (0.32). However, due to the low existing crash rate and the fact that there have been no reported K/A crashes, the overall monetary safety benefit is not significant. However, the No Build design does not effectively preclude K/A crashes from happening due to its intersection skew and 2-stage crossing. Therefore, it is recommended that MnDOT program the RCI intersection design.
- Results of the traffic operations analysis indicate that the RCI alternative is expected to operate at intersection LOS A, and have a similar overall intersection delay as the Traditional Intersection w/ Realignment alternative. Even with the additional travel time added to eastbound/westbound (CSAH 9) left and through movement (average of 17 seconds additional delay), their total travel time differences from the other alternative (and No Build condition) are within a reasonable range, and is a small inconvenience compared to the expected safety benefit.

Once the proposed project moves into preliminary engineering, key design considerations include:

- The ICE does not indicate an immediate need for intersection reconstruction. If project funding allows, the RCI should be constructed with the currently programmed 2022 project at this intersection. If current funding does not allow for a near-term implementation, the alternative design should be proactively programed to minimize the potential for future K/A crashes from happening due to the current geometric design.
- The specific locations of the median U-turns will need to consider the roadway profile of the two directions of TH 61 to ensure an acceptable grade in the median and motorist visibility. If grades on the northern U-turn are unacceptable, it may be necessary to position this U-turn closer to the main intersection.
- The northern U-turn lane radius may not accommodate WB-62 design vehicle due to the narrow median width.
- The TH 61 left-turn lanes should be laterally separated to provide a more neutral offset (improved sight line), while still accommodating the ability to make a U-turn.
- Intersection street lighting should be provided.
- CSAH 9 right-turn movements should be realigned and brought perpendicular to TH 61.

- Investigation of all sight triangles between CSAH 9, CSAH 10, and TH 61 should be performed to verify they are adequate.
- The separation between CSAH 10 and TH 61 should be maximized, and concrete channelization islands provided to clarify the intended vehicle paths.
- Storm pond near CSAH 9 may be affected due to realignment of the roadway - geometry appears to be outside of the pond but grading may slightly affect it.

Appendix A:
Detailed Signal Warrant Analysis

SIGNAL WARRANT ANALYSIS
WARRANT 1
LOCATION: TH 61 & CSAH 9

Count Date:	**April 2018**
Source:	Alliant Engineerin
Factor:	1.00
Population < 10,000?	YES
Speed over 40 mph?	YES
VOLUME REQ AT 70%	YES

APPROACH	DESCRIPTION	NUMBER OF LANES	SPEED (MPH)
Major Approach 1	TH 61 (NB)	2	65
Major Approach 3	TH 61 (SB)	2	65
Minor Approach 2	CSAH 9 (EB)	1	50
Minor Approach 4	CSAH 9 (WB)	1	50

If population is less than 10,000; or the major street speed is over 40 mph, seventy percent factor can be applied. Apply seventy percent factor? **YES**

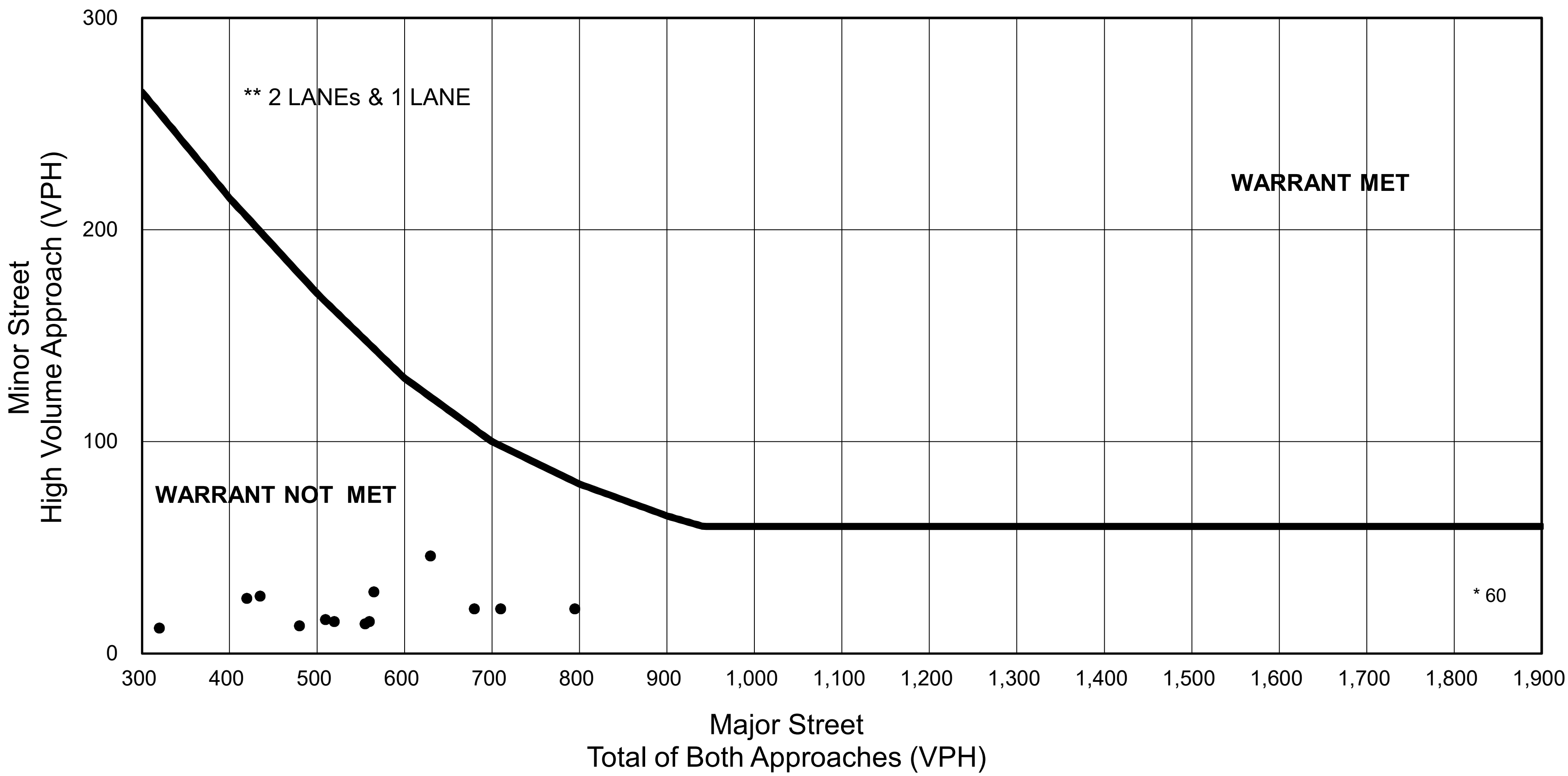
	MAJOR STREET								
	APPROACH VOLUME			WARRANT MET *					
				Cond. A	Cond. B	(A&B) Comb.		Existing Signal	
			TOTAL			80% of A	80% of B	60% of A	60% of B
HOUR	**1**	**3**	**1 + 3**	**420**	**630**	**336**	**504**	**252**	**378**
12 - 1 AM	0	0	0						
1 - 2 AM	0	0	0						
2 - 3 AM	0	0	0						
3 - 4 AM	0	0	0						
4 - 5 AM	0	0	0						
5 - 6 AM	83	85	168						
6 - 7 AM	215	205	420	X		X		X	X
7 - 8 AM	312	317	629	X		X	X	X	X
8 - 9 AM	259	253	512	X		X	X	X	X
9 - 10 AM	216	265	481	X		X		X	X
10 - 11 AM	219	262	481	X		X		X	X
11 - Noon	236	286	522	X		X	X	X	X
12 - 1 PM	240	324	564	X		X	X	X	X
1 - 2 PM	265	296	561	X		X	X	X	X
2 - 3 PM	290	267	557	X		X	X	X	X
3 - 4 PM	319	391	710	X	X	X	X	X	X
4 - 5 PM	342	455	797	X	X	X	X	X	X
5 - 6 PM	363	315	678	X	X	X	X	X	X
6 - 7 PM	235	201	436	X		X		X	X
7 - 8 PM	190	131	321					X	
8 - 9 PM	180	97	277					X	
9 - 10 PM	151	61	212						
10 - 11 PM	81	49	130						
11 - Midnight	0	0	0						

	MINOR STREET													
	APPROACH VOLUME		WARRANT MET APPROACH 2 *						WARRANT MET APPROACH 4 *					
			Cond. A	Cond. B	(A&B) Comb.		Existing Signal		Cond. A	Cond. B	(A&B) Comb.		Existing Signal	
					80% of A	80% of B	60% of A	60% of B			80% of A	80% of B	60% of A	60% of B
HOUR	**2**	**4**	**105**	**53**	**84**	**42.4**	**63**	**31.8**	**105**	**53**	**84**	**42.4**	**63**	**31.8**
12 - 1 AM	0	0											u	
1 - 2 AM	0	0												
2 - 3 AM	0	0												
3 - 4 AM	0	0												
4 - 5 AM	0	0												
5 - 6 AM	6	0												
6 - 7 AM	26	8												
7 - 8 AM	46	2				X		X						
8 - 9 AM	16	4												
9 - 10 AM	13	12												
10 - 11 AM	14	11												
11 - Noon	15	12												
12 - 1 PM	29	18												
1 - 2 PM	13	15												
2 - 3 PM	14	13												
3 - 4 PM	20	21												
4 - 5 PM	21	19												
5 - 6 PM	21	16												
6 - 7 PM	27	5												
7 - 8 PM	12	11												
8 - 9 PM	10	3												
9 - 10 PM	10	4												
10 - 11 PM	11	5												
11 - Midnight	0	0												

