# CSAH 50/Kenwood Trail and CSAH 60/185th Street Intersection Study

# CP 50-17

## Lakeville,

## Dakota County, MN

## July 22, 2011

Prepared by: Bolton & Menk, Inc.
T42.103034

# CSAH 50 AND CSAH 60 INTERSECTION STUDY

## EXECUTIVE SUMMARY

The intersection of Dakota County State Aid Highway (CSAH) 50/Kenwood Trail and CSAH 60/185th Street located within Lakeville, MN. Both roadways are functionally classified as minor arterials and provide essential connections to Interstate 35, north of the intersection on CSAH 50 and west of the intersection on CSAH 60. Both highways are currently one lane in each direction with turn lanes at the intersection. Current traffic volumes are 17,000 vehicles per day on CSAH 50 and 14,000 vehicles per day on CSAH 60. The roadways are projected to carry over 25,000 vehicles per day at full planned growth of the area. The intersection is signalized and is currently facing operational challenges.

This study was initiated by Dakota County, in participation with the City of Lakeville, to provide a detailed analysis of the intersection needs and evaluation of intersection alternatives to ensure the most appropriate design. The most appropriate intersection design increases mobility and safety of all users now and into the future, is cost effective, and minimizes environmental impacts. The two primary alternatives considered were signalized intersection improvements and a double-lane roundabout.

In March of 2011, an Open House meeting was held with the community. This meeting displayed evaluation criteria and included figures of the alternative intersection options being considered. Citizens reviewed the alternatives and provided various concerns and provided comments. Comments received included support for a roundabout and support for an expanded signal. Comments in support of one alternative or the other were approximately equal. The most significant conclusion out of the meeting was that given the nature of a large roundabout and the lack of familiarity with driving a roundabout, additional education is needed if a roundabout alternative were to move forward.

Evaluation of the intersection alternatives focused on four primary criteria: operations, safety, environment (right-of-way), and financial impacts. Operations include delay to traffic due to the intersection traffic control and the capacity of the intersection. Safety includes crashes, crash severity, and pedestrian safety. Right-of-way includes the analysis of additional property needed to construct the intersection alternative. Financial impacts not only include project costs for the design and construction of the alternative, but also operating costs and safety benefits of intersection improvements.

The current intersection is close to capacity and motorists experience unacceptable delay for some movements during the peak hours. All movements are anticipated to have unacceptable operations as traffic volumes increase within the next few years (over 55 seconds delay per vehicle and LOS E to F). Both of the proposed alternatives reduce delay to acceptable levels, through Full Planned Growth although the roundabout alternative reduces delay further as shown in Table A. Both alternatives have the ability to handle traffic fluctuations.

**TABLE A. OPERATIONAL ANALYSIS SUMMARY**

| Alternative | Intersection Delay | Intersection LOS |
|---|---|---|
| Signal Improvements | 50 to 55 sec. per veh. | LOS D |
| Multi-Lane Roundabout | 14 to 17 sec. per veh. | LOS B/C |

Data from the past five years indicates that the current intersection does not have significant safety issues. The number of crashes for the type of traffic control, roadway speed, and traffic volume is below the statewide average. As traffic increases, delay and crashes are anticipated to increase, especially as the intersection can no longer handle the traffic volumes. As delays get unacceptable, motorists tend to make decisions that are unsafe to reduce travel times. Both of the alternatives are anticipated to reduce the number of crashes as compared to the base condition with no improvements. While property damage collisions may increase from existing conditions initially, analysis and review of other locations indicates the roundabout alternative is anticipated to have a lower number of crashes per year (20 year assessment). The roundabout alternative also reduces the severity of crashes due to the angles of incidence and lower vehicle speeds. The lower speeds also increase pedestrian safety.

Both intersection alternatives impact approximately the same number of properties. The alternatives provide vehicle cost savings and safety benefits as compared to the project cost, resulting in a positive benefit-cost ratio as shown in Table B. The roundabout provides a greater delay benefit over the 20-year project life than the signal alternative. The roundabout alternative also provides a greater cost benefit over the signal improvement alternative.

**TABLE B. 20 YEAR COST AND BENEFIT SUMMARY (IN 2011 DOLLARS)**

| | **Signal Improvements** | **Multi-Lane Roundabout** |
|---|---|---|
| **Vehicle Operating Cost Savings** | $49,024,000 | $73,300,000 |
| **Safety Benefit** | $1,916,000 | $5,106,000 |
| **Total Benefit** | *$50,940,000* | *$78,406,000* |
| **Total Project Cost** | $8,300,000 | $3,500,000 |
| **Benefit-Cost Ratio** | **6.1** | **22.4** |

Both options are acceptable and could alleviate the recognized traffic control issues at the intersection. The best intersection control option:

- minimizes delay to traffic,
- produces a low crash potential,
- is low cost, and
- is compatible with the roadway and community.

The intersection at Full Growth volume is one of the highest volume proposed or built double-lane roundabouts at the intersection of two high speed corridors in the State of Minnesota. Additional analysis was completed to understand how the proposed roundabout alternative would compare to the capacity of double-lane roundabouts throughout the United States. This state of practice review indicated that the proposed roundabout alternative can operate well and manage the future traffic volumes.

Based on the considerations of operations, safety and right-of-way (environment), financial impacts, and public input, implementing the double-lane roundabout alternative is recommended for this intersection to accommodate current and future traffic volumes.

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## ATTACHMENTS

# CERTIFICATION

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 laws of the State of Minnesota.

By: ______________________
Bryan T. Nemeth
License No. 43354

Date: July 22, 2011

# CSAH 50 AND CSAH 60 INTERSECTION STUDY

## I. INTRODUCTION

This report documents the analysis and conclusions for the intersection study of County State Aid Highway (CSAH) 50/Kenwood Trail and CSAH 60/185th Street in Lakeville, Dakota County, Minnesota.

The intersection is located east of I-35 at the crossroads of two minor arterial roadways. CSAH 50 is a north-south highway that connects to I-35 to the north of the intersection and CSAH 60 is an east-west highway that connects to I-35 to the west of the intersection. CSAH 50 and CSAH 60 are two-lane undivided highways with long range needs of a four-lane divided roadway with a projected growth over 25,000 vehicles per day. The intersection of these two highways is currently controlled with a traffic signal which experiences operational challenges during the peak periods. As traffic volumes increase due to development and other factors, the intersection is expected to have multiple approaches in which the volume exceeds the capacity of the existing facility resulting in unacceptable delay and queuing.

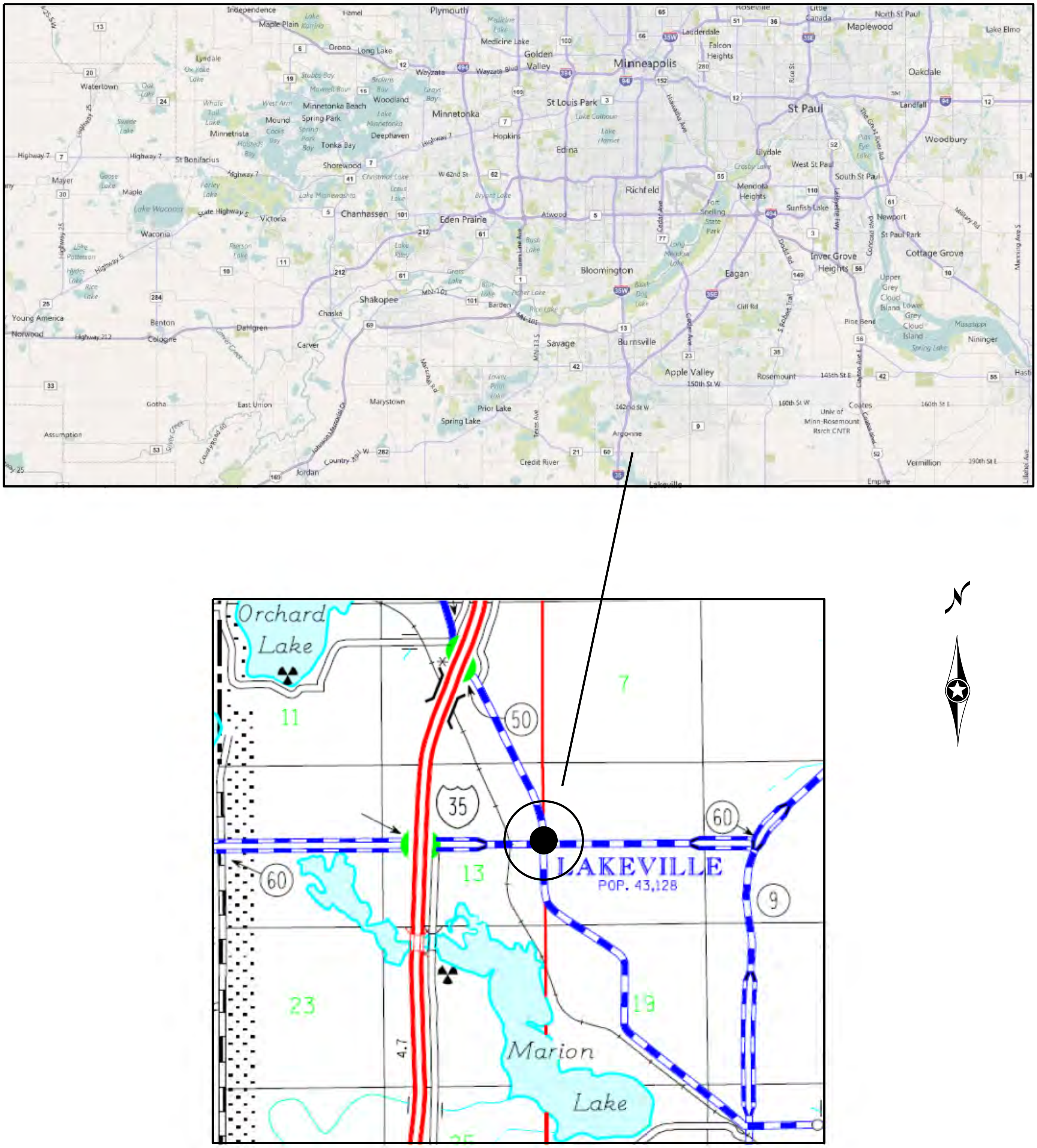
The goal of this study is to determine the best intersection alternative to increase mobility and safety while ensuring improvements are cost effective and minimize environmental impacts for the intersection of CSAH 50/Kenwood Trail and CSAH 60 /185th Street (see Figure 1). A thorough analysis of the needs of the intersection and evaluation of alternatives including a signal and roundabout concept was conducted to determine the most appropriate design.

### A. STUDY OBJECTIVES

The study included technical analysis and assessment of all factors for this intersection with involvement of City of Lakeville and Dakota County staff. Five primary objectives to ensure the project goal is accomplished:

1. Evaluate the existing conditions.
    a. Determine existing mobility and safety issues.
2. Evaluate the future conditions.
    a. Develop future traffic forecasts.
    b. Determine future mobility and safety issues.
3. Develop alternative intersection and traffic control options.
    a. Develop concept plans of preferred alternatives.
    b. Evaluate the alternatives.
    c. Determine the mobility and safety improvements provided by the alternatives.
4. Present the alternatives to the Public.
    a. Determine the alternative intersection and traffic control options that are acceptable to the public.
    b. Refine the alternatives based on TAC and public comment.
5. Determine the preferred alternative.
    a. Develop timeline of interim and full build out alternatives.

The study assessed traffic conditions and needs at the intersection in consideration of the current and long-term needs of both the highway 50 and 60 road segments. Signalized and roundabout traffic control alternatives were evaluated to develop a preferred alternative for the intersection that meets study goals.




# FIGURE 1 LOCATION MAP

CSAH 50(KENWOOD TR) AT CSAH 60(185TH ST)
INTERSECTION CONTROL EVALUATION

Dakota County

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## B. PUBLIC AND AGENCY INVOLVEMENT

The study was guided by a Technical Advisory Committee (TAC) that consisted of technical staff from the City of Lakeville, Dakota County, and Bolton & Menk, Inc. This group met approximately four times throughout the study to review the data, analysis methodologies, assumptions, alternatives, and study results.

The TAC was tasked with evaluating the intersection alternatives and assessing the best solution for the intersection. The sustainable solution is economically viable, technically feasible, environmentally compatible, and publicly acceptable.

In addition to the TAC meetings, there was one public open house held on March 22, 2011 with local property owners, business owners, and building owners to discuss the proposed intersection alternatives.


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## C. OPEN HOUSE COMMENTS

The open house was well attended by the community with 50 non-TAC members signing in. Information displayed consisted of a study map, evaluation criteria, existing and future conditions, intersection concepts, and an evaluation matrix. Most of the comments focused on support or concern for a roundabout concept, but there were some other comments related to the intersection overall. The following comments are a synopsis of the comments received. For a full listing of comments please see Attachment A.

**TABLE 1: CITIZEN COMMENTS SUMMARY**

| | **Roundabout** | **Traffic Signal** |
|---|---|---|
| **Support** | Safety is the number one consideration. | People know how to use them. |
| | Will slow down traffic. | Traditional tool for higher volume intersections |
| **Opposed** | They are very complex. | Proposed signal intersection takes too much property. |
| | People do not know how to drive them (learning curve, merging/ yielding/ crossing concerns). | |
| | Concern for capacity threshold | |
| | Roundabout training is needed if alternative is chosen. | |

Additional Comments:

Adjacent intersection Concerns

- Left turns are already difficult during peak hours and this needs to be improved

with either option. Public streets mentioned: Jaguar Path, Jasper Path, Orchard Trail, 188th Street, and Joplin Avenue.
- Median not acceptable past commercial drives
- Median acceptable if it makes it safer and eliminates cut-through trips in neighborhoods

Pedestrian Concerns
- Need sidewalk along 185th Street to Ipava Avenue
- Need sidewalk along Kenwood Trail to Jaguar Path

Other Comments/Concerns
- Take into consideration of property affected by either alternative.
- Traffic speed on CSAH 50 and 60 needs to be decreased.

Citizen feedback in support of a traffic signal or a roundabout alternative was approximately even. The most significant conclusion out of the meeting was that additional education is needed if a roundabout were to move forward as the selected alternative.

# II. BACKGROUND

## A. LOCATION

The intersection of CSAH 50 and CSAH 60 is located on the west side of Dakota County, within the western portion of the City of Lakeville. Lakeville is a southern suburb of the Twin Cities Metropolitan Area and is located 20 miles south of Downtown Minneapolis. Lakeville's population is 55,954 (2010 census). The intersection is 1.25 miles southeast of I-35 along CSAH 50 and 0.75 miles east of I-35 along CSAH 60. Both CSAH 50 and CSAH 60 are functionally classified as Minor Arterial roadways. Minor Arterials typically link urban areas and rural Principal Arterials to larger towns and other major traffic generators, capable of attracting trips over similarly long distances. Minor Arterials service medium length trips, and their emphasis is primarily on mobility as opposed to access. They connect with principal arterials, other minor arterials, and collector streets. Connections to local streets should be avoided if possible.

North and west from the intersection, both CSAH 50 and CSAH 60 connect to commercial destinations and interchanges with Interstate 35. South and east of the intersection, these roadways connect to residential, educational, and recreation land uses. The intersection serves a high volume of vehicular traffic given its proximity to the interstate as well as local retail and education destinations along these routes. As the community of Lakeville and Dakota County continues to grow, the traffic volumes through the intersection are anticipated to increase.

## B. ROADWAYS AND INTERSECTION

Both CSAH 50 and 60 are two-lane undivided highways. The posted speed limit is 50 mph on CSAH 50 and 45 mph on CSAH 60. At the intersection, all approaches have left turn lanes and right turn lanes are provided on the north, south, and west approaches. The intersection operates under signalized control with protected left turn phasing. The existing signalized intersection experiences congestion during the peak hours. As the community continues to grow, the need for additional capacity is anticipated. The intersection has some limitations that will impact design alternatives. To the west, CSAH 60 drops in elevation and there is a railroad crossing 0.2 miles from the intersection. On the south side of the intersection there are buildings and parking lots within 20 feet of the right-of-way lines. All four legs of the intersection have adjacent off-street pedestrian and bike facilities but there is an absence of sidewalk to push button locations, pedestrian ramps at the crosswalk locations, and truncated domes.

Figure 2 shows the existing intersection layout.

## C. TRAFFIC DATA AND CURRENT VOLUMES

In January and February 2011, traffic volumes were collected at the intersection of CSAH 50 and 60 and along CSAH 50 and 60 away from the intersection. Traffic turning movement counts were taken during the AM and PM peak hours on February 1, 2011 and weekday approach counts were taken on January 12, 18, and 25, 2011. All counts were completed when the weather was clear and traffic was not adversely impacted by snow conditions (see Figure 2).

Currently there are 28,250 vehicles per day entering the intersection. This includes 1,930 during the AM peak hour and 2,420 during the PM peak hour.

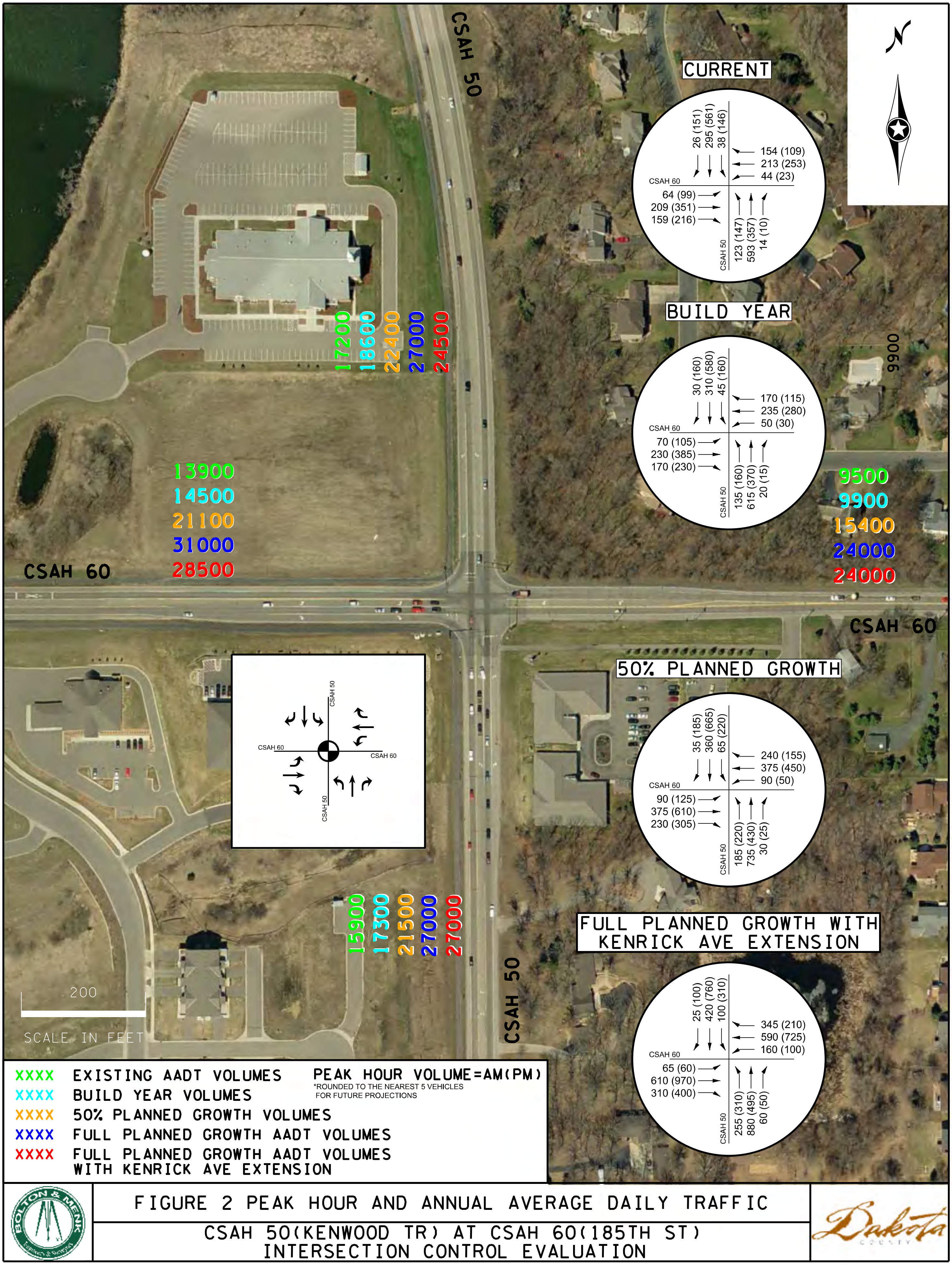
**TABLE 2: DAILY TRAFFIC VOLUMES**

| Roadway | 2009 AADT |
|---|---|
| CSAH 50, north of CSAH 60 | 17,200 |
| CSAH 50, south of CSAH 60 | 15,900 |
| CSAH 60, west of CSAH 50 | 13,900 |
| CSAH 60, east of CSAH 50 | 9,500 |

Based on the traffic data, heavy vehicles comprise approximately 2% of the daily traffic on CSAH 50 and CSAH 60. This heavy vehicle percentage is the typical expected percentage of heavy vehicles for a county highway facility that is just off of the state freeway system and is the same as the Heavy Commercial Average Daily Traffic (HCADT) percentage of 2% measured on TH 77/Cedar Avenue in Dakota County in 2006 by the Minnesota Department of Transportation.

## D. SATURATION FLOW RATE

To assist in the evaluation of the signalized intersection options, the saturation flow rate of the most congested movement at the intersection was collected. This includes the collection of data during the PM peak hour for the southbound movement. The saturation flow rate is the flow in vehicles per hour that can be accommodated by the approach assuming that the green phase is displayed 100% of the time. The saturation flow rate will help ascertain how much traffic is able to move through the intersection during each traffic signal cycle to provide a more accurate determination of the capacity of the intersection for local traffic. Based on the field measurements of 20 cycles, the saturation flow rate of the intersection is 1,892 vehicles per hour. This saturation flow is almost equal to the base saturation flow rate of 1,900 vehicles per hour.



CSAH 50
CSAH 60
CURRENT
CSAH 60
CSAH 50
26 (151)
295 (561)
38 (146)
154 (109)
213 (253)
44 (23)
64 (99)
209 (351)
159 (216)
123 (147)
593 (357)
14 (10)
BUILD YEAR
30 (160)
310 (580)
45 (160)
170 (115)
235 (280)
50 (30)
70 (105)
230 (385)
170 (230)
135 (160)
615 (370)
20 (15)
50% PLANNED GROWTH
35 (185)
360 (665)
65 (220)
240 (155)
375 (450)
90 (50)
90 (125)
375 (610)
230 (305)
185 (220)
735 (430)
30 (25)
FULL PLANNED GROWTH WITH
KENRICK AVE EXTENSION
25 (100)
420 (760)
100 (310)
345 (210)
590 (725)
160 (100)
65 (60)
610 (970)
310 (400)
255 (310)
880 (495)
60 (50)
17200
18600
22400
27000
24500
13900
14500
21100
31000
28500
9500
9900
15400
24000
24000
9900
15900
17300
21500
27000
27000
200
SCALE IN FEET
XXXX EXISTING AADT VOLUMES
XXXX BUILD YEAR VOLUMES
XXXX 50% PLANNED GROWTH VOLUMES
XXXX FULL PLANNED GROWTH AADT VOLUMES
XXXX FULL PLANNED GROWTH AADT VOLUMES WITH KENRICK AVE EXTENSION
PEAK HOUR VOLUME=AM(PM)
*ROUNDED TO THE NEAREST 5 VEHICLES FOR FUTURE PROJECTIONS
FIGURE 2 PEAK HOUR AND ANNUAL AVERAGE DAILY TRAFFIC
CSAH 50(KENWOOD TR) AT CSAH 60(185TH ST)
INTERSECTION CONTROL EVALUATION
BOLTON & MENK
Dakota

# III. STUDY EVALUATION CRITERIA

The evaluation of the existing intersection and proposed intersection alternatives considers many factors including operations, safety, and costs.

## A. OPERATIONS

The operational analysis of the traffic volume scenarios and alternatives were performed using the 2000 Highway Capacity Manual methodology through SYNCHRO traffic analysis software for signalized conditions. To measure level of service and delay for roundabouts, the design program RODEL was used. Rodel is recommended by the Minnesota Department of Transportation in the Mn/DOT Road Design Manual, for analysis of roundabouts.

Measures of effectiveness display quantitative information about the performance of an intersection or network of intersections. The primary measures that are used in this study are level of service and delay.

### DELAY AND LEVEL OF SERVICE

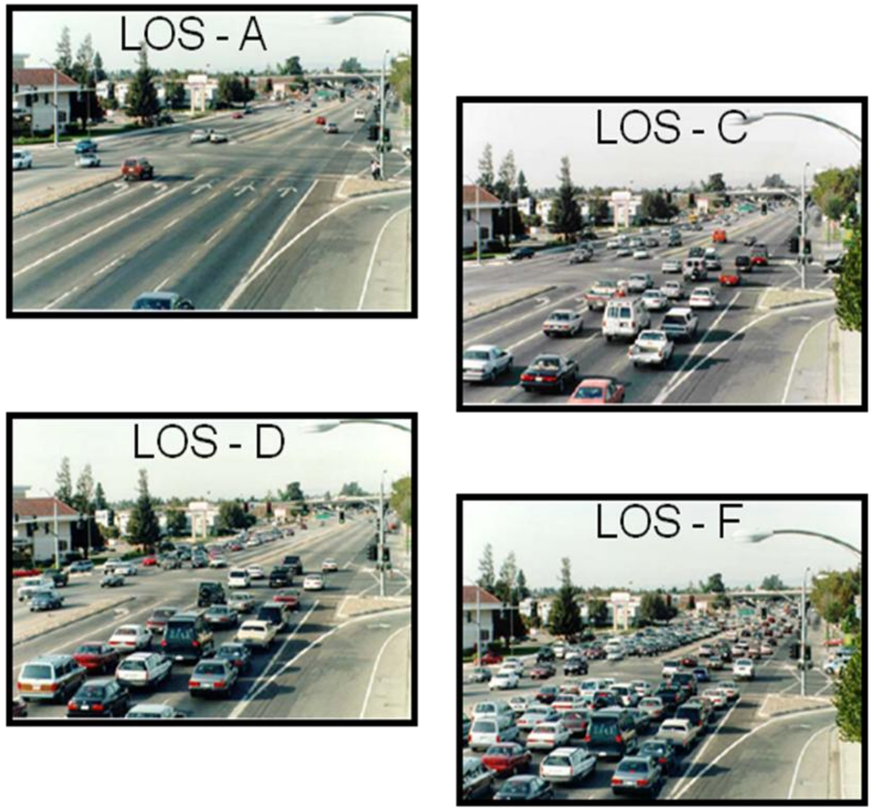
The operational analysis results are described as a Level of Service (LOS) ranging from A to F. These letters serve to describe a range of operating conditions for different types of facilities. Level of Service is calculated based on control delay in the 2000 Highway Capacity Manual. Control delay is the delay experienced by vehicles slowing down as they are approaching the intersection, the wait time at the intersection, and the time for the vehicle to speed up through the intersection and enter into the traffic stream. The average intersection control delay is a volume weighted average of delay experienced by all motorists entering the intersection on all intersection approaches for signalized and roundabout intersections. Level of Service D is commonly taken as an acceptable design year LOS. The level of service and its associated intersection delay for a signalized and unsignalized intersection is presented below. The delay threshold for unsignalized intersections is lower for each LOS compared to signalized intersections, which accounts for the fact that people expect a higher level of service when at a stop-controlled intersection. Roundabout intersections are evaluated as unsignalized intersections.

**TABLE 3: LEVEL OF SERVICE CRITERIA**

| | SIGNALIZED INTERSECTION | UNSIGNALIZED INTERSECTION |
|---|---|---|
| LOS | Control Delay per Vehicle (sec.) | Control Delay per Vehicle (sec.) |
| A | ≤ 10 | ≤ 10 |
| B | >10 and ≤ 20 | >10 and ≤ 15 |
| C | >20 and ≤ 35 | >15 and ≤ 25 |
| D | >35 and ≤ 55 | >25 and ≤ 35 |
| E | >55 and ≤ 80 | >35 and ≤ 50 |
| F | >80 | >50 |

LOS – measure of average delay at an intersection

- LOS A: little to no delay
- LOS C: acceptable in rural area
- LOS D: acceptable in urban/urbanizing area
- LOS F: over capacity with excessive delay




* Pictures obtained from City of San Jose Evergreen Transportation Analysis

### CAPACITY

The capacity of a roadway facility is the maximum number of vehicles that can reasonably be expected to traverse through an intersection or along a roadway during a given time period under prevailing roadway and traffic control conditions. Volume to capacity (v/c) ratio is the proportion of the actual traffic utilizing the facility to the facility's physical ability to carry the specific maximum volume for a facility. The capacity of the facility depends on a number of factors including number of lanes and traffic control. The volume-to-capacity ratio is calculated by dividing the total traffic using the facility by the capacity of the facility. This can then determine if a facility is sufficient to handle the traffic that is expected to be traveling on it. A ratio greater than 1.00 predicts that the facility will be unable to discharge all of the demand arriving on it. Such a situation would result in long queues and extensive delays, or diversion to alternate routes.

## B. SAFETY

Safety is an important consideration when evaluating an intersection and the traffic control at an intersection. Different geometry and traffic control options will change the look and character of an intersection, altering how a motorist, bicyclist, or pedestrian will react to potential conflict.

### AREA COLLISION ASSESSMENT

Crashes are inherently random and can differ from one year to the next at a specific intersection. Different intersection traffic control types typically have different crash trends and expected number of crashes at an intersection. Typically crashes are evaluated with three or more years of data. The total number of crashes over the analysis period can indicate crash trends. The crash frequency is averaging the number of crashes over the analysis period to determine the crash frequency (crashes per year) since crashes can vary from year to year. While crashes and crash frequency at intersections can provide a comparison they tend to be a function of the volume of traffic traveling through the intersection. As a result, intersection crash rate is a more reasonable measure that takes into account the exposure or volume variability of an intersection. Crash rate is measured as the number of crashes per million entering vehicles (MEV).

State and national references provide historical traffic signal and roundabout crash rates and crash reduction factors for intersection improvements. The 2009 Metro District Average Crash Rate and Statewide Average Crash Rate is 0.6 crashes per MEV for a high volume and high speed signalized intersection. While these rates provide a safety comparison of the different traffic control options, changes in traffic volume, delay, or capacity from the average can alter how the intersection operates.

Crash severity is a measure how severe a crash is. Crashes can be categorized into five major categories:
1. Fatal (K),
2. Incapacitating (Injury Type A),
3. Non-Incapacitating (Injury Type B),
4. Possible Injury (Injury Type C), and
5. Property Damage Only (PDO).

The crash severity rate applies a higher factor to more severe crashes to determine the severity rate of an intersection. This can then be used to determine which intersections have a higher number of severe crashes for the traffic volume. The 2009 Metro District and Statewide Average Severity Rate is 0.9 crashes per MEV for a high volume and high speed signalized intersection.

### PEDESTRIANS

Pedestrian safety is important at all intersections. While pedestrian collision data is reviewed, pedestrian crashes can be somewhat random and difficult to identify collision trends. Pedestrian safety can be evaluated using two other measures, vehicle travel speed and exposure time. Lower vehicle speeds can reduce the severity of injuries when crashes occur. The following information is provided by the Insurance Institute for Highway Safety (IIHS).

#### TABLE 4: PEDESTRIAN CRASH SEVERITY AND VEHICLE SPEED

| Vehicle Speed | Chance of Fatal Crash |
|---|---|
| 40 MPH | 80% |
| 30 MPH | 40% |
| 20 MPH | 5% |

Exposure time accounts for the travel distance across an intersection and the time it takes for a pedestrian to cross the street. The less time a pedestrian is on the roadway, the less time a pedestrian is exposed to traffic conflicts on the roadway.

## C. RIGHT-OF-WAY

Right-of-way is the boundary line between the property owned by a private citizen and the land that is granted to or owned by a public entity for transportation purposes such as trail or highway. A right-of-way is reserved for the purposes of maintenance and/or expansion of existing services with the right-of-way. Right-of-way may be acquired from neighboring properties to construct an intersection alternative if there is not enough right-of-way currently available.

## D. FINANCIAL IMPACTS

The cost of a roadway improvement is an important consideration when evaluating an intersection alternative. Different geometry and traffic control options can affect the cost of an alternative and can affect how much land is taken from adjacent properties to build the alternative.

### PROJECT COSTS

Project costs consider the capital and maintenance costs of an alternative. These are expressed in terms of current (2011) dollars. The capital cost of the traffic signal improvement includes all of the improvements as designated in the concept layout for the project. The roundabout capital costs include the initial investment of the multi-lane roundabout.

The maintenance costs of the alternatives are approximately equal based on the following assumptions. The maintenance and operating costs for a traffic signal intersection is approximately $1,500 per year for maintenance, $40 per month for signal power, and $12 per month for maintenance and power for the two lights attached to the signal. This equates to a sum of $2,124 per year for operation and maintenance for the signalized intersection alternative. The maintenance and operating costs for a roundabout intersection is approximately $17 per month for maintenance and power of eight lighting unit poles, one on each entrance and exit of the roundabout. This equates to a sum of $1,632 per year for operation and maintenance for the roundabout intersection alternative. Overall, the difference in operating and maintenance costs of the alternatives is minimal over the 20 year time frame of analysis and was not added into the project costs for the benefit cost calculations.

### OPERATING COSTS (COST SAVINGS)

An alternative can have cost savings if travel distance or if travel time is reduced. A reduction in travel distance results in less fuel consumption whereas a reduction in travel time results in less fuel consumption and an increase in time available for other activities. As far as intersection improvements, travel time reduction is the most appropriate measure. The travel time (or operating cost) savings are calculated based on the difference in between the Base Case (existing) and each Alternative. Travel time is expressed as vehicle-hours traveled (VHT). The estimation of travel time savings includes both the driver and passengers in the vehicle. The valuation of travel time savings is calculated using a standardized cost-per-hour-per-person for different vehicles (auto or truck).

#### SAFETY COSTS (SAFETY BENEFIT)

Safety benefits are the benefits that an alternative provides in terms of crash reduction. The severity of a crash is assigned a cost per crash. The number of crashes can be reduced with roadway and intersection improvements. For this study, the safety benefits were calculated using the methodology of the Highway Safety Improvement Program (HSIP) to determine the crash reduction.

#### RECOMMENDED STANDARD VALUES

The guidance for the costs calculations is based on “User Benefit Analysis for Highways”, AASHTO, August 2003 and the Benefit/Cost Analysis for Transportation Projects by the Minnesota Department of Transportation (MnDOT). The fiscal year 2011 recommended standard values used in the calculations are included in Attachment C.

## IV. TRAFFIC FORECASTS

### A. TRAFFIC VOLUME

Dakota County and the City of Lakeville have developed 2030 traffic forecasts for the roadways as part of their 2010 Comprehensive Plan Updates. The 2030 Annual Average Daily Traffic (AADT) forecasts are summarized in the Table 5.

**TABLE 5: 2030 AADT FORECASTS**

| Roadway | Dakota County AADT |
|---|---|
| CSAH 50, north of CSAH 60 | 27,000 |
| CSAH 50, south of CSAH 60 | 27,000 |
| CSAH 60, west of CSAH 50 | 31,000 |
| CSAH 60, east of CSAH 50 | 24,000 |

These traffic forecasts are for the Full Planned Growth of the area as detailed in the Dakota County 2030 Transportation Plan. The traffic volumes are forecasted to be at the intersection at “Full Planned Growth” of the surrounding area and not an exact year, especially considering recent growth trends. The Build Year is the year that the intersection alternative is anticipated to be open to traffic after construction (assumed to be 2014). The 50% Planned Growth is a mid-year forecast at 50% growth of the surrounding area and is shown in Table 7.

**TABLE 6: EXISTING AND BUILD YEAR AADT VOLUMES**

| Roadway | 2009 AADT | Build Year AADT |
|---|---|---|
| CSAH 50, north of CSAH 60 | 17,200 | 18,600 |
| CSAH 50, south of CSAH 60 | 15,900 | 17,300 |
| CSAH 60, west of CSAH 50 | 13,900 | 14,500 |
| CSAH 60, east of CSAH 50 | 9,500 | 9,900 |

The Full Planned Growth traffic forecasts at the intersection are altered due to a planned roadway extension within Lakeville, east of I-35 called the Kenrick Avenue Extension.

## B. KENRICK AVENUE EXTENSION

The Kenrick Avenue Extension is in the City of Lakeville's Comprehensive Plan and connects between CSAH 50 and CSAH 60, adjacent to I-35. The extension location is shown in Figure 3. As part of this study, the traffic implications of the extension to the traffic volumes at the CSAH 50/CSAH 60 intersection were evaluated and determined to have limited effect on the options needed to handle Full Planned Growth. Since the roadway connection is in the City's Comprehensive Plan, the Full Planned Growth traffic volumes assume the Kenrick Avenue Extension is in place. In addition to the Full Planned Growth forecasts, 50% Planned Growth forecasts were developed. The "50% Planned Growth" forecasts assume half of the Full Planned Growth of the surrounding area as designated in the City and County Comprehensive Plans.

**TABLE 7: PLANNED GROWTH AADT FORECASTS WITH KENRICK AVENUE EXTENSION**

| Roadway | Full Planned Growth AADT | 50% Planned Growth AADT |
|---|---|---|
| CSAH 50, north of CSAH 60 | 24,500 | 22,400 |
| CSAH 50, south of CSAH 60 | 27,000 | 21,500 |
| CSAH 60, west of CSAH 50 | 28,500 | 21,100 |
| CSAH 60, east of CSAH 50 | 24,000 | 15,400 |

The final traffic volumes for Full Planned Growth, 50% Planned Growth, Build Year, and Current Year are included in Figure 2.

