Intersection Control Evaluation

Fall 2007

Office of
Traffic,
Safety,
& Operations

TABLE OF CONTENTS

1. INTRODUCTION 1-1
1.1 Background 1-1
1.2 Definition 1-1
1.3 Purpose 1-1
1.4 General Information 1-1

2. TYPES OF INTERSECTIONS 2-1
2.1 Multi-way Stop Control 2-1
2.1.1 Advantages 2-2
2.1.2 Disadvantages 2-2
2.2 Traffic Signals 2-3
2.2.1 Advantages 2-5
2.2.2 Disadvantages 2-5
2.3 Roundabouts 2-6
2.3.1 Advantages 2-7
2.3.2 Disadvantages 2-8
2.4 Non-traditional Intersections (Indirect Left-Turn Treatments) 2-8
2.4.1 Superstreet Intersection (J-Turn Intersection) 2-9
2.4.2 Jughandle Intersection 2-10
2.4.3 Quadrant Intersection 2-11
2.4.4 Median U-Turn Intersection 2-12
2.4.5 Continuous Flow Intersection 2-14
2.4.6 Split Intersection 2-16
2.4.7 Bowtie Intersection 2-17
2.4.8 Continuous Green T-Intersection 2-18
2.4.9 Paired Intersections 2-19
2.4.10 Echelon Interchange 2-20
2.4.11 Center Turn Overpass Interchange 2-21
2.5 Grade Separation 2-23

3. THE ICE PROCESS 3-1
3.1 Phase I – Scoping 3-2
3.1.1 Identify Intersections 3-2
3.1.2 Collect Data 3-2
3.1.3 Perform Warrant Analysis & Justification 3-3
3.1.4 Metro Traffic Signal Justification Methodology 3-5
3.1.5 Analyze Alternatives 3-9
3.1.6 Recommend Alternatives 3-11
3.2 Phase II – Alternative Selection 3-11
3.2.1 Prepare Conceptual Designs 3-11
3.2.2 Identify Right-of-Way Requirements 3-11
3.2.3 Develop Cost Estimates 3-11
3.2.4 Political/Public Considerations 3-11
3.2.5 Reevaluate Alternatives 3-11
3.2.6 Approve Staff Layout 3-11
3.3 Approval & Report 3-12
3.3.1 Write Report 3-12
3.3.2 DTE Approval 3-13

4. CASE STUDY 4-1
4.1 Description of Location 4-3
4.2 Existing Conditions 4-3
4.3 Future Conditions 4-7
4.4 Analysis of Alternatives 4-7

4.4.1 Traffic Safety Analysis 4-7
4.4.2 Traffic Signal Warrant Analysis 4-9
4.5 Section 5 – Alternatives Analysis 4-11
4.5.1 TH 901 & TH 902 South Intersection Analysis 4-12
4.5.2 TH 901 & TH 902 North Intersection Analysis 4-14
4.5.3 TH 902 & Local Road 1 Intersection Analysis 4-16
4.5.4 TH 902 & County Road Intersection Analysis 4-18
4.5.5 Network Analysis 4-20
4.6 Conclusion 4-21
4.7 Supporting Documentation 4-21

5. ICE CHECKLIST 5-1

6. APPENDIX 6-1
6.1 ICE Guidelines for Implementation (Draft) 6-2
6.2 Sample ICE Report 1 6-3
6.3 Sample ICE Report 2 6-4

LIST OF FIGURES

Figure 1 – Roundabout with Key Elements 2-6
Figure 2 – Superstreet Intersection 2-9
Figure 3 – Near-Side Jughandle Intersections 2-10
Figure 4 – Far-Side Jughandle Intersection 2-11
Figure 5 – Quadrant Intersection 2-12
Figure 6 – Median U-Turn Intersection 2-13
Figure 7 – Median U-Turn Intersection with Narrow Median 2-13
Figure 8 – Continuous Flow Intersection 2-15
Figure 9 – Split Intersection 2-16
Figure 10 – Bowtie Intersection 2-17
Figure 11 – Channelized and non-channelized Continuous Green T-Intersections 2-18
Figure 12 – Paired Intersections 2-19
Figure 13 – Echelon Interchange 2-20
Figure 14 – Center Turn Overpass Interchange 2-21
Figure 15 – The ICE Process 3-1
Figure 16 – Study Area 4-3
Figure 17 – Existing Geometrics 4-4
Figure 18 – Existing Traffic Counts 4-5
Figure 19 – Study Area AADT 4-6

LIST OF TABLES

Table 1 – Potential Intersection Control by ADT Volumes 1-2
Table 2 – Right Turn Capacity 3-7
Table 3 – Warrant 1 3-8
Table 4 – Anytown Traffic Signal Warrant Analysis Summary 4-10
Table 5 – Level of Service Descriptions 4-10

1. INTRODUCTION

1.1 Background

Engineers have an increasing number of options for intersection traffic control. Previously, the only solution to traffic delay and safety problems for at grade intersections was the installation of a traffic signal. Currently, other options including roundabouts, reduced access intersections, and higher capacity intersections are acceptable alternatives to the designer. Previously, Signal Justification Reports (SJR's) must have been completed before a new signal or significant modification of a signal could proceed (MN MUTCD May 2005 and Mn/DOT Traffic Engineering Manual updated July 1, 2003). The SJR is straight-forward but does not consider other alternatives that include, but are not limited to: All-Way Stop Control (AWSC), traffic signals, roundabouts, access management, grade separation and non-traditional designs (i.e., continuous flow intersection (CFI), Median U-turn, Superstreet, etc.).

1.2 Definition

Intersection Control Evaluation, or ICE, is a process that identifies the best intersection control through a comprehensive analysis and documentation of the technical (safety and operational), economic, and political issues of viable alternatives.

1.3 Purpose

The goal of ICE is to select the optimal control for an intersection based on an objective analysis for the existing conditions and future needs. ICE would replace the current process.

In order to determine the optimal intersection control strategy, the overall design of the intersection must be considered. The flexibility of significant change in intersection design will largely be decided by the scope and location of the project. Some general objectives for good intersection design that should be considered are:

- Provide adequate sight distance
- Minimize points of conflict
- Simplify conflict areas
- Limit conflict frequency
- Minimize the severity of conflicts
- Minimize delay
- Provide acceptable capacity

The purpose of the ICE report is to document all of the analysis (technical, financial, political) that went into determining the recommended alternative. Early decisions help limit scope creep. The ICE process will help collaborate with local agencies and considers all options on an equal basis.

1.4 General Information

All intersection treatments must be considered as early in the project development process as feasible. This could occur during planning or corridor studies but no later than the scoping portion of an improvement project. A corridor analysis will be necessary for some projects. This will depend on the location of the intersection in relation to adjacent intersections and the respective traffic control of each.

An ICE is not required for intersections that are determined to need minimal traffic control (two way stop or no control). However, for any other type of control (All-way stop, roundabout, traffic signal, median treatment to reduce traffic movements or other advanced traffic control systems such as continuous flow intersections) an ICE report is required for intersections on trunk highways.

Generally, intersection improvement projects are developed as a portion of a much larger project or as a safety or capacity project at a specific location. For smaller projects, the proposed intersection traffic control modification is usually the major component of these types of projects and the ICE process will have a major impact in the development process. However, as part of a larger project, intersection control treatments may be a much smaller component and other project decisions will have more impact on how ICE will proceed. It is important to emphasize that the ICE process occur as early in the project development process as practical so that the project proceeds smoothly.

ICE is conducted in two phases (refer to section 3). If only one alternative is viable at the conclusion of Phase I, the evaluation is complete and it is unnecessary to proceed to Phase II. The report should document the Phase I analysis. For evaluations completed as a portion of a planning or corridor study, a Phase I analysis may be sufficient until specified projects are further defined. Depending on a project's complexity and scope, a detailed ICE report may be unnecessary. The District Traffic Engineer in coordination with District management can reduce the amount of analysis and documentation if a preferred alternative is obvious. However, these decisions should be documented in the modified ICE report.

An ICE must be written under the supervision of a licensed Professional Engineer in the State of Minnesota and approved by the District Traffic Engineer before the preliminary plan is finalized. Each district can require additional review and approvals, if it is desired.

All projects programmed for fiscal year 2008 and beyond must have an ICE completed.

Table 1 is included as a guide to assist in determining which intersection options should be evaluated based upon combined average daily traffic (ADT) volumes. The values are approximate and if an intersection is near a range change, consideration should be given to evaluating traffic control for both ranges. The ICE process is detail oriented and will have high resource demands. The process should only be done for intersections in which traffic control other than a two-way stop is required. As a guide, if the ADT for the minor leg or the intersection is less than 1000 ADT, an ICE is not required.

Table 1 – Potential Intersection Control by ADT Volumes

APPROXIMATE COMBINED ADT	FOUR WAY STOP	SIGNAL	ROUNDABOUT	NON-TRADITIONAL INTERSECTION	ACCESS MANAGEMENT TREATMENTS	GRADE SEPARATION
7500 - 10000	X		X		X	
10000 - 50000	X	X	X	X	X	X
50000 - 80000		X	X	X	X	X
> 80000						X

2. TYPES OF INTERSECTIONS

Engineers can select from a number of different alternatives for intersection control. Each type of control has advantages and disadvantages. Additionally, some types of control are not as common in Minnesota as traditional traffic control methods (roundabouts versus traffic signals). Each type of control should also be acceptable to the public, the local governmental unit, and the local road authority. Some types of traffic control with a few of their associated advantages and disadvantages are listed below. This is not intended to be an all-inclusive list of options. Depending on the existing circumstances and problems at a certain location, an entirely different or unique solution may be preferred and/or justified.

2.1 Multi-way Stop Control

Multi-way stop control can be useful as a safety measure at intersections if certain traffic conditions exist. Safety concerns associated with multi-way stops include pedestrians, bicyclists, and all road users expecting other road users to stop. Multi-way stop control is used where the volume of traffic on the intersecting roads is approximately equal.

The restrictions on the use of STOP signs described in Section 2B.5 of the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) also apply to multi-way stop applications.

The decision to install multi-way stop control should be based on an engineering study. The following criteria should be considered in the engineering study for a multi-way STOP sign installation:

A. Where traffic control signals are justified, the multi-way stop is an interim measure that can be installed quickly to control traffic while arrangements are being made for the installation of the traffic control signal.

B. A crash problem, as indicated by 5 or more reported crashes in a 12-month period that are susceptible to correction by a multi-way stop installation. Such crashes include right- and left-turn collisions as well as right-angle collisions.

C. Minimum volumes:

   1. The vehicular volume entering the intersection from the major street approaches (total of both approaches) averages at least 300 vehicles per hour for any 8 hours of an average day, and

   2. The combined vehicular, pedestrian, and bicycle volume entering the intersection from the minor street approaches (total of both approaches) averages at least 200 units per hour for the same 8 hours, with an average delay to minor-street vehicular traffic of at least 30 seconds per vehicle during the highest hour, but

   3. If the 85th-percentile approach speed of the major street traffic exceeds 40 mph, the minimum vehicular volume warrants are 70 percent of the above values.

D. Where no single criterion is satisfied, but where Criteria B, C.1, and C.2 are all satisfied to 80 percent of the minimum values. Criterion C.3 is excluded from this condition.

Other criteria that may be considered in an engineering study include:

A. The need to control left-turn conflicts;

B. The need to control vehicle/pedestrian conflicts near locations that generate high pedestrian volumes;

C. Locations where a road user, after stopping, cannot see conflicting traffic and is not able to reasonably safely negotiate the intersection unless conflicting cross traffic is also required to stop; and

D. An intersection of two residential neighborhood collector (through) streets of similar design and operating characteristics where multi-way stop control would improve traffic operational characteristics of the intersection.

A Flashing Beacon is a highway traffic signal with one or more signal sections that operates in a flashing mode. It can provide traffic control when used as an intersection control beacon or warning in alternative uses.

An Intersection Control Beacon shall consist of two or more signal faces mounted overhead directed toward each approach to an intersection to supplement an all-way stop sign configuration. Each signal face shall consist of one or more signal sections of a standard traffic signal face, with flashing CIRCULAR RED signal indications in each signal face.

Application of Intersection Control Beacon signal indications shall be limited to Red for all approaches.

A STOP sign shall be used on approaches to which a flashing red signal indication is shown on an Intersection Control Beacon.

Supplemental signal indications may be used on one or more approaches in order to provide adequate visibility to approaching road users.

Intersection Control Beacons may be used at intersections where traffic or physical conditions do not justify conventional traffic control signals but crash rates indicate the possibility of a special need.

An Intersection Control Beacon is generally located over the center of an intersection; however, it may be used at other suitable locations.

Studies have shown that at locations having flashing CIRCULAR YELLOW signal indications for the major approach and flashing CIRCULAR RED signal indications for the minor approach, drivers facing the flashing red on the minor approach may assume that the major approach is also displaying a flashing red, and could pull out in front of a conflicting vehicle.

If there is a need for warning at a two-way stop intersection, a warning beacon in an Intersection Ahead (W2 series) sign for the major approach and/or a stop beacon with the Stop sign for the minor approach may be appropriate.

A Stop Beacon shall consist of one or more signal sections of a standard traffic signal face with a flashing CIRCULAR RED signal indication in each signal section. If two horizontally aligned signal lenses are used, they shall be flashed simultaneously to avoid being confused with a highway-rail grade crossing flashing-light signals. If two vertically aligned signal lenses are used, they shall be flashed alternately.

2.1.1 Advantages

- Provide for orderly flow of traffic
- Reduce the severity and frequency of right angle and left turn crashes
- Relatively inexpensive and quick to implement

2.1.2 Disadvantages

- Some types of crashes will increase
- Limited to lower volume intersections
- Increases delay to all legs of the intersection
- Works best with single lane approaches
- Total intersection capacity is limited
- Providing for U turns can be difficult and may be prohibited

Information in this section was taken from the MN MUTCD, 2005.

2.2 Traffic Signals

A traffic control signal (traffic signal) shall be defined as any highway traffic signal by which traffic is alternately directed to stop and permitted to proceed.

Traffic signals are a common form of traffic control used by State and local agencies to address roadway operations. They allow the shared use of road space by separating conflicting movements in time and allocating delay. They can also be used to enhance the mobility of some movements as, for example, along a major arterial.

In some cases, the dual objectives of mobility and safety conflict. To meet increasing and changing demands, one element may need to be sacrificed to some degree to achieve improvements in another. In all cases, it is important to understand the degree to which traffic signals are providing mobility and safety for each mode of transportation. An engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location shall be performed to determine whether installation of a traffic control signal is justified at a particular location. The investigation of the need for a traffic control signal shall include an analysis of the applicable factors contained in the following traffic signal warrants and other factors related to existing operation and safety at the study location:

- Warrant 1, Eight-Hour Vehicular Volume.
- Warrant 2, Four-Hour Vehicular Volume.
- Warrant 3, Peak Hour.
- Warrant 4, Pedestrian Volume.
- Warrant 5, School Crossing.
- Warrant 6, Coordinated Signal System.
- Warrant 7, Crash Experience.
- Warrant 8, Roadway Network.

The satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic control signal (**refer to Metro Traffic Signal Justification Report on page 3-5**). A traffic control signal should not be installed unless an engineering study indicates that installing a traffic control signal will improve the overall safety and/or operation of the intersection. A traffic control signal should not be installed if it will seriously disrupt progressive traffic flow.

As with the installation of a traffic control signal, a comprehensive investigation and engineering study shall be completed to determine whether to remove or to retain a traffic control signal. The failure to satisfy any warrant is not in itself justification for removal of a signal. Information should be obtained by means of engineering studies and compared with the requirements in “User Guide For Removal Of Not Needed Traffic Signals”, Implementation Package, FHWA-IP-80-12, November, 1980 (see Government Printing Office, page ii).

The engineering study should indicate whether the removal or retention of a traffic control signal will improve the overall safety and/or operation of the intersection. The need for retaining or removing a traffic control signal may be determined by the following criteria:

1. A signalized intersection that does not meet 80 percent of the volume requirements of Warrant 1, but meets 60 percent of the volume requirements of Warrant 1 may be considered for removal. Engineering studies, findings, judgement, and documentation will be needed to justify retaining the traffic control signal.
2. A signalized intersection that does not meet 60 percent of the volume requirements of Warrant 1 and meets no other warrant should be considered not warranted and should be removed from operation.

Other reasons may also be considered for removing a traffic control signal in addition to the volume parameters described above. Such reasons may include improvement of traffic operations, safety, and traffic control signal spacing considerations.

The decision to remove a traffic control signal shall follow the process a set forth in the "User Guide For Removal Of Not Needed Traffic Signals", Implementation Package, FHWA-IP-80-12, November, 1980 (see Government Printing Office, page ii). This decision must consider all study findings and engineering judgement. If the engineering study indicates that the traffic control signal is no longer justified, removal may be accomplished using the following steps:

A. Determine the appropriate traffic control to be used after removal of the signal.

B. Remove any sight-distance restrictions as necessary.

C. Inform the public of the removal study, for example by installing an informational sign (or signs) with the legend TRAFFIC SIGNAL UNDER STUDY FOR REMOVAL at the signalized location in a position where it is visible to all road users.

D. Flash or cover the signal heads for a minimum of 90 days, and install the appropriate stop control or other traffic control devices.

E. Remove the signal if the engineering data collected during the removal study period confirms that the signal is no longer justified. Instead of total removal of the traffic control signal, the poles and cables may remain in place for 1 year after removal of the signal heads for continued analysis.

Since vehicular delay and the frequency of some types of crashes are sometimes greater under traffic signal control than under STOP sign control, consideration should be given to providing alternatives to traffic control signals even if one or more of the signal warrants has been satisfied. These alternatives may include, but are not limited to, the following:

A. Installing signs along the major street to warn road users approaching the intersection;

B. Relocating the stop line(s) and making other changes to improve the sight distance at the intersection;

C. Installing measures designed to reduce speeds on the approaches;

D. Installing a flashing beacon at the intersection to supplement STOP sign control;

E. Installing flashing beacons on warning signs in advance of a STOP sign controlled intersection on major- and/or minor-street approaches;

F. Adding one or more lanes on a minor-street approach to reduce the number of vehicles per lane on the approach;

G. Revising the geometrics at the intersection to channelize vehicular movements and reduce the time required for a vehicle to complete a movement, which could also assist pedestrians;

H. Installing roadway lighting if a disproportionate number of crashes occur at night;

I. Restricting one or more turning movements, perhaps on a time-of-day basis, if alternate routes are available;

J. If the warrant is satisfied, installing multi-way STOP sign control;

K. Installing a roundabout intersection; and

L. Employing other alternatives, depending on conditions at the intersection.

2.2.1 Advantages

When properly used, traffic control signals are valuable devices for the control of vehicular and pedestrian traffic. They assign the right-of-way to the various traffic movements and thereby profoundly influence traffic flow. Traffic control signals that are properly designed, located, operated, and maintained will have one or more of the following advantages:

- Provide for orderly flow of traffic
- Works extremely well in coordinated systems
- At times it may reduce the severity and frequency of right angle and left turn crashes
- Excellent for emergency vehicles if pre-emption devices are installed
- Interrupt heavy traffic to allow non-motorized traffic to cross
- Delay can be minimized for specific traffic movements

2.2.2 Disadvantages

Traffic control signals are often considered a panacea for all traffic problems at intersections. This belief has led to traffic control signals being installed at many locations where they are not needed, adversely affecting the safety and efficiency of vehicular, bicycle, and pedestrian traffic. Traffic control signals, even when justified by traffic and roadway conditions, can be ill-designed, ineffectively placed, improperly operated, or poorly maintained. Improper or unjustified traffic control signals can result in one or more of the following disadvantages:

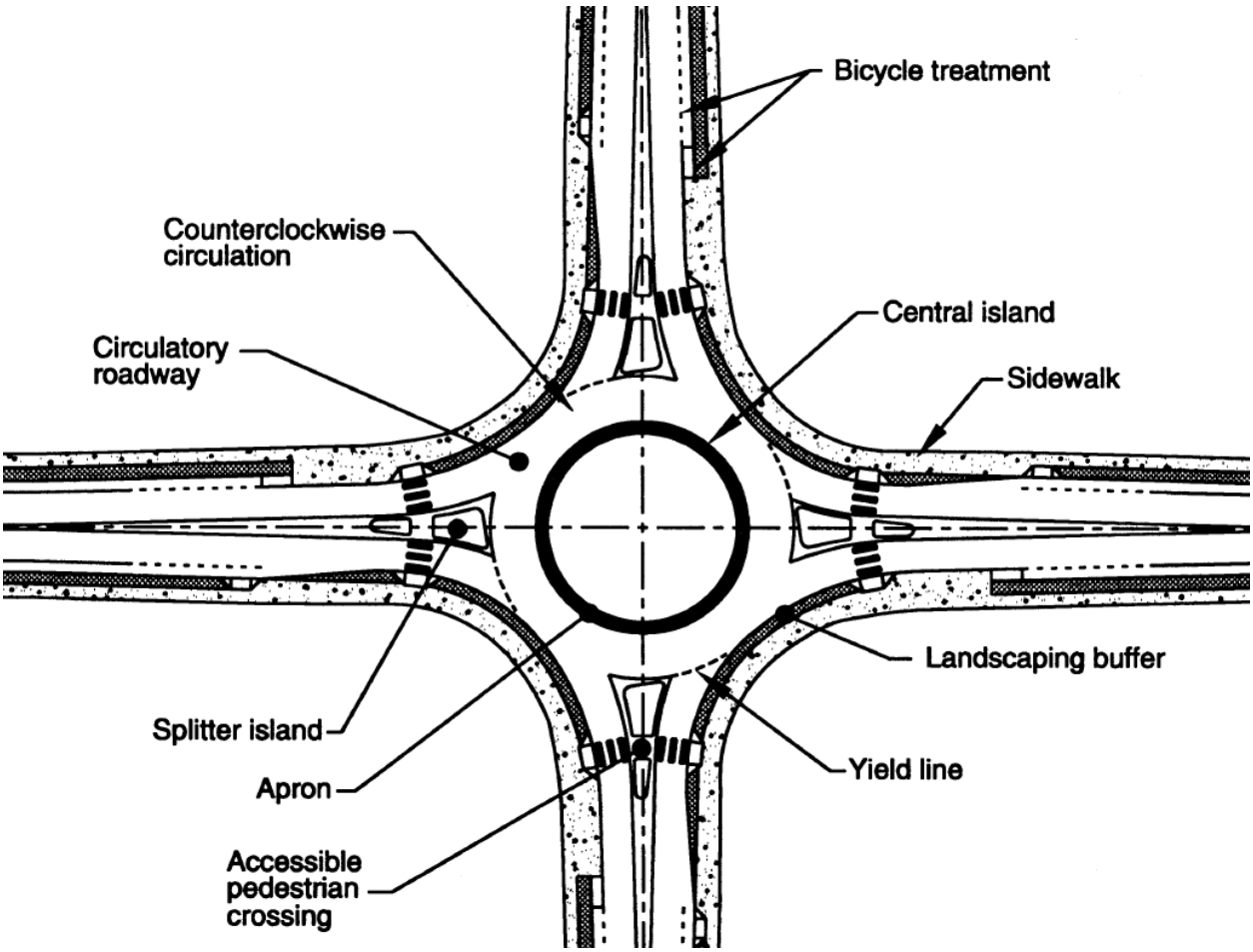
- Significant increase in crash frequency (e.g. rear end collisions)
- Costly to install
- Requires considerable maintenance
- May increase vehicular delay and traffic queues (primarily mainline traffic)
- Higher traffic volumes increase size of intersection and number of lanes prior to intersection
- May require additional right of way beyond intersection for additional turn lanes
- Decreased efficiency with high left turning volumes
- Providing for U turns can be difficult and may be prohibited

Information in this section was taken from the MUTCD, 2005 and Signalized Intersections: Informational Guide (FHWA,2004).

2.3 Roundabouts

Roundabouts are circular intersections with specific design and traffic control features. These features include field control of all entering traffic, channelized approaches, and appropriate geometric curvature to ensure that travel speeds on the circulatory roadway are typically less than 50 km/h (30 mph). Figure 1 illustrates a typical roundabout with four legs.

Figure 1 – Roundabout with Key Elements



A roundabout is a type of circular intersection, but not all circular intersections can be classified as roundabouts. Besides roundabouts, there are at least two other distinct types of circular intersections:

- Rotaries are old-style circular intersections common to the United States prior to the 1960's. Rotaries are characterized by a large diameter, often in excess of 100 m (300 ft). This large diameter typically results in travel speeds within the circulatory roadway that exceed 50 km/h (30 mph). They typically provide little or no horizontal deflection of the paths of through traffic and may even operate according to the traditional "yield-to-the-right" rule, i.e., circulating traffic yields to entering traffic.
- Neighborhood traffic circles are typically built at the intersections of local streets for reasons of traffic calming and/or aesthetics. The intersection approaches may be uncontrolled or stop-controlled. They do not typically include raised channelization to guide the approaching driver onto the circulatory roadway. At some traffic circles, left-turning movements are allowed to occur to the left of (clockwise around) the central island, potentially conflicting with other circulating traffic.

Roundabouts have been categorized according to size and environment to facilitate discussion of specific performance or design issues. There are six basic categories based on environment, number of lanes, and size:

- Mini-roundabouts
- Urban compact roundabouts
- Urban single-lane roundabouts
- Urban double-lane roundabouts
- Rural single-lane roundabouts
- Rural double-lane roundabouts

In most cases, designers should anticipate the needs of pedestrians, bicyclists, and large vehicles. Whenever a raised splitter island is provided, there should also be an at-grade pedestrian refuge. In this case, the pedestrian crossing facilitates two separate moves: curb-to-island and island-to-curb. The exit crossing will typically require more vigilance from the pedestrian and motorist than the entry crossing. Further, it is recommended that all urban crosswalks be marked. Under all urban design categories, special attention should be given to assist pedestrian users who are visually impaired or blind, through design elements. For example, these users typically attempt to maintain their approach alignment to continue across a street in the crosswalk, since the crosswalk is often a direct extension of the sidewalk. A roundabout requires deviation from that alignment, and attention needs to be given to providing appropriate informational cues to pedestrians regarding the location of the sidewalk and the crosswalk, even at mini-roundabouts. For example, appropriate landscaping is one method of providing some information. Another is to align the crosswalk ramps perpendicular to the pedestrian's line of travel through the pedestrian refuge.

Table summarizes and compares some fundamental design and operational elements for each of the six roundabout categories.

Table 3 – Basic Design Characteristics for each Roundabout Category

Design Element	Mini-Roundabout	Urban Compact	Urban Single-Lane	Urban Double-Lane	Rural Single-Lane	Rural Double-Lane
Recommended maximum entry design speed	25 km/h (15 mph)	25 km/h (15 mph)	35 km/h (20 mph)	40 km/h (25 mph)	40 km/h (25 mph)	50 km/h (30 mph)
Maximum number of entering lanes per approach	1	1	1	2	1	2
Typical inscribed circle diameter[1]	13 m to 25 m (45 ft to 80 ft)	25 to 30 m (80 to 100 ft)	30 to 40 m (100 to 130 ft)	45 to 55 m (150 to 180 ft)	35 to 40 m (115 to 130 ft)	55 to 60 m (180 to 200 ft)
Splitter island treatment	Raised if possible, crosswalk cut if raised	Raised, with crosswalk cut	Raised, with crosswalk cut	Raised, with crosswalk cut	Raised and extended, with crosswalk cut	Raised and extended, with crosswalk cut
Typical daily service volumes on 4-leg roundabout (veh/day)	10,000	15,000	20,000	Refer to Chapter 4 procedures	20,000	Refer to Chapter 4 procedures

1. Assumes 90-degree entries and no more than four legs.

2.3.1 Advantages

- Provide for orderly flow of traffic
- Works extremely well in series (multiple roundabouts along corridors)
- Minimizes the severity and frequency of most crash types
- Provide the least amount of vehicular conflict points
- Lifecycle costs are less than traffic signals

- Width of approach legs can be minimized
- Comparable if not greater capacity than other alternatives
- U turns are easily handled
- Works well with high percentages of left turning traffic
- Works well at diamond interchange termini
- Typically less delay than other types of intersection control
- Handles multiple legs and skewed intersections better than other types of intersection control
- Excellent for access controlled corridors or with areas using right-in/right-out accesses

2.3.2 Disadvantages

- May need additional right of way at intersection
- Operates poorly if the geometrics are not designed properly
- Typically requires additional features such as landscaping, lighting, and truck aprons
- Typically requires more initial design effort than other intersection types
- May operate very poorly if intersection is near signalized or all-way stop controlled intersections
- Works best with single lane approaches
- May operate poorly if traffic volumes are greatly unbalanced
- May hinder efficient traffic flow in a coordinated signal system
- May be infeasible in areas of steep terrain where grades at the intersection cannot maintain less than 4% slope at the approaches and exits
- May not function properly if located on the crest of a vertical curve

Information in this section was taken from Roundabouts: An Informational Guide (FHWA, 2000).

2.4 Non-traditional Intersections (Indirect Left-Turn Treatments)

Indirect left turns can improve the safety and operations of high-volume intersections. These designs remove the left-turning vehicles from the traffic stream without causing them to slow down or stop in a through-traffic lane, thereby reducing the potential for delay and rear-end crashes. Right-angle crashes are also likely to decrease after indirect left-turn treatments are implemented. Such treatments are effective on divided highways with medians too narrow to accommodate left turn lanes with sufficient storage capacity.

In some cases, it is possible to implement indirect left turns using appropriate signing. Implementation costs and time could be quite high, however, if right-of-way needs to be acquired to construct indirect left turns. Care should be taken to ensure that safety problems are not transferred to nearby intersections if drivers choose alternative routes. Clear signing is a necessity for indirect left-turn designs, especially if there are not similar treatments at other intersections in an area.

Advantages of non-traditional intersections include:

- Usually reduce vehicular conflicts
- Increased capacity beyond traditional signalized intersection
- May reduce overall delay
- Reduce crashes by eliminating vehicular conflicts
- Provides refuge for pedestrians crossing roadway
- Minimize additional traffic control (signal may not be needed)

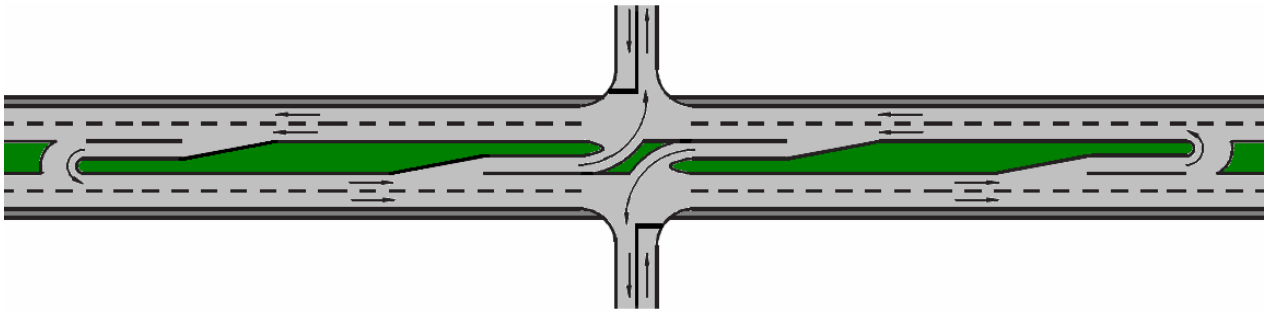
Disadvantages of non-traditional intersections include:

- Much higher cost than traditional signalized intersections
- Usually requires additional right of way
- Reduces choices for drivers and may cause confusion
- May increase delay at adjacent intersections
- May not be politically acceptable
- Increases U-turn volumes at adjacent intersections

2.4.1 Superstreet Intersection (J-Turn Intersection)

The super-street median crossover design (also know as a J-Turn or ¾ Intersection) improves operation of the major street through movement, and also reduces delay for left turns off the major road. The super-street median crossover, shown in Figure 2, is similar to the median U-turn crossover in that an indirect maneuver is accomplished with a U-turn in the median. With a superstreet median crossover, crossroad drivers cannot proceed straight through the intersection. A through movement is accomplished by turning right onto the major road, turning left through the crossover, and turning right again back onto the minor road. Also, as with the median U-turn design, drivers are not able to turn left from the crossroad onto the major road, and a median U-turn is used to accomplish the left-turn maneuver. Left turns from the major road are direct.

Figure 2 – Superstreet Intersection



The design of a super-street median crossover is similar to that of a median U-turn crossover. Crossovers should be located approximately 180 m (600 ft) from the main intersection. A semi trailer combination design vehicle would need a median width of 18 m (60 ft) to accommodate a U-turn. Additional right-of-way would not be required to construct this treatment where the major streets already have a wide median.

Two two-phase traffic signals are required at the main intersection—one for each minor street approach. Because no minor street through or left-turn movements are allowed, these two signals can operate independently with different signal cycle lengths, if desired. In addition, a traffic signal may be needed at each of the upstream median crossover locations; these signals would also have only two phases. Because the two halves of the intersection operate independently, it is possible to achieve a maximum amount of traffic progression in both directions along the major street.

There are fewer conflict points with this intersection design than with conventional intersections. Though this design may cause confusion for pedestrians, there is less opportunity for conflicts with vehicles. The crossing is a two-stage process.

This design is appropriate in situations where there are high through volumes on the major road but only relatively low volumes of through traffic on the cross road, since this through movement is interrupted. For crossroads with higher through volumes, offset super-street crossover design can be used. With this design, the approaches on the crossroad are offset, and are at the same location as the median crossovers. This allows minor road through vehicles to proceed straight from the crossover to the crossroad without turning.

2.4.1.1 Advantages

- Fewer conflict points.
- Improved delay for major street movements.

2.4.1.2 Disadvantages

- Longer travel distance and time for minor street movements.
- Two-stage pedestrian crossing.
- Potential pedestrian way-finding challenges.
- Wide median required.
- May result in restrictions to access.
- Potential for driver and pedestrian confusion.

Information in this section was taken from Signalized Intersections: Informational Guide (FHWA, 2004).

2.4.2 Jughandle Intersection

As defined in the New Jersey Department of Transportation (NJDOT) design manual, a jughandle is "an at-grade ramp provided at or between intersections to permit the motorists to make indirect left turns and/or U-turns."(144) The NJDOT has used jughandles for years to minimize left turn conflicts at intersections. Other States that have implemented jughandles to a lesser degree include Connecticut, Delaware, Oregon, and Pennsylvania.

Jughandles are one-way roadways in two quadrants of the intersection that allow for removal of left-turning traffic from the through stream without providing left-turn lanes. All turns—right, left, and U-turns—are made from the right side of the roadway. Drivers wishing to turn left exit the major roadway at a ramp on the right and turn left onto the minor road at a terminus separated from the main intersection. Less right-of-way is needed along the roadway because left-turn lanes are unnecessary. However, more right-of-way is needed at the intersection to accommodate the jughandles.

Figure 3 illustrates a jughandle intersection with the ramps located in advance of the intersection. If left-turn movements onto the cross street are problematic, a loop ramp may be constructed beyond the intersection to allow these vehicles to make a right turn onto the cross street, as shown in Figure 4.

Figure 3 – Near-Side Jughandle Intersections

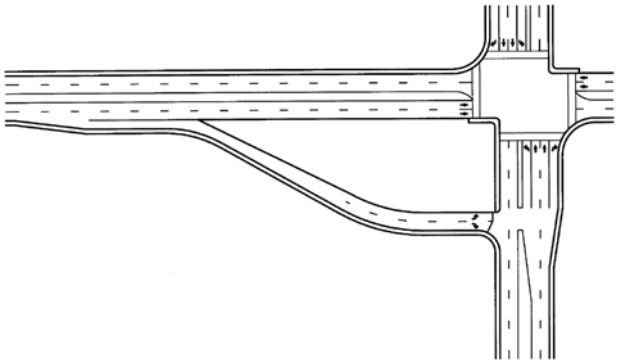
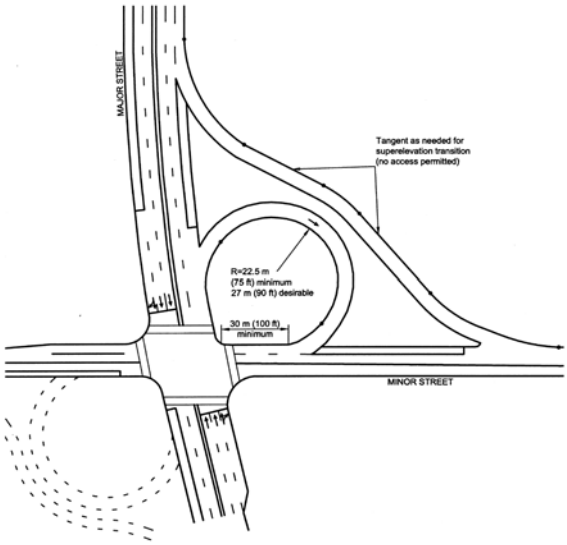


Figure 4 – Far-Side Jughandle Intersection



2.4.2.1 Advantages

- Potential reduction in left-turn collisions
- Potential reduction in overall travel time and stops.
- Pedestrian crossing distance may be less due to lack of left-turn lanes on the major street
- Pedestrian delay may be reduced due to potentially shorter cycle lengths.

2.4.2.2 Disadvantages

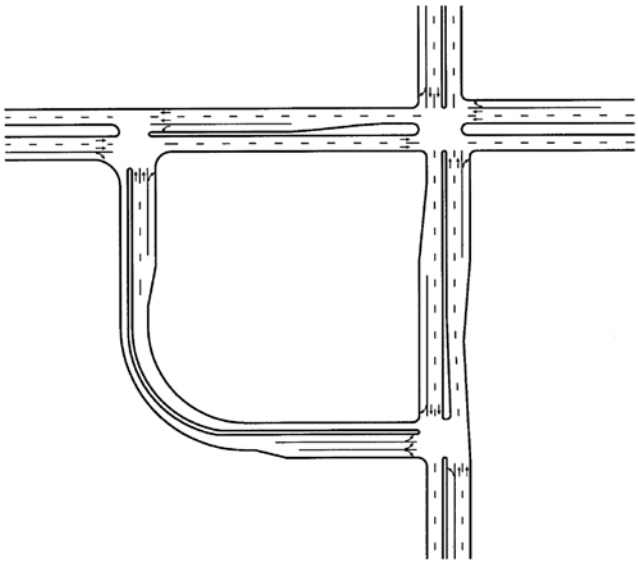
- Longer travel time and more stops for left-turning vehicles using the jughandle.
- Increased exposure for pedestrians crossing the ramp terminal.
- Ramp diverges may create higher speed conflicts between bicyclists and motor vehicles.
- Transit stops may need to be relocated outside the influence area of the intersection.
- Additional right-of-way may be required.
- Education may be needed unless good visual cues are provided.

Information in this section was taken from Signalized Intersections: Informational Guide (FHWA, 2004).

2.4.3 Quadrant Intersection

A quadrant roadway intersection includes an extra roadway between two legs of the intersection and is illustrated in Figure 5. Drivers who wish to turn left from either the major or minor road will travel further to do so, but all left turns will be removed from the main intersection. This design creates two additional intersections, which operate as three-phase signals, but the signal at the main intersection can operate as a two-phase signal. The signals at the quadrant ramps should be located a sufficient distance upstream of the main intersection to eliminate the potential for queue spillback.

Figure 5 – Quadrant Intersection



Intersections of roadways with high through and turn movements may benefit from a quadrant roadway intersection design. If protected left turns at the main intersection are not necessary, more green time can be allocated to the through movements. This application can be useful where right-of-way is limited and there is an existing bypass street on any of the quadrants.

2.4.3.1 Advantages

- Potential major decrease in left turn collisions.
- Potential reduction in delay and queueing.
- Pedestrian crossing distance at each intersection may decrease.

2.4.3.2 Disadvantages

- Potential minor increase in rear-end collisions.
- Number of intersections to cross increases.
- If the quadrant roadway does not exist, may be high construction and right-of-way costs.
- Greater potential for driver confusion.

Information in this section was taken from Signalized Intersections: Informational Guide (FHWA, 2004).

2.4.4 Median U-Turn Intersection

Median U-turn crossovers eliminate left turns at intersections and move them to median crossovers beyond the intersection. For median U-turn crossovers located on the major road, drivers turn left off the major road by passing through the intersection, making a U-turn at the crossover, and turning right at the cross road. Drivers wishing to turn left onto the major road from the cross street turn right onto the major road and make a U-turn at the crossover.
Figure 6 illustrates a median U-turn configuration, and Figure 7 illustrates some of the vehicle movements at such an intersection.

Figure 6 – Median U-Turn Intersection

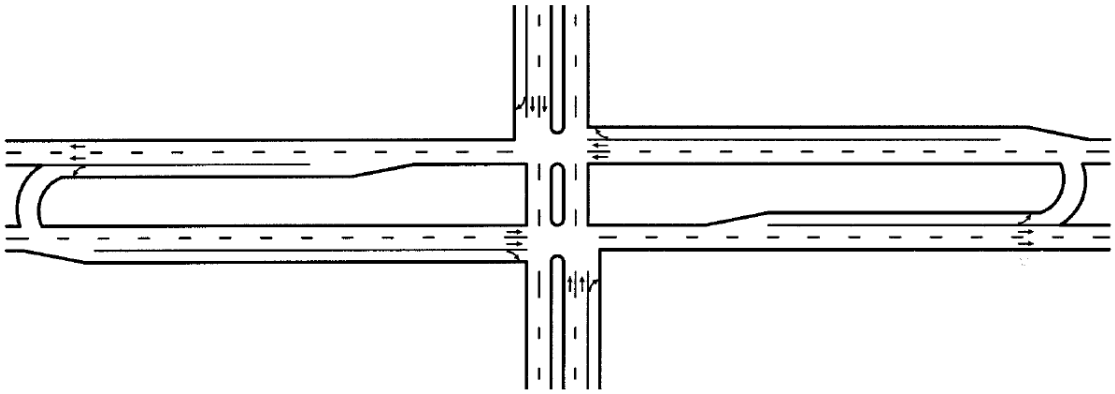
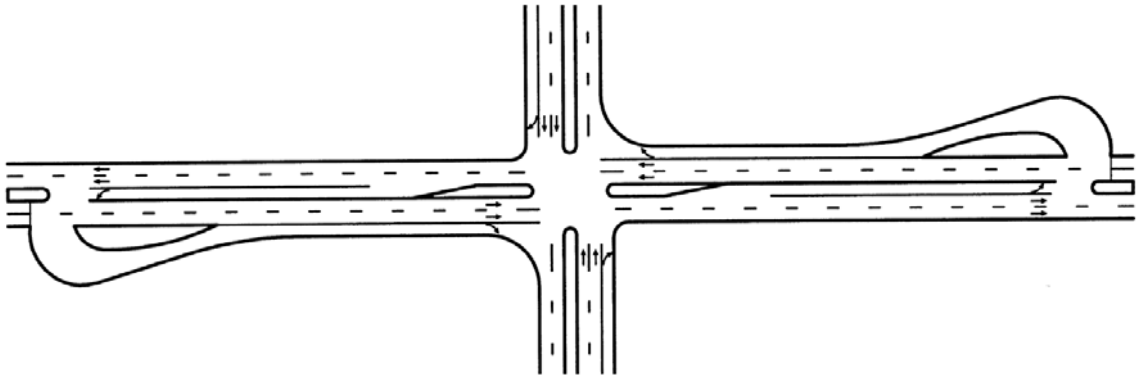


Figure 7 – Median U-Turn Intersection with Narrow Median



The median crossover may also be located on the minor road. In this case, drivers wishing to turn left from the major road turn right on the minor road, and left through the median crossover. Minor road vehicles turn left onto the major road by proceeding through the intersection, making a U-turn, and turning right at the major road. Median U-turn crossovers also may be provided on both the major and minor roads at an intersection.

Median U-turn crossovers are very common in Michigan, and drivers are very familiar with them. They have been in use for more than 30 years, and the signing has evolved to become more user friendly.

2.4.4.1 Advantages

- Potential major reduction in left-turn collisions
- Potential reduction merging/diverging collisions.
- Potential reduction in overall travel time.
- Reduction in stops for mainline through movements.
- Mixed findings with respect to overall stops.
- Number of conflicting movements at intersections is reduced.

2.4.4.2 Disadvantages

- Mixed findings with respect to overall stops.
- Increased pedestrian crossing distance.

- Turning paths of the median u-turn may encroach on bike lanes.
- May be additional right-of-way needs depending on the width of existing median.
- Access may beed to be restricted within the influence of the median u-turn locations.
- Enforcement and education may be necessary to prevent illegal left turns at the main intersections.

Information in this section was taken from Signalized Intersections: Informational Guide (FHWA, 2004).

2.4.5 Continuous Flow Intersection

Continuous flow intersections (CFI), both full and partial, have recently been constructed in a small number of locations in the United States. Although too new for a full evaluation of the effect on operations and safety, continuous flow intersections are gaining in popularity. CFI are also sometimes referred to as crossover-displaced left-turn (XDL) intersections.