	WARRANT MET SAME HOURS ON MAJOR AND MINOR STREETS						WARRANT MET SAME HOURS ON MAJOR AND MINOR STREETS						
			(A&B) Comb.		Existing Signal					(A&B) Comb.		Existing Signal	
HOUR	**Cond. A**	**Cond. B**	**80% of A**	**80% of B**	**60% of A**	**60% of B**	**Cond. A**	**Cond. B**	**80% of A or B**	**80% of A**	**80% of B**	**60% of A**	**60% of B**
12 - 1 AM													
1 - 2 AM													
2 - 3 AM													
3 - 4 AM													
4 - 5 AM													
5 - 6 AM													
6 - 7 AM													
7 - 8 AM				X		X			1		1		1
8 - 9 AM													
9 - 10 AM													
10 - 11 AM													
11 - Noon													
12 - 1 PM													
1 - 2 PM													
2 - 3 PM													
3 - 4 PM													
4 - 5 PM													
5 - 6 PM													
6 - 7 PM													
7 - 8 PM													
8 - 9 PM													
9 - 10 PM													
10 - 11 PM													
11 - Midnight													

WARRANT ANALYSIS SUMMARY - EXISTING CONDITIONS

Warrant 1 - Cond. A was	not met:	0	hours satisfied requirements
Warrant 1 - Cond. B was	not met:	0	hours satisfied requirements
Warrant 1 - Combine A & B was	not met:	0	hours satisfied requirements
Warrant 2 - Four Hour was	not met:	0	hours satisfied requirements
Warrant 3 - Peak Hour was	not met:	0	hours satisfied requirements
Signal Retention (60%) Warrant A	not met:	0	hours satisfied requirements
Signal Retention (60%) Warrant B	not met:	1	hours satisfied requirements



Warrant Met for 0 Hours

* NOTE: 60 vph applies as the lower threshold volume for a minor street approach with one lane.

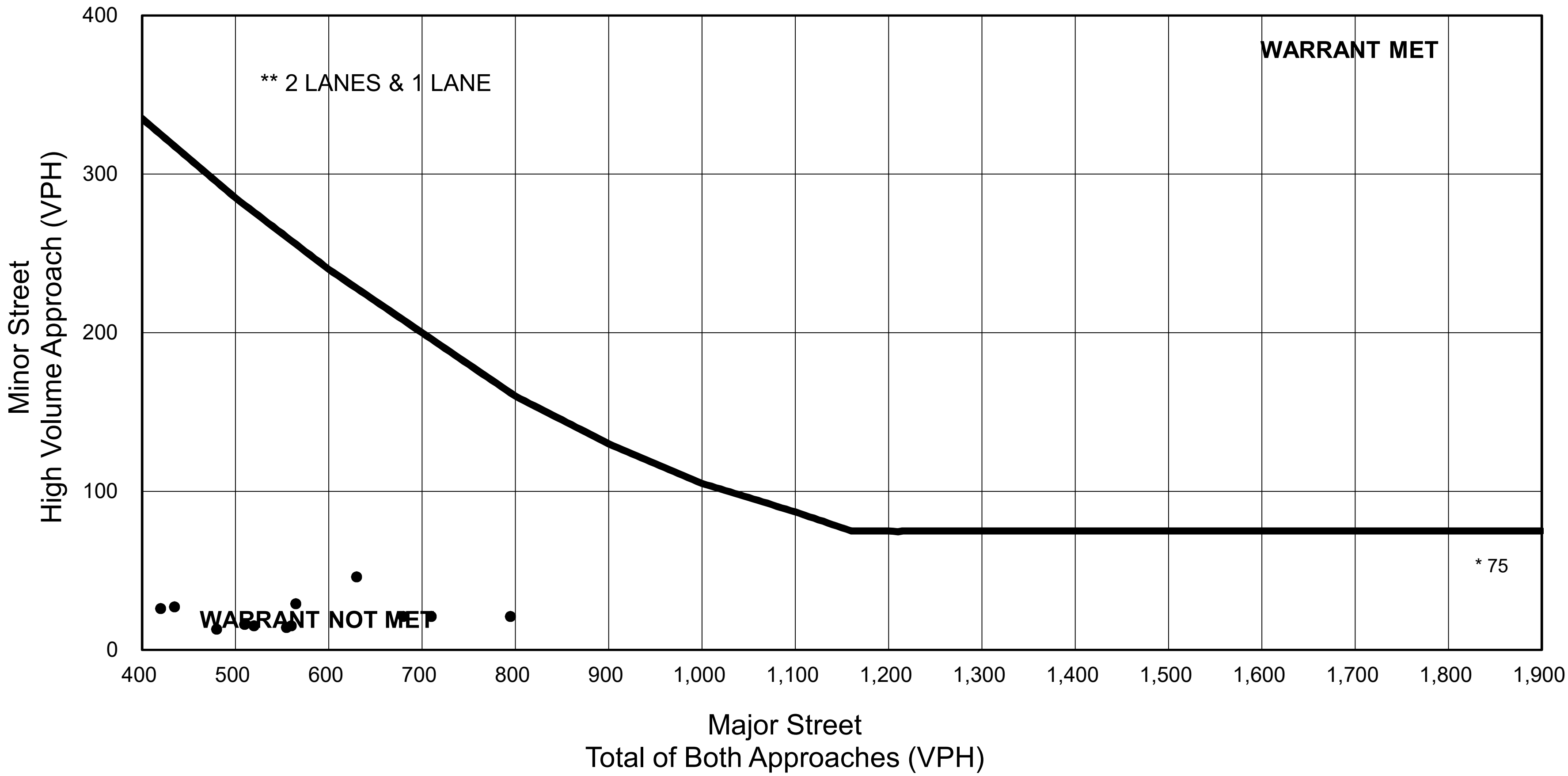
** The first number refers to the number of lanes of approach on the major street and the second number refers to the number of lanes of approach on the minor street.

TH 61 & CSAH 9 ICE
SIGNAL WARRANT ANALYSIS
Existing 2018 Weekday Nominal Volume

WARRANT 2 - FOUR HOUR

Source: 2015 Minnesota Manual on Uniform Traffic Control Devices

3_Warrant Analysis_Existing(1st_4HrChart), 6/20/2018



Warrant Met for 0 Hours

* NOTE: 75 vph applies as the lower threshold volume for a minor street approach with one lane.

** The first number refers to the number of lanes of approach on the major street and the second number refers to the number of lanes of approach on the minor street.

TH 61 & CSAH 9 ICE
SIGNAL WARRANT ANALYSIS
Existing 2018 Weekday Nominal Volume

WARRANT 3 - PEAK HOUR

Source: 2015 Minnesota Manual on Uniform Traffic Control Devices

SIGNAL WARRANT ANALYSIS
WARRANT 1
LOCATION: TH 61 & CSAH 9

Count Date:	**April 2040**
Source:	Alliant Engineering
Factor:	1.00
Population < 10,000?	YES
Speed over 40 mph?	YES
VOLUME REQ AT 70%	YES

APPROACH	DESCRIPTION	NUMBER OF LANES	SPEED (MPH)
Major Approach 1	TH 61 (NB)	2	65
Major Approach 3	TH 61 (SB)	2	65
Minor Approach 2	CSAH 9 (EB)	1	50
Minor Approach 4	CSAH 9 (WB)	1	50

If population is less than 10,000; or the major street speed is over 40 mph, seventy percent factor can be applied. Apply seventy percent factor? **YES**

MAJOR STREET

	APPROACH VOLUME			WARRANT MET *					
				Cond. A	Cond. B	(A&B) Comb.		Existing Signal	
			TOTAL			80% of A	80% of B	60% of A	60% of B
HOUR	**1**	**3**	**1 + 3**	**420**	**630**	**336**	**504**	**252**	**378**
12 - 1 AM	0	0	0						
1 - 2 AM	0	0	0						
2 - 3 AM	0	0	0						
3 - 4 AM	0	0	0						
4 - 5 AM	0	0	0						
5 - 6 AM	100	102	202						
6 - 7 AM	263	251	514	X		X	X	X	X
7 - 8 AM	378	384	762	X	X	X	X	X	X
8 - 9 AM	316	309	625	X		X	X	X	X
9 - 10 AM	262	322	584	X		X	X	X	X
10 - 11 AM	267	317	584	X		X	X	X	X
11 - Noon	287	350	637	X	X	X	X	X	X
12 - 1 PM	291	392	683	X	X	X	X	X	X
1 - 2 PM	322	362	684	X	X	X	X	X	X
2 - 3 PM	355	325	680	X	X	X	X	X	X
3 - 4 PM	388	473	861	X	X	X	X	X	X
4 - 5 PM	417	554	971	X	X	X	X	X	X
5 - 6 PM	441	383	824	X	X	X	X	X	X
6 - 7 PM	282	247	529	X		X	X	X	X
7 - 8 PM	231	159	390			X		X	X
8 - 9 PM	218	119	337			X		X	
9 - 10 PM	184	74	258					X	
10 - 11 PM	96	59	155						
11 - Midnight	0	0	0						