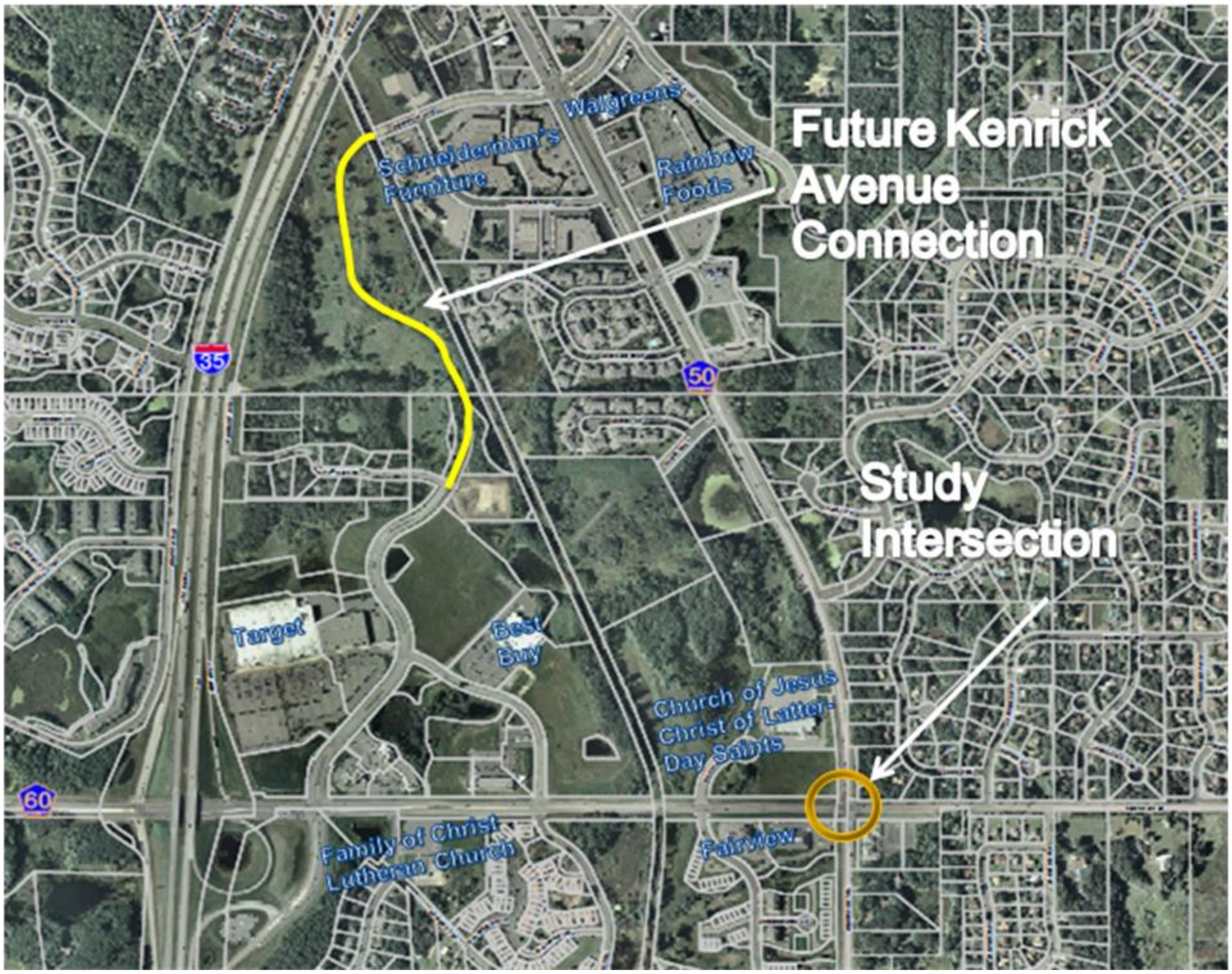



FIGURE 3. KENRICK AVENUE EXTENSION

# V. EXISTING CONDITIONS ANALYSIS

## A. ASSUMPTIONS

The first step of the analysis effort focuses on the study area and the capacity of the existing intersection. The analysis assumes no undue influence by upstream and downstream constraints. It is noted, however, that occasional upstream capacity constraints exist on CSAH 50 and CSAH 60. Specifically, CSAH 50 to the north and CSAH 60 to the west are 4-lane divided roadway facilities that merge to 2-lane undivided facilities closer to the intersection. This merge can limit the traffic volume that can get to the intersection. This primarily occurs during the PM peak hour.

## B. SIGNAL WARRANT ANALYSIS

The existing traffic control signal was evaluated to determine if a signal is justified according to the Minnesota Manual on Uniform Traffic Control Devices (MMUTCD). Analysis of the existing traffic volumes results in the intersection meeting warrants for signalization

(MMUTCD Chapter 4C). Warrants met include; Warrant 1, Eight Hour Vehicular Volumes; Warrant 2, Four Hour Volume; and Warrant 3, Peak Hour Volume and Delay. The analysis is included in the Intersection Control Evaluation included as Attachment B. Although warrants are met, this does not necessarily indicate that a traffic signal is justified.

The justification for a change in traffic control may not be met due to low daily traffic volume from some approaches, even though there may be high peak hour volume. Traffic control changes are anticipated to be reviewed, determined, and programmed as the volume of traffic through the intersection increases, as correctable crashes increase, and as funding dictates. Dakota County has a process to evaluate the needs and determine when a traffic control change is appropriate. For County roadways, Dakota County Transportation Department staff will install or permit a change in traffic control based on a County engineering study that indicates that a change is appropriate. The installation of signals is based on priority and considers safety, delay, access spacing, traffic volumes and other factors. It is noted that a change in traffic control may not necessarily improve the safety of an intersection (according to the State of Minnesota Traffic Safety Fundamentals Handbook). Installation of a traffic signal on a county roadway requires County Board approval.

The signal is justified based on the Intersection Control Evaluation in Attachment B.

## C. OPERATIONS

Analysis of the existing traffic and intersection control indicates that the intersection with a traffic signal is functioning within acceptable service levels during the peak hours. However some traffic movements experience excessive delay during the peak hours. A summary of the operations is presented in Tables 8 and 9.

**TABLE 8: EXISTING SIGNALIZED CONTROL OPERATIONAL ANALYSIS**

| Traffic Scenario | Intersection Design | Peak Hour | Intersection Delay*- LOS | Worst Movement Delay-LOS-v/c** | Worst Movements |
|---|---|---|---|---|---|
| Current | Existing 2-Lane 50/60 | AM | 36 sec. – D | 53 sec. – D – 0.90 | Westbound Left & Northbound Thru |
| | | PM | 50 sec. – D | 122 sec. – F – 1.01 | Eastbound Left & Southbound Thru |

*Delay in seconds per vehicle

** Maximum delay, LOS, and v/c ratio on any approach and/or movement

**TABLE 9: EXISTING SIGNALIZED QUEUE ANALYSIS**

| Traffic Scenario | Intersection Design | Peak Hour | Maximum Queue (ft.)* | | | |
|---|---|---|---|---|---|---|
| | | | North Leg | West Leg | South Leg | East Leg |
| Current | Existing 2-Lane 50/60 | AM | 255 | 195 | 605 | 200 |
| | | PM | 565 | 380 | 290 | 230 |

*Maximum queue length likely to be observed for each leg of the intersection during the weekday AM or PM peak hour.

The existing intersection operates acceptably overall but is capacity constrained on some movements during the PM peak hour. The worst delay and volume-to-capacity movements include the northbound thru lane in the AM peak hour and the southbound thru lane in the PM peak hour. These are also the movements with the longest queues. This is consistent with the field observations during the AM and PM peak hours. Any increase in traffic volume is expected to bring the intersection operations to unacceptable service levels.

### D. ADJACENT INTERSECTION OPERATIONS

Based on residents' concerns for long delays making left turns from these side roads at nearby intersections during peak periods, Dakota County conducted a delay study on adjacent intersections. The County performed PM peak hour delay studies and 24 hour road tube counts at the following intersections on CSAH 50: 188th Street and Jaguar Path and on CSAH 60: Jaeger Path, Jamaica Path, Jasmine Way, and Orchard Trail. The study analysis indicated that the average delay experienced by all vehicles entering onto CSAH 50 and CSAH 60 during the peak hour is acceptable at 5 to 30 seconds per vehicle. Gaps were sufficient in length of time and frequency to allow vehicles to enter onto CSAH 50 and 60. No impatient or risky maneuvers were observed. This study in included as Attachment E.

### E. SAFETY

According to the state data, there have been ten reported crashes at the intersection between January 2006 and October 2010 (see the Crash Diagram in Attachment B). All but one of the crashes were rear-end crashes. The one non-rear-end crash was a right-angle crash in 2009. Five of the crashes occurred in 2006. The crash frequency is two crashes per year. There was a fatal crash at the intersection in 2005.

The crash rate for the intersection is 0.19 crashes per million entering vehicles (MEV). This is lower than the 2009 Metro District Average Crash Rate and Statewide Average Crash Rate of 0.6 for a high volume and high speed signalized intersection.

The intersection has a crash severity rate of 0.35 which is lower than the 2009 Metro District and Statewide Average Severity Rate of 0.9. These comparisons indicate that the intersection is safe when compared to similar intersections in the Metro Area and Statewide.

There were an additional 13 crashes noted on incident reports by the City with $1000 or more property damage that were not in the state database. All of these crashes except two were rear-end type crashes. If this data were added to the analysis, the crash rate is 0.45 crashes per MEV and the severity rate is 0.6. Even with these additional crashes the crash rate is lower than the Metro District and Statewide Average Crash Rate and the severity rate is equal to the Metro District and Statewide Severity Rate. Although the intersection is closer to the average in terms of safety with the additional crashes it is still an overall safe intersection.

## VI. ALTERNATIVES ANALYSIS

According to the Mn/DOT Intersection Control Evaluation Technical Memorandum No. 07-02-T-01, there are three primary traditional intersection types that can acceptably handle the forecasted traffic volumes at CSAH 50 and CSAH 60. These include a roundabout, signalized intersection, and grade separation. Non-traditional intersection options are limited in the area due to the limited right-of-way and the roadway network.

While grade separation of the intersection would alleviate the delay at the intersection, Dakota County typically does not consider an interchange at these traffic volume levels. It would require significant additional right-of-way at the intersection and the construction and right-of-way cost is expected to be prohibitive relative to the benefit.

Signal warrants analysis for future years was not completed since the justification for signalization is currently met and the traffic volumes are at levels where the justification of signals or other comparable traffic control is necessary.

### ACCESS MANAGEMENT

Implementing access management strategies along CSAH 50 and CSAH 60 ensures mobility and safety are maintained for these A-Minor Arterials. This functional classification designates spacing of at least ¼ mile for full movement intersections and spacing of ⅛ mile for secondary (partial) access. As the intersection is reconstructed, the secondary accesses and driveway operation may necessitate change along the corridors to maintain safety and mobility.

## VII. BASE CONDITION

### A. OPERATIONS

The existing intersection design and signal at this location is not anticipated to maintain acceptable operations or acceptable service levels within approximately four (4) years (see Table 10).

**TABLE 10: BASE CONDITION OPERATIONAL ANALYSIS**

| Traffic Scenario | Intersection Design | Peak Hour | Intersection Delay*- LOS | Worst Movement Delay-LOS-v/c** | Worst Movements |
|---|---|---|---|---|---|
| Current | Existing 2-Lane 50/60 | AM | 36 sec. – D | 53 sec. – D – 0.90 | Westbound Left & Northbound Thru |
| | | PM | 50 sec. – D | 122 sec. – F – 1.01 | Eastbound Left & Southbound Thru |
| Build Year | Existing 2-Lane 50/60 | AM | 39 sec. – D | 82 sec. – F – 0.92 | Westbound Left & Northbound Thru |
| | | PM | 54 sec. – D | 126 sec. – F – 1.03 | Eastbound Left & Northbound Left |
| 50% Planned Growth*** | Existing 2-Lane 50/60 | AM | 73 sec. – F | 174 sec. – F – 1.06 | Southbound Left & Westbound Left |
| | | PM | 108 sec. – F | 277 sec. – F – 1.32 | Eastbound Left & Westbound Left |
| Full Planned Growth*** | Existing 2-Lane 50/60 | AM | 153 sec. – F | 324 sec. – F – 1.49 | Eastbound Left & Westbound Left |
| | | PM | 234 sec. – F | 410 sec. – F – 1.79 | Southbound Left |

*Delay in seconds per vehicle
** Maximum average delay, LOS, and v/c ratio on any approach and/or movement
*** Population and Employment Projections in Comprehensive Plans

The signal analysis evaluated vehicle queue lengths with the forecasted traffic as shown in Table 11. These queue lengths determine how long the turn lanes need to be and also provide a look into how the intersection would appear to be operating to the traveling public.

**TABLE 11: BASE CONDITION QUEUE ANALYSIS**

| Traffic Scenario | Intersection Design | Peak Hour | Maximum Queue (ft.)* | | | |
|---|---|---|---|---|---|---|
| | | | North Leg | West Leg | South Leg | East Leg |
| Current | Existing 2-Lane 50/60 | AM | 255 | 195 | 605 | 200 |
| | | PM | 565 | 380 | 290 | 230 |
| Build Year | Existing 2-Lane 50/60 | AM | 250 | 220 | 600 | 215 |
| | | PM | 605 | 465 | 320 | 310 |
| 50% Planned Growth*** | Existing 2-Lane 50/60 | AM | 435 | 630 | 1,040 | 475 |
| | | PM | 1,065 | 1,005 | 550 | 695 |
| Full Planned Growth*** | Existing 2-Lane 50/60 | AM | 605 | 1,090 | 1,430 | 910 |
| | | PM | 1,375 | 1,765 | 735 | 1,140 |

*Maximum queue length likely to be observed for each leg of the intersection during the weekday AM or PM peak hour.
*** Population and Employment Projections in Comprehensive Plans

Based on current intersection geometry, which includes one through lane in each direction at the intersection, queue lengths are anticipated to be acceptable for a couple years but are anticipated to be unacceptable before 50% Planned Growth. The queue lengths are unacceptable for the current intersection design at Full Planned Growth with maximum queues of ⅓ mile on the south leg of the intersection in the AM peak hour and west leg of the intersection in the PM peak hour. Maximum queues at Full Planned Growth are slightly less on the north and east legs of the intersection at ¼ mile. These queues would block the adjacent public street intersections of:

- Jaguar Path to the north, ¼ mile from the intersection,
- Joplin Avenue/Kachina Court to the west, 800 feet from the intersection,
- Orchard Trail to the west, ⅓ mile from the intersection,
- 188th Street to the south, ¼ mile from the intersection,
- Jasper Path to the east, 800 feet from the intersection, and
- Jasmine Way to the east, 1,200 feet from the intersection.

## B. ADJACENT INTERSECTION OPERATIONS

It is anticipated that the adjacent intersections on CSAH 50 and 60 to the study intersection including Jaguar Path, 188th Street, Orchard Trail, Joplin Avenue/Kachina Court, Jasper Path, Jaeger Path, Jamaica Path, and Jasmine Way will experience unacceptable delay by Full Planned Growth during peak hours. Drivers will have difficulty turning left onto CSAH 50 and 60 during the peak hours with the projected the traffic volume.

# VIII. SIGNALIZED IMPROVEMENTS ALTERNATIVE

## A. OPERATIONS

A signal at this location would maintain acceptable operations with widening and reconstruction of the intersection (see Table 12). The widening and reconstruction of the intersection includes analysis based on the Full Planned Growth traffic volumes. The design is then evaluated to accommodate the Build Year and 50% Planned Growth traffic volumes.

The intersection design at Full Planned Growth is anticipated to include both CSAH 50 and CSAH 60 as four lane divided highways in all directions. To accommodate 50% Planned Growth, expansion to four lanes is needed to the north and west to match the existing four lane and tapers with transition back to a 2-lane section is required to the south and east.

**TABLE 12: SIGNALIZED CONTROL OPERATIONAL ANALYSIS**

| Traffic Scenario | Intersection Design | Peak Hour | Intersection Delay*- LOS | Worst Movement Delay-LOS-v/c** | Worst Movements |
|---|---|---|---|---|---|
| Current | Existing 2-Lane 50/60 | AM | 36 sec. – D | 53 sec. – D – 0.90 | Westbound Left & Northbound Thru |
| | | PM | 50 sec. – D | 122 sec. – F – 1.01 | Eastbound Left & Southbound Thru |
| Build Year | Full 4-Lane 50/60 | AM | 24 sec. – C | 49 sec. – D – 0.71 | Westbound Left & Northbound Left |
| | | PM | 26 sec. – C | 57 sec. – E – 0.79 | Northbound Left |
| 50% Planned Growth*** | Full 4-Lane 50/60 | AM | 34 sec. – C | 81 sec. – F – 0.95 | Northbound Left & Westbound Left |
| | | PM | 33 sec. – C | 69 sec. – E – 0.90 | Eastbound Left & Northbound Left |
| Full Planned Growth*** | Full 4-Lane 50/60 | AM | 55 sec. – D | 104 sec. – F – 1.02 | Southbound Left & Westbound Left |
| | | PM | 50 sec. – D | 104 sec. – F – 1.04 | Westbound Left & Northbound Left |

*Delay in seconds per vehicle
** Maximum average delay, LOS, and v/c ratio on any approach and/or movement
*** Population and Employment Projections in Comprehensive Plans

A traffic signal with capacity improvements is anticipated to provide acceptable operations for traffic through Full Planned Growth. By Full Planned Growth several movements are anticipated to operate with unacceptable delay, while the overall intersection would still have acceptable delay.

The signal analysis evaluated vehicle queue lengths with the forecasted traffic as shown in Table 13. These queue lengths determine how long the turn lanes need to be and also provide a look into how the intersection would appear to be operating to the traveling public.

**TABLE 13: SIGNALIZED QUEUE ANALYSIS**

| Traffic Scenario | Intersection Design | Peak Hour | Maximum Queue (ft.)* | | | |
|---|---|---|---|---|---|---|
| | | | North Leg | West Leg | South Leg | East Leg |
| Current | Existing 2-Lane 50/60 | AM | 255 | 195 | 605 | 200 |
| | | PM | 565 | 380 | 290 | 230 |
| Build Year | Full 4-Lane 50/60 | AM | 95 | 85 | 195 | 80 |
| | | PM | 195 | 125 | 125 | 95 |
| 50% Planned Growth*** | Full 4-Lane 50/60 | AM | 130 | 140 | 310 | 125 |
| | | PM | 240 | 220 | 150 | 165 |
| Full Planned Growth*** | Full 4-Lane 50/60 | AM | 215 | 380 | 490 | 230 |
| | | PM | 395 | 490 | 225 | 290 |

*Maximum queue length likely to be observed for each leg of the intersection during the weekday AM or PM peak hour.
*** Population and Employment Projections in Comprehensive Plans

The queue lengths are acceptable and the storage length needed for the queues are incorporated into the design. The traffic queues that will be observed by drivers are likely to be shorter in the off-peak hours.

## B. IMPLEMENTATION

The signalized intersection design accommodates the Build Year and 50% Planned Growth traffic volumes. The intersection design includes two through lanes in each direction. Dual left turn lanes and single right turn lanes are provided on the CSAH 50 approaches while single left turn lanes and right turn lanes are provided on the CSAH 60 approaches. To provide the two through lanes in each direction and to ensure lane utilization the signalized intersection design includes four lane expansion on CSAH 50 to the north and 60 to the west. The CSAH 50 four lane expansion is ½ mile north to Jurel Way and the CSAH 60 four lane expansion is ⅓ mile west to Orchard Trail. These expansion limits match into the current four lane highway sections.

The widening and transitioning from a four lane highway to two lane roadways occurs east and south of the intersection. Analysis of the transition needs indicated that both through lanes are necessary for a minimum of 550’ east of the intersection and 800’ south of the intersection. The actual transition would occur after this distance.

A layout of the signalized intersection concept design is included as Figure 4.

By Full Planned Growth CSAH 50 and 60 are anticipated to be four lane divided highways in all directions. This includes the expansion of CSAH 60 to a four lane divided highway one mile east to Ipava Avenue to match into the current 4-lane divided roadway. The widening of CSAH 50 as a four-lane divided roadway to the south will be extended as necessary. The implementation of the roadway expansions to the east and south will be based on the needs of traffic.

The following implementation timeline is provided to ascertain which improvements are anticipated to be completed first. This does not preclude an improvement from being moved to earlier in the timeline to meet the needs of traffic.

1. Intersection improvements
   Four lane divided roadway north to match into existing four lane roadway at Jurel Way
   Four lane divided roadway west to match into existing four lane roadway at Orchard Trail
2. Four lane divided roadway east to match into existing four lane roadway at Ipava Avenue
3. Four lane divided roadway south as needed

## C. RIGHT-OF-WAY

It is estimated that additional right-of-way is needed for the signalized intersection alternative. This right-of-way need is located on the intersection approaches due to the lanes needed. This additional right-of-way need affects a total of seven parcels and partial takes of approximately 0.7 acres in total.

## D. FINANCIAL IMPACTS

The cost estimate for the signalized intersection alternative as shown in Figure 4 is $8,300,000. This estimate includes construction, engineering, and right-of-way costs (see Table 14).

**TABLE 14: COST ESTIMATE**

| | |
|---|---|
| **Construction** | $6,690,000 |
| **Engineering** | $1,200,000 |
| **Right-of-Way** | $410,000 |
| **Total Construction** | $8,300,000 |

## E. CONSTRUCTION STAGING

The project phasing will allow for all movements to take place throughout construction. Some one day or nighttime closures for some or all movements are anticipated for construction activities such as installation of signal mast arms, paving through the intersection, and lane shifts. Temporary widening is anticipated for some phases of construction since the new intersection will be in place of the existing intersection. A long term detour route during construction is not anticipated to be needed.

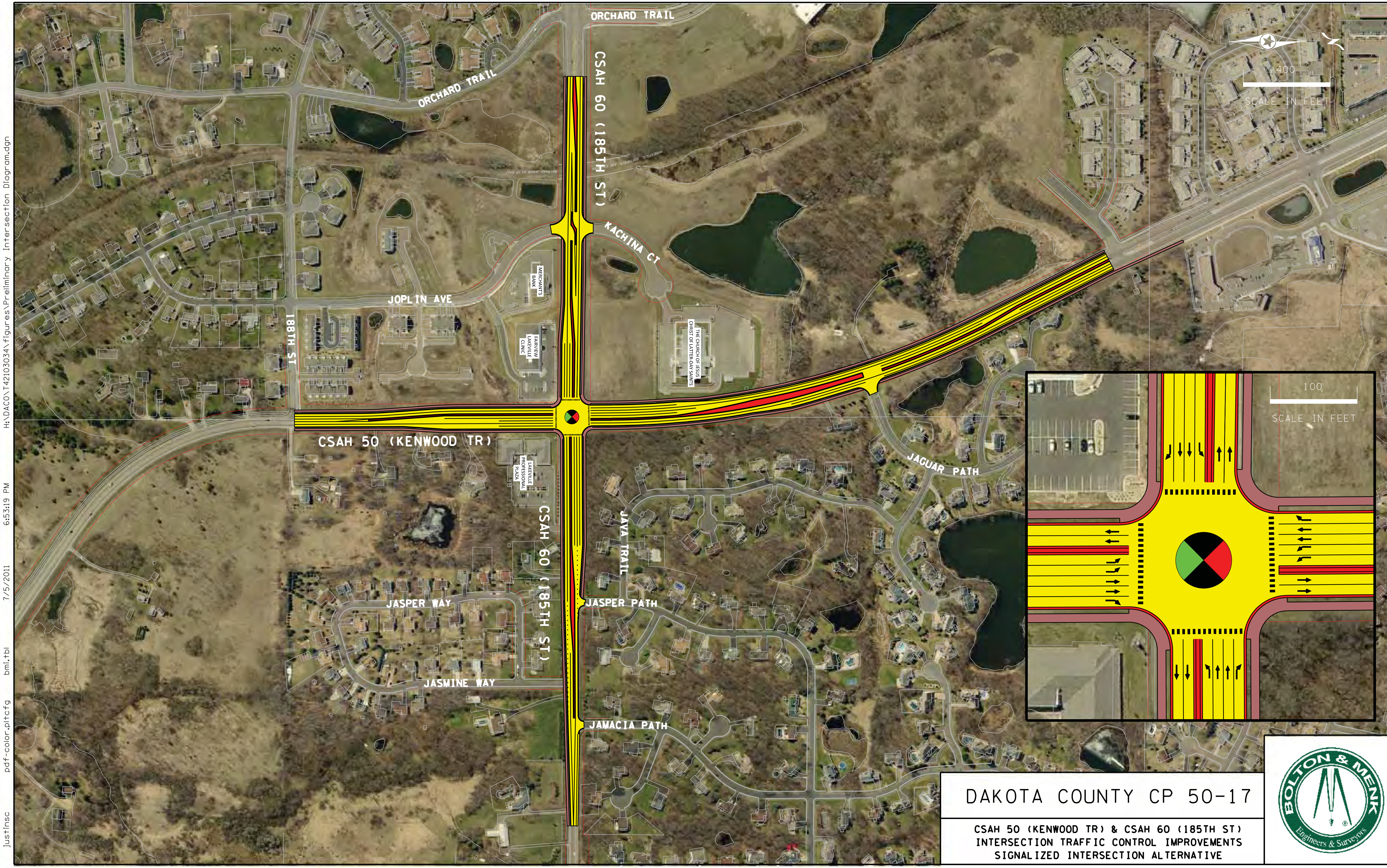





Figure 4. Signalized Intersection Alternative

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# IX. ROUNDABOUT ALTERNATIVE

## A. OPERATIONS

A roundabout at this location would provide acceptable operations (see Table 15). With a change of traffic control to a roundabout, the reconstruction of the intersection would be necessary. The reconstruction of the intersection includes analyzing what roundabout configuration would be necessary to accommodate Build Year, 50% Planned Growth, and Full Planned Growth traffic volumes.

Similar to the traffic signal alternative, the intersection design at Full Planned Growth is anticipated to include both CSAH 50 and CSAH 60 as four lane divided highways in all directions. The intersection design needed to accommodate 50% Planned Growth traffic volumes does not include expansion of CSAH 50 and 60 beyond the intersection. The lane expansion on CSAH 50 and 60 may be built in phases as necessary until Full Planned Growth.

Analysis was completed for 85% confidence levels. Based on Rodel analysis of roundabouts within MN, a confidence level of 85 is deemed to be appropriate and was used in the analysis of the CSAH 50/60 intersection evaluation. This was deemed to be an acceptable confidence level by Dakota County and the City of Lakeville that helps to account for the capacity reductions of roundabouts in this region of the country. As drivers get more familiar with roundabouts, it is expected that this confidence level may be modified when roundabouts will be able to handle higher volumes of traffic. The tables of the 15 minute data were collected from Rodel to ascertain the maximum queues and v/c ratios were during the peak 15 minute period.

**TABLE 15: ROUNDABOUT CONTROL OPERATIONAL ANALYSIS (85 CONFIDENCE LEVEL)**

| Traffic Scenario | Intersection Design | Peak Hour | Intersection Delay*- LOS | Worst Movement Delay-LOS-v/c** | Worst Movements |
|---|---|---|---|---|---|
| Build Year | Double-Lane | AM | 4 sec. – A | 4 sec. – A – 0.50 | Westbound & Northbound |
| | | PM | 5 sec. – A | 5 sec. – A – 0.63 | Eastbound & Southbound |
| 50% Planned Growth*** | Double-Lane | AM | 5 sec. – A | 7 sec. – A – 0.68 | Westbound & Northbound |
| | | PM | 6 sec. – A | 7 sec. – A – 0.72 | Eastbound & Southbound |
| Full Planned Growth*** | Double-Lane | AM | 16 sec. – C | 26 sec. – D – 0.97 | Westbound |
| | | PM | 57 sec. – E | 151 sec. – F – 1.11 | Eastbound |
| Full Planned Growth*** | Double-Lane with Free EBR | AM | 17 sec. – C | 25 sec. – C – 0.96 | Westbound |
| | | PM | 14 sec. – B | 23 sec. – C – 0.95 | Northbound & Southbound |

*Delay in seconds per vehicle
** Maximum average delay, LOS, and v/c ratio on any approach and/or movement
*** Population and Employment Projections in Comprehensive Plans

A single-lane roundabout is not anticipated to provide acceptable service levels with Build

Year traffic volumes. Two lanes are needed for each approach into the roundabout. Consequently, a double-lane roundabout is needed to provide acceptable service levels in the Build Year. It is anticipated that with 50% Planned Growth the intersection would continue to operate acceptably during the peak hours. With Full Planned Growth the roundabout is anticipated to have unacceptable service levels without any further improvements. An eastbound free right turn is anticipated to decrease delay for the critical eastbound movement and bring the intersection to acceptable service levels at Full Planned Growth.

**TABLE 16: ROUNDABOUT QUEUE ANALYSIS**

| Traffic Scenario | Intersection Design | Peak Hour | Maximum Queue (ft.)* | | | |
|---|---|---|---|---|---|---|
| | | | North Leg | West Leg | South Leg | East Leg |
| Build Year | Double-Lane | AM | 20 | 20 | 30 | 20 |
| | | PM | 45 | 30 | 20 | 20 |
| 50% Planned Growth*** | Double-Lane | AM | 20 | 20 | 55 | 50 |
| | | PM | 65 | 60 | 35 | 40 |
| Full Planned Growth*** | Double-Lane | AM | 25 | 40 | 230 | 285 |
| | | PM | 250 | 1,840 | 140 | 115 |
| Full Planned Growth*** | Double-Lane with Free EBR | AM | 25 | 20 | 280 | 275 |
| | | PM | 250 | 105 | 180 | 115 |

*Maximum queue length likely to be observed for each leg of the intersection during the weekday AM or PM peak hour.
*** Population and Employment Projections in Comprehensive Plans

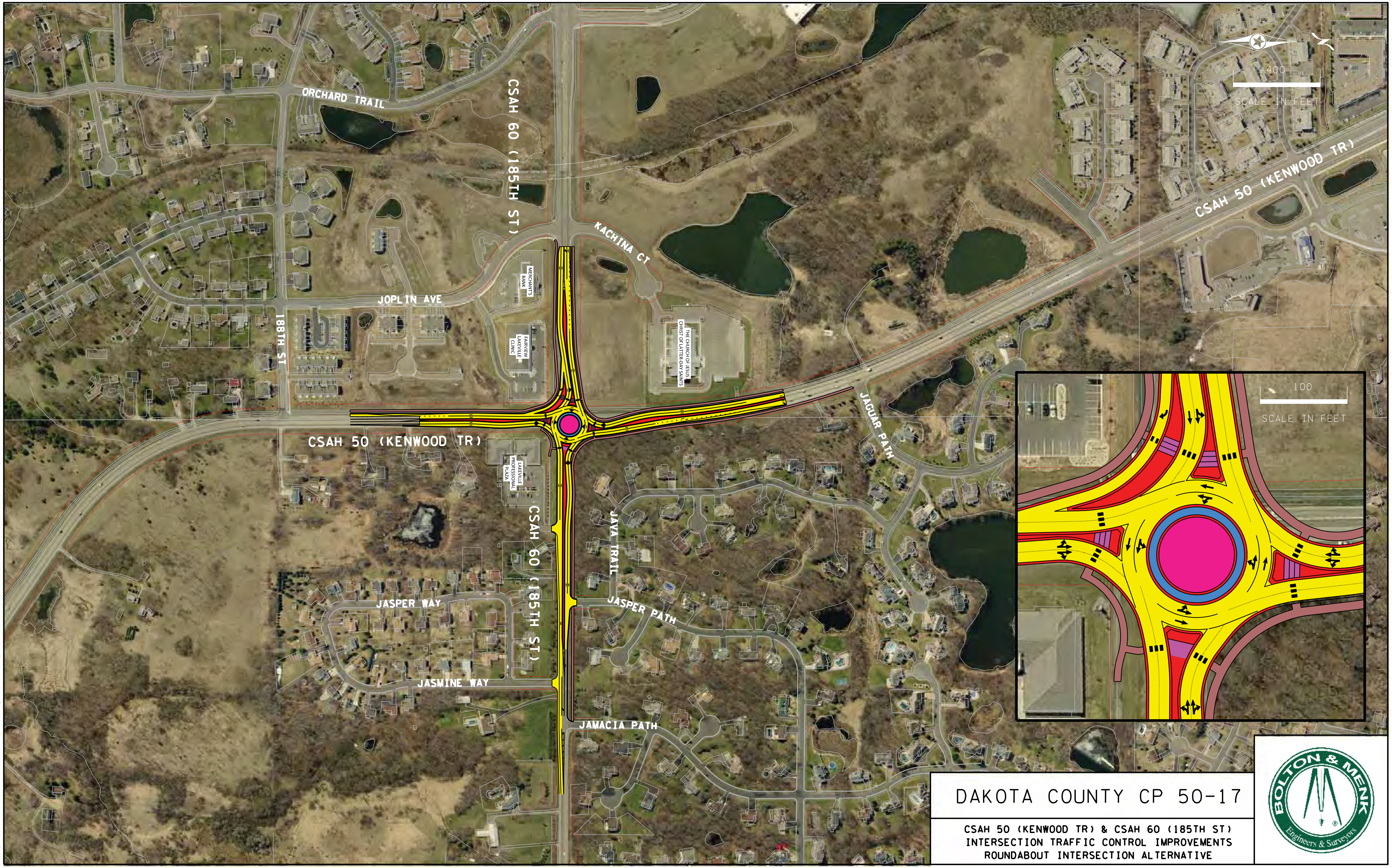
The queue lengths are acceptable and the storage length needed for the queues are incorporated into the design. The traffic queues that will be observed by drivers are likely to be shorter in the off-peak hours.

## B. IMPLEMENTATION

The roundabout intersection design includes two approach lanes from each direction and two circulating lanes throughout the roundabout. The free right turn lane for the eastbound movement is needed after 50% Planned Growth and will be constructed when needed by traffic. The widening and transitioning from a four lane highway at the roundabout to two lane roadways occurs away from the intersection occurs in all directions. Analysis of the transition needs indicated that both through lanes are necessary for a minimum of 300’ north of the intersection, 450’ south of the intersection, 300’ west of the intersection, and 350’ east of the intersection. The actual transition would occur after this distance.

A layout of the double-lane roundabout intersection concept design for the Opening Year with the option for the free right turn lane is included as Figure 5.

By Full Planned Growth CSAH 50 and 60 are anticipated to be four lane divided highways in all directions. This includes the expansion of CSAH 50 to a four lane divided highway north ½ mile to Jurel Way and south as necessary. Expansion of CSAH 60 to a four lane divided highway occurs ⅓ mile west to Orchard Trail and one mile east to Ipava Avenue. These expansion limits match into the current four lane highway sections to the north, west, and


ORCHARD TRAIL
CSAH 60 (185TH ST)
KACHINA CT
JOPLIN AVE
188TH ST
MERCHANTS BANK
FAIRVIEW LAKEVILLE CLINIC
THE CHURCH OF JESUS CHRIST OF LATTER-DAY SAINTS
CSAH 50 (KENWOOD TR)
LAKEVILLE PROFESSIONAL PLAZA
JAGUAR PATH
JAVA TRAIL
JASPER WAY
JASPER PATH
JASMINE WAY
JAMACIA PATH
400
SCALE IN FEET
100
SCALE IN FEET
DAKOTA COUNTY CP 50-17
CSAH 50 (KENWOOD TR) & CSAH 60 (185TH ST)
INTERSECTION TRAFFIC CONTROL IMPROVEMENTS
ROUNDABOUT INTERSECTION ALTERNATIVE
BOLTON & MENK
Engineers & Surveyors

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south. The implementation of the roadway expansions will be based on the needs of traffic.

The following implementation timeline is provided to ascertain which improvements are anticipated to be completed first. This does not preclude an improvement from being moved to earlier in the timeline to meet the needs of traffic.

1. Intersection improvements
2. Four lane divided roadway north to match into existing four lane roadway at Jurel Way
3. Four lane divided roadway west to match into existing four lane roadway at Orchard Trail
4. Four lane divided roadway east to match into existing four lane roadway at Ipava Avenue
5. Four lane divided roadway south as needed
6. Free right turn lane as needed

## C. RIGHT-OF-WAY

It is estimated that additional right-of-way is needed for the roundabout intersection alternative. This right-of-way need is primarily located at the intersection due to the size of the roundabout. This additional right-of-way need affects a total of eight parcels and partial takes of approximately 0.6 acres in total.

## D. FINANCIAL IMPACTS

The cost estimate for the roundabout intersection alternative as shown in Figure 5 is $3,500,000. This estimate includes construction, engineering, and right-of-way costs (see Table 17).

#### TABLE 17: ROUNDABOUT COST ESTIMATE

| | |
|---|---|
| **Construction** | $2,840,000 |
| **Engineering** | $520,000 |
| **Right-of-Way** | $140,000 |
| **Total Construction** | $3,500,000 |

The cost estimate for the expansion of CSAH 50 to the north and CSAH 60 to the west is provided to ascertain the cost of the expansion when needed (see Table 18).

#### TABLE 18: ROADWAY EXPANSION COST ESTIMATE

| | **CSAH 50 north (50/60 to Jurel Way)** | **CSAH 60 west (50/60 to Orchard Trail)** |
|---|---|---|
| **Construction** | $1,690,000 | $850,000 |
| **Engineering** | $310,000 | $150,000 |
| **Right-of-Way** | $0 | $0 |
| **Total Construction** | $2,000,000 | $1,000,000 |

## E. CONSTRUCTION STAGING

The construction phasing for a double-lane roundabout is similar to the construction phasing for a traditional intersection with a signal. All movements will be allowed to take place through construction. Some one day or nighttime closures of some or all movements are anticipated for construction activities such as center island work, the paving of the final wear course of pavement in the roundabout, and lane shifts. Temporary widening is anticipated for some phases of construction since the new intersection will be in place of the existing intersection. A long term detour route during construction is not anticipated to be needed.

## F. DOUBLE-LANE ROUNDABOUT CAPACITY STATE OF PRACTICE

To fully evaluate the intersection of Kenwood Trail (CSAH 50) and 185th Street (CSAH 60) in Lakeville, Dakota County, a review of the capacity of the proposed double-lane roundabout was completed. While the analysis indicated that the double-lane roundabout would operate acceptably with forecasted traffic volumes, given the limited number in Minnesota, further review to incorporate information from other roundabouts in the United States operating at or near the existing and forecasted traffic volumes was conducted.

Roundabouts, expecially modern roundabouts, in the United States are relatively new, and consequently there is a learning curve associated with driving them. With any roundabout design, it becomes important to understand the capacity of the design and to understand when the traffic control will no longer operate effectively. This can help determine if a roundabout is an effective traffic control option at an intersection based on the operations, safety, cost, and right-of-way available or if additional capacity will be needed.

There are few double-lane roundabout examples in Minnesota, especially ones that are currently operating at traffic volumes near or at capacity. Nationally, there are more double-lane roundabouts, but again there are few operating at or near capacity today.