A CFI removes the conflict between left-turning vehicles and oncoming traffic by introducing a left-turn bay placed to the left of oncoming traffic. Vehicles access the left-turn bay at a midblock signalized intersection on the approach where continuous flow is desired. Figure 8 shows the design of a CFI with crossover displaced left turns. As can be seen, the left turns potentially stop three times: once at the midblock signal on approach, once at the main intersection, and once at the midblock signal on departure. However, careful signal coordination can minimize the number of stops. Note that this section describes an at-grade CFI; a grade-separated version of the CFI was patented (U.S. Patent No. 5,049,000), but the patent expired in 2003.

Figure 8 – Continuous Flow Intersection

The complete CFI design operates as a set of two-phase signals. As part of the first phase, traffic is permitted to enter the left-turn bay by crossing the oncoming traffic lanes during the signal phase serving cross-street traffic. The second signal phase, which serves through traffic, also serves the protected left-turn movements. Intersections with high through and left-turn volumes may be appropriate sites for continuous flow intersections. There should be a low U-turn demand because U-turns are restricted with this design. Right-of-way adjacent to the intersection is needed for the left-turn ramps. Left-turning vehicles make more stops than at conventional intersections, and may experience a slightly higher delay. Through traffic benefits greatly from this design.

2.4.5.1 Advantages

- Left turns removed from main intersection.
- More green time for through movements.
- No conflicts during pedestrian crossing.
- Smaller footprint than interchange alternative.
- Air quality.

2.4.5.2 Disadvantages

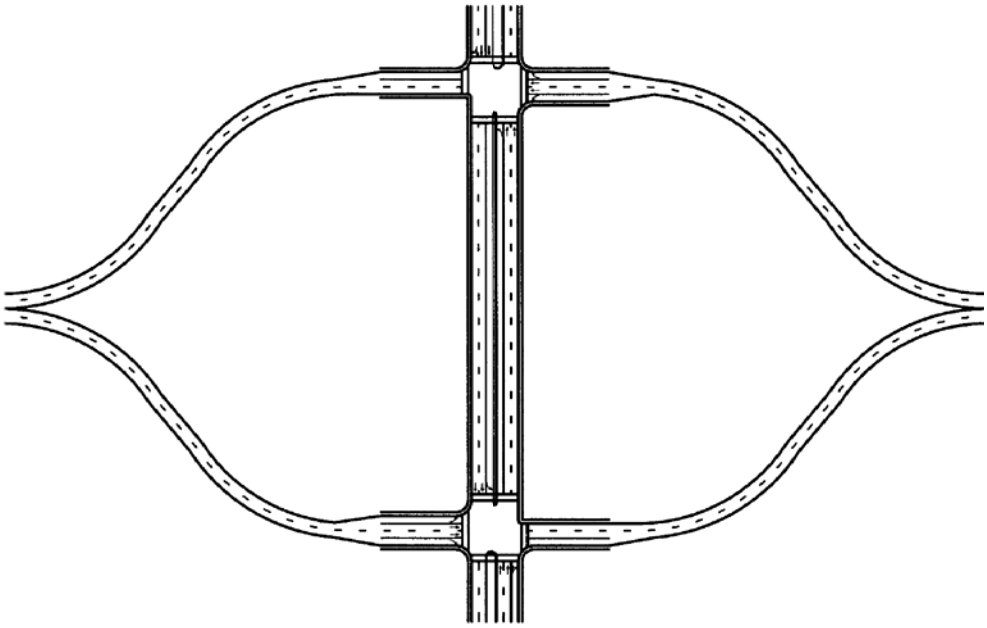
- More stops and delay for left turn movements.
- Two-stage pedestrian crossing.
- Layout may not be immediately apparent especially for visually impaired pedestrians.
- Right-of-way needed.
- Larger footprint than conventional intersection.
- Access management.
- Construction cost.
- Public information campaign may be needed.

Information in this section was taken from Signalized Intersections: Informational Guide (FHWA, 2004).

2.4.6 Split Intersection

A split intersection, shown in Figure 9, requires that the major road approaches to an intersection be converted into two one-way streets. Essentially, the split intersection becomes an at-grade diamond configuration. Rather than one intersection that would operate as a four-phase signal (assuming protected left-turn phasing), two intersections are created that can operate as three-phase signals. The split intersection can be a potential “stage” to constructing a diamond (or other) interchange. The split intersection facilitates smoother traffic flows with less delay and also may improve safety by reducing the number of intersection conflict points.

Figure 9 – Split Intersection



A split intersection may be considered where significant delays or a high number of left-turn collisions occur.

2.4.6.1 Advantages

- Reduced left-turn collisions.
- More green time for through movements.
- Shorter pedestrian crossing distance.

- Preliminary stage to grade separation.

2.4.6.2 Disadvantages

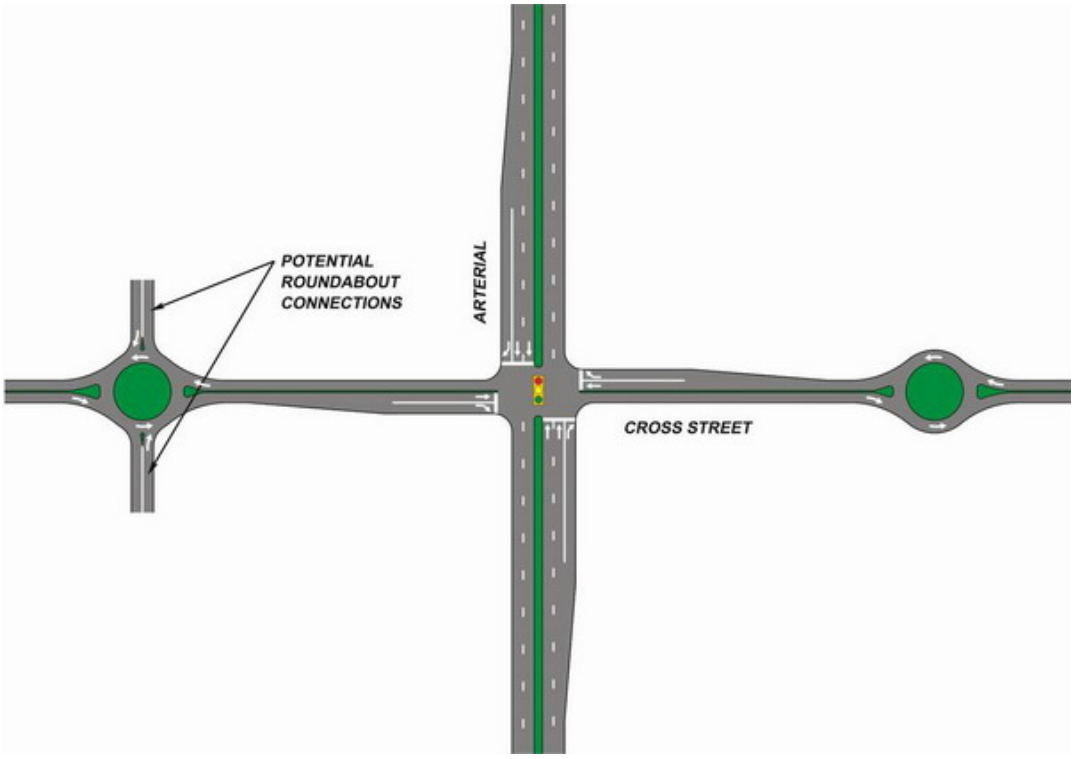
- Wrong way movements.
- May not be perceived as being pedestrian friendly.
- High initial construction costs.
- Right-of-way requirements.

Information in this section was taken from Signalized Intersections: Informational Guide (FHWA, 2004).

2.4.7 Bowtie Intersection

Roundabouts on the cross-street are used to accommodate arterial and cross-street left turns. Arterial left turns turn right at the cross-street and use the roundabout to "double back" thru the main intersection. Left turns at the main intersection are prohibited, eliminating the left turn bays and reducing right-of-way requirements. The main intersection operates under a simple two-phase signal control. Figure 10 illustrates this intersection.

Figure 10 – Bowtie Intersection



Joseph Hummer, a professor at North Carolina State University in Raleigh, and graduate student Jonathan Boone first conceived of the Bowtie Intersection in a 1992-research report. The Bowtie alternative was inspired by the raindrop interchange concept popular in England. The concept is also similar to the Median U-Turn design with directional crossovers on the cross street. The 1992 study and other subsequent studies using microsimulation analysis have found the Bowtie Intersection can have modest travel timesaving over conventional intersections for some volume combinations. Several state agencies are experimenting with roundabouts on cross streets, several that include turning prohibitions, but as of yet no agency has constructed a full Bowtie design.

Good candidates for Bowtie designs include arterials with narrow or non-existent medians and/or no prospects for obtaining additional right-of-way for widening.

Agencies may consider the Bowtie alternative where high arterial through-volumes conflict with moderate to low cross street through and left-turn volumes. If the left-turn volume is proportionately high, the extra left turn travel distance and potential spillback may outweigh the benefits (or timesaving) for arterial through-traffic. If cross street through-traffic is high, delays caused by the roundabout may also counteract benefits/timesaving for arterial through-traffic.

Roundabouts are not typically used directly on multilane arterial. The Bowtie many not be a preferred alternative if it is anticipated that the cross street will be expanded to a multi-lane facility.

There is no known intentional application of the Bowtie in the US today. Many states have intersections with roundabouts at adjacent intersections but do not limit turns at the main intersection.

The advantages of the Bowtie Intersection relative to the conventional intersection include reduced delay for arterial through-traffic, reduced stops for arterial through-traffic, easier progression for arterial through-traffic, fewer threats to crossing pedestrians, and reduced and separated conflict points.

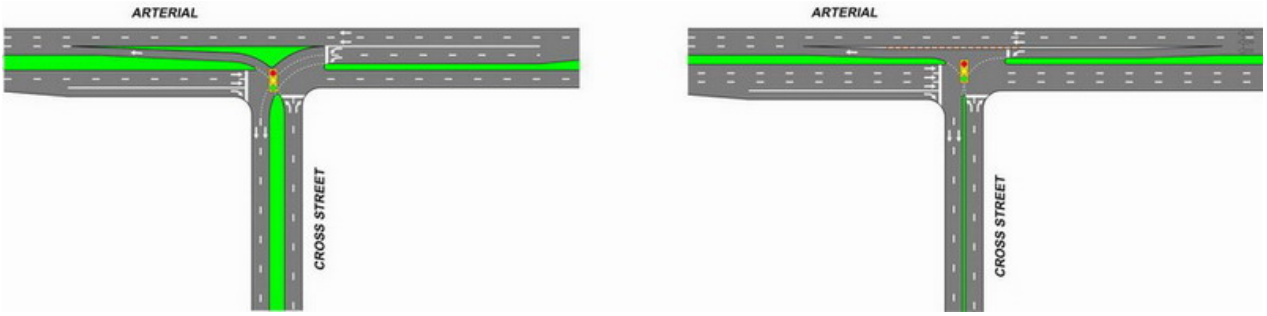
The disadvantages of the Bowtie Intersection relative to conventional intersection include greater potential for driver confusion and driver disregard for the left-turn prohibition at the main intersection, increased distance and possibly delay for left-turning traffic, additional right-of-way needed for the roundabouts, and more circuitous arterial U-turns.

Information in this section was taken from Signalized Intersections: Informational Guide (FHWA, 2004).

2.4.8 Continuous Green T-Intersection

The Continuous Green-T, as shown in Figure 11 can only be used at T-intersections. The design provides free-flow operations in one direction on the arterial and can reduces the number of approach movements that need to stop to three by using free-flow right turn lanes on the arterial and cross streets and acceleration/merge lanes for left turn movements from the cross street.

Figure 11 – Channelized and non-channelized Continuous Green T-Intersections



While most unconventional designs can be evaluated as alternatives at both three- and four-leg intersection approaches, the Continuous Green T-intersection design can only be implemented at T-intersections. Of the states and other jurisdictions that have constructed Continuous Green T-intersections, the state of Florida appears to utilize the design most, with several FDOT districts reporting long-tem experience with the design without significant accident problems. Other states known to implement the Continuous Green T-intersection include: North Carolina, South Carolina, Maryland,

The CGT-intersection has a fairly restricted application niche. Engineers should only consider the CGT at intersections with three approaches, moderate to low left-turn volumes from the cross street, high arterial through-volumes, and where there are few pedestrian crossings and no driveways along the arterial opposite the cross street.

Advantages of the Continuous Green T-intersection (compared to a conventional multiphase signalized T-intersection design) include: significantly reduced intersection delay, narrower right-of-way requirements and free-flow movements for one direction of travel on the arterial.

Disadvantages of the CGT-intersection include: lack of a protected (signalized) pedestrian crossing of the arterial, increased merging or weaving maneuvers, and restricted access to parcels adjacent to the arterial through-lanes.

Many states have isolated applications of the Continuous Green-T intersection, the most prominent probably being Florida.

Information in this section was obtained from the Maryland SHA and the University of Maryland (2007).

2.4.9 Paired Intersections

The Paired Intersection concept alternates prohibited left turn movements from the arterial then the cross street at consecutive intersections along an arterial corridor. Circulation to provide adequate turning movement connection to the cross-streets requires a system of two-way "backage" roads parallel to the arterial. This type of intersection is illustrated in Figure 12.

Figure 12 – Paired Intersections

Edison Johnson, a traffic engineer with the City of Raleigh, North Carolina, conceived of a paired intersection arterial design using directional crossovers in conjunction with parallel collector streets. The concept was born as part of a 1988 study of the US 70 corridor in Raleigh, where conversion to a full-access-control freeway was not politically acceptable. The guiding principles of the paired intersection concept are the separation of left turns and the emphasis of through-vehicle movements. Highway agencies have been prohibiting left turns from or onto arterials for years (particularly in downtown areas), relying on a good parallel street system or frontage roadways to provide circulation. The paired intersection concept allows this to be done in areas without a pre-existing system of parallel streets or frontage roads.

Noted advantages of the paired intersection design compared to conventional design include reduced delay for arterial through-traffic and for some left turns, easier progression for arterial through-traffic, and reduced and separated conflict points.

Noted disadvantages of the paired intersection design compared to conventional design include greater potential for driver and pedestrian confusion, increased travel distances for cross street through- and some left-turning traffic, and potential for driver confusion/route guidance issues on backage roads. There are also additional right-of-way, construction, maintenance and operation costs for the parallel collector/backage roads.

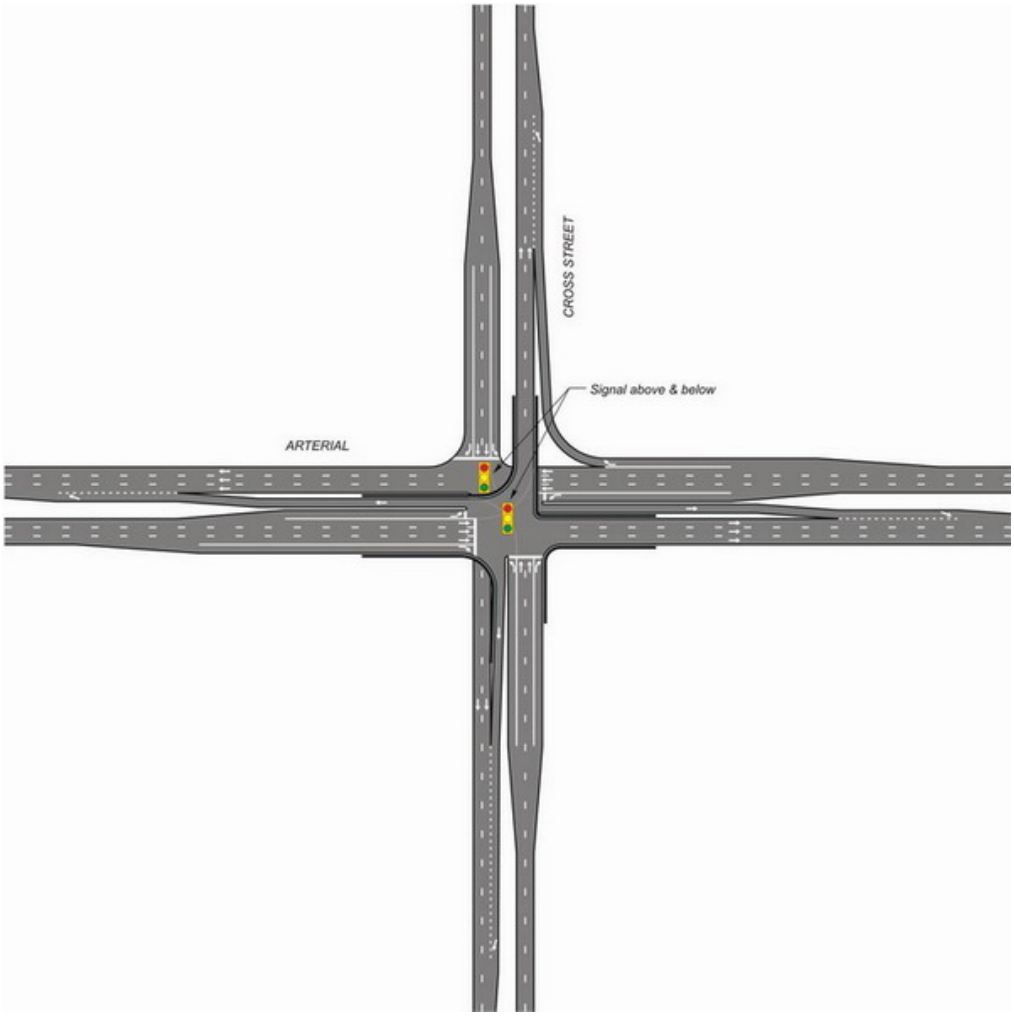
There is no known intentional application of the Paired Intersection in the US today. Many states have corridors with turning movement prohibitions at some intersections and some corridors (US 70 in Raleigh NC) are attempting to piecemeal the concept over time.

Information in this section was obtained from the Maryland SHA and the University of Maryland (2007).

2.4.10 Echelon Interchange

One approach on both the arterial and intersecting cross-street are elevated on structure as they intersect, while the other approach halves intersect at-grade. The result is a symmetrical but offset pair of two-phase intersections separated by grade, both operated by two-phase signals as in the meeting of two one-way streets. This type of interchange is illustrated in Figure 13.

Figure 13 – Echelon Interchange



The Echelon design was born of necessity for a single intersection improvement project at US 1 and NE 203rd Street in Aventura, Florida. This design location, opened in June 2000, is currently the only known application in the world. The Echelon Interchange was so named by the late Don Beccasio of the Florida Department of Transportation's Planning Division, who worked on this initial design application. The design's feature of one intersection offset and over another reminded him of the U.S. Navy Flight Demonstration Team's "Echelon" formation, where each plane flies offset and over one another.

The Echelon interchange has specific application to arterial roadways. The Echelon interchange is unique in that there are no free-flow movements. This interchange would not be suitable on a freeway facility.

The Echelon interchange is a simple concept that uses retaining wall structures to elevate one-half the roadway on each intersection approach to meet at an elevated intersection, while the other halves intersect at-grade. The result is a symmetrical but offset pair of one-way street meetings separated by grade.

The design provides logical movements from each approach and requires little advance signing. Motorists experience the same decision processes as at an intersection of two one-way streets.

The Echelon design very is pedestrian friendly, as all pedestrian movements can be made directly on the at-grade part of the intersection, which operates under two-phase signal control. Shorter signal cycles mean shorter crossing wait times and pedestrians cross only one travel direction.

The Echelon design provides great flexibility for engineers and designers, as any one of the four through-movements and connecting ramps can be placed at-grade or elevated, depending on volume forecasts, right-of-way constraints and/or intersection geometric features (such as a rail crossing or intersection skew).

In a study comparing operations of the Echelon versus the Compressed Diamond and single-point urban interchange (SPUI) designs (using Traf-Netsim), the Echelon was able to process the most vehicles and had no failing LOS, while the Compressed Diamond had two failing LOS approaches under the same volume conditions, and the SPUI had three.

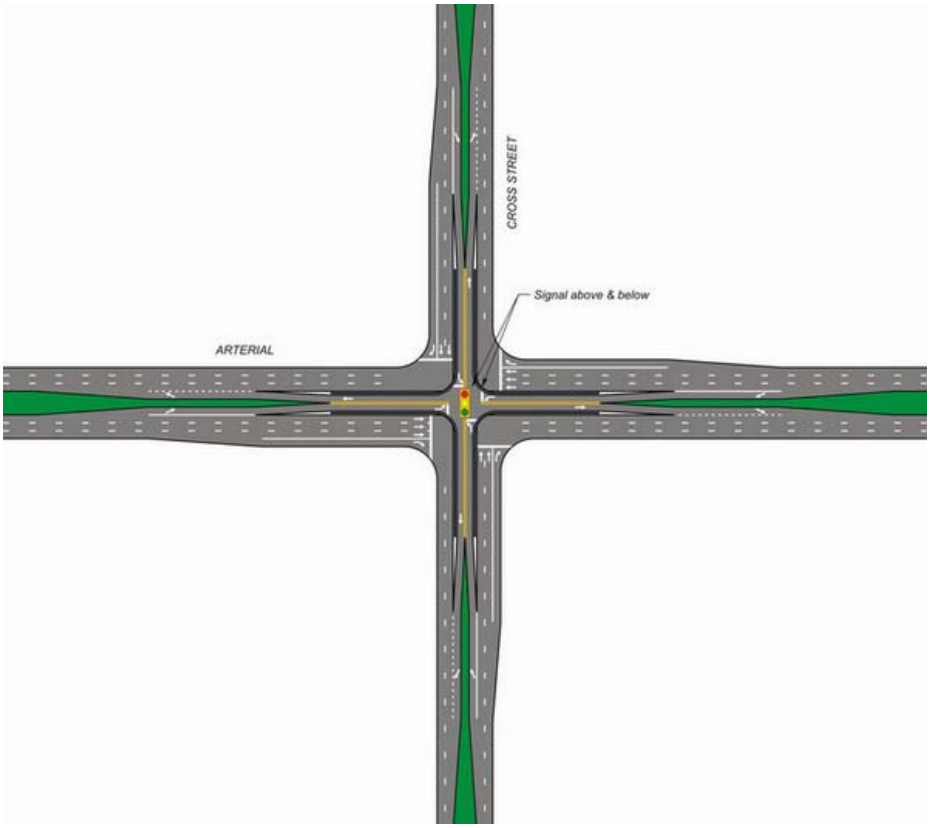
Another second study showed the capacity and delays at the Echelon to be competitive with conventional freeway-style interchanges, and found that bottlenecks were not transferred to the downstream intersection in a signalized network.

Information in this section was obtained from the Maryland SHA and the University of Maryland (2007).

2.4.11 Center Turn Overpass Interchange

Left turn traffic is separated from arterial and cross-street thru and right-turn movements by elevating all left turns to a separate, elevated intersection using narrow ramps within the median. Both the elevated and at-grade intersections are controlled by simple two-phase signal. Left turn traffic descends from the elevated intersection and merges into thru traffic lanes. Figure 14 illustrates this interchange.

Figure 14 – Center Turn Overpass Interchange



Bob Clayton of Clearwater, Florida, conceived of the Center Turn Overpass (CTO), and currently holds U.S. patent No. 5921701 on this design. The CTO design concept is relatively new and is continuing to be refined, and there is currently no design application of its kind in the U.S. Several highway agencies have considered the CTO design (Maryland, Nevada, North Carolina) because of its ability to handle large turning-traffic volumes and minimize impacts to adjacent properties and right-of-way, but so far all have selected to implement a more conventional design or no immediate improvement at all.

The CTO design separates all left-turn movements by grade (on structure) from the main intersection to maximize through and left-turn capacity. Unlike freeway-style flyover designs, the CTO ramps fit vertically within a wide center median, replacing dual left-turn bay slots with two-lane roadways on structure.

The CTO grade separates turning traffic from through and right-turning traffic by elevating left-turn to an intersection on structure directly atop the main intersection. Both the ground and upper level intersections are governed by two-phase signals.

As left-turning traffic is grade-separated from through-traffic, heavy turn volumes are less likely to choke the intersection compared to a conventional at-grade intersection.

The CTO can be simpler to construct than a traditional fly-over overpass. Column and retaining wall supports are confined to the center median, minimizing their impact on the outside right-of-way and adjacent properties.

A minimal CTO approach roadway can be built within a 32-foot median, assuming two 12-foot approach and departure lanes and 2-foot offsets to the outside 2-foot concrete barriers. The ramp design concept is very similar to T-ramp designs on HOV facilities.

In locations with greater concerns about property access, the CTO design could be modified to permit ground-level left turns for direct access to corner parcels. These modifications would also support access by emergency and over-sized vehicles. The U-turns would not have protected signal phases, thus negating some of the benefits of the two-phase intersections.

In a study comparing operations of the CTO to several other arterial interchange designs, the CTO design was found to have considerably greater capacity compared to the traditional Diamond interchange, and had the greatest operational benefits on a six-lane or wider arterial with moderate- to high left-turn volumes.

Capacity studies have shown that the CTO can have up to 75 percent more green time allotted for left turns compared to dual left-turn lanes at a conventional intersection, and ground level through-volumes can receive up to 40 percent more green time.

Pedestrians are accommodated on the ground level and can make one or two-stage crossings. Pedestrian phases are at greater frequency due to shorter cycle lengths, and pedestrian crossing with left-turning vehicles are eliminated by grade.

There has not been a full CTO Intersection design implemented to date in the U.S. by which to draw any specific lessons learned.

In northern climates, snow and ice removal may be problematic, as the slender ramp approaches leave little room for snow on the shoulders, and ice may be a concern on shorter, steeper grades.

Accident response and clearance could also be an issue on minimal width ramp approaches.

Sight distance issues for both the elevated and at-grade roadways can be overcome with a wider, more open structure design made possible using steel construction.

Information in this section was obtained from the Maryland SHA and the University of Maryland (2007).

2.5 Grade Separation

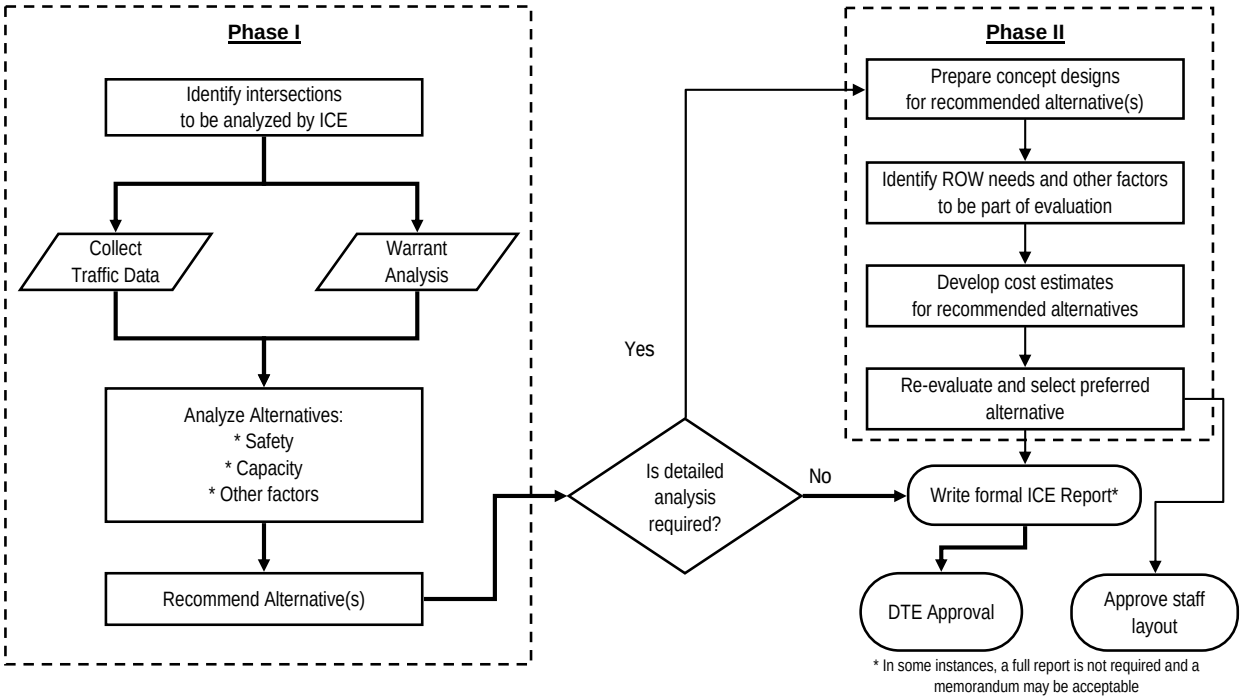
If traffic volumes are so intense that all at grade control options will cause excessive vehicular delay, grade separation may be necessary. Additionally grade separation may be an option in order to solve a safety problem, improve access density, improve connectivity of the minor legs, or provide consistency of traffic control on the mainline. To determine if an interchange will be constructed and what type of interchange to construct should be based on an adopted corridor study or good access management practices.

Table 1 on page 1-2 is included as a guide to assist in determining which intersection options should be evaluated based upon combined average daily traffic (ADT) volumes. The values are approximate and if an intersection is near a range change, consideration should be given to evaluating traffic control for both ranges. The ICE process is detail oriented and will have high resource demands. The process should only be done for intersections in which traffic control other than thru stop is required. As a guide, if the ADT for the minor leg or the intersection is less than 1000 ADT, an ICE is not required.

3. THE ICE PROCESS

The process needed to complete an ICE is highly dependent on two factors. These factors will influence how much effort is involved in completing the study, who is involved in each stage of the study and for what they are accountable. Figure 15 illustrates the ICE process.

Figure 15 – The ICE Process



As shown in Figure 15, the ICE is conducted in two phases. The first phase is usually done very early in the project development process, oftentimes, before a project is programmed. This could occur during planning or corridor studies but no later than the scoping portion of an improvement project. The purpose of the first phase is to recommend one or more traffic control strategies for further development. Under normal circumstances, an ICE would be needed if a safety or capacity problem has been identified, that has an associated infrastructure improvement. An ICE is also required for a new intersection being constructed due to development or expansion of the highway system. The second phase, Alternative Selection, involves other functional units (Design, Land Management, etc) and parallels the process of developing an approved preliminary layout. Based on a number of factors the recommended traffic control is determined in this phase.

Avoid overanalyzing a location. If a decision has been made or one traffic control type will be the choice, document the decision making process and include in a short memo or basic report. It still may be necessary to gather traffic data, conduct a warrant analysis and complete a safety and capacity analysis.

A decision may be reached after Phase 1. It may still be necessary to develop preliminary layouts, cost estimates and other project development tasks, but an ICE report can be completed at this time. However, if the project development process negates what has occurred in Phase 1, it will be necessary to revise the report.

For larger projects in areas where traffic volumes may increase on the local system as well as the arterial, careful consideration should be taken to determine if an ICE is necessary. Relying on future

traffic projections, in which traffic volume warrants are barely met, should not be a requirement to perform an ICE. Generally speaking, if warrants are unlikely to be met within a 5 year time frame, an ICE is unnecessary.

3.1 Phase I – Scoping

The project can originate within Mn/DOT or from an outside jurisdiction. If the project originates from an outside jurisdiction, that entity is responsible for conducting the ICE. It is imperative that Mn/DOT Traffic units be involved early in the process to ensure that the analysis will be accepted and approved. Within Mn/DOT, projects can originate within or outside of Traffic Engineering. For those projects originating within Traffic Engineering, all of the responsibilities in completing the ICE will be coordinated through that unit. For all other projects, Traffic Engineering should be consulted early in the project development process to ensure that an ICE can be completed in a timely manner. For all ICEs completed by outside jurisdictions or consultants, Traffic Engineering is responsible for review and approval.

3.1.1 Identify Intersections

Generally, smaller projects will require less analysis and therefore less documentation. Preservation projects (e.g. signal rebuilds) will require minimal analysis. However, a memo/letter must be submitted for approval. The document should state rationale for the work being done and why other types of traffic control are not being considered. Stand-alone intersections will require safety and capacity analyses as well as documentation of other impacts (cost, ROW, political concerns, etc). The amount of analysis will depend on each project's location and scope. Intersections, which are a part of larger projects, will probably require significant analysis and documentation. Coordination with Traffic Engineering on these projects is important. Making decisions on traffic control earlier in the project development process will improve the quality of the design and minimize conflicts with stakeholders.

3.1.2 Collect Data

For completion of the report, the following data may be required. Some of these requirements can be waived depending on existing conditions and the available improvement alternatives. The District Traffic Engineer must be contacted to approve a change in requirements.

3.1.2.1 Traffic Volumes

- Hourly intersection approach counts (must be less than 2 years old) for 48 hours
- Turning movement counts for the AM and PM peak periods (3 hours each and less than 2 years old)
- Future intersection approach volumes (only needed if Warrant is unmet in existing time period)
- Future turning movement volumes for the AM and PM peak hours using pre- approved growth rates or future modeling parameters
- Pedestrian and bicycle volumes by approach, if applicable

Discuss with the District Traffic Engineer the traffic volume requirements for the particular study.

3.1.2.2 Crash Data

- Crash data for the last three full calendar years (Must be obtained from the Mn/DOT TIS database).
- Crash diagrams must be included in the report. Rationale for crash reductions based on each alternative must be documented. Crash listings should be included in an appendix.

3.1.2.3 Existing Geometrics

- The existing geometrics of the intersection being considered for improvement must be documented. It is preferable to provide a layout or graphical display of the intersections showing lane configurations with existing striping, lane widths, parking lanes, shoulders and/or curb treatments, medians, pedestrian and bicycle facilities, right of way limits and access driveways or adjacent roadways for all approaches. The posted speed limit and the current traffic control of each roadway must also be shown or stated. Adjacent structures, overhead utilities, and vaults should also be outlined such as buildings, bridges, box culverts, power poles, etc.
- A larger scale map showing the intersection in relationship to parallel roadways and its relationship (including distances) to other access points along the corridor is also required.
- The locations of schools or other significant land uses, which may require more specialized treatment for pedestrians or vehicles, should be documented, if applicable.
- Geographic features must be shown if they will influence the selection of an alternative, such as severe grades, wetlands, parkland, etc.

3.1.2.4 Proposed Geometrics/Traffic Control Alternative

A layout or conceptual plan showing the proposed geometrics for the recommended traffic control alternative must be included. An electronic copy of the design is preferred and may be required depending on the intersection alternative. The plan should document all changes from the existing conditions.

3.1.2.5 Capacity Analysis

A summary table of delays for all movements, approaches and overall intersection delay must be provided for AM and PM peak hours, both existing and future conditions, for each alternative analyzed. Software output should be included in an appendix. An electronic copy of the analysis is preferred.

Additional data may be necessary depending on the location and alternatives analyzed. These could include – community considerations (need for parking, sidewalks, bike lanes, etc); future development plans, which may influence access; types of vehicles intersecting roadway, if unusual; transit routes and frequency; compatibility with corridor plans or local transportation plans; Interregional Corridor performance and political considerations.

3.1.3 Perform Warrant Analysis & Justification

In order for the engineer to determine if any traffic control is necessary at an intersection, data must be examined to determine if a “Warrant” is met for the particular intersection control alternative. Even if a “Warrant” is met, it may not be the correct action to take for a given situation. The engineer must determine if the treatment is “Justified.” The “Warrant” and “Justification” process is detailed below.

3.1.3.1 Warrants

The Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) contains warrants for All-way Stops and for Traffic Signals. Generally speaking, warrants are met if the amount of vehicular traffic, crashes, or pedestrians is significant enough to meet minimum levels. These levels are based on research, which documented the conditions where additional traffic control was considered. Information needed to determine if a warrant is met is contained in the MN MUTCD and the Mn/DOT Traffic Engineering Manual.

A Mn/DOT District Traffic Engineer will interpret this information to determine which warrants apply to a given location. For example, refer to the Metro District’s practice on traffic signal justification.

Traffic volumes must be obtained. For most cases existing volumes are preferred. However, future anticipated volumes may be used if development is imminent. For new roadways projections must be used. Confer with the District Traffic Engineer on which warrant will be allowed.

Warrants are commonly used to determine if either an all-way stop control or a traffic signal should be considered for a location. Roundabouts are considered to be warranted if traffic volumes meet the criteria for either all-way stops or traffic signals.

However, site-specific safety issues may warrant the installation of a traffic control device (e.g. a roundabout) where traffic volume warrants are not met. Special considerations to install a traffic control device should be taken at any intersection where "typical" warrants are not met but safety issues are present. The District Traffic Engineer must be consulted when these conditions are present for guidance on whether additional traffic control will be considered.

3.1.3.2 Justification

Even if an intersection meets a warrant for traffic control, that treatment may not be justified. The justification process requires engineering judgment. Whether an intersection justifies a particular type of intersection control is based upon a number of factors. The ICE report should document these factors to support the alternative or not. These factors should include, but are not limited to, the following:

- Existing safety and congestion issues
- Plans for the roadway based on an adopted corridor study
- The spacing of nearby intersections or driveways and how they conform to adopted access management guidelines
- The environment in the corridor
- Future anticipated traffic volumes
- The distance to the nearest traffic controlled intersections
- The amount of turning traffic
- The breakdown and percentage of types of vehicles
- The amounts of non-motorized traffic
- Sight distance
- Available right of way
- Available funds for construction
- Support of the local users and local agencies

3.1.4 Metro Traffic Signal Justification Methodology

The Mn/DOT Metro division has developed a justification process that is discussed in this section. This is to be used for all districts except when the particular district has a written methodology for signal justification. The Metro process looks a particular warrants (not all eight) and mitigating factors. In addition, this process defines how to handle right turn movements at the intersection.

The decision to install a traffic signal at a trunk highway intersection in the Metro District is determined by the Program Support Unit of the Traffic Engineering Section. The installation of the signal must be justified through an engineering study. Contained in this section of the ICE Manual is the current methodology in determining if a signal installation is justified **in the Metro District**. If a location is justified, it does not necessarily mean that a signal will be programmed or the installation will occur immediately. Funding must be available and the location must be a higher priority than other safety needs.

Qualifying Criteria

For a specific intersection to be considered for a traffic signal installation one of the following criteria must be met.

1. The intersection meets Warrant 1A, 1B or 7 of the current MN MUTCD.
2. Current traffic volumes do not meet Warrant 1A or 1B, but development in the area will occur such that the warrants will be met in a reasonable period of time and state funds are not used for construction.

Mitigating Factors

As part of the engineering study, the following factors should be considered in determining if a signal installation is justified.

1. Access spacing guidelines. Is spacing between signals on the mainline adequate? Is spacing between all nearby public and private access points adequate?
2. Is the installation of a signal at this location consistent with an adopted access management plan for the roadway?
3. Lane geometrics. Metro requires one lane of approach for each traffic movement for all directions of travel. For a typical four-legged intersection, a minimum of three lanes would be required for each approach, including the minor legs. (Metro will consider 2 lanes of approach from the minor legs under some conditions) Does the proposed layout provide minimal geometrics?
4. Each intersection should be modeled using acceptable simulation software in order to demonstrate acceptable traffic operations for opening day and for a reasonable period into the future (preferably 20 years). Adjacent intersections may be required to be included depending on spacing and other considerations. Will the proposed geometrics provide enough capacity for acceptable operations?
5. Is installation of a traffic signal the only solution or are better alternatives available?
6. Will the intersection be safer after the signal is installed?

Warrants

<u>Warrant 1 – Eight Hour Vehicular Volume</u>

If the intersection meets either Condition A (Minimum Vehicular Volume) or Condition B (Interruption of Continuous Traffic), then the intersection is considered to have met this warrant. Meeting a warrant does not necessarily mean the location is justified for a signal. Engineering judgment is required for that step and all mitigating factors must be considered.

Current traffic volumes must be collected to analyze the volume warrants. It is desirable to collect a 48-hour approach count AND a 6-hour turning movement count (3 in each of the peak periods) for

each intersection. These counts should be done Tuesday, Wednesday or Thursday to accurately depict typical weekday traffic volumes.

Right turning traffic from the minor leg is usually not included in the warrant analysis. The rationale for this practice is these movements are usually made relatively easily, have minimal conflicts and therefore do not require a traffic signal to minimize delay or improve safety. After the traffic volume data is collected, the percentage of right turning vehicles from the minor legs is determined based upon the turning movement count. The right turn percentage is removed from the approach counts to determine the volume to be used in the warrant analysis. (Typically it is assumed that the percentage of right turns during the two peak periods (6 hours) is representative of the entire day.)

In the event that there is a significant amount of right turning traffic and conflicting traffic, 50% of the right turns can be added back into the approach counts. If the right turning volume exceeds 70% of its potential capacity (see Table 2) for any hour for each approach, 50% of the right turning volume for all hours should be added back in. To use the table determine the conflicting flow rate for each minor approach. The rate will be the conflicting mainline approach traffic, in the lane the right turning vehicles are merging into (For multiple through lane roadways divide the volumes evenly across each lane). Utilizing the correct table (2 lane or 4 lane) the user must determine if the right turn volume exceeds the 70% potential capacity. (The capacity of the minor leg right turning volume is calculated based on procedures documented in the Highway Capacity Manual.)

To be warranted, one of the following must occur:

1. Condition A or B is met for at least 8 hours a day as shown on the 100% column (Table 3)
2. Condition A or B is met for at least 8 hours a day as shown on the 70% column (Table 3) if the posted or 85th percentile speed on the mainline exceeds 40 MPH or the intersection lies within the built-up area of an isolated community having a population of less than 10,000.

Table 2 – Right Turn Capacity

Potential Capacity for Two-Lane Streets			Potential Capacity for Four-Lane Streets		
Conflicting Flow Rate	**Potential Capacity**	**70% of Potential Capacity**	**Conflicting Flow Rate**	**Potential Capacity**	**70% of Potential Capacity**
0.01	1090	760	0.01	1090	760
100	960	670	100	940	660
200	850	600	200	810	570
300	740	520	300	700	490
400	650	460	400	610	430
500	570	400	500	520	360
600	500	350	600	450	320
700	440	310	700	390	270
800	390	270	800	330	230
900	340	240	900	290	200
1000	300	210	1000	250	180
1100	260	180	1100	210	150
1200	230	160	1200	180	130
1300	200	140	1300	150	110
1400	170	120	1400	130	90
1500	150	110	1500	110	80
1600	130	90	1600	100	70
1700	120	80	1700	80	60
1800	100	70	1800	70	50
1900	90	60	1900	60	40
2000	80	60	2000	50	40
2100	70	50	2100	40	30
2200	60	40	2200	40	30
2300	50	40	2300	30	20
2400	40	30	2400	30	20
2500	40	30	2500	20	10
2600	30	20	2600	20	10
2700	30	20	2700	20	10
2800	20	10	2800	10	10
2900	20	10	2900	10	10
3000	20	10	3000	10	10

Table 3 – Warrant 1

Condition A - Minimum Vehicle Volume									
Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1.....	1.....	500	400	350	280	150	120	105	84
2 or more...	1.....	600	480	420	336	150	120	105	84
2 or more...	2 or more...	600	480	420	336	200	160	140	112
1.....	2 or more...	500	400	350	280	200	160	140	112

Condition B - Interruption of Continuous Traffic									
Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1.....	1.....	750	600	525	420	75	60	53	42
2 or more...	1.....	900	720	630	504	75	60	53	42
2 or more...	2 or more...	900	720	630	504	100	80	70	56
1.....	2 or more...	750	600	525	420	100	80	70	56

[a] Basic minimum hourly volume.

[b] Used for combination of Conditions A and B after adequate trial of other remedial measures.

[c] May be used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000.

[d] May be used with Warrant 7, Crash Experience.

To determine the number of lanes to use in Table 2, the proposed lane geometrics must be used. Right turn lanes are not counted, but in most cases the row referring to two or more for both the major street and the minor street will be used. Left turn lanes are included in the total number of lanes.

Warrant 7 – Crash Experience

To meet this warrant two conditions must be met:

1. Five or more reported correctible crashes have occurred within any twelve-month period. Data can be used for the last 3 reported calendar years. Correctable crashes are those involving left turning movements from either the mainline or the minor street and through movements from the minor leg. These are typically, right angle and left turn related crashes. All other crashes are not considered (rear ends, run off road, etc...).
2. The eight-hour vehicular warrant described above must be met for the 80% column for either Condition A or Condition B. The treatment of traffic volumes is the same as described above.

If you have questions, please contact Lars Impola of Metro District Traffic – Program Support.

3.1.5 Analyze Alternatives

3.1.5.1 Crash Evaluation

Depending on the existing crash pattern at an intersection, different traffic control treatments will have predictable impacts on these patterns. For each alternative, an estimate of crash frequency should be completed. There are a number of methods for this task. The goal should be to determine the impacts of each alternative as accurately as feasible. The utilization of crash reduction factors, crash rates, comparisons to similar intersections, research and logic can all be used, but should be tempered by common sense. Consultation with the District Traffic Engineer is recommended on the most recent acceptable methods for a given treatment and location. [Note: Crash reduction factors are currently being developed for the ICE method. Be sure to check with the DTE to determine if these rates are available.]