MINOR STREET

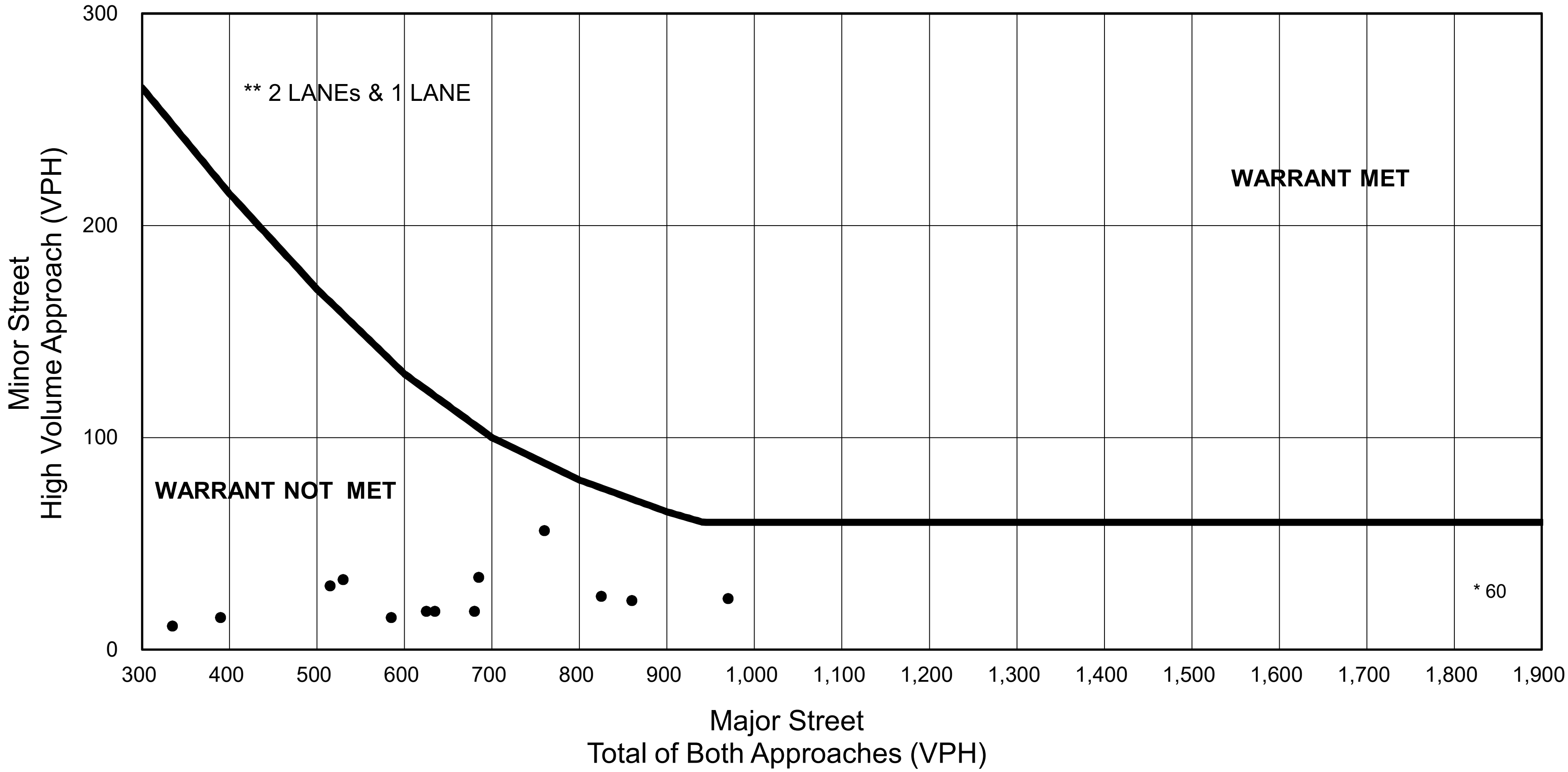
	APPROACH VOLUME		WARRANT MET APPROACH 2 *						WARRANT MET APPROACH 4 *					
			Cond. A	Cond. B	(A&B) Comb.		Existing Signal		Cond. A	Cond. B	(A&B) Comb.		Existing Signal	
					80% of A	80% of B	60% of A	60% of B			80% of A	80% of B	60% of A	60% of B
HOUR	**2**	**4**	**105**	**53**	**84**	**42.4**	**63**	**31.8**	**105**	**53**	**84**	**42.4**	**63**	**31.8**
12 - 1 AM	0	0											u	
1 - 2 AM	0	0												
2 - 3 AM	0	0												
3 - 4 AM	0	0												
4 - 5 AM	0	0												
5 - 6 AM	7	0												
6 - 7 AM	30	8												
7 - 8 AM	56	3		X		X		X						
8 - 9 AM	18	4												
9 - 10 AM	15	13												
10 - 11 AM	14	14												
11 - Noon	18	15												
12 - 1 PM	34	21						X						
1 - 2 PM	15	18												
2 - 3 PM	17	18												
3 - 4 PM	22	23												
4 - 5 PM	24	22												
5 - 6 PM	25	17												
6 - 7 PM	33	6						X						
7 - 8 PM	15	14												
8 - 9 PM	11	3												
9 - 10 PM	13	5												
10 - 11 PM	13	5												
11 - Midnight	0	0												

WARRANT MET SAME HOURS ON MAJOR AND MINOR STREETS

			(A&B) Comb.		Existing Signal	
HOUR	**Cond. A**	**Cond. B**	**80% of A**	**80% of B**	**60% of A**	**60% of B**
12 - 1 AM						
1 - 2 AM						
2 - 3 AM						
3 - 4 AM						
4 - 5 AM						
5 - 6 AM						
6 - 7 AM						
7 - 8 AM		X		X		X
8 - 9 AM						
9 - 10 AM						
10 - 11 AM						
11 - Noon						
12 - 1 PM						X
1 - 2 PM						
2 - 3 PM						
3 - 4 PM						
4 - 5 PM						
5 - 6 PM						
6 - 7 PM						X
7 - 8 PM						
8 - 9 PM						
9 - 10 PM						
10 - 11 PM						
11 - Midnight						

WARRANT ANALYSIS SUMMARY - EXISTING CONDITIONS

Warrant 1 - Cond. A was	not met:	0	hours satisfied requirements
Warrant 1 - Cond. B was	not met:	1	hours satisfied requirements
Warrant 1 - Combine A & B was	not met:	0	hours satisfied requirements
Warrant 2 - Four Hour was	not met:	0	hours satisfied requirements
Warrant 3 - Peak Hour was	not met:	0	hours satisfied requirements
Signal Retention (60%) Warrant A	not met:	0	hours satisfied requirements
Signal Retention (60%) Warrant E	not met:	3	hours satisfied requirements



Warrant Met for 0 Hours

* NOTE: 60 vph applies as the lower threshold volume for a minor street approach with one lane.

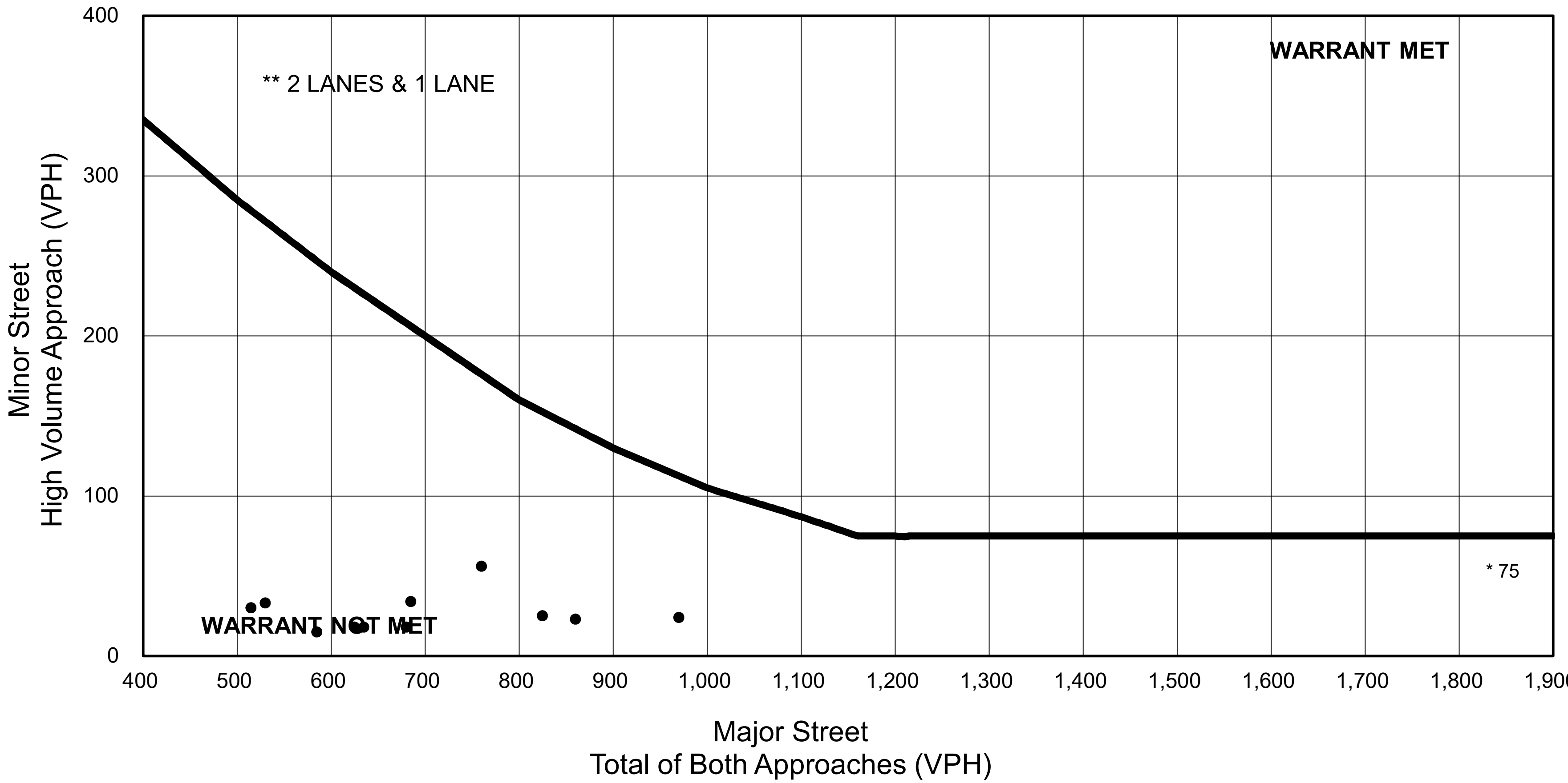
** The first number refers to the number of lanes of approach on the major street and the second number refers to the number of lanes of approach on the minor street.

TH 61 & CSAH 9 ICE
SIGNAL WARRANT ANALYSIS
Forecast 2040 Weekday Volume

WARRANT 2 - FOUR HOUR

Source: 2015 Minnesota Manual on Uniform Traffic Control Devices

3_Warrant Analysis_2040(1st_4HrChart), 6/20/2018



Warrant Met for 0 Hours

* NOTE: 75 vph applies as the lower threshold volume for a minor street approach with one lane.