There are multi-lane roundabouts within the United States that provide a good comparison to the proposed roundabout in Lakeville at CSAH 50 and CSAH 60. There is one known roundabout in MN, at the intersection of 66th Street and Portland Avenue in Richfield, operating at volumes near the existing traffic volumes of the CSAH 50/60 intersection. There are at least another 18 roundabouts within the United State and Canada that are operating with traffic volumes either near or higher than the existing traffic volume at CSAH 50/60. This indicates that the proposed roundabout is not unusual and it will be able to operate effectively. While many of the example roundabouts are not operating at traffic volumes as high as the Full Planned Growth forecasted traffic volumes at CSAH 50/60, the expectation is that traffic will continue to increase at all of these roundabouts. Most of them are located in areas where future growth expansion is planned and there is open land available. With these traffic volumes it is anticipated that most of these intersections would operate with traffic volumes either near or higher than the forecasted traffic volumes at CSAH 50/60 of 52,000 vehicles per day based on the existing traffic volumes.

Based on the Rodel analysis, NCHRP analysis, and national examples of roundabouts at higher volumes, the proposed roundabout at CSAH 50/60 in Lakeville can manage the proposed traffic volumes and is anticipated to operate acceptably.

The State of the Practice of the traffic volume capacity of a double-lane roundabout, analysis methods, reports, and real-life examples is included in Attachment D.

# X. ALTERNATIVES COMPARISON

The following is a summary of the alternatives analysis for comparison of the alternatives.

## A. OPERATIONS

The 50/60 intersection is anticipated to operate unacceptably during peak hours with minimal traffic increase. A signal or roundabout intersection improvement alternative provides improvement over the existing base intersection. This includes reduction in delay and an increase in capacity. The signal and roundabout alternatives each produce acceptable operation with respect to delay and Level of Service (LOS) for traffic through the intersection until Full Planned Growth of the area. Acceptable operations have a maximum delay per vehicle of 55 seconds and LOS D or better.

The roundabout alternative is anticipated to operate at slightly higher service levels as compared to the signal alternative but both are acceptable during the peak hours. This is also true with reserve capacity. Both intersection alternatives have acceptable reserve capacity to handle most traffic fluctuations. Reserve capacity is excess capacity to handle traffic fluctuations and minor increases. Recommended reserve capacity to maintain acceptable service levels during most traffic fluctuations is 15%. Traffic operations are also anticipated to be acceptable for the intersection alternatives during the off-peak hours.

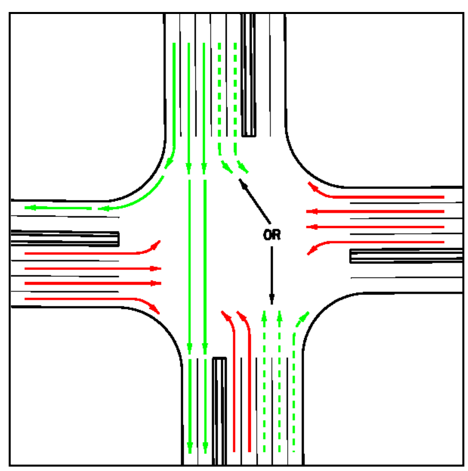
**TABLE 19: INTERSECTION ALTERNATIVES OPERATIONAL ANALYSIS SUMMARY**

| Traffic Scenario | Design Alternative | Intersection Delay | Intersection LOS | Reserve Capacity |
|---|---|---|---|---|
| Full Planned Growth*** | Signal | 50 to 55 sec. per veh. | LOS D | 19 to 27% |
| | Roundabout | 14 to 17 sec. per veh. | LOS B/C | 25 to 42% |

*** Population and Employment Projections in Comprehensive Plans

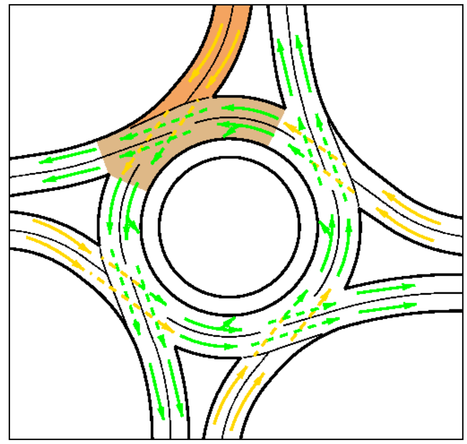
### COMPARISON OF OPERATIONS

In the PM peak hour the southbound approach has the highest traffic volumes and the longest backups. The graphics shown on the right side demonstrate the traffic movements through a signalized versus roundabout intersection and explain how a roundabout has lower delay than a traffic signal at this intersection.




At a signal, due to the multiple movements there is limited time available for each movement, in this case the southbound thru. The southbound thru movement (solid green) can occur with the southbound left (dashed green) or the northbound thru (dashed green). With the traffic volumes and signal phases the southbound movement uses about 40% of the total green time available at the traffic signal.

At a double-lane roundabout, drivers entering into the intersection yield (solid yellow) for conflicting vehicles in the roundabout to clear (dashed green). The only vehicles that the approaching vehicle has to be concerned with are the vehicles in direct conflict with any entering movement (solid green). This includes all vehicles to the left of the intersection entrance. Since the conflicting movements occur in a tighter area (dashed green versus dashed yellow) and the queue of vehicles is constantly moving as vehicles enter the roundabout, the southbound vehicles have less delay. The southbound movement at the double-lane roundabout has approximately 65% move time versus 35% wait time. As traffic volumes increase the wait times become longer but the queues continue to move as vehicles enter the roundabout. Additionally, vehicles on all approaches can be moving at the same time.



## B. ADJACENT INTERSECTION OPERATIONS

It is anticipated that the intersections adjacent to the CSAH 50/60 intersection including Jaguar Path, 188th Street, Orchard Trail, Jamaica Path, and Jasmine Way will operate acceptably with the signal improvement and roundabout intersection alternatives. The signal is expected to provide larger gaps for traffic to enter the traffic stream than the roundabout, but the roundabout is expected to have more gaps provided. As observed at the local roundabout of 66th Street and Portland Avenue in Richfield, MN, the roundabout alternative does provide adequate gaps for adjacent intersection traffic to turn onto the mainline roadways away from the roundabout.

The widening of CSAH 50 and 60 to four-lane highways in the future is anticipated to increase the number and length of gaps to provide acceptable operations but motorists will have difficulty turning left onto CSAH 50 and 60 during the peak hours. Right turns onto CSAH 50 and 60 are anticipated to be acceptable through Full Planned Growth.

## C. SAFETY

Safety is an important consideration when changing the traffic control at an intersection. Both a signal and roundabout will change the look and character of an intersection, altering how a motorist, bicyclist, or pedestrian will react to potential conflict. A change in intersection traffic control will also change the type of crashes and the expected number of crashes at an intersection.

The statewide average crash rate is 0.6 crashes per million entering vehicles (MEV). These crashes are distributed among the five different crash severities as shown in Table 20.

**TABLE 20: CRASH SEVERITY TYPE DISTRIBUTION**

| Fatal | Incapacitating Injury | Non-Incapacitating Injury | Possible Injury | Property Damage Only | Total Crashes |
|---|---|---|---|---|---|
| 0.4% | 1.0% | 8.1% | 25.0% | 65.5% | 100.0% |

This data is used to predict the types of crashes anticipated as traffic volumes increase. This results in the predicted crashes as shown in Table 21 for the Base Alternative (existing traffic signal and lanes).

The safety of the intersection can be improved with the signal and roundabout intersection alternatives as shown in Table 21. The primary crash reduction of the signal and roundabout intersection alternatives is the reduction of injury crashes. For the signal alternative this is a result of a raised median which provides more pedestrian protection and separates traffic directions. It is anticipated that the median will reduce fatal and injury crashes by a factor of 0.25 according to national data.

For the roundabout alternative the injury reduction is a result of the angles of incidence, where right-angle crashes are virtually eliminated. It is anticipated that the roundabout will reduce injury crashes by a factor of 0.65 according to State of Minnesota data. The low speeds associated with roundabouts also allow drivers more time to react to potential conflicts and the differential speeds within a roundabouts results in lower speed crashes if a conflict occurs. Signalized intersections typically involve a higher number of right-angle and rear-end type crashes which, due to higher speed differential, can result in higher number of injury related collisions.

**TABLE 21: INTERSECTION ALTERNATIVES CRASH SEVERITY ANALYSIS**

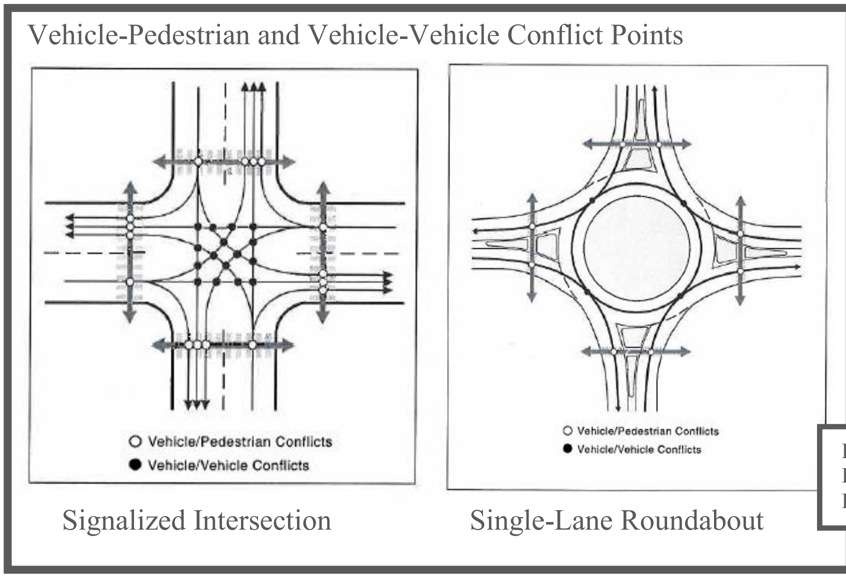
| | Build Year | | | 50% Planned Growth | | | Full Planned Growth | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Annual Average Daily Traffic (AADT) Volume | 30,150 | | | 40,200 | | | 52,000 (with Kenrick Extension) | | | |
| | Predicted Number of Crashes of Each Severity Type per Year | | | | | | | | | |
| Alternative | Injury | PDO | Total | Injury | PDO | Total | Injury | PDO | Total | Crash Rate |
| Base (1)* | 3 | 4 | **7** | 3 | 6 | **9** | 4 | 7 | **11** | 0.60 |
| Signal (2)* | 2 | 4 | **6** | 2 | 6 | **8** | 3 | 7 | **10** | 0.55 |
| Roundabout (3)* | 1 | 4 | **5** | 1 | 6 | **7** | 1 | 7 | **8** | 0.44 |

* Crashes determined using Highway Safety Manual methodology.
Crash Rate is measured as crashes per Million Entering Vehicles (MEV)
PDO= Property Damage Only
(1) Base = Existing Lanes with Signal Control
(2) Signal = Signal Control with Two Thru Lanes and Turn Lanes on All Approaches
(3) Roundabout = Double-Lane Roundabout

Crash frequency at intersections is measured based on the crash rate, which is shown as the crashes per million entering vehicles (MEV). The crash rates provide a safety comparison of the different traffic control options. The rates along with the total crashes for each alternative and each analysis year are provided in Table 21. Changes in traffic volume, delay, or capacity from the average can alter how the intersection operates. This can result in a situation where the average crash rates may no longer apply.

The roundabout also has fewer conflict points in comparison to a conventional intersection. Pedestrian conflict points are also reduced with a roundabout as shown in Figure 6.

**FIGURE 6. INTERSECTION CONFLICT POINTS**




Figures From:
Roundabouts: An Informational Guide
FHWA (Pub. No. FHWA-RD-00-067)

There is anticipated to be an increase in crashes as traffic volumes increase. This increase is anticipated to be less with the signal and roundabout intersection alternatives as compared to maintaining the current signal and lanes. With this intersection as a roundabout, there is expected to be a learning curve to the intersection design and operation. This learning curve is expected to result in an increase in crashes during the first year of opening. This learning curve is anticipated to subside as drivers become more comfortable with the intersection design and control as has been shown with other roundabouts in the State of Minnesota and throughout the United States. After the first year, the roundabout is anticipated to have crash rates lower than a signal as shown above. The roundabout is expected to result in fewer crashes and less severe crashes than the other alternatives.

The complete safety analysis is included in Attachment B.

## D. PEDESTRIANS AND BICYCLES

Pedestrian and bicycle facilities are accommodated under both options, but a roundabout has shorter crossing distances and the speed of vehicles through the crossing location is lower with the roundabout. Pedestrian facilities are provided at the existing intersection and would be integrated into either traffic control option. The sidewalk and trail facilities will accommodate pedestrian and bicycle travel at the intersection as well as connect the existing residential areas and parks near this intersection.

## E. IMPLEMENTATION

The differences in project cost are a result of the project schedule and lane need. The signal improvements alternative implements the 4-lane expansion of CSAH 50 to the north and CSAH 60 to the west at the same time as the intersection improvements. This is a result of the need to ensure lane utilization with the signal improvements. The implementation of other improvements in conjunction with the roundabout intersection improvements can be scheduled incrementally as they are needed by traffic.

Additionally, longer transitions from 4 lanes to 2 lanes are needed with the signal where traffic travels side by side through the intersection. Traffic is staggered in the lanes of a roundabout and the second through lane can be transitioned more quickly with shorter merge distances.

**TABLE 22: IMPLEMENTATION SCHEDULE**

| | Signal Improvements | Multi-Lane Roundabout |
|---|---|---|
| **Intersection Improvements** | Build Year | Build Year |
| **CSAH 50 Expansion North** | Build Year | Before 50% Planned Growth |
| **CSAH 60 Expansion West** | Build Year | Before 50% Planned Growth |
| **EB Free Right Turn Lane** | None | Before Full Planned Growth |
| **CSAH 60 Expansion East** | Before Full Planned Growth | Before Full Planned Growth |
| **CSAH 50 Expansion South** | Before Full Planned Growth | Before Full Planned Growth |

## F. RIGHT-OF-WAY

Both options require some right-of-way acquisition from nearby properties. Estimates are approximately the same number for each alternative. Exact impacts are to be determined during preliminary and final design.

## G. FINANCIAL IMPACTS

A summary of the costs and benefits is provided below based on the methodology presented in Section III D. The benefit to cost (B/C) ratio presented is the total benefit of the improvement over its cost. Generally, a B/C ratio of 1.00 is needed to substantiate a project.

**TABLE 23: COST AND BENEFIT SUMMARY TABLE (IN 2011 DOLLARS)**

| | Signal Improvements | Multi-Lane Roundabout |
|---|---|---|
| **Project Costs (A)** | $8,300,000 | $3,500,000 |
| **Vehicle Operating Cost Savings (B)** | $49,024,000 | $73,300,000 |
| **Safety Benefits (C)** | $1,916,000 | $5,106,000 |
| **Total Benefit (B+C)** | *$50,940,000* | *$78,406,000* |
| **Benefit-Cost Ratio ((B+C)/A)** | **6.1** | **22.4** |

Both alternatives do provide vehicle cost savings and safety benefits as compared to the project cost, resulting in a positive project benefit in terms of the benefit-cost ratio. The most significant difference in the costs and benefits between the two alternatives is the vehicle operating cost savings. The roundabout provides a larger delay benefit over the 20-year project life than the signal alternative, which is a result of the lower delay experienced by vehicles at a roundabout. Taking into account all of the costs and benefits as calculated in this study the roundabout alternative provides a larger cost benefit of approximately $27.5 million over the signal improvement alternative and results in a higher benefit to cost ratio. The complete economic evaluation is included in Attachment C.

## H. OTHER CONSIDERATIONS

Other items typically considered in this type of evaluation may include steep terrain issues, unconventional intersection geometry, adjacent intersections and coordinated signal systems, system consistency, and pedestrian and/or bicycle issues.

### TERRAIN

This intersection is located in an area with some terrain issues. To the west of the intersection the roadway drops in elevation. This elevation change will require evaluation of sight lines entering and exiting the intersection on the west leg. A roundabout is slightly more acceptable in these conditions since vehicles entering a roundabout only have to yield to movements directly in front of the approach lane and the roundabout can be designed with a tilt through the intersection. This is discouraged in signalized intersection design where each movement must be able to see all other movements. The signalized intersection alternative design would be located at the top of the hill, which will likely necessitate modifying the roadway grades on the hill, making it more difficult to match into the railroad crossing 0.2 miles to the west at the bottom of the hill.

### SYSTEM CONSISTENCY

There are signalized intersections to the west (0.6 miles), north (0.7 miles), and east (1.0 miles) of the intersection. Either a traffic signal or roundabout would be an acceptable operational control feature. The adjacent signals will minimally affect the operations at the intersection. A roundabout at the intersection would not be the first roundabout for the City, but would be the first double-lane roundabout for the City.  There is a single lane roundabout located at 175th Street/Kenrick Avenue to the north near the Lakeville Fire Station east of CSAH 50.

## I. EVALUATION MATRIX

The attached evaluation matrix provides a summary of the evaluation measures and their results in comparison to each alternative. Further explanation of each measure shown in the evaluation matrix is provided in the results section.

## EVALUATION MATRIX

| Intersection Design | Intersection Type | Acceptable Level of Service | Capacity Available to Handle Traffic Fluctuations | Corridor Travel Times Maintained | Minimizes Anticipated Crashes | Minimizes Potential Crash Severity | Pedestrian Safety Increased | Ability to Implement Incremental Improvements | Limits Additional Right-of-Way Need | Operating Cost | Estimated Project Cost (in Millions) | Benefit to Cost Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Existing 2-Lane (No-Build) |  | – | – | – | – | – | O | N/A | N/A | O | N/A | N/A |
| Proposed 4-Lane Divided |  | O | + | + | O | – | – | – | O | O | $8.3 | 6.1 |
| Proposed Double Lane |  | + | + | + | + | + | + | + | O | + | $3.5 | 22.4 |

| – | O | + |
|---|---|---|
| Does Not Meet Measure | Minimally Meets Measure | Meets Measure |

N/A = Not Applicable

# XI. RESULTS

While both options are acceptable and could alleviate the recognized traffic control issues at the intersection, the best intersection control option provides minimal delay to traffic with a low crash rate potential at a low cost and fits with the nature of the roadway and community.

The following are key differences and improvement study conclusions.

- The delay is lower with the roundabout during all hours of the day.
- While traffic does slow down in a roundabout, traffic may be stopped at a traffic signal, resulting is similar corridor travel times.
- Predicted crashes are lower for the roundabout.
- The roundabout provides safety benefits where crashes tend to be less severe due to the lower vehicle speeds and the angle of incidence.
- Pedestrian safety is increased with the roundabout alternative due to shorter time exposure to traffic and the lower vehicle speeds at the pedestrian crossing locations.
- The CSAH 50 and 60 expansions to four-lane divided facilities and the eastbound free right turn lane can more easily be applied incrementally with the roundabout.
- Based on the planning level cost estimates, the roundabout has a lower project cost.
- Taking into account the delay to the users of the system and the safety benefits of both alternatives, the roundabout has a higher benefit for the cost.

Based on the Rodel analysis, NCHRP analysis, and national examples of roundabouts operating acceptably at higher traffic volumes, the proposed roundabout at CSAH 50/60 in Lakeville can manage the proposed traffic volumes and is anticipated to operate acceptably.

# XII. RECOMMENDATION

The roundabout alternative is the preferred intersection alternative to maintain mobility and increase safety at the intersection of CSAH 50 (Kenwood Trail) and CSAH 60 (185th Street). Based on the considerations of operations (technically feasible), safety and right-of-way (environmentally compatible), financial impacts (economically viable), and public input (publicly acceptable) implementing the double-lane roundabout is recommended for this intersection to accommodate current and future traffic volumes.

# Attachment A

# Public Comments

# CSAH 50 (KENWOOD TRAIL) AND CSAH 60 (185TH STREET) INTERSECTION TRAFFIC CONTROL IMPROVEMENTS STUDY

## OPEN HOUSE

Tuesday, March 22, 2011
4:00 – 7:00 PM

Meeting Location: Lakeville Water Treatment Facility

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## MEETING SUMMARY

**Technical Advisory Committee (TAC) Representatives Attending:**

| | |
|---|---|
| Kristi Sebastian, Dakota County | Bryan Nemeth, Bolton & Menk |
| Keith Nelson, City of Lakeville | Gina Mitchell, Bolton & Menk |
| Chris Chromy, Bolton & Menk | |

**Overall Attendance:** 50 non-TAC members signed in.

**Information Displayed:**

1. Meeting Purpose
2. Study Area Map
3. Study Evaluation Criteria: Level of Service
4. Existing and Future Conditions
5. Comparison of Alternatives: Traffic Signal Schematic Layout
6. Comparison of Alternatives: Double-Lane Roundabout Schematic Layout
7. Comparison of Alternatives: Signal and Roundabout Operational Differences
8. Comparison of Alternatives: Evaluation Matrix
9. Next Steps

**Written Comments Received:** At the Open House: 29,
Before or after the Open House: 9

The following is a summary of all of the written comments received. They are sorted into categories for ease of reading. Each bullet point under "Support for a Traffic Signal" and "Support for a Roundabout" is by a separate person. The bullet points under other categories may be repeats from the first two and more than one bullet may be from the same person in those other categories.

**Support for a Traffic Signal:**

- Minnesotans do not know how to use a single-lane roundabout, let alone a double-lane one. Lots of buses and teens in this neighborhood area. Roundabouts are disorganized. Stick to good-old traffic lights.
- Double-lane roundabout seems very complex and fraught with danger. Roundabout option would provide a continuous flow of traffic making it more difficult for traffic to access Kenwood Trail from Jaguar Path. Seems a red/green light is needed currently.
- Roundabout option is unrealistic, but like the concept. People struggle with one-lane roundabout on Kenrick. Double-lane? Good grief.
- Have lived in Europe, do not believe drivers understand roundabouts to a level where they would work at this high volume location. Concept should be 5-10 years out due to lack of other locations.
- This is the best way to go. How does a person cross a roundabout if cars are always going around?
- I believe that the signalized intersection option is the best and safest option.
- Educating users on how to use a double-lane roundabout will be difficult. Other examples in MN? How long in use, local resident opinions, accidents? Need these details to sell a roundabout.
- The roundabout is a bad idea. People do not know how to merge.
- Would prefer the traffic signal- please.
- Totally against the double-lane roundabout. Lived in England and people here do not know how to drive them. People do not use their signals because the ones here are not large enough. Variety of ages of drivers. Bad flow with land use. Why fix if the signal is working with a low traffic accident history? Just because accidents in roundabout are at lower speeds doesn't mean it's ok if there are more of them. Traffic will be slower and more congested in a roundabout. Left turns out of neighborhoods on north side of 185th will be more difficult with a roundabout during high peak traffic times. More chance of accidents with roundabout. Will happen.
- Very much prefer the signalized intersection option. No one uses roundabouts correctly. Purposely avoid one near Southfork and that is single lane. Number of trucks through intersection will be a problem with the roundabout. Accidents will increase in roundabouts especially with inexperienced teen drivers coming from the high schools. Roundabout is a bad idea.

- Roundabout is a very poor option. Lights would be a better traffic control. I feel the roundabout would increase traffic accidents. Less severe does not matter, an accident is an accident.
- Do not like the idea of a roundabout. Have used the one by Fleet Farm and as an older driver, I do not like it. Faster drivers do not wait, going to cause an accident. Lights tell us what to do. Where is the training in how to use these?
- I am very concerned about the learning curve for a double-lane roundabout. I would prefer the extra lanes and stoplights. The light could be better timed for the heavy traffic.
- Really don't want a roundabout.
- Do not like the idea of roundabouts because too many people are impatient and do not yield. Run into this many times at the Fleet Farm area roundabout.
- Understand arguments on why the roundabout might be the preferred option (cost, safety,…), but I'm not convinced that it is the best choice for the intersection. With the pedestrian traffic, including many kids and bikes, and the high school traffic, I feel the signalized intersection is the best option. Please also consider the hill on 185th Street eastbound coming up to a possible roundabout. In winter, the waiting at a roundabout could be terrible with snowy and icy conditions.
- Concern with Jaguar Path access to Kenwood Trail with a roundabout option that provides continuous flow. Right-turn entry very difficult, left turn entry nigh impossible. Want traffic light at Jaguar Path and Kenwood Trail. More lights means more traffic will use I-35 instead of Kenwood Trail.

**Support for a Roundabout:**

- In favor of the roundabout design for Kenwood & 185th Street.
- Prefer the double-lane roundabout option. Travel through intersection on a daily basis. Trust whatever option is recommended that is best and safest for community.
- Proposed number of lanes in the signalized option is mind-boggling. Puts it on par with CH 42/Cedar in Apple Valley. Would lose at least 1.5 lanes of real estate. How will this impact property values?
- Safety is the #1 consideration and the roundabout definitely offers the best safety profile. Traffic needs to slow down. 7-lanes with a light is over the top. Roundabout is a highly viable option to accommodate the traffic needs of the future.
- Double lane roundabout option is my first choice. It makes more sense. My driveway may be affected in some ways, but I'm sure it will work out.
- Have concerns into how a roundabout would handle the heavy volumes. Feel more comfortable after seeing the boards/statistics. Need to educate the community to efficiently/safely utilize a roundabout.

- I'd rather see the roundabout solution.
- If the signal option does not have protected/permitted left turns (flashing yellow or solid green), fully support the roundabout even though I do not think the typical driver will be able to handle it.
- Favor the roundabout solution. Lived in UK for years and they work well.
- The winner.
- I am in favor of the roundabout as it would slow traffic speed.
- Like to see the roundabout, however it might be hard to take a left onto 185th from Orchard with more traffic coming from the roundabout.
- Prefer the double-lane roundabout with curb sections to easily route traffic on and off. The space saving and traffic control would be nice. The large size greatly improves the entrance and exit problems of the small roundabout by Kenrick and 175th.
- We prefer the roundabout option. Keeps things simple and moving. Also, please landscape the middle with low maintenance plants. I would help lead a group of volunteers to maintain any planting in the roundabout.
- I really like roundabouts. Hopefully it will be conjunction with 4 lanes on 185th Street.

**Adjacent Intersection Concerns:**

- Not able to access Kenwood Trail from Jaguar Path due to the back-up during rush hour. Need more lanes to move traffic through.
- Concern with Jaguar Path access to Kenwood Trail with a roundabout option that provides continuous flow. Right-turn entry very difficult, left turn entry nigh impossible. Want traffic light at Jaguar Path and Kenwood Trail. More lights means more traffic will use I-35 instead of Kenwood Trail.
- With this much traffic and lanes, we will not be able to turn out of our driveway onto Kenwood Trail other than north.
- Concerns regarding how to access Kenwood Trail from Jaguar Path and 185th Street from Jasper Path. Not addressed in either option.
- Like to see Jasper Path closed to through traffic (in conjunction with roundabout support comment).
- Left turns out of neighborhoods on north side of 185th will be more difficult with a roundabout during high peak traffic times.
- Can't make a left hand turn out of Jaguar Path. By the looks of the roundabout, the lane from 185th to 50 will be a constant run of cars. Jaguar is the only road that goes into our neighborhood of 200+ homes.

- Concerned about a roundabout. Already have a difficult time exiting with a controlled intersection. A roundabout would be a constant flow of traffic and make it more difficult to exit my area. Very difficult seeing traffic when look west. CR 60 needs to be more level to see cars.
- At certain times of the day it is impossible to exit from Jaguar Path to CR 50.
- Like to see the roundabout, however it might be hard to take a left onto 185$^{th}$ from Orchard with more traffic coming from the roundabout.
- Major concern with a median that extends past the commercial area driveway entrance on the southeast corner along 185$^{th}$ Street. Any median past entry will significantly impair business.
- Attempting to enter 185$^{th}$ from Orchard Trail heading north would become much more difficult (with roundabout?). There are limited egress options.
- Concerned about lack of break in traffic to allow for traffic from Italy Avenue. I understand that Italy may be a right-in/right-out. I'm okay with that. Safety improvement.
- With the proposed number of lanes, we will only be able to turn right out of our driveway and do not know how turn into driveway from any direction but north on CR 50. How about 188$^{th}$ Street? Joplin Avenue? Jasper Path?

**Pedestrian Concerns:**

- Concern for pedestrian traffic with roads this size. Need sidewalk down 185$^{th}$ Street from Kenwood to Ipava.
- Concern regarding pedestrian safety under either option.
- Very dangerous for kids to cross CR 50 at Jaguar Path to get to sidewalk on west side. Sidewalk needs to be added to east side of CR 50.
- I no longer walk on 185$^{th}$ because of the fast traffic and people passing on the right.
- Keep in mind to connect all pedestrian paths.

**Other Comments/Concerns:**

- Training for the use of a roundabout would be necessary.
- Trust that the best decision will be made for the intersection to address the traffic volumes. Comfortable with the analysis.
- See advantages of putting in a new intersection. Want decision that is best, but please take into consideration the residential lots affected by either option. Think about it as if it were your property.
- Does not want Kenwood Trail or 185$^{th}$ Street to become major thoroughfares.

- Would trees be planted where property is taken?
- Like to know how much of property would be taken.
- Slow down CR 60.
- Slow down the speeds. Traffic moves faster than the speed limits. Cars always passing on right. Trucks go way over speed limit.
- Lived in area for approximately 11 years and traffic speeds have increased very much.
- Not sure if want any change.
- Intersection is only busy during peak hours and not peak hours. Existing data doesn't seem to indicate that there is a need to expand the intersection.
- No plans to widen CSAH 50 to the south. Has this changed?
- Plan for CSAH 60? Last heard that it will be a major east-west artery.
- What is driving the forecast? Seems unlikely given unemployment picture.
- What are funding sources for this? This should not be highest priority.
- With major budget deficits, how could this be a priority?
- Higher priority should be the Kenrick connection to move traffic away from 50/60.
- Please be sure to mail entire neighborhoods about options.
- Request a survey be done at Dodd and 50 so there can be left turn signals for Dodd. Sight lines with big vehicles make it impossible to see oncoming traffic.

# Attachment B

# Intersection Control Evaluation

# CSAH 50/KENWOOD TRAIL AT CSAH 60/185TH STREET INTERSECTION CONTROL EVALUATION

# CITY OF LAKEVILLE, DAKOTA COUNTY, MN

**Prepared by:**

**Bolton & Menk, Inc.**

**July 2011**

BOLTON & MENK, INC.
Consulting Engineers & Surveyors
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Phone (952) 890-0509 • Fax (952) 890-8065
www.bolton-menk.com

# Intersection Control Evaluation, Phase 1

## County State Aid Highway (CSAH) 50/Kenwood Trail at CSAH 60/185th Street

in

Lakeville, Dakota County

Program: Pending

Funding: Pending

Letting Date: Pending

Work Identification: S.P. Pending

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.

| | | |
|---|---|---|
| [signature] | 43354 | 7/7/2011 |
| Bryan T. Nemeth, P.E., P.T.O.E. | Reg. No. | Date |

***REVIEWED:***

| | |
|---|---|
| ____________________ | ________ |
| City Engineer | Date |

***APPROVED:***

| | |
|---|---|
| ____________________ | ________ |
| Metro District Traffic Engineer – Program Support | Date |
| ____________________ | ________ |
| Dakota County Engineer | Date |

## Executive Summary

The intersection of County State Aid Highway (CSAH) 50/Kenwood Trail and CSAH 60/185th Street in the City of Lakeville and Dakota County is a traffic signal controlled intersection that is close to exceeding capacity during the peak hours of the day. The intersection is located east of I-35 at the crossroads of two minor arterial roadways. CSAH 50 runs north-south and connects to I-35 to the north while CSAH 60 runs east-west and connects to I-35 to the west. As traffic volumes increase due to development and other factors, the intersection is expected to have multiple movements in which the volume exceeds the capacity of the existing facility resulting in unacceptable delay and queuing.

Two potential intersection design alternatives were evaluated to alleviate the anticipated congestion. This includes a signalized intersection with additional capacity and a multi-lane roundabout. Both intersection/traffic control alternatives are considered viable at this intersection location due to their ability to handle traffic volumes in the range needed. The signal and roundabout options minimize delay and provide acceptable capacity for the volumes projected through Full Planned Growth. Both options are also anticipated to improve safety.

While both options are acceptable and could alleviate the anticipated traffic control issues at the intersection, the best intersection control option provides minimal delay to traffic with a low crash rate potential at a low cost and fits with the nature of the roadway and community. The roundabout is deemed preferable to the signal as there is less overall delay for traffic, lower crash potential, and the severity of crashes are less. This intersection control is acceptable to the City of Lakeville and Dakota County.

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## Appendices

# Phase I Intersection Control Evaluation

## I. CSAH 50 at CSAH 60 Intersection Analysis

The intersection of County State Aid Highway (CSAH) 50/Kenwood Trail and CSAH 60/185th Street in the City of Lakeville and Dakota County operates under signalized intersection control. North and west from the intersection, both CSAH 50 and CSAH 60 connect to commercial destinations and interchanges with Interstate 35. South and east of the intersection, these Minor Arterial roadways connect to residential, educational, and recreation land uses. As the community of Lakeville continues to grow, the traffic volumes through the intersection are anticipated to increase.

The intersection serves a high volume of vehicular traffic given its proximity to the interstate as well as local retail and education destinations along these routes. The land uses immediately adjacent to the project area include a variety of medical facilities and generate a larger portion of infrequent vehicular trips in the intersection. In addition, these land uses typically attract a broad spectrum of users, from juvenile to elderly.

The existing signalized intersection experiences congestion back-ups during the peak hours. As the community continues to grow, the need for increased capacity is anticipated. The intersection has some limitations that will impact design alternatives. To the west, CSAH 60 drops in elevation resulting in limited sight lines for eastbound traffic. This is a safety issue during the morning hours with the sun in the eastern sky, which can temporarily blind drivers from seeing signal indications, oncoming or queued vehicles, and pedestrians. All four legs of the intersection have adjacent off-street pedestrian and bike facilities but there is an absence of sidewalk to push button locations, pedestrian ramps at the crosswalk locations, and truncated domes.

It is proposed that the intersection of CSAH 50 and CSAH 60 be redesigned to accommodate the growing traffic volumes. The City of Lakeville, with Dakota County, has taken a proactive approach in securing federal funding for intersection improvements. The intersection control alternatives studied will establish the recommended improvements based on an objective, comprehensive analysis.

## II. Location

Lakeville is a southern suburb of the Twin Cities Metropolitan Area and is located 20 miles south of Downtown Minneapolis. Lakeville’s population is stated at 55,954 in the year 2010 census. The intersection of CSAH 50 and CSAH 60 is located on the west side of Dakota County, within the western portion of the City of Lakeville. The intersection is approximately 1.25 miles southeast of I-35 along CSAH 50 and 0.75 miles east of I-35 along CSAH 60.

## III. Measures of Effectiveness

The analysis of the traffic volume scenarios and alternatives in this study were performed using the methodology of the 2000 Highway Capacity Manual through SYNCHRO, a traffic analysis software program by Trafficware, for signalized conditions. To measure level of service and delay for roundabouts, the design program RODEL was used. Rodel is recommended by the Minnesota Department of Transportation in the Mn/DOT Road Design Manual, for analysis of roundabouts.

Measures of effectiveness display quantitative information about the performance of an intersection or network of intersections. The primary measures that are used in this study are level of service and delay.

Level of Service

The operational analysis results are described as a Level of Service (LOS) ranging from A to F. These letters serve to describe a range of operating conditions for different types of facilities. Levels of Service are calculated based on the 2000 Highway Capacity Manual, which defines the level of service, based on control delay. Control delay is the delay experienced by vehicles slowing down as they are approaching the intersection, the wait time at the intersection, and the time for the vehicle to speed up through the intersection and enter into the traffic stream. The average intersection control delay is a volume weighted average of delay experienced by all motorists entering the intersection on all intersection approaches for signalized and roundabout intersections. Level of Service D is commonly taken as an acceptable design year LOS. The level of service and its associated intersection delay for a signalized and unsignalized intersection is presented below. The delay threshold for unsignalized intersections is lower for each LOS compared to signalized intersections, which accounts for the fact that people expect a higher level of service when at a stop-controlled intersection. Roundabout intersections are evaluated as unsignalized intersections.

**Table 1: Level of Service Criteria**

| | **Signalized Intersection** | **Unsignalized Intersection** |
|---|---|---|
| **LOS** | **Control Delay per Vehicle (sec.)** | **Control Delay per Vehicle (sec.)** |
| A | ≤ 10 | ≤ 10 |
| B | >10 and ≤ 20 | >10 and ≤ 15 |
| C | >20 and ≤ 35 | >15 and ≤ 25 |
| D | >35 and ≤ 55 | >25 and ≤ 35 |
| E | >55 and ≤ 80 | >35 and ≤ 50 |
| F | >80 | >50 |

Volume to Capacity Ratios

Volume to capacity ratio is the proportion of the actual traffic utilizing the facility to the facility's physical ability to carry a specific maximum volume. This is calculated by dividing the total traffic using the facility by the capacity of the facility. This can then determine if a facility is sufficient to handle the traffic that is expected to be traveling on it. A ratio greater than 1.00 predicts that the facility will be unable to discharge all of the demand arriving on it. Such a situation would result in long queues and extensive delays, or diversion to alternate routes.

## IV. Existing (2010) Conditions

CSAH 50/Kenwood Trail is part of the Dakota County State Aid Highway System. It runs northwest/southeast between I-35 and CSAH 23/Cedar Avenue. It connects through the City of Lakeville and is classified as an "A" Minor Arterial Expander.

CSAH 60/185th Street is part of the Dakota County State Aid Highway System. It runs east/west between I-35 and CSAH 9/Dodd Boulevard. West of I-35, it becomes Scott County State Aid Highway (CSAH) 21 at Judicial Road and connects to the City of Prior Lake, seven miles west of I-35, before heading north to CSAH 42 and US 169 in Shakopee. It is classified as an "A" Minor Arterial Expander.