Existing crash records should be obtained and shown in the report as stated in the Tech Memo.

For each alternative an estimate of future crashes should be obtained. It is suggested that this analysis utilize crash rates to keep it simple. If desired, a more thorough crash reduction methodology can be used. A table of average crash rates for each alternative has been developed and will be updated and revised periodically. Refer to the Traffic Safety Fundamentals Handbook available at http://www.dot.state.mn.us/trafficeng/otepubl/fundamentals/safetyfundamentals.pdf.

A comparison of anticipated total crashes and severe crashes should be documented for a target year. It is unnecessary to compute crash reductions per year and crash cost. Currently, this additional data is considered to be unnecessary.

3.1.5.2 Capacity Evaluation

To evaluate the capacity and level of service of a particular intersection it is important to begin with basic traffic data:

1. Existing AM and PM turning volumes
2. Design year AM and PM turning volumes (Compare design year flows with the existing flows and check out any anomalies. It is critical that the design year flows do not exceed the capacity of the surrounding network.)
3. Design vehicle
4. Base Plan with defined horizontal, vertical, and site constraints
5. Existing and design year pedestrian and bicycle volumes

For Phase I, Scoping, the capacity analysis will vary depending on the type of project. The primary goal in Phase I is to determine if the alternative will operate at an acceptable level of service. A secondary goal is to provide a gross comparison between alternatives. Consult with the District's Traffic Engineering unit on acceptable procedures for this analysis. In all cases, analysis with acceptable capacity analysis software will meet this condition. Simplified methods are being explored and developed.

<u>Year of analysis</u>

20 year projects are the default for this type of analysis, however, due to the variability in accuracy of traffic projections, shorter time frames should be strongly considered in many instances. If total development is expected to occur within 5 years, 5 years should be the target year for analysis. If the capacity analysis appears to highlight near failures within this timeframe, future projections should be analyzed.

<u>Choice of models</u>

Generally speaking, avoiding the use of VISSIM should always be the rule. If analysis of individual intersections indicates no potential for queues impacting adjacent intersections, there is no need to conduct a VISSIM analysis, no matter how many intersections are analyzed or their lack of adequate spacing. However, if the opposite is true, first optimize the individual intersection analysis or increase geometric options which increase capacity and only if that fails should VISSIM be used.

The primary goal of this exercise is to first – insure that each intersection will operate acceptably for each type of traffic control and second – to provide a gross level of comparison between options.

3.1.5.3 Additional Factors

Right of Way Impacts and Project Cost

Each alternative that is recommended to proceed to Phase II, Alternative Selection, will have concept drawings prepared for the purposes of determining right of way impacts as well as construction costs. The level of detail in the design will be determined by the project manager depending on the location, type of intersection alternative, and other issues. The goal of this step is to have reasonable assurance that all right of way impacts are determined and an accurate cost estimate is obtained.

Political/Public Considerations

A large factor in the decision of intersection control is driver expectancy. Each feasible alternative should be assessed for driver expectations and political viability. In Phase II, typically the local jurisdictions and other important stakeholders would be consulted to determine the acceptability of an alternative. If the result was negative, this alternative should be dropped from further consideration, especially if cost participation is required. During Phase II, the degree of public involvement in the discussion of alternatives must be determined by the project manager in consultation with local stakeholders and Mn/DOT functional units. In any event, stakeholders should be aware of the technical merits of each alternative.

Other Considerations

Unconventional Intersection Geometry Evaluation. Conventional forms of traffic control are often less efficient at intersections with a difficult skew angle, significant offset, odd number of approaches, or close spacing to other intersections. Roundabouts may be better suited for such intersections, because they do not require complicated signing or signal phasing. Their ability to accommodate high turning volumes makes them especially effective at “Y” or “T” junctions. Roundabouts may also be useful in eliminating a pair of closely spaced intersections by combining them to form a multi-legged roundabout. Intersection sight distance for roundabouts are significantly less demanding than for other conventional intersection treatments.

Terrain. Traffic signals and roundabouts typically should be constructed on relatively level or rolling terrain. For traffic signals, the maximum approach grade will vary depending on the ability for approaching traffic to see the signal heads and the impact of the approach grade on the operations of the predominate vehicle type. For roundabouts, the maximum approach grade should be 4% within the required Stopping Sight Distance (SSD) of the yield line. Grades approaching these values and steeper terrain may require greater transitions to provide an appropriate level area or plateau for the intersection.

Adjacent Intersections and Coordinated Signal Systems. The spacing of intersections along a highway corridor should be consistent with the spacing of primary full-movement intersections as shown in the Mn/DOT Access Management Policy. District Traffic Engineering may allow intersection spacing exceptions for roundabouts based on justifiable merits on a case-by-case basis. Generally speaking, positioning a roundabout within a coordinated signal system or very near to an adjacent signal is not preferred, however, under some circumstances it may be an acceptable option. A comprehensive traffic analysis is needed to determine if it is appropriate to locate a roundabout within a coordinated signal network.

System Consistency. On Interregional Corridors (IRC) or other highways where a corridor study has previously been prepared, any alternative should address the impact on the Interregional Corridor performance or should be compared to the recommendations of the corridor study. If the alternative adversely influences the performance of the IRC or it is not consistent with the corridor study, justification for the alternative should be included.

Pedestrian and/or Bicycle Issues. Accommodating non-motorized users is a Mn/DOT priority. Depending on the volume of users and the sensitivity of the location, one alternative may be preferred to another. Additionally, if large numbers of non-motorized users are anticipated, they should be reflected in the capacity calculations.

The study should address any of the above issues, if applicable, and indicate how they are considered in the final recommendation.

3.1.6 Recommend Alternatives

Through the above analysis steps, a recommended alternative should be identified. The selection of the preferred alternative should be documented in the ICE report. Any conclusions specific to the selected alternative should be documented.

3.2 Phase II – Alternative Selection

For Phase II, Alternative Selection, a more rigorous capacity analysis should be completed. An analysis using acceptable software is required. Currently, RODEL is required for roundabout analysis, SYNCHRO, SIM-TRAFFIC is required for traffic signals and four way stops, and VISSIM may be required for multiple roundabouts, which are a portion of an overall system of traffic control. Due to the high rate of change in modeling software and technology, these requirements could change, please consult with District Traffic Engineering to insure that certain software is required.

The product of this analysis is a comparison of level of service, delay and queue lengths for each alternative. This analysis should provide sufficient detail such that comparisons between alternatives can be made.

The results of the capacity analysis should be summarized in the report. Levels of Service, delay and maximum queue lengths should be reported for all approaches and/or traffic movements for all time periods and analysis years. It is recommended that an electronic copy of the initial conceptual design sketch and analysis be provided as documentation. ICE reports submitted without proper use of software will be rejected.

3.2.1 Prepare Conceptual Designs

Each alternative that is recommended to proceed to Phase II, Alternative Selection, will have concept drawings prepared for the purposes of determining right of way impacts as well as construction costs. The level of detail in the design will be determined by the project manager depending on the location, type of intersection alternative, and other issues. The goal of this step is to have reasonable assurance that all right of way impacts are determined and an accurate cost estimate is obtained.

3.2.2 Identify Right-of-Way Requirements

For the given alternative, determine the Right-of-Way (ROW) needs for the selected alternative(s).

3.2.3 Develop Cost Estimates

Determine the cost estimates for the selected alternative(s).

3.2.4 Political/Public Considerations

Each feasible alternative should be assessed for political viability. In Phase II, typically the local jurisdictions and other important stakeholders would be consulted to determine the acceptability of an alternative. If the result was negative, this alternative should be dropped from further consideration, especially if cost participation is required. During Phase II, the degree of public involvement in the discussion of alternatives must be determined by the project manager in consultation with local stakeholders and Mn/DOT functional units. In any event, stakeholders should be aware of the technical merits of each alternative.

3.2.5 Reevaluate Alternatives

As necessary, perform additional warrant, crash and capacity analysis. Use this information, along with engineering judgment to compare and contrast the alternatives.

3.2.6 Approve Staff Layout

If Phase II is required and alternatives are re-evaluated, the design layout should be approved by DTE staff. This is prior to or concurrent with the reporting process. In general, it is best to receive approval prior to finalizing the report.

3.3 Approval & Report

During this stage, the formal report is created and final approvals are given.

3.3.1 Write Report

The purpose of the ICE report is to document all of the analysis (technical, financial, political) used to determine the recommended alternative.

Depending on the amount of analysis, an actual report may be unnecessary. For some projects, a memorandum may be all that is necessary (e.g., Traffic signal rebuild projects). In that case, a memorandum signed by the District Traffic Engineer with rationale that supports the decision is sufficient. Otherwise, the ICE report should follow the outline below and thoroughly document the process described previously.

Concurrence (Approval) Letter (not needed if report is done internally)

The cover letter must be addressed to the District Traffic Engineer. It should include the name and address of the submitter along with any specific information on expected project letting dates, funding sources and linkages to other projects. The submitter should allow at least one month to obtain approval.

Cover Sheet

The cover sheet requests the approval of the District Traffic Engineer for the recommendations contained in the report. A signature block must be included with spaces for the report preparer (must be a registered engineer in the State of Minnesota), the engineering representative for the agency(s) with jurisdiction over the intersecting roadway and the District Traffic Engineer.

Description of Location

The report must document the location of the project in relation to other roadways and include an accompanying map at a suitable scale.

Existing Conditions

The report must document the existing conditions of the roadway including existing traffic control, traffic volumes, crash data, roadway geometrics, conditions of the roadway, right of way limits, land use, etc. A graphic/layout should be used to display much of this information.

Future Conditions

The report must document future conditions (normally 20 years) based on anticipated development including traffic volumes, new or improved adjacent or parallel roadways, anticipated change in access (additions or removals), etc.

Analysis of Alternatives

The report must include a discussion of each alternative and why it is recommended or not. The report should document the following analyses for each alternative considered: warrant analyses, crash analyses capacity analyses, right of way and construction cost impacts, political considerations, system consistency, and other considerations. Warrant analyses are usually done for existing conditions, however, in some cases future volumes (usually no more than 5 years) can be used if the submitter can document that development is imminent. Crash analysis is done comparing the existing crashes with those anticipated after the change in traffic control. It may be necessary to analyze crashes at nearby intersections if access is proposed to be restricted at the subject intersection. A capacity analysis for each alternative must be completed for existing conditions with and without the improvement. Additionally, a capacity analysis must be done for future conditions (usually 20 years into the future, unless the improvement is anticipated to be temporary (in that case 5 years would be acceptable)). A discussion of the relative intersection delays for each alternative must be included. The Mn/DOT District Traffic Engineering unit should be contacted for acceptable software packages for capacity analysis for each alternative. Currently, RODEL is recommended for isolated roundabouts, VISSIM is recommended for roundabouts in very close proximity to other roundabouts or signalized intersections in addition to RODEL analyses, and SYNCHRO is recommended for traffic signals and all-way stops.

Recommended Alternative

The report must recommend an alternative based upon the alternative analysis and a discussion of the justification factors. The report must document the justification factors, which are appropriate for each alternative and come to a logical conclusion on which alternative is recommended.

Appendices

The report should include supporting data, diagrams and software reports that support the recommendations being made.

3.3.2 DTE Approval

An ICE must be written under the supervision of a licensed Professional Engineer in the State of Minnesota and approved by the District Traffic Engineer. Each district can require additional review and approvals, if it is desired.

4. CASE STUDY

In the section, a sample ICE report of a fictitious location is presented. For additional samples, refer to the appendix of this Manual.

Minnesota Department of Transportation

Intersection Control Evaluation

For

S.P. XXXX-XX

T.H. 901 and T.H. 902

In Anytown, County

Program: SC (Safety Capacity) Funding: SF (State Funds)

Letting Date: October 30, 2007

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

Preparer's name, P.E.	Reg. No.	Date

Reviewed:

County Engineer	Date
	Date

Approved:

District Traffic Engineer	Date

4.1 Description of Location

The City of Anytown is located along TH 901 and TH 902 in Southwest Minnesota. The 2000 US Census population of Anytown is 11,000 persons. The study area is shown in Figure 16 below.

The City of Anytown has concerns about traffic operations and safety at the intersections in the area. New development in this area has increased traffic.

An overall concern within this corridor was the increasing amount of traffic traversing sequential non-standard intersections. All proposed long term alternatives should consider the standardization of intersection and segment geometrics.

Figure 16 – Study Area

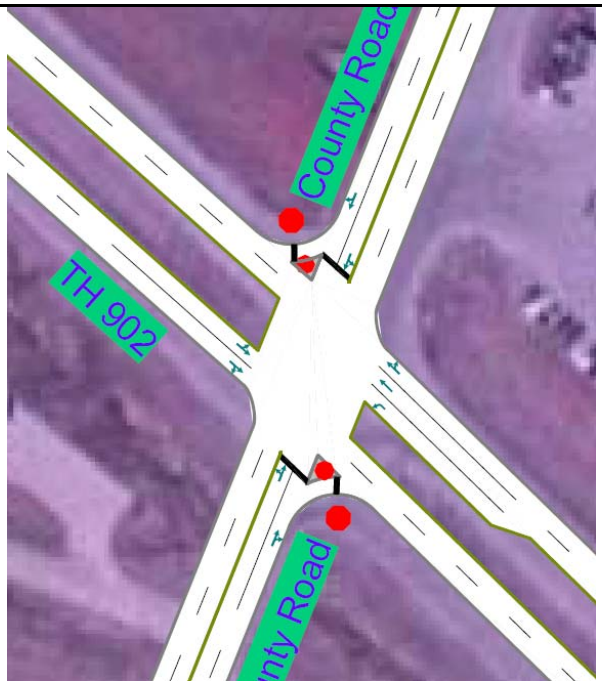
4.2 Existing Conditions

This section of the study report identifies the data collected and benchmarks the current study area traffic operations.

Data Collection

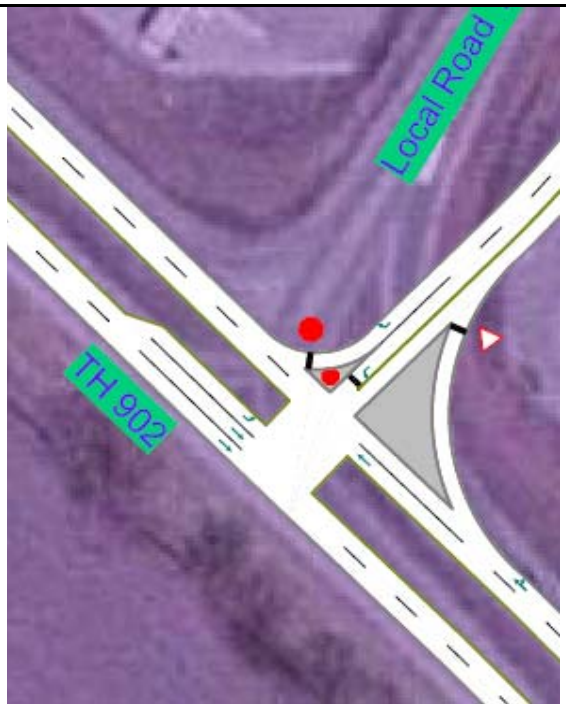
A kickoff meeting was held in Anytown on June 3, 2007. The existing geometry is shown in Figure 17. The year 2007 traffic turning movement counts for the intersections were provided by the DOT. These are shown in Figure 18.

Figure 17 – Existing Geometrics



TH 902 & County Road

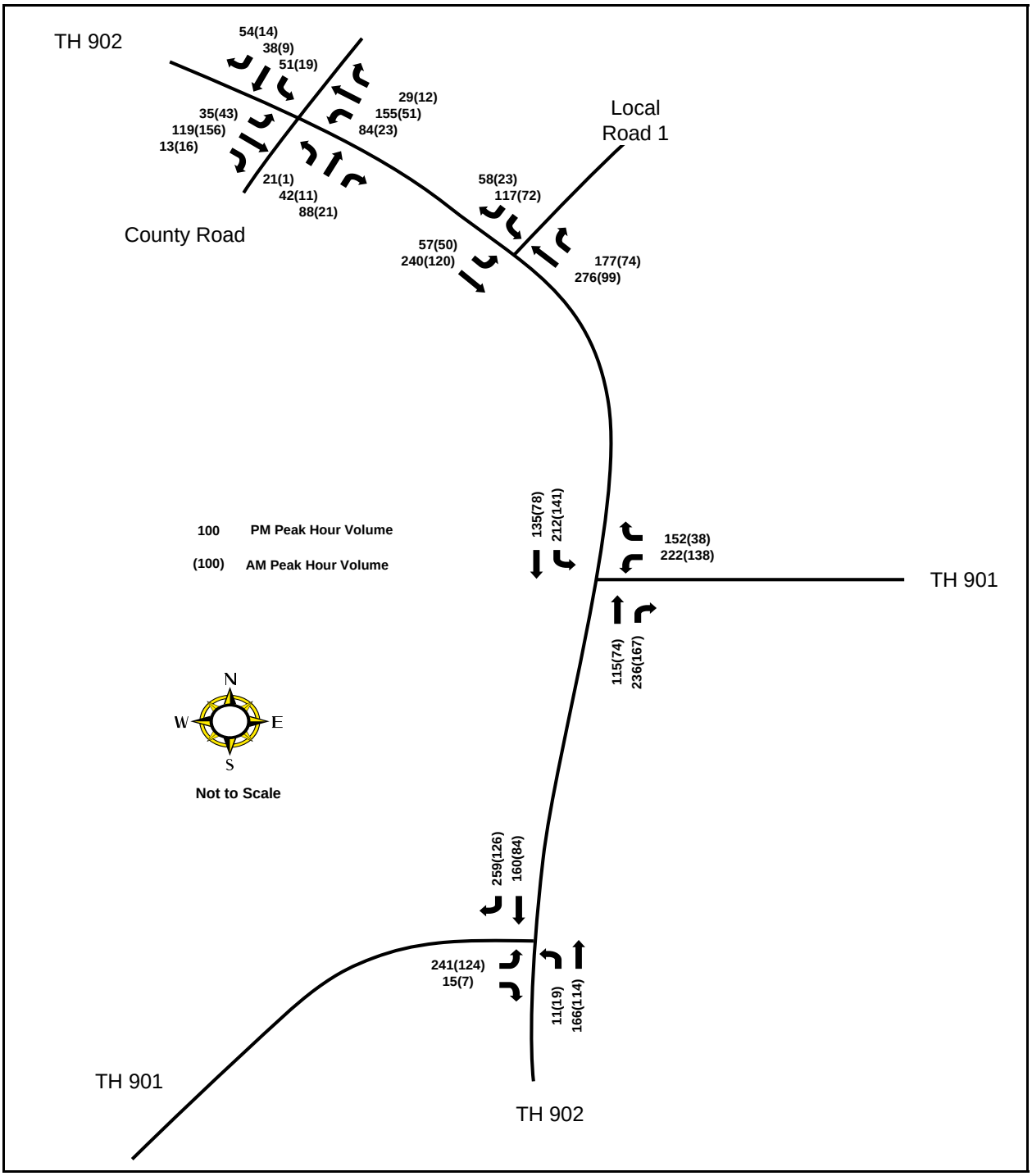
TH 901 & 902 North Intersection



TH 902 & Local Road 1

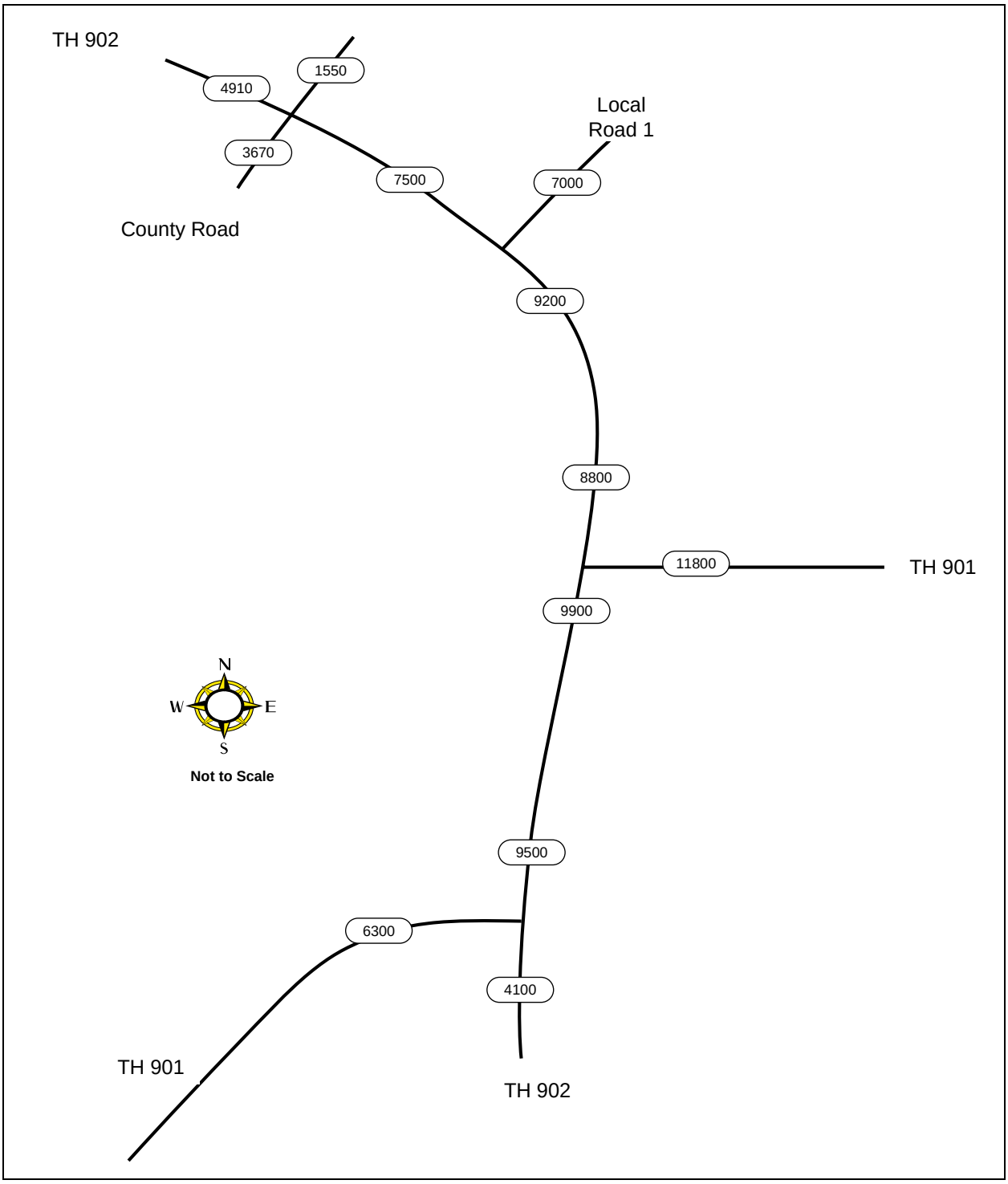
TH 901 & 902 South Intersection

Figure 18 – Existing Traffic Counts



The DOT provided Annual Average Daily Traffic (AADT) for the roadway segments within the study area. The AADT volumes are illustrated in Figure 19.

Figure 19 – Study Area AADT



4.3 Future Conditions

New development in the area has been reviewed and additional traffic is anticipated. Population growth in this area is anticipated to be 2% per year based on historical data. This analysis will look at the year 2020 for the future year.

The additional trips in the area will increase delay and degrade the LOS for the intersections in the study area. In particular for the TH 901 & TH 902 North Intersection (see section 4.5.2). Under existing volumes, the intersections are anticipated to operate with acceptable LOS ranges. However, in the future, some intersections and movements will degrade to unacceptable levels.

4.4 Analysis of Alternatives

4.4.1 Traffic Safety Analysis

This section of the report reviews the traffic safety analysis for the study corridor intersections.

Background Information

Traffic crashes are events that in some cases can indicate a need for traffic engineering improvements. Several aspects of a crash are considered in the safety analysis, including the following:

- Crash Rate
  For the study area intersections, intersection crash rates were calculated and compared against the statewide average crash rate for similar intersections. In general, higher than average crash rates may indicate a need for safety improvements.
- Crash Type
  Crash types were identified for each collision at the study area intersections. An identifiable trend in crash type can help determine movements of concern.
- Crash Severity
  Crash severity is identified as property damage only (PDO) or injury (fatality in the worst cases). A high injury to property damage only ratio may indicate high intensity crashes stemming from high speeds or other factors. Crash severity ratios in the range of two-thirds property damage only and one-third injury, with fatalities comprising only a very small fraction of all crashes, are considered normal. The ranges vary based on number of crashes reported and type of traffic control.

Intersection Safety Analysis

The following crash data were provided by the DOT for the years 2001-2006. Crash rates were calculated using available traffic data.

TH 901 and TH 902 South Intersection	
Summary:	20 crashes, 5 major injuries, 3 minor injuries, 4 possible injuries
By year:	2006 4 crashes, 2 major injuries, 2 property damage only 2005 3 crashes, no injuries 2004 2 crashes, no injuries 2003 3 crashes, no injuries 2002 2 crashes, no injuries 2001 6 crashes, 3 major injuries, 3 minor injuries, 4 possible injuries
Intersection Crash Rate:	0.87

TH 901 and TH 902 North Intersection	
Summary:	24 crashes, 1 minor injury, 2 possible injuries
By year:	2006 5 crashes, 1 minor injury, 1 possible injury 2005 4 crashes, no injuries 2004 3 crashes, no injuries 2003 5 crashes, no injuries 2002 5 crashes, 1 possible injury 2001 2 crashes, no injuries
Intersection Crash Rate:	0.68

TH 902 and Local Road 1	
Summary:	10 crashes, 1 major injury, 2 minor injuries, 5 possible injuries
By year:	2006 1 crash, no injuries 2005 0 crashes 2004 2 crashes, no injuries 2003 2 crashes, 1 possible injury 2002 3 crashes, 1 minor injury, 1 possible injury 2001 2 crashes, 1 major injury, 1 minor injury, 3 possible injuries
Intersection Crash Rate:	0.37

TH 902 and County Road	
Summary:	19 crashes, 1 fatality, 6 minor injuries, 4 possible injuries
By year:	2006 3 crashes, 1 possible injuries 2005 6 crashes, no injuries 2004 3 crashes, 1 possible injury 2003 4 crashes, 1 fatality, 3 minor injury, 2 possible injuries 2002 2 crashes, no injuries 2001 4 crashes, 3 minor injuries, 1 possible injury
Intersection Crash Rate:	1.05

The following were noted regarding the safety analysis:

- The crash rate for the intersections in the study area ranges from a low of 0.37 at Local Road 1 to a high of 1.05 at County Road.
- Three out of four intersections have a crash rate that is higher than the statewide average crash rate of 0.4 for a STOP controlled intersection.
- The crash rate of 0.4 for a STOP controlled intersection is listed in the Mn/DOT Traffic Safety Fundamentals Handbook.
- One fatality occurred in the study area between 2001 and 2006.

4.4.2 Traffic Signal Warrant Analysis

A traffic signal warrant analysis was performed to determine the need for a traffic signal at the intersections of:

- TH 901 and TH 902 South Intersection
- TH 901 and TH 902 North Intersection
- TH 902 and Local Road 1
- TH 902 and County Road

This section contains the traffic signal warrant analysis.

Background Information

The MN MUTCD is the reference for all traffic control devices such as signals, stops signs, and pavement markings. Part 4 contains information pertaining to highway traffic signals, including a series of traffic signal warrants that define the minimum conditions under which installing a traffic signal might be justified. Traffic signal warrants have been developed as national guidelines to promote continuity of traffic control devices and to ensure that traffic signals are installed at intersections that would benefit from their use. The following are the eight MN MUTCD traffic signal warrants:

- Warrant 1, Eight-Hour Vehicular Volume
- Warrant 2, Four-Hour Vehicular Volume
- Warrant 3, Peak Hour
- Warrant 4, Pedestrian Volume
- Warrant 5, School Crossing
- Warrant 6, Coordinated Signal System
- Warrant 7, Crash Experience
- Warrant 8, Roadway Network

Intersection Traffic Signal Warrant Analysis

Warrants 1 (1A and 1B) and 7 were reviewed using the intersection turning movement counts and 48-hour counts collected by the Department of Transportation. These are the only warrants analyzed based on 3.1.4 Metro Traffic Signal Justification Report Methodology of the ICE Manual. Warrant 7 was reviewed, but was not satisfied. For more detailed information regarding the signal warrants, refer to the MN MUTCD, Part 4, Section 4C.

The meeting of a warrant or warrants does not alone justify the installation of a signal. The analysis indicates that none of the intersections meet signal warrants in the year 2007. The delay and LOS analysis indicates that these intersections will operate with acceptable levels under unsignalized control. Therefore, signalization is not recommended for any of the intersections in the study area with existing volumes.

In the year 2027, it is projected that Warrant 1 will be met at TH 901 & TH 902 North intersection and at TH 902 & Local Road Intersection. However, this does not justify the installation of a signal and capacity analysis of other methods should be performed, particularly when the minimum warrant has been met.

Table 4 – Anytown Traffic Signal Warrant Analysis Summary

Intersection	MN MUTCD Traffic Signal Warrant			
	Warrant 1 Eight-Hour Vehicular Volume		Warrant 7 Crash Experience	
	2007	2027	2007	2027
TH 901 and TH 902 South Intersection	No, 1 hour met	No, 5 hours met	No	N/A
TH 901 and TH 902 North Intersection	No, 5 hours met	Yes, 8 hours met	No	N/A
TH 902 and Local Road 1	No, 5 hours met	Yes, 8 hours met	No	N/A
TH 902 and County Road	No, 2 hours met	No, 7 hours met	No	N/A

Notes:

1. 8 hours are required to meet Warrant 1.
2. Free flow and side street right turns are excluded from the analysis.

Traffic Operations Analysis

Traffic operations are influenced by vehicle and pedestrian volume, traffic peaking behavior, geometric design of the intersection, traffic control, access control, and many other external factors. Observations of traffic volumes provide an understanding of the general nature of traffic, but are insufficient to indicate either the ability of the street network to carry additional traffic or the quality of service provided by the street system. For this reason, the concept of level of service (LOS) has been developed to correlate numerical traffic volume data to subjective descriptions of traffic performance at intersections. LOS categories range from A (best) to F (worst) are shown in Table 5.

Table 5 – Level of Service Descriptions

Level of Service	Delay per Vehicle (seconds)		Description
	Signalized Intersection	Unsignalized Intersection	
A	0 - 10	0 - 10	Free flow, minimal delays
B	>10 - 20	>10 - 15	Stable flow, occasional delays
C	>20 - 35	>15 - 25	Stable flow, periodic delays
D	>35 - 55	>25 - 35	Restricted flow, regular delays
E	>55 - 80	>35 - 50	Maximum capacity, extended delays
F	>80	>50	Forced flow, excessive delays

Highway Capacity Manual 2000

At signalized intersections, level of service is based on the weighted average of all approach delays. For unsignalized intersections, the LOS is based on the worst minor street movement delay (usually the left turn movements on the cross streets).

Section 4.5.1 to Section 4.5.4 summarize the current intersection delay and LOS for intersections in the study area for the AM and PM peak hours. The delay values come from a SimTraffic microsimulation analysis. Simulation was used due to the non-standard intersection configurations. The Highway Capacity Manual macroscopic based methods are not capable of modeling the non-standard configurations and roundabouts. Five simulation runs were performed and averaged. The results are included in the Appendix.

Existing Traffic Operations Analysis Summary

The intersections in the study area are operating with acceptable delays and LOS in the year 2007. There are no movements that operate with a LOS worse then C and many operate at LOS A.

4.5 Section 5 – Alternatives Analysis

This section of the report contains the possible alternatives for the study area. The alternatives are compared based on capacity/delay analysis, crash history and warrant analysis. The alternatives are summarized for the intersections and for network measures. The following alternatives are considered for the study area.

Alternative 1 – Do Nothing

In this option, no changes are made. Currently, the intersections are operating at an acceptable level of service. However three out of four intersections are above the average statewide rate.

Intersection crash rates and volumes should be monitored to check for changes. In the year 2027, the intersection of TH 901 & TH 902 North Intersection is anticipated to fail under the do nothing alternative during the PM Peak Hour (see Section 4.5.2).

Alternative 2 – AWSC

In order to standardize the traffic control in the area, this alternative is to add All-way Stop Control (AWSC) for the four intersections in the area.

Alternative 3 – Roundabout

In this option, the intersections are converted to modern roundabouts. This provides standardized control with the sequential T intersections in the study area.

The analysis results indicate that the roundabout intersections will operate more efficiently than the existing conditions and the AWSC option.

Alternative 4 – Traffic Signals

The North and South junctions of TH 901 and 902 met warrants for a signal into the year 2027. However, as a test of the capacity analysis, the intersections are tested for signalization to allow capacity comparisons between alternatives. Under signal operations, the delay would increase as compared to the roundabout option.

4.5.1 TH 901 & TH 902 South Intersection Analysis

Year 2007 Analysis

	AM Peak Hour	T.H. 901 & T.H. 902 South Intersection												
		T.H. 901						T.H. 902			T.H. 901/902			
Existing TWSC	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	1.2		0.8				5.6	6.5			7.7	2.4	4.1
	Mvmt. LOS	A		A				A	A			A	A	A
	Mvmt. Volume	124		7				19	114			89	126	479
	Approach Delay	1.2						6.4			4.6			
	Approach LOS	A						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	0						16	54		41			
	Max Queue	4						53	93		73			
AWSC	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	6.8		0.9				4.7	6.6			8.5	3.5	6.0
	Mvmt. LOS	A		A				A	A			A	A	A
	Mvmt. Volume	124		7				19	114			89	126	479
	Approach Delay	6.5						6.3			5.6			
	Approach LOS	A						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	47						16	54		41			
	Max Queue	78						52	95		75			
Roundabouts	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	2.7		3.5				3.1	3.7			4.1	3.4	3.4
	Mvmt. LOS	A		A				A	A			A	A	A
	Mvmt. Volume	124		7				19	114			89	126	479
	Approach Delay	2.7						3.6			3.7			
	Approach LOS	A						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	2						5	7		6			
	Max Queue	17						28	33		29			
Signals	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	17.7		4.3				5.3	2.7			3.4	3.4	6.9
	Mvmt. LOS	B		A				A	A			A	A	A
	Mvmt. Volume	124		7				19	114			89	126	479
	Approach Delay	17.0						3.1			3.4			
	Approach LOS	B						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	64						5	9		22			
	Max Queue	120						30	40		68			

	PM Peak Hour	T.H. 901 & T.H. 902 South Intersection												
		T.H. 901						T.H. 902			T.H. 901/902			
Existing TWSC	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	2.0		1.0				6.4	7.1			10.1	3.6	5.0
	Mvmt. LOS	A		A				A	A			B	A	A
	Mvmt. Volume	241		15				11	166			162	259	854
	Approach Delay	1.9						7.1			6.1			
	Approach LOS	A						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	3						11	61		61			
	Max Queue	23						43	99		108			
AWSC	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	8.2		1.0				4.4	7.1			9.4	4.1	6.8
	Mvmt. LOS	A		A				A	A			A	A	A
	Mvmt. Volume	241		15				11	166			162	259	854
	Approach Delay	7.8						6.9			6.1			
	Approach LOS	A						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	65						10	61		55			
	Max Queue	109						42	100		94			
Roundabouts	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	3.4		3.4				3.0	4.2			5.2	4.1	4.1
	Mvmt. LOS	A		A				A	A			A	A	A
	Mvmt. Volume	241		15				11	166			162	259	854
	Approach Delay	3.4						4.1			4.5			
	Approach LOS	A						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	11						23	10		14			
	Max Queue	42						66	41		48			
Signals	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	21.6		3.6				8.9	4.9			6.5	4.7	9.9
	Mvmt. LOS	C		A				A	A			A	A	A
	Mvmt. Volume	241		15				11	166			162	259	854
	Approach Delay	20.5						5.1			5.4			
	Approach LOS	C						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	117						15	8		42			
	Max Queue	210						54	36		101			

Year 2027 Analysis

	AM Peak Hour	T.H. 901 & T.H. 902 South Intersection												
		T.H. 901						T.H. 902			T.H. 901/902			
Existing TWSC	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	1.7		1.1				6.2	7.0			9.4	3.2	4.9
	Mvmt. LOS	A		A				A	A			A	A	A
	Mvmt. Volume	185		10				28	170			131	188	712
	Approach Delay	1.7						6.9			5.7			
	Approach LOS	A						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	1						25	60		53			
	Max Queue	10						62	97		92			
AWSC	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	7.9		1.1				4.9	7.0			9.0	3.9	6.7
	Mvmt. LOS	A		A				A	A			A	A	A
	Mvmt. Volume	185		10				28	170			131	188	712
	Approach Delay	7.6						6.7			6.0			
	Approach LOS	A						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	59						25	61		51			
	Max Queue	105						62	101		88			
Roundabouts	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	3.1		4.0				3.3	4.1			4.8	3.8	3.9
	Mvmt. LOS	A		A				A	A			A	A	A
	Mvmt. Volume	185		10				28	170			131	188	712
	Approach Delay	3.1						4.0			4.2			
	Approach LOS	A						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	8						19	11		14			
	Max Queue	32						60	44		50			
Signals	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	19.2		4.3				7.5	4.4			6.5	4.8	9.0
	Mvmt. LOS	B		A				A	A			A	A	A
	Mvmt. Volume	185		10				28	170			131	188	712
	Approach Delay	18.4						4.8			5.5			
	Approach LOS	B						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	98						10	14		38			
	Max Queue	189						45	48		90			

	PM Peak Hour	T.H. 901 & T.H. 902 South Intersection												
		T.H. 901						T.H. 902			T.H. 901/902			
Existing TWSC	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	2.8		1.3				6.9	8.1			13.4	4.1	6.1
	Mvmt. LOS	A		A				A	A			B	A	A
	Mvmt. Volume	359		22				16	247			240	386	1270
	Approach Delay	2.7						8.0			7.7			
	Approach LOS	A						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	5						16	76		70			
	Max Queue	28						51	115		130			
AWSC	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	11.5		1.3				5.6	8.0			11.3	5.0	8.6
	Mvmt. LOS	B		A				A	A			B	A	A
	Mvmt. Volume	359		22				16	247			240	386	1270
	Approach Delay	10.9						7.9			7.4			
	Approach LOS	B						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	93						16	75		69			
	Max Queue	169						51	115		113			
Roundabouts	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	4.5		5.9				5.1	4.9			6.5	5.1	5.1
	Mvmt. LOS	A		A				A	A			A	A	A
	Mvmt. Volume	359		22				16	247			240	386	1270
	Approach Delay	4.6						4.9			5.6			
	Approach LOS	A						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	26						41	25		26			
	Max Queue	69						92	68		63			
Signals	**Movement**	EBL		EBR				NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	22.0		4.1				15.4	9.0			11.5	7.6	12.8
	Mvmt. LOS	C		A				B	A			B	A	B
	Mvmt. Volume	359		22				16	247			240	386	1270
	Approach Delay	21.0						9.4			9.1			
	Approach LOS	C						A			A			
	Lane	EBL						NBL	NBT		SBL			
	Avg. Queue	173						17	14		81			
	Max Queue	305						65	47		167			

4.5.2 TH 901 & TH 902 North Intersection Analysis

Year 2007 Analysis

	AM Peak Hour	T.H. 901 & T.H. 902 North Intersection												
					T.H. 902			T.H. 901/T.H. 902			T.H. 901			
Existing TWSC	Movement				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				12.1		1.0		3.2	3.6	3.7	0.6		4.7
	Mvmt. LOS				B		A		A	A	A	A		A
	Mvmt. Volume				128		38		78	167	141	78		630
	Approach Delay				9.6			3.5			2.6			
	Approach LOS				A			A			A			
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				62		0		30		0			
	Max Queue				116		10		79		0			
AWSC	Movement				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				6.9		1.0		10.3	4.2	6.4	6.5		6.1
	Mvmt. LOS				A		A		B	A	A	A		A
	Mvmt. Volume				128		38		78	167	141	78		630
	Approach Delay				5.5			6.1			6.4			
	Approach LOS				A			A			A			
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				53		48		52		43			
	Max Queue				91		88		92		78			
Roundabouts	Movement				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				3.4		2.7		4.7	4.0	3.2	4.7		3.8
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				128		38		78	167	141	78		630
	Approach Delay				3.2			4.2			3.7			
	Approach LOS				A			A			A			
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				11		23		14		5			
	Max Queue				48		69		51		24			
Signals	Movement				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				18.0		4.3		5.7	4.0	6.6	3.3		7.6
	Mvmt. LOS				B		A		A	A	A	A		A
	Mvmt. Volume				128		38		78	167	141	78		630
	Approach Delay				14.9			4.5			5.4			
	Approach LOS				B			A			A			
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				69		24		22		25			
	Max Queue				130		59		67		58			

	PM Peak Hour	T.H. 901 & T.H. 902 North Intersection												
					T.H. 902			T.H. 901/T.H. 902			T.H. 901			
Existing TWSC	Movement				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				32.2		1.8		3.3	4.1	5.5	1.1		9.1
	Mvmt. LOS				D		A		A	A	A	A		A
	Mvmt. Volume				222		152		171	236	212	145		1138
	Approach Delay				19.8			3.8			3.7			
	Approach LOS				C			A			A			
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				125		12		1		49			
	Max Queue				278		106		15		107			
AWSC	Movement				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				10.1		1.7		9.0	4.7	8.8	6.9		7.0
	Mvmt. LOS				B		A		A	A	A	A		A
	Mvmt. Volume				222		152		171	236	212	145		1138
	Approach Delay				6.7			6.5			8.0			
	Approach LOS				A			A			A			
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				74		59		67		56			
	Max Queue				143		101		111		95			
Roundabouts	Movement				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				4.4		3.3		4.5	5.0	4.5	6.2		4.6
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				222		152		171	236	212	145		1138
	Approach Delay				4.0			4.8			5.2			
	Approach LOS				A			A			A			
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				24		1		34		20			
	Max Queue				77		15		87		62			
Signals	Movement				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				21.7		5.1		6.3	6.1	12.9	5.4		10.2
	Mvmt. LOS				C		A		A	A	B	A		B
	Mvmt. Volume				222		152		171	236	212	145		1138
	Approach Delay				15.0			6.2			9.9			
	Approach LOS				B			A			A			
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				121		49		40		45			
	Max Queue				238		99		101		95			

Year 2027 Analysis

	AM Peak Hour	T.H. 901 & T.H. 902 North Intersection												
					T.H. 902			T.H. 901/T.H. 902			T.H. 901			
Existing TWSC	**Movement**				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				24.6		1.1		3.5	4.1	5.1	0.9		7.9
	Mvmt. LOS				C		A		A	A	A	A		A
	Mvmt. Volume				191		57		118	249	210	116		941
	Approach Delay				19.2				3.9			3.6		
	Approach LOS				C				A			A		
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				103		1		47		0			
	Max Queue				206		8		99		0			
AWSC	**Movement**				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				8.8		1.1		11.5	4.7	9.0	7.0		7.3
	Mvmt. LOS				A		A		B	A	A	A		A
	Mvmt. Volume				191		57		118	249	210	116		941
	Approach Delay				7.0				6.9			8.3		
	Approach LOS				A				A			A		
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				67		57		66		54			
	Max Queue				116		100		120		94			
Roundabouts	**Movement**				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				4.1		3.0		5.9	4.8	4.0	5.9		4.6
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				191		57		118	249	210	116		941
	Approach Delay				3.8				5.2			4.7		
	Approach LOS				A				A			A		
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				24		0		34		19			
	Max Queue				75		5		82		54			
Signals	**Movement**				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				18.7		4.4		7.3	5.8	10.0	5.0		9.4
	Mvmt. LOS				B		A		A	A	A	A		A
	Mvmt. Volume				191		57		118	249	210	116		941
	Approach Delay				15.4				6.3			8.2		
	Approach LOS				B				A			A		
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				98		29		33		42			
	Max Queue				166		65		86		77			