** The first number refers to the number of lanes of approach on the major street and the second number refers to the number of lanes of approach on the minor street.

TH 61 & CSAH 9 ICE
SIGNAL WARRANT ANALYSIS
Forecast 2040 Weekday Volume

WARRANT 3 - PEAK HOUR

Source: 2015 Minnesota Manual on Uniform Traffic Control Devices

3_Warrant Analysis_2040(1st_PkHrChart), 6/20/2018

Appendix B:

Detailed Roundabout Capacity Analysis

TH 61 & CSAH 9 (2018)

PM Peak

4% Trucks

0.961538 f_{HV}

228 Max 15-Minute Volume

	Southbound				Westbound				Northbound				Eastbound				
Start Time	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	
3:30 PM	1	108	7	0	4	1	1	0	6	84	1	0	6	0	6	0	225
3:45 PM	1	106	7	2	4	2	1	0	5	77	2	2	5	0	2	0	212
4:00 PM	1	99	10	0	2	5	2	0	6	72	7	0	4	0	2	0	210
4:15 PM	0	104	7	0	4	6	0	0	12	87	1	0	2	1	4	0	228
	3	417	31	2	14	14	4	0	29	320	11	2	17	1	14	0	875
Peak 15-Minutes	0	104	7	0	4	6	0	0	12	87	1	0	2	1	4	0	

North Leg (SB):	Demand =	451	Conflicting Flow Rate = WBL+WBT+NBL =	57	CFR (PCE) =	59	D (PCE) =	469	Capacity=	1299
South Leg (NB):	Demand =	360	Conflicting Flow Rate = EBL+EBT+SBL=	21	CFR (PCE) =	22	D (PCE) =	374	Capacity=	1349
East Leg (WB):	Demand =	32	Conflicting Flow Rate = EBL+NBL+NBT=	366	CFR (PCE) =	381	D (PCE) =	33	Capacity=	936
West Leg (EB):	Demand =	32	Conflicting Flow Rate = WBL+SBL+SBT=	434	CFR (PCE) =	451	D (PCE) =	33	Capacity=	871

Entering Total = 875

TH 61 & CSAH 9 (2040)

PM Peak

4% Trucks

0.961538 f_{HV}

277 Max 15-Minute Volume

	Southbound				Westbound				Northbound				Eastbound				
Start Time	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	
3:30 PM	1	131	9	0	4	1	1	0	7	103	1	0	7	0	7	0	272
3:45 PM	1	130	9	3	4	3	1	0	6	94	3	3	6	0	3	0	260
4:00 PM	1	121	12	0	3	6	3	0	7	88	9	0	4	0	3	0	257
4:15 PM	0	127	9	0	4	7	0	0	15	106	1	0	3	1	4	0	277
	3	509	39	3	15	17	5	0	35	391	14	3	20	1	17	0	1066
Peak 15-Minutes	0	127	9	0	4	7	0	0	15	106	1	0	3	1	4	0	

North Leg (SB):	Demand =	551	Conflicting Flow Rate = WBL+WBT+NBL =	67	CFR (PCE) =	70	D (PCE) =	573	Capacity=	1285
South Leg (NB):	Demand =	440	Conflicting Flow Rate = EBL+EBT+SBL=	24	CFR (PCE) =	25	D (PCE) =	458	Capacity=	1345
East Leg (WB):	Demand =	37	Conflicting Flow Rate = EBL+NBL+NBT=	446	CFR (PCE) =	464	D (PCE) =	38	Capacity=	860
West Leg (EB):	Demand =	38	Conflicting Flow Rate = WBL+SBL+SBT=	527	CFR (PCE) =	548	D (PCE) =	40	Capacity=	789

Entering Total = 1066

Appendix C:

Detailed Safety Analysis

TH 61 and CSAH 9

Crash Cost Analysis

	Rear End	Right Angle	Run Off	Head On	Sideswipe	Right Turn	Left Turn	Total
	14%	86%	0%	0%	0%	0%	0%	
Mainline Crashes	1							1
Fatal								
A Injury								
B Injury								1
C Injury	1							
PDO								
Cross-Street Crashes		6						6
Fatal								
A Injury								
B Injury		2						6
C Injury		2						
PDO		2						
Alternative 1 - Traditional Intersection with Realignment								
Reduction Factors** (mainline)		19.0%					19.0%	
Reduction Factors** (cross-street thru/right)		19.0%					19.0%	
Reduction Factors** (cross-street left)		19.0%					19.0%	
Fatal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
A Injury	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
B Injury	0.0	-0.4	0.0	0.0	0.0	0.0	0.0	-0.38
C Injury	0.0	-0.4	0.0	0.0	0.0	0.0	0.0	-0.38
PDO	0.0	-0.4	0.0	0.0	0.0	0.0	0.0	-0.38
Total Crash Reduction	0.00	-1.14	0.00	0.00	0.00	0.00	0.00	-1.14
Alternative 2 - RCI								
Reduction Factors***	25.0%	-78.1%	0.0%	0.0%	100.0%	0.0%	0.0%	
Total Estimated Crash†	1.25	1.31	0.00	0.00	1.00	0.00	0.00	3.56
Alternative 3 - RCI and Realignment								
Reduction Factors** (mainline)							19.0%	
Reduction Factors (RCUT)***	25.0%	-78.1%	0.0%	0.0%	100.0%	0.0%	0.0%	
Total Estimated Crash†	1.25	1.31	0.00	0.00	1.00	0.00	0.00	3.56
Alternative 4 - RCI and Offset T								
Reduction Factors** (mainline)		-20.0%					-20.0%	
Reduction Factors** (cross-street)								
Reduction Factors (RCUT)***	25.0%	-78.1%	0.0%	0.0%	100.0%	0.0%	0.0%	
Total Estimated Crash†	1.25	1.31	0.00	0.00	1.00	0.00	0.00	3.56
Alternative 5 - 2x1 Roundabout								
Severity Distribution Factors*								
Fatal	0.0%							
A Injury	0.0%							
B Injury	3.8%							
C Injury	14.7%							
PDO	81.5%							

Alternative 6 - 2x1 Roundabout + U-turn								
Expected RAB Crashes*	4.55	6.46	3.46	0.75	9.74	0.00	0.29	
Reduction Factors (RAB)*	-23.9%	-24.9%	501.0%	2.8%	774.6%	0.0%	-82.5%	
U-Turn Movement Crashes‡		2					0.0%	
Reduction Factors** (U-Turn Movements)‡		-20.0%					-20.0%	
Relative Reduction Factor		4.9%					62.5%	
Relative U-Turn Crashes		0.098					0	
Total Roadway Reduction	4.55	6.55	3.46	0.75	9.74	0.00	0.29	25.35

*Source: A Study of the Traffic Safety at Roundabouts in Minnesota (October 30, 2017)
**Source: CMF Clearinghouse
***Source: A Study of the Traffic Safety at Reduced Conflict Intersections in Minnesota (May 23, 2017)
† An additional crash was added to account for predicted increase in sideswipe crashes
‡ Reduction only applies to crashes that occurred on movements displaced from the roundabout by the u-turn.

2018 Annual Crash Cost

Scenario	Traffic Control	Severity*	Severity Proportion	Crash Rate	Total Entering Volume (2018)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
Alternative 0 - No Build	Thru-Stop	K	0.0%	0.23	3,322,003	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	28.6%			0.200	$ 170,000	$ 34,000.00
		C	42.9%			0.300	$ 87,000	$ 26,100.00
		PD	28.6%			0.200	$ 7,800	$ 1,560.00
		Total	**100%**			**0.700**		**$ 61,660.00**

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	Total Entering Volume (2018)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
Alternative 1 - Traditional Intersection with Realignment	Thru-Stop	K	0.0%	0.18	3,322,003	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	27.6%			0.162	$ 170,000	$ 27,540.00
		C	44.7%			0.262	$ 87,000	$ 22,794.00
		PD	27.6%			0.162	$ 7,800	$ 1,263.60
		Total	**100%**			**0.586**		**$ 51,597.60**

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	Total Entering Volume (2018)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
Alternative 2 - RCI	Thru-Stop	K	0.0%	0.11	3,322,003	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	12.7%			0.045	$ 170,000	$ 7,680.17
		C	22.5%			0.080	$ 87,000	$ 6,987.45
		PD	64.8%			0.231	$ 7,800	$ 1,801.07
		Total	**100%**			**0.356**		**$ 16,468.69**

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	Total Entering Volume (2018)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
Alternative 3 - RCI and Realignment	Thru-Stop	K	0.0%	0.11	3,322,003	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	12.7%			0.045	$ 170,000	$ 7,680.17
		C	22.5%			0.080	$ 87,000	$ 6,987.45
		PD	64.8%			0.231	$ 7,800	$ 1,801.07
		Total	**100%**			**0.356**		**$ 16,468.69**

Scenario	Traffic Control	Severity	Severity Proportion	Crash Rate	Total Entering Volume (2018)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
Alternative 4 - RCI and Offset T	Thru-Stop	K	0.0%	0.11	3,322,003	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	12.7%			0.045	$ 170,000	$ 7,680.17
		C	22.5%			0.080	$ 87,000	$ 6,987.45
		PD	64.8%			0.231	$ 7,800	$ 1,801.07
		Total	**100%**			**0.356**		**$ 16,468.69**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume (2018)**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alternative 5 - 2x1 Roundabout	Roundabout	K	0.0%	0.76	3,322,003	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	3.8%			0.096	$ 170,000	$ 16,244.73
		C	14.7%			0.372	$ 87,000	$ 32,378.81
		PD	81.5%			2.057	$ 7,800	$ 16,044.56
		Total	**100%**			**2.525**		**$ 64,668.11**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume (2018)**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alternative 6 - 2x1 Roundabout + U-turn	Roundabout	K	0.0%	0.76	3,322,003	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	3.8%			0.096	$ 170,000	$ 16,307.79
		C	14.7%			0.374	$ 87,000	$ 32,504.50
		PD	81.5%			2.065	$ 7,800	$ 16,106.84
		Total	**100%**			**2.535**		**$ 64,919.12**