Both CSAH 50 and CSAH 60 are currently two-lane highways through the intersection. The north, west, and south approaches have left and right turn lanes, but the east approach has only a left turn lane. The posted speed limit is 50 MPH on CSAH 50 and 45 MPH on CSAH 60. On CSAH 50 the 2009 AADT is 17,200 north of CSAH 60 and 15,900 south of CSAH 60. On CSAH 60 the 2009 AADT is 13,900 west of CSAH 50 and 9,500 east of CSAH 50. The intersection currently operates under signal control. Traffic turning movement counts were taken during the AM and PM peak hours on February 1, 2011. Approach counts along each roadway were taken on January 12, 18, and 25, 2011. These counts are shown in Figure 2 of Appendix A. All counts were completed when the weather was clear and traffic was not adversely impacted by snow conditions.

Based on visual counts, heavy vehicles comprise approximately 2% of the daily traffic on CSAH 50 and CSAH 60. This heavy vehicle percentage is the same as the Heavy Commercial Average Daily Traffic (HCADT) percentage of 2% measured on TH 77/Cedar Avenue in Dakota County in 2006 by the Minnesota Department of Transportation.

Analysis of the existing traffic indicates that the intersection with a signal is functioning within acceptable service levels during the peak hours, but is close to exceeding its capacity for some movements. A summary of the operations is presented in Tables 2 and 3.

**Table 2: Existing Signalized Control Operational Analysis**

| Traffic Scenario | Intersection Design | Peak Hour | Intersection Delay*- LOS | Worst Movement Delay-LOS-v/c** | Worst Movements |
|---|---|---|---|---|---|
| Current | Existing 2-Lane 50/60 | AM | 36 sec. – D | 53 sec. – D – 0.90 | Westbound Left & Northbound Thru |
| | | PM | 50 sec. – D | 122 sec. – F – 1.01 | Eastbound Left & Southbound Thru |
| Build Year | Existing 2-Lane 50/60 | AM | 39 sec. – D | 82 sec. – F – 0.92 | Westbound Left & Northbound Thru |
| | | PM | 54 sec. – D | 126 sec. – F – 1.03 | Eastbound Left & Northbound Left |
| 50% Planned Growth*** | Existing 2-Lane 50/60 | AM | 73 sec. – F | 174 sec. – F – 1.06 | Southbound Left & Westbound Left |
| | | PM | 108 sec. – F | 277 sec. – F – 1.32 | Eastbound Left & Westbound Left |
| Full Planned Growth*** | Existing 2-Lane 50/60 | AM | 153 sec. – F | 324 sec. – F – 1.49 | Eastbound Left & Westbound Left |
| | | PM | 234 sec. – F | 410 sec. – F – 1.79 | Southbound Left |

*Delay in seconds per vehicle
** Maximum delay, LOS, and v/c ratio on any approach and/or movement
*** Population and Employment Projections in Comprehensive Plans

**Table 3: Existing Signalized Queue Analysis**

| Traffic Scenario | Intersection Design | Peak Hour | Maximum Queue (ft.)* | | | |
|---|---|---|---|---|---|---|
| | | | North Leg | West Leg | South Leg | East Leg |
| Current | Existing 2-Lane 50/60 | AM | 255 | 195 | 605 | 200 |
| | | PM | 565 | 380 | 290 | 230 |
| Build Year | Existing 2-Lane 50/60 | AM | 250 | 220 | 600 | 215 |
| | | PM | 605 | 465 | 320 | 310 |
| 50% Planned Growth*** | Existing 2-Lane 50/60 | AM | 435 | 630 | 1,040 | 475 |
| | | PM | 1,065 | 1,005 | 550 | 695 |
| Full Planned Growth*** | Existing 2-Lane 50/60 | AM | 605 | 1,090 | 1,430 | 910 |
| | | PM | 1,375 | 1,765 | 735 | 1,140 |

*Maximum queue length likely to be observed for each leg of the intersection during the weekday AM or PM peak hour.
*** Population and Employment Projections in Comprehensive Plans

With minimal traffic growth, the existing operations can be maintained with little noticeable increase to delay to the driving public. As traffic increases unacceptable operations are anticipated. This includes queue lengths that are unacceptable for the current intersection design at Full Planned Growth with maximum queues at around ⅓ mile on the south leg of the intersection in the AM peak hour and west leg of the intersection in the PM peak hour. Maximum queues at Full Planned Growth are slightly less on the north and east legs of the intersection at ¼ mile. These queues would block the adjacent public street intersections of:

- Jaguar Path to the north, ¼ mile from the intersection,
- Joplin Avenue/Kachina Court to the west, 800 feet from the intersection,
- Orchard Trail to the west, ⅓ mile from the intersection,
- 188$^{th}$ Street to the south, ¼ mile from the intersection,
- Jasper Path to the east, 800 feet from the intersection, and
- Jasmine Way to the east, 1,200 feet from the intersection.

There have been ten reported crashes to the state at the intersection between January 2006 and October 2010. All but one of the crashes were rear-end crashes. The one non-rear-end crash was a right-angle crash in 2009. Five of the crashes occurred in 2006. There was a fatal crash at the intersection in 2005. The crash rate for the intersection is 0.19 crashes per million entering vehicles (MEV). This is lower than the 2009 Metro District Average Crash Rate and Statewide Average Crash Rate of 0.6 for a high volume and high speed signalized intersection. The intersection has a crash severity rate of 0.35 which is lower than the 2009 Metro District and Statewide Average Severity Rate of 0.9. These comparisons indicate that the intersection is safe when compared to similar intersections in the Metro Area and Statewide.

There were an additional 13 crashes noted on incident reports by the City with $1000 or more property damage, but these were not in the state database. All of these crashes except two were rear-end type crashes. Adding this data to the above data results in five or more crashes per year from 2006 to 2008, with three crashes per year in 2009 and 2010. If this data were added to analysis comparison to the Metro District and Statewide Average Crash Rates and Severity Rates, it indicates that the intersection is closer to the average but is still less than the average, indicating an overall safe intersection.

## V. Future Conditions

Dakota County and the City of Lakeville have developed 2030 traffic forecasts for the roadways as part of their 2010 Comprehensive Plan Updates. The 2030 Annual Average Daily Traffic (AADT) forecasts are summarized in the Table 4.

**Table 4: 2030 AADT Forecasts**

| Roadway | Dakota County |
|---|---|
| CSAH 50, north of CSAH 60 | 27,000 |
| CSAH 50, south of CSAH 60 | 27,000 |
| CSAH 60, west of CSAH 50 | 31,000 |
| CSAH 60, east of CSAH 50 | 24,000 |

These traffic forecasts are for the Full Planned Growth of the area as detailed in the Dakota County 2030 Transportation Plan. The traffic volumes are forecasted to be at the intersection at Full Planned Growth and not an exact year, especially considering recent growth trends.

The traffic forecasts will be altered at the intersection due to a planned roadway extension within Lakeville, east of I-35. This Kenrick Avenue Extension is in the City's Comprehensive Plan and connects between CSAH 50 and CSAH 60, adjacent to I-35. As part of this study, the traffic implications of the extension to the traffic volumes at the CSAH 50/CSAH 60 intersection were evaluated and determined to have limited effect on the options needed to handle Full Planned Growth. Since the roadway connection is in the City's Comprehensive Plan, the Full Planned Growth traffic volumes assume the Kenrick Avenue Extension is in place.

The proposed traffic volumes are shown in Figure 2 of Appendix A.

## VI. Operational and Safety Analysis of Alternatives

Analysis was completed for the traffic volume scenarios for the A.M. and P.M. peak hours. The analysis was performed using the methodology of the 2000 Highway Capacity Manual. According to the Mn/DOT Intersection Control Evaluation Technical Memorandum No. 07-02-T-01, there are three primary traditional intersection types that can acceptably handle the forecasted traffic volumes at CSAH 50 and CSAH 60. These include a roundabout, signalized intersection, and grade separation. Non-traditional intersection options are limited in the area due to the limited right-of-way and the roadway network.

While grade separation of the intersection would alleviate the delay at the intersection, Dakota County typically does not consider an interchange at these traffic volume levels. It would require significant additional right-of-way at the intersection and the construction and right-of-way cost is expected to be prohibitive relative to the benefit.

Results of the analysis are displayed as measures of effectiveness as outlined above.

### A. Operational Analysis

Signalized Control

The existing traffic control signal at the intersection was evaluated to determine whether the installation of a signal is justified. This includes an investigation into the need for the traffic control signal through a traffic signal warrant analysis as outlined in the May 2005 (with 2007 and 2008 revisions)

Minnesota Manual on Uniform Traffic Control Devices **(MMUTCD)**. The existing traffic at the intersection was evaluated with respect to the traffic signal warrants outlined in Chapter 4C. Analysis of the existing traffic volumes results in the intersection meeting warrants for signalization. Warrants met include; Warrant 1, Eight Hour Vehicular Volumes; Warrant 2, Four Hour Volume; and Warrant 3, Peak Hour Volume and Delay. This analysis is included in Appendix E.

Analysis of the signal warrants analysis for future years was not completed since the warrants for signalization are currently met and the traffic volumes are at levels where the justification of signals or other comparable traffic control is necessary.

Current lane geometry was used for the initial signalized control analysis of the existing traffic. Proposed future lane needs increase the number of traffic lanes but these additional lanes do not change the warrants analysis.

The widening and reconstruction of the intersection includes analyzing what would be needed for the Full Planned Growth traffic volumes and then evaluating the design to accommodate the Build Year and 50% Planned Growth traffic volumes. The intersection design at Full Planned Growth is anticipated to include both CSAH 50 and CSAH 60 as four lane divided highways north, south, west, and east of the intersection. The signalized intersection design is not able to be scaled back to an interim design due to the lanes and right-of-way needed. While the intersection would remain the same, the lanes on CSAH 50 and 60 may be built in phases as necessary until Full Planned Growth.

A signal at this location would maintain acceptable operations with widening and reconstruction of the intersection and expansion to four lanes in all directions to maintain acceptable service levels.

**Table 5: Signalized Control Operational Analysis**

| Traffic Scenario | Intersection Design | Peak Hour | Intersection Delay*- LOS | Worst Movement Delay-LOS-v/c** | Worst Movements |
|---|---|---|---|---|---|
| Current | Existing 2-Lane 50/60 | AM | 36 sec. – D | 53 sec. – D – 0.90 | Westbound Left & Northbound Thru |
| | | PM | 50 sec. – D | 122 sec. – F – 1.01 | Eastbound Left & Southbound Thru |
| Build Year | Full 4-Lane 50/60 | AM | 24 sec. – C | 49 sec. – D – 0.71 | Westbound Left & Northbound Left |
| | | PM | 26 sec. – C | 57 sec. – E – 0.79 | Northbound Left |
| 50% Planned Growth*** | Full 4-Lane 50/60 | AM | 34 sec. – C | 81 sec. – F – 0.95 | Northbound Left & Westbound Left |
| | | PM | 33 sec. – C | 69 sec. – E – 0.90 | Eastbound Left & Northbound Left |
| Full Planned Growth*** | Full 4-Lane 50/60 | AM | 55 sec. – D | 104 sec. – F – 1.02 | Southbound Left & Westbound Left |
| | | PM | 50 sec. – D | 104 sec. – F – 1.04 | Westbound Left & Northbound Left |

*Delay in seconds per vehicle
** Maximum average delay, LOS, and v/c ratio on any approach and/or movement
*** Population and Employment Projections in Comprehensive Plans

The existing intersection design and traffic signal are not anticipated to provide acceptable operations through to Full Planned Growth.

A traffic signal with lane improvements is anticipated to provide acceptable operations for traffic through Full Planned Growth. By Full Planned Growth several movements are anticipated to operate with unacceptable delay, while the overall intersection would still have acceptable delay.

The signal analysis included the evaluation of vehicle queue lengths that are likely to appear with the proposed traffic. These queue lengths determine how long the turn lanes need to be and also provide a look into how the intersection would appear to be operating to the traveling public.

**Table 6: Signalized Queue Analysis**

| Traffic Scenario | Intersection Design | Peak Hour | Maximum Queue (ft.)* | | | |
|---|---|---|---|---|---|---|
| | | | North Leg | West Leg | South Leg | East Leg |
| Current | Existing 2-Lane 50/60 | AM | 255 | 195 | 605 | 200 |
| | | PM | 565 | 380 | 290 | 230 |
| Build Year | Full 4-Lane 50/60 | AM | 95 | 85 | 195 | 80 |
| | | PM | 195 | 125 | 125 | 95 |
| 50% Planned Growth*** | Full 4-Lane 50/60 | AM | 130 | 140 | 310 | 125 |
| | | PM | 240 | 220 | 150 | 165 |
| Full Planned Growth*** | Full 4-Lane 50/60 | AM | 215 | 380 | 490 | 230 |
| | | PM | 395 | 490 | 225 | 290 |

*Maximum queue length likely to be observed for each leg of the intersection during the weekday AM or PM peak hour.
*** Population and Employment Projections in Comprehensive Plans

The existing The queue lengths are acceptable, but indicate that some turn lanes may need to be extended up to 500'.

The Build Year and 50% Planned Growth traffic volumes were evaluated for the lane needs beyond the intersection. The analysis indicated the need for a four lane divided roadway for CSAH 50 north of the intersection and a four lane divided roadway for CSAH 60 west of the intersection. CSAH 50 south of the intersection and CSAH 60 east of the intersection could be accommodated with the existing two lane undivided roadways away from the intersection. The transition from a four lane divided roadway to a two lane undivided roadway would occur downstream of the intersection with lane drops east and south of the intersection. Analysis of the lane drop needs indicated that both lanes are necessary for a minimum of 550' east of the intersection and 800' south of the intersection. The actual lane drop transition would occur after this distance.

A layout of the signalized intersection concept design is included as Figure 3 in Appendix A.

Roundabout Control

With a change of traffic control to a roundabout, the reconstruction of the intersection would be necessary. The reconstruction of the intersection includes analyzing what roundabout configuration would be necessary to accommodate Build Year, 50% Planned Growth, and Full Planned Growth traffic volumes.

The widening and reconstruction of the intersection includes analyzing what would be needed for the Full Planned Growth traffic volumes. Similar to the traffic signal alternative, the intersection design at Full Planned Growth is anticipated to include both CSAH 50 and CSAH 60 as four lane divided highways north, south, west, and east of the intersection. The lanes on CSAH 50 and 60 may be built in phases as necessary until Full Planned Growth. Evaluation of the design to accommodate the 50% Planned Growth traffic volumes was also assessed.

Analysis was completed for 85% confidence levels. Based on Rodel analysis of roundabouts within MN, a confidence level of 85 is deemed to be appropriate and was used in the analysis of the CSAH 50/60 intersection evaluation. This was deemed to be an acceptable confidence level by Dakota County and the City of Lakeville that helps to account for the capacity reductions of roundabouts in this region of the country. As drivers get more familiar with roundabouts, it is expected that this confidence level may be modified when roundabouts will be able to handle higher volumes of traffic. The tables of the 15 minute data were collected from Rodel to ascertain the maximum queues and v/c ratios were during the peak 15 minute period.

**Table 7: Roundabout Control Operational Analysis (85 Confidence Level)**

| Traffic Scenario | Intersection Design | Peak Hour | Intersection Delay*- LOS | Worst Movement Delay-LOS-v/c** | Worst Movements |
|---|---|---|---|---|---|
| Build Year | Double-Lane | AM | 4 sec. – A | 4 sec. – A – 0.50 | Westbound & Northbound |
| | | PM | 5 sec. – A | 5 sec. – A – 0.63 | Eastbound & Southbound |
| 50% Planned Growth*** | Double-Lane | AM | 5 sec. – A | 7 sec. – A – 0.68 | Westbound & Northbound |
| | | PM | 6 sec. – A | 7 sec. – A – 0.72 | Eastbound & Southbound |
| Full Planned Growth*** | Double-Lane | AM | 16 sec. – C | 26 sec. – D – 0.97 | Westbound |
| | | PM | 57 sec. – E | 151 sec. – F – 1.11 | Eastbound |

| | | | | | |
|---|---|---|---|---|---|
| Full Planned Growth*** | Double-Lane with Free EBR | AM | 17 sec. – C | 25 sec. – C – 0.96 | Westbound |
| | | PM | 14 sec. – B | 23 sec. – C – 0.95 | Northbound & Southbound |

*Delay in seconds per vehicle
** Maximum average delay, LOS, and v/c ratio on any approach and/or movement
*** Population and Employment Projections in Comprehensive Plans

A single-lane roundabout is not anticipated to provide acceptable service levels with Build Year traffic volumes. Two lanes are needed for each approach into the roundabout. Consequently, a double-lane roundabout is needed to provide acceptable service levels in the Build Year. It is anticipated that with 50% Planned Growth the intersection would continue to operate acceptably during the AM and PM peak hours. With Full Planned Growth the roundabout is anticipated to have unacceptable service levels without any further improvements. An eastbound free right turn is anticipated to decrease delay for the critical eastbound movement and bring the intersection to acceptable service levels at Full Planned Growth.

**Table 8: Roundabout Queue Analysis**

| Traffic Scenario | Intersection Design | Peak Hour | Maximum Queue (ft.)* | | | |
|---|---|---|---|---|---|---|
| | | | North Leg | West Leg | South Leg | East Leg |
| Build Year | Double-Lane | AM | 20 | 20 | 30 | 20 |
| | | PM | 45 | 30 | 20 | 20 |
| 50% Planned Growth*** | Double-Lane | AM | 20 | 20 | 55 | 50 |
| | | PM | 65 | 60 | 35 | 40 |
| Full Planned Growth*** | Double-Lane | AM | 25 | 40 | 230 | 285 |
| | | PM | 250 | 1,840 | 140 | 115 |
| Full Planned Growth*** | Double-Lane with Free EBR | AM | 25 | 20 | 280 | 275 |
| | | PM | 250 | 105 | 180 | 115 |

*Maximum queue length likely to be observed for each leg of the intersection during the weekday AM or PM peak hour.
*** Population and Employment Projections in Comprehensive Plans

Queue Analysis indicates there may be queues of up to 300 feet on almost all of the intersection legs during either the AM or PM peak hour at Full Planned Growth. The traffic queues that will be observed by drivers are likely to be lower for a roundabout in the off-peak hours.

The roundabout intersection design is able to be scaled back to an interim design. This interim design would include reduction of traffic lanes away from the intersection.

The 50% Planned Growth traffic volumes were evaluated for the lane needs beyond the intersection. The analysis indicated the need for a four lane divided roadway for CSAH 50 north of the intersection and a four lane divided roadway for CSAH 60 west of the intersection. CSAH 50 south of the intersection and CSAH 60 east of the intersection could be accommodated with the existing two lane undivided roadways away from the intersection. The transition from a four lane roadway at the roundabout to a two lane undivided roadway would occur downstream of the intersection with lane drops east and south of the intersection. Analysis of the lane drop needs indicated that both lanes are necessary for a minimum of 350' east of the intersection and 450' south of the intersection. The actual lane drop transition would occur after this distance.

The Opening Year traffic volumes were evaluated for the lane needs beyond the intersection to the north and west. The analysis indicated that is not an Opening Year need for a four lane divided roadway for CSAH 50 north of the intersection and for CSAH 60 west of the intersection. CSAH 50 north of the intersection and CSAH 60 west of the intersection could be accommodated with the existing two lane undivided roadways away from the intersection. The transition from a four lane roadway at the roundabout to a two lane undivided roadway would occur downstream of the intersection with lane drops west and north of the intersection. Analysis of the lane drop needs indicated that both lanes are necessary for a minimum of 300' west of the intersection and 300' north of the intersection. The actual lane drop transition would occur after this distance. At the Build Year, the free right turn lane may be eliminated and constructed when needed by traffic.

A layout of the double-lane roundabout intersection concept design for the Opening Year with the option for the free right turn lane is included as Figure 4 in Appendix A.

Access Management

Implementing access management strategies along CSAH 50 and CSAH 60 ensures mobility and safety are maintained for these A-Minor Arterials. This functional classification designates spacing of at least ¼ mile for full movement intersections and spacing of ⅛ mile for secondary (right-in/right-out) access. As the intersection is reconstructed, the secondary accesses and driveways may change along the corridors to meet these access spacing requirements. This includes limiting movements as necessary to maintain safety and mobility.

### B. Safety Analysis

Safety is an important consideration when changing the traffic control at an intersection. Both a signal and roundabout will change the look and character of an intersection, altering how a motorist, bicyclist, or pedestrian will react to potential conflict. A change in intersection traffic control will also change the type of crashes and the expected number of crashes at an intersection.

The statewide average crash rate is 0.6 crashes per million entering vehicles (MEV). These crashes are distributed among the five different crash severities as shown in Table 9.

**Table 9: Crash Severity Type Distribution**

| Fatal | Incapacitating Injury | Non-Incapacitating Injury | Possible Injury | Property Damage Only | Total Crashes |
|---|---|---|---|---|---|
| 0.4% | 1.0% | 8.1% | 25.0% | 65.5% | 100.0% |

This data is used to predict the types of crashes anticipated as traffic volumes increase. This results in the predicted crashes as shown in Table 10 for the Base Alternative (existing traffic signal and lanes).

The safety of the intersection can be improved with the signal and roundabout intersection alternatives as shown in Table 10. The primary crash reduction of the signal and roundabout intersection alternatives is the reduction of injury crashes. For the signal alternative this is a result of a raised median which provides more pedestrian protection and separates traffic directions. It is anticipated that the median will reduce fatal and injury crashes by a factor of 0.25 according to national data.

For the roundabout alternative the injury reduction is a result of the angles of incidence, where right-angle crashes are virtually eliminated. It is anticipated that the roundabout will reduce injury crashes by a factor of 0.65 according to State of Minnesota data. The low speeds associated with roundabouts also allow drivers more time to react to potential conflicts and the differential speeds within a roundabout result in lower speed crashes. The installation of a signal usually involves rear-end type crashes, while the installation of a roundabout usually involves side-swipe crashes, which tend to be less severe and are more likely to be property damage only crashes as compared to injury type crashes.

**Table 10: Intersection Alternatives Crash Analysis**

| | Build Year | | | 50% Planned Growth | | | Full Planned Growth | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Annual Average Daily Traffic (AADT) Volume | 30,150 | | | 40,200 | | | 52,000 (with Kenrick Extension) | | | |
| | Predicted Number of Crashes of Each Severity Type per Year | | | | | | | | | |
| Alternative | Injury | PDO | Total | Injury | PDO | Total | Injury | PDO | Total | Crash Rate |
| Base [(1)*] | 3 | 4 | **7** | 3 | 6 | **9** | 4 | 7 | **11** | 0.60 |
| Signal [(2)*] | 2 | 4 | **6** | 2 | 6 | **8** | 3 | 7 | **10** | 0.55 |
| Roundabout [(3)*] | 1 | 4 | **5** | 1 | 6 | **7** | 1 | 7 | **8** | 0.44 |

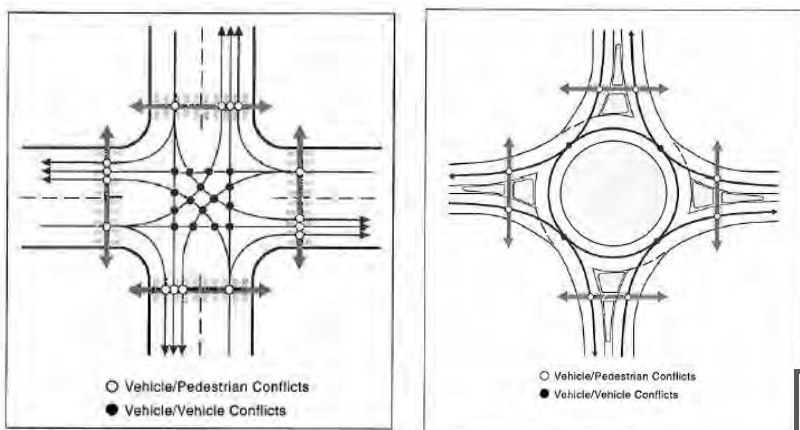
* Crashes determined using Highway Safety Manual methodology.
Crash Rate is measured as crashes per Million Entering Vehicles (MEV)

PDO= Property Damage Only
(1) Base = Existing Lanes with Signal Control
(2) Signal = Signal Control with Two Thru Lanes and Turn Lanes on All Approaches
(3) Roundabout = Double-Lane Roundabout

Crash frequency at intersections is measured based on the crash rate, which is shown as the crashes per million entering vehicles (MEV). The crash rates provide a safety comparison of the different traffic control options. The rates along with the total crashes for each alternative and each analysis year are provided in Table 10. Changes in traffic volume, delay, or capacity from the average can alter how the intersection operates. This can result in a situation where the average crash rates may no longer apply.

The roundabout does have fewer conflict points in comparison to a conventional intersection. Pedestrian conflict points are also reduced with a roundabout.

Vehicle-Pedestrian and Vehicle-Vehicle Conflict Points




Signalized Intersection Single-Lane Roundabout

Figures From:
Roundabouts: An Informational Guide
FHWA (Pub. No. FHWA-RD-00-067)

There is anticipated to be an increase in crashes as traffic volumes increase. This increase is anticipated to be less with the signal and roundabout intersection alternatives as compared to maintaining the current signal and lanes. With this intersection as a roundabout, there is expected to be a learning curve to the intersection design and operation. This learning curve is expected to result in an increase in crashes during the first year of opening. This learning curve is anticipated to subside as drivers become more comfortable with the intersection design and control as has been shown with other roundabouts in the State of Minnesota and throughout the United States. After the first year, the roundabout is anticipated to have crash rates lower than a signal as shown above. The roundabout is expected to result in fewer crashes and less severe crashes than the other alternatives.

## VII. Additional Considerations

Other items typically considered in this type of evaluation may include steep terrain issues, unconventional intersection geometry, adjacent intersections and coordinated signal systems, and system consistency.

Terrain

This intersection is located in an area with some terrain issues. To the west of the intersection the roadway drops in elevation. This elevation change will require evaluation of sight lines entering and exiting the intersection on the west leg. A roundabout is slightly more acceptable in these conditions since vehicles entering a roundabout only have to yield to movements directly in front of the approach lane and the roundabout can be designed with a tilt through the intersection. This is discouraged in signalized intersection design where each movement must be able to see all other movements. The signalized intersection alternative design would be located at the top of the hill, which will likely necessitate modifying the roadway grades on the hill, making it more difficult to match into the railroad crossing 0.2 miles to the west at the bottom of the hill.

Pedestrian and Bicycle Issues

Pedestrian safety is important at all intersections. Pedestrian safety can be measured by the number of pedestrian crashes but pedestrian crashes are random and data is much more difficult to come by. The presence of a pedestrian crash does not necessarily indicate that an intersection is unsafe and the absence of pedestrian crashes does not necessarily indicate that an intersection is safe.

Pedestrian safety can be evaluated using two other measures, vehicle travel speed and exposure time.  Lower vehicle speeds can reduce the severity of injuries when crashes occur. The following information is provided by the Insurance Institute for Highway Safety (IIHS).

**Table 11: Pedestrian Crash Severity and Vehicle Speed**

| Vehicle Speed | Chance of Fatal Crash |
|---|---|
| 40 MPH | 80% |
| 30 MPH | 40% |
| 20 MPH | 5% |

Exposure time accounts for the travel distance across an intersection and the time it takes for a pedestrian to cross the street. The less time a pedestrian is on the roadway, the less chance that they can be hit by a vehicle.

Pedestrian and bicycle facilities are accommodated equally under both options, but a roundabout has shorter crossing distances and the speed of vehicles through the intersection is lower with the roundabout. The signalized alternative has a long pedestrian exposure time (six to seven lanes plus a median to cross at a time for a total of approximately 22 to 25 seconds) and vehicle speeds across the pedestrians crossing is high at the speed limit of 45 to 50 mph. The roundabout alternative has a short pedestrian exposure time (two lanes to cross at a time for a total of approximately 8 seconds) and vehicle speeds across the pedestrians crossing are lower due to approach geometry that slows down traffic to approximately 25 mph.

Pedestrian facilities are provided at the existing intersection and would be integrated into either traffic control option. The sidewalk and trail facilities will accommodate pedestrian and bicycle travel at the intersection as well as connect the existing residential areas and parks near this intersection.

System Consistency

There are signalized intersections to the west (0.6 miles), north (0.7 miles), and east (1.0 miles) of the intersection. Either a traffic signal or roundabout would be an acceptable operational control feature. The adjacent signals will affect the operations at the intersection slightly. A roundabout at the intersection would not be the first roundabout for the City, but would be the first double-lane roundabout for the City. There is a single lane roundabout located at 175$^{th}$ Street/Kenrick Avenue to the north near the Lakeville Fire Station east of CSAH 50.

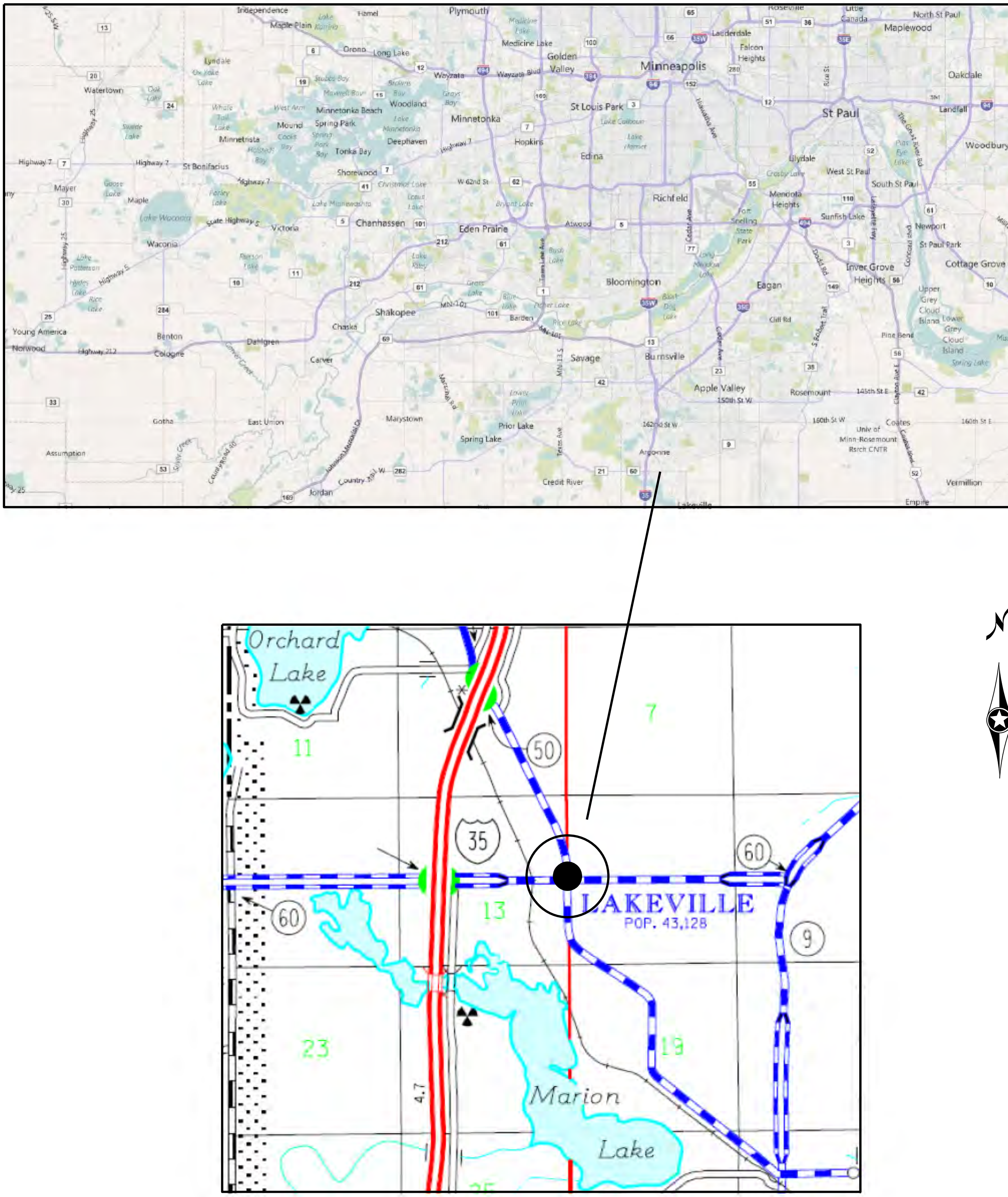
## VIII. Conclusion/Engineering Recommendations

Both the signal and roundabout alternatives are considered viable traffic control alternatives at this intersection location. The signal and roundabout each produce acceptable operation with respect to delay for traffic through the intersection until Full Planned Growth of the area. While both options are acceptable and could alleviate the recognized traffic control issues at the intersection, the best intersection control option provides minimal delay to traffic with a low crash rate potential at a low cost and fits with the nature of the roadway and community.

Based on the considerations of operations and safety analysis implementing the double-lane roundabout is recommended for this intersection to accommodate current and future traffic volumes.

## IX. Appendices

# APPENDIX A
Figures

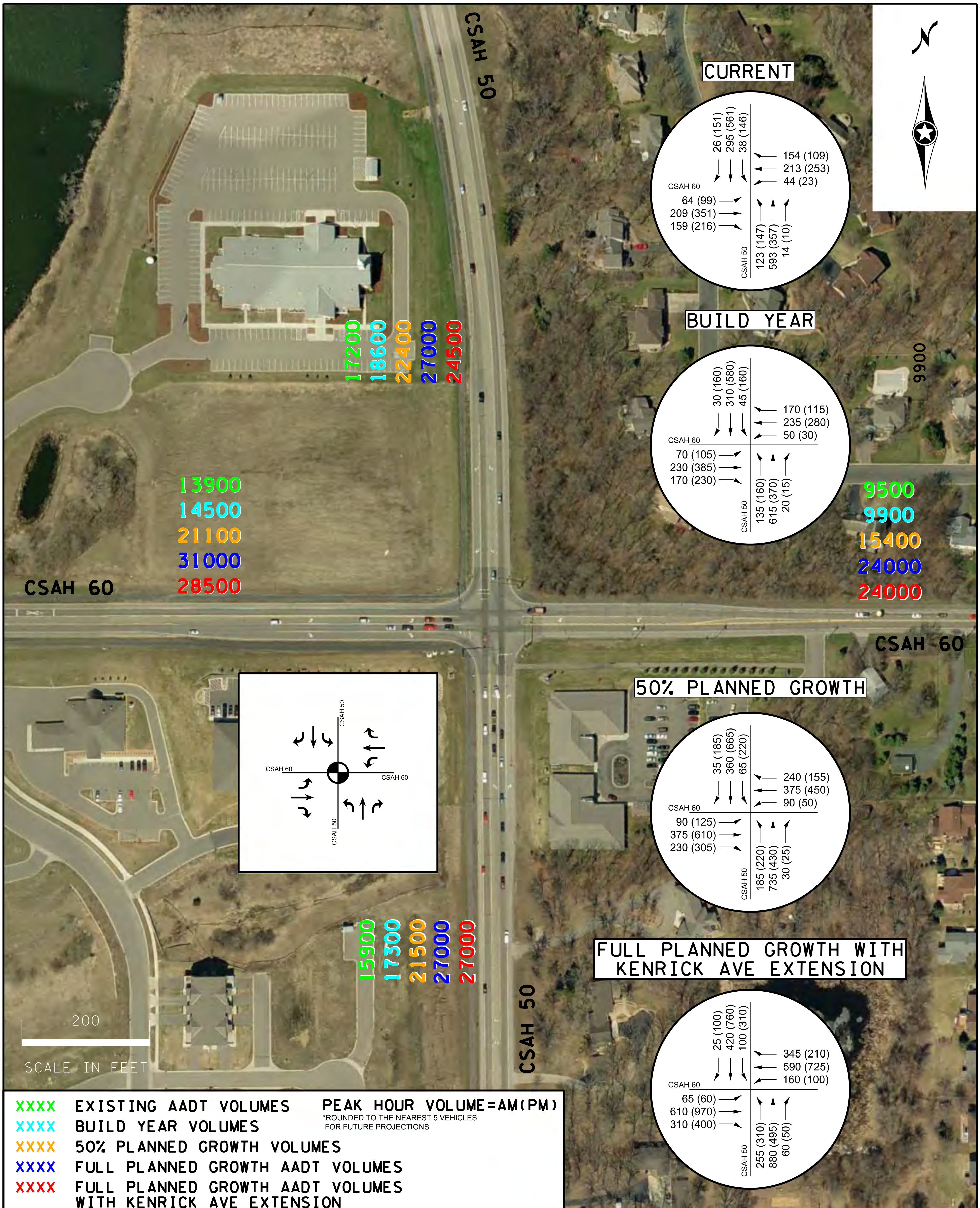



# FIGURE 1 LOCATION MAP

## CSAH 50(KENWOOD TR) AT CSAH 60(185TH ST) INTERSECTION CONTROL EVALUATION

BOLTON & MENK Engineers & Surveyors

Dakota County




XXXX EXISTING AADT VOLUMES

XXXX BUILD YEAR VOLUMES

XXXX 50% PLANNED GROWTH VOLUMES

XXXX FULL PLANNED GROWTH AADT VOLUMES

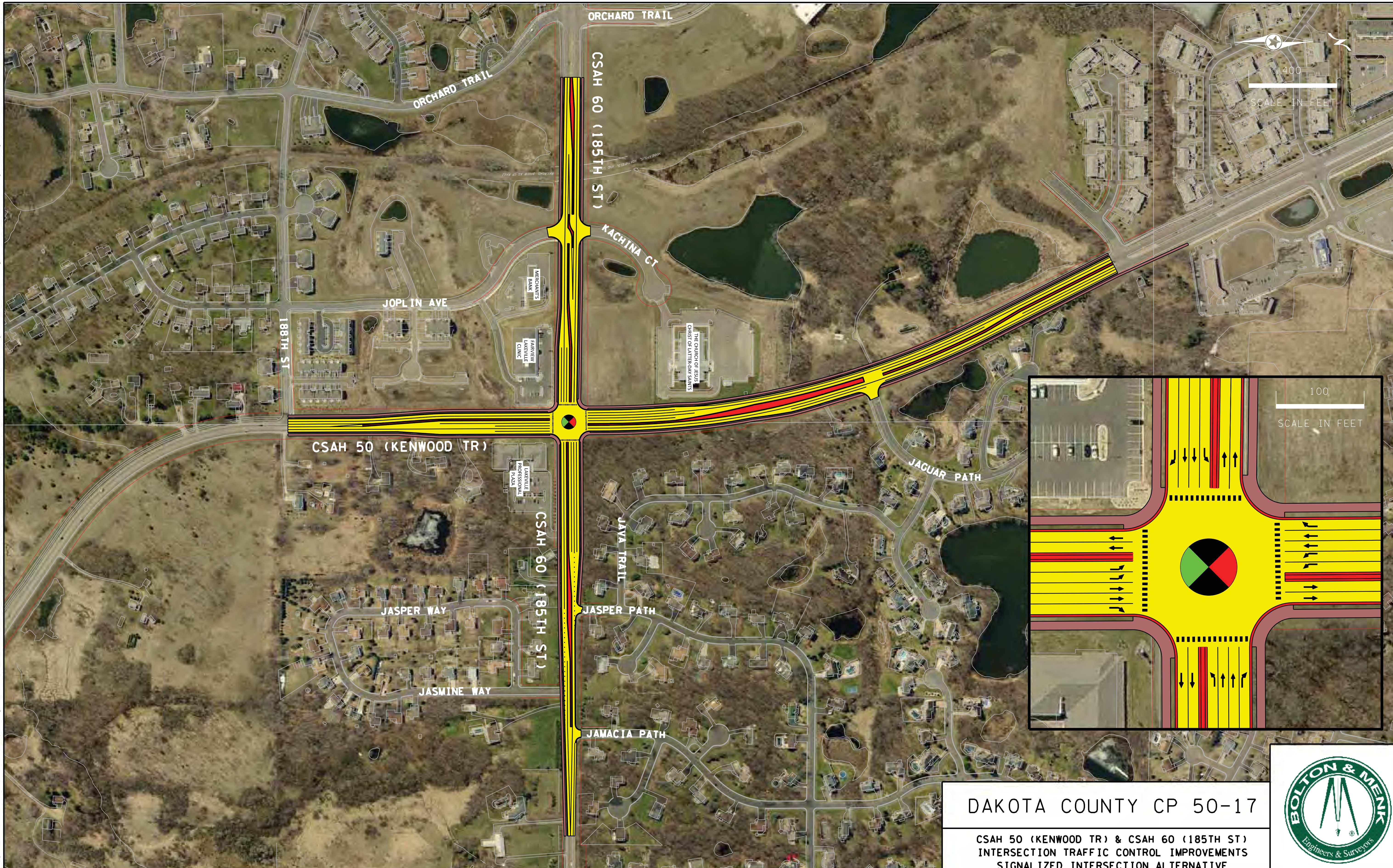
XXXX FULL PLANNED GROWTH AADT VOLUMES WITH KENRICK AVE EXTENSION