	PM Peak Hour	T.H. 901 & T.H. 902 North Intersection												
					T.H. 902			T.H. 901/T.H. 902			T.H. 901			
Existing TWSC	**Movement**				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				862.1		384.2		4.5	5.4	9.2	1.6		195.4
	Mvmt. LOS				F		F		A	A	A	A		F
	Mvmt. Volume				331		226		254	352	316	217		1696
	Approach Delay				668.2				5.0			6.1		
	Approach LOS				F				A			A		
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				1476		*1436*		8		84			
	Max Queue				2343		2371		41		153			
AWSC	**Movement**				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				23.6		2.4		13.2	5.5	17.5	7.9		12.3
	Mvmt. LOS				C		A		B	A	C	A		B
	Mvmt. Volume				331		226		254	352	316	217		1696
	Approach Delay				15.0				8.7			13.6		
	Approach LOS				B				A			B		
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				141		10		81		109			
	Max Queue				269		115		141		203			
Roundabouts	**Movement**				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				6.8		4.0		7.0	6.7	7.0	9.3		6.8
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				331		226		254	352	316	217		1696
	Approach Delay				5.7				6.8			7.9		
	Approach LOS				A				A			A		
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				55		3		68		37			
	Max Queue				127		22		137		85			
Signals	**Movement**				WBL		WBR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				23.7		5.5		8.9	8.1	25.9	8.3		14.2
	Mvmt. LOS				C		A		A	A	C	A		B
	Mvmt. Volume				331		226		254	352	316	217		1696
	Approach Delay				16.3				8.4			18.7		
	Approach LOS				B				A			B		
	Lane				WBL		WBL		NBT		SB L/T			
	Avg. Queue				177		54		61		57			
	Max Queue				295		113		135		99			

4.5.3 TH 902 & Local Road 1 Intersection Analysis

Year 2007 Analysis

	AM Peak Hour	T.H. 902 & Local Road												
					Local Road			T.H. 902			T.H. 902			
Existing TWSC	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				6.0		1.6		1.4	3.2	3.6	1.4		2.7
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				72		23		107	74	50	146		472
	Approach Delay				4.9				2.1			2.0		
	Approach LOS				A				A			A		
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				0				26		35	28		
	Max Queue				0				52		74	55		
AWSC	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				4.8		1.6		6.4	3.3	7.6	8.3		6.1
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				72		23		107	74	50	146		472
	Approach Delay				4.0				5.1			8.1		
	Approach LOS				A				A			A		
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				22				26		35	28		
	Max Queue				57				52		74	55		
Roundabout	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				2.8		2.5		3.4	3.2	2.7	2.9		3.0
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				72		23		107	74	50	146		472
	Approach Delay				2.7				3.3			2.8		
	Approach LOS				A				A			A		
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				0				26		35	28		
	Max Queue				10				52		74	55		
Signal	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				16.4		2.3		2.1	1.8	5.8	2.3		4.8
	Mvmt. LOS				B		A		A	A	A	A		A
	Mvmt. Volume				72		23		107	74	50	146		472
	Approach Delay				13.0				2.0			3.2		
	Approach LOS				B				A			A		
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				3				26		35	28		
	Max Queue				21				52		74	55		

	PM Peak Hour	T.H. 902 & Local Road												
					Local Road			T.H. 902			T.H. 902			
Existing TWSC	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				11.3		1.9		2.8	4.6	6.9	2.5		4.4
	Mvmt. LOS				B		A		A	A	A	A		A
	Mvmt. Volume				117		58		280	177	57	241		930
	Approach Delay				8.2				3.5			3.3		
	Approach LOS				A				A			A		
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				50				46		56	29		
	Max Queue				89				78		89	55		
AWSC	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				5.9		1.9		8.6	4.5	8.6	9.6		7.3
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				117		58		280	177	57	241		930
	Approach Delay				4.6				7.0			9.4		
	Approach LOS				A				A			A		
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				37				46		56	29		
	Max Queue				73				78		89	55		
Roundabout	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				4.0		3.5		4.3	4.2	3.0	3.9		4.0
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				117		58		280	177	57	241		930
	Approach Delay				3.8				4.3			3.7		
	Approach LOS				A				A			A		
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				1				46		56	29		
	Max Queue				14				78		89	55		
Signal	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				21.0		3.1		4.1	3.9	12.2	4.0		6.7
	Mvmt. LOS				C		A		A	A	B	A		A
	Mvmt. Volume				117		58		280	177	57	241		930
	Approach Delay				15.1				4.0			5.6		
	Approach LOS				B				A			A		
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				14				46		56	29		
	Max Queue				55				78		89	55		

Year 2027 Analysis

	AM Peak Hour	T.H. 902 & Local Road												
					Local Road			T.H. 902			T.H. 902			
Existing TWSC	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				8.6		1.6		1.7	3.3	4.4	1.6		3.3
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				107		34		158	110	75	216		700
	Approach Delay				6.9				2.4		2.3			
	Approach LOS				A				A		A			
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				0				31		43	35		
	Max Queue				0				59		75	66		
AWSC	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				5.4		1.6		6.9	3.4	8.3	8.8		6.6
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				107		34		158	110	75	216		700
	Approach Delay				4.5				5.5		8.7			
	Approach LOS				A				A		A			
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				31				31		43	35		
	Max Queue				68				59		75	66		
Roundabout	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				3.2		2.7		3.5	3.5	3.1	3.3		3.3
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				107		34		158	110	75	216		700
	Approach Delay				3.1				3.5		3.2			
	Approach LOS				A				A		A			
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				1				31		43	35		
	Max Queue				15				59		75	66		
Signal	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				17.3		2.4		3.0	2.4	7.2	3.0		5.6
	Mvmt. LOS				B		A		A	A	A	A		A
	Mvmt. Volume				107		34		158	110	75	216		700
	Approach Delay				13.7				2.8		4.1			
	Approach LOS				B				A		A			
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				5				31		43	35		
	Max Queue				30				59		75	66		

	PM Peak Hour	T.H. 902 & Local Road												
					Local Road			T.H. 902			T.H. 902			
Existing TWSC	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				26.4		2.1		3.7	5.3	9.8	2.9		6.8
	Mvmt. LOS				D		A		A	A	A	A		A
	Mvmt. Volume				174		86		418	264	85	360		1387
	Approach Delay				18.4				4.3		4.2			
	Approach LOS				C				A		A			
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				81				63		64	34		
	Max Queue				171				103		106	60		
AWSC	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				7.5		2.0		10.3	5.6	10.6	10.5		8.6
	Mvmt. LOS				A		A		B	A	B	B		A
	Mvmt. Volume				174		86		418	264	85	360		1387
	Approach Delay				5.7				8.5		10.5			
	Approach LOS				A				A		B			
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				46				63		64	34		
	Max Queue				82				103		106	60		
Roundabout	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				5.4		4.3		5.1	5.6	3.8	4.4		4.9
	Mvmt. LOS				A		A		A	A	A	A		A
	Mvmt. Volume				174		86		418	264	85	360		1387
	Approach Delay				5.0				5.3		4.3			
	Approach LOS				A				A		A			
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				4				63		64	34		
	Max Queue				30				103		106	60		
Signal	Movement				SWL		SWR		NBT	NBR	SBL	SBT		All
	Mvmt. Delay				22.2		3.8		6.2	6.2	19.9	5.4		8.6
	Mvmt. LOS				C		A		A	A	B	A		A
	Mvmt. Volume				174		86		418	264	85	360		1387
	Approach Delay				16.1				6.2		8.2			
	Approach LOS				B				A		A			
	Lane				SWL				NB T/R		SBL	SB T/R		
	Avg. Queue				30				63		64	34		
	Max Queue				86				103		106	60		

4.5.4 TH 902 & County Road Intersection Analysis

Year 2007 Analysis

	AM Peak Hour	T.H. 902 & County Road												
		T.H. 902			T.H. 902			County Road			County Road			
Existing TWSC	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	2.3	1.1	0.7	3.2	1.9	1.4		7.9	1.4	5.7	8.2	1.1	2.2
	Mvmt. LOS	A	A	A	A	A	A		A	A	A	A	A	A
	Mvmt. Volume	43	156	16	23	87	12		11	21	19	9	4	402
	Approach Delay	1.3			2.1			3.6			5.8			
	Approach LOS	A			A			A			A			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	2	1		0			3	8		25	7		
	Max Queue	17	8		5			15	28		66	27		
AWSC	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	4.9	6.9	2.4	6.7	6.8	4.6		6.2	1.5	4.4	6.4	1.1	5.8
	Mvmt. LOS	A	A	A	A	A	A		A	A	A	A	A	A
	Mvmt. Volume	43	156	16	23	87	12		11	21	19	9	4	402
	Approach Delay	6.2			6.6			3.1			4.6			
	Approach LOS	A			A			A			A			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	27	20		5			1	5		3	7		
	Max Queue	62	52		17			9	28		16	28		
Roundabouts	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	3.0	3.8	2.9	2.5	2.0	2.4		3.4	2.8	2.1	3.9	2.1	3.0
	Mvmt. LOS	A	A	A	A	A	A		A	A	A	A	A	A
	Mvmt. Volume	43	156	16	23	87	12		11	21	19	9	4	402
	Approach Delay	3.6			2.1			3.0			2.6			
	Approach LOS	A			A			A			A			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	5	6		2			2	4		1	2		
	Max Queue	29	30		15			15	23		11	21		
Signals	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	4.0	3.1	1.1	5.5	1.2	1.0		16.4	3.6	20.7	15.1	2.0	4.5
	Mvmt. LOS	A	A	A	A	A	A		B	A	C	B	A	A
	Mvmt. Volume	43	156	16	23	87	12		11	21	19	9	4	402
	Approach Delay	3.1			2.0			8.0			16.8			
	Approach LOS	A			A			A			B			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	8	5		2			0	2		17	23		
	Max Queue	36	26		9			6	11		42	66		

	PM Peak Hour	T.H. 902 & County Road												
		T.H. 902			T.H. 902			County Road			County Road			
Existing TWSC	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	3.0	1.0	0.8	3.7	2.4	2.3	8.2	10.4	2.0	9.7	9.8	1.5	3.6
	Mvmt. LOS	A	A	A	A	A	A	A	B	A	A	A	A	A
	Mvmt. Volume	35	119	13	84	221	29	21	42	88	51	39	54	796
	Approach Delay	1.4			2.7			5.2			6.7			
	Approach LOS	A			A			A			A			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	4	0		5			17	20		38	20		
	Max Queue	23	7		21			41	46		78	47		
AWSC	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	5.4	7.5	2.7	8.3	8.8	6.0	6.5	7.6	2.0	5.3	7.4	1.5	6.5
	Mvmt. LOS	A	A	A	A	A	A	A	A	A	A	A	A	A
	Mvmt. Volume	35	119	13	84	221	29	21	42	88	51	39	54	796
	Approach Delay	6.7			8.4			4.2			4.4			
	Approach LOS	A			A			A			A			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	24	19		14			10	19		17	19		
	Max Queue	61	50		37			39	55		42	45		
Roundabouts	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	3.2	4.1	3.2	3.0	3.0	3.3	2.9	4.7	3.1	2.9	4.5	3.4	3.4
	Mvmt. LOS	A	A	A	A	A	A	A	A	A	A	A	A	A
	Mvmt. Volume	35	119	13	84	221	29	21	42	88	51	39	54	796
	Approach Delay	3.8			3.0			3.5			3.5			
	Approach LOS	A			A			A			A			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	13	11		10			8	1		16	8		
	Max Queue	49	46		40			35	8		47	38		
Signals	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	6.3	3.3	1.4	5.4	3.0	2.0	24.4	20.6	5.7	22.7	19.3	4.9	7.2
	Mvmt. LOS	A	A	A	A	A	A	C	C	A	C	B	A	A
	Mvmt. Volume	35	119	13	84	221	29	21	42	88	51	39	54	796
	Approach Delay	3.8			3.5			12.4			15.1			
	Approach LOS	A			A			B			B			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	10	4		8			1	4		16	41		
	Max Queue	38	24		31			8	19		41	80		

Year 2027 Analysis

	AM Peak Hour	T.H. 902 & County Road												
		T.H. 902			T.H. 902			County Road			County Road			
Existing TWSC	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	2.8	1.5	1.0	3.7	1.6	1.7	5.5	8.5	1.7	7.8	9.6	1.2	2.4
	Mvmt. LOS	A	A	A	A	A	A	A	A	A	A	A	A	A
	Mvmt. Volume	64	232	24	34	130	18	1	16	31	28	13	6	597
	Approach Delay	1.7			2.0			4.0			7.5			
	Approach LOS	A			A			A			A			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	4	0		2			1	4		8	24		
	Max Queue	20	0		10			9	19		29	60		
AWSC	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	5.8	7.6	3.4	7.5	7.2	5.3	3.5	6.9	1.7	4.8	7.1	1.2	6.5
	Mvmt. LOS	A	A	A	A	A	A	A	A	A	A	A	A	A
	Mvmt. Volume	64	232	24	34	130	18	1	16	31	28	13	6	597
	Approach Delay	6.9			7.1			3.5			5.0			
	Approach LOS	A			A			A			A			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	36	34		7			3	9		4	8		
	Max Queue	74	70		21			16	35		19	29		
Roundabouts	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	3.6	4.4	3.5	2.6	2.1	2.7	3.2	4.3	3.1	2.4	3.5	2.2	3.4
	Mvmt. LOS	A	A	A	A	A	A	A	A	A	A	A	A	A
	Mvmt. Volume	64	232	24	34	130	18	1	16	31	28	13	6	597
	Approach Delay	4.2			2.3			3.5			2.7			
	Approach LOS	A			A			A			A			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	14	13		2			4	0		8	2		
	Max Queue	57	55		18			23	4		34	15		
Signals	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	5.7	3.4	1.7	5.2	1.9	1.0	19.0	21.3	5.2	20.5	18.4	2.3	4.9
	Mvmt. LOS	A	A	A	A	A	A	B	C	A	C	B	A	A
	Mvmt. Volume	64	232	24	34	130	18	1	16	31	28	13	6	597
	Approach Delay	3.7			2.4			10.9			17.6			
	Approach LOS	A			A			B			B			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	18	10		2			0	1		3	21		
	Max Queue	61	43		11			3	8		14	52		

	PM Peak Hour	T.H. 902 & County Road												
		T.H. 902			T.H. 902			County Road			County Road			
Existing TWSC	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	3.9	1.7	1.2	4.5	2.8	2.6	14.5	18.1	3.1	18.8	13.3	1.9	5.5
	Mvmt. LOS	A	A	A	A	A	A	B	C	A	C	B	A	A
	Mvmt. Volume	52	177	19	125	329	43	31	63	131	76	58	80	1184
	Approach Delay	2.1			3.2			8.9			11.0			
	Approach LOS	A			A			A			B			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	12	2		10			0	0		25	32		
	Max Queue	43	19		35			0	5		53	68		
AWSC	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	7.7	9.3	3.8	10.7	9.8	7.6	7.0	9.1	2.6	7.0	8.8	1.7	7.9
	Mvmt. LOS	A	A	A	B	A	A	A	A	A	A	A	A	A
	Mvmt. Volume	52	177	19	125	329	43	31	63	131	76	58	80	1184
	Approach Delay	8.5			9.8			5.0			5.5			
	Approach LOS	A			A			A			A			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	36	29		24			14	27		23	29		
	Max Queue	77	68		53			42	59		47	57		
Roundabouts	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	4.7	5.1	4.1	3.8	3.4	4.0	3.4	4.9	4.4	4.0	5.3	4.0	4.1
	Mvmt. LOS	A	A	A	A	A	A	A	A	A	A	A	A	A
	Mvmt. Volume	52	177	19	125	329	43	31	63	131	76	58	80	1184
	Approach Delay	4.9			3.6			4.4			4.4			
	Approach LOS	A			A			A			A			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	33	27		21			22	3		31	17		
	Max Queue	79	73		58			63	18		72	59		
Signals	**Movement**	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	All
	Mvmt. Delay	9.5	6.0	2.1	9.8	4.5	3.1	24.6	19.9	7.5	25.1	18.4	5.3	9.1
	Mvmt. LOS	A	A	A	A	A	A	C	B	A	C	B	A	A
	Mvmt. Volume	52	177	19	125	329	43	31	63	131	76	58	80	1184
	Approach Delay	6.4			5.7			13.3			15.9			
	Approach LOS	A			A			B			B			
	Lane	EB L/T	EB T/R		WBL			NB L/T	NB T/R		SB L/T	SB T/R		
	Avg. Queue	24	15		22			2	13		25	53		
	Max Queue	70	52		62			15	47		59	99		

4.5.5 Network Analysis

The tables below summarize the total network measures for the four options and the four time periods.

AM Peak Hour Network MOEs

	Existing (Year 2007) AM Peak			
Alternative	Exist	AWSC	Roundabout	Signal
Total Delay (hr)	3.01	4.41	2.16	3.92
Delay / Veh (s)	11.7	17.2	8.4	15.3
Total Stops	590	1519	153	728
Stop/Veh	0.64	1.64	0.17	0.79
Hourly Exit Rate	925	924	924	922

PM Peak Hour Network MOEs

	Existing (Year 2007) PM Peak			
Alternative	Exist	AWSC	Roundabout	Signal
Total Delay (hr)	8.32	9.51	4.92	10.14
Delay / Veh (s)	17.4	19.9	10.3	21.2
Total Stops	1194	2728	435	1573
Stop/Veh	0.69	1.59	0.25	0.91
Hourly Exit Rate	1722	1721	1721	1722

AM 2027 Peak Hour Network MOEs

	Year 2027 AM Peak			
Alternative	Exist	AWSC	Roundabout	Signal
Total Delay (hr)	5.78	7.23	3.66	7.00
Delay / Veh (s)	15.5	19.4	9.8	18.8
Total Stops	872	2203	321	1158
Stop/Veh	0.65	1.64	0.24	0.86
Hourly Exit Rate	1343	1342	1343	1340

PM 2027 Peak Hour Network MOEs

	Year 2027 PM Peak			
Alternative	Exist	AWSC	Roundabout	Signal
Total Delay (hr)	93.67	18.54	9.78	19.77
Delay / Veh (s)	139.8	26.2	13.8	27.9
Total Stops	3129	4106	1145	2697
Stop/Veh	1.3	1.61	0.45	1.06
Hourly Exit Rate	2412	2548	2551	2551

As noted in the tables, the roundabout alternative shows the best overall performance measures when compared to the Existing, ASWC, and the Signal alternatives. Roundabouts have been shown to be generally safer than other forms of at-grade intersections. According to a series of case studies in the FHWA publication "Roundabouts: An Informational Guide", roundabouts were shown to reduce total accidents by up to 51%. In the same document, it is noted that good roundabout design encourages speed reduction and speed consistency. This should then provide the following safety benefits:

- Provide more time for entering drivers to judge, adjust speed for, and enter a gap in circulating traffic;
- Allow safer merges into circulating traffic;
- Provide more time for all users to detect and correct for their mistakes or mistakes of others;
- Make collisions less frequent and less severe; and

- Make the intersection safer for novice users;
- Reduce crash severity for pedestrians and bicyclists (pedestrians are minimal in this study area).

In general, roundabouts operate with lower delay when compared to other types of intersection control. However, delays to the major roadway may be increased since all movements are treated equally.

4.6 Conclusion

This section of the report contains the proposed improvement recommendations for the study area.

As noted earlier in the report, drivers in this area proceed through a series of T intersections. The recommendation is to standardize the intersection traffic control by installing roundabouts. Roundabouts have been shown to be a safe solution as compared to standard at-grade intersections. They are also acceptable to the politically in this area.

4.7 Supporting Documentation

For this fictitious report, supporting documentation is not included. However, it is shown for the sample reports in the appendix.

- Intersection Turning Movement Counts
- Warrant Analysis
- Traffic Analysis Output
- Diagrams, Aerials
- Other

5. ICE CHECKLIST

INTERSECTION: _____ DATE/TIME _____
S.P.: _____ CITY _____
FIELD REVIEWER: _____ RIGHT OF WAY/PROPERTY LINES: _____
COUNTY: _____ FUNDING _____
SPEED: _____ (TH) (CROSS ST.)
(TH) (CROSS ST.)

Phase 1 - Scoping, Data Collection, Analysis

❑	District Traffic Engineering Contact Info:
	Name: _____ Phone: _____
	Location: _____ Email: _____
❑	Local Agency Contact Info (if applicable):
	Name: _____ Phone: _____
	Location: _____ Email: _____
❑	Setup Meeting with District Traffic Engineer / Local Agency?
❑	Identify Study Area Limits

Data Collection - Traffic Volumes		See Page
❑	Collect AM and PM peak period turning movement counts (TMC's), typically 3 hours each	3-2
❑	Identify count start/end times	
❑	Any special counts required (Off peak, Saturday, etc.)?	
❑	Collect hourly approach counts, typically for 48 hours	
❑	Future TMC's required (if Warrant is unmet)?	
❑	Future Intersection approach counts required (if warrant is unmet)?	
❑	Pedestrian or bicycle volumes required?	
❑	Identify special instructions for volume data collection (i.e., DTE waives some requirements, existing data is available, special count periods, etc.)	

Data Collection - Crash Data		See Page
❑	Obtain data from Mn/DOT TIS database for the last 3 full calendar years	3-2
❑	Create/obtain crash diagrams	
❑	Crash reduction rates required?	
❑	If using crash reduction rates, what is the source (document in the appendix)	

Data Collection - Existing Geometrics	See Page
❑ Layout of existing geometrics available? If so, include in ICE report.	3-3
❑ Show existing lane configurations, striping, lane widths, parking lanes, shoulders and/or curb treatments, medians, pedestrian and bicycle facilities, ROW limits and access driveways or adjacent roadways for all approaches.	
❑ Identify Speed limit and Traffic Control	
❑ Identify adjacent structures, overhead utilities and vaults	
❑ Include larger scale map	
❑ Indicate locations of schools or other significant land uses	
❑ Identify geographic features that will influence the selection of an alternative (i.e., severe grades, wetlands, parkland, etc.)	

Data Collection - Proposed Geometrics	See Page
❑ Include a conceptual plan showing the proposed geometry	3-3
❑ Electronic copy of the plan available to include with ICE?	
❑ Document all changes from existing geometry	

Data Collection - List additional data requirements	See Page
❑ Community considerations (need for parking, sidewalks, bike lanes, etc.)	
❑ Future development plans	
❑ Types of vehicles	
❑ Political considerations	
❑ Driver expectations considered?	
❑ Others? List: _____	

Capacity Analysis of Existing Conditions	See Page
❑ Perform a capacity analysis of AM and PM Peak hour using accepted software (determine software requirements with DTE)	3-3
❑ Create/include a summary table of delays for all movements, approaches and overall intersection delay	
❑ Include software output in the Appendix	
❑ Electronic software files included with ICE submittal preferred	

Warrant Analysis	See Page
❑ Warrant analysis for All-Way Stop Control (AWSC) performed?	3-3
❑ Warrant analysis for Traffic Signal performed?	
❑ Using Metro Process for Signal Justification?	3-5
❑ If not using Metro Process, is alternative method documented? Include documented method in the appendix of ICE Report.	

Warrant Analysis - Metro SJR Methodology	See Page
❑ Consider only warrants 1A, 1B or 7 of the current Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD)	3-5
❑ If above are not met, consider future volumes (typically 5 years) if state funds are not used	
❑ Current traffic volumes do not meet Warrant 1A or 1B, but a significant crash problem exists (an average of at least three correctable crashes per year (any 12-month period) over the most recent 3-year period) and traffic volumes are likely to meet warrants within a reasonable period.	
❑ The intersection has significant amounts of pedestrian traffic, which can be documented.	
❑ Is spacing between signals on the mainline adequate? Is spacing between all nearby public and private access points adequate?	
❑ Is the installation of a signal at this location consistent with an adopted access management plan for the roadway?	
❑ Metro requires at least 1 lane of approach for each traffic volume. Is this requirement met? If not, list why.	
❑ Operations modeled with acceptable simulation software?	
❑ Is a signal the ONLY feasible solution? Better solutions available?	
❑ Will intersection be safer with signal installation?	
❑ Have the right turn volumes from the side street been excluded based on the methods in the ICE Manual?	

Analyze Alternatives - Crash Evaluation	See Page
❑ Is a estimate of crash frequency for proposed alternative required (check with DTE)?	3-9
❑ Have you checked to see if ICE published crash reduction factors are available?	

Analyze Alternatives - Capacity Evaluation	See Page
❑ Is the required data available for the analysis (current and design year volumes, alternative geometry, design vehicle, base plan with defined horizontal, vertical and site constraints, existing and design year peds and bikes).	3-9
❑ Identify and list the analysis software tools of choice (discuss with DTE)	
❑ Any ROW issues?	
❑ Any public/political considerations to consider at this point?	
❑ Are roundabouts to be considered?	
❑ Any unconventinal intersection designs to be considered?	
❑ Is terrain an issue to consider?	
❑ Does intersection spacing meet the Mn/DOT Access Management Policy?	
❑ Any impact on Interregional Corridors (IRC)?	
❑ Any pedestrian or bicycle issues?	

Phase 2 - Alternative Selection

❑ Is a Phase 2 analysis Required? If not, complete ICE document	

Alternative Selections	See Page
❑ Prepare Conceptual Designs for feasible alternatives	3-11
❑ Identify ROW requirements for alternatives	
❑ Develop cost estimates for alternatives	
❑ Consider any political or public considerations to the alternatives	
❑ Reevaluate the alternatives	
❑ Approve layout of preferred alternative	

Approval and Report

Write Report & Obtain DTE Approval	See Page
❑ Is a full report or memorandum required?	3-12
❑ Include a concurrence letter (not needed if project internal to Mn/DOT)	
❑ Include a cover sheet with signature blocks for report preparer and other approving agencies	
❑ Description of Location	
❑ Existing Conditions summary	
❑ Future Conditions summary	
❑ Analysis of Alternatives	
❑ Recommended Alternative	
❑ Appendices (supporting data, diagrams, software reports, etc.)	
❑ Obtain approval and signature from DTE	

6. APPENDIX

6.1 ICE Guidelines for Implementation (Draft)

INTERSECTION CONTROL EVALUATION (ICE)
GUIDELINES FOR IMPLEMENTATION

(Draft 8/1/07)

The purpose of this document is to provide direction and recommendations for completing an ICE for any intersection. Since this is a new process, this will be a living document and updates will be necessary. Please check with the Dave Engstrom at the Office of Traffic, Safety and Operations or the local District Traffic Engineer to determine if you possess the latest draft of this document or need clarification on what will be required.

GENERAL

The process needed to complete an ICE is highly dependent on two factors. These factors will impact how much effort is involved in completing the study, who is involved in each stage of the study and what they are accountable for. These major factors are described below.

Project origination. The project can originate within Mn/DOT or from an outside jurisdiction. If the project originates from an outside jurisdiction, that entity is responsible for completing the ICE. It is imperative that the appropriate Mn/DOT Traffic Engineer be involved early in the process to insure that the analysis will be accepted and approved. Most of the work needed for the ICE will be done by Traffic Engineering (unless an outside consultant is hired for this purpose). For all ICE's completed by outside jurisdictions or consultants, Traffic Engineering is accountable for review and approval.

Size/Type of Project. Generally, smaller projects will require less analysis and therefore less work. Preservation projects (Signal rebuilds) will require minimal analysis. However a memo/letter must be submitted for approval. The document should state some rationale for the work being done and why other types of traffic control are not being considered.
Stand-alone intersections will require a safety and capacity analyses as well as documentation of other impacts (cost, ROW, political concerns, etc.). The amount of analysis will depend on each project's location and scope.
Intersections which are a part of larger projects and/or have significant impact to adjacent intersections will probably require significant analysis and documentation. Early coordination with the District Traffic Engineer on these projects is important. Making decisions on traffic control earlier in the project development process will improve the quality of the design and minimize conflicts with stakeholders.

THE PROCESS

The process is described in Tech Memo 07-02-T-01. This section is intended to act as guidance for completion of the study. Hopefully, it will answer most questions, but if

not, the local District Traffic Engineer should be contacted for clarification. Each project is unique, and therefore the required analysis and documentation will vary. The following is a guide on what analyses and documentation should be done.

General. The purpose of ICE is to determine the optimum traffic control based on a technical and financial analysis as well as political factors. The following is general guidance on completing an ICE study.

1. Avoid overanalyzing a location. If a decision has been made or one traffic control type will be the choice, document the decision making process and include in a short memo or basic report. It still may be necessary to gather traffic data, conduct a warrant analysis and complete a safety and capacity analysis.
2. A decision may be reached after Phase 1. It will still be necessary to develop preliminary layouts, cost estimates and other project development tasks, but an ICE report can be completed at this time. However, if the project development process negates what has occurred in Phase 1, it will be necessary to revise the report.
3. All projects programmed for fiscal year 2008 and beyond must have an ICE completed.
4. For larger projects in areas where traffic volumes may increase on the local system as well as the arterial, careful consideration should be taken to determine if an ICE is necessary. Relying on future traffic projections, in which traffic volume warrants are barely met, should not be a requirement to perform an ICE. Generally speaking, if warrants are unlikely to be met within a 5 year time frame, an ICE is unnecessary.

Warrant Analysis. For any intersection beyond thru-stop control, a warrant analysis must be completed.

1. Traffic volumes must be obtained. For most cases existing volumes are preferred. However, future anticipated volumes may be used if development is imminent. For new roadways projections must be used.
2. Confer with the District Traffic Engineer on which warrant will be allowed. In most instances, follow the procedures within the Tech Memo.

Safety Analysis. If the warrant analysis confirms that additional traffic control will be needed at a location, a safety analysis should be performed for all intersection alternatives.

1. Existing crash records should be obtained and shown in the report as stated in the Tech Memo.
2. For each alternative an estimate of future crashes should be obtained. It is suggested that this analysis utilize crash rates to keep it simple. If desired, a more thorough crash reduction methodology can be used. A table of average crash rates for each alternative has been developed and will be updated and

revised periodically. A comparison of anticipated total crashes and severe crashes should be documented for a target year.

3. **Although stated in the Tech Memo, it is unnecessary to compute crash reductions per year and crash cost. Currently, this additional data is considered to be unnecessary.**

Capacity Analysis. For comparison purposes a capacity analysis should be conducted for each alternative. We recognize that the capacity analysis contained in current software for roundabouts has some issues. We anticipate advances in this area and may change software requirements at a future date.

1. Year of analysis. 20 year projects are the default for this type of analysis, however, due to the variability in accuracy of traffic projections, shorter time frames should be strongly considered in many instances. If total development is expected to occur within 5 years, 5 years should be the target year for analysis. If the capacity analysis appears to highlight near failures within this timeframe, future projections should be analyzed.
2. Choice of models. Generally speaking, avoiding the use of VISSIM should always be the rule. If analysis of individual intersections indicates no potential for queues impacting adjacent intersections, there is no need to conduct a VISSIM analysis, no matter how many intersections are analyzed or their lack of adequate spacing. However, if the opposite is true, first optimize the individual intersection analysis or increase geometric options which increase capacity and only if that fails should VISSIM be used.
3. The primary goal of this exercise is to first – insure that each intersection will operate acceptably for each type of traffic control and second – to provide a gross level of comparison between options.

6.2 Sample ICE Report 1

 *** HANDOUT ***

MINNESOTA DEPARTMENT OF TRANSPORTATION

INTERSECTION CONTROL EVALUATION

ICE REPORT

for
S.P. 1908-74
T.H. 3 at CSAH 26/70th St
In Inver Grove Heights, Dakota County

Program: SC (Safety Capacity) Funding: SF (State Funds)

Letting Date: December 19, 2008

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

Preparer's name, P.E. Reg. No. Date

REVIEWED:

County Engineer Date

APPROVED:

Metro District Traffic Engineer - Program Support Date

SAMPLE

 *** HANDOUT ***

*** HANDOUT ***

I. DESCRIPTION OF LOCATION

The proposed traffic control revision is located at the intersection of Trunk Highway (TH) 3 and County State Aid Highway (CSAH) 26 in Inver Grove Heights, Dakota County, Minnesota. The City of Inver Grove Heights is located just south of the capitol city of St. Paul and is situated in the northern portion of Dakota County. The intersection itself is located approximately 1 mile north of TH 55 and approximately 1¾ miles south of I-494. Approximately 1¼ miles east of this intersection along CSAH 26 is USTH 52. (See Figure 1, Project Location Map). The US Census Bureau 2005 Population Estimate for the City of Inver Grove Heights is 33,182.

II. EXISTING CONDITIONS

TH 3 is currently a two lane undivided north-south highway at the proposed project location. It is classified as a minor arterial and has a posted speed limit of 50 mph. TH 3 currently has right turn lanes in both directions at the intersection with CSAH 26/70th Street. The AADT (2006) on TH 3 is 6,900 south of the intersection and 6,800 north of the intersection.

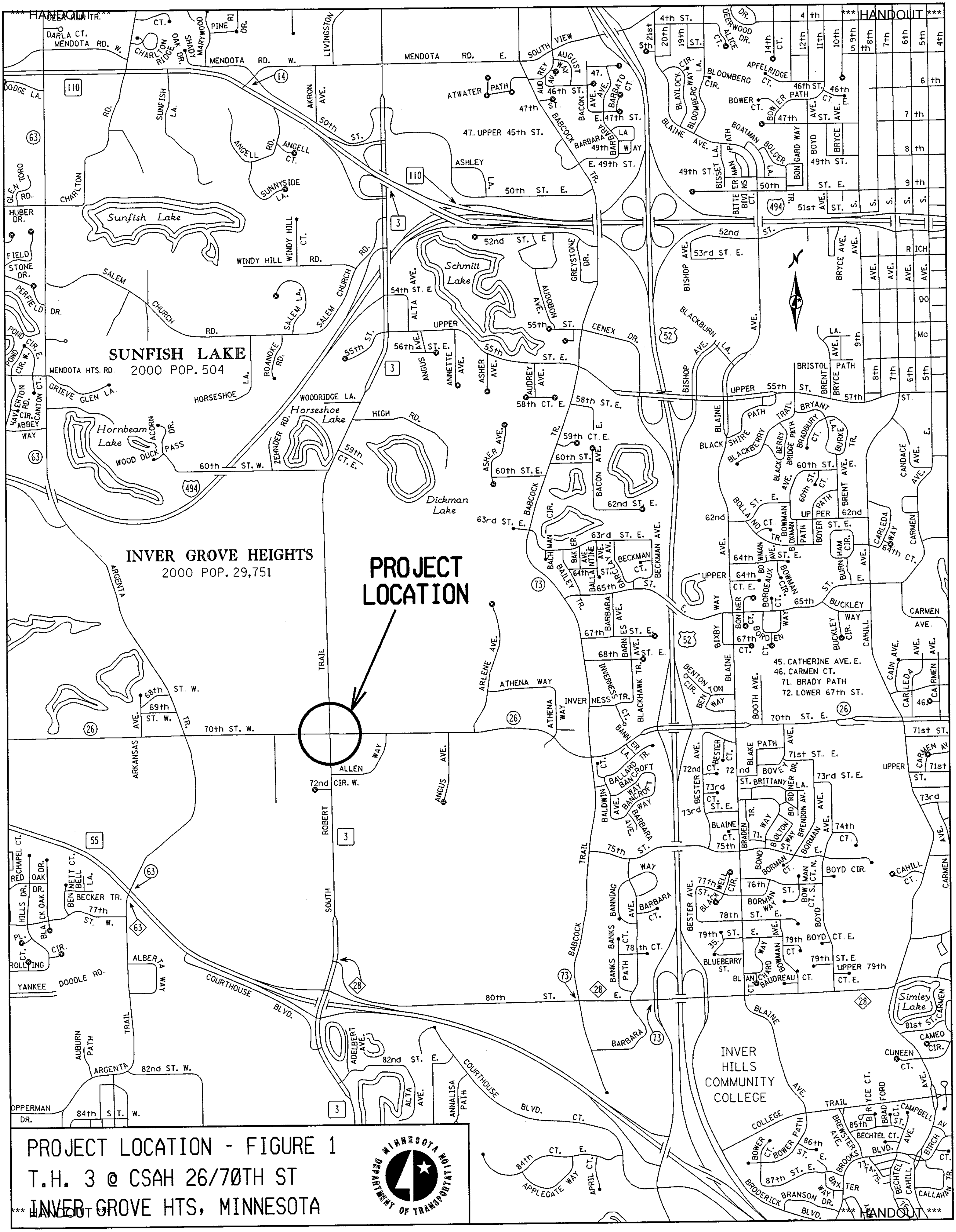
CSAH 26/70th Street is a two lane undivided east-west County State Aid Highway in the City of Inver Grove Heights in Dakota County. At the intersection with TH 3, both the eastbound and westbound directions of CSAH 26 have only a single lane of approach with no turn lanes. The posted speed limit on CSAH 26/70th Street is 50 mph and the AADT (2005) is 6,700 east of TH 3 and 5,600 to the west of this location. The 2004 analysis in Table 2 shows a LOS F for northbound TH 3 during the AM peak, and a LOS F for southbound TH 3 and both eastbound and westbound CSAH 26 during the PM peak. This analysis shows the delays at this intersection justify a new traffic control, which is also supported by citizen complaints received.

The grade approaching this intersection from the west is approximately -8%. The other approaching grades are relatively flat.

This intersection has been operating in its current all-way stop condition since 1998. (See Figure 2, Existing Geometrics).

*** HANDOUT ***

*** HANDOUT ***



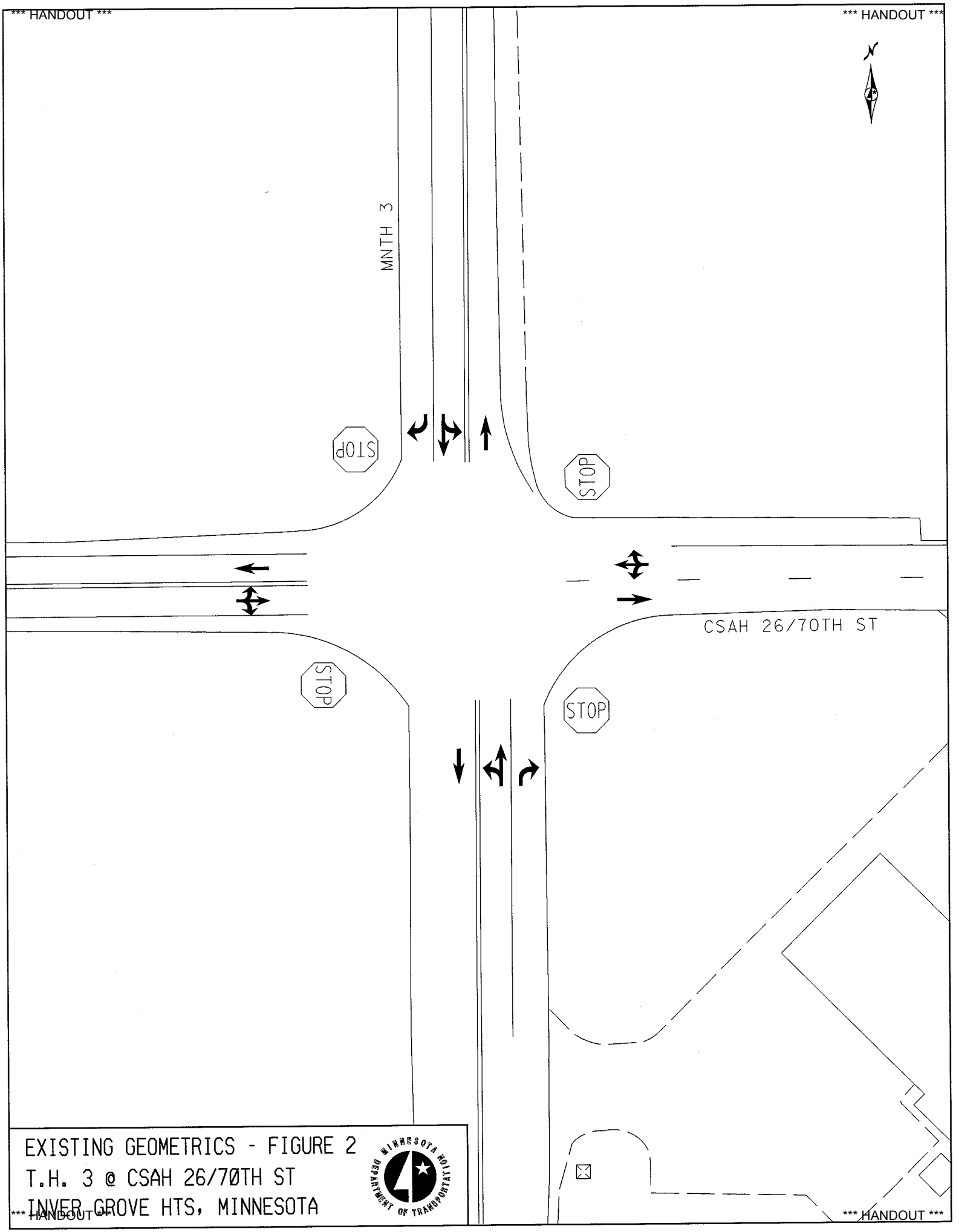
PROJECT LOCATION - FIGURE 1

T.H. 3 @ CSAH 26/7ØTH ST

INVER GROVE HTS, MINNESOTA

*** HANDOUT ***
*** HANDOUT ***
*** HANDOUT ***

*** HANDOUT ***
*** HANDOUT ***



EXISTING GEOMETRICS - FIGURE 2
T.H. 3 @ CSAH 26/70TH ST
INVER GROVE HTS, MINNESOTA

*** HANDOUT ***
*** HANDOUT ***

III. FUTURE CONDITIONS

A number of new development concepts have been reviewed for this area, including one in the northeast corner of this intersection. The additional trips generated by these proposed developments, will increase the delay and degrade the LOS if an all way stop condition remains inplace.

The current all way stop condition has been at this intersection since 1998 and would be operating at an overall LOS F in 2025 if no other modification were done. Population growth in this area of Dakota County is anticipated to be 3% per year based on historical data. Volume data for 2025 was projected from 2004 field gathered traffic data.

IV. ANALYSIS OF ALTERNATIVES

Crash Analysis

Projected 2025 ADT volumes for the TH 3 and CSAH 26 intersection and standard crash rates by control type for state highway intersections were used to estimate annual numbers of crashes for each alternative. Standard crash rates of 0.6 crashes/Million Entering Vehicles (MEV) for an all-way stop intersection and a rate of 0.7 crashes/MEV for a signalized intersection were used in determining future crash estimates. These rates were taken from The Traffic Safety Fundamentals Handbook, April 2001, published by the Minnesota Department of Transportation. Typically, roundabouts reduce the number of crashes by approximately 50 percent as compared to a signalized intersection thus, a standard crash rate of 0.35 crashes/MEV was used for this alternative.

Table 1 shows the current and projected crash totals for each alternative.

Table 1
Predicted Crash Totals

Alternative	Average Crash Rate	Average Crashes/Year 2003-2005	Projected Crashes/Year 2025
All-Way Stop	0.6	5	5-9 **
Traffic Signal	0.7	NA	6
Roundabout	0.35	NA	3

** This intersection had a total of 15 crashes for the years 2003-2005 for an average of 5 crashes per year. See the collision diagrams in Appendix B. The existing crash rate for the current all-way stop condition at this intersection is 1.0, which is higher than the average (0.6) listed in the Mn/DOT Traffic Safety Fundamentals Handbook. Using the average (0.6) the projected number of crashes per year in 2025 is 5. Using the existing 1.0 crash rate and projecting to 2025, the number of crashes projected per year is 9.

Warrant Analysis
A signal warrant analysis was done using 48-hour counts taken in September, 2004. The signal warrant requirements were reduced to 70 percent of their stated value based on the fact that the posted speed limit on TH 3 exceeds 40 mph. A Mn/DOT standard practice is to remove 100% of the right turning volumes from the minor legs for this signal warrant analysis based on the turn movement counts at the intersection. The rationale for this practice is that these movements are usually made relatively easily, have minimal conflicts and therefore do not require a traffic signal to minimize delay or improve safety.

The traffic volume at the intersection of TH 3 at CSAH 26/70th Street satisfies the requirements of warrants 1A, 2, and 3. The installation of a traffic signal for this intersection would be justified if this is considered to be the preferred alternative. A roundabout is considered to be justified if the intersection meets either a signal warrant or the all way stop warrant. Because this intersection meets both, a roundabout can also be justified at this location.

The signal warrant analysis, and turning movement counts, are included in Appendix C and D respectively.

Capacity Analysis
A capacity analysis was completed for each of the proposed intersection control alternatives using both current and forecasted AM and PM peak hour volumes. The proposed geometrics for a roundabout option and a signalized option are shown in Appendix A. These are only concept layouts with refinements likely during the final design of each alternative.

An analysis was performed using SYNCHRO traffic modeling software for both the all-way stop and the signal controlled intersection alternatives. An analysis was also conducted using RODEL traffic modeling for the roundabout alternative.

This initial RODEL analysis used typical design parameters and indicates acceptable delay and LOS for opening day for a single lane roundabout. The 2025 analysis, with the same design parameters, shows one approach in the AM and one approach in the PM performing at LOS F. During the final design of a roundabout, these design parameters will be adjusted in order to design a roundabout that will perform at LOS D or better for all approaches 20 years after opening. This may or may not require an approach to have two approach lanes initially.

The capacity analysis measured the effectiveness of each alternative in regards to LOS, average delay, average queue and maximum queue. The data gathered in these analyses is contained in Table 2, Capacity Analysis Table.