Note: Cost/Crash reflects Minnesota's three-year crash history and procedures contained in "Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses— 2016 Adjustment" published August 8, 2016, and specifying a VSL of $9.6 million in 2015$. (http://www.dot.state.mn.us/planning/program/appendix_a.html)

2042 Annual Crash Cost (0.9% Annual Growth)

Scenario	Traffic Control	Severity*	Severity Proportion	Crash Rate	Total Entering Volume (2042)	Average Crashes / Year (No.)	Cost / Crash ($)	Cost / Year ($)
Alternative 0 - No Build	Thru-Stop	K	0.0%	0.23	4,118,965	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	28.6%			0.266	$ 170,000	$ 45,289.37
		C	42.9%			0.400	$ 87,000	$ 34,766.25
		PD	28.6%			0.266	$ 7,800	$ 2,077.98
		Total	**100%**			**0.932**		**$ 82,133.60**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume (2042)**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
rnative 1 - Traditional Intersection with Realignm	Thru-Stop	K	0.0%	0.18	4,118,965	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	27.6%			0.201	$ 170,000	$ 34,091.30
		C	44.7%			0.325	$ 87,000	$ 28,256.11
		PD	27.6%			0.201	$ 7,800	$ 1,564.19
		Total	**100%**			**0.727**		**$ 63,911.60**

Scenario	Traffic	Severity	Severity	Crash Rate	Total Entering Volume	Average Crashes / Year	Cost / Crash	Cost / Year
Alternative 2 - RCI	Thru-Stop	K	0.0%	0.11	4,118,965	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	12.7%			0.056	$ 170,000	$ 9,522.67
		C	22.5%			0.100	$ 87,000	$ 8,663.76
		PD	64.8%			0.286	$ 7,800	$ 2,233.16
		Total	**100%**			**0.442**		**$ 20,419.59**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume (2042)**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alternative 3 - RCI and Realignment	Thru-Stop	K	0.0%	0.11	4,118,965	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	12.7%			0.056	$ 170,000	$ 9,522.67
		C	22.5%			0.100	$ 87,000	$ 8,663.76
		PD	64.8%			0.286	$ 7,800	$ 2,233.16
		Total	**100%**			**0.442**		**$ 20,419.59**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume (2042)**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alternative 4 - RCI and Offset T	Thru-Stop	K	0.0%	0.11	4,118,965	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	12.7%			0.056	$ 170,000	$ 9,522.67
		C	22.5%			0.100	$ 87,000	$ 8,663.76
		PD	64.8%			0.286	$ 7,800	$ 2,233.16
		Total	**100%**			**0.442**		**$ 20,419.59**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume (2042)**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alternative 5 - 2x1 Roundabout	Roundabout	K	0.0%	0.76	4,118,965	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	3.8%			0.118	$ 170,000	$ 20,141.90
		C	14.7%			0.461	$ 87,000	$ 40,146.61
		PD	81.5%			2.550	$ 7,800	$ 19,893.71
		Total	**100%**			**3.130**		**$ 80,182.23**
Scenario	**Traffic Control**	**Severity**	**Severity Proportion**	**Crash Rate**	**Total Entering Volume (2042)**	**Average Crashes / Year (No.)**	**Cost / Crash ($)**	**Cost / Year ($)**
Alternative 6 - 2x1 Roundabout + U-turn	Roundabout	K	0.0%	0.76	4,118,965	0.000	$ 11,000,000	N/A
		A	0.0%			0.000	$ 590,000	$ -
		B	3.8%			0.119	$ 170,000	$ 20,220.08
		C	14.7%			0.463	$ 87,000	$ 40,302.45
		PD	81.5%			2.560	$ 7,800	$ 19,970.93
		Total	**100%**			**3.143**		**$ 80,493.47**

Note: Cost/Crash reflects Minnesota's three-year crash history and procedures contained in "Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses— 2016 Adjustment" published August 8, 2016, and specifying a VSL of $9.6 million in 2015$. (http://www.dot.state.mn.us/planning/program/appendix_a.html)

Crash Reduction Assumptions

CMF Clearinghouse	Rear Ends	Right Angle	Run Off	Head On	Sideswipe	Right Turn	Left Turn
Remove Skew (1)		0.81					0.81
Install U-Turn (2)		0.8					0.8

Roundabout*	Dist	Rate	2x1	Single		RCI***	Dist
K	0.0%		0	1	0.2%	0	0.0%
A	0.0%		1	4	0.8%	1	0.0%
B	3.8%		18	35	6.8%	8	12.7%
C	14.7%		74	87	16.8%	16	22.5%
PD	81.5%		409	391	75.5%	46	64.8%
Total	**100.0%**	**0.76**	502	518	100.0%	71	100.0%

Crash Modification Factor Assumptions and Crash Distribution

(1) CMF=0.81; Countermeasure: Change intersection skew angle; CMF ID: 5189; Remove 39 degree skew at existing.

(2) CMF=0.8; Countermeasure: Replace direct left-turn with right-turn/U-turn; CMF ID: 351; Applied to all or mainline LT cras

RCI Crash Type Reduction***

	Right Angle	Rear End	Run Off	Head On	Left Turn	Other	Sideswipe
% Increase/Decrease	-78.1%	25.0%	46.2%	8.3%	0.0%	14.3%	100%

RAB Crash Type Reduction*

	Rear End	Right Angle	Run Off	Head On	Sideswipe	Left Turn	Total
% Increase/Decrease	-23.9%	-24.9%	501.0%	2.8%	774.6%	-82.5%	
# of Crashes	79	112	60	13	169	5	438
Distribution	18.0%	25.6%	13.7%	3.0%	38.6%	1.1%	100%

*Source: A Study of the Traffic Safety at Roundabouts in Minnesota (October 30, 2017)

***Source: A Study of the Traffic Safety at Reduced Conflict Intersections in Minnesota (May 23, 2017)

Appendix D:

Detailed Intersection Operations Analysis

2018 Existing & Alt Traditional Intersection AM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
TH 61 & CSAH 9	Delay (sec/veh)	12.9	14.1	2.3	24.1	16.3	2.0	6.9	1.8	0.8	7.8	1.8	1.0	2.7
	Total Delay (hr)	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.5
	LOS	B	B	A	C	C	A	A	A	A	A	A	A	A
	Volume	36	7	22	2	1	5	3	297	8	19	298	11	709
	95th Queue (ft)	37	37	35	17	17	16	0	0	0	0	0	0	

2018 ALT RCI AM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
TH 61 & CSAH 9	Delay (sec/veh)	24.4	24.2	2.3	22.6	22.4	2.1	4.9	1.8	2.0	3.6	1.8	0.3	3.3
	Total Delay (hr)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.6
	LOS	C	C	A	C	C	A	A	A	A	A	A	A	A
	Volume	36	7	20	2	1	3	2	302	10	16	295	11	705
	95th Queue (ft)	46	46	46	22	22	22	0	0	0	0	0	0	

Delay for WB/EB left & thru movements includes 17 sec additional travel time due to the re-route
Delay for NB/SB thru movements are assumed to be the same as those of No Build condition

2018 Existing & Alt Traditional Intersection MID Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
TH 61 & CSAH 9	Delay (sec/veh)	11.1	11.6	1.5	14.4	13.7	2.8	5.4	1.8	2.0	5.5	1.7	0.7	2.3
	Total Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.4
	LOS	B	B	A	B	B	A	A	A	A	A	A	A	A
	Volume	7	5	18	5	9	5	16	265	5	11	286	9	641
	95th Queue (ft)	22	22	29	28	28	22	0	0	0	3	2	0	

2018 ALT RCI MID Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
TH 61 & CSAH 9	Delay (sec/veh)	22.6	22.4	2.0	24.3	24.2	2.5	5.0	1.8	1.8	3.8	1.7	0.4	2.7
	Total Delay (hr)	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.5
	LOS	C	C	A	C	C	A	A	A	A	A	A	A	A
	Volume	8	5	18	3	9	7	20	268	5	11	294	8	656
	95th Queue (ft)	43	43	43	33	33	33	6	0	0	0	0	0	

Delay for WB/EB left & thru movements includes 17 sec additional travel time due to the re-route

Delay for NB/SB thru movements are assumed to be the same as those of No Build condition

2018 Existing & Alt Traditional Intersection PM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
TH 61 & CSAH 9	Delay (sec/veh)	14.6	17.3	2.7	17.5	18.8	2.6	8.3	1.8	0.9	9.1	2.0	1.0	2.9
	Total Delay (hr)	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.2	0.0	0.0	0.2	0.0	0.7
	LOS	B	C	A	C	C	A	A	A	A	A	A	A	A
	Volume	14	2	16	15	17	7	27	320	10	3	430	31	892
	95th Queue (ft)	23	23	30	38	38	20	3	0	0	0	0	0	

2018 ALT RCI PM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
TH 61 & CSAH 9	Delay (sec/veh)	24.5	24.3	2.7	25.1	24.9	2.6	5.0	1.8	1.9	3.3	2.0	0.5	3.2
	Total Delay (hr)	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.8
	LOS	C	C	A	D	C	A	A	A	A	A	A	A	A
	Volume	17	2	12	9	17	2	24	319	12	3	416	23	856
	95th Queue (ft)	42	42	42	44	44	44	0	0	0	0	0	0	

Delay for WB/EB left & thru movements includes 17 sec additional travel time due to the re-route

Delay for NB/SB thru movements are assumed to be the same as those of No Build condition

2040 No Build & Alt Traditional Intersection AM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
TH 61 & CSAH 9	Delay (sec/veh)	14.6	16.5	2.9	13.3	13.3	1.9	5.4	1.9	1.1	9.6	1.8	0.9	3.0
	Total Delay (hr)	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.7
	LOS	B	C	A	B	B	A	A	A	A	A	A	A	A
	Volume	45	13	23	3	1	5	3	363	11	17	357	13	854
	95th Queue (ft)	41	41	39	15	15	16	0	0	0	0	0	0	