PEAK HOUR VOLUME=AM(PM)

*ROUNDED TO THE NEAREST 5 VEHICLES FOR FUTURE PROJECTIONS

# FIGURE 2 PEAK HOUR AND ANNUAL AVERAGE DAILY TRAFFIC

## CSAH 50(KENWOOD TR) AT CSAH 60(185TH ST) INTERSECTION CONTROL EVALUATION

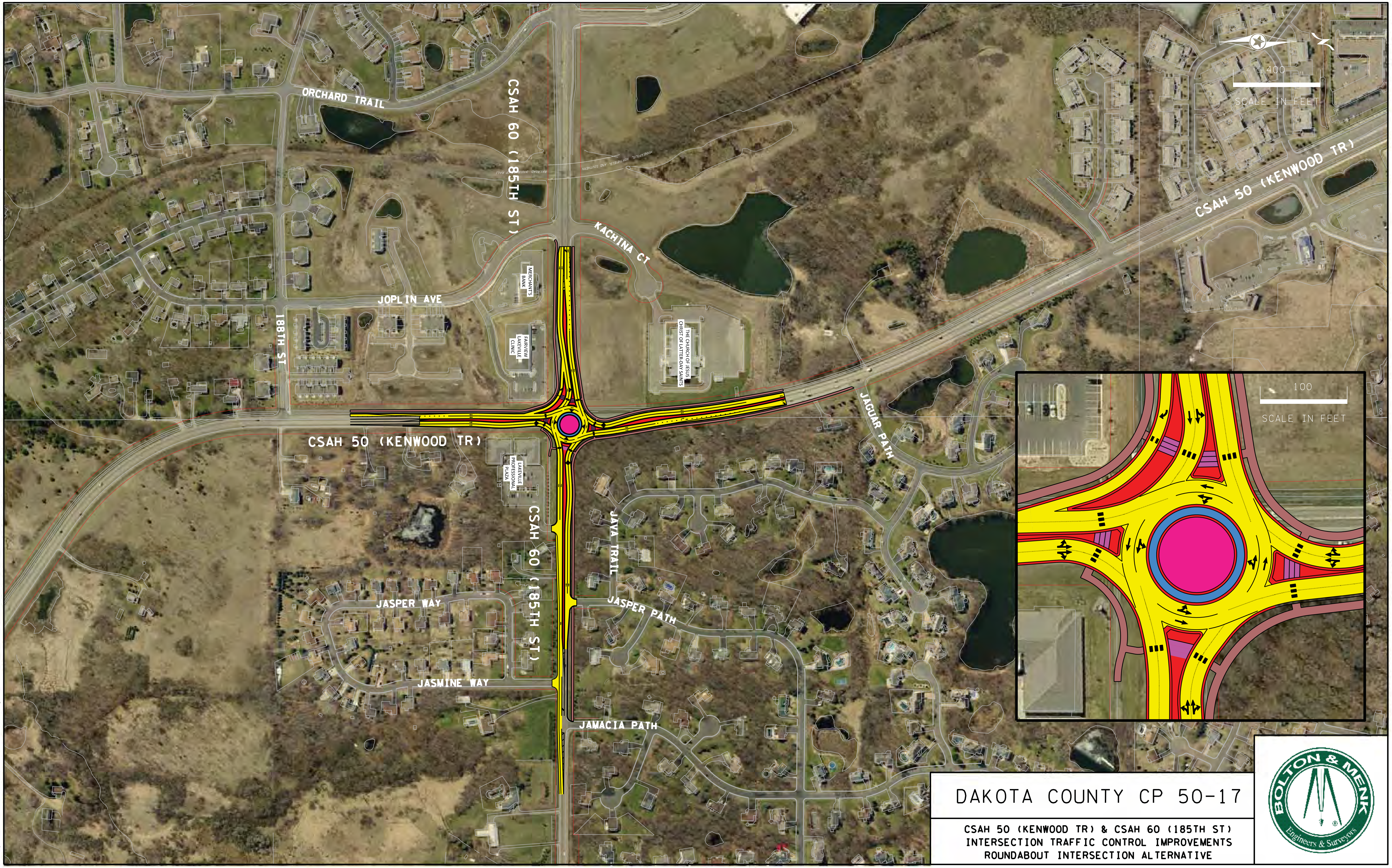



# DAKOTA COUNTY CP 50-17

CSAH 50 (KENWOOD TR) & CSAH 60 (185TH ST)
INTERSECTION TRAFFIC CONTROL IMPROVEMENTS
SIGNALIZED INTERSECTION ALTERNATIVE

BOLTON & MENK Engineers & Surveyors

H:\DACO\T42103034\figures\Preliminary Intersection Diagram.dgn 6:53:19 PM 7/5/2011 bmi.tbl pdf-color.pltcfg justinsc

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6:53:29 PM
7/5/2011
bmi.tbl
pdf-color.pltcfg
justinsc

DAKOTA COUNTY CP 50-17

CSAH 50 (KENWOOD TR) & CSAH 60 (185TH ST)
INTERSECTION TRAFFIC CONTROL IMPROVEMENTS
ROUNDABOUT INTERSECTION ALTERNATIVE

# APPENDIX B
Traffic Count Data

# Bolton & Menk, Inc.

Turning Movement Count

CSAH 50 at CSAH 60
Lakeville, MN

File Name : CSAH 50 at CSAH 60 - Whole Count
Site Code : 00000000
Start Date : 1/12/2011
Page No : 1

Groups Printed- Class 1

| | CSAH 50 Southbound | | | | | CSAH 60 Westbound | | | | | CSAH 50 Northbound | | | | | CSAH 60 Eastbound | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start Time | Rght | Thru | Left | Other | App. Total | Rght | Thru | Left | Other | App. Total | Rght | Thru | Left | Other | App. Total | Rght | Thru | Left | Other | App. Total | Int. Total |
| 06:00 AM | 3 | 13 | 2 | 0 | 18 | 17 | 32 | 0 | 0 | 49 | 0 | 86 | 12 | 0 | 98 | 14 | 14 | 7 | 0 | 35 | 200 |
| 06:15 AM | 1 | 49 | 6 | 0 | 56 | 19 | 40 | 0 | 0 | 59 | 1 | 96 | 20 | 0 | 117 | 13 | 24 | 7 | 0 | 44 | 276 |
| 06:30 AM | 6 | 58 | 8 | 0 | 72 | 37 | 61 | 3 | 0 | 101 | 0 | 132 | 25 | 0 | 157 | 21 | 28 | 9 | 0 | 58 | 388 |
| 06:45 AM | 8 | 77 | 10 | 0 | 95 | 33 | 49 | 7 | 0 | 89 | 4 | 137 | 21 | 0 | 162 | 39 | 40 | 11 | 0 | 90 | 436 |
| Total | 18 | 197 | 26 | 0 | 241 | 106 | 182 | 10 | 0 | 298 | 5 | 451 | 78 | 0 | 534 | 87 | 106 | 34 | 0 | 227 | 1300 |
| 07:00 AM | 2 | 89 | 14 | 0 | 105 | 40 | 54 | 33 | 0 | 127 | 4 | 134 | 20 | 0 | 158 | 57 | 39 | 10 | 0 | 106 | 496 |
| 07:15 AM | 5 | 66 | 4 | 0 | 75 | 50 | 64 | 4 | 0 | 118 | 2 | 158 | 44 | 0 | 204 | 38 | 57 | 13 | 0 | 108 | 505 |
| 07:30 AM | 11 | 70 | 6 | 0 | 87 | 41 | 43 | 6 | 0 | 90 | 3 | 166 | 34 | 0 | 203 | 28 | 55 | 21 | 0 | 104 | 484 |
| 07:45 AM | 8 | 70 | 14 | 0 | 92 | 23 | 52 | 1 | 0 | 76 | 5 | 135 | 25 | 0 | 165 | 36 | 58 | 20 | 0 | 114 | 447 |
| Total | 26 | 295 | 38 | 0 | 359 | 154 | 213 | 44 | 0 | 411 | 14 | 593 | 123 | 0 | 730 | 159 | 209 | 64 | 0 | 432 | 1932 |
| 08:00 AM | 8 | 45 | 14 | 0 | 67 | 41 | 43 | 3 | 0 | 87 | 2 | 118 | 31 | 0 | 151 | 31 | 40 | 11 | 0 | 82 | 387 |
| 08:15 AM | 8 | 43 | 9 | 0 | 60 | 33 | 43 | 0 | 0 | 76 | 4 | 110 | 32 | 0 | 146 | 26 | 33 | 18 | 0 | 77 | 359 |
| 08:30 AM | 20 | 44 | 21 | 0 | 85 | 25 | 42 | 3 | 0 | 70 | 1 | 87 | 15 | 0 | 103 | 17 | 45 | 14 | 0 | 76 | 334 |
| 08:45 AM | 12 | 60 | 10 | 0 | 82 | 24 | 51 | 2 | 0 | 77 | 3 | 80 | 22 | 0 | 105 | 20 | 56 | 20 | 0 | 96 | 360 |
| Total | 48 | 192 | 54 | 0 | 294 | 123 | 179 | 8 | 0 | 310 | 10 | 395 | 100 | 0 | 505 | 94 | 174 | 63 | 0 | 331 | 1440 |
| *** BREAK *** | | | | | | | | | | | | | | | | | | | | | |
| 03:30 PM | 32 | 116 | 27 | 0 | 175 | 18 | 52 | 4 | 0 | 74 | 7 | 105 | 36 | 0 | 148 | 52 | 65 | 13 | 0 | 130 | 527 |
| 03:45 PM | 36 | 126 | 19 | 0 | 181 | 26 | 68 | 7 | 0 | 101 | 2 | 103 | 55 | 0 | 160 | 52 | 72 | 10 | 0 | 134 | 576 |
| Total | 68 | 242 | 46 | 0 | 356 | 44 | 120 | 11 | 0 | 175 | 9 | 208 | 91 | 0 | 308 | 104 | 137 | 23 | 0 | 264 | 1103 |
| 04:00 PM | 31 | 115 | 26 | 0 | 172 | 22 | 79 | 3 | 0 | 104 | 3 | 113 | 39 | 0 | 155 | 64 | 58 | 17 | 0 | 139 | 570 |
| 04:15 PM | 40 | 121 | 24 | 0 | 185 | 51 | 54 | 2 | 0 | 107 | 6 | 101 | 36 | 0 | 143 | 66 | 71 | 20 | 0 | 157 | 592 |
| 04:30 PM | 30 | 127 | 36 | 0 | 193 | 30 | 59 | 7 | 0 | 96 | 6 | 86 | 42 | 0 | 134 | 61 | 102 | 24 | 0 | 187 | 610 |
| 04:45 PM | 45 | 133 | 42 | 0 | 220 | 19 | 54 | 3 | 0 | 76 | 2 | 96 | 33 | 0 | 131 | 51 | 85 | 34 | 0 | 170 | 597 |
| Total | 146 | 496 | 128 | 0 | 770 | 122 | 246 | 15 | 0 | 383 | 17 | 396 | 150 | 0 | 563 | 242 | 316 | 95 | 0 | 653 | 2369 |
| 05:00 PM | 45 | 138 | 31 | 0 | 214 | 26 | 58 | 3 | 0 | 87 | 0 | 109 | 32 | 0 | 141 | 52 | 101 | 24 | 0 | 177 | 619 |
| 05:15 PM | 29 | 133 | 37 | 0 | 199 | 21 | 55 | 2 | 0 | 78 | 3 | 84 | 47 | 0 | 134 | 70 | 94 | 17 | 0 | 181 | 592 |
| 05:30 PM | 37 | 129 | 33 | 0 | 199 | 34 | 84 | 9 | 0 | 127 | 5 | 82 | 28 | 0 | 115 | 50 | 75 | 23 | 0 | 148 | 589 |
| 05:45 PM | 40 | 161 | 45 | 0 | 246 | 28 | 56 | 9 | 0 | 93 | 2 | 82 | 40 | 0 | 124 | 44 | 81 | 35 | 0 | 160 | 623 |
| Total | 151 | 561 | 146 | 0 | 858 | 109 | 253 | 23 | 0 | 385 | 10 | 357 | 147 | 0 | 514 | 216 | 351 | 99 | 0 | 666 | 2423 |
| 06:00 PM | 50 | 130 | 27 | 0 | 207 | 26 | 55 | 3 | 0 | 84 | 2 | 90 | 38 | 0 | 130 | 47 | 85 | 27 | 0 | 159 | 580 |
| 06:15 PM | 41 | 122 | 33 | 0 | 196 | 16 | 69 | 4 | 0 | 89 | 4 | 81 | 33 | 0 | 118 | 42 | 75 | 22 | 0 | 139 | 542 |
| Grand Total | 548 | 2235 | 498 | 0 | 3281 | 700 | 1317 | 118 | 0 | 2135 | 71 | 2571 | 760 | 0 | 3402 | 991 | 1453 | 427 | 0 | 2871 | 11689 |
| Apprch % | 16.7 | 68.1 | 15.2 | 0 | | 32.8 | 61.7 | 5.5 | 0 | | 2.1 | 75.6 | 22.3 | 0 | | 34.5 | 50.6 | 14.9 | 0 | | |
| Total % | 4.7 | 19.1 | 4.3 | 0 | 28.1 | 6 | 11.3 | 1 | 0 | 18.3 | 0.6 | 22 | 6.5 | 0 | 29.1 | 8.5 | 12.4 | 3.7 | 0 | 24.6 | |

# Bolton & Menk, Inc.

Turning Movement Count

CSAH 50 at CSAH 60
Lakeville, MN

File Name : CSAH 50 at CSAH 60 - Whole Count
Site Code : 00000000
Start Date : 1/12/2011


| | CSAH 50 Southbound | | | | | CSAH 60 Westbound | | | | | CSAH 50 Northbound | | | | | CSAH 60 Eastbound | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start Time | Rght | Thru | Left | Other | App. Total | Rght | Thru | Left | Other | App. Total | Rght | Thru | Left | Other | App. Total | Rght | Thru | Left | Other | App. Total | Int. Total |
| Peak Hour Analysis From 06:00 AM to 09:00 AM - Peak 1 of 1 | | | | | | | | | | | | | | | | | | | | | |
| Peak Hour for Entire Intersection Begins at 07:00 AM | | | | | | | | | | | | | | | | | | | | | |
| 07:00 AM | 2 | **89** | **14** | 0 | **105** | 40 | 54 | **33** | 0 | **127** | 4 | 134 | 20 | 0 | 158 | **57** | 39 | 10 | 0 | 106 | 496 |
| 07:15 AM | 5 | 66 | 4 | 0 | 75 | **50** | **64** | 4 | 0 | 118 | 2 | 158 | **44** | 0 | **204** | 38 | 57 | 13 | 0 | 108 | **505** |
| 07:30 AM | **11** | 70 | 6 | 0 | 87 | 41 | 43 | 6 | 0 | 90 | 3 | **166** | 34 | 0 | 203 | 28 | 55 | **21** | 0 | 104 | 484 |
| 07:45 AM | 8 | 70 | 14 | 0 | 92 | 23 | 52 | 1 | 0 | 76 | **5** | 135 | 25 | 0 | 165 | 36 | **58** | 20 | 0 | **114** | 447 |
| Total Volume | 26 | 295 | 38 | 0 | 359 | 154 | 213 | 44 | 0 | 411 | 14 | 593 | 123 | 0 | 730 | 159 | 209 | 64 | 0 | 432 | 1932 |
| % App. Total | 7.2 | 82.2 | 10.6 | 0 | | 37.5 | 51.8 | 10.7 | 0 | | 1.9 | 81.2 | 16.8 | 0 | | 36.8 | 48.4 | 14.8 | 0 | | |
| PHF | .591 | .829 | .679 | .000 | .855 | .770 | .832 | .333 | .000 | .809 | .700 | .893 | .699 | .000 | .895 | .697 | .901 | .762 | .000 | .947 | .956 |
| Peak Hour Analysis From 03:30 PM to 06:15 PM - Peak 1 of 1 | | | | | | | | | | | | | | | | | | | | | |
| Peak Hour for Entire Intersection Begins at 05:00 PM | | | | | | | | | | | | | | | | | | | | | |
| 05:00 PM | **45** | 138 | 31 | 0 | 214 | 26 | 58 | 3 | 0 | 87 | 0 | **109** | 32 | 0 | **141** | 52 | **101** | 24 | 0 | 177 | 619 |
| 05:15 PM | 29 | 133 | 37 | 0 | 199 | 21 | 55 | 2 | 0 | 78 | 3 | 84 | **47** | 0 | 134 | **70** | 94 | 17 | 0 | **181** | 592 |
| 05:30 PM | 37 | 129 | 33 | 0 | 199 | **34** | **84** | **9** | 0 | **127** | **5** | 82 | 28 | 0 | 115 | 50 | 75 | 23 | 0 | 148 | 589 |
| 05:45 PM | 40 | **161** | **45** | 0 | **246** | 28 | 56 | 9 | 0 | 93 | 2 | 82 | 40 | 0 | 124 | 44 | 81 | **35** | 0 | 160 | **623** |
| Total Volume | 151 | 561 | 146 | 0 | 858 | 109 | 253 | 23 | 0 | 385 | 10 | 357 | 147 | 0 | 514 | 216 | 351 | 99 | 0 | 666 | 2423 |
| % App. Total | 17.6 | 65.4 | 17 | 0 | | 28.3 | 65.7 | 6 | 0 | | 1.9 | 69.5 | 28.6 | 0 | | 32.4 | 52.7 | 14.9 | 0 | | |
| PHF | .839 | .871 | .811 | .000 | .872 | .801 | .753 | .639 | .000 | .758 | .500 | .819 | .782 | .000 | .911 | .771 | .869 | .707 | .000 | .920 | .972 |

**AVERAGE DAILY TRAFFIC VOLUME CALCUATIONS**

**CP 50-17: CSAH 50 (Kenwood Trail) and CSAH 60 (185th Street) Intersection Traffic Control Improvements**

**Lakeville, Dakota County, MN**

| | EAST LEG | | | | WEST LEG | | | | NORTH LEG | | | | SOUTH LEG | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TIME | 1/12/2011 | 1/18/2011 | 1/25/2011 | AVERAGE | 1/12/2011 | 1/18/2011 | 1/25/2011 | AVERAGE | 1/12/2011 | 1/18/2011 | 1/25/2011 | AVERAGE | 1/12/2011 | 1/18/2011 | 1/25/2011 | AVERAGE |
| 12:00 AM | 20 | | | 20 | 52 | 34 | | 43 | | 47 | 40 | 44 | 29 | | 36 | 33 |
| 1:00 AM | 12 | | | 12 | 33 | 43 | | 38 | | 20 | 20 | 20 | 31 | | 29 | 30 |
| 2:00 AM | 3 | | | 3 | 19 | 29 | | 24 | | 26 | 18 | 22 | 16 | | 22 | 19 |
| 3:00 AM | 9 | | | 9 | 16 | 17 | | 17 | | 10 | 15 | 13 | 17 | | 14 | 16 |
| 4:00 AM | 22 | | | 22 | 42 | 38 | | 40 | | 75 | 71 | 73 | 46 | | 53 | 50 |
| 5:00 AM | 95 | | | 95 | 69 | 75 | | 72 | | 74 | 85 | 80 | 180 | | 186 | 183 |
| 6:00 AM | 292 | | | 292 | 255 | | | 255 | | 22 | 238 | 130 | 540 | | 543 | 542 |
| 7:00 AM | 395 | | | 395 | 422 | | | 422 | | | 382 | 382 | 741 | | 765 | 753 |
| 8:00 AM | 316 | | | 316 | 326 | | | 326 | | | 282 | 282 | 544 | | 542 | 543 |
| 9:00 AM | 242 | | | 242 | 330 | 297 | | 314 | | | 295 | 295 | 469 | | 474 | 472 |
| 10:00 AM | | 237 | | 237 | | 303 | | 303 | | 323 | 303 | 313 | | | 355 | 355 |
| 11:00 AM | | 271 | | 271 | | 302 | | 302 | | 434 | 440 | 437 | | | 393 | 393 |
| 12:00 PM | | 242 | | 242 | | 383 | | 383 | | 503 | 505 | 504 | | | 456 | 456 |
| 1:00 PM | | 251 | | 251 | | 365 | | 365 | | 523 | 492 | 508 | | | 389 | 389 |
| 2:00 PM | | 274 | | 274 | | 466 | | 466 | | 630 | 597 | 614 | 525 | | 523 | 524 |
| 3:00 PM | 313 | 353 | | 333 | 589 | 574 | | 582 | | 841 | 707 | 774 | 650 | | 691 | 671 |
| 4:00 PM | 411 | 387 | | 399 | 653 | 707 | | 680 | | 830 | 895 | 863 | 616 | | 639 | 628 |
| 5:00 PM | 386 | 362 | | 374 | 783 | 748 | | 766 | | 877 | 860 | 869 | 574 | | 529 | 552 |
| 6:00 PM | 344 | 294 | | 319 | 596 | 501 | | 549 | | 653 | 637 | 645 | 476 | | 439 | 458 |
| 7:00 PM | 256 | 193 | | 225 | 393 | 378 | | 386 | | 474 | 464 | 469 | 304 | | 349 | 327 |
| 8:00 PM | 223 | 215 | | 219 | 366 | 315 | | 341 | | 351 | 351 | 351 | 265 | | 315 | 290 |
| 9:00 PM | 229 | 141 | | 185 | 239 | 221 | | 230 | | 265 | 259 | 262 | 154 | | 264 | 209 |
| 10:00 PM | 97 | 78 | | 88 | 119 | 108 | | 114 | | 142 | 111 | 127 | 71 | | 89 | 80 |
| 11:00 PM | 37 | **34** | | **36** | 96 | 59 | | 78 | | 71 | 87 | 79 | 48 | | 54 | 51 |
| | | **EAST LEG ADT =** | | **4859** | | **WEST LEG ADT =** | | **7096** | | **NORTH LEG ADT =** | | **8156** | | **SOUTH LEG ADT =** | | **8024** |

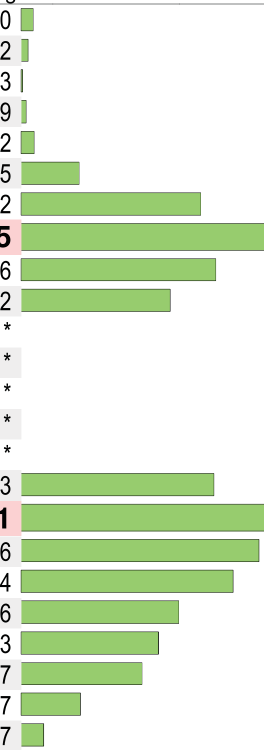
# Bolton & Menk, Inc.

Hourly Volume Count



Site Code: 000002222222
Station ID:
CSAH 50 at CSAH 60 - East Leg
Lakeville, MN
Latitude: 0' 0.000 Undefined

| Start Time | Mon 10-Jan-11 | Tue 11-Jan-11 | Wed 12-Jan-11 | Thu 13-Jan-11 | Fri 14-Jan-11 | Average Day | Sat 15-Jan-11 | Sun 16-Jan-11 | Week Average |
|---|---|---|---|---|---|---|---|---|---|
| 12:00 AM | * | * | * | 20 | * | 20 | * | * | 20 |
| 01:00 | * | * | * | 12 | * | 12 | * | * | 12 |
| 02:00 | * | * | * | 3 | * | 3 | * | * | 3 |
| 03:00 | * | * | * | 9 | * | 9 | * | * | 9 |
| 04:00 | * | * | * | 22 | * | 22 | * | * | 22 |
| 05:00 | * | * | * | 95 | * | 95 | * | * | 95 |
| 06:00 | * | * | * | 292 | * | 292 | * | * | 292 |
| 07:00 | * | * | * | **395** | * | **395** | * | * | **395** |
| 08:00 | * | * | * | 316 | * | 316 | * | * | 316 |
| 09:00 | * | * | * | 242 | * | 242 | * | * | 242 |
| 10:00 | * | * | * | * | * | * | * | * | * |
| 11:00 | * | * | * | * | * | * | * | * | * |
| 12:00 PM | * | * | * | * | * | * | * | * | * |
| 01:00 | * | * | * | * | * | * | * | * | * |
| 02:00 | * | * | * | * | * | * | * | * | * |
| 03:00 | * | * | 313 | * | * | 313 | * | * | 313 |
| 04:00 | * | * | **411** | * | * | **411** | * | * | **411** |
| 05:00 | * | * | 386 | * | * | 386 | * | * | 386 |
| 06:00 | * | * | 344 | * | * | 344 | * | * | 344 |
| 07:00 | * | * | 256 | * | * | 256 | * | * | 256 |
| 08:00 | * | * | 223 | * | * | 223 | * | * | 223 |
| 09:00 | * | * | 197 | * | * | 197 | * | * | 197 |
| 10:00 | * | * | 97 | * | * | 97 | * | * | 97 |
| 11:00 | * | * | 37 | * | * | 37 | * | * | 37 |
| Day Total | 0 | 0 | 2264 | 1406 | 0 | 3670 | 0 | 0 | 3670 |
| % Avg. WkDay | 0.0% | 0.0% | 61.7% | 38.3% | 0.0% | | | | |
| % Avg. Week | 0.0% | 0.0% | 61.7% | 38.3% | 0.0% | 100.0% | 0.0% | 0.0% | |
| AM Peak | | | | 07:00 | | 07:00 | | | 07:00 |
| Vol. | | | | 395 | | 395 | | | 395 |
| PM Peak | | | 16:00 | | | 16:00 | | | 16:00 |
| Vol. | | | 411 | | | 411 | | | 411 |
| Grand Total | 0 | 0 | 2264 | 1406 | 0 | 3670 | 0 | 0 | 3670 |



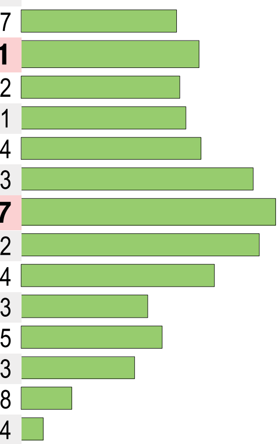
ADT Not Calculated

# Bolton & Menk, Inc.

Hourly Volume Count

Site Code: 000033333333
Station ID:
CSAH 50 at CSAH 60 - East Leg
Lakeville, MN
Latitude: 0' 0.000 Undefined

| Start Time | Mon 17-Jan-11 | Tue 18-Jan-11 | Wed 19-Jan-11 | Thu 20-Jan-11 | Fri 21-Jan-11 | Average Day | Sat 22-Jan-11 | Sun 23-Jan-11 | Week Average |
|---|---|---|---|---|---|---|---|---|---|
| 12:00 AM | * | * | * | * | * | * | * | * | * |
| 01:00 | * | * | * | * | * | * | * | * | * |
| 02:00 | * | * | * | * | * | * | * | * | * |
| 03:00 | * | * | * | * | * | * | * | * | * |
| 04:00 | * | * | * | * | * | * | * | * | * |
| 05:00 | * | * | * | * | * | * | * | * | * |
| 06:00 | * | * | * | * | * | * | * | * | * |
| 07:00 | * | * | * | * | * | * | * | * | * |
| 08:00 | * | * | * | * | * | * | * | * | * |
| 09:00 | * | * | * | * | * | * | * | * | * |
| 10:00 | * | 237 | * | * | * | 237 | * | * | 237 |
| 11:00 | * | **271** | * | * | * | **271** | * | * | **271** |
| 12:00 PM | * | 242 | * | * | * | 242 | * | * | 242 |
| 01:00 | * | 251 | * | * | * | 251 | * | * | 251 |
| 02:00 | * | 274 | * | * | * | 274 | * | * | 274 |
| 03:00 | * | 353 | * | * | * | 353 | * | * | 353 |
| 04:00 | * | **387** | * | * | * | **387** | * | * | **387** |
| 05:00 | * | 362 | * | * | * | 362 | * | * | 362 |
| 06:00 | * | 294 | * | * | * | 294 | * | * | 294 |
| 07:00 | * | 193 | * | * | * | 193 | * | * | 193 |
| 08:00 | * | 215 | * | * | * | 215 | * | * | 215 |
| 09:00 | * | 173 | * | * | * | 173 | * | * | 173 |
| 10:00 | * | 78 | * | * | * | 78 | * | * | 78 |
| 11:00 | * | 34 | * | * | * | 34 | * | * | 34 |
| Day Total | 0 | 3364 | 0 | 0 | 0 | 3364 | 0 | 0 | 3364 |
| % Avg. WkDay | 0.0% | 100.0% | 0.0% | 0.0% | 0.0% | | | | |
| % Avg. Week | 0.0% | 100.0% | 0.0% | 0.0% | 0.0% | 100.0% | 0.0% | 0.0% | |
| AM Peak | | 11:00 | | | | 11:00 | | | 11:00 |
| Vol. | | 271 | | | | 271 | | | 271 |
| PM Peak | | 16:00 | | | | 16:00 | | | 16:00 |
| Vol. | | 387 | | | | 387 | | | 387 |
| Grand Total | 0 | 3364 | 0 | 0 | 0 | 3364 | 0 | 0 | 3364 |



ADT    ADT 286    AADT 286

# Bolton & Menk, Inc.

Hourly Volume Count



Site Code: 000000444444
Station ID:
CSAH 50 at CSAH 60 - West Leg
Lakeville, MN
Latitude: 0' 0.000 Undefined

| Start Time | Mon 10-Jan-11 | Tue 11-Jan-11 | Wed 12-Jan-11 | Thu 13-Jan-11 | Fri 14-Jan-11 | Average Day | Sat 15-Jan-11 | Sun 16-Jan-11 | Week Average |
|---|---|---|---|---|---|---|---|---|---|
| 12:00 AM | * | * | * | 52 | * | 52 | * | * | 52 |
| 01:00 | * | * | * | 33 | * | 33 | * | * | 33 |
| 02:00 | * | * | * | 19 | * | 19 | * | * | 19 |
| 03:00 | * | * | * | 16 | * | 16 | * | * | 16 |
| 04:00 | * | * | * | 42 | * | 42 | * | * | 42 |
| 05:00 | * | * | * | 69 | * | 69 | * | * | 69 |
| 06:00 | * | * | * | 255 | * | 255 | * | * | 255 |
| 07:00 | * | * | * | **422** | * | **422** | * | * | **422** |
| 08:00 | * | * | * | 326 | * | 326 | * | * | 326 |
| 09:00 | * | * | * | 330 | * | 330 | * | * | 330 |
| 10:00 | * | * | * | * | * | * | * | * | * |
| 11:00 | * | * | * | * | * | * | * | * | * |
| 12:00 PM | * | * | * | * | * | * | * | * | * |
| 01:00 | * | * | * | * | * | * | * | * | * |
| 02:00 | * | * | * | * | * | * | * | * | * |
| 03:00 | * | * | 589 | * | * | 589 | * | * | 589 |
| 04:00 | * | * | 653 | * | * | 653 | * | * | 653 |
| 05:00 | * | * | **783** | * | * | **783** | * | * | **783** |
| 06:00 | * | * | 596 | * | * | 596 | * | * | 596 |
| 07:00 | * | * | 393 | * | * | 393 | * | * | 393 |
| 08:00 | * | * | 366 | * | * | 366 | * | * | 366 |
| 09:00 | * | * | 239 | * | * | 239 | * | * | 239 |
| 10:00 | * | * | 119 | * | * | 119 | * | * | 119 |
| 11:00 | * | * | 96 | * | * | 96 | * | * | 96 |
| Day Total | 0 | 0 | 3834 | 1564 | 0 | 5398 | 0 | 0 | 5398 |
| % Avg. WkDay | 0.0% | 0.0% | 71.0% | 29.0% | 0.0% | | | | |
| % Avg. Week | 0.0% | 0.0% | 71.0% | 29.0% | 0.0% | 100.0% | 0.0% | 0.0% | |
| AM Peak | | | | 07:00 | | 07:00 | | | 07:00 |
| Vol. | | | | 422 | | 422 | | | 422 |
| PM Peak | | | 17:00 | | | 17:00 | | | 17:00 |
| Vol. | | | 783 | | | 783 | | | 783 |
| Grand Total | 0 | 0 | 3834 | 1564 | 0 | 5398 | 0 | 0 | 5398 |

ADT Not Calculated

# Bolton & Menk, Inc.

Hourly Volume Count

Site Code: 000000111111
Station ID:
CSAH 50 at CSAH 60 - West Leg
Lakeville, MN
Latitude: 0' 0.000 Undefined

| Start Time | Mon 17-Jan-11 | Tue 18-Jan-11 | Wed 19-Jan-11 | Thu 20-Jan-11 | Fri 21-Jan-11 | Average Day | Sat 22-Jan-11 | Sun 23-Jan-11 | Week Average |
|---|---|---|---|---|---|---|---|---|---|
| 12:00 AM | * | * | 34 | * | * | 34 | * | * | 34 |
| 01:00 | * | * | 43 | * | * | 43 | * | * | 43 |
| 02:00 | * | * | 29 | * | * | 29 | * | * | 29 |
| 03:00 | * | * | 17 | * | * | 17 | * | * | 17 |
| 04:00 | * | * | 38 | * | * | 38 | * | * | 38 |
| 05:00 | * | * | **75** | * | * | 75 | * | * | 75 |
| 06:00 | * | * | * | * | * | * | * | * | * |
| 07:00 | * | * | * | * | * | * | * | * | * |
| 08:00 | * | * | * | * | * | * | * | * | * |
| 09:00 | * | 297 | * | * | * | 297 | * | * | 297 |
| 10:00 | * | **303** | * | * | * | **303** | * | * | **303** |
| 11:00 | * | 302 | * | * | * | 302 | * | * | 302 |
| 12:00 PM | * | 383 | * | * | * | 383 | * | * | 383 |
| 01:00 | * | 365 | * | * | * | 365 | * | * | 365 |
| 02:00 | * | 466 | * | * | * | 466 | * | * | 466 |
| 03:00 | * | 574 | * | * | * | 574 | * | * | 574 |
| 04:00 | * | 707 | * | * | * | 707 | * | * | 707 |
| 05:00 | * | **748** | * | * | * | **748** | * | * | **748** |
| 06:00 | * | 501 | * | * | * | 501 | * | * | 501 |
| 07:00 | * | 378 | * | * | * | 378 | * | * | 378 |
| 08:00 | * | 315 | * | * | * | 315 | * | * | 315 |
| 09:00 | * | 221 | * | * | * | 221 | * | * | 221 |
| 10:00 | * | 108 | * | * | * | 108 | * | * | 108 |
| 11:00 | * | 59 | * | * | * | 59 | * | * | 59 |
| Day Total | 0 | 5727 | 236 | 0 | 0 | 5963 | 0 | 0 | 5963 |
| % Avg. WkDay | 0.0% | 96.0% | 4.0% | 0.0% | 0.0% | | | | |
| % Avg. Week | 0.0% | 96.0% | 4.0% | 0.0% | 0.0% | 100.0% | 0.0% | 0.0% | |
| AM Peak | | 10:00 | 05:00 | | | 10:00 | | | 10:00 |
| Vol. | | 303 | 75 | | | 303 | | | 303 |
| PM Peak | | 17:00 | | | | 17:00 | | | 17:00 |
| Vol. | | 748 | | | | 748 | | | 748 |
| Grand Total | 0 | 5727 | 236 | 0 | 0 | 5963 | 0 | 0 | 5963 |