*** HANDOUT ***

Capacity Analysis Table

Table 2

MNTH 3 @ 70TH ST/CSAH 26

Peak Hour Analysis - 2004

AM Peak Hour		Minor Leg: EB CSAH 26			Minor Leg: WB CSAH 26			Major Leg: NB TH 3			Major Leg: SB TH 3		
		L	T	R	L	T	R	L	T	R	L	T	R
Approach Volume (veh/hr)		69	143	16	53	330	29	45	421	248	13	92	88
			LTR			LTR			LT	R		LT	R
All-way Stop Control	LOS		C			E			F	C		B	B
	Avg. Delay		19.7			45.3			97.8	16.4		13.7	11.8
	Avg. Queue		51			110			156	54		38	36
	Max. Queue		124			195			293	92		55	73
Traffic Signal Control	LOS	B	C	B	B	C	A	B	C	A	B	C	A
	Avg. Delay	15.9	23.4	11.1	15.2	29.6	9.4	15.0	25.6	4.6	16.2	22.6	6.3
	Avg. Queue	16	49	0	13	131	0	12	145	0	3	34	0
	Max. Queue	54	127	15	44	297	21	40	395	55	17	90	37
	Approach LOS		C			C			B			B	
Roundabout	Avg. Delay		3.0			4.2			5.4			3.0	
	Avg. Queue		0			25			25			0	
	Max. Queue		0			25			50			0	
	Approach LOS		A			A			A			A	

PM Peak Hour		Minor Leg: EB CSAH 26			Minor Leg: WB CSAH 26			Major Leg: NB TH 3			Major Leg: SB TH 3		
		L	T	R	L	T	R	L	T	R	L	T	R
Approach Volume (veh/hr)		62	362	42	217	188	23	21	167	98	57	375	80
			LTR			LTR			LT	R		LT	R
All-way Stop Control	LOS		F			F			C	B		F	B
	Avg. Delay		142.0			111.4			22.8	14.0		130.8	12.1
	Avg. Queue		559			648			60	39		1176	273
	Max. Queue		892			1151			88	63		3932	452
Traffic Signal Control	LOS	B	D	A	B	C	A	B	C	A	B	C	A
	Avg. Delay	13.7	36.7	8.5	19.5	20.2	9.1	15.6	23.9	5.9	15.5	28.3	6.1
	Avg. Queue	15	159	0	57	67	0	7	74	0	18	148	0
	Max. Queue	44	#335	25	#134	147	17	20	131	35	42	303	32
	Approach LOS		C			B			B			C	
Roundabout	Avg. Delay		5.4			3.6			3.6			4.8	
	Avg. Queue		25			0			0			25	
	Max. Queue		25			25			0			25	
	Approach LOS		A			A			A			A	

Peak Hour Analysis - 2025

AM Peak Hour		Minor Leg: EB CSAH 26			Minor Leg: WB CSAH 26			Major Leg: NB TH 3			Major Leg: SB TH 3		
		L	T	R	L	T	R	L	T	R	L	T	R
Approach Volume (veh/hr)		125	258	29	96	596	52	81	760	448	23	166	159
			LTR			LTR			LT	R		LT	R
All-way Stop Control	LOS		F			F			F	F		C	C
	Avg. Delay		108.0			477.0			625.0	115.0		23.1	17.5
	Avg. Queue		179			3124			3328	328		65	48
	Max. Queue		362			3808			3582	345		161	110
Traffic Signal Control	LOS	E	D	B	C	E	B	B	E	A	B	C	A
	Avg. Delay	68.5	37.0	10.1	25.8	77.6	12.5	18.1	65.2	9.9	19.6	26.5	4.0
	Avg. Queue	76	198	0	57	~630	8	40	~798	81	11	101	0
	Max. Queue	#200	286	24	98	#868	40	69	#1049	187	26	156	44
	Approach LOS		D			E			D			B	
Roundabout	Avg. Delay		3.6			15.0			105.6			4.8	
	Avg. Queue		0			75			1075			0	
	Max. Queue		0			125			1975			25	
	Approach LOS		A			C			F			A	

PM Peak Hour		Minor Leg: EB CSAH 26			Minor Leg: WB CSAH 26			Major Leg: NB TH 3			Major Leg: SB TH 3		
		L	T	R	L	T	R	L	T	R	L	T	R
Approach Volume (veh/hr)		112	654	76	392	340	42	38	302	177	103	677	144
			LTR			LTR			LT	R		LT	R
All-way Stop Control	LOS		F			F			F	C		F	C
	Avg. Delay		653.0			577.2			77.0	18.7		605.3	16.3
	Avg. Queue		3084			3248			153	76		3570	290
	Max. Queue		3536			3808			3377	200		3966	337
Traffic Signal Control	LOS	C	F	B	F	C	A	C	D	A	C	F	B
	Avg. Delay	22.3	137.8	15.8	144.8	30.8	6.5	30.7	42.9	5.5	29.8	116.6	14.1
	Avg. Queue	60	~838	20	~453	250	0	23	254	0	66	~838	36
	Max. Queue	98	#1085	61	#673	343	25	49	354	55	109	#1089	92
	Approach LOS		F			F			C			F	
Roundabout	Avg. Delay		128.4			7.2			6.6			30.6	
	Avg. Queue		850			50			25			200	
	Max. Queue		1625			50			25			375	
	Approach LOS		F			A			A			D	

NOTES:
LOS – Level of Service
Avg Delay – Average Delay for that movement in seconds
Avg Queue – Average queue length for that lane in feet
Max Queue – Maximum queue length for that lane in feet

L – Left Turn Lane T – Through Lane R – Right Turn Lane
~ indicates that the approach is above capacity and the queue length could be much longer
# indicates that the volume for the 95th percentile cycle exceeds capacity

*** HANDOUT ***

V. RECOMMENDED ALTERNATIVE

Based on the information provided within this document and engineering judgment the following conclusions have been drawn:

- Using the volume projections for year 2025, the current all way stop condition shows all four thru movements would operate at LOS F during PM peak, if no modifications were done to the intersection. An all way stop condition with multiple approach lanes on each leg, introduces driver confusion on whose turn it is to go next, resulting in an inefficient operation of the intersection. The all way stop condition is not being considered further, because of these concerns.

- Using the volume projections for 2025, a signalized intersection with 3 lanes of approach for each leg, would result in three of the approaches operating at LOS F in the PM peak. Additional lanes of approach (thru, left turn lane) would be required before 2025 to keep an acceptable LOS. This would require two lanes departing from the intersection to accept the two thru and/or dual left turn lanes.

- A roundabout would be designed for a LOS D, for each approach leg, for 20 years after constructed.

- The single lane roundabout layout would be designed to accommodate a future multi lane roundabout by using an increased inscribed diameter. Future traffic volumes may warrant an increased capacity need.

- Constructing a roundabout at this location would have a slightly lower initial cost than a signalized intersection, and would not have the associated signal maintenance and power costs a signalized intersection would have.

- The cost for expansion of a roundabout in the future, is determined to be less expensive than to expand a signalized intersection with additional thru and/or left turn lanes.

- The greatest crash reduction is anticipated if a roundabout is constructed at this location.

Because of costs, an interchange, continuous flow, and other non-traditional types of intersections were not analyzed beyond initial discussion.

Based on the above mentioned conclusions, a roundabout is recommended at this intersection. It is anticipated that the roundabout will be designed to have a LOS D for all approach legs at 20 years after construction is completed. It is also anticipated that additional modeling of the roundabout may be necessary during the final layout approval process, as this ICE Report has not modeled the final configuration.

*** HANDOUT ***

Meetings with the City and County to discuss the different options will happen in the near future. At these meetings, both vertical and horizontal alignment of the intersection and approaches will be discussed, which will determine if additional right-of-way will need to be obtained. It appears that there is an option where no right-of-way will be needed, but shifting the intersection to the east to reduce the approach grade from the west, may result in the need for additional right-of-way.

A final decision for the type of traffic control at this intersection will be made after discussions with the City and County are completed.

VI. APPENDIX

A. Proposed Alternative Geometrics
B. Collision Diagrams
C. Signal Warrant Analysis
D. Turn Movement Counts
E. SYNCHRO Modeling Data
F. RODEL Modeling Data

SAMPLE

*** HANDOUT ***

*** HANDOUT ***

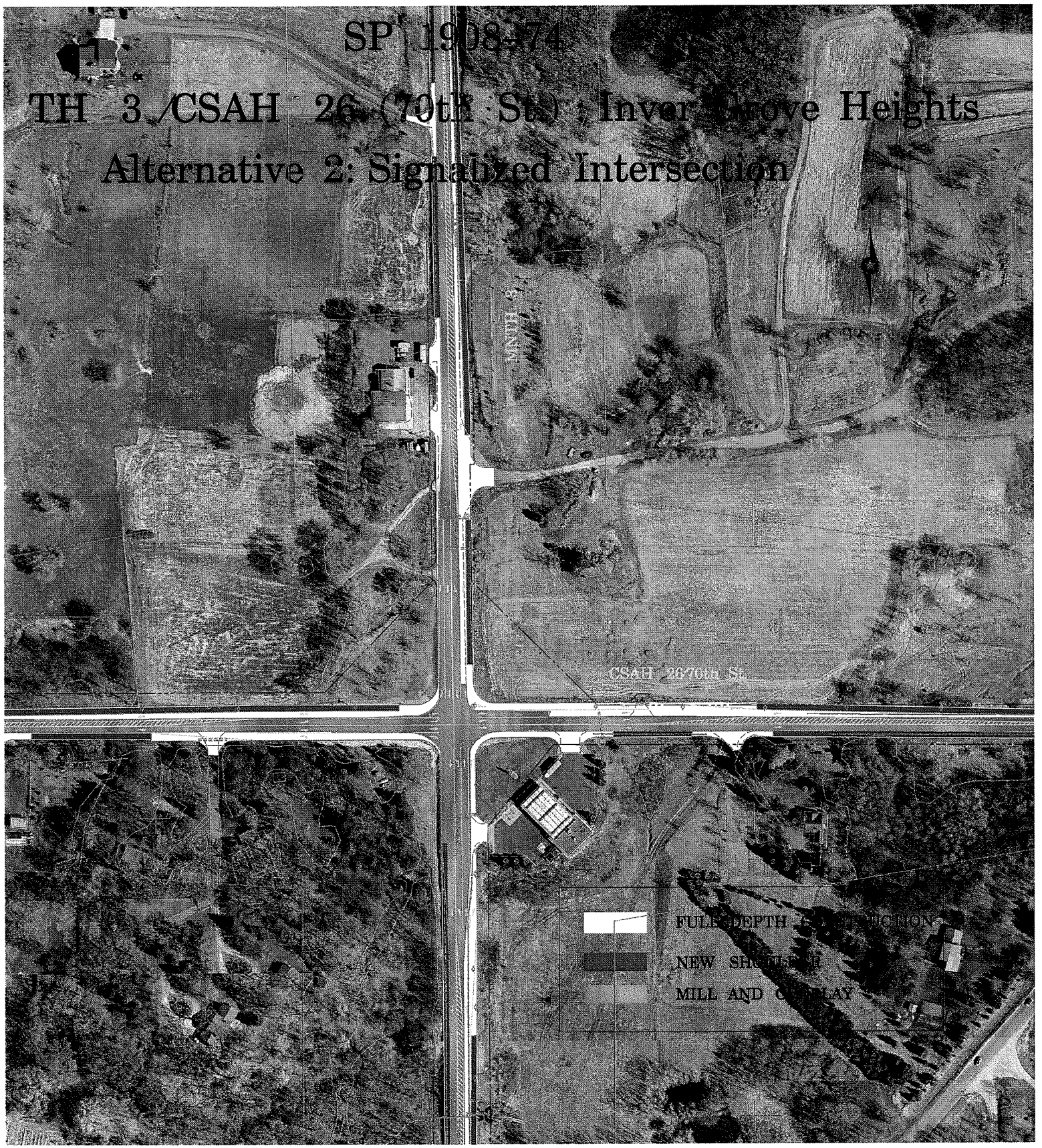
Appendix A

Proposed Alternative Geometrics

SAMPLE

*** HANDOUT ***

*** HANDOUT ***



*** HANDOUT ***

*** HANDOUT ***

*** HANDOUT ***

*** HANDOUT ***

Appendix B

Collision Diagrams

SAMPLE

*** HANDOUT ***
*** HANDOUT ***

MN DOT 2942 (rev 9-11-92)

COLLISION DIAGRAM

Minnesota Department of Transportation

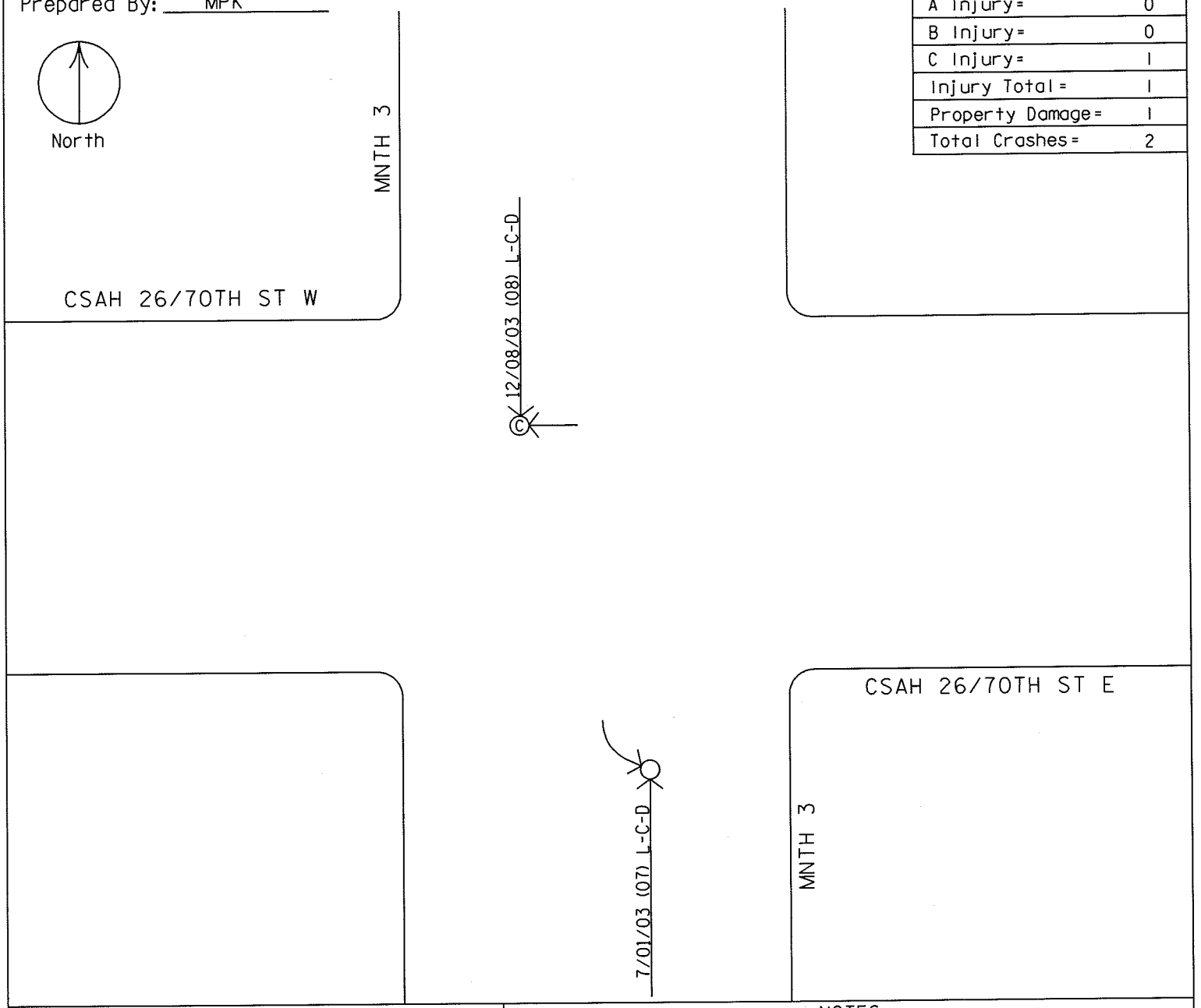
*** HANDOUT ***

Location: C.S.1908 MNTH 3 @ CSAH 26/70TH ST 41+00.713

Time Period: 1/1/03 - 12/31/03 Date: 9/7/05

Prepared By: MPK

No. of Crashes	
Fatal =	0
A Injury =	0
B Injury =	0
C Injury =	1
Injury Total =	1
Property Damage =	1
Total Crashes =	2



KEY

- Motor Vehicle Out of Control
- Motor Vehicle Backing Up
- Motor Vehicle Rollover
- Motor Vehicle Sideswipe
- Fixed Object
- Fatal Crash
- A Injury Crash
- B Injury Crash
- C Injury Crash
- Property Damage Crash
- Pedestrian
- Bicycle
- Motorcycle
- Parked Vehicle
- Rear End Property Damage
- Right Angle B Injury

NOTES

[1]
[2]
[3]

Light:	Weather:	Surface:
L = Daylight (1)	C = Clear or Cloudy (1 or 2)	D = Dry (1)
Dn = Dawn (2)	R = Rain (3)	W = Wet (2)
Du = Dusk (3)	S = Snow or Sleet (4 or 5)	S = Snow or Ice (3 or 4)
Dl = Dark, Lighted (4)	F = Fog, Smog, Smoke (6)	M = Muddy (5)
Do = Dark, Lights Off (5)	B = Blowing Sand/Dust (7)	Db = Debris (6)
D = Dark, Unlighted (6)	W = Severe Crosswinds (8)	O = Oily (7)
X = Unknown (99)	X = Other or Unknown (99)	X = Other or Unknown (99)

(X) = Number of Vehicles in Crash (X) Other Vehicle Injury Type [Date]—[Time (hrs)]—[Light-Weather-Surface]

3@70thSt-csah26.dgn 3/19/2007 2:37:06 PM

*** HANDOUT ***

COLLISION DIAGRAM

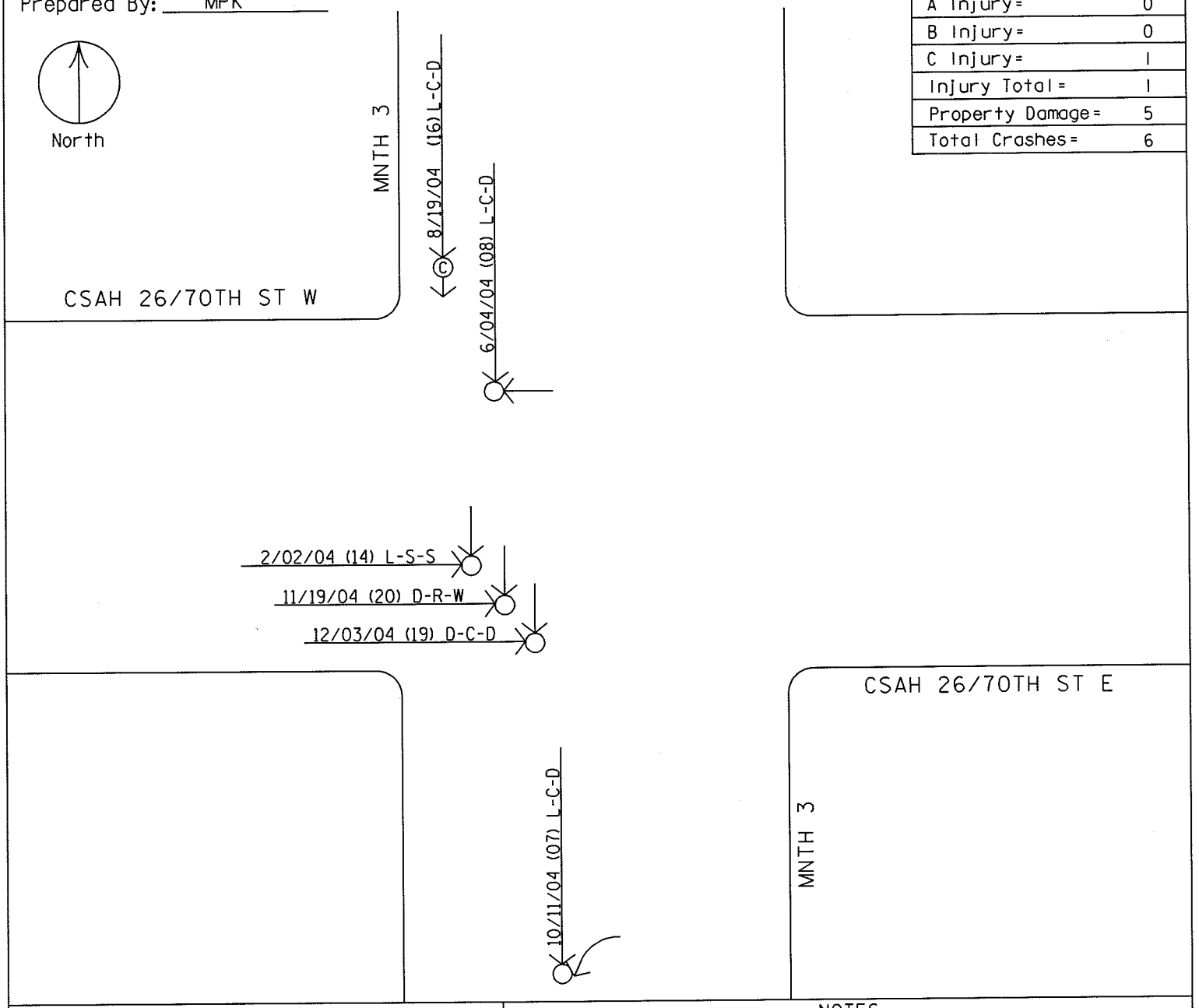
Minnesota Department of Transportation

Location: C.S.1908 MNTH 3 @ CSAH 26/70TH ST 41+00.713

Time Period: 1/1/04 - 12/31/04 Date: 9/7/05

Prepared By: MPK

No. of Crashes	
Fatal =	0
A Injury =	0
B Injury =	0
C Injury =	1
Injury Total =	1
Property Damage =	5
Total Crashes =	6



KEY

- Motor Vehicle Out of Control
- Motor Vehicle Backing Up
- Motor Vehicle Rollover
- Motor Vehicle Sideswipe
- Fixed Object
- Fatal Crash
- A Injury Crash
- B Injury Crash
- C Injury Crash
- Property Damage Crash
- Pedestrian
- Bicycle
- Motorcycle
- Parked Vehicle
- Rear End Property Damage
- Right Angle B Injury

NOTES

[1]
[2]
[3]

Light:	Weather:	Surface:
L = Daylight (1)	C = Clear or Cloudy (1 or 2)	D = Dry (1)
Dn = Dawn (2)	R = Rain (3)	W = Wet (2)
Du = Dusk (3)	S = Snow or Sleet (4 or 5)	S = Snow or Ice (3 or 4)
Dl = Dark, Lighted (4)	F = Fog, Smog, Smoke (6)	M = Muddy (5)
Do = Dark, Lights Off (5)	B = Blowing Sand/Dust (7)	Db = Debris (6)
D = Dark, Unlighted (6)	W = Severe Crosswinds (8)	O = Oily (7)
X = Unknown (99)	X = Other or Unknown (99)	X = Other or Unknown (99)

(X) = Number of Vehicles in Crash (X) Other Vehicle — Injury Type — [Date]—[Time (hrs)]—[Light-Weather-Surface]

COLLISION DIAGRAM

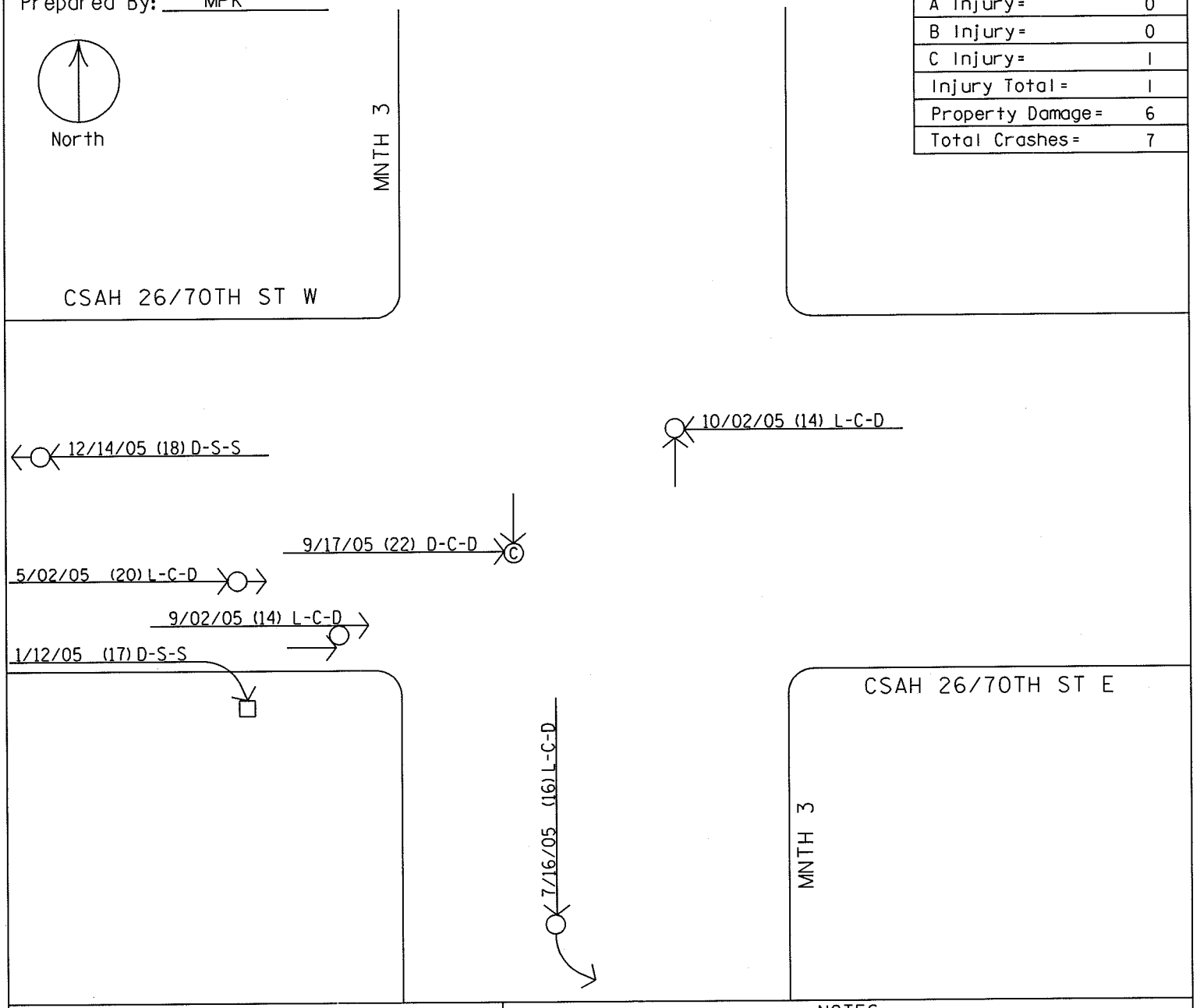
Minnesota Department of Transportation

Location: C.S.1908 MNTH 3 @ CSAH 26/70TH ST 41+00.713

Time Period: 1/1/05 - 12/31/05 Date: 11/8/06

Prepared By: MPK

No. of Crashes	
Fatal =	0
A Injury =	0
B Injury =	0
C Injury =	1
Injury Total =	1
Property Damage =	6
Total Crashes =	7



KEY

- Motor Vehicle Out of Control
- Motor Vehicle Backing Up
- Motor Vehicle Rollover
- Motor Vehicle Sideswipe
- Fixed Object
- Fatal Crash
- A Injury Crash
- B Injury Crash
- C Injury Crash
- Property Damage Crash
- Pedestrian
- Bicycle
- Motorcycle
- Parked Vehicle
- Rear End Property Damage
- Right Angle B Injury

NOTES

[1]
[2]
[3]

Light:	Weather:	Surface:
L = Daylight (1)	C = Clear or Cloudy (1 or 2)	D = Dry (1)
Dn = Dawn (2)	R = Rain (3)	W = Wet (2)
Du = Dusk (3)	S = Snow or Sleet (4 or 5)	S = Snow or Ice (3 or 4)
Dl = Dark, Lighted (4)	F = Fog, Smog, Smoke (6)	M = Muddy (5)
Do = Dark, Lights Off (5)	B = Blowing Sand/Dust (7)	Db = Debris (6)
D = Dark, Unlighted (6)	W = Severe Crosswinds (8)	O = Oily (7)
X = Unknown (99)	X = Other or Unknown (99)	X = Other or Unknown (99)

(X) = Number of Vehicles in Crash (X) Other Vehicle Injury Type [Date]—[Time (hrs)]—[Light-Weather-Surface]

*** HANDOUT ***

Appendix C

Signal Warrant Analysis

SAMPLE

*** HANDOUT ***
*** HANDOUT ***

*** HANDOUT ***

MINNESOTA DEPARTMENT OF TRANSPORTATION

METRO DIVISION - TRAFFIC ENGINEERING

SIGNAL WARRANTS ANALYSIS

LOCATION: TH 3 @ CSAH 26 / 70th St
COUNTY: Dakota
REF. POINT: 41+00.713
DATE: 9/27/2004

OPERATOR: LI

100% OF RIGHT TURNS REMOVED FROM MINOR LEGS

Speed	Approach Description	Lanes
50	Major App1: NB TH3, south of 70th St	2
50	Major App3: SB TH3, north of 70th St	2
50	Minor App2: EB 70th, west of TH3	2
45	Minor App4: WB 70th, east of TH3	2

0.70 FACTOR USED? YES
POPULATION < 10,000? No
EXISTING SIGNAL ? No

THRESHOLDS 1A/1B:				420/630	-9%		-7% 140/70	140/70	
HOUR	MAJOR APP. 1	MAJOR APP. 3	TOTAL 1+3	MAJOR 1A/1B	MINOR APP. 2	MINOR 2 1A/1B	MINOR APP. 4	MINOR 4 1A/1B	**MET SAME 1A/1B**
0:00 - 1:00	12	12	24	/	12	/	10	/	/
1:00 - 2:00	6	9	15	/	20	/	7	/	/
2:00 - 3:00	12	5	17	/	16	/	6	/	/
3:00 - 4:00	7	7	14	/	15	/	17	/	/
4:00 - 5:00	16	15	31	/	5	/	28	/	/
5:00 - 6:00	76	69	145	/	20	/	109	/X	/
6:00 - 7:00	341	133	474	X/	64	/	304	X/X	**X/**
7:00 - 8:00	740	187	927	X/X	182	X/X	376	X/X	**X/X**
8:00 - 9:00	423	167	590	X/	165	X/X	237	X/X	**X/**
9:00 - 10:00	245	185	430	X/	114	/X	138	/X	/
10:00 - 11:00	191	168	359	/	106	/X	124	/X	/
11:00 - 12:00	198	187	385	/	169	X/X	146	X/X	/
12:00 - 13:00	231	227	458	X/	165	X/X	167	X/X	**X/**
13:00 - 14:00	215	235	450	X/	142	X/X	160	X/X	**X/**
14:00 - 15:00	271	254	525	X/	211	X/X	204	X/X	**X/**
15:00 - 16:00	285	373	658	X/X	351	X/X	254	X/X	**X/X**
16:00 - 17:00	298	514	812	X/X	459	X/X	344	X/X	**X/X**
17:00 - 18:00	274	485	759	X/X	409	X/X	416	X/X	**X/X**
18:00 - 19:00	231	259	490	X/	217	X/X	223	X/X	**X/**
19:00 - 20:00	166	185	351	/	146	X/X	137	/X	/
20:00 - 21:00	124	161	285	/	95	/X	104	/X	/
21:00 - 22:00	83	119	202	/	73	/X	89	/X	/
22:00 - 23:00	39	61	100	/	49	/	60	/	/
23:00 - 24:00	25	26	51	/	48	/	21	/	/

	Met (Hr)	Required (Hr)	
Warrant 1A	**10**	8	**Satisfied**
Warrant 1B	4	8	Not satisfied
Warrant 2	6	4	**Satisfied**
Warrant 3	4	1	**Satisfied**
Warrant 7	**14**	8	**Satisfied, check accident record**

*** HANDOUT ***

*** HANDOUT ***

Appendix D

Turn Movement Counts

SAMPLE

*** HANDOUT ***
*** HANDOUT ***

MINNESOTA DEPARTMENT OF TRANSPORTATION
METRO Traffic - Program Support

Location: TH-3 @ CSAH-26 70 TH ST.
Ref.Pt.: 041+00.713
Operator: JAMAR # 632 DR
TURN MOVEMENT COUNT

File Name : TH 3 @ CSAH 26 041+OO.713 2004
Site Code : 00000000
Start Date : 9/28/2004
Page No : 1

Groups Printed- Unshifted

	TH 3 Southbound				CSAH 26 Westbound				TH 3 Northbound				CSAH 26 Eastbound				
Start Time	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Int. Total
06:00	1	21	4	0	11	52	3	0	4	24	18	0	2	5	0	0	145
06:15	2	17	12	0	14	59	4	0	1	42	29	0	2	4	1	0	187
06:30	3	22	11	0	8	70	6	0	9	46	36	0	3	23	2	0	239
06:45	0	22	8	0	9	66	4	0	10	66	39	0	7	20	5	0	256
Total	6	82	35	0	42	247	17	0	24	178	122	0	14	52	8	0	827
07:00	3	20	15	0	16	60	5	0	12	70	59	0	9	25	3	0	297
07:15	2	20	17	0	15	86	7	0	14	97	51	0	14	33	4	0	360
07:30	3	27	25	0	13	76	5	0	13	100	74	0	20	37	6	0	399
07:45	5	26	29	0	14	105	9	0	15	122	69	0	16	35	3	0	448
Total	13	93	86	0	58	327	26	0	54	389	253	0	59	130	16	0	1504
08:00	3	19	17	0	11	63	8	0	3	102	54	0	19	38	3	0	340
08:15	3	18	9	0	11	47	1	0	8	71	42	0	6	29	0	0	245
08:30	4	27	13	0	7	45	3	0	2	54	30	0	8	17	3	0	213
08:45	3	32	9	0	8	32	5	0	3	29	22	0	5	10	1	0	159
Total	13	96	48	0	37	187	17	0	16	256	148	0	38	94	7	0	957
AUTO TRUCK																	
15:00	3	55	6	0	21	25	4	0	2	53	27	0	13	80	8	0	297
15:15	10	61	14	0	37	26	4	0	8	34	13	0	12	56	8	0	283
15:30	18	61	9	0	22	23	5	0	3	33	18	0	16	84	7	0	299
15:45	15	93	17	0	35	37	9	0	6	40	18	0	16	62	7	0	355
Total	46	270	46	0	115	111	22	0	19	160	76	0	57	282	30	0	1234
16:00	8	77	20	0	33	36	3	0	3	39	21	0	16	87	10	0	353
16:15	19	89	18	0	38	36	7	0	0	50	20	0	19	89	7	0	392
16:30	12	88	25	0	41	54	6	0	9	36	29	0	11	93	8	0	412
16:45	15	103	28	0	48	53	8	0	5	42	31	0	19	89	17	0	458
Total	54	357	91	0	160	179	24	0	17	167	101	0	65	358	42	0	1615
17:00	14	88	12	0	59	43	3	0	3	39	23	0	13	91	7	0	395
17:15	16	96	15	0	69	38	6	0	4	50	15	0	19	89	10	0	427
17:30	13	90	13	0	50	50	14	0	7	33	22	0	10	88	17	0	407
17:45	8	61	13	0	48	32	6	0	3	45	31	0	6	60	7	0	320
Total	51	335	53	0	226	163	29	0	17	167	91	0	48	328	41	0	1549
Grand Total	183	1233	359	0	638	1214	135	0	147	1317	791	0	281	1244	144	0	7686
Apprch %	10.3	69.5	20.2	0.0	32.1	61.1	6.8	0.0	6.5	58.4	35.1	0.0	16.8	74.5	8.6	0.0	
Total %	2.4	16.0	4.7	0.0	8.3	15.8	1.8	0.0	1.9	17.1	10.3	0.0	3.7	16.2	1.9	0.0	

AM PEAK

PM PEAK

*** HANDOUT ***

Appendix E

SYNCHRO Modeling Data

SAMPLE

*** HANDOUT ***

*** HANDOUT ***

HCM Unsignalized Intersection Capacity Analysis
3: 70th st & TH 3

AM AWS 2004
2/8/2007

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	69	143	16	53	330	29	45	421	248	13	92	88
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	75	155	17	58	359	32	49	458	270	14	100	96

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total (vph)	248	448	507	270	114	96
Volume Left (vph)	75	58	49	0	14	0
Volume Right (vph)	17	32	0	270	0	96
Hadj (s)	0.05	0.02	0.08	-0.67	0.10	-0.67
Departure Headway (s)	7.8	7.2	7.8	7.0	8.7	7.9
Degree Utilization, x	0.54	0.89	1.10	0.53	0.28	0.21
Capacity (veh/h)	438	448	472	507	395	430
Control Delay (s)	19.7	45.3	97.8	16.4	13.7	11.8
Approach Delay (s)	19.7	45.3	69.5		12.9	
Approach LOS	C	E	F		B	

Intersection Summary			
Delay	48.7		
HCM Level of Service	E		
Intersection Capacity Utilization	62.2%	ICU Level of Service	B
Analysis Period (min)	15		

*** HANDOUT ***

*** HANDOUT ***

HCM Unsignalized Intersection Capacity Analysis
3: 70th st & TH 3

PM AWS 2004
2/8/2007

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	62	362	42	217	188	23	21	167	98	57	375	80
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	67	393	46	236	204	25	23	182	107	62	408	87

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total (vph)	507	465	204	107	470	87
Volume Left (vph)	67	236	23	0	62	0
Volume Right (vph)	46	25	0	107	0	87
Hadj (s)	0.01	0.10	0.09	-0.67	0.10	-0.67
Departure Headway (s)	8.6	8.7	9.7	9.0	9.0	8.3
Degree Utilization, x	1.21	1.12	0.55	0.27	1.18	0.20
Capacity (veh/h)	424	427	360	397	396	430
Control Delay (s)	142.0	111.4	22.8	14.0	130.8	12.1
Approach Delay (s)	142.0	111.4	19.8		112.3	
Approach LOS	F	F	C		F	

Intersection Summary			
Delay	104.6		
HCM Level of Service	F		
Intersection Capacity Utilization	94.5%	ICU Level of Service	F
Analysis Period (min)	15		

*** HANDOUT ***

*** HANDOUT ***

HCM Unsignalized Intersection Capacity Analysis
3: 70th st & TH 3

AM AWS 2025
2/8/2007

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	125	258	29	96	596	52	81	760	448	23	166	159
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	136	280	32	104	648	57	88	826	487	25	180	173

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total (vph)	448	809	914	487	205	173
Volume Left (vph)	136	104	88	0	25	0
Volume Right (vph)	32	57	0	487	0	173
Hadj (s)	0.05	0.02	0.08	-0.67	0.09	-0.67
Departure Headway (s)	8.9	8.9	9.2	8.4	9.8	9.0
Degree Utilization, x	1.11	2.00	2.33	1.14	0.56	0.43
Capacity (veh/h)	395	412	401	431	359	396
Control Delay (s)	107.5	476.8	624.5	114.7	23.1	17.5
Approach Delay (s)	107.5	476.8	447.3		20.6	
Approach LOS	F	F	F		C	

Intersection Summary			
Delay	351.9		
HCM Level of Service	F		
Intersection Capacity Utilization	108.2%	ICU Level of Service	G
Analysis Period (min)	15		

*** HANDOUT ***

*** HANDOUT ***

HCM Unsignalized Intersection Capacity Analysis
3: 70th st & TH 3

PM AWS 2025
2/8/2007

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	112	654	76	392	340	42	38	302	177	103	677	144
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	122	711	83	426	370	46	41	328	192	112	736	157

Direction, Lane #	EB 1	WB 1	NB 1	NB 2	SB 1	SB 2
Volume Total (vph)	915	841	370	192	848	157
Volume Left (vph)	122	426	41	0	112	0
Volume Right (vph)	83	46	0	192	0	157
Hadj (s)	0.01	0.10	0.09	-0.67	0.10	-0.67
Departure Headway (s)	9.4	9.5	9.7	9.0	9.7	8.9
Degree Utilization, x	2.39	2.22	1.00	0.48	2.28	0.39
Capacity (veh/h)	391	387	370	388	379	399
Control Delay (s)	653.0	577.2	77.0	18.7	605.3	16.3
Approach Delay (s)	653.0	577.2	57.1		513.5	
Approach LOS	F	F	F		F	

Intersection Summary			
Delay	490.9		
HCM Level of Service	F		
Intersection Capacity Utilization	160.0%	ICU Level of Service	H
Analysis Period (min)	15		

*** HANDOUT ***

*** HANDOUT ***

Queues
3: 70th st & TH 3

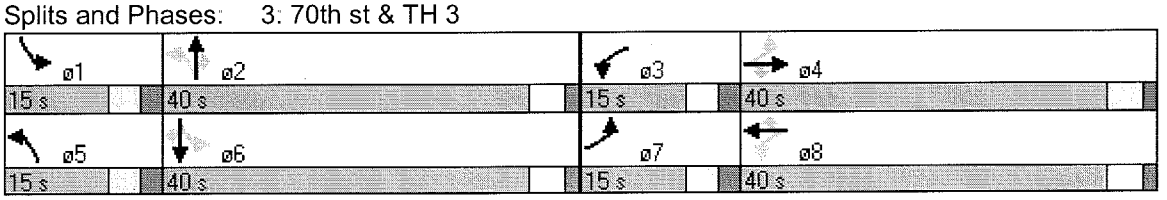
AM Signal 2004
2/8/2007

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1863	1583	1770	1863	1583	1770	1863	1583
Flt Permitted	0.327			0.604			0.686			0.204		
Satd. Flow (perm)	609	1863	1583	1125	1863	1583	1278	1863	1583	380	1863	1583
Satd. Flow (RTOR)			17			32			270			96
Volume (vph)	69	143	16	53	330	29	45	421	248	13	92	88
Lane Group Flow (vph)	75	155	17	58	359	32	49	458	270	14	100	96
Turn Type	pm+pt		Perm	pm+pt		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Total Split (s)	15.0	40.0	40.0	15.0	40.0	40.0	15.0	40.0	40.0	15.0	40.0	40.0
Act Effct Green (s)	25.9	21.7	21.7	24.9	21.3	21.3	29.0	27.9	27.9	27.6	25.1	25.1
Actuated g/C Ratio	0.35	0.31	0.31	0.34	0.31	0.31	0.39	0.40	0.40	0.36	0.36	0.36
v/c Ratio	0.20	0.26	0.03	0.12	0.62	0.06	0.09	0.61	0.34	0.05	0.15	0.15
Control Delay	15.9	23.4	11.1	15.2	29.6	9.4	15.0	25.6	4.6	16.2	22.6	6.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	15.9	23.4	11.1	15.2	29.6	9.4	15.0	25.6	4.6	16.2	22.6	6.3
LOS	B	C	B	B	C	A	B	C	A	B	C	A
Approach Delay		20.3			26.3			17.6			14.7	
Approach LOS		C			C			B			B	
Queue Length 50th (ft)	16	49	0	13	131	0	12	145	0	3	34	0
Queue Length 95th (ft)	54	127	15	44	297	21	40	395	55	17	90	37
Internal Link Dist (ft)		3464			3736			3496			3880	
Turn Bay Length (ft)	300		300	300		300	300		300	300		300
Base Capacity (vph)	400	862	741	486	857	745	572	923	921	355	896	811
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.19	0.18	0.02	0.12	0.42	0.04	0.09	0.50	0.29	0.04	0.11	0.12

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 69
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.62
Intersection Signal Delay: 20.0 — Intersection LOS: B
Intersection Capacity Utilization 55.4% — ICU Level of Service B
Analysis Period (min) 15