2040 ALT RCI AM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
TH 61 & CSAH 9	Delay (sec/veh)	24.3	24.1	2.3	23.5	23.3	2.1	9.1	1.9	2.1	4.6	1.8	0.4	3.4
	Total Delay (hr)	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.8
	LOS	C	C	A	C	C	A	A	A	A	A	A	A	A
	Volume	39	13	25	2	1	2	2	368	10	19	352	10	843
	95th Queue (ft)	46	46	46	22	22	22	0	0	0	0	0	0	

Delay for WB/EB left & thru movements includes 17 sec additional travel time due to the re-route

Delay for NB/SB thru movements are assumed to be the same as those of No Build condition

2040 No Build & Alt Traditional Intersection MID Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
TH 61 & CSAH 9	Delay (sec/veh)	13.3	13.1	2.0	15.5	16.1	3.0	6.5	1.8	0.9	6.7	1.8	1.0	2.5
	Total Delay (hr)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.5
	LOS	B	B	A	C	C	A	A	A	A	A	A	A	A
	Volume	10	4	24	5	11	9	21	316	7	12	345	17	781
	95th Queue (ft)	26	26	36	29	29	29	4	0	0	0	0	0	

2040 ALT RCI MID Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
TH 61 & CSAH 9	Delay (sec/veh)	23.9	23.6	2.3	24.2	24.0	2.6	5.6	1.8	1.9	3.5	1.8	0.4	2.8
	Total Delay (hr)	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.6
	LOS	C	C	A	C	C	A	A	A	A	A	A	A	A
	Volume	10	4	20	5	11	5	26	324	7	18	357	17	804
	95th Queue (ft)	41	41	41	37	37	37	3	0	0	0	0	0	

Delay for WB/EB left & thru movements includes 17 sec additional travel time due to the re-route
Delay for NB/SB thru movements are assumed to be the same as those of No Build condition

2040 No Build & Alt Traditional Intersection PM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
TH 61 & CSAH 9	Delay (sec/veh)	19.2	21.5	2.8	21.4	19.9	3.1	9.2	1.9	1.0	9.2	2.0	1.1	3.1
	Total Delay (hr)	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.2	0.0	0.0	0.3	0.0	0.9
	LOS	C	C	A	C	C	A	A	A	A	A	A	A	A
	Volume	18	1	15	16	17	6	36	391	13	4	498	43	1058
	95th Queue (ft)	29	29	29	34	34	21	0	0	0	3	5	0	

2040 ALT RCI PM Peak Hour

Intersection	MOE	Eastbound Approach			Westbound Approach			Northbound Approach			Southbound Approach			Intersection Total
		EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
TH 61 & CSAH 9	Delay (sec/veh)	24.8	24.5	2.5	26.1	25.8	2.7	6.4	1.9	2.0	4.4	2.0	0.5	3.2
	Total Delay (hr)	0.2	0.0	0.0	0.1	0.1	0.0	0.1	0.2	0.0	0.0	0.3	0.0	1.0
	LOS	C	C	A	D	D	A	A	A	A	A	A	A	A
	Volume	23	1	14	12	17	13	32	393	14	3	502	41	1065
	95th Queue (ft)	41	41	41	47	47	47	0	0	0	0	0	0	

Delay for WB/EB left & thru movements includes 17 sec additional travel time due to the re-route

Delay for NB/SB thru movements are assumed to be the same as those of No Build condition

Appendix E:

Detailed Construction Cost Estimates

ENGINEER'S CONCEPTUAL OPINION OF PROBABLE COST
MnDOT District 1 Intersection Control Evaluation - TH 61 at CSAH 9 & CSAH 10
Alliant Project No. 180042

Date Prepared:
September 19, 2018

ALLIANT
ENGINEERING

Item #	Description	Unit	Unit Price	Traditional Intersection		Reduced Conflict Intersection (RCI)	
				Quantity	**Total**	**Quantity**	**Total**
Paving and Grading Costs							
1.	Removals - Pavement	SQ YD	$3.00	7600	$22,800	7500	$22,500
2.	Common Excavation & Subgrade	CU YD	$7.00	8500	$59,500	10400	$72,800
3.	Granular Subgrade (CV)	CU YD	$20.00	4700	$94,000	6900	$138,000
4.	Mainline Pavement	SQ YD	$40.00	7000	$280,000	9300	$372,000
5.	Concrete Walk/Median/Truck Apron	SQ YD	$45.00		$0	1100	$49,500
6.	Concrete Curb and Gutter	LIN FT	$24.00		$0	1100	$26,400
	Subtotal Paving and Grading Costs				**$456,300**		**$681,200**
Drainage and Erosion Control Costs							
7.	Drainage			10%	$46,000	10%	$68,000
8.	Turf Establishment & Erosion Control			10%	$46,000	10%	$68,000
	Subtotal Drainage and Erosion Control Costs				**$92,000**		**$136,000**
Signal and Lighting Costs							
9.	Intersection Lighting System	LUMP SUM		1	$30,000	1	$100,000
	Subtotal Signal and Lighting Costs				**$30,000**		**$100,000**
Miscellaneous Costs							
10.	Mobilization			10%	$58,000	10%	$92,000
11.	Signing & Striping			8%	$46,000	8%	$73,000
12.	Temporary Pavement & Drainage			5%	$29,000	5%	$46,000
13.	Traffic Control			5%	$29,000	5%	$46,000
	Subtotal Miscellaneous Costs				**$162,000**		**$257,000**
	Construction Subtotal				$740,300		$1,174,200
	Contingency		30%		$222,000		$352,000
	Total Opinion of Construction Cost Plus Contingency				**$962,300**		**$1,526,200**
Professional Services							
18.	Design Services (Engineering, Survey, Architecture)		10%		$96,000		$153,000
19.	Overhead (Legal, Fiscal, Etc.)		7%		$67,000		$107,000
	Subtotal Professional Services				$163,000		$260,000
	Total Opinion of Project Cost				**$1,125,300**		**$1,786,200**

Note: Right-of-way costs not included in estimate. Survey needed in pre-design phase to confirm necessary right-of-way acquisition.

Appendix F:

Detailed Benefit/Cost Analysis

Benefit Cost Assumptions

Analysis Timeframe	
Existing Year	2018
Duration of Benefit Cost Analysis (years)	20
Year of Opening	2022
Design Year	2042
Days Per Year	365.25

Crash Costs	
Fatal Type K	$ 11,000,000
Injury Type A	$ 590,000
Injury Type B	$ 170,000
Injury Type C	$ 87,000
Property Damage Only	$ 7,800

Time Costs	
Vehicles Miles of Travel (Auto)	$ 18.30
Vehicles Miles of Travel (Truck)	$ 29.40

Vehicle Occupancy	
All Auto Trips (7 County Metro Area - Daily)	1.31
Percentage Auto	95%
Percentage Trucks	5%

Traffic Control Device	
Average Annual Maintenance/Operation Cost of Traffic Signal	$ 2,500.00
Average Cost of Maintenance Lighting System	$ 1,000.00

Component Service Life	Years	20 Year Analysis Capital Value Factor
Preliminary Engineering	0	0.00
Right of Way	100	0.89
Major Structures (Bridges)	60	0.75
Roadway	30	0.38
Traffic Signals / Lighting	25	0.23

Depreciation	
Discount Rate	1.3%

Source: MnDOT Office of Investment Management, Cost Benefit Analysis for Transportation Projects, Appendix A, FY2018 Standard Values.

Daily and Annual Vehicle Hours Traveled

2018 Vehicle Hours Traveled (VHT)

Time Period	Grouping	Percent of Grouping by Volume	2018 No Build (Veh-Hr)	2018 ALT 1 Total Delay (Veh-Hr)	2018 ALT 2 Total Delay (Veh-Hr)
12:00 AM	AM OFF	5.1%	0.03	0.03	0.03
1:00 AM	AM OFF	4.5%	0.02	0.02	0.03
2:00 AM	AM OFF	3.9%	0.02	0.02	0.03
3:00 AM	AM OFF	11.0%	0.06	0.06	0.07
4:00 AM	AM OFF	18.2%	0.10	0.10	0.12
5:00 AM	AM OFF	25.3%	0.14	0.14	0.16
6:00 AM	AM	70.5%	0.38	0.38	0.46
7:00 AM	**AM**	**100.0%**	**0.54**	**0.54**	**0.65**
8:00 AM	AM	81.2%	0.44	0.44	0.53
9:00 AM	AM	74.9%	0.40	0.40	0.49
10:00 AM	AM	74.5%	0.40	0.40	0.49
11:00 AM	OFF	94.3%	0.39	0.39	0.45
12:00 PM	OFF	104.9%	0.44	0.44	0.51
1:00 PM	**OFF**	**100.0%**	**0.42**	**0.42**	**0.48**
2:00 PM	PM	71.0%	0.51	0.51	0.56
3:00 PM	PM	88.9%	0.64	0.64	0.70
4:00 PM	**PM**	**100.0%**	**0.72**	**0.72**	**0.79**
5:00 PM	PM	85.8%	0.62	0.62	0.68
6:00 PM	PM	54.4%	0.39	0.39	0.43
7:00 PM	PM OFF	41.4%	0.30	0.30	0.33
8:00 PM	PM OFF	34.1%	0.25	0.25	0.27
9:00 PM	PM OFF	26.9%	0.20	0.20	0.21
10:00 PM	PM OFF	17.3%	0.13	0.13	0.14
11:00 PM	PM OFF	7.6%	0.05	0.05	0.06
2018 Daily Vehicle Hours Traveled (VHT)			**7.6**	**7.6**	**8.7**
2018 Annual Vehicle Hours Traveled (VHT)			**2777.3**	**2777.3**	**3160.5**