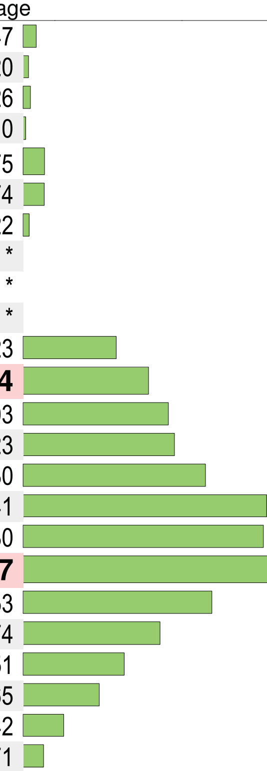
ADT    ADT 527    AADT 527

# Bolton & Menk, Inc.

Hourly Volume Count

Site Code: 000002222222
Station ID:
CSAH 50 at CSAH 60 - North Leg
Lakeville, MN
Latitude: 0' 0.000 Undefined

| Start Time | Mon 17-Jan-11 | Tue 18-Jan-11 | Wed 19-Jan-11 | Thu 20-Jan-11 | Fri 21-Jan-11 | Average Day | Sat 22-Jan-11 | Sun 23-Jan-11 | Week Average |
|---|---|---|---|---|---|---|---|---|---|
| 12:00 AM | * | * | 47 | * | * | 47 | * | * | 47 |
| 01:00 | * | * | 20 | * | * | 20 | * | * | 20 |
| 02:00 | * | * | 26 | * | * | 26 | * | * | 26 |
| 03:00 | * | * | 10 | * | * | 10 | * | * | 10 |
| 04:00 | * | * | **75** | * | * | 75 | * | * | 75 |
| 05:00 | * | * | 74 | * | * | 74 | * | * | 74 |
| 06:00 | * | * | 22 | * | * | 22 | * | * | 22 |
| 07:00 | * | * | * | * | * | * | * | * | * |
| 08:00 | * | * | * | * | * | * | * | * | * |
| 09:00 | * | * | * | * | * | * | * | * | * |
| 10:00 | * | 323 | * | * | * | 323 | * | * | 323 |
| 11:00 | * | **434** | * | * | * | **434** | * | * | **434** |
| 12:00 PM | * | 503 | * | * | * | 503 | * | * | 503 |
| 01:00 | * | 523 | * | * | * | 523 | * | * | 523 |
| 02:00 | * | 630 | * | * | * | 630 | * | * | 630 |
| 03:00 | * | 841 | * | * | * | 841 | * | * | 841 |
| 04:00 | * | 830 | * | * | * | 830 | * | * | 830 |
| 05:00 | * | **877** | * | * | * | **877** | * | * | **877** |
| 06:00 | * | 653 | * | * | * | 653 | * | * | 653 |
| 07:00 | * | 474 | * | * | * | 474 | * | * | 474 |
| 08:00 | * | 351 | * | * | * | 351 | * | * | 351 |
| 09:00 | * | 265 | * | * | * | 265 | * | * | 265 |
| 10:00 | * | 142 | * | * | * | 142 | * | * | 142 |
| 11:00 | * | 71 | * | * | * | 71 | * | * | 71 |
| Day Total | 0 | 6917 | 274 | 0 | 0 | 7191 | 0 | 0 | 7191 |
| % Avg. WkDay | 0.0% | 96.2% | 3.8% | 0.0% | 0.0% | | | | |
| % Avg. Week | 0.0% | 96.2% | 3.8% | 0.0% | 0.0% | 100.0% | 0.0% | 0.0% | |
| AM Peak | | 11:00 | 04:00 | | | 11:00 | | | 11:00 |
| Vol. | | 434 | 75 | | | 434 | | | 434 |
| PM Peak | | 17:00 | | | | 17:00 | | | 17:00 |
| Vol. | | 877 | | | | 877 | | | 877 |
| Grand Total | 0 | 6917 | 274 | 0 | 0 | 7191 | 0 | 0 | 7191 |



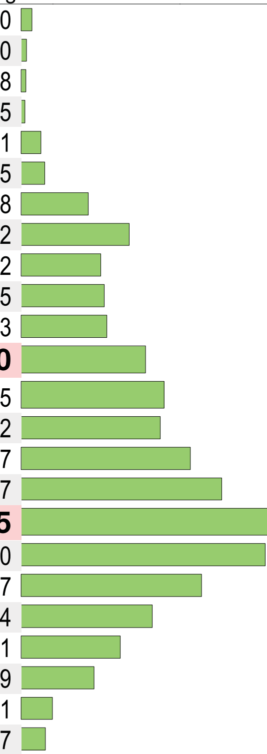
ADT    ADT 278    AADT 278

# Bolton & Menk, Inc.

Hourly Volume Count

Site Code: 000002222222
Station ID:
CSAH 50 at CSAH 60- North Leg
Lakeville, MN
Latitude: 0' 0.000 Undefined

| Start Time | Mon 24-Jan-11 | Tue 25-Jan-11 | Wed 26-Jan-11 | Thu 27-Jan-11 | Fri 28-Jan-11 | Average Day | Sat 29-Jan-11 | Sun 30-Jan-11 | Week Average |
|---|---|---|---|---|---|---|---|---|---|
| 12:00 AM | * | * | 40 | * | * | 40 | * | * | 40 |
| 01:00 | * | * | 20 | * | * | 20 | * | * | 20 |
| 02:00 | * | * | 18 | * | * | 18 | * | * | 18 |
| 03:00 | * | * | 15 | * | * | 15 | * | * | 15 |
| 04:00 | * | * | 71 | * | * | 71 | * | * | 71 |
| 05:00 | * | * | 85 | * | * | 85 | * | * | 85 |
| 06:00 | * | * | 238 | * | * | 238 | * | * | 238 |
| 07:00 | * | * | 382 | * | * | 382 | * | * | 382 |
| 08:00 | * | * | 282 | * | * | 282 | * | * | 282 |
| 09:00 | * | * | 295 | * | * | 295 | * | * | 295 |
| 10:00 | * | * | 303 | * | * | 303 | * | * | 303 |
| 11:00 | * | * | **440** | * | * | **440** | * | * | **440** |
| 12:00 PM | * | * | **505** | * | * | 505 | * | * | 505 |
| 01:00 | * | * | 492 | * | * | 492 | * | * | 492 |
| 02:00 | * | 597 | * | * | * | 597 | * | * | 597 |
| 03:00 | * | 707 | * | * | * | 707 | * | * | 707 |
| 04:00 | * | **895** | * | * | * | **895** | * | * | **895** |
| 05:00 | * | 860 | * | * | * | 860 | * | * | 860 |
| 06:00 | * | 637 | * | * | * | 637 | * | * | 637 |
| 07:00 | * | 464 | * | * | * | 464 | * | * | 464 |
| 08:00 | * | 351 | * | * | * | 351 | * | * | 351 |
| 09:00 | * | 259 | * | * | * | 259 | * | * | 259 |
| 10:00 | * | 111 | * | * | * | 111 | * | * | 111 |
| 11:00 | * | 87 | * | * | * | 87 | * | * | 87 |
| Day Total | 0 | 4968 | 3186 | 0 | 0 | 8154 | 0 | 0 | 8154 |
| % Avg. WkDay | 0.0% | 60.9% | 39.1% | 0.0% | 0.0% | | | | |
| % Avg. Week | 0.0% | 60.9% | 39.1% | 0.0% | 0.0% | 100.0% | 0.0% | 0.0% | |
| AM Peak | | | 11:00 | | | 11:00 | | | 11:00 |
| Vol. | | | 440 | | | 440 | | | 440 |
| PM Peak | | 16:00 | 12:00 | | | 16:00 | | | 16:00 |
| Vol. | | 895 | 505 | | | 895 | | | 895 |
| Grand Total | 0 | 4968 | 3186 | 0 | 0 | 8154 | 0 | 0 | 8154 |



ADT Not Calculated

# Bolton & Menk, Inc.

Hourly Volume Count

Site Code: 000000111111
Station ID:
CSAH 50 at CSAH 60 - South Leg
Lakeville, MN
Latitude: 0' 0.000 Undefined

| Start Time | Mon 10-Jan-11 | Tue 11-Jan-11 | Wed 12-Jan-11 | Thu 13-Jan-11 | Fri 14-Jan-11 | Average Day | Sat 15-Jan-11 | Sun 16-Jan-11 | Week Average |
|---|---|---|---|---|---|---|---|---|---|
| 12:00 AM | * | * | * | 29 | * | 29 | * | * | 29 |
| 01:00 | * | * | * | 31 | * | 31 | * | * | 31 |
| 02:00 | * | * | * | 16 | * | 16 | * | * | 16 |
| 03:00 | * | * | * | 17 | * | 17 | * | * | 17 |
| 04:00 | * | * | * | 46 | * | 46 | * | * | 46 |
| 05:00 | * | * | * | 180 | * | 180 | * | * | 180 |
| 06:00 | * | * | * | 540 | * | 540 | * | * | 540 |
| 07:00 | * | * | * | **741** | * | **741** | * | * | **741** |
| 08:00 | * | * | * | 544 | * | 544 | * | * | 544 |
| 09:00 | * | * | * | 469 | * | 469 | * | * | 469 |
| 10:00 | * | * | * | * | * | * | * | * | * |
| 11:00 | * | * | * | * | * | * | * | * | * |
| 12:00 PM | * | * | * | * | * | * | * | * | * |
| 01:00 | * | * | * | * | * | * | * | * | * |
| 02:00 | * | * | 525 | * | * | 525 | * | * | 525 |
| 03:00 | * | * | **650** | * | * | **650** | * | * | **650** |
| 04:00 | * | * | 616 | * | * | 616 | * | * | 616 |
| 05:00 | * | * | 574 | * | * | 574 | * | * | 574 |
| 06:00 | * | * | 476 | * | * | 476 | * | * | 476 |
| 07:00 | * | * | 304 | * | * | 304 | * | * | 304 |
| 08:00 | * | * | 265 | * | * | 265 | * | * | 265 |
| 09:00 | * | * | 154 | * | * | 154 | * | * | 154 |
| 10:00 | * | * | 71 | * | * | 71 | * | * | 71 |
| 11:00 | * | * | 48 | * | * | 48 | * | * | 48 |
| Day Total | 0 | 0 | 3683 | 2613 | 0 | 6296 | 0 | 0 | 6296 |
| % Avg. WkDay | 0.0% | 0.0% | 58.5% | 41.5% | 0.0% | | | | |
| % Avg. Week | 0.0% | 0.0% | 58.5% | 41.5% | 0.0% | 100.0% | 0.0% | 0.0% | |
| AM Peak | | | | 07:00 | | 07:00 | | | 07:00 |
| Vol. | | | | 741 | | 741 | | | 741 |
| PM Peak | | | 15:00 | | | 15:00 | | | 15:00 |
| Vol. | | | 650 | | | 650 | | | 650 |
| Grand Total | 0 | 0 | 3683 | 2613 | 0 | 6296 | 0 | 0 | 6296 |

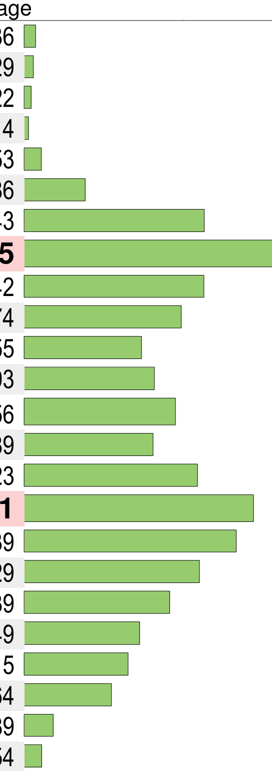
ADT Not Calculated

# Bolton & Menk, Inc.

Hourly Volume Count

Site Code: 000000111111
Station ID:
CSAH 50 at CSAH 60 - South Leg
Lakeville, MN
Latitude: 0' 0.000 Undefined

| Start Time | Mon 24-Jan-11 | Tue 25-Jan-11 | Wed 26-Jan-11 | Thu 27-Jan-11 | Fri 28-Jan-11 | Average Day | Sat 29-Jan-11 | Sun 30-Jan-11 | Week Average |
|---|---|---|---|---|---|---|---|---|---|
| 12:00 AM | * | * | 36 | * | * | 36 | * | * | 36 |
| 01:00 | * | * | 29 | * | * | 29 | * | * | 29 |
| 02:00 | * | * | 22 | * | * | 22 | * | * | 22 |
| 03:00 | * | * | 14 | * | * | 14 | * | * | 14 |
| 04:00 | * | * | 53 | * | * | 53 | * | * | 53 |
| 05:00 | * | * | 186 | * | * | 186 | * | * | 186 |
| 06:00 | * | * | 543 | * | * | 543 | * | * | 543 |
| 07:00 | * | * | **765** | * | * | **765** | * | * | **765** |
| 08:00 | * | * | 542 | * | * | 542 | * | * | 542 |
| 09:00 | * | * | 474 | * | * | 474 | * | * | 474 |
| 10:00 | * | * | 355 | * | * | 355 | * | * | 355 |
| 11:00 | * | * | 393 | * | * | 393 | * | * | 393 |
| 12:00 PM | * | * | **456** | * | * | 456 | * | * | 456 |
| 01:00 | * | 411 | 367 | * | * | 389 | * | * | 389 |
| 02:00 | * | 523 | * | * | * | 523 | * | * | 523 |
| 03:00 | * | **691** | * | * | * | **691** | * | * | **691** |
| 04:00 | * | 639 | * | * | * | 639 | * | * | 639 |
| 05:00 | * | 529 | * | * | * | 529 | * | * | 529 |
| 06:00 | * | 439 | * | * | * | 439 | * | * | 439 |
| 07:00 | * | 349 | * | * | * | 349 | * | * | 349 |
| 08:00 | * | 315 | * | * | * | 315 | * | * | 315 |
| 09:00 | * | 264 | * | * | * | 264 | * | * | 264 |
| 10:00 | * | 89 | * | * | * | 89 | * | * | 89 |
| 11:00 | * | 54 | * | * | * | 54 | * | * | 54 |
| Day Total | 0 | 4303 | 4235 | 0 | 0 | 8149 | 0 | 0 | 8149 |
| % Avg. WkDay | 0.0% | 52.8% | 52.0% | 0.0% | 0.0% | | | | |
| % Avg. Week | 0.0% | 52.8% | 52.0% | 0.0% | 0.0% | 100.0% | 0.0% | 0.0% | |
| AM Peak | | | 07:00 | | | 07:00 | | | 07:00 |
| Vol. | | | 765 | | | 765 | | | 765 |
| PM Peak | | 15:00 | 12:00 | | | 15:00 | | | 15:00 |
| Vol. | | 691 | 456 | | | 691 | | | 691 |
| Grand Total | 0 | 4303 | 4235 | 0 | 0 | 8149 | 0 | 0 | 8149 |



ADT    ADT 4,370    AADT 4,370

# APPENDIX C
Traffic Projections

**Current Year** **AM Peak**

| Time | SBR | SBT | SBL | WBR | WBT | WBL | NBR | NBT | NBL | EBR | EBT | EBL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6:45 AM | 8 | 77 | 10 | 33 | 49 | 7 | 4 | 137 | 21 | 39 | 40 | 11 |
| 7:00 AM | 2 | 89 | 14 | 40 | 54 | 33 | 4 | 134 | 20 | 57 | 39 | 10 |
| 7:15 AM | 5 | 66 | 4 | 50 | 64 | 4 | 2 | 158 | 44 | 38 | 57 | 13 |
| 7:30 AM | 11 | 70 | 6 | 41 | 43 | 6 | 3 | 166 | 34 | 28 | 55 | 21 |
| 7:45 AM | 8 | 70 | 14 | 23 | 52 | 1 | 5 | 135 | 25 | 36 | 58 | 20 |
| 8:00 AM | 8 | 45 | 14 | 41 | 43 | 3 | 2 | 118 | 31 | 31 | 40 | 11 |
| 6:45 AM | | 95 | | | 89 | | | 162 | | | 90 | |
| 7:00 AM | | 105 | | | 127 | | | 158 | | | 106 | |
| 7:15 AM | | 75 | | | 118 | | | 204 | | | 108 | |
| 7:30 AM | | 87 | | | 90 | | | 203 | | | 104 | |
| 7:45 AM | | 92 | | | 76 | | | 165 | | | 114 | |
| 8:00 AM | | 67 | | | 87 | | | 151 | | | 82 | |
| **PEAK HR** | | 359 | | | 411 | | | 730 | | | 432 | |
| **PEAK HR** | 26 | 295 | 38 | 154 | 213 | 44 | 14 | 593 | 123 | 159 | 209 | 64 |

**Full Planned Growth** **AM Peak**

| Time | SBR | SBT | SBL | WBR | WBT | WBL | NBR | NBT | NBL | EBR | EBT | EBL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6:45 AM | 7 | 109 | 25 | 73 | 136 | 25 | 16 | 203 | 43 | 76 | 116 | 10 |
| 7:00 AM | 2 | 126 | 35 | 89 | 150 | 118 | 16 | 199 | 41 | 111 | 113 | 10 |
| 7:15 AM | 4 | 94 | 10 | 111 | 177 | 14 | 8 | 234 | 90 | 74 | 165 | 12 |
| 7:30 AM | 10 | 99 | 15 | 91 | 119 | 21 | 12 | 246 | 69 | 54 | 159 | 20 |
| 7:45 AM | 7 | 99 | 35 | 51 | 144 | 4 | 20 | 200 | 51 | 70 | 168 | 19 |
| 8:00 AM | 7 | 64 | 35 | 91 | 119 | 11 | 8 | 175 | 63 | 60 | 116 | 10 |
| 6:45 AM | | 141 | | | 234 | | | 262 | | | 202 | |
| 7:00 AM | | 163 | | | 357 | | | 256 | | | 234 | |
| 7:15 AM | | 108 | | | 302 | | | 332 | | | 251 | |
| 7:30 AM | | 124 | | | 231 | | | 327 | | | 233 | |
| 7:45 AM | | 141 | | | 199 | | | 271 | | | 257 | |
| 8:00 AM | | 106 | | | 221 | | | 246 | | | 186 | |
| **PEAK HR** | | 538 | | | 1088 | | | 1186 | | | 976 | |
| **PEAK HR** | 23 | 419 | 96 | 341 | 590 | 157 | 56 | 879 | 251 | 309 | 606 | 61 |

**Build Year** **AM Peak**

| Time | SBR | SBT | SBL | WBR | WBT | WBL | NBR | NBT | NBL | EBR | EBT | EBL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6:45 AM | 8 | 80 | 11 | 36 | 54 | 8 | 5 | 142 | 22 | 41 | 44 | 12 |
| 7:00 AM | 2 | 92 | 15 | 43 | 59 | 37 | 5 | 139 | 21 | 61 | 43 | 10 |
| 7:15 AM | 5 | 68 | 4 | 54 | 70 | 4 | 2 | 164 | 47 | 40 | 63 | 14 |
| 7:30 AM | 11 | 72 | 6 | 44 | 47 | 7 | 3 | 172 | 36 | 30 | 61 | 22 |
| 7:45 AM | 8 | 72 | 15 | 25 | 57 | 1 | 6 | 140 | 27 | 38 | 64 | 21 |
| 8:00 AM | 8 | 47 | 15 | 44 | 47 | 3 | 2 | 122 | 33 | 33 | 44 | 12 |
| 6:45 AM | | 99 | | | 98 | | | 169 | | | 97 | |
| 7:00 AM | | 109 | | | 139 | | | 165 | | | 114 | |
| 7:15 AM | | 77 | | | 128 | | | 213 | | | 117 | |
| 7:30 AM | | 89 | | | 98 | | | 211 | | | 113 | |
| 7:45 AM | | 95 | | | 83 | | | 173 | | | 123 | |
| 8:00 AM | | 70 | | | 94 | | | 157 | | | 89 | |
| PEAK HR | | 373 | | | 449 | | | 762 | | | 466 | |
| PEAK HR | 27 | 305 | 41 | 166 | 234 | 49 | 16 | 615 | 131 | 169 | 230 | 67 |

**50% Planned Growth** **AM Peak**

| Time | SBR | SBT | SBL | WBR | WBT | WBL | NBR | NBT | NBL | EBR | EBT | EBL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6:45 AM | 10 | 93 | 17 | 51 | 85 | 14 | 9 | 170 | 31 | 56 | 72 | 15 |
| 7:00 AM | 3 | 108 | 23 | 62 | 94 | 66 | 9 | 166 | 29 | 82 | 70 | 14 |
| 7:15 AM | 6 | 80 | 7 | 77 | 111 | 8 | 4 | 196 | 65 | 54 | 102 | 18 |
| 7:30 AM | 14 | 85 | 10 | 63 | 75 | 12 | 6 | 206 | 50 | 40 | 98 | 29 |
| 7:45 AM | 10 | 85 | 23 | 36 | 91 | 2 | 11 | 167 | 37 | 52 | 104 | 28 |
| 8:00 AM | 10 | 54 | 23 | 63 | 75 | 6 | 4 | 146 | 46 | 44 | 72 | 15 |
| 6:45 AM | | 120 | | | 150 | | | 210 | | | 143 | |
| 7:00 AM | | 134 | | | 222 | | | 204 | | | 166 | |
| 7:15 AM | | 93 | | | 196 | | | 265 | | | 174 | |
| 7:30 AM | | 109 | | | 150 | | | 262 | | | 167 | |
| 7:45 AM | | 118 | | | 129 | | | 215 | | | 184 | |
| 8:00 AM | | 87 | | | 144 | | | 196 | | | 131 | |
| PEAK HR | | 453 | | | 697 | | | 946 | | | 690 | |
| PEAK HR | 33 | 357 | 63 | 238 | 371 | 88 | 30 | 735 | 181 | 228 | 374 | 88 |

**Current Year** — **PM Peak**

| Time | | SBR | SBT | SBL | WBR | WBT | WBL | NBR | NBT | NBL | EBR | EBT | EBL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **6:45 AM** | 45 | 133 | 42 | 19 | 54 | 3 | 2 | 96 | 33 | 51 | 85 | 34 |
| | **7:00 AM** | 45 | 138 | 31 | 26 | 58 | 3 | 0 | 109 | 32 | 52 | 101 | 24 |
| | **7:15 AM** | 29 | 133 | 37 | 21 | 55 | 2 | 3 | 84 | 47 | 70 | 94 | 17 |
| | **7:30 AM** | 37 | 129 | 33 | 34 | 84 | 9 | 5 | 82 | 28 | 50 | 75 | 23 |
| | **7:45 AM** | 40 | 161 | 45 | 28 | 56 | 9 | 2 | 82 | 40 | 44 | 81 | 35 |
| | **8:00 AM** | 50 | 130 | 27 | 26 | 55 | 3 | 2 | 90 | 38 | 47 | 85 | 27 |
| | **6:45 AM** | | 220 | | | 76 | | | 131 | | | 170 | |
| | **7:00 AM** | | 214 | | | 87 | | | 141 | | | 177 | |
| | **7:15 AM** | | 199 | | | 78 | | | 134 | | | 181 | |
| | **7:30 AM** | | 199 | | | 127 | | | 115 | | | 148 | |
| | **7:45 AM** | | 246 | | | 93 | | | 124 | | | 160 | |
| | **8:00 AM** | | 207 | | | 84 | | | 130 | | | 159 | |
| **PEAK HR** | | | 858 | | | 385 | | | 514 | | | 666 | |
| **PEAK HR** | | 151 | 561 | 146 | 109 | 253 | 23 | 10 | 357 | 147 | 216 | 351 | 99 |

**Full Planned Growth** — **PM Peak**

| Time | | SBR | SBT | SBL | WBR | WBT | WBL | NBR | NBT | NBL | EBR | EBT | EBL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **6:45 AM** | 29 | 179 | 88 | 36 | 154 | 13 | 9 | 133 | 69 | 94 | 234 | 19 |
| | **7:00 AM** | 29 | 186 | 65 | 49 | 166 | 13 | 0 | 151 | 67 | 96 | 278 | 14 |
| | **7:15 AM** | 19 | 179 | 78 | 40 | 157 | 8 | 14 | 116 | 98 | 129 | 259 | 10 |
| | **7:30 AM** | 24 | 174 | 69 | 64 | 240 | 38 | 23 | 113 | 58 | 92 | 206 | 13 |
| | **7:45 AM** | 26 | 217 | 94 | 53 | 160 | 38 | 9 | 113 | 83 | 81 | 223 | 20 |
| | **8:00 AM** | 32 | 175 | 57 | 49 | 157 | 13 | 9 | 124 | 79 | 87 | 234 | 15 |
| | **6:45 AM** | | 296 | | | 203 | | | 211 | | | 347 | |
| | **7:00 AM** | | 280 | | | 228 | | | 218 | | | 388 | |
| | **7:15 AM** | | 276 | | | 205 | | | 228 | | | 398 | |
| | **7:30 AM** | | 267 | | | 342 | | | 194 | | | 311 | |
| | **7:45 AM** | | 337 | | | 251 | | | 205 | | | 324 | |
| | **8:00 AM** | | 264 | | | 219 | | | 212 | | | 336 | |
| **PEAK HR** | | | 1161 | | | 1025 | | | 845 | | | 1420 | |
| **PEAK HR** | | 98 | 757 | 306 | 206 | 723 | 96 | 46 | 493 | 306 | 398 | 966 | 56 |

**Build Year** **PM Peak**

| Time | SBR | SBT | SBL | WBR | WBT | WBL | NBR | NBT | NBL | EBR | EBT | EBL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6:45 AM** | 46 | 137 | 45 | 20 | 59 | 3 | 2 | 99 | 35 | 54 | 93 | 35 |
| **7:00 AM** | 46 | 142 | 33 | 27 | 64 | 3 | 0 | 112 | 34 | 55 | 111 | 25 |
| **7:15 AM** | 30 | 137 | 40 | 22 | 60 | 2 | 3 | 87 | 50 | 74 | 103 | 18 |
| **7:30 AM** | 38 | 132 | 35 | 36 | 92 | 10 | 6 | 85 | 30 | 53 | 82 | 24 |
| **7:45 AM** | 41 | 165 | 48 | 30 | 62 | 10 | 2 | 85 | 43 | 46 | 89 | 36 |
| **8:00 AM** | 52 | 133 | 29 | 27 | 60 | 3 | 2 | 93 | 41 | 50 | 93 | 28 |
| **6:45 AM** | | 228 | | | 82 | | | 136 | | | 182 | |
| **7:00 AM** | | 221 | | | 94 | | | 146 | | | 191 | |
| **7:15 AM** | | 207 | | | 84 | | | 140 | | | 195 | |
| **7:30 AM** | | 205 | | | 138 | | | 121 | | | 159 | |
| **7:45 AM** | | 254 | | | 102 | | | 130 | | | 171 | |
| **8:00 AM** | | 214 | | | 90 | | | 136 | | | 171 | |
| **PEAK HR** | | 888 | | | 419 | | | 536 | | | 715 | |
| **PEAK HR** | 156 | 576 | 156 | 115 | 278 | 26 | 11 | 368 | 157 | 228 | 385 | 102 |

**50% Planned Growth** **PM Peak**

| Time | SBR | SBT | SBL | WBR | WBT | WBL | NBR | NBT | NBL | EBR | EBT | EBL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6:45 AM** | 55 | 157 | 63 | 27 | 96 | 7 | 5 | 115 | 49 | 71 | 148 | 42 |
| **7:00 AM** | 55 | 163 | 47 | 37 | 103 | 7 | 0 | 130 | 48 | 72 | 176 | 29 |
| **7:15 AM** | 35 | 157 | 56 | 30 | 98 | 4 | 7 | 100 | 70 | 98 | 163 | 21 |
| **7:30 AM** | 45 | 152 | 50 | 48 | 149 | 20 | 12 | 98 | 42 | 70 | 130 | 28 |
| **7:45 AM** | 49 | 190 | 68 | 40 | 99 | 20 | 5 | 98 | 60 | 61 | 141 | 43 |
| **8:00 AM** | 61 | 153 | 41 | 37 | 98 | 7 | 5 | 107 | 57 | 65 | 148 | 33 |
| **6:45 AM** | | 275 | | | 130 | | | 169 | | | 261 | |
| **7:00 AM** | | 265 | | | 147 | | | 178 | | | 277 | |
| **7:15 AM** | | 248 | | | 132 | | | 177 | | | 282 | |
| **7:30 AM** | | 247 | | | 217 | | | 152 | | | 228 | |
| **7:45 AM** | | 307 | | | 159 | | | 163 | | | 245 | |
| **8:00 AM** | | 255 | | | 142 | | | 169 | | | 246 | |
| **PEAK HR** | | 1064 | | | 653 | | | 668 | | | 1032 | |
| **PEAK HR** | 184 | 661 | 219 | 154 | 449 | 50 | 23 | 426 | 219 | 301 | 610 | 121 |

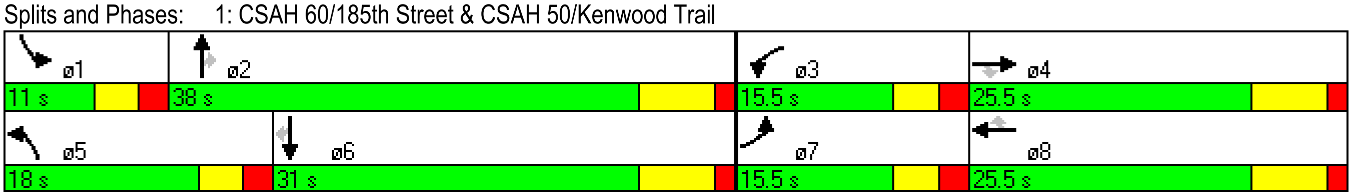
# APPENDIX D
Synchro Analysis

| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 64 | 209 | 159 | 44 | 213 | 154 | 123 | 593 | 14 | 38 | 295 | 26 |
| Satd. Flow (prot) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Satd. Flow (RTOR) | | | 227 | | | 200 | | | 20 | | | 44 |
| Lane Group Flow (vph) | 84 | 232 | 227 | 133 | 257 | 200 | 176 | 666 | 20 | 56 | 355 | 44 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 15.5 | 25.5 | 25.5 | 15.5 | 25.5 | 25.5 | 18.0 | 38.0 | 38.0 | 11.0 | 31.0 | 31.0 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 8.1 | 15.0 | 15.0 | 9.3 | 18.6 | 18.6 | 11.3 | 32.1 | 32.1 | 5.8 | 21.6 | 21.6 |
| Actuated g/C Ratio | 0.10 | 0.19 | 0.19 | 0.12 | 0.23 | 0.23 | 0.14 | 0.40 | 0.40 | 0.07 | 0.27 | 0.27 |
| v/c Ratio | 0.48 | 0.67 | 0.46 | 0.66 | 0.60 | 0.43 | 0.71 | 0.90 | 0.03 | 0.44 | 0.71 | 0.09 |
| Control Delay | 45.9 | 42.0 | 7.7 | 52.8 | 37.0 | 7.9 | 51.8 | 43.8 | 8.7 | 50.5 | 37.0 | 8.6 |
| 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 | 45.9 | 42.0 | 7.7 | 52.8 | 37.0 | 7.9 | 51.8 | 43.8 | 8.7 | 50.5 | 37.0 | 8.6 |
| LOS | D | D | A | D | D | A | D | D | A | D | D | A |
| Approach Delay | | 28.2 | | | 30.7 | | | 44.6 | | | 35.9 | |
| Approach LOS | | C | | | C | | | D | | | D | |
| Queue Length 50th (ft) | 44 | 120 | 0 | 70 | 131 | 0 | 92 | 357 | 0 | 30 | 172 | 0 |
| Queue Length 95th (ft) | 75 | 195 | 19 | 45 | 196 | 32 | 124 | #605 | 10 | 52 | 251 | 10 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 315 | | 315 | 245 | | 245 | 240 | | 240 | 265 | | 265 |
| Base Capacity (vph) | 234 | 445 | 576 | 234 | 457 | 487 | 289 | 738 | 681 | 133 | 574 | 551 |
| 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 | 0.36 | 0.52 | 0.39 | 0.57 | 0.56 | 0.41 | 0.61 | 0.90 | 0.03 | 0.42 | 0.62 | 0.08 |

**Intersection Summary**

Cycle Length: 90
Actuated Cycle Length: 80.6
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.90
Intersection Signal Delay: 36.0 Intersection LOS: D
Intersection Capacity Utilization 70.1% 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: 1: CSAH 60/185th Street & CSAH 50/Kenwood Trail



| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | ↰ | ↑ | ↱ | ↰ | ↑ | ↱ | ↰ | ↑ | ↱ | ↰ | ↑ | ↱ |
| Volume (vph) | 99 | 351 | 216 | 23 | 253 | 109 | 147 | 357 | 10 | 146 | 561 | 151 |
| Satd. Flow (prot) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Satd. Flow (RTOR) | | | 281 | | | 136 | | | 20 | | | 180 |
| Lane Group Flow (vph) | 139 | 403 | 281 | 36 | 337 | 136 | 188 | 435 | 20 | 180 | 645 | 180 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 12.0 | 27.5 | 27.5 | 10.0 | 25.5 | 25.5 | 15.0 | 35.5 | 35.5 | 17.0 | 37.5 | 37.5 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 7.0 | 24.1 | 24.1 | 5.0 | 18.1 | 18.1 | 10.0 | 29.7 | 29.7 | 11.3 | 31.0 | 31.0 |
| Actuated g/C Ratio | 0.08 | 0.27 | 0.27 | 0.06 | 0.20 | 0.20 | 0.11 | 0.33 | 0.33 | 0.13 | 0.35 | 0.35 |
| v/c Ratio | 1.01 | 0.80 | 0.43 | 0.36 | 0.89 | 0.35 | 0.95 | 0.70 | 0.03 | 0.81 | 1.00 | 0.26 |
| Control Delay | 122.3 | 46.1 | 5.9 | 51.6 | 62.2 | 8.4 | 94.3 | 33.7 | 9.4 | 65.3 | 66.3 | 4.4 |
| 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 | 122.3 | 46.1 | 5.9 | 51.6 | 62.2 | 8.4 | 94.3 | 33.7 | 9.4 | 65.3 | 66.3 | 4.4 |
| LOS | F | D | A | D | E | A | F | C | A | E | E | A |
| Approach Delay | | 45.2 | | | 47.1 | | | 50.7 | | | 55.0 | |
| Approach LOS | | D | | | D | | | D | | | E | |
| Queue Length 50th (ft) | ~82 | 225 | 0 | 20 | 186 | 0 | 108 | 217 | 0 | 100 | ~370 | 0 |
| Queue Length 95th (ft) | #140 | #377 | 32 | 36 | #231 | 33 | #191 | 287 | 5 | #169 | #564 | 35 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 315 | | 315 | 245 | | 245 | 240 | | 240 | 265 | | 265 |
| Base Capacity (vph) | 138 | 503 | 661 | 99 | 396 | 399 | 198 | 619 | 575 | 237 | 646 | 703 |
| 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 | 1.01 | 0.80 | 0.43 | 0.36 | 0.85 | 0.34 | 0.95 | 0.70 | 0.03 | 0.76 | 1.00 | 0.26 |

Intersection Summary

Cycle Length: 90
Actuated Cycle Length: 89.1
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.01
Intersection Signal Delay: 50.0 Intersection LOS: D
Intersection Capacity Utilization 79.7% ICU Level of Service D
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.

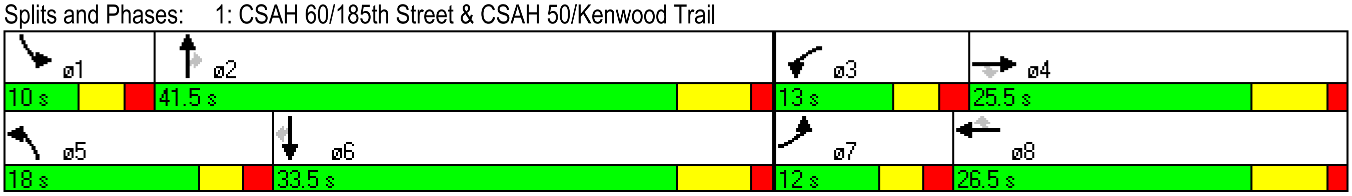
Splits and Phases: 1: CSAH 60/185th Street & CSAH 50/Kenwood Trail

| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 67 | 230 | 169 | 49 | 234 | 166 | 131 | 615 | 16 | 41 | 305 | 27 |
| Satd. Flow (prot) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Satd. Flow (RTOR) | | | 241 | | | 216 | | | 23 | | | 46 |
| Lane Group Flow (vph) | 88 | 256 | 241 | 148 | 282 | 216 | 187 | 691 | 23 | 60 | 367 | 46 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 12.0 | 25.5 | 25.5 | 13.0 | 26.5 | 26.5 | 18.0 | 41.5 | 41.5 | 10.0 | 33.5 | 33.5 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 6.7 | 15.6 | 15.6 | 8.1 | 19.8 | 19.8 | 11.6 | 33.7 | 33.7 | 5.1 | 24.6 | 24.6 |
| Actuated g/C Ratio | 0.08 | 0.19 | 0.19 | 0.10 | 0.24 | 0.24 | 0.14 | 0.40 | 0.40 | 0.06 | 0.29 | 0.29 |
| v/c Ratio | 0.62 | 0.74 | 0.47 | 0.86 | 0.64 | 0.44 | 0.76 | 0.92 | 0.03 | 0.56 | 0.67 | 0.09 |
| Control Delay | 60.7 | 46.2 | 7.7 | 82.1 | 39.0 | 7.6 | 57.4 | 45.0 | 7.2 | 62.3 | 33.3 | 7.7 |
| 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 | 60.7 | 46.2 | 7.7 | 82.1 | 39.0 | 7.6 | 57.4 | 45.0 | 7.2 | 62.3 | 33.3 | 7.7 |
| LOS | E | D | A | F | D | A | E | D | A | E | C | A |
| Approach Delay | | 32.5 | | | 38.4 | | | 46.6 | | | 34.5 | |
| Approach LOS | | C | | | D | | | D | | | C | |
| Queue Length 50th (ft) | 49 | 134 | 0 | 84 | 148 | 0 | 101 | 364 | 0 | 34 | 176 | 0 |
| Queue Length 95th (ft) | #87 | 216 | 19 | 51 | 212 | 32 | 130 | #594 | 10 | 56 | 249 | 9 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 315 | | 315 | 245 | | 245 | 240 | | 240 | 265 | | 265 |
| Base Capacity (vph) | 151 | 430 | 575 | 172 | 470 | 508 | 280 | 792 | 732 | 108 | 618 | 591 |
| 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 | 0.58 | 0.60 | 0.42 | 0.86 | 0.60 | 0.43 | 0.67 | 0.87 | 0.03 | 0.56 | 0.59 | 0.08 |

Intersection Summary

Cycle Length: 90
Actuated Cycle Length: 83.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.92
Intersection Signal Delay: 39.2 — Intersection LOS: D
Intersection Capacity Utilization 72.4% — 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: 1: CSAH 60/185th Street & CSAH 50/Kenwood Trail

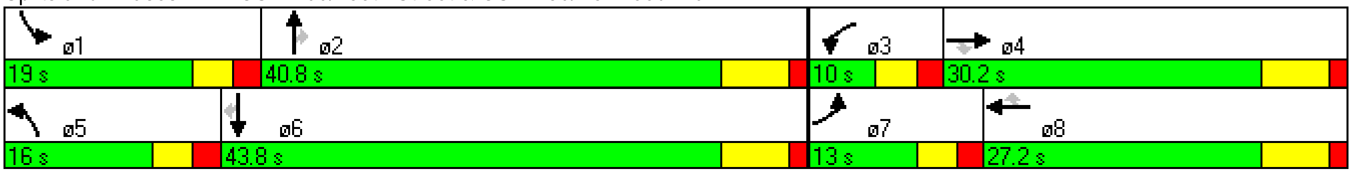


| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 102 | 385 | 228 | 26 | 278 | 115 | 157 | 368 | 11 | 156 | 576 | 156 |
| Satd. Flow (prot) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Satd. Flow (RTOR) | | | 296 | | | 144 | | | 22 | | | 186 |
| Lane Group Flow (vph) | 144 | 443 | 296 | 41 | 371 | 144 | 201 | 449 | 22 | 193 | 662 | 186 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 13.0 | 30.2 | 30.2 | 10.0 | 27.2 | 27.2 | 16.0 | 40.8 | 40.8 | 19.0 | 43.8 | 43.8 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 8.0 | 27.8 | 27.8 | 5.0 | 20.7 | 20.7 | 11.0 | 34.1 | 34.1 | 13.1 | 36.1 | 36.1 |
| Actuated g/C Ratio | 0.08 | 0.28 | 0.28 | 0.05 | 0.21 | 0.21 | 0.11 | 0.34 | 0.34 | 0.13 | 0.37 | 0.37 |
| v/c Ratio | 1.01 | 0.85 | 0.43 | 0.46 | 0.95 | 0.36 | 1.03 | 0.70 | 0.04 | 0.83 | 0.98 | 0.25 |
| Control Delay | 125.7 | 52.6 | 6.0 | 63.2 | 76.0 | 8.6 | 115.9 | 35.3 | 9.2 | 70.5 | 61.3 | 4.2 |
| 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 | 125.7 | 52.6 | 6.0 | 63.2 | 76.0 | 8.6 | 115.9 | 35.3 | 9.2 | 70.5 | 61.3 | 4.2 |
| LOS | F | D | A | E | E | A | F | D | A | E | E | A |
| Approach Delay | | 48.9 | | | 57.6 | | | 58.5 | | | 52.8 | |
| Approach LOS | | D | | | E | | | E | | | D | |
| Queue Length 50th (ft) | ~98 | ~287 | 0 | 26 | 236 | 0 | ~139 | 246 | 0 | 120 | 405 | 0 |
| Queue Length 95th (ft) | #154 | #462 | 32 | 43 | #306 | 35 | #226 | 316 | 5 | #192 | #602 | 35 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 315 | | 315 | 245 | | 245 | 240 | | 240 | 265 | | 265 |
| Base Capacity (vph) | 143 | 522 | 685 | 89 | 389 | 400 | 196 | 645 | 599 | 250 | 700 | 751 |
| 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 | 1.01 | 0.85 | 0.43 | 0.46 | 0.95 | 0.36 | 1.03 | 0.70 | 0.04 | 0.77 | 0.95 | 0.25 |

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 98.9
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.03
Intersection Signal Delay: 53.8 Intersection LOS: D
Intersection Capacity Utilization 82.9% ICU Level of Service E
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.