Splits and Phases: 3: 70th st & TH 3



*** HANDOUT ***

*** HANDOUT ***

*** HANDOUT ***

Queues
3: 70th st & TH 3

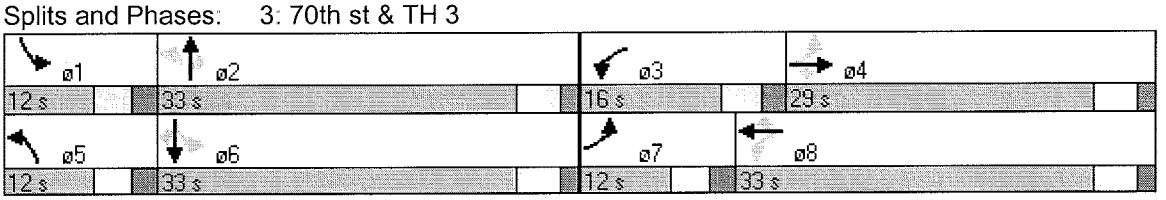
PM Signal 2004
2/8/2007

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1863	1583	1770	1863	1583	1770	1863	1583
Flt Permitted	0.630			0.198			0.272			0.579		
Satd. Flow (perm)	1174	1863	1583	369	1863	1583	507	1863	1583	1079	1863	1583
Satd. Flow (RTOR)			46			25			107			87
Volume (vph)	62	362	42	217	188	23	21	167	98	57	375	80
Lane Group Flow (vph)	67	393	46	236	204	25	23	182	107	62	408	87
Turn Type	pm+pt		Perm	pm+pt		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Total Split (s)	12.0	29.0	29.0	16.0	33.0	33.0	12.0	33.0	33.0	12.0	33.0	33.0
Act Effct Green (s)	27.6	19.6	19.6	34.8	28.8	28.8	25.3	21.3	21.3	26.0	23.6	23.6
Actuated g/C Ratio	0.37	0.28	0.28	0.49	0.41	0.41	0.32	0.30	0.30	0.34	0.33	0.33
v/c Ratio	0.14	0.76	0.10	0.59	0.27	0.04	0.08	0.32	0.19	0.14	0.66	0.15
Control Delay	13.7	36.7	8.5	19.5	20.2	9.1	15.6	23.9	5.9	15.5	28.3	6.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	13.7	36.7	8.5	19.5	20.2	9.1	15.6	23.9	5.9	15.5	28.3	6.1
LOS	B	D	A	B	C	A	B	C	A	B	C	A
Approach Delay		31.1			19.3			17.1			23.4	
Approach LOS		C			B			B			C	
Queue Length 50th (ft)	15	159	0	57	67	0	7	74	0	18	148	0
Queue Length 95th (ft)	44	#335	25	#134	147	17	20	131	35	42	303	32
Internal Link Dist (ft)		3464			3736			3496			3880	
Turn Bay Length (ft)	300		300	300		300	300		300	300		300
Base Capacity (vph)	494	631	566	423	788	684	298	709	669	446	729	672
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.14	0.62	0.08	0.56	0.26	0.04	0.08	0.26	0.16	0.14	0.56	0.13

Intersection Summary

Cycle Length: 90
Actuated Cycle Length: 70.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 23.4 Intersection LOS: C
Intersection Capacity Utilization 70.0% ICU Level of Service C
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: 70th st & TH 3



*** HANDOUT ***
*** HANDOUT ***

*** HANDOUT ***

Queues
3: 70th st & TH 3

AM Signal 2025
2/8/2007

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1863	1583	1770	1863	1583	1770	1863	1583
Flt Permitted	0.085			0.425			0.593			0.066		
Satd. Flow (perm)	158	1863	1583	792	1863	1583	1105	1863	1583	123	1863	1583
Satd. Flow (RTOR)			32			44			348			173
Volume (vph)	125	258	29	96	596	52	81	760	448	23	166	159
Lane Group Flow (vph)	136	280	32	104	648	57	88	826	487	25	180	173
Turn Type	pm+pt		Perm	pm+pt		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Total Split (s)	12.0	51.3	51.3	12.0	51.3	51.3	12.0	64.7	64.7	12.0	64.7	64.7
Act Effct Green (s)	55.4	47.4	47.4	55.4	47.4	47.4	65.5	60.8	60.8	63.9	55.7	55.7
Actuated g/C Ratio	0.41	0.35	0.35	0.41	0.35	0.35	0.48	0.45	0.45	0.46	0.41	0.41
v/c Ratio	0.84	0.43	0.06	0.27	0.99	0.10	0.15	0.99	0.54	0.17	0.23	0.23
Control Delay	68.5	37.0	10.1	25.8	77.6	12.5	18.1	65.2	9.9	19.6	26.5	4.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	68.5	37.0	10.1	25.8	77.6	12.5	18.1	65.2	9.9	19.6	26.5	4.0
LOS	E	D	B	C	E	B	B	E	A	B	C	A
Approach Delay		44.6			66.4			43.0			15.7	
Approach LOS		D			E			D			B	
Queue Length 50th (ft)	76	198	0	57	~630	8	40	~798	81	11	101	0
Queue Length 95th (ft)	#200	286	24	98	#868	40	69	#1049	187	26	156	44
Internal Link Dist (ft)		3464			3736			3496			3880	
Turn Bay Length (ft)	300		300	300		300	300		300	300		300
Base Capacity (vph)	161	653	576	383	653	584	574	838	903	150	808	784
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.84	0.43	0.06	0.27	0.99	0.10	0.15	0.99	0.54	0.17	0.22	0.22

Intersection Summary

Cycle Length: 140
Actuated Cycle Length: 135.2
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.99
Intersection Signal Delay: 46.1 Intersection LOS: D
Intersection Capacity Utilization 97.5% ICU Level of Service F
Analysis Period (min) 15

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

*** HANDOUT ***

*** HANDOUT ***

Queues
3: 70th st & TH 3

PM Signal 2025
2/8/2007

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Satd. Flow (prot)	1770	1863	1583	1770	1863	1583	1770	1863	1583	1770	1863	1583
Flt Permitted	0.541			0.077			0.077			0.370		
Satd. Flow (perm)	1008	1863	1583	143	1863	1583	143	1863	1583	689	1863	1583
Satd. Flow (RTOR)			54			46			192			102
Volume (vph)	112	654	76	392	340	42	38	302	177	103	677	144
Lane Group Flow (vph)	122	711	83	426	370	46	41	328	192	112	736	157
Turn Type	pm+pt		Perm	pm+pt		Perm	pm+pt		Perm	pm+pt		Perm
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases	4		4	8		8	2		2	6		6
Total Split (s)	12.0	52.0	52.0	30.0	70.0	70.0	12.0	56.0	56.0	12.0	56.0	56.0
Act Effct Green (s)	56.1	48.1	48.1	78.1	66.1	66.1	57.6	49.5	49.5	58.4	52.1	52.1
Actuated g/C Ratio	0.38	0.33	0.33	0.53	0.45	0.45	0.38	0.34	0.34	0.40	0.35	0.35
v/c Ratio	0.29	1.17	0.15	1.18	0.44	0.06	0.29	0.52	0.29	0.34	1.12	0.25
Control Delay	22.3	137.8	15.8	144.8	30.8	6.5	30.7	42.9	5.5	29.8	116.6	14.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	22.3	137.8	15.8	144.8	30.8	6.5	30.7	42.9	5.5	29.8	116.6	14.1
LOS	C	F	B	F	C	A	C	D	A	C	F	B
Approach Delay		111.4			87.2			29.2			90.9	
Approach LOS		F			F			C			F	
Queue Length 50th (ft)	60	~838	20	~453	250	0	23	254	0	66	~838	36
Queue Length 95th (ft)	98	#1085	61	#673	343	25	49	354	55	109	#1089	92
Internal Link Dist (ft)		3464			3736			3496			3880	
Turn Bay Length (ft)	300		300	300		300	300		300	300		300
Base Capacity (vph)	424	606	552	362	834	734	142	646	674	331	657	624
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.29	1.17	0.15	1.18	0.44	0.06	0.29	0.51	0.28	0.34	1.12	0.25

Intersection Summary

Cycle Length: 150
Actuated Cycle Length: 147.6
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.18
Intersection Signal Delay: 85.2 Intersection LOS: F
Intersection Capacity Utilization 110.9% ICU Level of Service H
Analysis Period (min) 15

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

*** HANDOUT ***

*** HANDOUT ***

Appendix F

RODEL Modeling Data

SAMPLE

*** HANDOUT ***

 *** HANDOUT ***

RODEL Analysis - TH 3 at CSAH 26 **(06-19-07)**

This is an addendum to the previous report of November 13, 2006. A new concept design for the single lane roundabout has been developed using a 180 foot diameter.

A Rodel analysis was performed for the intersection at TH 3 and CSAH 26 in Inver Grove Heights to see if a roundabout would be an acceptable option. Volume data included turning counts and tube counts from 2004. A 3% annual growth rate was applied to the volume data to estimate 2025 traffic conditions.

With the 2004 volumes, it was found that the modified single lane roundabout will work and have a LOS A for both the AM and PM time period.

With the 2025 volumes, the modified single lane roundabout just passes the LOS F threshold during the AM peak with the northbound leg operating at LOS F with a queue length of 43 vehicles (860 feet). This roundabout operates just below the LOS F threshold during the PM peak with the eastbound leg operating at LOS F with a queue length of 34 vehicles (680 feet).

The first 2 tables show the traffic volumes and roundabout geometrics utilized in the analysis. The remaining tables are the Rodel analysis tables.

Table 1 : Traffic Turning Movements (TH 3 at CSAH 26)

	SB TH 3			EB CSAH 26			NB TH 3			WB CSAH 26		
	SBR	SBT	SBL	EBR	EBT	EBL	NBR	NBT	NBL	WBR	WBT	WBL
2004 AM Peak	88	92	13	16	143	69	248	421	45	29	330	53
2004 PM Peak	80	375	57	42	362	62	98	167	21	23	188	217
2025 AM Peak	159	166	23	29	258	125	448	760	81	52	596	96
2025 PM Peak	144	677	103	76	654	112	177	302	38	42	340	392

2025 turning movements assume a 3% growth rate applied to the 2004 volumes over a 20 year time period.

Table 2 : Modified Roundabout Design Parameters (TH 3 at CSAH 26)

	Single Lane Roundabout	
Entry Width (E)	18 ft	
Half Width (V)	12 ft	
Flare Length (L')	150 ft	
Entry Radius (R)	80 ft	
Entry Angle (phi)	30 deg	
Inscribed Circle Diameter (D)	180 ft	

 *** HANDOUT ***

*** HANDOUT ***

Table 3 : Modified Single Lane Roundabout - 2004 AM Peak

```
*****************************************************************************
*                                                                           *
*  8:11:06                      TH 3 AT CSAH 26                        2004 *
*                                                                           *
*****************************************************************************
*                                                 *                         *
* E     (m)    5.49   5.49   5.49   5.49          * TIME PERIOD     min    90 *
* L'    (m)   45.72  45.72  45.72  45.72          * TIME SLICE      min    15 *
* V     (m)    3.66   3.66   3.66   3.66          * RESULTS PERIOD  min 15 75 *
* RAD   (m)   24.38  24.38  24.38  24.38          * TIME COST      $/hr 15.00 *
* PHI   (d)   30.00  30.00  30.00  30.00          * FLOW PERIOD     min 15 75 *
* DIA   (m)   54.86  54.86  54.86  54.86          * FLOW TYPE   pcu/veh   VEH *
* GRAD SEP       0      0      0      0          * FLOW PEAK  am/op/pm    AM *
*                                                 *                         *
*****************************************************************************
* LEG NAME *PCU *VEH TURNS (1st exit, 2nd..U)*CAPF*CL*  FLOW RATIO   *FLOW TIME*
*          *    *                            *    *  *               *         *
* SB       *1.05*   88   92   13  0          *1.00*50*0.75 1.125 0.75*15 45 75 *
* EB       *1.05*   16  143   69  0          *1.00*50*0.75 1.125 0.75*15 45 75 *
* NB       *1.05*  248  421   45  0          *1.00*50*0.75 1.125 0.75*15 45 75 *
* WB       *1.05*   29  330   53  0          *1.00*50*0.75 1.125 0.75*15 45 75 *
*          *    *                            *    *  *               *         *
*          *    *                            *    *  *               *         *
*          *    *                            *    *  *               *         *
*****************************************************************************
*                      SB     EB     NB     WB                *                 *
* FLOW        veh     193    228    714    412                * AVEDEL  s   4.4 *
* CAPACITY    veh    1293   1447   1409   1232                * LOS   SIG     A *
* AVE DELAY  mins    0.05   0.05   0.09   0.07                * LOS UNSIG     A *
* MAX DELAY  mins    0.07   0.06   0.12   0.10                *                 *
* AVE QUEUE   veh       0      0      1      1                * VEHIC HRS   1.9 *
* MAX QUEUE   veh       0      0      1      1                * COST    $    28 *
* LOS UNSIG             A      A      A      A                *                 *
*****************************************************************************
```


*** HANDOUT ***

*** HANDOUT ***

Table 4 : Modified Single Lane Roundabout - 2004 PM Peak

```
*****************************************************************************
*                                                                           *
*  8:11:06                      TH 3 AT CSAH 26                        2004 *
*                                                                           *
*****************************************************************************
*                                                 *                         *
* E     (m)    5.49   5.49   5.49   5.49          * TIME PERIOD     min    90 *
* L'    (m)   45.72  45.72  45.72  45.72          * TIME SLICE      min    15 *
* V     (m)    3.66   3.66   3.66   3.66          * RESULTS PERIOD  min 15 75 *
* RAD   (m)   24.38  24.38  24.38  24.38          * TIME COST      $/hr 15.00 *
* PHI   (d)   30.00  30.00  30.00  30.00          * FLOW PERIOD     min 15 75 *
* DIA   (m)   54.86  54.86  54.86  54.86          * FLOW TYPE   pcu/veh   VEH *
* GRAD SEP       0      0      0      0          * FLOW PEAK  am/op/pm    PM *
*                                                 *                         *
*****************************************************************************
* LEG NAME *PCU *VEH TURNS (1st exit, 2nd..U)*CAPF*CL*  FLOW RATIO   *FLOW TIME*
*          *    *                            *    *  *              *         *
* SB       *1.05*   80  375   57  0           *1.00*50*0.75 1.125 0.75*15 45 75 *
* EB       *1.05*   42  362   62  0           *1.00*50*0.75 1.125 0.75*15 45 75 *
* NB       *1.05*   98  167   21  0           *1.00*50*0.75 1.125 0.75*15 45 75 *
* WB       *1.05*   23  188  217  0           *1.00*50*0.75 1.125 0.75*15 45 75 *
*          *    *                            *    *  *              *         *
*          *    *                            *    *  *              *         *
*          *    *                            *    *  *              *         *
*****************************************************************************
*                       SB     EB     NB     WB                 *             *
* FLOW        veh      512    466    286    428                 * AVEDEL  s   4.3 *
* CAPACITY    veh     1294   1167   1263   1395                 * LOS   SIG     A *
* AVE DELAY  mins     0.08   0.09   0.06   0.06                 * LOS UNSIG     A *
* MAX DELAY  mins     0.10   0.12   0.08   0.08                 *                 *
* AVE QUEUE   veh        1      1      0      0                 * VEHIC HRS   2.0 *
* MAX QUEUE   veh        1      1      0      1                 * COST    $    30 *
* LOS UNSIG              A      A      A      A                 *                 *
*****************************************************************************
```


*** HANDOUT ***

*** HANDOUT ***

Table 5 : Modified Single Lane Roundabout - 2025 AM Peak

```
*****************************************************************************
*                                                                           *
*  9:11:06                      TH 3 AT CSAH 26                        2025 *
*                                                                           *
*****************************************************************************
*                                                 *                         *
* E     (m)    5.49   5.49   5.49   5.49          * TIME PERIOD     min    90 *
* L'    (m)   45.72  45.72  45.72  45.72          * TIME SLICE      min    15 *
* V     (m)    3.66   3.66   3.66   3.66          * RESULTS PERIOD  min 15 75 *
* RAD   (m)   24.38  24.38  24.38  24.38          * TIME COST      $/hr 15.00 *
* PHI   (d)   30.00  30.00  30.00  30.00          * FLOW PERIOD     min 15 75 *
* DIA   (m)   54.86  54.86  54.86  54.86          * FLOW TYPE   pcu/veh   VEH *
* GRAD SEP       0      0      0      0           * FLOW PEAK  am/op/pm    AM *
*                                                 *                         *
*****************************************************************************
* LEG NAME *PCU *VEH TURNS (1st exit, 2nd..U)*FLOF*CL*  FLOW RATIO   *FLOW TIME*
*          *    *                            *    *  *              *         *
* SB       *1.05*  159  166   23  0           *1.00*50*1.00 1.000 1.00*15 45 75 *
* EB       *1.05*   29  258  125  0           *1.00*50*1.00 1.000 1.00*15 45 75 *
* NB       *1.05*  448  760   81  0           *1.00*50*1.00 1.000 1.00*15 45 75 *
* WB       *1.05*   52  596   96  0           *1.00*50*1.00 1.000 1.00*15 45 75 *
*          *    *                            *    *  *              *         *
*          *    *                            *    *  *              *         *
*          *    *                            *    *  *              *         *
*****************************************************************************
*                      SB     EB     NB     WB                *               *
* FLOW        veh     348    412   1289    744                * AVEDEL  s  53.8 *
* CAPACITY    veh    1098   1375   1306   1000                * LOS   SIG     D *
* AVE DELAY  mins    0.08   0.06   1.76   0.25                * LOS UNSIG     F *
* MAX DELAY  mins    0.11   0.08   3.63   0.41                *                 *
* AVE QUEUE   veh       0      0     43      3                * VEHIC HRS  41.8 *
* MAX QUEUE   veh       1      0     79      5                * COST    $   626 *
* LOS UNSIG             A      A      F      C                *                 *
*****************************************************************************
```


*** HANDOUT ***

*** HANDOUT ***

Table 6 : Modified Single Lane Roundabout - 2025 PM Peak

```
*****************************************************************************
*                                                                           *
*  9:11:06                      TH 3 AT CSAH 26                        2025 *
*                                                                           *
*****************************************************************************
*                                                 *                         *
* E     (m)    5.49   5.49   5.49   5.49          * TIME PERIOD     min    90 *
* L'    (m)   45.72  45.72  45.72  45.72          * TIME SLICE      min    15 *
* V     (m)    3.66   3.66   3.66   3.66          * RESULTS PERIOD  min 15 75 *
* RAD   (m)   24.38  24.38  24.38  24.38          * TIME COST      $/hr 15.00 *
* PHI   (d)   30.00  30.00  30.00  30.00          * FLOW PERIOD     min 15 75 *
* DIA   (m)   54.86  54.86  54.86  54.86          * FLOW TYPE   pcu/veh   VEH *
* GRAD SEP       0      0      0      0           * FLOW PEAK  am/op/pm    PM *
*                                                 *                         *
*****************************************************************************
* LEG NAME *PCU *VEH TURNS (1st exit, 2nd..U)*FLOF*CL*  FLOW RATIO   *FLOW TIME*
*          *    *                             *    *  *              *        *
* SB       *1.05*  144  677  103  0           *1.00*50*1.00 1.000 1.00*15 45 75 *
* EB       *1.05*   76  654  112  0           *1.00*50*1.00 1.000 1.00*15 45 75 *
* NB       *1.05*  177  302   38  0           *1.00*50*1.00 1.000 1.00*15 45 75 *
* WB       *1.05*   42  340  392  0           *1.00*50*1.00 1.000 1.00*15 45 75 *
*          *    *                             *    *  *              *        *
*          *    *                             *    *  *              *        *
*          *    *                             *    *  *              *        *
*****************************************************************************
*                       SB     EB     NB     WB                *               *
* FLOW        veh      924    842    517    774                * AVEDEL  s  47.5 *
* CAPACITY    veh     1098    868   1056   1282                * LOS   SIG     D *
* AVE DELAY  mins     0.51   2.14   0.11   0.12                * LOS UNSIG     E *
* MAX DELAY  mins     1.03   4.38   0.15   0.18                *                 *
* AVE QUEUE   veh        8     34      1      2                * VEHIC HRS  40.3 *
* MAX QUEUE   veh       15     65      1      2                * COST    $   605 *
* LOS UNSIG              D      F      A      A                *                 *
*****************************************************************************
```


*** HANDOUT ***

6.3 Sample ICE Report 2

*** HANDOUT ***

INTERSECTION CONTROL EVALUATION
FOR
TRUNK HIGHWAY 7 & COUNTY ROAD 11/
KINGS POINT ROAD
MINNETRISTA, MN

Prepared for Lennar

by Traffic Data Inc.

May 2007

*** HANDOUT ***

*** HANDOUT ***

INTERSECTION CONTROL EVALUATION

For

Trunk Highway 7 at County State Aid Highway 11/ Kings Point Road Minnetrista, Hennepin County

Program: N/A

Funding: Mn/DOT
City of Minnetrista

Letting Date:

Work Identification: Intersection Construction

I hereby certify that this plan, specification or 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.

Michael P. Spack 40936 9-11-07

Michael P. Spack, P.E. — Reg. No. — Date
License No. 40936

REVIEWED:

City Engineer - Minnetrista — Date

County Engineer — Date

APPROVED:

Metro District Traffic Engineer – Program Support — Date

-

*** HANDOUT ***

TABLE OF CONTENTS

1. Purpose and Need 1
2. Description of Location 1
3. Existing Conditions 2
4. Future Conditions 4
5. Analysis of Alternatives 6
6. Recommended Alternative 11
7. Appendix 11

LIST OF FIGURES

Figure 2.1 – Location Map 2
Figure 3.1 – Existing Conditions 3

LIST OF TABLES

Table 3.1 – TH 7/CSAH 11 - 2005 Turning Movement 3
Table 3.2 – TH 7/Kings Point Road - 2005 Turning Movement 3
Table 4.1 – 2015 Turning Movement Peak Hour Volumes 4
Table 4.2 – 2030 Turning Movement Peak Hour Volumes 4
Table 5.1 – 2030 Peak Hour Capacity Analyses – Signal vs. Roundabout 9
Table 5.2 – 2030 Peak Hour VISSIM™ Analyses – Signal vs. Roundabout 10

*** HANDOUT ***

1. Purpose and Need

The City of Minnetrista has prepared an Alternative Urban Areawide Review (AUAR) to determine the environmental impacts of developing approximately 530 acres located north of Trunk Highway 7 (TH 7) and east of Kings Point Road. To provide adequate access to this development and to promote access management along TH 7, the following mitigation measures were recommended in the approved AUAR:

- Realign both County State Aid Highway 11 (CSAH 11) and Kings Point Road to intersect TH 7 at one four legged intersection.
- Determine what level of traffic control will be needed at the intersection through Mn/DOT's Intersection Control Evaluation (ICE) process.

The purpose of this ICE Report is to determine the most appropriate level of traffic control for the new TH 7/CSAH 11/Kings Point Road intersection. The 530 acre development is anticipated to be fully occupied by 2015. The traffic control alternatives are analyzed in the build out horizon (Year 2015) and the long term horizon (Year 2030).

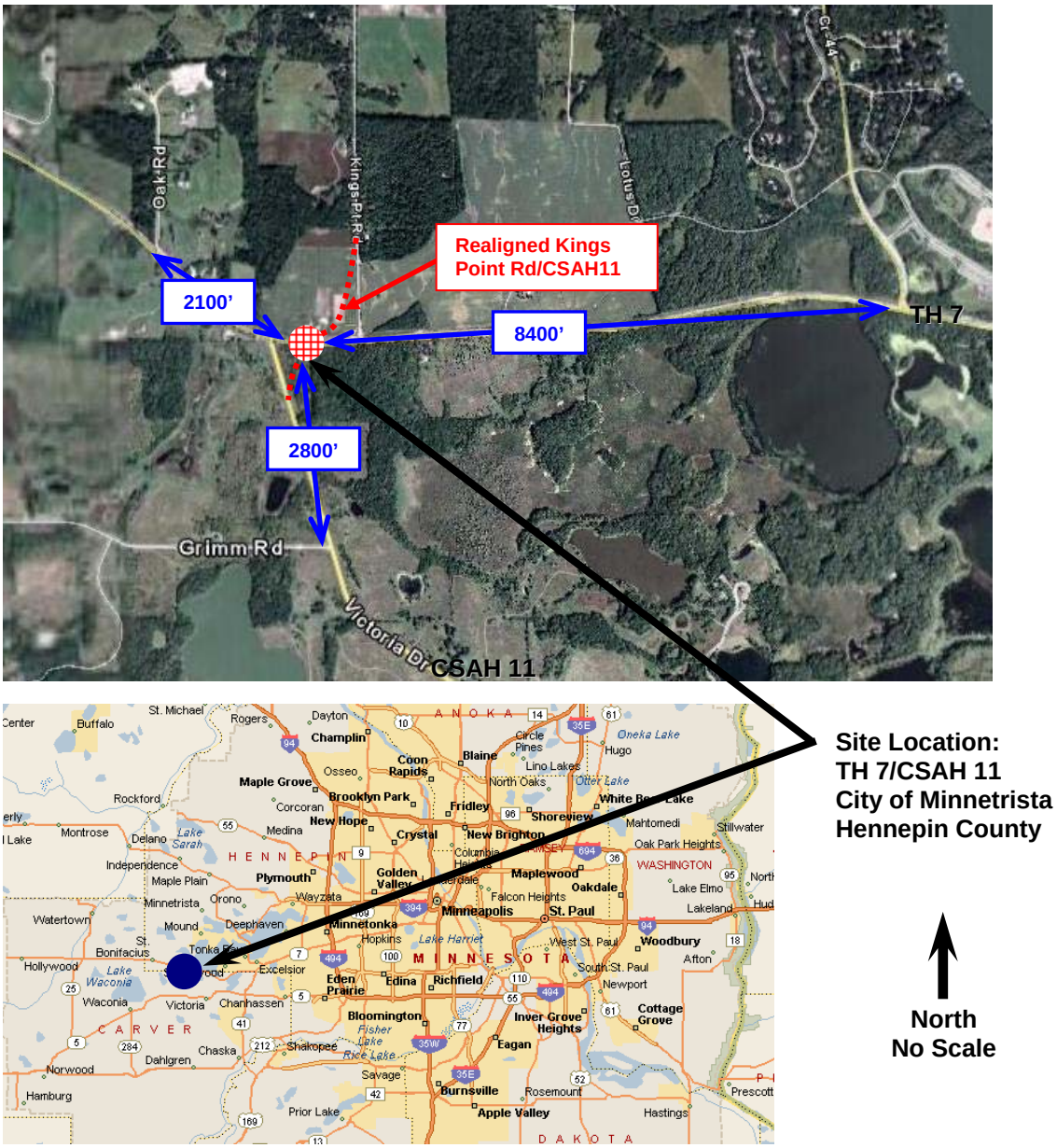
2. Description of Location

Plans are underway to realign Kings Point Road and CSAH 11 to intersect TH 7 at the same location. The existing TH 7/CSAH 11 intersection is located at TH 7 Reference Point 175.259 and the existing TH 7/Kings Point Road intersection is located at TH 7 Reference Point 175.483. These two tee intersections will be closed and the new four legged intersection will be at TH 7 Reference Point 175.383. The proposed project is located in Minnetrista, Hennepin County, MN. Figure 2.1 shows the location of the study intersection as well as its proximity to major intersections.

*** HANDOUT ***
*** HANDOUT ***

*** HANDOUT ***

Figure 2.1 – Location Map



3. Existing Conditions

a. Intersection Geometry

<u>Trunk Highway 7</u>

Near the intersection at CSAH 11, TH 7 is a principal arterial with a 55 mph speed limit. It is a two lane rural roadway with turn lanes provided at major intersections.

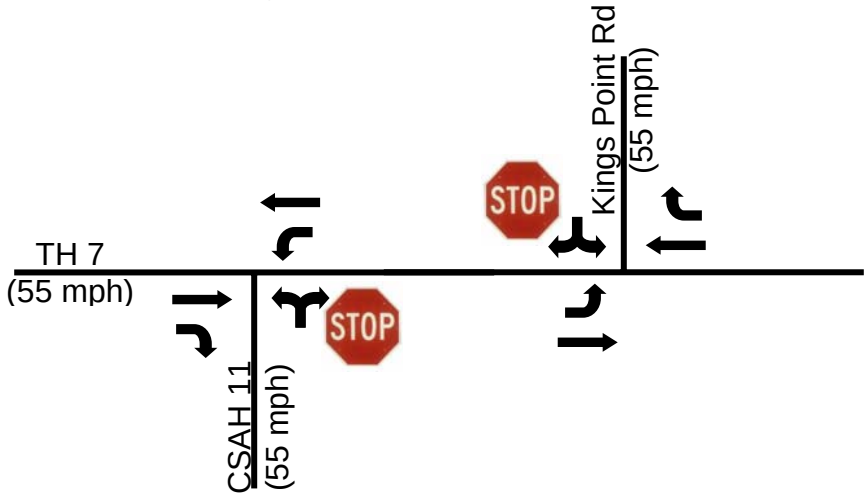
*** HANDOUT ***
*** HANDOUT ***

*** HANDOUT ***

County State Aid Highway 11
Near the intersection at TH 7, CSAH 11 is a major collector with a 55 mph speed limit. It is a two lane rural roadway.

Kings Point Road
Near the intersection at TH 7, Kings Point Road is a local city street with a 55 mph speed limit. It is a two lane rural roadway.

Figure 3.1 – Existing Conditions



b. Traffic Data

Hourly traffic volumes for the existing northbound, eastbound, and westbound approaches of the existing TH 7/CSAH 11 intersection are contained in the Appendix (Table A1). The existing turning movement volumes for the TH 7/CSAH 11 intersection are shown in Table 3.1. The existing turning movement volumes for the TH 7/Kings Point Road intersection are shown in Table 3.2.

Table 3.1 – TH 7/CSAH 11 - 2005 Turning Movement

	WB TH 7		NB CSAH 11		EB TH 7	
	Lt	Thru	Lt	Rt	Thru	Rt
AM Peak Hour	23	289	15	16	1,110	170
PM Peak Hour	24	1,093	166	32	408	62

Source: November 2006, Final Revised, *Park Cove AUAR*.

Table 3.2 – TH 7/Kings Point Road - 2005 Turning Movement

	WB TH 7		SB Kings Pt Rd		EB TH 7	
	Rt	Thru	Lt	Rt	Lt	Thru
AM Peak Hour	0	283	7	4	4	1,187
PM Peak Hour	12	1,116	0	1	2	421

Source: November 2006, Final Revised, *Park Cove AUAR*.

*** HANDOUT ***
*** HANDOUT ***

c. *Crash Data*

According to Mn/DOT staff, there were seven crashes at the TH 7/CSAH 11 intersection and three crashes at the TH 7/Kings Point Road intersection from January 1, 2002 to December 31, 2005. Crash diagrams for each year (supplied by Mn/DOT) are contained in the Appendix.

4. Future Conditions

a. *Traffic Forecasts*

The final revised Park Cove AUAR is dated November 2006. Mn/DOT staff has determined the through volumes forecasted in the AUAR for TH 7 are not realistic given the capacity constraints of TH 7. Based on the AUAR and discussions with Mn/DOT staff, the agreed upon 2015 forecasted turning movement volumes for the TH 7/CSAH 11/Kings Point Road intersection are shown in Table 4.1. The 2030 peak hour turning movement volume forecasts shown in Table 4.2 were developed by factoring the cross street movements with a 1% per year growth factor.

Table 4.1 – 2015 Turning Movement Peak Hour Volumes

	SB Kings Pt			WB TH 7			NB CSAH 11			EB TH 7		
	Lt	Thru	Rt	Lt	Thru	Rt	Lt	Thru	Rt	Lt	Thru	Rt
AM	281	56	65	38	333	92	95	18	26	25	1222	301
PM	221	47	54	40	1084	344	300	69	52	76	396	115

Source: City of Minnetrista engineering staff.

Table 4.2 – 2030 Turning Movement Peak Hour Volumes

	SB Kings Pt			WB TH 7			NB CSAH 11			EB TH 7		
	Lt	Thru	Rt	Lt	Thru	Rt	Lt	Thru	Rt	Lt	Thru	Rt
AM	326	65	75	38	333	92	110	21	30	25	1222	301
PM	257	55	63	40	1084	344	348	80	60	76	396	115

Source: Mn/DOT engineering staff.

The following methodology was used to develop the hourly approach volumes for 2015 contained in the Appendix:

1. Determine the distribution of each hour compared to the 24 hour volume (see Appendix Table A2).
2. Apply these distribution patterns to the 2015 PM peak hour approach volumes to develop 24 hour volumes (see Appendix Table A3). The eastbound TH 7 distribution was used to develop the southbound Kings Point Road forecasts. The hourly volumes from midnight to noon are based on the a.m. peak hour forecasts in Table 4.1. The hourly volumes from

*** HANDOUT ***

noon to midnight are based on the p.m. peak hour forecasts in Table 4.1.

3. Factor out the right turn percentages. Reductions were made in the hourly volumes from midnight to noon based on the a.m. peak hour right turn volume forecasts in Table 4.1. Reductions were made in the hourly volumes from noon to midnight based on the p.m. peak hour right turn volume forecasts in Table 4.1. The resultant hourly forecasts for use in the Warrant Analyses are shown in Appendix Table A4.

b. Future Intersection Configuration

Based on mitigation recommendations in the Final *Park Cove AUAR* and discussions with Mn/DOT staff, it is assumed the new TH 7/CSAH 11/Kings Point Road intersection will have one of the following configurations:

<u>Roundabout Control (a preliminary plan is included in the Appendix)</u>

- Northbound CSAH 11: dual entry
- Southbound Kings Point Road: dual entry
- Eastbound TH 7: dual entry
- Westbound TH 7: dual entry
- The roundabout will be a two lane roundabout

- or -

<u>Traffic Signal Control</u>

- Northbound CSAH 11: 1 left turn lane, 1 through lane, 1 right turn lane
- Southbound Kings Point Road: 1 left turn lane, 1 combined through/right lane
- Eastbound TH 7: 1 left turn lane, 2 through lanes, 1 right turn lane
- Westbound TH 7: 1 left turn lane, 2 through lanes, 1 right turn lane
- Protected left turn phasing (left turns allowed on the green arrow only) for the TH 7 approaches and protected/permitted (left turns allowed on the green ball as well as the green arrow) phasing for the CSAH 11 and Kings Point Road approaches

*** HANDOUT ***

5. Analysis of Alternatives

The *Highway Capacity Manual* documents procedures for determining the performance of different traffic control measures at intersections. Intersections are assigned a "Level of Service" letter grade for the peak hour of traffic based on the number of lanes at the intersection, traffic volumes, and traffic control. Level of Service A (LOS A) represents light traffic flow (free flow conditions) while Level of Service F (LOS F) represents heavy traffic flow (over capacity conditions). LOS D is considered acceptable in urban conditions.

a. All Way Stop

An intersection capacity analysis was attempted for the intersection as an all way stop per the *Highway Capacity Manual*. The lane configuration noted above for the traffic signal control scenario was used along with the peak hour volumes from Table 4.1 to determine the 2015 peak hour LOS. The *Highway Capacity Manual* does not have procedures for all way stops with as many lanes as was identified as necessary in the AUAR to mitigate the intersection operation. Controlling the intersection with an all way stop is ruled out as a viable traffic control option.

b. Traffic Control Signal

<u>Warrant Analysis</u>

A warrant analysis was conducted for the intersection per the *Minnesota Manual on Uniform Traffic Control Devices*. The warrant analysis is based on the following assumptions:

- 2005 Analysis – Existing TH 7/CSAH 11
  - Volumes from Table A1
  - TH 7 is the major roadway with two approach lanes (it is Mn/DOT practice to evaluate based on proposed lane configurations)
  - CSAH 11 is the minor roadway with two approach lanes (it is Mn/DOT practice to evaluate based on proposed lane configurations)
  - Reduction in criteria based on 55 mph speed limits
- 2015 Analysis – Proposed TH 7/CSAH 11/Kings Point Road
  - Volumes from Table A4
  - TH 7 is the major roadway with approach lanes as described on page 5
  - CSAH 11 and Kings Point Road are the minor legs with approach lanes as described on page 5
  - Reduction in criteria based on 55 mph speed limits

The full warrant analyses are contained in the Appendix. Warrant 1 (Eight Hour Vehicular Volumes), Warrant 2 (Four Hour Volumes), and Warrant 3 (Peak Hour Volumes) are met in both the 2005 and 2015 scenarios. Traffic will continue to grow (not decline), leading to the conclusion the same warrants will also be met in 2030.

Capacity Analyses

An intersection capacity analysis was conducted for the intersection as a traffic signal controlled intersection per the *Highway Capacity Manual*. The analysis was performed using Synchro™ software.

A SimTraffic™ micro-simulation model was run for the intersection to determine the queue lengths within each lane. The simulation software was seeded with a random number seed of 0, a seeding duration of 1 minute, and a recording duration of 60 minutes. Then the simulation software was run and recorded five times with random number seeds of 1, 2, 3, 4, and 5; using a seeding duration of 1 minutes and a recording duration of 60 minutes.

The lane configuration noted for the traffic signal control scenario in Section 4b was used along with the peak hour volumes from Table 4.2 to determine the 2030 peak hour LOS and queues. The eastbound through lanes will be merged to a single through lane east of the intersection and the westbound through lanes will be merged to a single through lane west of the intersection in all scenarios. This was accounted for in the SimTraffic™ results. The full results are contained in the Appendix and a summary of the results are shown in Table 5.1.

VISSIM™ is a more refined micro-simulation model that depends on a gap analysis, which leads to a more accurate comparison of traffic signal control versus roundabout control. A VISSIM™ model was built for the proposed intersection (including the lane drop situation on TH 7) with the same data inputs in the above analysis. The results are shown in Table 5.2.

c. Roundabout

An intersection capacity analysis was conducted for the intersection as a roundabout controlled intersection. The analysis was performed using RODEL™ software, which also calculates vehicle queues.

The lane configuration noted for the roundabout scenario in Section 4b was used along with the peak hour volumes from Table 4.2 to determine the 2030 peak hour LOS and queues. The full results are contained in the Appendix and a summary of the results are

*** HANDOUT ***

shown in Table 5.1. Table 5.2 shows the results of the VISSIM™ model that was built for the roundabout scenario.

d. Non-Traditional Intersection

The additional right-of-way required for the different non-traditional intersections is not justified at the TH 7/CSAH 11 intersection. The traditional roundabout or traffic signal will provide adequate capacity.

e. Access Management Treatments

TH 7/CSAH 11/Kings Point Road will be approximately 2,100 feet east of Oak Road and 8,400 feet west of CSAH 44 along TH 7. Access management is being applied by realigning Kings Point Road and CSAH 11 to create the new intersection.

f. Grade Separation

TH 7 west of I-494 is a highway corridor with at-grade intersections. An interchange would be inconsistent with the corridor east and west of the site. The forecasted traffic volumes at the study intersection do not warrant the expense of an interchange.

*** HANDOUT ***

*** HANDOUT ***

Table 5.1 – 2030 Peak Hour Capacity Analyses – Signal vs. Roundabout

AM Peak Hour		EB on TH 7			WB on TH 7			NB on CSAH 11			SB on Kings Pt Rd		
		Lt	Thru	Rt	Lt	Thru	Rt	Lt	Thru	Rt	Lt	Thru	Rt
Traffic Signal Control	LOS[1]	D	C	B	D	B	B	C	C	C	C	C	n/a
	Avg Delay[2]	44.2	23.8	13.6	41.1	12.9	11.9	24.7	27.1	26.9	28.2	25.0	n/a
	Avg Queue[3]	2	17	2	2	3	1	2	1	1	7	4	n/a
	Max Queue[3]	11	30	10	3	5	2	5	2	3	10	15	n/a
Double Lane Roundabout	LOS[4]	C			B			B			B		
	Avg Delay[5]	21.0			10.2			13.8			11.4		
	Avg Queue[6]	6			0			0			0		
	Max Queue[6]	9			0			0			1		
PM Peak Hour		**EB on TH 7**			**WB on TH 7**			**NB on CSAH 11**			**SB on Kings Pt Rd**		
		Lt	**Thru**	**Rt**	**Lt**	**Thru**	**Rt**	**Lt**	**Thru**	**Rt**	**Lt**	**Thru**	**Rt**
Traffic Signal Control	LOS[1]	E	B	B	D	C	B	D	C	C	C	C	n/a
	Avg Delay[2]	59.9	15.2	13.7	43.4	26.2	15.8	35.9	29.1	27.5	24.7	29.8	n/a
	Avg Queue[3]	3	4	1	3	23	3	8	3	1	5	3	n/a
	Max Queue[3]	6	8	2	14	35	14	13	11	2	10	8	n/a
Double Lane Roundabout	LOS[4]	B			C			B			C		
	Avg Delay[5]	10.8			19.8			12.0			16.2		
	Avg Queue[6]	0			5			1			1		
	Max Queue[6]	0			8			1			1		

[1]Level of Service from *Highway Capacity Manual* signal analysis.
[2]Average delay in seconds from *Highway Capacity Manual* signal analysis.
[3]Queue length (in vehicles – assumes 25 feet per vehicle) from SimTraffic™ simulation.
[4] Level of Service from RODEL™. *Highway Capacity Manual* unsignalized thresholds used.
[5]Average delay in seconds from RODEL™ analysis.
[6] Queue length (in vehicles) from RODEL™ analysis.

*** HANDOUT ***
*** HANDOUT ***

*** HANDOUT ***

Table 5.2 – 2030 Peak Hour VISSIM™ Analyses – Signal vs. Roundabout

AM Peak Hour		EB on TH 7	WB on TH 7	NB on CSAH 11	SB on Kings Pt Rd
Traffic Signal Control	LOS[1]	B	B	C	C
	Avg Delay[2]	15.0	12.4	27.8	26.6
	Avg Queue[3]	2	1	1	2
Double Lane Roundabout	LOS[4]	C	A	D	A
	Avg Delay[5]	15.1	3.0	29.3	7.5
	Avg Queue[6]	2	0	1	1
PM Peak Hour		**EB on TH 7**	**WB on TH 7**	**NB on CSAH 11**	**SB on Kings Pt Rd**
Traffic Signal Control	LOS[1]	B	B	C	C
	Avg Delay[2]	16.6	19.2	30.6	30.6
	Avg Queue[3]	1	3	2	2
Double Lane Roundabout	LOS[4]	A	D	B	F
	Avg Delay[5]	4.5	26.9	10.3	59.5
	Avg Queue[6]	1	5	1	5

[1] Level of Service from VISSIM™. *Highway Capacity Manual* signalized thresholds used.
[2]Average delay in seconds from VISSIM™ signal analysis.
[3]Queue length (in vehicles – assumes 25 feet per vehicle) from VISSIM™ signal simulation.
[4]Level of Service from VISSIM™. *Highway Capacity Manual* unsignalized thresholds used.
[5]Average delay in seconds from VISSIM™ roundabout analysis.
[6]Queue length (in vehicles – assumes 25 feet per vehicle) from VISSIM™ roundabout simulation.

*** HANDOUT ***
*** HANDOUT ***

*** HANDOUT ***

6. Recommended Alternative

It is recommended that the TH 7/CSAH 11/Kings Point Road intersection be controlled with a two lane roundabout when CSAH 11 and Kings Point Road are realigned for the following reasons:

- The intersection will need an increased level of traffic control. The existing TH 7/CSAH 11 intersection currently meets the Eight Hour Warrant for traffic signal control per the *Minnesota Manual on Uniform Traffic Control Devices*.
- The two lane roundabout provides approximately the same amount of delay and vehicle queuing a traffic signal would. This was confirmed with a VISSIM micro-simulation model Mn/DOT reviewed and approved.
- The Insurance Institute for Highway Safety found in their March 2000 report titled "Crash Reductions Following Installation of Roundabouts in the United States" that crashes are reduced by 39% and injury crashes are reduced by 76% when an intersection is converted to roundabout control. Intersections controlled with roundabouts are significantly safer than intersections controlled with traffic signals.
- Neither right-of-way nor vertical grades are a constraint to construction of a roundabout at the intersection.
- All way stop control, non-traditional intersections, access management treatments, and grade separation were found to be inadequate and/or infeasible.
- Implementation can wait until CSAH 11 and Kings Point Road are realigned to create the four legged intersection. Neither existing intersection has a current crash problem that needs to be corrected.
- Construction of the roundabout will be most cost effective when Kings Point Road and CSAH 11 are realigned.