2040 Vehicle Hours Traveled (VHT)

Time Period	Grouping	Percent of Grouping by Volume	2040 No Build (Veh-Hr)	2040 ALT 1 Total Delay (Veh-Hr)	2040 ALT 2 Total Delay (Veh-Hr)
12:00 AM	AM OFF	5.1%	0.04	0.04	0.04
1:00 AM	AM OFF	4.5%	0.03	0.03	0.04
2:00 AM	AM OFF	3.9%	0.03	0.03	0.03
3:00 AM	AM OFF	11.0%	0.08	0.08	0.09
4:00 AM	AM OFF	18.2%	0.13	0.13	0.15
5:00 AM	AM OFF	25.3%	0.18	0.18	0.20
6:00 AM	AM	70.5%	0.50	0.50	0.57
7:00 AM	**AM**	**100.0%**	**0.70**	**0.70**	**0.80**
8:00 AM	AM	81.2%	0.57	0.57	0.65
9:00 AM	AM	74.9%	0.53	0.53	0.60
10:00 AM	AM	74.5%	0.53	0.53	0.60
11:00 AM	OFF	94.3%	0.51	0.51	0.57
12:00 PM	OFF	104.9%	0.57	0.57	0.63
1:00 PM	**OFF**	**100.0%**	**0.54**	**0.54**	**0.60**
2:00 PM	PM	71.0%	0.65	0.65	0.67
3:00 PM	PM	88.9%	0.81	0.81	0.84
4:00 PM	**PM**	**100.0%**	**0.91**	**0.91**	**0.95**
5:00 PM	PM	85.8%	0.78	0.78	0.81
6:00 PM	PM	54.4%	0.50	0.50	0.52
7:00 PM	PM OFF	41.4%	0.38	0.38	0.39
8:00 PM	PM OFF	34.1%	0.31	0.31	0.32
9:00 PM	PM OFF	26.9%	0.25	0.25	0.26
10:00 PM	PM OFF	17.3%	0.16	0.16	0.16
11:00 PM	PM OFF	7.6%	0.07	0.07	0.07
2040 Daily Vehicle Hours Traveled (VHT)			**9.7**	**9.7**	**10.6**
2040 Annual Vehicle Hours Traveled (VHT)			**3550.3**	**3550.3**	**3860.7**

Present Value Crash Benefit - 2042 Forecast

Year	Annual Crash Cost			Crash Benefit			Present Value Crash Benefit		
	No Build (0.9% Growth)	Alt 1 (0.9% Growth)	Alt 2 (0.9% Growth)	No Build (0.9% Growth)	Alt 1 (0.9% Growth)	Alt 2 (0.9% Growth)	No Build (0.9% Growth)	Alt 1 (0.9% Growth)	Alt 2 (0.9% Growth)
2018	$ 61,660	$ 61,660	$ 61,660	$ -	$ -	$ -	$ -	$ -	$ -
2019	$ 62,513	$ 62,513	$ 62,513	$ -	$ -	$ -	$ -	$ -	$ -
2020	$ 63,366	$ 63,366	$ 63,366	$ -	$ -	$ -	$ -	$ -	$ -
2021	$ 64,219	$ 64,219	$ 64,219	$ -	$ -	$ -	$ -	$ -	$ -
2022	$ 65,072	$ 53,480	$ 17,070	$ -	$ 11,592	$ 48,003	$ -	$ 11,008	$ 45,586
2023	$ 65,925	$ 54,002	$ 17,237	$ -	$ 11,923	$ 48,688	$ -	$ 11,178	$ 45,643
2024	$ 66,778	$ 54,523	$ 17,405	$ -	$ 12,255	$ 49,374	$ -	$ 11,341	$ 45,692
2025	$ 67,631	$ 55,045	$ 17,572	$ -	$ 12,586	$ 50,059	$ -	$ 11,498	$ 45,732
2026	$ 68,485	$ 55,567	$ 17,740	$ -	$ 12,918	$ 50,745	$ -	$ 11,650	$ 45,763
2027	$ 69,338	$ 56,088	$ 17,907	$ -	$ 13,249	$ 51,430	$ -	$ 11,795	$ 45,786
2028	$ 70,191	$ 56,610	$ 18,075	$ -	$ 13,581	$ 52,116	$ -	$ 11,935	$ 45,801
2029	$ 71,044	$ 57,131	$ 18,242	$ -	$ 13,912	$ 52,802	$ -	$ 12,070	$ 45,808
2030	$ 71,897	$ 57,653	$ 18,410	$ -	$ 14,244	$ 53,487	$ -	$ 12,199	$ 45,807
2031	$ 72,750	$ 58,174	$ 18,577	$ -	$ 14,575	$ 54,173	$ -	$ 12,323	$ 45,799
2032	$ 73,603	$ 58,696	$ 18,745	$ -	$ 14,907	$ 54,858	$ -	$ 12,441	$ 45,784
2033	$ 74,456	$ 59,218	$ 18,912	$ -	$ 15,238	$ 55,544	$ -	$ 12,555	$ 45,761
2034	$ 75,309	$ 59,739	$ 19,080	$ -	$ 15,570	$ 56,229	$ -	$ 12,663	$ 45,731
2035	$ 76,162	$ 60,261	$ 19,247	$ -	$ 15,901	$ 56,915	$ -	$ 12,767	$ 45,695
2036	$ 77,015	$ 60,782	$ 19,415	$ -	$ 16,233	$ 57,601	$ -	$ 12,866	$ 45,652
2037	$ 77,868	$ 61,304	$ 19,582	$ -	$ 16,564	$ 58,286	$ -	$ 12,960	$ 45,602
2038	$ 78,721	$ 61,825	$ 19,750	$ -	$ 16,896	$ 58,972	$ -	$ 13,050	$ 45,546
2039	$ 79,574	$ 62,347	$ 19,917	$ -	$ 17,227	$ 59,657	$ -	$ 13,135	$ 45,485
2040	$ 80,427	$ 62,868	$ 20,085	$ -	$ 17,559	$ 60,343	$ -	$ 13,216	$ 45,417
2041	$ 81,281	$ 63,390	$ 20,252	$ -	$ 17,890	$ 61,028	$ -	$ 13,292	$ 45,343
2042	$ 82,134	$ 63,912	$ 20,420	$ -	$ 18,222	$ 61,714	$ -	$ 13,365	$ 45,264
	$ 1,797,420	**$ 1,484,374**	**$ 645,395**	**$ -**	**$ 313,046**	**$ 1,152,025**	**$ -**	**$ 259,305**	**$ 958,699**

Discount Rate	1.3%
Current Year	2018

TH 61 & CSAH 9 --- Benefit / Cost Analysis for Alternative Traditional Intersection w/ Realignment - 2042 Forecast

BASE 2018	Total
DELAY (Stop)	2,777

2040 No Improvement	Total	2018 No Improvement	Total
DELAY (Stop)	3,550	DELAY (Stop)	2,777

2040 Improvement	Total	2018 Improvement	Total
DELAY (Alt)	3,550	DELAY (Alt)	2,777

2040 Changes:	Total	
DELAY	-	0.0%

	COST ITEM				
	1	2	3	4	5
Category	Roadway	Bridge	Traffic Signal Lighting	Contingency Construciton Costs	ROW
Capital Value ($)	710,300	$0	$30,000	$ 385,000	$0
Remaining Life (%)-20yr	38%	75%	23%	38%	89%
Remaining Life (%)-5yr	0%	0%	0%	0%	0%
Remaining Cap. Value	$ 269,914	$ -	$ 6,900	$ 146,300	$ -

Note: Assume Expected Life of 30 Years. Analysis Period is 20 years (assume 20 year capital value, remaining life values).

B/C Analysis Summary

BENEFITS		*Value(Discounted)*
1. Travel Time Savings:	$	-
TOTAL	$	-

COSTS		*Value(Discounted)*
1. Roadway/Interchange	$	(710,300)
2. Bridges	$	-
3. Traffic Signal/Lighting	$	(46,630)
4. Contingency Costs	$	(385,000)
5. Right-of-way (ROW)	$	-
Remaining Capital	$	326,790
TOTAL	$	(815,140)

Benefit/Cost Analysis Results

20-Yr Operation Benefit	$	-
20-Yr Safety Benefit	$	259,305
COSTS	$	815,140
B/C Ratio*:		**0.318**

Cost Category	Improvement Description	Estimated NA	Estimated Layout: Roundabout	Estimated NA
1	Roadway Paving	$0	$456,300	$0
1	Drainage and Erosion	$0	$92,000	$0
1	Misc	$0	$162,000	$0
2	Bridge	$0	$0	$0
2				
3	Traffic Signal/Lighting	$0	$30,000	$0
4				
4				
	Total Estimated Construction Co:	$0	$740,300	$0
4	Indirect Costs & Contingency	$0	$222,000	$0
5	Right-of-Way/Easement Costs	$0	$0	$0
4	Professional Services	$0	$163,000	$0
	Total Project Costs	$0	$1,125,300	$0

TH 61 & CSAH 9 --- Benefit / Cost Analysis for Alternative Traditional Intersection w/ Realignment - 2042 Forecast

BENEFIT 1: Travel Time Savings (VHT)

YEAR	Annual VHT: 2040 No Improvement	Annual VHT: 2040 Improvement	Annualized Savings: Improvement w/ VHT Savings	Annualized Savings: '00 cost per hour $ 18.30	Discounted Value (1.3%)
2018	2,777	2,777	-	$0	$0
2019	2,812	2,812	-	$0	$0
2020	2,848	2,848	-	$0	$0
2021	2,883	2,883	-	$0	$0
2022	2,918	2,918	-	$0	$0
2023	2,953	2,953	-	$0	$0
2024	2,988	2,988	-	$0	$0
2025	3,023	3,023	-	$0	$0
2026	3,058	3,058	-	$0	$0
2027	3,094	3,094	-	$0	$0
2028	3,129	3,129	-	$0	$0
2029	3,164	3,164	-	$0	$0
2030	3,199	3,199	-	$0	$0
2031	3,234	3,234	-	$0	$0
2032	3,269	3,269	-	$0	$0
2033	3,304	3,304	-	$0	$0
2034	3,339	3,339	-	$0	$0
2035	3,375	3,375	-	$0	$0
2036	3,410	3,410	-	$0	$0
2037	3,445	3,445	-	$0	$0
2038	3,480	3,480	-	$0	$0
2039	3,515	3,515	-	$0	$0
2040	3,550	3,550	-	$0	$0
2041	3,585	3,585	-	$0	$0
2042	3,621	3,621	-	$0	$0
TOTAL				$ -	$ -