Splits and Phases: 1: CSAH 60/185th Street & CSAH 50/Kenwood Trail

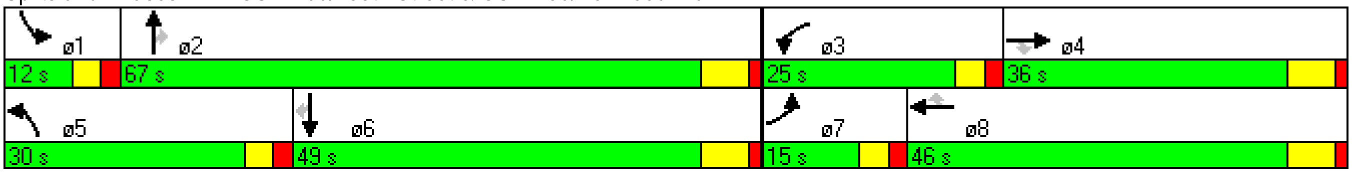


| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 88 | 374 | 228 | 88 | 371 | 238 | 181 | 735 | 30 | 63 | 357 | 33 |
| Satd. Flow (prot) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Satd. Flow (RTOR) | | | 326 | | | 189 | | | 25 | | | 56 |
| Lane Group Flow (vph) | 116 | 416 | 326 | 267 | 447 | 309 | 259 | 826 | 43 | 93 | 430 | 56 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 15.0 | 36.0 | 36.0 | 25.0 | 46.0 | 46.0 | 30.0 | 67.0 | 67.0 | 12.0 | 49.0 | 49.0 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 10.0 | 29.5 | 29.5 | 20.0 | 39.5 | 39.5 | 23.0 | 60.5 | 60.5 | 7.0 | 44.5 | 44.5 |
| Actuated g/C Ratio | 0.07 | 0.21 | 0.21 | 0.14 | 0.28 | 0.28 | 0.16 | 0.43 | 0.43 | 0.05 | 0.32 | 0.32 |
| v/c Ratio | 0.92 | 1.06 | 0.53 | 1.06 | 0.85 | 0.59 | 0.89 | 1.03 | 0.06 | 1.06 | 0.73 | 0.10 |
| Control Delay | 124.9 | 115.3 | 8.1 | 129.3 | 64.2 | 21.3 | 88.5 | 78.7 | 12.6 | 173.5 | 51.5 | 8.9 |
| 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 | 124.9 | 115.3 | 8.1 | 129.3 | 64.2 | 21.3 | 88.5 | 78.7 | 12.6 | 173.5 | 51.5 | 8.9 |
| LOS | F | F | A | F | E | C | F | E | B | F | D | A |
| Approach Delay | | 75.9 | | | 68.3 | | | 78.5 | | | 67.0 | |
| Approach LOS | | E | | | E | | | E | | | E | |
| Queue Length 50th (ft) | 107 | ~417 | 0 | ~267 | 387 | 92 | 230 | ~803 | 9 | ~93 | 356 | 0 |
| Queue Length 95th (ft) | #178 | #627 | 6 | 114 | 471 | 133 | 247 | #1036 | 23 | #140 | 435 | 9 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 315 | | 315 | 245 | | 245 | 240 | | 240 | 265 | | 265 |
| Base Capacity (vph) | 126 | 391 | 612 | 252 | 523 | 521 | 315 | 802 | 741 | 88 | 590 | 573 |
| 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 | 0.92 | 1.06 | 0.53 | 1.06 | 0.85 | 0.59 | 0.82 | 1.03 | 0.06 | 1.06 | 0.73 | 0.10 |

Intersection Summary

Cycle Length: 140
Actuated Cycle Length: 140
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.06
Intersection Signal Delay: 73.1 Intersection LOS: E
Intersection Capacity Utilization 86.8% ICU Level of Service E
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.

Splits and Phases: 1: CSAH 60/185th Street & CSAH 50/Kenwood Trail

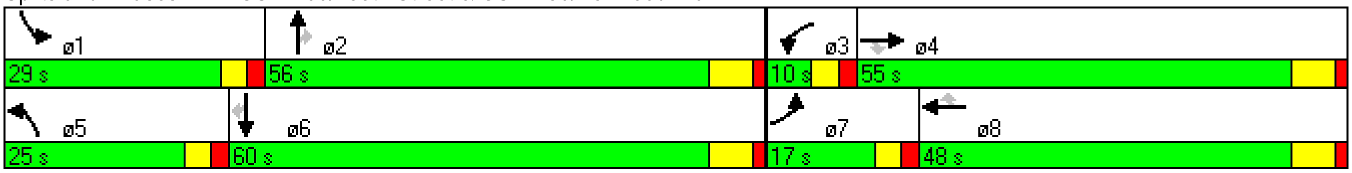


| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 121 | 610 | 301 | 50 | 449 | 154 | 219 | 426 | 23 | 219 | 661 | 184 |
| Satd. Flow (prot) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Satd. Flow (RTOR) | | | 269 | | | 115 | | | 34 | | | 125 |
| Lane Group Flow (vph) | 170 | 701 | 391 | 78 | 599 | 192 | 281 | 520 | 46 | 270 | 760 | 219 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 17.0 | 55.0 | 55.0 | 10.0 | 48.0 | 48.0 | 25.0 | 56.0 | 56.0 | 29.0 | 60.0 | 60.0 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 12.0 | 48.5 | 48.5 | 5.0 | 41.5 | 41.5 | 20.0 | 49.7 | 49.7 | 23.8 | 53.5 | 53.5 |
| Actuated g/C Ratio | 0.08 | 0.32 | 0.32 | 0.03 | 0.28 | 0.28 | 0.13 | 0.33 | 0.33 | 0.16 | 0.36 | 0.36 |
| v/c Ratio | 1.21 | 1.17 | 0.54 | 1.32 | 1.17 | 0.42 | 1.20 | 0.85 | 0.08 | 0.96 | 1.15 | 0.32 |
| Control Delay | 196.7 | 137.2 | 15.2 | 276.9 | 141.8 | 20.6 | 175.1 | 60.8 | 14.7 | 107.0 | 126.6 | 15.9 |
| 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 | 196.7 | 137.2 | 15.2 | 276.9 | 141.8 | 20.6 | 175.1 | 60.8 | 14.7 | 107.0 | 126.6 | 15.9 |
| LOS | F | F | B | F | F | C | F | E | B | F | F | B |
| Approach Delay | | 107.4 | | | 127.2 | | | 96.2 | | | 103.0 | |
| Approach LOS | | F | | | F | | | F | | | F | |
| Queue Length 50th (ft) | ~202 | ~814 | 91 | ~99 | ~695 | 58 | ~332 | 474 | 8 | 266 | ~871 | 63 |
| Queue Length 95th (ft) | #253 | #1004 | 123 | #133 | #691 | 105 | #419 | 550 | 11 | #375 | #1061 | 114 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 315 | | 315 | 245 | | 245 | 240 | | 240 | 265 | | 265 |
| Base Capacity (vph) | 141 | 600 | 726 | 59 | 513 | 461 | 235 | 614 | 580 | 282 | 662 | 680 |
| 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 | 1.21 | 1.17 | 0.54 | 1.32 | 1.17 | 0.42 | 1.20 | 0.85 | 0.08 | 0.96 | 1.15 | 0.32 |

Intersection Summary

Cycle Length: 150
Actuated Cycle Length: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.32
Intersection Signal Delay: 107.9 Intersection LOS: F
Intersection Capacity Utilization 102.7% ICU Level of Service G
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.

Splits and Phases: 1: CSAH 60/185th Street & CSAH 50/Kenwood Trail

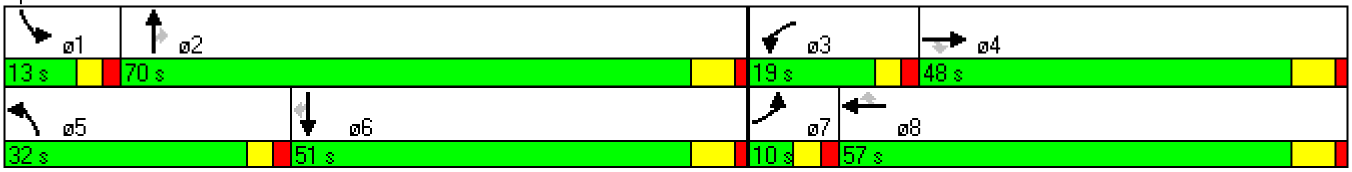


| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 61 | 606 | 309 | 157 | 590 | 341 | 251 | 879 | 56 | 96 | 419 | 23 |
| Satd. Flow (prot) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Satd. Flow (RTOR) | | | 260 | | | 154 | | | 46 | | | 22 |
| Lane Group Flow (vph) | 86 | 697 | 401 | 245 | 787 | 426 | 322 | 1072 | 112 | 119 | 482 | 27 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 10.0 | 48.0 | 48.0 | 19.0 | 57.0 | 57.0 | 32.0 | 70.0 | 70.0 | 13.0 | 51.0 | 51.0 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 5.0 | 41.5 | 41.5 | 14.0 | 50.5 | 50.5 | 27.0 | 63.5 | 63.5 | 8.0 | 44.5 | 44.5 |
| Actuated g/C Ratio | 0.03 | 0.28 | 0.28 | 0.09 | 0.34 | 0.34 | 0.18 | 0.42 | 0.42 | 0.05 | 0.30 | 0.30 |
| v/c Ratio | 1.46 | 1.36 | 0.61 | 1.49 | 1.26 | 0.76 | 1.02 | 1.37 | 0.15 | 1.27 | 0.88 | 0.05 |
| Control Delay | 324.3 | 214.8 | 20.3 | 295.2 | 170.4 | 37.5 | 114.1 | 207.6 | 16.1 | 233.6 | 68.1 | 16.5 |
| 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 | 324.3 | 214.8 | 20.3 | 295.2 | 170.4 | 37.5 | 114.1 | 207.6 | 16.1 | 233.6 | 68.1 | 16.5 |
| LOS | F | F | C | F | F | D | F | F | B | F | E | B |
| Approach Delay | | 156.9 | | | 152.5 | | | 173.4 | | | 97.2 | |
| Approach LOS | | F | | | F | | | F | | | F | |
| Queue Length 50th (ft) | ~115 | ~893 | 118 | ~330 | ~963 | 247 | ~332 | ~1378 | 38 | ~146 | 450 | 4 |
| Queue Length 95th (ft) | #172 | #1086 | 152 | #314 | #908 | 309 | #417 | #1427 | 31 | #246 | #604 | 25 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 315 | | 315 | 245 | | 245 | 240 | | 240 | 265 | | 265 |
| Base Capacity (vph) | 59 | 513 | 653 | 164 | 625 | 562 | 317 | 785 | 739 | 94 | 550 | 514 |
| 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 | 1.46 | 1.36 | 0.61 | 1.49 | 1.26 | 0.76 | 1.02 | 1.37 | 0.15 | 1.27 | 0.88 | 0.05 |

Intersection Summary

Cycle Length: 150
Actuated Cycle Length: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.49
Intersection Signal Delay: 152.9 Intersection LOS: F
Intersection Capacity Utilization 111.7% 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.

Splits and Phases: 1: CSAH 60 & CSAH 50

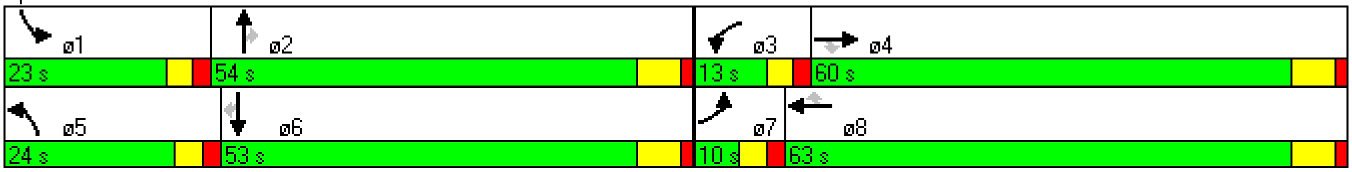


| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 56 | 966 | 398 | 96 | 723 | 206 | 306 | 493 | 46 | 306 | 757 | 98 |
| Satd. Flow (prot) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 1855 | 1682 | 1762 | 1855 | 1366 | 1762 | 1855 | 1682 | 1762 | 1855 | 1682 |
| Satd. Flow (RTOR) | | | 236 | | | 111 | | | 57 | | | 54 |
| Lane Group Flow (vph) | 79 | 1110 | 517 | 150 | 964 | 258 | 392 | 601 | 92 | 378 | 870 | 117 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 10.0 | 60.0 | 60.0 | 13.0 | 63.0 | 63.0 | 24.0 | 54.0 | 54.0 | 23.0 | 53.0 | 53.0 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 5.0 | 53.5 | 53.5 | 8.0 | 56.5 | 56.5 | 19.0 | 47.5 | 47.5 | 18.0 | 46.5 | 46.5 |
| Actuated g/C Ratio | 0.03 | 0.36 | 0.36 | 0.05 | 0.38 | 0.38 | 0.13 | 0.32 | 0.32 | 0.12 | 0.31 | 0.31 |
| v/c Ratio | 1.34 | 1.68 | 0.69 | 1.60 | 1.38 | 0.44 | 1.76 | 1.02 | 0.16 | 1.79 | 1.51 | 0.21 |
| Control Delay | 282.6 | 342.7 | 26.8 | 353.8 | 216.0 | 21.8 | 394.7 | 93.0 | 16.5 | 409.9 | 275.8 | 21.6 |
| 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 | 282.6 | 342.7 | 26.8 | 353.8 | 216.0 | 21.8 | 394.7 | 93.0 | 16.5 | 409.9 | 275.8 | 21.6 |
| LOS | F | F | C | F | F | C | F | F | B | F | F | C |
| Approach Delay | | 244.2 | | | 194.6 | | | 195.5 | | | 291.1 | |
| Approach LOS | | F | | | F | | | F | | | F | |
| Queue Length 50th (ft) | ~101 | ~1581 | 241 | ~209 | ~1247 | 105 | ~569 | ~623 | 24 | ~552 | ~1182 | 44 |
| Queue Length 95th (ft) | #158 | #1761 | 266 | #227 | #1139 | 150 | #648 | #733 | 19 | #664 | #1372 | 86 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 315 | | 315 | 245 | | 245 | 240 | | 240 | 265 | | 265 |
| Base Capacity (vph) | 59 | 662 | 752 | 94 | 699 | 584 | 223 | 587 | 572 | 211 | 575 | 559 |
| 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 | 1.34 | 1.68 | 0.69 | 1.60 | 1.38 | 0.44 | 1.76 | 1.02 | 0.16 | 1.79 | 1.51 | 0.21 |

Intersection Summary

Cycle Length: 150
Actuated Cycle Length: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.79
Intersection Signal Delay: 233.9 Intersection LOS: F
Intersection Capacity Utilization 132.6% 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.

Splits and Phases: 1: CSAH 60 & CSAH 50

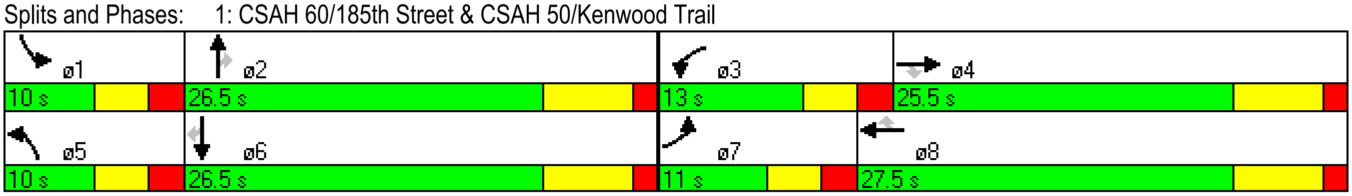


| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 67 | 230 | 169 | 49 | 234 | 166 | 131 | 615 | 16 | 41 | 305 | 27 |
| Satd. Flow (prot) | 1762 | 3524 | 1682 | 1762 | 3524 | 1366 | 3419 | 3524 | 1682 | 3419 | 3524 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 3524 | 1682 | 1762 | 3524 | 1366 | 3419 | 3524 | 1682 | 3419 | 3524 | 1682 |
| Satd. Flow (RTOR) | | | 241 | | | 216 | | | 23 | | | 46 |
| Lane Group Flow (vph) | 88 | 256 | 241 | 148 | 282 | 216 | 187 | 691 | 23 | 60 | 367 | 46 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 11.0 | 25.5 | 25.5 | 13.0 | 27.5 | 27.5 | 10.0 | 26.5 | 26.5 | 10.0 | 26.5 | 26.5 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 5.8 | 11.4 | 11.4 | 7.8 | 15.5 | 15.5 | 5.0 | 21.8 | 21.8 | 5.0 | 17.5 | 17.5 |
| Actuated g/C Ratio | 0.09 | 0.18 | 0.18 | 0.12 | 0.24 | 0.24 | 0.08 | 0.34 | 0.34 | 0.08 | 0.27 | 0.27 |
| v/c Ratio | 0.56 | 0.41 | 0.49 | 0.70 | 0.33 | 0.44 | 0.71 | 0.58 | 0.04 | 0.23 | 0.39 | 0.09 |
| Control Delay | 45.1 | 26.3 | 7.5 | 48.7 | 23.2 | 7.0 | 47.1 | 21.7 | 8.5 | 31.9 | 20.8 | 7.0 |
| 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 | 45.1 | 26.3 | 7.5 | 48.7 | 23.2 | 7.0 | 47.1 | 21.7 | 8.5 | 31.9 | 20.8 | 7.0 |
| LOS | D | C | A | D | C | A | D | C | A | C | C | A |
| Approach Delay | | 21.4 | | | 23.6 | | | 26.6 | | | 20.9 | |
| Approach LOS | | C | | | C | | | C | | | C | |
| Queue Length 50th (ft) | 33 | 48 | 0 | 56 | 51 | 0 | 37 | 125 | 0 | 11 | 60 | 0 |
| Queue Length 95th (ft) | #68 | 82 | 20 | 40 | 78 | 29 | #56 | 195 | 10 | 22 | 93 | 9 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 300 | | 300 | 300 | | 300 | 300 | | 300 | 300 | | 300 |
| Base Capacity (vph) | 164 | 1038 | 665 | 219 | 1157 | 594 | 265 | 1209 | 593 | 265 | 1093 | 553 |
| 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 | 0.54 | 0.25 | 0.36 | 0.68 | 0.24 | 0.36 | 0.71 | 0.57 | 0.04 | 0.23 | 0.34 | 0.08 |

**Intersection Summary**

Cycle Length: 75
Actuated Cycle Length: 64.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.71
Intersection Signal Delay: 23.7 — Intersection LOS: C
Intersection Capacity Utilization 52.9% — ICU Level of Service A
Analysis Period (min) 15
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: CSAH 60/185th Street & CSAH 50/Kenwood Trail

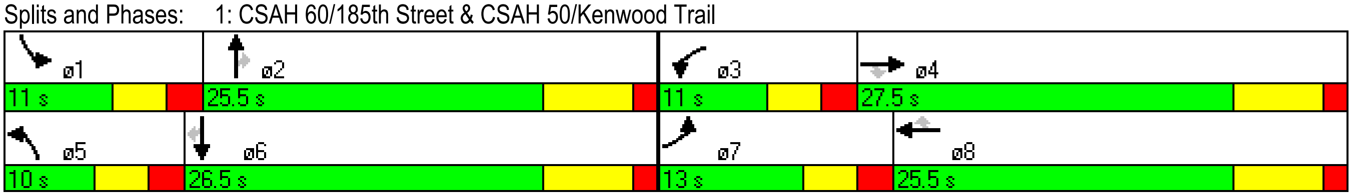


| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 102 | 385 | 228 | 26 | 278 | 115 | 157 | 368 | 11 | 156 | 576 | 156 |
| Satd. Flow (prot) | 1762 | 3524 | 1682 | 1762 | 3524 | 1366 | 3419 | 3524 | 1682 | 3419 | 3524 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 3524 | 1682 | 1762 | 3524 | 1366 | 3419 | 3524 | 1682 | 3419 | 3524 | 1682 |
| Satd. Flow (RTOR) | | | 296 | | | 144 | | | 22 | | | 186 |
| Lane Group Flow (vph) | 144 | 443 | 296 | 41 | 371 | 144 | 201 | 449 | 22 | 193 | 662 | 186 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 13.0 | 27.5 | 27.5 | 11.0 | 25.5 | 25.5 | 10.0 | 25.5 | 25.5 | 11.0 | 26.5 | 26.5 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 7.7 | 20.1 | 20.1 | 5.6 | 13.6 | 13.6 | 5.0 | 17.2 | 17.2 | 6.0 | 18.2 | 18.2 |
| Actuated g/C Ratio | 0.11 | 0.30 | 0.30 | 0.08 | 0.20 | 0.20 | 0.07 | 0.25 | 0.25 | 0.09 | 0.27 | 0.27 |
| v/c Ratio | 0.72 | 0.42 | 0.42 | 0.28 | 0.53 | 0.37 | 0.79 | 0.50 | 0.05 | 0.63 | 0.70 | 0.32 |
| Control Delay | 52.5 | 22.1 | 5.0 | 36.3 | 27.1 | 7.6 | 56.8 | 24.4 | 9.9 | 42.3 | 27.4 | 5.4 |
| 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 | 52.5 | 22.1 | 5.0 | 36.3 | 27.1 | 7.6 | 56.8 | 24.4 | 9.9 | 42.3 | 27.4 | 5.4 |
| LOS | D | C | A | D | C | A | E | C | A | D | C | A |
| Approach Delay | | 21.4 | | | 22.7 | | | 33.6 | | | 26.2 | |
| Approach LOS | | C | | | C | | | C | | | C | |
| Queue Length 50th (ft) | 60 | 87 | 0 | 17 | 74 | 0 | 44 | 83 | 0 | 41 | 130 | 0 |
| Queue Length 95th (ft) | #105 | 125 | 29 | 33 | 92 | 30 | #86 | 123 | 6 | #74 | 194 | 36 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 300 | | 300 | 300 | | 300 | 300 | | 300 | 300 | | 300 |
| Base Capacity (vph) | 210 | 1131 | 741 | 157 | 996 | 490 | 255 | 996 | 491 | 305 | 1049 | 631 |
| 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 | 0.69 | 0.39 | 0.40 | 0.26 | 0.37 | 0.29 | 0.79 | 0.45 | 0.04 | 0.63 | 0.63 | 0.29 |

Intersection Summary

Cycle Length: 75
Actuated Cycle Length: 67.7
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.79
Intersection Signal Delay: 25.8 Intersection LOS: C
Intersection Capacity Utilization 54.5% ICU Level of Service A
Analysis Period (min) 15
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: CSAH 60/185th Street & CSAH 50/Kenwood Trail

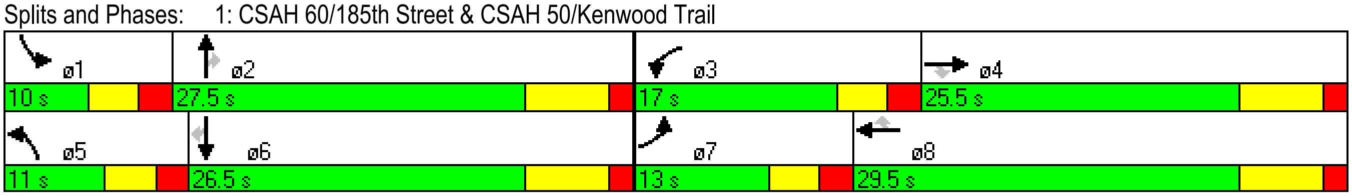


| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 88 | 374 | 228 | 88 | 371 | 238 | 181 | 735 | 30 | 63 | 357 | 33 |
| Satd. Flow (prot) | 1762 | 3524 | 1682 | 1762 | 3524 | 1366 | 3419 | 3524 | 1682 | 3419 | 3524 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 3524 | 1682 | 1762 | 3524 | 1366 | 3419 | 3524 | 1682 | 3419 | 3524 | 1682 |
| Satd. Flow (RTOR) | | | 258 | | | 232 | | | 43 | | | 56 |
| Lane Group Flow (vph) | 116 | 416 | 326 | 267 | 447 | 309 | 259 | 826 | 43 | 93 | 430 | 56 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 13.0 | 25.5 | 25.5 | 17.0 | 29.5 | 29.5 | 11.0 | 27.5 | 27.5 | 10.0 | 26.5 | 26.5 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 7.5 | 15.2 | 15.2 | 12.1 | 22.2 | 22.2 | 6.0 | 22.3 | 22.3 | 5.0 | 19.0 | 19.0 |
| Actuated g/C Ratio | 0.10 | 0.20 | 0.20 | 0.16 | 0.29 | 0.29 | 0.08 | 0.30 | 0.30 | 0.07 | 0.25 | 0.25 |
| v/c Ratio | 0.66 | 0.58 | 0.60 | 0.95 | 0.43 | 0.55 | 0.95 | 0.79 | 0.08 | 0.41 | 0.49 | 0.12 |
| Control Delay | 53.6 | 30.8 | 11.8 | 77.7 | 24.3 | 11.0 | 81.3 | 33.2 | 8.1 | 41.1 | 26.6 | 7.8 |
| 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 | 53.6 | 30.8 | 11.8 | 77.7 | 24.3 | 11.0 | 81.3 | 33.2 | 8.1 | 41.1 | 26.6 | 7.8 |
| LOS | D | C | B | E | C | B | F | C | A | D | C | A |
| Approach Delay | | 26.7 | | | 34.2 | | | 43.3 | | | 27.1 | |
| Approach LOS | | C | | | C | | | D | | | C | |
| Queue Length 50th (ft) | 54 | 94 | 27 | 129 | 95 | 29 | 64 | 196 | 0 | 22 | 91 | 0 |
| Queue Length 95th (ft) | #93 | 138 | 45 | 70 | 125 | 63 | #96 | #308 | 14 | 34 | 127 | 10 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 300 | | 300 | 300 | | 300 | 300 | | 300 | 300 | | 300 |
| Base Capacity (vph) | 188 | 893 | 619 | 282 | 1123 | 593 | 273 | 1040 | 527 | 228 | 940 | 490 |
| 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 | 0.62 | 0.47 | 0.53 | 0.95 | 0.40 | 0.52 | 0.95 | 0.79 | 0.08 | 0.41 | 0.46 | 0.11 |

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 75.4
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.95
Intersection Signal Delay: 34.1 Intersection LOS: C
Intersection Capacity Utilization 59.0% ICU Level of Service B
Analysis Period (min) 15
# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: CSAH 60/185th Street & CSAH 50/Kenwood Trail

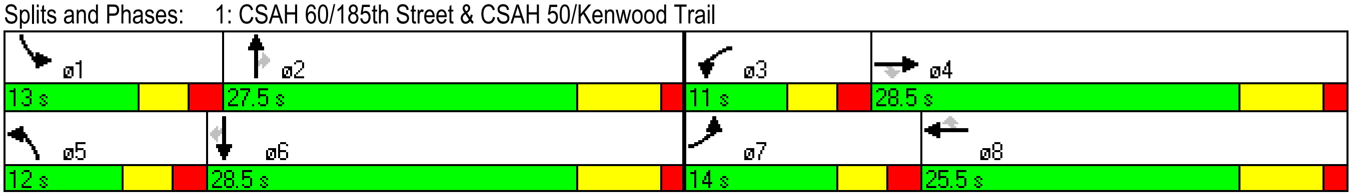


| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 121 | 610 | 301 | 50 | 449 | 154 | 219 | 426 | 23 | 219 | 661 | 184 |
| Satd. Flow (prot) | 1762 | 3524 | 1682 | 1762 | 3524 | 1366 | 3419 | 3524 | 1682 | 3419 | 3524 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 3524 | 1682 | 1762 | 3524 | 1366 | 3419 | 3524 | 1682 | 3419 | 3524 | 1682 |
| Satd. Flow (RTOR) | | | 290 | | | 192 | | | 46 | | | 219 |
| Lane Group Flow (vph) | 170 | 701 | 391 | 78 | 599 | 192 | 281 | 520 | 46 | 270 | 760 | 219 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 14.0 | 28.5 | 28.5 | 11.0 | 25.5 | 25.5 | 12.0 | 27.5 | 27.5 | 13.0 | 28.5 | 28.5 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 8.9 | 22.8 | 22.8 | 5.8 | 17.4 | 17.4 | 7.0 | 19.5 | 19.5 | 7.9 | 20.4 | 20.4 |
| Actuated g/C Ratio | 0.12 | 0.30 | 0.30 | 0.08 | 0.23 | 0.23 | 0.09 | 0.25 | 0.25 | 0.10 | 0.27 | 0.27 |
| v/c Ratio | 0.83 | 0.67 | 0.56 | 0.59 | 0.75 | 0.42 | 0.90 | 0.58 | 0.10 | 0.77 | 0.81 | 0.36 |
| Control Delay | 68.8 | 28.7 | 10.4 | 55.1 | 34.6 | 7.3 | 68.4 | 28.3 | 8.0 | 50.8 | 34.7 | 5.4 |
| 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 | 68.8 | 28.7 | 10.4 | 55.1 | 34.6 | 7.3 | 68.4 | 28.3 | 8.0 | 50.8 | 34.7 | 5.4 |
| LOS | E | C | B | E | C | A | E | C | A | D | C | A |
| Approach Delay | | 28.5 | | | 30.4 | | | 40.5 | | | 33.0 | |
| Approach LOS | | C | | | C | | | D | | | C | |
| Queue Length 50th (ft) | 85 | 166 | 39 | 39 | 145 | 0 | 73 | 118 | 0 | 69 | 184 | 0 |
| Queue Length 95th (ft) | #131 | 217 | 73 | 57 | 161 | 34 | #115 | 149 | 6 | #105 | 238 | 39 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 300 | | 300 | 300 | | 300 | 300 | | 300 | 300 | | 300 |
| Base Capacity (vph) | 207 | 1055 | 707 | 138 | 876 | 484 | 313 | 969 | 495 | 358 | 1015 | 640 |
| 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 | 0.82 | 0.66 | 0.55 | 0.57 | 0.68 | 0.40 | 0.90 | 0.54 | 0.09 | 0.75 | 0.75 | 0.34 |

Intersection Summary

Cycle Length: 80
Actuated Cycle Length: 76.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.90
Intersection Signal Delay: 32.6 Intersection LOS: C
Intersection Capacity Utilization 64.9% 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: 1: CSAH 60/185th Street & CSAH 50/Kenwood Trail

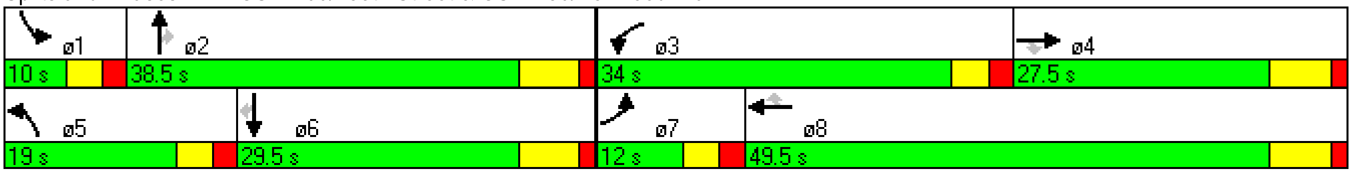


| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 61 | 606 | 309 | 157 | 590 | 341 | 251 | 879 | 56 | 96 | 419 | 23 |
| Satd. Flow (prot) | 1762 | 3524 | 1682 | 1762 | 3524 | 1366 | 3419 | 3524 | 1682 | 3419 | 3524 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 3524 | 1682 | 1762 | 3524 | 1366 | 3419 | 3524 | 1682 | 3419 | 3524 | 1682 |
| Satd. Flow (RTOR) | | | 235 | | | 185 | | | 80 | | | 39 |
| Lane Group Flow (vph) | 80 | 673 | 441 | 476 | 711 | 443 | 359 | 988 | 80 | 141 | 505 | 39 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 12.0 | 27.5 | 27.5 | 34.0 | 49.5 | 49.5 | 19.0 | 38.5 | 38.5 | 10.0 | 29.5 | 29.5 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 6.8 | 21.0 | 21.0 | 29.0 | 43.2 | 43.2 | 13.5 | 31.5 | 31.5 | 5.0 | 22.9 | 22.9 |
| Actuated g/C Ratio | 0.06 | 0.19 | 0.19 | 0.26 | 0.39 | 0.39 | 0.12 | 0.29 | 0.29 | 0.05 | 0.21 | 0.21 |
| v/c Ratio | 0.73 | 1.00 | 0.86 | 1.02 | 0.51 | 0.68 | 0.85 | 0.98 | 0.15 | 0.90 | 0.68 | 0.10 |
| Control Delay | 86.8 | 78.3 | 37.6 | 87.3 | 26.9 | 21.7 | 66.3 | 62.2 | 7.2 | 103.6 | 45.5 | 11.9 |
| 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 | 86.8 | 78.3 | 37.6 | 87.3 | 26.9 | 21.7 | 66.3 | 62.2 | 7.2 | 103.6 | 45.5 | 11.9 |
| LOS | F | E | D | F | C | C | E | E | A | F | D | B |
| Approach Delay | | 63.9 | | | 43.1 | | | 60.1 | | | 55.5 | |
| Approach LOS | | E | | | D | | | E | | | E | |
| Queue Length 50th (ft) | 56 | ~252 | 148 | ~359 | 198 | 150 | 129 | 361 | 0 | 52 | 174 | 0 |
| Queue Length 95th (ft) | #102 | #378 | 153 | 134 | 230 | 193 | 136 | #488 | 18 | #71 | 211 | 11 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 300 | | 300 | 300 | | 300 | 300 | | 300 | 300 | | 300 |
| Base Capacity (vph) | 113 | 676 | 512 | 467 | 1392 | 652 | 437 | 1030 | 548 | 156 | 741 | 385 |
| 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 | 0.71 | 1.00 | 0.86 | 1.02 | 0.51 | 0.68 | 0.82 | 0.96 | 0.15 | 0.90 | 0.68 | 0.10 |

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 109.5
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.02
Intersection Signal Delay: 54.8 Intersection LOS: D
Intersection Capacity Utilization 73.3% ICU Level of Service D
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.