7. Appendix

a. 24 Hour Traffic Volumes (Tables A1 through A4)

b. Crash Diagrams

c. Preliminary Roundabout Design

d. Traffic Signal Warrant Analyses

e. Level of Service and Queuing Analyses for Signal

f. RODEL™ Analyses

*** HANDOUT ***

*** HANDOUT ***

Table A1 - Average Hourly Volume from 9/7/05 and 9/8/05 (USED IN WARRANT ANALYSES)

Start of Hour	Approaches to TH 7/CSAH 11 Intersection		
	EB TH 7	WB TH 7	NB CSAH 11
0:00	35	84	7
1:00	23	44	1
2:00	26	36	2
3:00	32	42	1
4:00	146	47	5
5:00	556	76	15
6:00	1149	241	46
7:00	1243	365	95
8:00	750	308	102
9:00	497	359	96
10:00	414	346	80
11:00	409	376	84
12:00	411	377	93
13:00	396	417	102
14:00	367	571	112
15:00	357	817	143
16:00	374	1072	180
17:00	421	979	182
18:00	351	642	105
19:00	252	379	81
20:00	226	339	54
21:00	160	255	36
22:00	115	186	25
23:00	64	120	10

*** HANDOUT ***

*** HANDOUT ***

Table A2 - Hourly Distribution of Mechanical Volumes

Start of Hour	Approaches to TH 7/CSAH 11 Intersection		
	EB TH 7	WB TH 7	NB CSAH 11
0:00	0.4%	1.0%	0.4%
1:00	0.3%	0.5%	0.1%
2:00	0.3%	0.4%	0.1%
3:00	0.4%	0.5%	0.1%
4:00	1.7%	0.6%	0.3%
5:00	6.3%	0.9%	0.9%
6:00	13.1%	2.8%	2.8%
7:00	**14.2%**	**4.3%**	**5.7%**
8:00	8.5%	3.6%	6.2%
9:00	5.7%	4.2%	5.8%
10:00	4.7%	4.1%	4.8%
11:00	4.7%	4.4%	5.1%
12:00	4.7%	4.4%	5.6%
13:00	4.5%	4.9%	6.2%
14:00	4.2%	6.7%	6.8%
15:00	4.1%	9.6%	8.6%
16:00	4.3%	12.6%	10.9%
17:00	**4.8%**	**11.5%**	**11.0%**
18:00	4.0%	7.6%	6.3%
19:00	2.9%	4.5%	4.9%
20:00	2.6%	4.0%	3.3%
21:00	1.8%	3.0%	2.2%
22:00	1.3%	2.2%	1.5%
23:00	0.7%	1.4%	0.6%

*** HANDOUT ***

*** HANDOUT ***

Table A3 - 2015 Hourly Volume Forecasts

Start of Hour	Approaches to TH 7/CSAH 11 Intersection			
	EB TH 7	WB TH 7	NB CSAH 11	SB Kings Pt
0:00	44	107	10	11
1:00	29	56	1	7
2:00	32	46	3	8
3:00	40	53	1	10
4:00	182	60	7	47
5:00	692	96	22	180
6:00	1,431	306	67	372
7:00	**1,548**	**463**	**139**	**402**
8:00	934	391	149	243
9:00	619	455	140	161
10:00	516	439	117	134
11:00	509	477	123	132
12:00	573	565	215	314
13:00	552	625	236	303
14:00	512	856	259	281
15:00	498	1,225	331	273
16:00	521	1,607	416	286
17:00	**587**	**1,468**	**421**	**322**
18:00	489	963	243	268
19:00	351	568	187	193
20:00	315	508	125	173
21:00	223	382	83	122
22:00	160	279	58	88
23:00	89	180	23	49

*** HANDOUT ***

*** HANDOUT ***

Table A4 - 2015 Hourly Volume Forecasts with Right Turn Reduction (USED IN WARRANT ANALYSES)

Start of Hour	Approaches to TH 7/CSAH 11 Intersection			
	EB TH 7	WB TH 7	NB CSAH 11	SB Kings Pt
0:00	35	85	8	10
1:00	23	45	1	6
2:00	26	37	2	7
3:00	32	43	1	9
4:00	147	48	6	40
5:00	561	77	18	151
6:00	1,159	245	55	312
7:00	1,254	370	113	338
8:00	757	313	121	204
9:00	501	364	114	135
10:00	418	351	95	112
11:00	413	382	100	111
12:00	458	435	189	261
13:00	442	481	208	251
14:00	409	659	228	233
15:00	398	943	291	227
16:00	417	1,238	366	237
17:00	470	1,130	370	267
18:00	392	741	214	223
19:00	281	438	165	160
20:00	252	391	110	143
21:00	178	294	73	102
22:00	128	215	51	73
23:00	71	139	20	41

	Right Turn Percentages			
midnight to noon	19%	20%	19%	16%
noon to midnight	20%	23%	12%	17%

*** HANDOUT ***

MN/DOT 2942 (rev 9-11-92)

COLLISION DIAGRAM

Minnesota Department of Transportation

*** HANDOUT ***

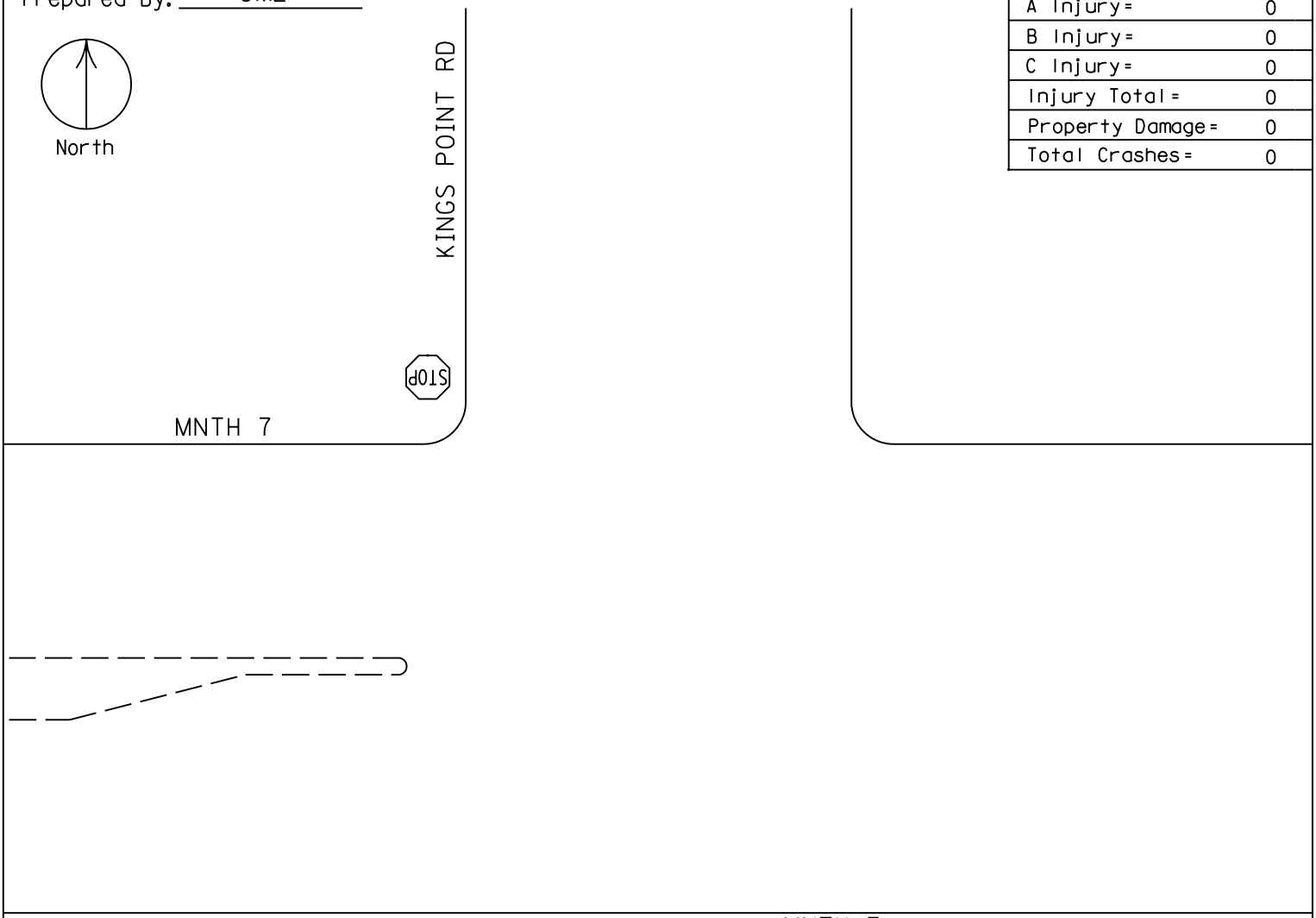
Location: MNTH 7 @ KINGS POINT ROAD RP 175+00.483

Time Period: 01/01/02 - 12/31/02 Date: 12/28/06

Prepared By: CME

No. of Crashes

Fatal =	0
A Injury =	0
B Injury =	0
C Injury =	0
Injury Total =	0
Property Damage =	0
Total Crashes =	0



KEY

- Motor Vehicle Out of Control
- Motor Vehicle Backing Up
- Motor Vehicle Rollover
- Motor Vehicle Sideswipe
- Fixed Object
- Fatal Crash
- A Injury Crash
- B Injury Crash
- C Injury Crash
- Property Damage Crash
- Pedestrian
- Bicycle
- Motorcycle
- Parked Vehicle
- Rear End Property Damage
- Right Angle B Injury

NOTES

[1]
[2]
[3]

Light:	Weather:	Surface:
L = Daylight (1)	C = Clear or Cloudy (1 or 2)	D = Dry (1)
DN = Dawn (2)	R = Rain (3)	W = Wet (2)
Du = Dusk (3)	S = Snow or Sleet (4 or 5)	S = Snow or Ice (3 or 4)
Dl = Dark, Lighted (4)	F = Fog, Smog, Smoke (6)	M = Muddy (5)
Do = Dark, Lights Off (5)	B = Blowing Sand/Dust (7)	Db = Debris (6)
D = Dark, Unlighted (6)	W = Severe Crosswinds (8)	O = Oily (7)
X = Unknown (99)	X = Other or Unknown (99)	X = Other or Unknown (99)

(X) = Number of Vehicles in Crash (X) Other Vehicle — Injury Type — [Date] — [Time (hrs)] — [Light-Weather-Surface]

7@KingsPtRd.dgn 1/5/2007 3:36:19 PM

*** HANDOUT ***

MN/DOT 2942 (rev 9-11-92)

COLLISION DIAGRAM

Minnesota Department of Transportation

*** HANDOUT ***

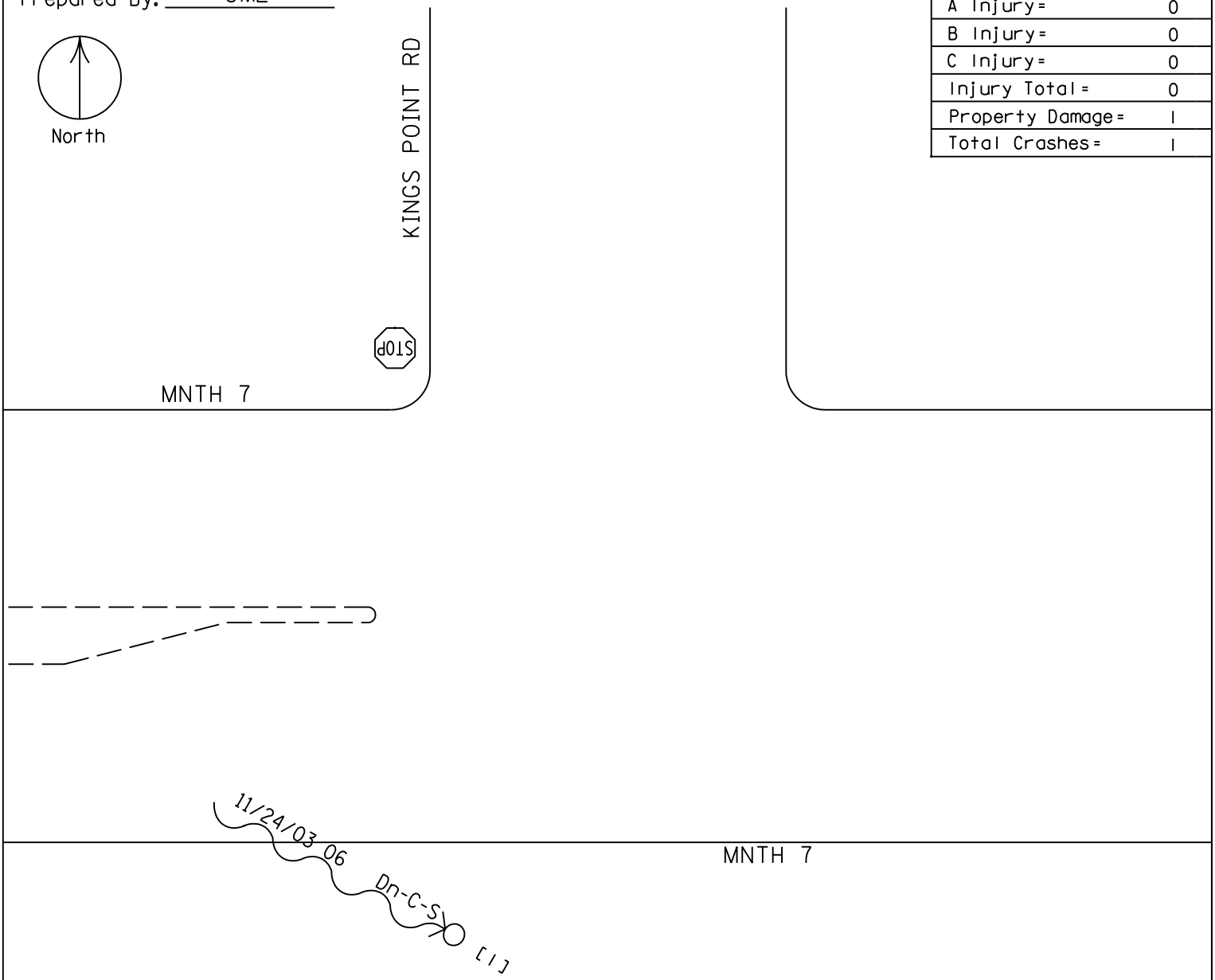
Location: MNTH 7 @ KINGS POINT ROAD RP 175+00.483

Time Period: 01/01/03 - 12/31/03 Date: 12/28/06

Prepared By: CME

No. of Crashes

Fatal =	0
A Injury =	0
B Injury =	0
C Injury =	0
Injury Total =	0
Property Damage =	1
Total Crashes =	1



KEY

- Motor Vehicle Out of Control
- Motor Vehicle Backing Up
- Motor Vehicle Rollover
- Motor Vehicle Sideswipe
- Fixed Object
- Fatal Crash
- A Injury Crash
- B Injury Crash
- C Injury Crash
- Property Damage Crash
- Pedestrian
- Bicycle
- Motorcycle
- Parked Vehicle
- Rear End Property Damage
- Right Angle B Injury

NOTES

[1] NOT INTERSECTION RELATED

[2]

[3]

Light:	Weather:	Surface:
L = Daylight (1)	C = Clear or Cloudy (1 or 2)	D = Dry (1)
DN = Dawn (2)	R = Rain (3)	W = Wet (2)
Du = Dusk (3)	S = Snow or Sleet (4 or 5)	S = Snow or Ice (3 or 4)
Dl = Dark, Lighted (4)	F = Fog, Smog, Smoke (6)	M = Muddy (5)
Do = Dark, Lights Off (5)	B = Blowing Sand/Dust (7)	Db = Debris (6)
D = Dark, Unlighted (6)	W = Severe Crosswinds (8)	O = Oily (7)
X = Unknown (99)	X = Other or Unknown (99)	X = Other or Unknown (99)

(X) = Number of Vehicles in Crash (X) Other Vehicle — Injury Type — [Date] — [Time (hrs)] — [Light-Weather-Surface]

7@KingsPtRd.dgn 1/5/2007 3:38:40 PM

*** HANDOUT ***

MN/DOT 2942 (rev 9-11-92)

COLLISION DIAGRAM

Minnesota Department of Transportation

*** HANDOUT ***

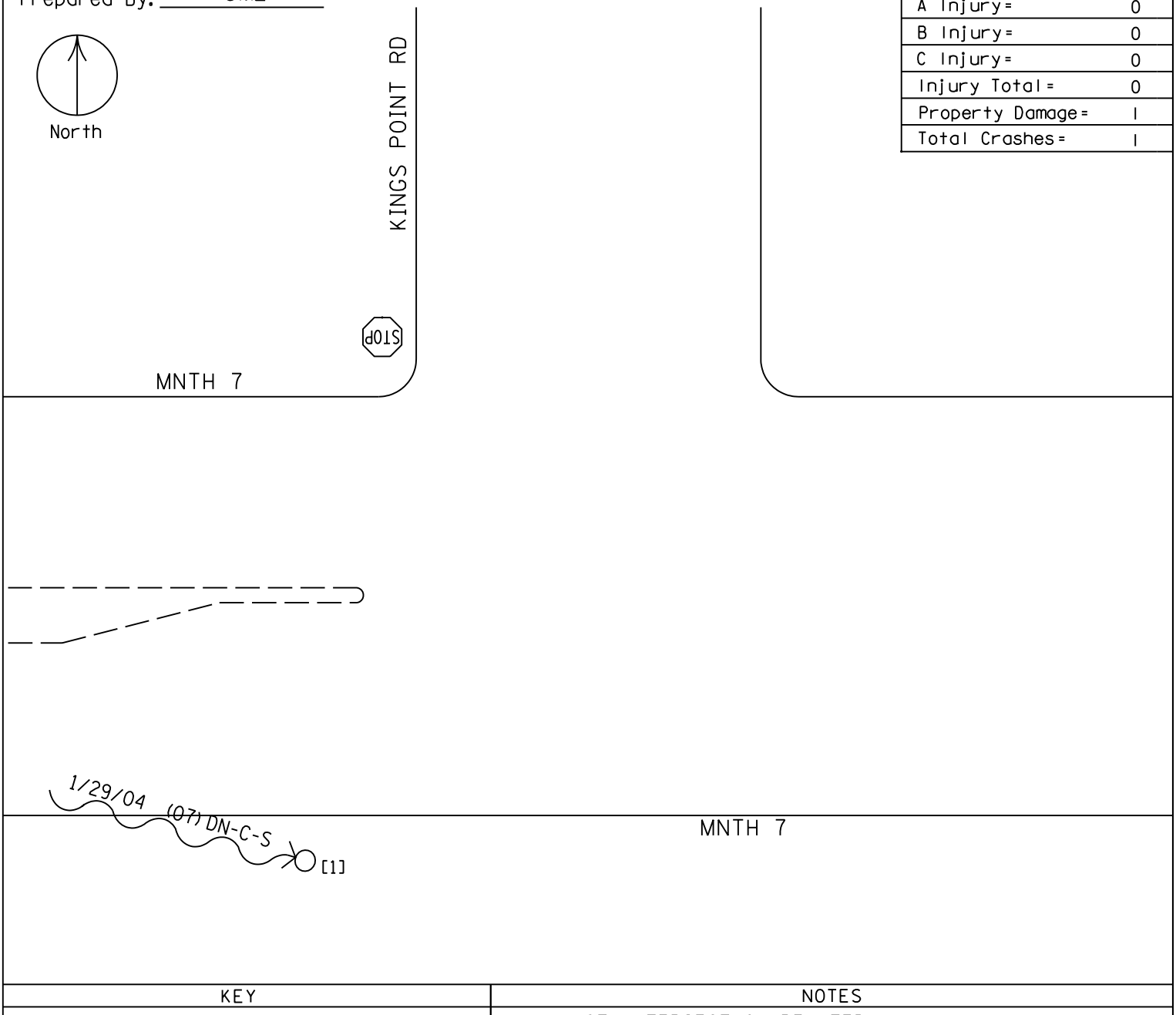
Location: MNTH 7 @ KINGS POINT ROAD RP 175+00.483

Time Period: 01/01/04 - 12/31/04 Date: 12/28/06

Prepared By: CME

No. of Crashes

Fatal =	0
A Injury =	0
B Injury =	0
C Injury =	0
Injury Total =	0
Property Damage =	1
Total Crashes =	1



KEY

- Motor Vehicle Out of Control
- Motor Vehicle Backing Up
- Motor Vehicle Rollover
- Motor Vehicle Sideswipe
- Fixed Object
- Fatal Crash
- A Injury Crash
- B Injury Crash
- C Injury Crash
- Property Damage Crash
- Pedestrian
- Bicycle
- Motorcycle
- Parked Vehicle
- Rear End Property Damage
- Right Angle B Injury

NOTES

[1] NOT INTERSECTION RELATED

[2]

[3]

Light:	Weather:	Surface:
L = Daylight (1)	C = Clear or Cloudy (1 or 2)	D = Dry (1)
DN = Dawn (2)	R = Rain (3)	W = Wet (2)
Du = Dusk (3)	S = Snow or Sleet (4 or 5)	S = Snow or Ice (3 or 4)
Dl = Dark, Lighted (4)	F = Fog, Smog, Smoke (6)	M = Muddy (5)
Do = Dark, Lights Off (5)	B = Blowing Sand/Dust (7)	Db = Debris (6)
D = Dark, Unlighted (6)	W = Severe Crosswinds (8)	O = Oily (7)
X = Unknown (99)	X = Other or Unknown (99)	X = Other or Unknown (99)

(X) = Number of Vehicles in Crash (X) Other Vehicle — Injury Type — [Date] — [Time (hrs)] — [Light-Weather-Surface]

7@KingsPtRd.dgn 1/5/2007 3:39:52 PM

*** HANDOUT ***

MN/DOT 2942 (rev 9-11-92)

COLLISION DIAGRAM

Minnesota Department of Transportation

*** HANDOUT ***

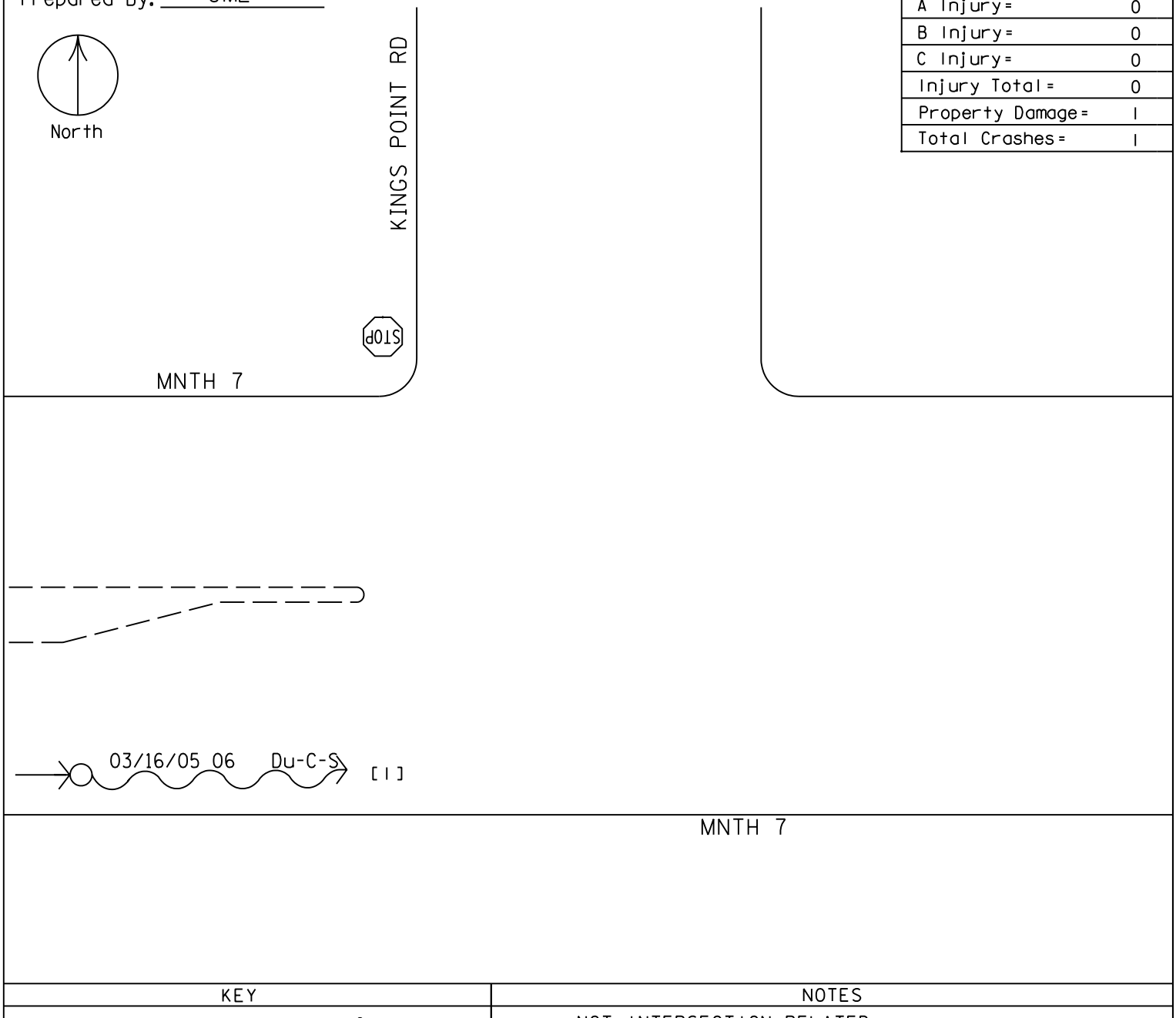
Location: MNTH 7 @ KINGS POINT ROAD RP 175+00.483

Time Period: 01/01/05 - 12/31/05 Date: 12/28/06

Prepared By: CME

No. of Crashes

Fatal =	0
A Injury =	0
B Injury =	0
C Injury =	0
Injury Total =	0
Property Damage =	1
Total Crashes =	1



KEY

- Motor Vehicle Out of Control
- Motor Vehicle Backing Up
- Motor Vehicle Rollover
- Motor Vehicle Sideswipe
- Fixed Object
- Fatal Crash
- A Injury Crash
- B Injury Crash
- C Injury Crash
- Property Damage Crash
- Pedestrian
- Bicycle
- Motorcycle
- Parked Vehicle
- Rear End Property Damage
- Right Angle B Injury

NOTES

[1] NOT INTERSECTION RELATED

[2]

[3]

Light:	Weather:	Surface:
L = Daylight (1)	C = Clear or Cloudy (1 or 2)	D = Dry (1)
DN = Dawn (2)	R = Rain (3)	W = Wet (2)
Du = Dusk (3)	S = Snow or Sleet (4 or 5)	S = Snow or Ice (3 or 4)
Dl = Dark, Lighted (4)	F = Fog, Smog, Smoke (6)	M = Muddy (5)
Do = Dark, Lights Off (5)	B = Blowing Sand/Dust (7)	Db = Debris (6)
D = Dark, Unlighted (6)	W = Severe Crosswinds (8)	O = Oily (7)
X = Unknown (99)	X = Other or Unknown (99)	X = Other or Unknown (99)

(X) = Number of Vehicles in Crash (X) Other Vehicle — Injury Type — [Date] — [Time (hrs)] — [Light-Weather-Surface]

7@KingsPtRd.dgn 1/5/2007 3:40:31 PM

*** HANDOUT ***

MN/DOT 2942 (rev 9-11-92)

COLLISION DIAGRAM

Minnesota Department of Transportation

*** HANDOUT ***

Location: MNTH 7 @ VICTORIA DR/CSAH 11 RP 175+00.259

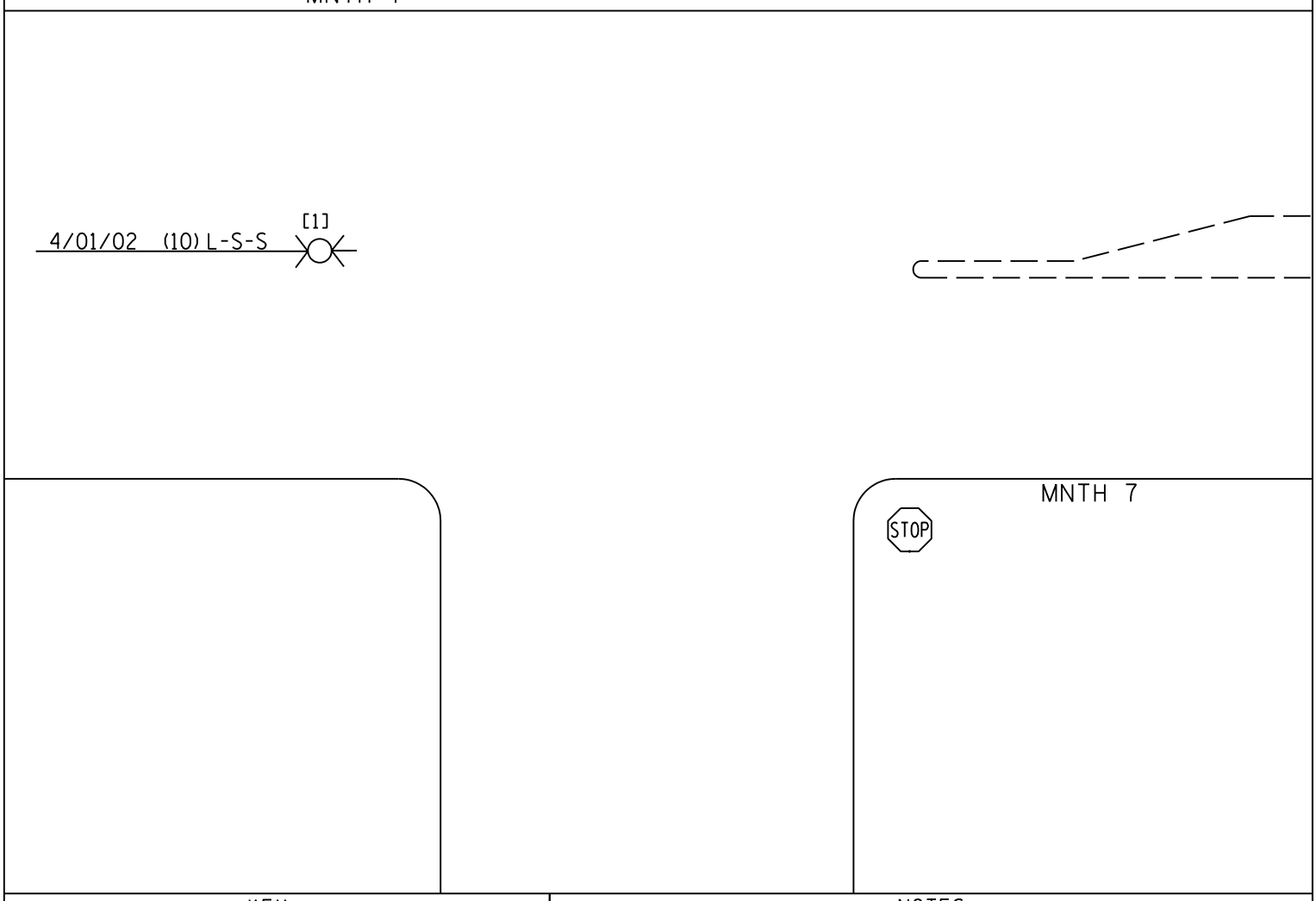
Time Period: 1/01/02 - 12/31/02 Date: 2/22/06

Prepared By: LMC

North

No. of Crashes

Fatal =	0
A Injury =	0
B Injury =	0
C Injury =	0
Injury Total =	0
Property Damage =	1
Total Crashes =	1



KEY

- Motor Vehicle Out of Control
- Motor Vehicle Backing Up
- Motor Vehicle Rollover
- Motor Vehicle Sideswipe
- Fixed Object
- Fatal Crash
- A Injury Crash
- B Injury Crash
- C Injury Crash
- Property Damage Crash
- Pedestrian
- Bicycle
- Motorcycle
- Parked Vehicle
- Rear End Property Damage
- Right Angle B Injury

NOTES

[1] Not intersection related

[2]

[3]

Light:	Weather:	Surface:
L = Daylight (1)	C = Clear or Cloudy (1 or 2)	D = Dry (1)
DN = Dawn (2)	R = Rain (3)	W = Wet (2)
Du = Dusk (3)	S = Snow or Sleet (4 or 5)	S = Snow or Ice (3 or 4)
Dl = Dark, Lighted (4)	F = Fog, Smog, Smoke (6)	M = Muddy (5)
Do = Dark, Lights Off (5)	B = Blowing Sand/Dust (7)	Db = Debris (6)
D = Dark, Unlighted (6)	W = Severe Crosswinds (8)	O = Oily (7)
X = Unknown (99)	X = Other or Unknown (99)	X = Other or Unknown (99)

(X) = Number of Vehicles in Crash (X) Other Vehicle — Injury Type — [Date] — [Time (hrs)] — [Light-Weather-Surface]

7@VictoriaDr-Csah11.dgn 1/5/2007 4:08:20 PM

*** HANDOUT ***

MN/DOT 2942 (rev 9-11-92)

COLLISION DIAGRAM

Minnesota Department of Transportation

*** HANDOUT ***

Location: MNTH 7 @ VICTORIA DR/CSAH 11 RP 175+00.259

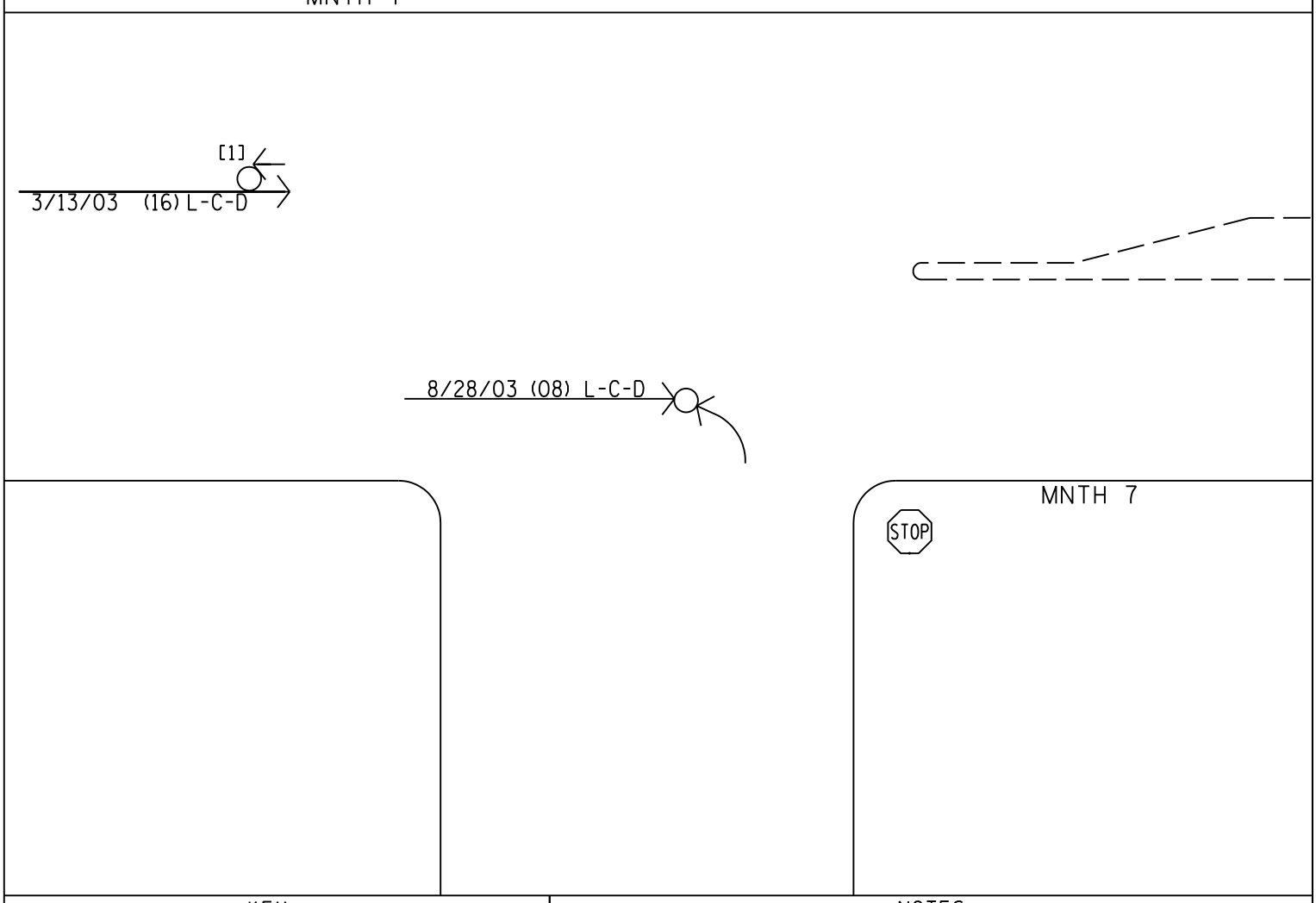
Time Period: 1/01/03 - 12/31/03 Date: 2/22/06

Prepared By: LMC

North

No. of Crashes

Fatal =	0
A Injury =	0
B Injury =	0
C Injury =	0
Injury Total =	0
Property Damage =	2
Total Crashes =	2



KEY

- Motor Vehicle Out of Control
- Motor Vehicle Backing Up
- Motor Vehicle Rollover
- Motor Vehicle Sideswipe
- Fixed Object
- Fatal Crash
- A Injury Crash
- B Injury Crash
- C Injury Crash
- Property Damage Crash
- Pedestrian
- Bicycle
- Motorcycle
- Parked Vehicle
- Rear End Property Damage
- Right Angle B Injury

NOTES

[1] Not intersection related

[2]

[3]

Light:	Weather:	Surface:
L = Daylight (1)	C = Clear or Cloudy (1 or 2)	D = Dry (1)
DN = Dawn (2)	R = Rain (3)	W = Wet (2)
Du = Dusk (3)	S = Snow or Sleet (4 or 5)	S = Snow or Ice (3 or 4)
Dl = Dark, Lighted (4)	F = Fog, Smog, Smoke (6)	M = Muddy (5)
Do = Dark, Lights Off (5)	B = Blowing Sand/Dust (7)	Db = Debris (6)
D = Dark, Unlighted (6)	W = Severe Crosswinds (8)	O = Oily (7)
X = Unknown (99)	X = Other or Unknown (99)	X = Other or Unknown (99)

(X) = Number of Vehicles in Crash (X) Other Vehicle — Injury Type — [Date] — [Time (hrs)] — [Light-Weather-Surface]

MN/DOT 2942 (rev 9-11-92)

COLLISION DIAGRAM

Minnesota Department of Transportation

*** HANDOUT ***

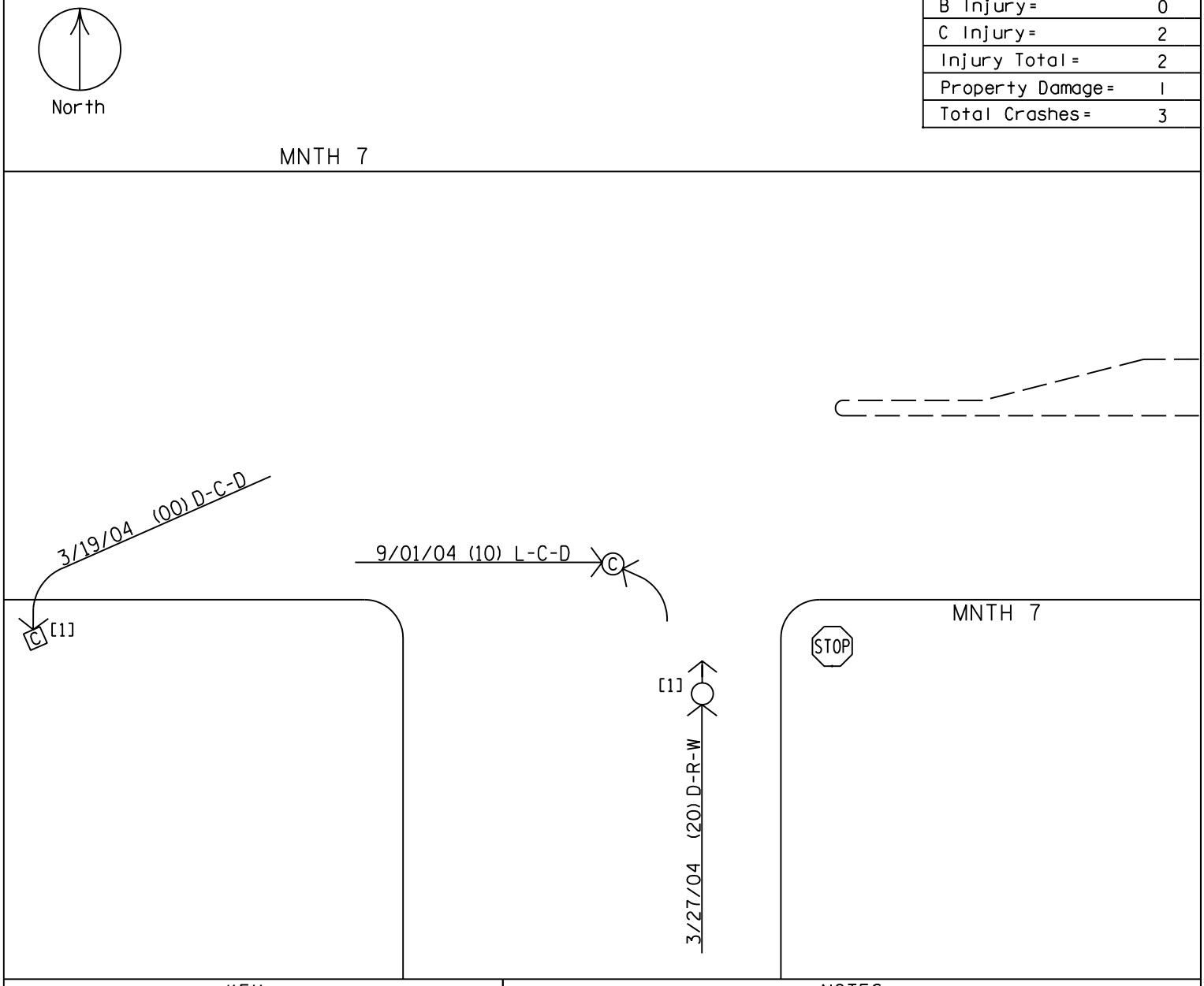
Location: MNTH 7 @ VICTORIA DR/CSAH 11 RP 175+00.259

Time Period: 1/01/04 - 12/31/04 Date: 2/22/06

Prepared By: LMC

No. of Crashes

Fatal =	0
A Injury =	0
B Injury =	0
C Injury =	2
Injury Total =	2
Property Damage =	1
Total Crashes =	3



KEY

- Motor Vehicle Out of Control
- Motor Vehicle Backing Up
- Motor Vehicle Rollover
- Motor Vehicle Sideswipe
- Fixed Object
- Fatal Crash
- A Injury Crash
- B Injury Crash
- C Injury Crash
- Property Damage Crash
- Pedestrian
- Bicycle
- Motorcycle
- Parked Vehicle
- Rear End Property Damage
- Right Angle B Injury

NOTES

[1] Arrested for DWI

[2]

[3]

Light:	Weather:	Surface:
L = Daylight (1)	C = Clear or Cloudy (1 or 2)	D = Dry (1)
DN = Dawn (2)	R = Rain (3)	W = Wet (2)
Du = Dusk (3)	S = Snow or Sleet (4 or 5)	S = Snow or Ice (3 or 4)
Dl = Dark, Lighted (4)	F = Fog, Smog, Smoke (6)	M = Muddy (5)
Do = Dark, Lights Off (5)	B = Blowing Sand/Dust (7)	Db = Debris (6)
D = Dark, Unlighted (6)	W = Severe Crosswinds (8)	O = Oily (7)
X = Unknown (99)	X = Other or Unknown (99)	X = Other or Unknown (99)

(X) = Number of Vehicles in Crash (X) Other Vehicle — Injury Type — [Date] — [Time (hrs)] — [Light-Weather-Surface]

MN/DOT 2942 (rev 9-11-92)

COLLISION DIAGRAM

Minnesota Department of Transportation

*** HANDOUT ***

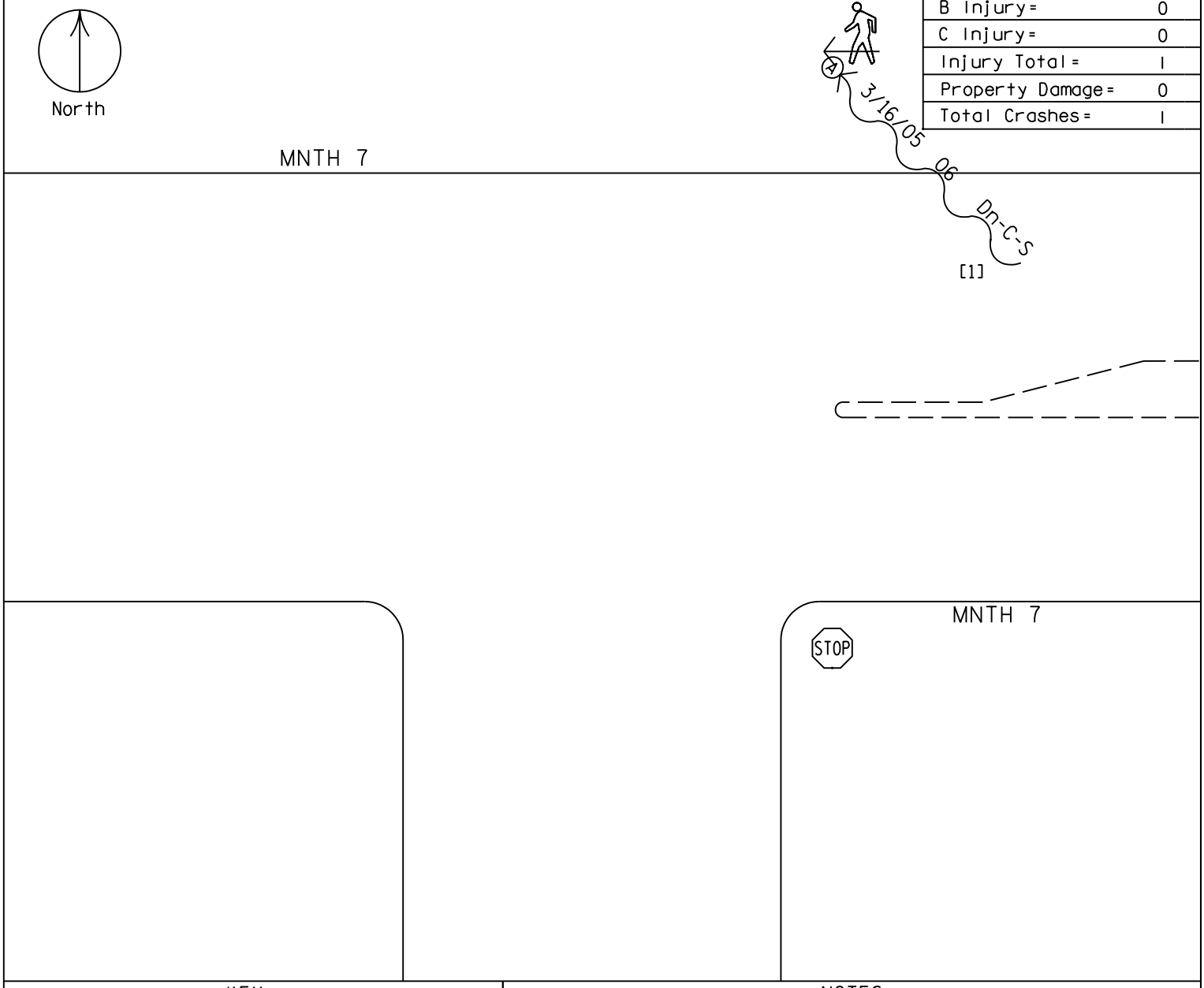
Location: MNTH 7 @ VICTORIA DR/CSAH 11 RP 175+00.259