COST 1: Roadways/Interchange Construction

YEAR	CHANGE with Improvement	Discounted Value (1.3%)
2018		
2019		
2020		
2021		
2022	$ (710,300)	(710,300)
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ (710,300)	$ (710,300)

COST 2: Bridge

YEAR	CHANGE with Improvement	Discounted Value (1.3%)
2017		-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

Note: Trucks on average account for approximately 5% of network traffic . Passenger vehicle occupancy assumed to be 1.31

MnDOT Office of Investment Management, Benefit Cost Analysis Trucks (Value of Time) $ 29.40

Standard Values, Appendix A, Fiscal Year 2015

COST 3: Traffic Signal / Maintenance & Operation

YEAR	CHANGE with Improvement	Discounted Value (1.3%)
2018		
2019		
2020		
2021		
2022	$ (30,000)	(30,000)
2023	$ (1,000)	(937)
2024	$ (1,000)	(925)
2025	$ (1,000)	(914)
2026	$ (1,000)	(902)
2027	$ (1,000)	(890)
2028	$ (1,000)	(879)
2029	$ (1,000)	(868)
2030	$ (1,000)	(856)
2031	$ (1,000)	(845)
2032	$ (1,000)	(835)
2033	$ (1,000)	(824)
2034	$ (1,000)	(813)
2035	$ (1,000)	(803)
2036	$ (1,000)	(793)
2037	$ (1,000)	(782)
2038	$ (1,000)	(772)
2039	$ (1,000)	(762)
2040	$ (1,000)	(753)
2041	$ (1,000)	(743)
2042	$ (1,000)	(733)
TOTAL	$ (50,000)	$ (46,630)

COST 4: Contingency Construction Costs

YEAR	CHANGE with Improvement	Discounted Value (1.3%)
2018		
2019		
2020		
2021		
2022	$ (385,000)	(385,000)
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ (385,000)	$ (385,000)

COST 5: Right of Way (ROW)

YEAR	CHANGE with Improvement	Discounted Value (1.3%)
2018		-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ -	$ -

Note: Assume operation, power and maintenance cost of the traffic signal and lighting system to be $1,000 per year.

Remaining Capital Value

YEAR	Remaining Capital Value	Discounted Value (1.3%)
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ 423,114	326,790
TOTAL	$ 423,114	$ 326,790

TH 61 & CSAH 9 --- Benefit / Cost Analysis for Alternative RCI - 2042 Forecast

BASE 2018	Total
DELAY (Stop)	2,777

2040 No Improvement	Total	2018 No Improvement	Total
DELAY (Stop)	3,550	DELAY (Stop)	2,777

2040 Improvement	Total	2018 Improvement	Total
DELAY (Alt)	3,861	DELAY (Alt)	3,161

2040 Changes:	Total	
DELAY	310	8.7%

	COST ITEM				
	1	2	3	4	5
Category	Roadway	Bridge	Traffic Signal Lighting	Contingency Construciton Costs	ROW
Capital Value ($)	1,074,200	$0	$100,000	$ 612,000	$0
Remaining Life (%)-20yr	38%	75%	23%	38%	89%
Remaining Life (%)-5yr	0%	0%	0%	0%	0%
Remaining Cap. Value	$ 408,196	$ -	$ 23,000	$ 232,560	$ -

Note: Assume Expected Life of 30 Years. Analysis Period is 20 years (assume 20 year capital value, remaining life values).

B/C Analysis Summary

BENEFITS		Value(Discounted)
1. Travel Time Savings:	$	(144,264)
TOTAL	$	(144,264)

COSTS		Value(Discounted)
1. Roadway/Interchange	$	(1,074,200)
2. Bridges	$	-
3. Traffic Signal/Lighting	$	(116,630)
4. Contingency Costs	$	(612,000)
5. Right-of-way (ROW)	$	-
Remaining Capital	$	512,648
TOTAL	$	(1,290,182)

Benefit/Cost Analysis Results

20-Yr Operation Benefit	$	(144,264)
20-Yr Safety Benefit	$	958,699
COSTS	$	1,290,182
B/C Ratio*:		0.631

Cost Category	Improvement Description	Estimated NA	Estimated Layout: Roundabout	Estimated NA
1	Roadway Paving	$0	$681,200	$0
1	Drainage and Erosion	$0	$136,000	$0
1	Misc	$0	$257,000	$0
2	Bridge	$0	$0	$0
2				
3	Traffic Signal/Lighting	$0	$100,000	$0
4				
4				
	Total Estimated Construction Co:	$0	$1,174,200	$0
4	Indirect Costs & Contingency	$0	$352,000	$0
5	Right-of-Way/Easement Costs	$0	$0	$0
4	Professional Services	$0	$260,000	$0
	Total Project Costs	$0	$1,786,200	$0

TH 61 & CSAH 9 --- Benefit / Cost Analysis for Alternative RCI - 2042 Forecast

BENEFIT 1: Travel Time Savings (VHT)

	Annual VHT		Annualized Savings		
YEAR	2040 No Improvement	2040 Improvement	Improvement w/ VHT Savings	'00 cost per hour $ 18.30	Discounted Value (1.3%)
2018	2,777	2,777	-	$0	$0
2019	2,812	2,812	-	$0	$0
2020	2,848	2,848	-	$0	$0
2021	2,883	2,883	-	$0	$0
2022	2,918	3,288	(370)	($8,971)	-$8,519
2023	2,953	3,320	(367)	($8,890)	-$8,334
2024	2,988	3,351	(363)	($8,810)	-$8,153
2025	3,023	3,383	(360)	($8,730)	-$7,975
2026	3,058	3,415	(357)	($8,650)	-$7,801
2027	3,094	3,447	(353)	($8,569)	-$7,629
2028	3,129	3,479	(350)	($8,489)	-$7,461
2029	3,164	3,511	(347)	($8,409)	-$7,295
2030	3,199	3,542	(344)	($8,329)	-$7,133
2031	3,234	3,574	(340)	($8,249)	-$6,974
2032	3,269	3,606	(337)	($8,168)	-$6,817
2033	3,304	3,638	(334)	($8,088)	-$6,664
2034	3,339	3,670	(330)	($8,008)	-$6,513
2035	3,375	3,702	(327)	($7,928)	-$6,365
2036	3,410	3,733	(324)	($7,847)	-$6,219
2037	3,445	3,765	(320)	($7,767)	-$6,077
2038	3,480	3,797	(317)	($7,687)	-$5,937
2039	3,515	3,829	(314)	($7,607)	-$5,800
2040	3,550	3,861	(310)	($7,526)	-$5,665
2041	3,585	3,893	(307)	($7,446)	-$5,532
2042	3,621	3,924	(304)	($7,366)	-$5,403
TOTAL				$ (171,534)	$ (144,264)

COST 1: Roadways/Interchange Construction

YEAR	CHANGE with Improvement	Discounted Value (1.3%)
2018		
2019		
2020		
2021		
2022	$ (1,074,200)	(1,074,200)
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ (1,074,200)	$ (1,074,200)

COST 2: Bridge

YEAR	CHANGE with Improvement	Discounted Value (1.3%)
2017		-
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
TOTAL	$ -	$ -

Note: Trucks on average account for approximately 5% of network traffic . Passenger vehicle occupancy assumed to be 1.31

MnDOT Office of Investment Management, Benefit Cost Analysis

Trucks (Value of Time) $ 29.40

Standard Values, Appendix A, Fiscal Year 2015

COST 3: Traffic Signal / Maintenance & Operation

YEAR	CHANGE with Improvement	Discounted Value (1.3%)
2018		
2019		
2020		
2021		
2022	$ (100,000)	(100,000)
2023	$ (1,000)	(937)
2024	$ (1,000)	(925)
2025	$ (1,000)	(914)
2026	$ (1,000)	(902)
2027	$ (1,000)	(890)
2028	$ (1,000)	(879)
2029	$ (1,000)	(868)
2030	$ (1,000)	(856)
2031	$ (1,000)	(845)
2032	$ (1,000)	(835)
2033	$ (1,000)	(824)
2034	$ (1,000)	(813)
2035	$ (1,000)	(803)
2036	$ (1,000)	(793)
2037	$ (1,000)	(782)
2038	$ (1,000)	(772)
2039	$ (1,000)	(762)
2040	$ (1,000)	(753)
2041	$ (1,000)	(743)
2042	$ (1,000)	(733)
TOTAL	$ (120,000)	$ (116,630)

COST 4: Contingency Construction Costs

YEAR	CHANGE with Improvement	Discounted Value (1.3%)
2018		
2019		
2020		
2021		
2022	$ (612,000)	(612,000)
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ (612,000)	$ (612,000)

COST 5: Right of Way (ROW)

YEAR	CHANGE with Improvement	Discounted Value (1.3%)
2018		-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ -	-
TOTAL	$ -	$ -

Remaining Capital Value

YEAR	Remaining Capital Value	Discounted Value (1.3%)
2018	$ -	-
2019	$ -	-
2020	$ -	-
2021	$ -	-
2022	$ -	-
2023	$ -	-
2024	$ -	-
2025	$ -	-
2026	$ -	-
2027	$ -	-
2028	$ -	-
2029	$ -	-
2030	$ -	-
2031	$ -	-
2032	$ -	-
2033	$ -	-
2034	$ -	-
2035	$ -	-
2036	$ -	-
2037	$ -	-
2038	$ -	-
2039	$ -	-
2040	$ -	-
2041	$ -	-
2042	$ 663,756	512,648
TOTAL	$ 663,756	$ 512,648

Note: Assume operation, power and maintenance cost of the traffic signal and lighting system to be $1,000 per year.