Time Period: 01/01/05 - 12/31/05 Date: 12/28/06

Prepared By: CME

No. of Crashes

Fatal =	0
A Injury =	1
B Injury =	0
C Injury =	0
Injury Total =	1
Property Damage =	0
Total Crashes =	1



KEY

- Motor Vehicle Out of Control
- Motor Vehicle Backing Up
- Motor Vehicle Rollover
- Motor Vehicle Sideswipe
- Fixed Object
- Fatal Crash
- A Injury Crash
- B Injury Crash
- C Injury Crash
- Property Damage Crash
- Pedestrian
- Bicycle
- Motorcycle
- Parked Vehicle
- Rear End Property Damage
- Right Angle B Injury

NOTES

[1] NOT INTERSECTION RELATED

[2]

[3]

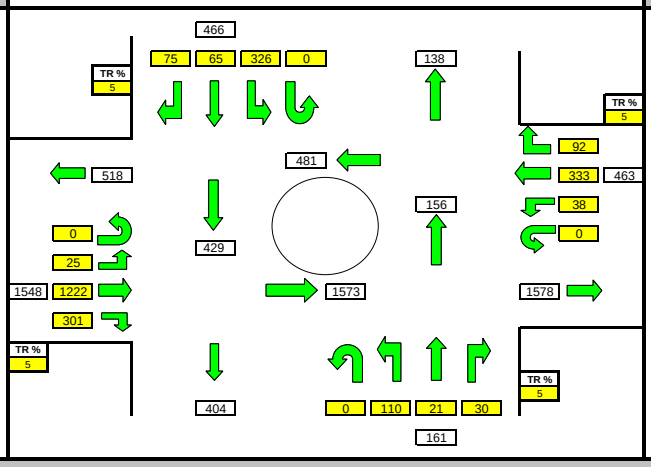
Light:	Weather:	Surface:
L = Daylight (1)	C = Clear or Cloudy (1 or 2)	D = Dry (1)
DN = Dawn (2)	R = Rain (3)	W = Wet (2)
Du = Dusk (3)	S = Snow or Sleet (4 or 5)	S = Snow or Ice (3 or 4)
Dl = Dark, Lighted (4)	F = Fog, Smog, Smoke (6)	M = Muddy (5)
Do = Dark, Lights Off (5)	B = Blowing Sand/Dust (7)	Db = Debris (6)
D = Dark, Unlighted (6)	W = Severe Crosswinds (8)	O = Oily (7)
X = Unknown (99)	X = Other or Unknown (99)	X = Other or Unknown (99)

(X) = Number of Vehicles in Crash (X) Other Vehicle — Injury Type — [Date] — [Time (hrs)] — [Light-Weather-Surface]

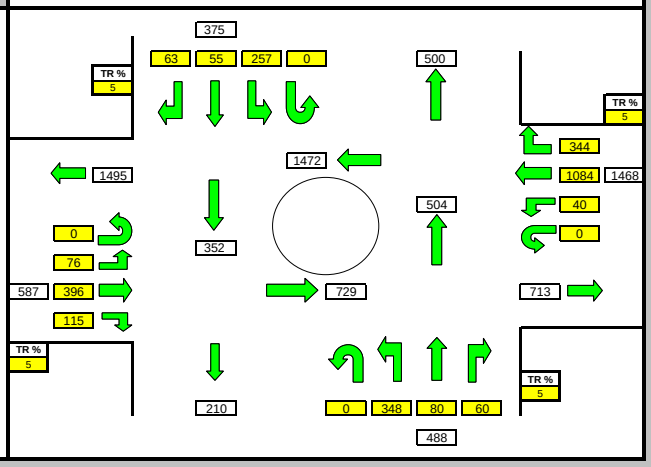
*** HANDOUT ***

2030 PEAK HOUR

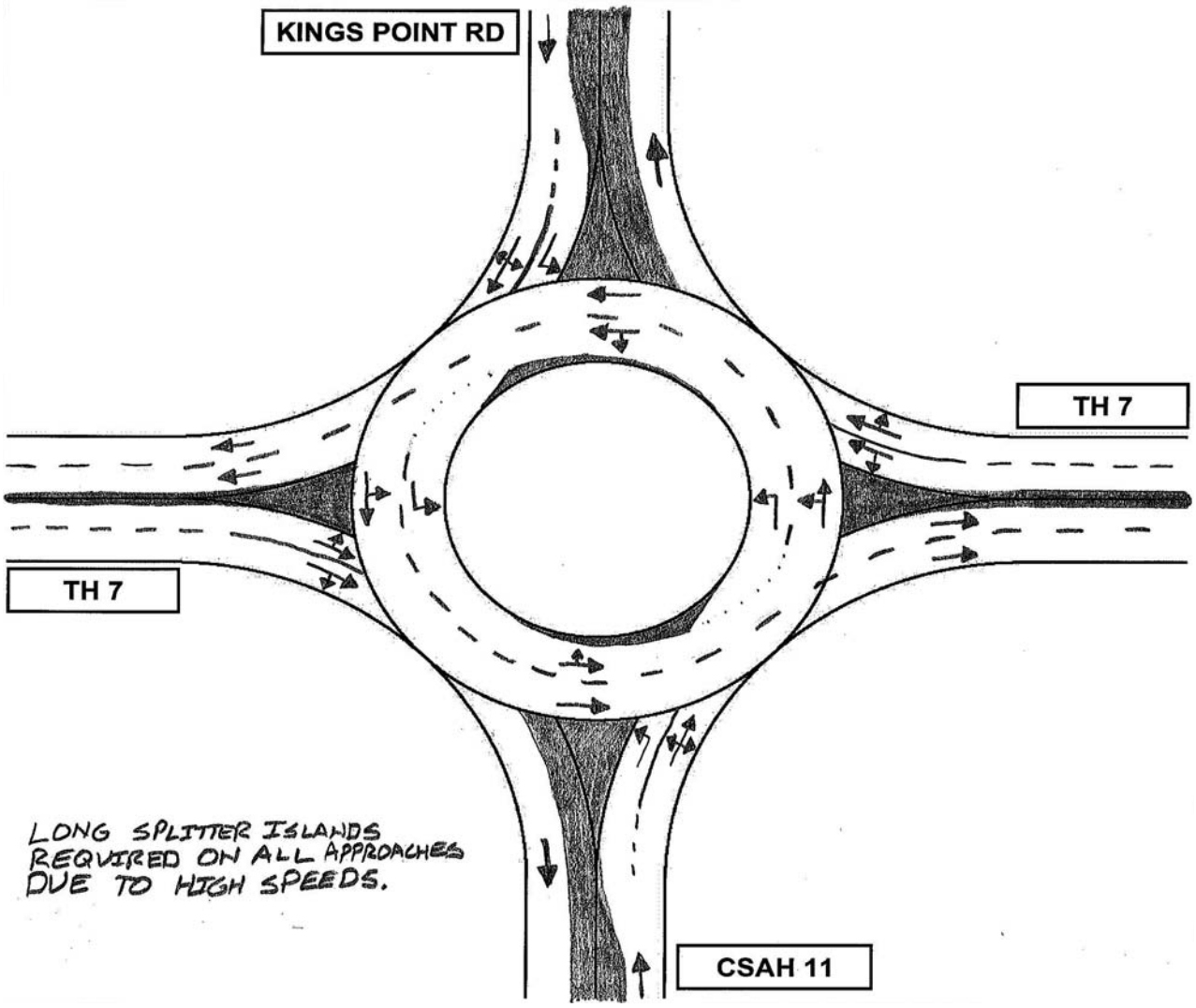
AM



PM



CONCEPTUAL LANE CONFIGURATION



Ourston Roundabout Engineering

HWY 7/CSAH 11/KINGS POINT ROAD
MINNETRISTA, MN
LANE CONFIGURATION

EXHIBIT: A

*** HANDOUT ***

2005 TH 7/CSAH 11 Warrant Study

Minnetrista, MN

Traffic Data Inc. (TDI)

Signal Warrants - Summary

Major Street Approaches

Eastbound: **TH 7**
Number of Lanes: **2**
Approach Speed: **55**
Total Approach Volume: **8,774**

Westbound: **TH 7**
Number of Lanes: **2**
Approach Speed: **55**
Total Approach Volume: **8,478**

Minor Street Approaches

Northbound: **CSAH 11**
Number of Lanes: **2**
Total Approach Volume: **1,657**

Southbound:
Number of Lanes: **2**
Total Approach Volume: **0**

Warrant Summary **(Rural values apply.)**

Warrant 1 - Eight Hour Vehicular Volumes ..... **Satisfied**

Warrant 1A - Minimum Vehicular Volume ..... **Not Satisfied**
Required volumes reached for 3 hours, 8 are needed

Warrant 1B - Interruption of Continuous Traffic ..... **Satisfied**
Required volumes reached for 13 hours, 8 are needed

Warrant 1 A&B - Combination of Warrants ..... **Not Satisfied**
Required volumes reached for 4 hours, 8 are needed

Warrant 2 - Four Hour Volumes ..... **Satisfied**
Number of hours (9) volumes exceed minimum >= minimum required (4).

Warrant 3 - Peak Hour ..... **Satisfied**

Warrant 3A - Peak Hour Delay ..... **Not Satisfied**
Total approach volumes and delays on minor street do not exceed minimums for any hour.

Warrant 3B - Peak Hour Volumes ..... **Satisfied**
Volumes exceed minimums for at least one hour.

Warrant 4 - Pedestrian Volumes ..... **Not Satisfied**
Required 4 Hr pedestrian volume reached for 0 hour(s) and the single hour volume for 0 hour(s)

Warrant 5 - School Crossing ..... **Not Satisfied**
Number of gaps > .0 seconds (0) exceeds the number of minutes in the crossing period (0).

Warrant 6 - Coordinated Signal System ..... **Not Satisfied**
No adjacent coordinated signals are present

Warrant 7 - Crash Experience ..... **Not Satisfied**
Number of accidents (-1) is less than minimum (5). Volume minimums are met.

Warrant 8 - Roadway Network ..... **Not Satisfied**
Major Route conditions not met. One or more volume requirement met.

*** HANDOUT ***

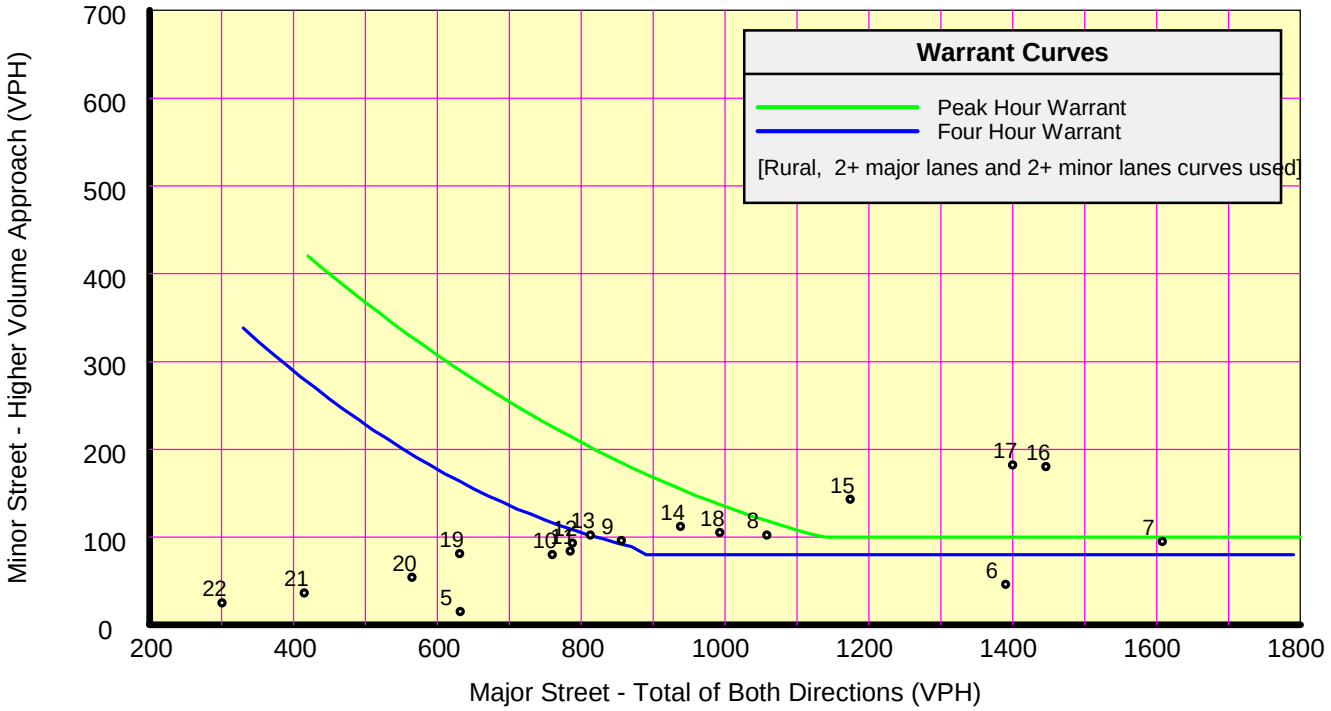
*** HANDOUT ***

2005 TH 7/CSAH 11 Warrant Study

Minnetrista, MN

Traffic Data Inc. (TDI)

Signal Warrants - Summary



Analysis of 8-Hour Volume Warrants:

Hour	Major	Higher Minor		War-1A			War-1B			War-1A&B		
Begin	Total	Vol	Dir	Major Crit	Minor Crit	Meets?	Major Crit	Minor Crit	Meets?	Major Crit	Minor Crit	Meets?
00:00	119	7	NB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---
01:00	67	1	NB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---
02:00	62	2	NB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---
03:00	74	1	NB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---
04:00	193	5	NB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---
05:00	632	15	NB	420-Yes	140-No	Major	630-Yes	70-No	Major	504-Yes	112-No	Major
06:00	1,390	46	NB	420-Yes	140-No	Major	630-Yes	70-No	Major	504-Yes	112-No	Major
07:00	1,608	95	NB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-No	Major
08:00	1,058	102	NB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-No	Major
09:00	856	96	NB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-No	Major
10:00	760	80	NB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-No	Major
11:00	785	84	NB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-No	Major
12:00	788	93	NB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-No	Major
13:00	813	102	NB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-No	Major
14:00	938	112	NB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
15:00	1,174	143	NB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
16:00	1,446	180	NB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
17:00	1,400	182	NB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
18:00	993	105	NB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-No	Major
19:00	631	81	NB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-No	Major
20:00	565	54	NB	420-Yes	140-No	Major	630-No	70-No	---	504-Yes	112-No	Major
21:00	415	36	NB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---
22:00	301	25	NB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---
23:00	184	10	NB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---

*** HANDOUT ***

*** HANDOUT ***

2015 Volumes

TH 7/CSAH 11

Traffic Data Inc. (TDI)

Signal Warrants - Summary

Major Street Approaches

Eastbound: **TH 7**
Number of Lanes: **2**
Approach Speed: **55**
Total Approach Volume: **9,222**

Westbound: **TH 7**
Number of Lanes: **2**
Approach Speed: **55**
Total Approach Volume: **9,464**

Minor Street Approaches

Northbound: **CSAH 11**
Number of Lanes: **2**

Total Approach Volume: **2,919**

Southbound: **Kings Point Rd**
Number of Lanes: **2**

Total Approach Volume: **3,653**

Warrant Summary **(Rural values apply.)**

Warrant 1 - Eight Hour Vehicular Volumes ..... **Satisfied**

Warrant 1A - Minimum Vehicular Volume ..... **Satisfied**
Required volumes reached for 13 hours, 8 are needed

Warrant 1B - Interruption of Continuous Traffic ..... **Satisfied**
Required volumes reached for 16 hours, 8 are needed

Warrant 1 A&B - Combination of Warrants ..... **Satisfied**
Required volumes reached for 15 hours, 8 are needed

Warrant 2 - Four Hour Volumes ..... **Satisfied**
Number of hours (13) volumes exceed minimum >= minimum required (4).

Warrant 3 - Peak Hour ..... **Satisfied**

Warrant 3A - Peak Hour Delay ..... **Not Satisfied**
Total approach volumes and delays on minor street do not exceed minimums for any hour.

Warrant 3B - Peak Hour Volumes ..... **Satisfied**
Volumes exceed minimums for at least one hour.

Warrant 4 - Pedestrian Volumes ..... **Not Satisfied**
Required 4 Hr pedestrian volume reached for 0 hour(s) and the single hour volume for 0 hour(s)

Warrant 5 - School Crossing ..... **Not Satisfied**
Number of gaps > .0 seconds (0) exceeds the number of minutes in the crossing period (0).

Warrant 6 - Coordinated Signal System ..... **Not Satisfied**
No adjacent coordinated signals are present

Warrant 7 - Crash Experience ..... **Not Satisfied**
Number of accidents (-1) is less than minimum (5). Volume minimums are met.

Warrant 8 - Roadway Network ..... **Not Satisfied**
Major Route conditions not met. One or more volume requirement met.

*** HANDOUT ***

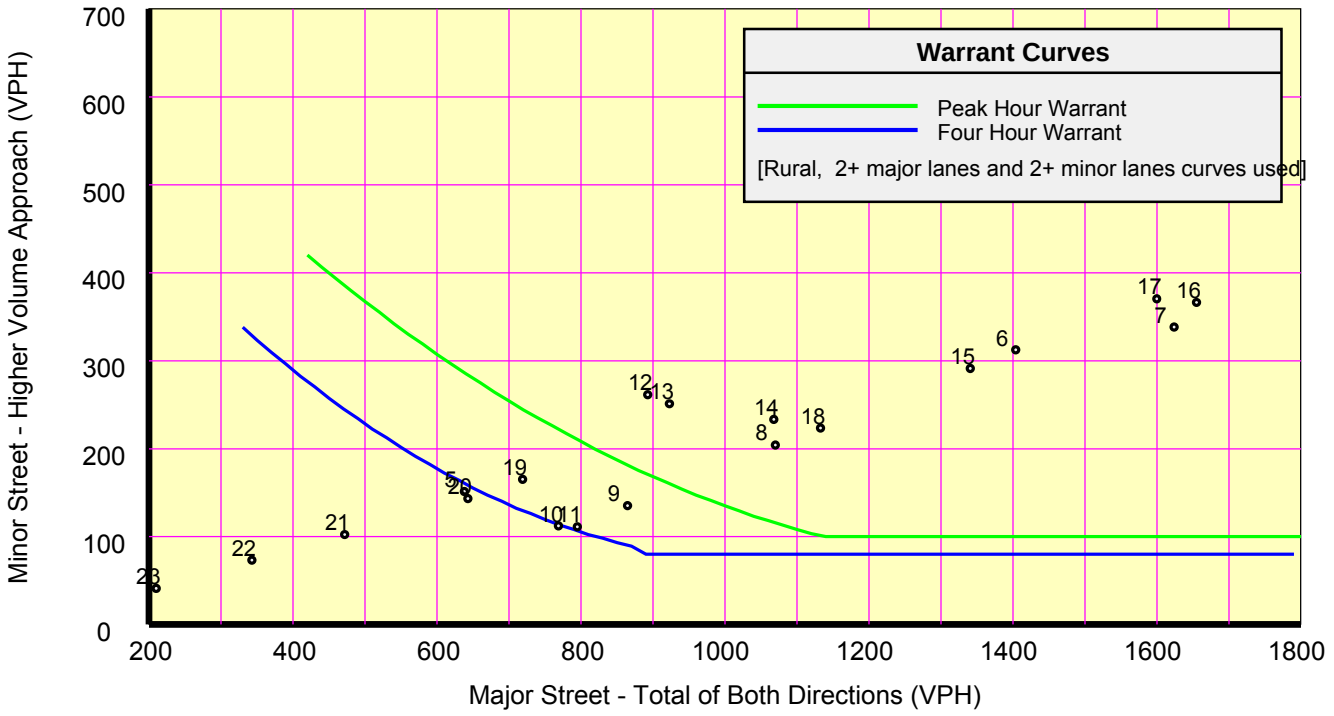
*** HANDOUT ***

2015 Volumes

TH 7/CSAH 11

Traffic Data Inc. (TDI)

Signal Warrants - Summary



Analysis of 8-Hour Volume Warrants:

Hour	Major	Higher Minor		War-1A			War-1B			War-1A&B		
Begin	Total	Vol	Dir	Major Crit	Minor Crit	Meets?	Major Crit	Minor Crit	Meets?	Major Crit	Minor Crit	Meets?
00:00	120	10	SB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---
01:00	68	6	SB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---
02:00	63	7	SB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---
03:00	75	9	SB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---
04:00	195	40	SB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---
05:00	638	151	SB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
06:00	1,404	312	SB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
07:00	1,624	338	SB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
08:00	1,070	204	SB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
09:00	865	135	SB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
10:00	769	112	SB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
11:00	795	111	SB	420-Yes	140-No	Major	630-Yes	70-Yes	Both	504-Yes	112-No	Major
12:00	893	261	SB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
13:00	923	251	SB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
14:00	1,068	233	SB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
15:00	1,341	291	NB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
16:00	1,655	366	NB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
17:00	1,600	370	NB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
18:00	1,133	223	SB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
19:00	719	165	NB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
20:00	643	143	SB	420-Yes	140-Yes	Both	630-Yes	70-Yes	Both	504-Yes	112-Yes	Both
21:00	472	102	SB	420-Yes	140-No	Major	630-No	70-Yes	Minor	504-No	112-No	---
22:00	343	73	SB	420-No	140-No	---	630-No	70-Yes	Minor	504-No	112-No	---
23:00	210	41	SB	420-No	140-No	---	630-No	70-No	---	504-No	112-No	---

*** HANDOUT ***

*** HANDOUT ***

2015 A.M.Peak Hour
HCM Signalized Intersection Capacity Analysis

TH 7/CSAH 11 ICE Report
7: TH 7 & Kings Point Rd.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.92	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	1770	1863	1583	1770	1712	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.67	1.00	1.00	0.62	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3539	1583	1253	1863	1583	1159	1712	
Volume (vph)	25	1222	301	38	333	92	95	18	26	281	56	65
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	27	1328	327	41	362	100	103	20	28	305	61	71
RTOR Reduction (vph)	0	0	178	0	0	53	0	0	23	0	48	0
Lane Group Flow (vph)	27	1328	149	41	362	47	103	20	5	305	84	0
Turn Type	Prot		Perm	Prot		Perm	pm+pt		Perm	pm+pt		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4			8	2		2	6		
Actuated Green, G (s)	2.5	32.8	32.8	3.7	34.0	34.0	17.2	11.8	11.8	22.8	14.6	
Effective Green, g (s)	2.5	35.3	35.3	3.7	36.5	36.5	19.7	14.3	14.3	25.3	17.1	
Actuated g/C Ratio	0.03	0.46	0.46	0.05	0.47	0.47	0.25	0.18	0.18	0.33	0.22	
Clearance Time (s)	4.0	6.5	6.5	4.0	6.5	6.5	4.0	6.5	6.5	4.0	6.5	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	57	1612	721	85	1667	746	355	344	292	443	378	
v/s Ratio Prot	0.02	c0.38		c0.02	0.10		0.02	0.01		c0.07	0.05	
v/s Ratio Perm			0.09			0.03	0.05		0.00	c0.15		
v/c Ratio	0.47	0.82	0.21	0.48	0.22	0.06	0.29	0.06	0.02	0.69	0.22	
Uniform Delay, d1	36.9	18.4	12.7	36.0	12.1	11.2	22.9	26.0	25.9	22.0	24.8	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	6.1	3.6	0.1	4.3	0.1	0.0	0.5	0.1	0.0	4.4	0.3	
Delay (s)	42.9	21.9	12.8	40.2	12.1	11.2	23.3	26.1	25.9	26.4	25.1	
Level of Service	D	C	B	D	B	B	C	C	C	C	C	
Approach Delay (s)		20.5			14.3			24.2			26.0	
Approach LOS		C			B			C			C	

Intersection Summary			
HCM Average Control Delay	20.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	77.5	Sum of lost time (s)	16.0
Intersection Capacity Utilization	67.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

*** HANDOUT ***

*** HANDOUT ***

2015 A.M.Peak Hour
Queuing and Blocking Report

TH 7/CSAH 11 ICE Report
2/22/2007

Intersection: 6: Bend

Movement	EB	EB
Directions Served	T	
Maximum Queue (ft)	698	156
Average Queue (ft)	40	5
95th Queue (ft)	337	110
Link Distance (ft)	1260	1260
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 7: TH 7 & Kings Point Rd.

Movement	EB	EB	EB	EB	WB	WB	WB	WB	NB	NB	NB	SB
Directions Served	L	T	T	R	L	T	T	R	L	T	R	L
Maximum Queue (ft)	220	701	572	75	78	152	104	29	100	46	53	224
Average Queue (ft)	29	355	264	40	27	64	19	6	46	9	12	132
95th Queue (ft)	124	597	480	67	59	118	60	17	86	30	34	213
Link Distance (ft)		1337	1337			1260	1260			2887		
Upstream Blk Time (%)												
Queuing Penalty (veh)												
Storage Bay Dist (ft)	300			300	300			300	300		250	200
Storage Blk Time (%)		15	1									2
Queuing Penalty (veh)		4	2									2

Intersection: 7: TH 7 & Kings Point Rd.

Movement	SB
Directions Served	TR
Maximum Queue (ft)	238
Average Queue (ft)	61
95th Queue (ft)	143
Link Distance (ft)	1634
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	
Storage Blk Time (%)	0
Queuing Penalty (veh)	0

Nework Summary

Network wide Queuing Penalty: 8

*** HANDOUT ***

*** HANDOUT ***

2015 P.M. Peak Hour
HCM Signalized Intersection Capacity Analysis

TH 7/CSAH 11 ICE Report
7: TH 7 & Kings Point Rd.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.92	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	1770	1863	1583	1770	1713	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.65	1.00	1.00	0.71	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3539	1583	1211	1863	1583	1319	1713	
Volume (vph)	76	396	115	40	1084	344	300	69	52	221	47	54
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	83	430	125	43	1178	374	326	75	57	240	51	59
RTOR Reduction (vph)	0	0	70	0	0	218	0	0	47	0	49	0
Lane Group Flow (vph)	83	430	55	43	1178	156	326	75	10	240	61	0
Turn Type	Prot		Perm	Prot		Perm	pm+pt		Perm	pm+pt		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4			8	2		2	6		
Actuated Green, G (s)	5.9	32.2	32.2	4.3	30.6	30.6	22.4	11.1	11.1	21.6	10.7	
Effective Green, g (s)	5.9	34.7	34.7	4.3	33.1	33.1	24.9	13.6	13.6	24.1	13.2	
Actuated g/C Ratio	0.07	0.44	0.44	0.05	0.42	0.42	0.31	0.17	0.17	0.30	0.17	
Clearance Time (s)	4.0	6.5	6.5	4.0	6.5	6.5	4.0	6.5	6.5	4.0	6.5	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	131	1545	691	96	1473	659	459	319	271	462	284	
v/s Ratio Prot	c0.05	0.12		0.02	c0.33		c0.10	0.04		0.07	0.04	
v/s Ratio Perm			0.03			0.10	c0.12		0.01	0.09		
v/c Ratio	0.63	0.28	0.08	0.45	0.80	0.24	0.71	0.24	0.04	0.52	0.21	
Uniform Delay, d1	35.7	14.4	13.1	36.4	20.3	15.0	23.1	28.5	27.5	22.3	28.7	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	9.6	0.1	0.0	3.3	3.1	0.2	5.1	0.4	0.1	1.0	0.4	
Delay (s)	45.4	14.5	13.1	39.8	23.4	15.2	28.2	28.8	27.5	23.3	29.0	
Level of Service	D	B	B	D	C	B	C	C	C	C	C	
Approach Delay (s)		18.2			21.9			28.2			25.1	
Approach LOS		B			C			C			C	

Intersection Summary			
HCM Average Control Delay	22.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.71		
Actuated Cycle Length (s)	79.5	Sum of lost time (s)	12.0
Intersection Capacity Utilization	69.1%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

*** HANDOUT ***

*** HANDOUT ***

2015 P.M. Peak Hour
Queuing and Blocking Report

TH 7/CSAH 11 ICE Report
2/22/2007

Intersection: 3: Bend

Movement	WB
Directions Served	T
Maximum Queue (ft)	301
Average Queue (ft)	27
95th Queue (ft)	265
Link Distance (ft)	1337
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Intersection: 7: TH 7 & Kings Point Rd.

Movement	EB	EB	EB	EB	WB	WB	WB	WB	NB	NB	NB	SB
Directions Served	L	T	T	R	L	T	T	R	L	T	R	L
Maximum Queue (ft)	125	187	130	44	277	751	666	237	267	94	41	205
Average Queue (ft)	46	82	39	21	47	361	272	46	144	39	17	103
95th Queue (ft)	92	144	93	38	174	630	524	130	240	83	36	183
Link Distance (ft)		1337	1337			1260	1260			2887		
Upstream Blk Time (%)												
Queuing Penalty (veh)												
Storage Bay Dist (ft)	300			300	300			300	300		250	200
Storage Blk Time (%)						16	1	0	0			1
Queuing Penalty (veh)						6	3	0	0			1

Intersection: 7: TH 7 & Kings Point Rd.

Movement	SB
Directions Served	TR
Maximum Queue (ft)	123
Average Queue (ft)	50
95th Queue (ft)	98
Link Distance (ft)	1634
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	
Storage Blk Time (%)	
Queuing Penalty (veh)	

Nework Summary

Network wide Queuing Penalty: 10

*** HANDOUT ***

*** HANDOUT ***

2030 A.M. Peak Hour
HCM Signalized Intersection Capacity Analysis

TH 7/CSAH 11 ICE Report
7: TH 7 & Kings Point Rd.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.92	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1770	3539	1583	1770	3539	1583	1770	1863	1583	1770	1713	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.66	1.00	1.00	0.58	1.00	
Satd. Flow (perm)	1770	3539	1583	1770	3539	1583	1229	1863	1583	1079	1713	
Volume (vph)	25	1222	301	38	333	92	110	21	30	326	65	75
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	27	1328	327	41	362	100	120	23	33	354	71	82
RTOR Reduction (vph)	0	0	181	0	0	54	0	0	27	0	47	0
Lane Group Flow (vph)	27	1328	146	41	362	46	120	23	6	354	106	0
Turn Type	Prot		Perm	Prot		Perm	pm+pt		Perm	pm+pt		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4			8	2		2	6		
Actuated Green, G (s)	2.5	32.8	32.8	3.8	34.1	34.1	17.1	11.7	11.7	25.7	16.3	
Effective Green, g (s)	2.5	35.3	35.3	3.8	36.6	36.6	19.6	14.2	14.2	28.2	18.8	
Actuated g/C Ratio	0.03	0.45	0.45	0.05	0.46	0.46	0.25	0.18	0.18	0.36	0.24	
Clearance Time (s)	4.0	6.5	6.5	4.0	6.5	6.5	4.0	6.5	6.5	4.0	6.5	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	56	1575	705	85	1633	731	341	334	283	471	406	
v/s Ratio Prot	0.02	c0.38		c0.02	0.10		0.02	0.01		c0.09	0.06	
v/s Ratio Perm			0.09			0.03	0.06		0.00	c0.17		
v/c Ratio	0.48	0.84	0.21	0.48	0.22	0.06	0.35	0.07	0.02	0.75	0.26	
Uniform Delay, d1	37.8	19.5	13.4	36.8	12.8	11.8	24.1	27.1	26.8	21.5	24.6	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	6.4	4.3	0.1	4.3	0.1	0.0	0.6	0.1	0.0	6.7	0.3	
Delay (s)	44.2	23.8	13.6	41.1	12.9	11.9	24.7	27.1	26.9	28.2	25.0	
Level of Service	D	C	B	D	B	B	C	C	C	C	C	
Approach Delay (s)		22.2			15.0			25.4			27.2	
Approach LOS		C			B			C			C	

Intersection Summary			
HCM Average Control Delay	22.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.78		
Actuated Cycle Length (s)	79.3	Sum of lost time (s)	12.0
Intersection Capacity Utilization	70.2%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

*** HANDOUT ***

*** HANDOUT ***

2030 A.M. Peak Hour
Queuing and Blocking Report

TH 7/CSAH 11 ICE Report
2/22/2007

Intersection: 6: Bend

Movement	EB	EB
Directions Served	T	
Maximum Queue (ft)	1011	699
Average Queue (ft)	182	78
95th Queue (ft)	788	483
Link Distance (ft)	1260	1260
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 7: TH 7 & Kings Point Rd.

Movement	EB	EB	EB	EB	WB	WB	WB	WB	NB	NB	NB	SB
Directions Served	L	T	T	R	L	T	T	R	L	T	R	L
Maximum Queue (ft)	270	746	668	230	75	117	86	27	113	42	58	229
Average Queue (ft)	39	421	319	46	26	57	20	7	49	11	13	161
95th Queue (ft)	162	714	592	120	60	105	59	17	95	33	38	248
Link Distance (ft)		1337	1337			1260	1260			2887		
Upstream Blk Time (%)												
Queuing Penalty (veh)												
Storage Bay Dist (ft)	300			300	300			300	300		250	200
Storage Blk Time (%)		22	1	0								6
Queuing Penalty (veh)		5	3	0								8

Intersection: 7: TH 7 & Kings Point Rd.

Movement	SB
Directions Served	TR
Maximum Queue (ft)	353
Average Queue (ft)	97
95th Queue (ft)	248
Link Distance (ft)	1634
Upstream Blk Time (%)	
Queuing Penalty (veh)	
Storage Bay Dist (ft)	
Storage Blk Time (%)	0
Queuing Penalty (veh)	1

Nework Summary

Network wide Queuing Penalty: 18

*** HANDOUT ***

*** HANDOUT ***

2030 P.M. Peak Hour
HCM Signalized Intersection Capacity Analysis

TH 7/CSAH 11 ICE Report
7: TH 7 & Kings Point Rd.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.92	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	
Satd. Flow (prot)	1703	3406	1524	1703	3406	1524	1703	1792	1524	1703	1650	
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.59	1.00	1.00	0.70	1.00	
Satd. Flow (perm)	1703	3406	1524	1703	3406	1524	1055	1792	1524	1256	1650	
Volume (vph)	76	396	115	40	1084	344	348	80	60	257	55	63
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	83	430	125	43	1178	374	378	87	65	279	60	68
RTOR Reduction (vph)	0	0	71	0	0	220	0	0	53	0	48	0
Lane Group Flow (vph)	83	430	54	43	1178	154	378	87	12	279	80	0
Turn Type	Prot		Perm	Prot		Perm	pm+pt		Perm	pm+pt		
Protected Phases	7	4		3	8		5	2		1	6	
Permitted Phases			4			8	2		2	6		
Actuated Green, G (s)	5.3	32.0	32.0	3.9	30.6	30.6	24.4	11.8	11.8	23.0	11.1	
Effective Green, g (s)	5.3	34.5	34.5	3.9	33.1	33.1	26.9	14.3	14.3	25.5	13.6	
Actuated g/C Ratio	0.07	0.43	0.43	0.05	0.41	0.41	0.33	0.18	0.18	0.32	0.17	
Clearance Time (s)	4.0	6.5	6.5	4.0	6.5	6.5	4.0	6.5	6.5	4.0	6.5	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Lane Grp Cap (vph)	112	1458	652	82	1399	626	453	318	270	463	278	
v/s Ratio Prot	c0.05	0.13		0.03	c0.35		c0.13	0.05		0.09	0.05	
v/s Ratio Perm			0.04			0.10	c0.15		0.01	0.10		
v/c Ratio	0.74	0.29	0.08	0.52	0.84	0.25	0.83	0.27	0.04	0.60	0.29	
Uniform Delay, d1	37.0	15.1	13.7	37.4	21.4	15.6	23.4	28.7	27.5	22.5	29.3	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Incremental Delay, d2	22.9	0.1	0.1	5.9	4.8	0.2	12.5	0.5	0.1	2.2	0.6	
Delay (s)	59.9	15.2	13.7	43.4	26.2	15.8	35.9	29.1	27.5	24.7	29.8	
Level of Service	E	B	B	D	C	B	D	C	C	C	C	
Approach Delay (s)		20.7			24.2			33.8			26.3	
Approach LOS		C			C			C			C	

Intersection Summary			
HCM Average Control Delay	25.4	HCM Level of Service	C
HCM Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	80.6	Sum of lost time (s)	12.0
Intersection Capacity Utilization	71.7%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

*** HANDOUT ***

*** HANDOUT ***

2030 P.M. Peak Hour
Queuing and Blocking Report

TH 7/CSAH 11 ICE Report
2/22/2007

Intersection: 3: Bend

Movement	WB	WB
Directions Served	T	
Maximum Queue (ft)	492	349
Average Queue (ft)	33	17
95th Queue (ft)	299	218
Link Distance (ft)	1337	1337
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)		
Storage Blk Time (%)		
Queuing Penalty (veh)		

Intersection: 7: TH 7 & Kings Point Rd.

Movement	EB	EB	EB	EB	WB	WB	WB	WB	B6	NB	NB	NB
Directions Served	L	T	T	R	L	T	T	R	T	L	T	R
Maximum Queue (ft)	137	197	154	49	332	858	661	330	68	310	263	46
Average Queue (ft)	58	94	49	21	63	554	382	64	2	185	64	23
95th Queue (ft)	105	161	112	42	226	979	650	191	48	304	182	44
Link Distance (ft)		1337	1337			1260	1260		3479		2887	
Upstream Blk Time (%)						0						
Queuing Penalty (veh)						0						
Storage Bay Dist (ft)	300			300	300			300		300		250
Storage Blk Time (%)						34	3	0		2		
Queuing Penalty (veh)						14	10	0		3		

Intersection: 7: TH 7 & Kings Point Rd.

Movement	SB	SB
Directions Served	L	TR
Maximum Queue (ft)	230	178
Average Queue (ft)	117	64
95th Queue (ft)	207	135
Link Distance (ft)		1634
Upstream Blk Time (%)		
Queuing Penalty (veh)		
Storage Bay Dist (ft)	200	
Storage Blk Time (%)	1	0
Queuing Penalty (veh)	1	0

Nework Summary

Network wide Queuing Penalty: 28

*** HANDOUT ***

*** HANDOUT ***

2030 A.M. Peak Hour Rodel Analysis

```
*******************************************************************************
*                                                                             *
*  10:5:07              TH 7 - CSAH 11 - KINGS PT ROAD                    53  *
*                                                                             *
*******************************************************************************
*                                                      *                      *
* E    (m)    8.50   8.50   8.50   8.50                 * TIME PERIOD     min    90  *
* L'   (m)   40.00  60.00  40.00  60.00                 * TIME SLICE      min    15  *
* V    (m)    3.65   7.30   3.65   7.30                 * RESULTS PERIOD  min 15 75  *
* RAD  (m)   20.00  20.00  20.00  20.00                 * TIME COST      $/hr 15.00  *
* PHI  (d)   30.00  30.00  30.00  30.00                 * FLOW PERIOD     min 15 75  *
* DIA  (m)   50.00  50.00  50.00  50.00                 * FLOW TYPE   pcu/veh   VEH  *
* GRAD SEP       0      0      0      0                 * FLOW PEAK  am/op/pm    AM  *
*                                                      *                      *
*******************************************************************************
* LEG NAME *PCU *VEH TURNS (1st exit, 2nd..U)*FLOF*CL*  FLOW RATIO   *FLOW TIME*
*          *    *                            *    *  *               *         *
* SB KINGS *1.05*   75   65  326  0          *1.00*85*0.75 1.125 0.75*15 45 75 *
* EB TH 7  *1.05*  301 1222   25  0          *1.00*85*0.75 1.125 0.75*15 45 75 *
* NB CSAH11*1.05*   30   21  110  0          *1.00*85*0.75 1.125 0.75*15 45 75 *
* WB TH 7  *1.05*   92  333   38  0          *1.00*85*0.75 1.125 0.75*15 45 75 *
*          *    *                            *    *  *               *         *
*          *    *                            *    *  *               *         *
*          *    *                            *    *  *               *         *
*******************************************************************************
*                                                                 *                 *
* FLOW        veh     466   1548    161    463                    * AVEDEL  s  16.8 *
* CAPACITY    veh    1530   1905    770   2115                    * LOS   SIG     B *
* AVE DELAY  mins    0.19   0.35   0.23   0.17                    * LOS UNSIG     C *
* MAX DELAY  mins    0.21   0.52   0.28   0.18                    *                 *
* AVE QUEUE   veh       0      6      0      0                    * VEHIC HRS  12.3 *
* MAX QUEUE   veh       1      9      0      0                    * COST    $   185 *
*                                                                 *                 *
*******************************************************************************
```


*** HANDOUT ***

*** HANDOUT ***

2030 P.M. Peak Hour Rodel Analysis

```
*******************************************************************************
*                                                                             *
*  10:5:07              TH 7 - CSAH 11 - KINGS PT ROAD                    57  *
*                                                                             *
*******************************************************************************
*                                                 *                           *
* E    (m)    8.50   8.50   8.50   8.50           * TIME PERIOD     min    90  *
* L'   (m)   40.00  60.00  40.00  60.00           * TIME SLICE      min    15  *
* V    (m)    3.65   7.30   3.65   7.30           * RESULTS PERIOD  min 15 75  *
* RAD  (m)   20.00  20.00  20.00  20.00           * TIME COST      $/hr 15.00  *
* PHI  (d)   30.00  30.00  30.00  30.00           * FLOW PERIOD     min 15 75  *
* DIA  (m)   50.00  50.00  50.00  50.00           * FLOW TYPE   pcu/veh   VEH  *
* GRAD SEP       0      0      0      0           * FLOW PEAK  am/op/pm    PM  *
*                                                 *                           *
*******************************************************************************
* LEG NAME *PCU *VEH TURNS (1st exit, 2nd..U)*FLOF*CL*  FLOW RATIO   *FLOW TIME*
*          *    *                            *    *  *              *         *
* SB KINGS *1.05*   63   55  257  0          *1.00*85*0.75 1.125 0.75*15 45 75 *
* EB TH 7  *1.05*  115  396   76  0          *1.00*85*0.75 1.125 0.75*15 45 75 *
* NB CSAH11*1.05*   60   80  348  0          *1.00*85*0.75 1.125 0.75*15 45 75 *
* WB TH 7  *1.05*  344 1084   40  0          *1.00*85*0.75 1.125 0.75*15 45 75 *
*          *    *                            *    *  *              *         *
*          *    *                            *    *  *              *         *
*          *    *                            *    *  *              *         *
*******************************************************************************
*                                                                 *                 *
* FLOW        veh     375    587    488   1468                   * AVEDEL  s  16.1 *
* CAPACITY    veh     840   1964   1357   1847                   * LOS   SIG     B *
* AVE DELAY  mins    0.27   0.18   0.20   0.33                   * LOS UNSIG     C *
* MAX DELAY  mins    0.35   0.19   0.23   0.48                   *                 *
* AVE QUEUE   veh       1      0      1      5                   * VEHIC HRS  13.1 *
* MAX QUEUE   veh       1      0      1      8                   * COST    $   196 *
*                                                                 *                 *
*******************************************************************************
```


*** HANDOUT ***