Splits and Phases: 1: CSAH 60/185th Street & CSAH 50/Kenwood Trail

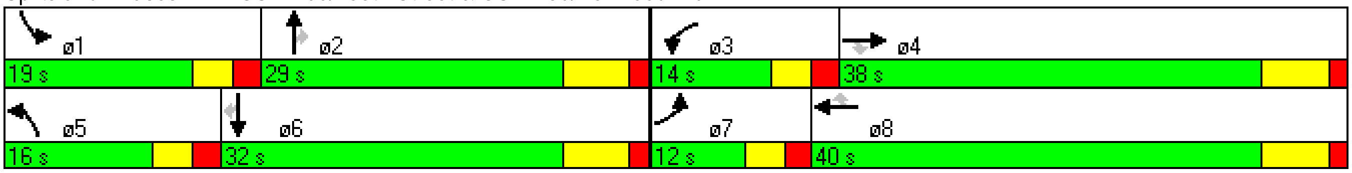


| Lane Group | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane Configurations | | | | | | | | | | | | |
| Volume (vph) | 56 | 966 | 398 | 96 | 723 | 206 | 306 | 493 | 46 | 306 | 757 | 98 |
| Satd. Flow (prot) | 1762 | 3524 | 1682 | 1762 | 3524 | 1366 | 3419 | 3524 | 1682 | 3419 | 3524 | 1682 |
| Flt Permitted | 0.950 | | | 0.950 | | | 0.950 | | | 0.950 | | |
| Satd. Flow (perm) | 1762 | 3524 | 1682 | 1762 | 3524 | 1366 | 3419 | 3524 | 1682 | 3419 | 3524 | 1682 |
| Satd. Flow (RTOR) | | | 323 | | | 258 | | | 92 | | | 117 |
| Lane Group Flow (vph) | 79 | 1110 | 517 | 150 | 964 | 258 | 392 | 601 | 92 | 378 | 870 | 117 |
| Turn Type | Prot | | Perm | Prot | | Perm | Prot | | Perm | Prot | | Perm |
| Protected Phases | 7 | 4 | | 3 | 8 | | 5 | 2 | | 1 | 6 | |
| Permitted Phases | | | 4 | | | 8 | | | 2 | | | 6 |
| Total Split (s) | 12.0 | 38.0 | 38.0 | 14.0 | 40.0 | 40.0 | 16.0 | 29.0 | 29.0 | 19.0 | 32.0 | 32.0 |
| Total Lost Time (s) | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 | 5.0 | 6.5 | 6.5 |
| Act Effct Green (s) | 6.7 | 31.5 | 31.5 | 9.0 | 35.9 | 35.9 | 11.0 | 22.8 | 22.8 | 13.4 | 25.3 | 25.3 |
| Actuated g/C Ratio | 0.07 | 0.32 | 0.32 | 0.09 | 0.36 | 0.36 | 0.11 | 0.23 | 0.23 | 0.13 | 0.25 | 0.25 |
| v/c Ratio | 0.67 | 1.00 | 0.69 | 0.94 | 0.76 | 0.39 | 1.04 | 0.75 | 0.20 | 0.82 | 0.97 | 0.23 |
| Control Delay | 73.2 | 61.4 | 16.1 | 104.4 | 33.8 | 5.1 | 101.4 | 42.5 | 8.0 | 57.5 | 62.4 | 6.8 |
| 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 | 73.2 | 61.4 | 16.1 | 104.4 | 33.8 | 5.1 | 101.4 | 42.5 | 8.0 | 57.5 | 62.4 | 6.8 |
| LOS | E | E | B | F | C | A | F | D | A | E | E | A |
| Approach Delay | | 48.2 | | | 36.1 | | | 60.9 | | | 56.3 | |
| Approach LOS | | D | | | D | | | E | | | E | |
| Queue Length 50th (ft) | 50 | 370 | 103 | 97 | 293 | 0 | ~140 | 189 | 0 | 121 | 289 | 0 |
| Queue Length 95th (ft) | 77 | #489 | 143 | #125 | 288 | 34 | #185 | 224 | 1 | 153 | #393 | 35 |
| Internal Link Dist (ft) | | 796 | | | 760 | | | 770 | | | 712 | |
| Turn Bay Length (ft) | 300 | | 300 | 300 | | 300 | 300 | | 300 | 300 | | 300 |
| Base Capacity (vph) | 123 | 1113 | 752 | 159 | 1269 | 657 | 377 | 806 | 456 | 480 | 901 | 517 |
| 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 | 0.64 | 1.00 | 0.69 | 0.94 | 0.76 | 0.39 | 1.04 | 0.75 | 0.20 | 0.79 | 0.97 | 0.23 |

Intersection Summary

Cycle Length: 100
Actuated Cycle Length: 99.8
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.04
Intersection Signal Delay: 49.7 Intersection LOS: D
Intersection Capacity Utilization 81.1% ICU Level of Service D
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.

Splits and Phases: 1: CSAH 60/185th Street & CSAH 50/Kenwood Trail



# APPENDIX E
Signal Warrant Analysis

## SIGNAL WARRANTS ANALYSIS
## CSAH 50 (Kenwood Trail) and CSAH 60 (185th Street)

LOCATION: Lakeville, MN
COUNTY: Dakota
REF. POINT:
DATE: 1/28/2011
OPERATOR: BTN

| Speed | Approach Description | | Lanes |
|---|---|---|---|
| 50 | Major App1: | Southbound CSAH 50 | 3 |
| 50 | Major App3: | Northbound CSAH 50 | 3 |
| 45 | Minor App2: | Eastbound CSAH 60 | 3 |
| 45 | Minor App4: | Westbound CSAH 60 | 2 |

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

| THRESHOLDS 1A/1B: | | | | 335/503 | | | 111/55 | 111/55 | |
|---|---|---|---|---|---|---|---|---|---|
| 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 | 43 | 32 | 75 | / | 28 | / | 12 | / | **/** |
| 1:00 - 2:00 | 20 | 30 | 50 | / | 25 | / | 7 | / | **/** |
| 2:00 - 3:00 | 22 | 19 | 41 | / | 16 | / | 2 | / | **/** |
| 3:00 - 4:00 | 12 | 15 | 27 | / | 11 | / | 6 | / | **/** |
| 4:00 - 5:00 | 73 | 49 | 122 | / | 26 | / | 14 | / | **/** |
| 5:00 - 6:00 | 79 | 183 | 262 | / | 47 | / | 59 | /X | **/** |
| 6:00 - 7:00 | 130 | 541 | 671 | X/X | 167 | X/X | 182 | X/X | **X/X** |
| 7:00 - 8:00 | 382 | 753 | 1135 | X/X | 277 | X/X | 247 | X/X | **X/X** |
| 8:00 - 9:00 | 282 | 543 | 825 | X/X | 214 | X/X | 197 | X/X | **X/X** |
| 9:00 - 10:00 | 295 | 471 | 766 | X/X | 206 | X/X | 151 | X/X | **X/X** |
| 10:00 - 11:00 | 313 | 355 | 668 | X/X | 199 | X/X | 148 | X/X | **X/X** |
| 11:00 - 12:00 | 437 | 393 | 830 | X/X | 198 | X/X | 169 | X/X | **X/X** |
| 12:00 - 13:00 | 504 | 456 | 960 | X/X | 250 | X/X | 173 | X/X | **X/X** |
| 13:00 - 14:00 | 507 | 388 | 895 | X/X | 239 | X/X | 180 | X/X | **X/X** |
| 14:00 - 15:00 | 613 | 524 | 1137 | X/X | 305 | X/X | 196 | X/X | **X/X** |
| 15:00 - 16:00 | 774 | 670 | 1444 | X/X | 380 | X/X | 238 | X/X | **X/X** |
| 16:00 - 17:00 | 862 | 627 | 1489 | X/X | 445 | X/X | 286 | X/X | **X/X** |
| 17:00 - 18:00 | 868 | 551 | 1419 | X/X | 500 | X/X | 268 | X/X | **X/X** |
| 18:00 - 19:00 | 645 | 457 | 1102 | X/X | 358 | X/X | 228 | X/X | **X/X** |
| 19:00 - 20:00 | 469 | 326 | 795 | X/X | 252 | X/X | 160 | X/X | **X/X** |
| 20:00 - 21:00 | 351 | 290 | 641 | X/X | 222 | X/X | 157 | X/X | **X/X** |
| 21:00 - 22:00 | 262 | 209 | 471 | X/ | 150 | X/X | 132 | X/X | **X/** |
| 22:00 - 23:00 | 126 | 80 | 206 | / | 74 | /X | 62 | /X | **/** |
| 23:00 - 24:00 | 79 | 51 | 130 | / | 50 | / | 25 | / | **/** |

| | Met (Hr) | Required (Hr) | |
|---|---|---|---|
| Warrant 1A | **16** | 8 | **Satisfied** |
| Warrant 1B | **15** | 8 | **Satisfied** |
| Warrant 2 | **15** | 4 | **Satisfied** |
| Warrant 3 | **10** | 1 | **Satisfied** |
| Warrant 7 | **16** | 8 | **Satisfied, check accident record** |

Four Hour Warrant

| | Minor App | | |
|---|---|---|---|
| Major App | 1 & 1 | 2 & 1 | 2 & 2 |
| 300 | 360 | 440 | 590 |
| 400 | 310 | 390 | 530 |
| 500 | 260 | 340 | 460 |
| 600 | 215 | 290 | 390 |
| 700 | 180 | 245 | 330 |
| 800 | 150 | 205 | 280 |
| 900 | 125 | 170 | 235 |
| 1000 | 100 | 145 | 195 |
| 1100 | 85 | 120 | 165 |
| 1200 | 80 | 100 | 135 |
| 1300 | 80 | 83 | 115 |
| 1400 | 80 | 80 | 115 |
| 1500 | 80 | 80 | 115 |
| 1600 | 80 | 80 | 115 |
| 1700 | 80 | 80 | 115 |
| 1800 | 80 | 80 | 115 |

Peak Hour Warrant

| | Minor App | | |
|---|---|---|---|
| Major App | 1 & 1 | 2 & 1 | 2 & 2 |
| 400 | 475 | 570 | 725 |
| 500 | 425 | 520 | 665 |
| 600 | 370 | 465 | 600 |
| 700 | 330 | 420 | 540 |
| 800 | 280 | 370 | 480 |
| 900 | 240 | 330 | 425 |
| 1000 | 204 | 285 | 375 |
| 1100 | 175 | 250 | 330 |
| 1200 | 150 | 220 | 285 |
| 1300 | 130 | 190 | 250 |
| 1400 | 115 | 160 | 220 |
| 1500 | 100 | 140 | 187 |
| 1600 | 100 | 115 | 165 |
| 1700 | 100 | 100 | 150 |
| 1800 | 100 | 100 | 150 |

Four Hour Warrant Factored

| | Minor App | | |
|---|---|---|---|
| Major App | 1 & 1 | 2 & 1 | 2 & 2 |
| 200 | 250 | 320 | 420 |
| 300 | 210 | 265 | 350 |
| 400 | 170 | 215 | 285 |
| 500 | 130 | 170 | 230 |
| 600 | 93 | 130 | 175 |
| 700 | 70 | 100 | 135 |
| 800 | 60 | 80 | 103 |
| 900 | 60 | 65 | 80 |
| 1000 | 60 | 60 | 80 |
| 1100 | 60 | 60 | 80 |
| 1200 | 60 | 60 | 80 |
| 1300 | 60 | 60 | 80 |
| 1400 | 60 | 60 | 80 |
| 1500 | 60 | 60 | 80 |
| 1600 | 60 | 60 | 80 |
| 1700 | 60 | 60 | 80 |
| 1800 | 60 | 60 | 80 |

Peak Hour Warrant Factored

| | Minor App | | |
|---|---|---|---|
| Major App | 1 & 1 | 2 & 1 | 2 & 2 |
| 300 | 320 | 380 | 500 |
| 400 | 270 | 335 | 435 |
| 500 | 225 | 285 | 370 |
| 600 | 180 | 240 | 315 |
| 700 | 145 | 200 | 260 |
| 800 | 115 | 160 | 215 |
| 900 | 90 | 135 | 175 |
| 1000 | 75 | 110 | 140 |
| 1100 | 75 | 95 | 115 |
| 1200 | 75 | 75 | 100 |
| 1300 | 75 | 75 | 100 |
| 1400 | 75 | 75 | 100 |
| 1500 | 75 | 75 | 100 |
| 1600 | 75 | 75 | 100 |
| 1700 | 75 | 75 | 100 |
| 1800 | 75 | 75 | 100 |

LOCATION: Lakeville, MN
COUNTY: Dakota
REF. POINT:
DATE: 1/28/2011

OPERATOR: BTN

| Speed | Approach Description | | Lanes |
|---|---|---|---|
| 50 | Major App1: | Southbound CSAH 50 | 3 |
| 50 | Major App3: | Northbound CSAH 50 | 3 |
| 45 | Minor App2: | Eastbound CSAH 60 | 3 |
| 45 | Minor App4: | Westbound CSAH 60 | 2 |

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

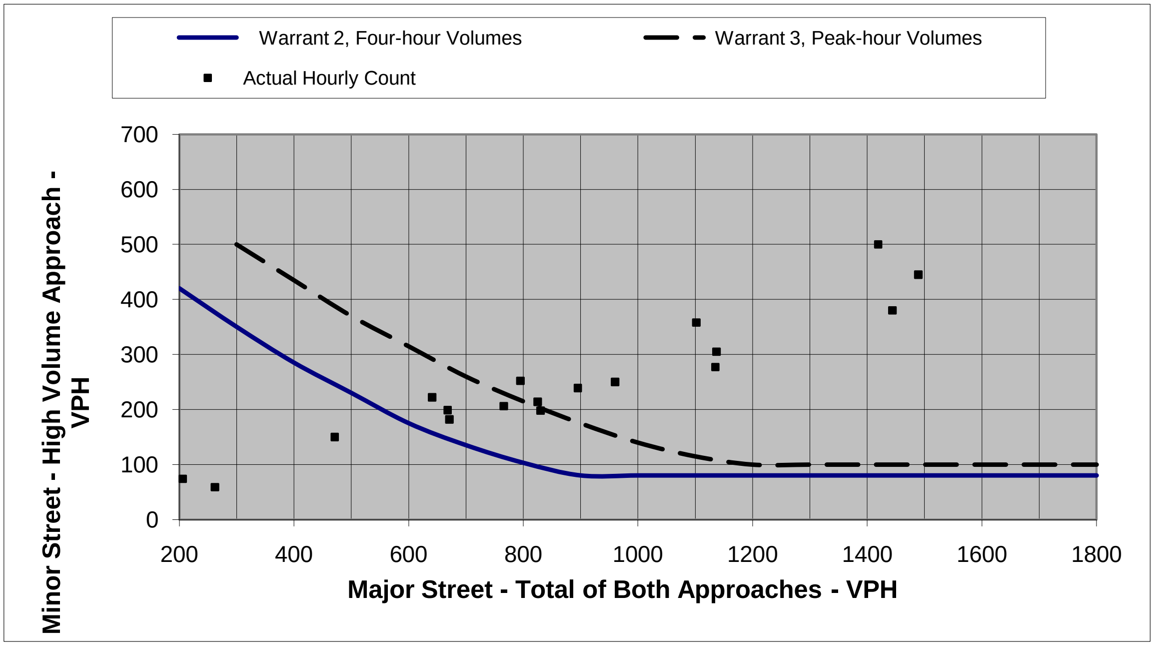



Figure 1. Four Hour and Peak Hour Warrant Analysis

*Note: For data points outside the graph range, check the minor street volume against the lower thresholds*

| | Warrant Criteria | | Actual Hourly Count | |
|---|---|---|---|---|
| Major | Warrant 2, I | Warrant 3, Pe | Major | Actual Hourly Count |
| 200 | 420 | | 75 | 28 |
| 300 | 350 | 500 | 50 | 25 |
| 400 | 285 | 435 | 41 | 16 |
| 500 | 230 | 370 | 27 | 11 |
| 600 | 175 | 315 | 122 | 26 |
| 700 | 135 | 260 | 262 | 59 |
| 800 | 103 | 215 | 671 | 182 |
| 900 | 80 | 175 | 1135 | 277 |
| 1000 | 80 | 140 | 825 | 214 |
| 1100 | 80 | 115 | 766 | 206 |
| 1200 | 80 | 100 | 668 | 199 |
| 1300 | 80 | 100 | 830 | 198 |
| 1400 | 80 | 100 | 960 | 250 |
| 1500 | 80 | 100 | 895 | 239 |
| 1600 | 80 | 100 | 1137 | 305 |
| 1700 | 80 | 100 | 1444 | 380 |
| 1800 | 80 | 100 | 1489 | 445 |
| | | | 1419 | 500 |
| | | | 1102 | 358 |
| | | | 795 | 252 |
| | | | 641 | 222 |
| | | | 471 | 150 |
| | | | 206 | 74 |
| | | | 130 | 50 |

# APPENDIX F
Rodel Roundabout Analysis

```
--------------------------------------------------------------------------------
|                                                                              |
|   2:6:11           CSAH 50 at CSAH 60 2013 2-L E&S 0518              134    |
|                                                                              |
|------------------------------------------------------------------------------|
|                                                  |                           |
| E    (m)    8.00   8.00   8.00   8.00            | 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)   28.96  28.96  28.96  28.96            | TIME COST      $/hr 15.00  |
| PHI  (d)   30.00  30.00  30.00  30.00            | FLOW PERIOD     min 15 75  |
| DIA  (m)   58.00  58.00  58.00  58.00            | FLOW TYPE   pcu/veh   VEH  |
| GRAD SEP       0      0      0      0            | FLOW PEAK  am/op/pm    AM  |
|                                                  |                           |
|------------------------------------------------------------------------------|
| LEG NAME |PCU | TURNS (1st exit, 2nd..U)    |FLOF|CL|     DIRECT    |FLOWS    |
|          |    |                             |    |  |               |         |
|CSAH 50 SB|1.02|   27  305   41  0           |1.00|85|    Press F7 to| edit    |
|CSAH 60 EB|1.02|  169  230   67  0           |1.00|85|    the  direct| flow    |
|CSAH 50 NB|1.02|   16  615  131  0           |1.00|85|               |         |
|CSAH 60 WB|1.02|  166  234   49  0           |1.00|85|   Direct flows| / leg   |
|          |    |                             |    |  |   must = FLOWS| / leg   |
|          |    |                             |    |  |               |         |
|          |    |                             |    |  |               |         |
|------------------------------------------------------------------------------|
|                                                             |                |
| FLOW        veh     373    465    762    449                | AVEDEL  s   3.5 |
| CAPACITY    veh    1635   1647   1685   1375                | LOS   SIG     A |
| AVE DELAY  secs     2.9    2.9    3.9    4.1                | LOS UNSIG     A |
| MAX DELAY  secs     4.4    4.3    5.2    5.8                |                 |
| AVE QUEUE   veh     0.3    0.4    0.8    0.5                | VEHIC HRS   2.0 |
| MAX QUEUE   veh     0.4    0.4    1.0    0.6                | COST    $    30 |
|                                                             |                 |
--------------------------------------------------------------------------------
```

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---------------------------------------------------------------------------------
|                                                                               |
|   2:6:11           CSAH 50 at CSAH 60 2013 2-L E&S 0518                 135  |
|                                                                               |
|-------------------------------------------------------------------------------|
|                                                  |                            |
| E    (m)    8.00   8.00   8.00   8.00            | 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)   28.96  28.96  28.96  28.96            | TIME COST      $/hr 15.00  |
| PHI  (d)   30.00  30.00  30.00  30.00            | FLOW PERIOD     min 15 75  |
| DIA  (m)   58.00  58.00  58.00  58.00            | FLOW TYPE   pcu/veh   VEH  |
| GRAD SEP       0      0      0      0            | FLOW PEAK  am/op/pm    PM  |
|                                                  |                            |
|-------------------------------------------------------------------------------|
| LEG NAME |PCU | TURNS (1st exit, 2nd..U)   |FLOF|CL|     DIRECT    |FLOWS      |
|          |    |                            |    |  |               |           |
|CSAH 50 SB|1.02|  156  576  156  0          |1.00|85|    Press F7 to| edit      |
|CSAH 60 EB|1.02|  228  385  102  0          |1.00|85|    the  direct| flow      |
|CSAH 50 NB|1.02|   11  368  157  0          |1.00|85|               |           |
|CSAH 60 WB|1.02|  115  278   26  0          |1.00|85|   Direct flows| / leg     |
|          |    |                            |    |  |   must = FLOWS| / leg     |
|          |    |                            |    |  |               |           |
|          |    |                            |    |  |               |           |
|-------------------------------------------------------------------------------|
|                                                             |                 |
| FLOW        veh     887    716    537    418                 | AVEDEL  s   4.5 |
| CAPACITY    veh    1604   1412   1485   1495                 | LOS   SIG     A |
| AVE DELAY  secs     4.9    5.2    3.9    3.3                 | LOS UNSIG     A |
| MAX DELAY  secs     7.0    6.6    4.6    4.9                 |                 |
| AVE QUEUE   veh     1.3    1.0    0.6    0.4                 | VEHIC HRS   3.2 |
| MAX QUEUE   veh     1.7    1.2    0.7    0.6                 | COST    $    48 |
|                                                             |                 |
---------------------------------------------------------------------------------
```

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--------------------------------------------------------------------------------
|                                                                              |
|   2:6:11              CSAH 50 at CSAH 60 2023 4-L 0518                116   |
|                                                                              |
|------------------------------------------------------------------------------|
|                                                  |                           |
| E    (m)    8.00   8.00   8.00   8.00            | TIME PERIOD     min    90 |
| L'   (m)   45.72  45.72  45.72  45.72            | TIME SLICE      min    15 |
| V    (m)    7.32   7.32   3.66   3.66            | RESULTS PERIOD  min 15 75 |
| RAD  (m)   28.96  28.96  28.96  28.96            | TIME COST      $/hr 15.00 |
| PHI  (d)   30.00  30.00  30.00  30.00            | FLOW PERIOD     min 15 75 |
| DIA  (m)   58.00  58.00  58.00  58.00            | FLOW TYPE   pcu/veh   VEH |
| GRAD SEP       0      0      0      0            | FLOW PEAK  am/op/pm    AM |
|                                                  |                           |
|------------------------------------------------------------------------------|
| LEG NAME |PCU | TURNS (1st exit, 2nd..U)   |FLOF|CL|     DIRECT    |FLOWS     |
|          |    |                            |    |  |               |          |
|CSAH 50 SB|1.02|   33  357   63  0          |1.00|85|    Press F7 to| edit     |
|CSAH 60 EB|1.02|  228  374   88  0          |1.00|85|    the  direct| flow     |
|CSAH 50 NB|1.02|   30  735  181  0          |1.00|85|               |          |
|CSAH 60 WB|1.02|  238  371   88  0          |1.00|85|   Direct flows| / leg    |
|          |    |                            |    |  |   must = FLOWS| / leg    |
|          |    |                            |    |  |               |          |
|          |    |                            |    |  |               |          |
|------------------------------------------------------------------------------|
|                                                             |                |
| FLOW        veh     454    691    946    697                 | AVEDEL  s   5.1 |
| CAPACITY    veh    1749   1841   1562   1250                 | LOS   SIG     A |
| AVE DELAY  secs     2.8    3.0    6.0    7.3                 | LOS UNSIG     A |
| MAX DELAY  secs     4.5    4.5    8.4   11.7                 |                |
| AVE QUEUE   veh     0.4    0.6    1.6    1.4                 | VEHIC HRS   3.9 |
| MAX QUEUE   veh     0.5    0.7    2.0    2.0                 | COST    $    59 |
|                                                             |                |
--------------------------------------------------------------------------------
```

2:6:11 CSAH 50 at CSAH 60 2023 4-L 0518 117

| | | | | | |
|---|---|---|---|---|---|
| E | (m) | 8.00 | 8.00 | 8.00 | 8.00 |
| L' | (m) | 45.72 | 45.72 | 45.72 | 45.72 |
| V | (m) | 7.32 | 7.32 | 3.66 | 3.66 |
| RAD | (m) | 28.96 | 28.96 | 28.96 | 28.96 |
| PHI | (d) | 30.00 | 30.00 | 30.00 | 30.00 |
| DIA | (m) | 58.00 | 58.00 | 58.00 | 58.00 |
| GRAD SEP | | 0 | 0 | 0 | 0 |

| | | |
|---|---|---|
| TIME PERIOD | min | 90 |
| TIME SLICE | min | 15 |
| RESULTS PERIOD | min | 15 75 |
| TIME COST | $/hr | 15.00 |
| FLOW PERIOD | min | 15 75 |
| FLOW TYPE | pcu/veh | VEH |
| FLOW PEAK | am/op/pm | PM |

| LEG NAME | PCU | TURNS (1st exit, 2nd..U) | | | | FLOF | CL | DIRECT | FLOWS |
|---|---|---|---|---|---|---|---|---|---|
| CSAH 50 SB | 1.02 | 184 | 661 | 219 | 0 | 1.00 | 85 | Press F7 to | edit |
| CSAH 60 EB | 1.02 | 301 | 610 | 121 | 0 | 1.00 | 85 | the direct | flow |
| CSAH 50 NB | 1.02 | 23 | 426 | 219 | 0 | 1.00 | 85 | | |
| CSAH 60 WB | 1.02 | 154 | 449 | 50 | 0 | 1.00 | 85 | Direct flows | / leg |
| | | | | | | | | must = FLOWS | / leg |

| | | | | | |
|---|---|---|---|---|---|
| FLOW | veh | 1064 | 1032 | 668 | 653 |
| CAPACITY | veh | 1694 | 1545 | 1286 | 1405 |
| AVE DELAY | secs | 5.5 | 7.2 | 6.0 | 4.8 |
| MAX DELAY | secs | 8.8 | 9.5 | 7.7 | 8.2 |
| AVE QUEUE | veh | 1.7 | 2.1 | 1.1 | 0.9 |
| MAX QUEUE | veh | 2.5 | 2.4 | 1.3 | 1.5 |

| | | |
|---|---|---|
| AVEDEL | s | 6.0 |
| LOS | SIG | A |
| LOS | UNSIG | A |
| VEHIC HRS | | 5.7 |
| COST | $ | 86 |

```
--------------------------------------------------------------------------------
|                                                                              |
|   2:6:11              CSAH 50 at CSAH 60 2033 4-L ken                 188   |
|                                                                              |
|------------------------------------------------------------------------------|
|                                                  |                           |
| E    (m)    8.00   8.00   8.00   8.00            | TIME PERIOD     min    90  |
| L'   (m)   45.72  45.72  45.72  45.72            | TIME SLICE      min    15  |
| V    (m)    7.32   7.32   3.66   7.32            | RESULTS PERIOD  min 15 75  |
| RAD  (m)   28.96  28.96  28.96  28.96            | TIME COST      $/hr 15.00  |
| PHI  (d)   30.00  30.00  30.00  30.00            | FLOW PERIOD     min 15 75  |
| DIA  (m)   58.00  58.00  58.00  58.00            | FLOW TYPE   pcu/veh   VEH  |
| GRAD SEP       0      0      0      0            | FLOW PEAK  am/op/pm    AM  |
|                                                  |                           |
|------------------------------------------------------------------------------|
| LEG NAME |PCU | TURNS (1st exit, 2nd..U)    |FLOF|CL|     DIRECT    |FLOWS     |
|          |    |                             |    |  |               |          |
|CSAH 50 SB|1.02|   23  419   96  0           |1.00|85|    Press F7 to| edit     |
|CSAH 60 EB|1.02|  309  606   61  0           |1.00|85|    the  direct| flow     |
|CSAH 50 NB|1.02|   56  879  251  0           |1.00|85|               |          |
|CSAH 60 WB|1.02|  341  590  157  0           |1.00|85|   Direct flows| / leg    |
|          |    |                             |    |  |   must = FLOWS| / leg    |
|          |    |                             |    |  |               |          |
|          |    |                             |    |  |               |          |
|------------------------------------------------------------------------------|
|                                                             |                |
| FLOW        veh     538    975   1186   1087                 | AVEDEL  s  15.5 |
| CAPACITY    veh    1497   1726   1408   1362                 | LOS   SIG     B |
| AVE DELAY  secs     3.9    4.6   20.5   25.6                 | LOS UNSIG     C |
| MAX DELAY  secs     7.4    6.9   34.6   50.4                 |                 |
| AVE QUEUE   veh     0.6    1.3    7.0    7.7                 | VEHIC HRS  16.3 |
| MAX QUEUE   veh     0.9    1.4   10.7   13.5                 | COST    $   245 |
|                                                             |                |
--------------------------------------------------------------------------------
```

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---------------------------------------------------------------------------------
|                                                                               |
|   2:6:11             CSAH 50 at CSAH 60 2033 4-L ken                  189    |
|                                                                               |
|-------------------------------------------------------------------------------|
|                                                  |                            |
| E    (m)    8.00   8.00   8.00   8.00           | TIME PERIOD     min    90  |
| L'   (m)   45.72  45.72  45.72  45.72           | TIME SLICE      min    15  |
| V    (m)    7.32   7.32   3.66   7.32           | RESULTS PERIOD  min 15 75  |
| RAD  (m)   28.96  28.96  28.96  28.96           | TIME COST      $/hr 15.00  |
| PHI  (d)   30.00  30.00  30.00  30.00           | FLOW PERIOD     min 15 75  |
| DIA  (m)   58.00  58.00  58.00  58.00           | FLOW TYPE   pcu/veh   VEH  |
| GRAD SEP       0      0      0      0           | FLOW PEAK  am/op/pm    PM  |
|                                                  |                            |
|-------------------------------------------------------------------------------|
| LEG NAME |PCU | TURNS (1st exit, 2nd..U)    |FLOF|CL|     DIRECT    |FLOWS     |
|          |    |                             |    |  |               |          |
|CSAH 50 SB|1.02|   98  757  306  0           |1.00|85|    Press F7 to| edit     |
|CSAH 60 EB|1.02|  398  966   56  0           |1.00|85|    the  direct| flow     |
|CSAH 50 NB|1.02|   46  493  306  0           |1.00|85|               |          |
|CSAH 60 WB|1.02|  206  723   96  0           |1.00|85|   Direct flows| / leg    |
|          |    |                             |    |  |   must = FLOWS| / leg    |
|          |    |                             |    |  |               |          |
|          |    |                             |    |  |               |          |
|-------------------------------------------------------------------------------|
|                                                             |                 |
| FLOW        veh    1160   1421    845   1026                | AVEDEL  s  57.0 |
| CAPACITY    veh    1407   1389   1059   1598                | LOS   SIG     E |
| AVE DELAY  secs    14.8  150.6   17.4    7.5                | LOS UNSIG     F |
| MAX DELAY  secs    38.6  240.0   27.2   16.7                |                 |
| AVE QUEUE   veh     5.8   64.5    4.1    2.2                | VEHIC HRS  70.5 |
| MAX QUEUE   veh    11.7   94.2    6.0    4.7                | COST    $  1057 |
|                                                             |                 |
---------------------------------------------------------------------------------
```

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--------------------------------------------------------------------------------
|                                                                              |
|   2:6:11          CSAH 50 at CSAH 60 2033 4-L ken w/EBR              195   |
|                                                                              |
|------------------------------------------------------------------------------|
|                                                  |                           |
| E    (m)    8.00   8.00   8.00   8.00           | TIME PERIOD     min    90 |
| L'   (m)   45.72  45.72  45.72  45.72           | TIME SLICE      min    15 |
| V    (m)    7.32   7.32   3.66   7.32           | RESULTS PERIOD  min 15 75 |
| RAD  (m)   28.96  28.96  28.96  28.96           | TIME COST      $/hr 15.00 |
| PHI  (d)   30.00  30.00  30.00  30.00           | FLOW PERIOD     min 15 75 |
| DIA  (m)   58.00  58.00  58.00  58.00           | FLOW TYPE   pcu/veh   VEH |
| GRAD SEP       0      0      0      0           | FLOW PEAK  am/op/pm    AM |
|                                                  |                           |
|------------------------------------------------------------------------------|
| LEG NAME |PCU | TURNS (1st exit, 2nd..U)    |FLOF|CL|     DIRECT    |FLOWS     |
|          |    |                             |    |  |               |          |
|CSAH 50 SB|1.02|   23  419   96  0           |1.00|85|    Press F7 to| edit     |
|CSAH 60 EB|1.02|    0  606   61  0           |1.00|85|    the  direct| flow     |
|CSAH 50 NB|1.02|   56  879  251  0           |1.00|85|               |          |
|CSAH 60 WB|1.02|  341  590  157  0           |1.00|85|   Direct flows| / leg    |
|          |    |                             |    |  |   must = FLOWS| / leg    |
|          |    |                             |    |  |               |          |
|          |    |                             |    |  |               |          |
|------------------------------------------------------------------------------|
|                                                             |                |
| FLOW         veh     538    666   1186   1087               | AVEDEL  s  16.8 |
| CAPACITY     veh    1497   1726   1408   1362               | LOS   SIG     B |
| AVE DELAY   secs     3.9    3.2   23.1   24.6               | LOS UNSIG     C |
| MAX DELAY   secs     7.4    5.4   42.9   48.3               |                |
| AVE QUEUE    veh     0.6    0.6    7.9    7.4               | VEHIC HRS  16.2 |
| MAX QUEUE    veh     0.9    0.8   13.4   13.0               | COST    $   243 |
|                                                             |                |
--------------------------------------------------------------------------------
```

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--------------------------------------------------------------------------------
|                                                                              |
|   2:6:11          CSAH 50 at CSAH 60 2033 4-L ken w/EBR              196     |
|                                                                              |
|------------------------------------------------------------------------------|
|                                                 |                            |
| E    (m)    8.00   8.00   8.00   8.00          | TIME PERIOD     min    90  |
| L'   (m)   45.72  45.72  45.72  45.72          | TIME SLICE      min    15  |
| V    (m)    7.32   7.32   3.66   7.32          | RESULTS PERIOD  min 15 75  |
| RAD  (m)   28.96  28.96  28.96  28.96          | TIME COST      $/hr 15.00  |
| PHI  (d)   30.00  30.00  30.00  30.00          | FLOW PERIOD     min 15 75  |
| DIA  (m)   58.00  58.00  58.00  58.00          | FLOW TYPE   pcu/veh   VEH  |
| GRAD SEP       0      0      0      0          | FLOW PEAK  am/op/pm    PM  |
|                                                 |                            |
|------------------------------------------------------------------------------|
| LEG NAME |PCU | TURNS (1st exit, 2nd..U)   |FLOF|CL|     DIRECT    |FLOWS     |
|          |    |                            |    |  |               |          |
|CSAH 50 SB|1.02|   98  757  306  0          |1.00|85|    Press F7 to| edit     |
|CSAH 60 EB|1.02|    0  966   56  0          |1.00|85|    the  direct| flow     |
|CSAH 50 NB|1.02|   46  493  306  0          |1.00|85|               |          |
|CSAH 60 WB|1.02|  206  723   96  0          |1.00|85|   Direct flows| / leg    |
|          |    |                            |    |  |   must = FLOWS| / leg    |
|          |    |                            |    |  |               |          |
|          |    |                            |    |  |               |          |
|------------------------------------------------------------------------------|
|                                                            |                 |
| FLOW        veh    1160   1023    845   1026                | AVEDEL  s  13.6 |
| CAPACITY    veh    1407   1389   1040   1597                | LOS   SIG     B |
| AVE DELAY  secs    14.9   10.5   22.9    7.5                | LOS UNSIG     B |
| MAX DELAY  secs    38.5   14.5   36.6   16.8                |                 |
| AVE QUEUE   veh     5.8    3.0    5.3    2.2                | VEHIC HRS  15.3 |
| MAX QUEUE   veh    11.7    4.3    8.1    4.8                | COST    $   229 |
|                                                            |                 |
--------------------------------------------------------------------------------
```

# APPENDIX G
Crash Data

**Crash Types Safety Analysis**
**CP50-17: CSAH 50 and CSAH 60 Intersection Study**
**Lakeville, Dakota County, MN**

**Crash Type Distribution for High Volume and High Speed Signalized Intersections** *From Mn/DOT for 2009

| | Fatal (K) | Incapacitating Injury (A) | Non-Incapacitating Injury (B) | Possible Injury (C) | Property Damage Only (PD) | Total Crashes |
|---|---|---|---|---|---|---|
| **# of Crashes Statewide** | ***32*** | ***86*** | ***731*** | ***2258*** | ***5911*** | ***9018*** |
| **% of Total Crashes** | 0.4% | 1.0% | 8.1% | 25.0% | 65.5% | 100.0% |

**Base (Existing Signalized Intersection)**

| | Fatal (K) | Incapacitating Injury (A) | Non-Incapacitating Injury (B) | Possible Injury (C) | Property Damage Only (PD) | Total Crashes |
|---|---|---|---|---|---|---|
| **Build** | 0 | 0 | 1 | 2 | 4 | 7 |
| **50% Planned Growth** | 0 | 0 | 1 | 2 | 6 | 9 |
| **Full Planned Growth** | 0 | 0 | 1 | 3 | 7 | 11 |

**Signalized Improvements Alternative**

| | Fatal (K) | Incapacitating Injury (A) | Non-Incapacitating Injury (B) | Possible Injury (C) | Property Damage Only (PD) | Total Crashes |
|---|---|---|---|---|---|---|
| **Build** | 0 | 0 | 0 | 2 | 4 | 6 |
| **50% Planned Growth** | 0 | 0 | 0 | 2 | 6 | 8 |
| **Full Planned Growth** | 0 | 0 | 1 | 2 | 7 | 10 |

**Crash Reduction Factors** *From FHWA Desktop Reference for Crash Reduction Factors

| | | |
|---|---|---|
| Install Median Islands (physical): | Fatal/Injury | 0.25 |

**Roundabout Alternative**

| | Fatal (K) | Incapacitating Injury (A) | Non-Incapacitating Injury (B) | Possible Injury (C) | Property Damage Only (PD) | Total Crashes |
|---|---|---|---|---|---|---|
| **Build** | 0 | 0 | 0 | 1 | 4 | 5 |
| **50% Planned Growth** | 0 | 0 | 0 | 1 | 6 | 7 |
| **Full Planned Growth** | 0 | 0 | 0 | 1 | 7 | 8 |

**Crash Reduction Factors** *From Mn/DOT

| | | |
|---|---|---|
| Signalized to Multi-Lane Roundabout: | Injury Only | 0.65 |

**Safety Analysis**

**CP50-17: CSAH 50 and CSAH 60 Intersection Study**

**Lakeville, Dakota County, MN**

| | Build Year | | 50% Planned Growth | | Full Planned Growth | |
|---|---|---|---|---|---|---|
| Annual Average Daily Traffic (AADT) Volume | 30,150 | | 40,200 | | 52,000 | |
| | crashes per year | crash rate | crashes per year | crash rate | crashes per year | crash rate |
| Base (Existing Signalized Intersection) | 7 | 0.60 | 9 | 0.60 | 11 | 0.60 |
| Signalized Improvements Alternative | 6 | 0.55 | 8 | 0.55 | 10 | 0.55 |
| Roundabout Alternative | 5 | 0.44 | 7 | 0.44 | 8 | 0.44 |

# COLLISION DIAGRAM
## BOLTON & MENK, INC.

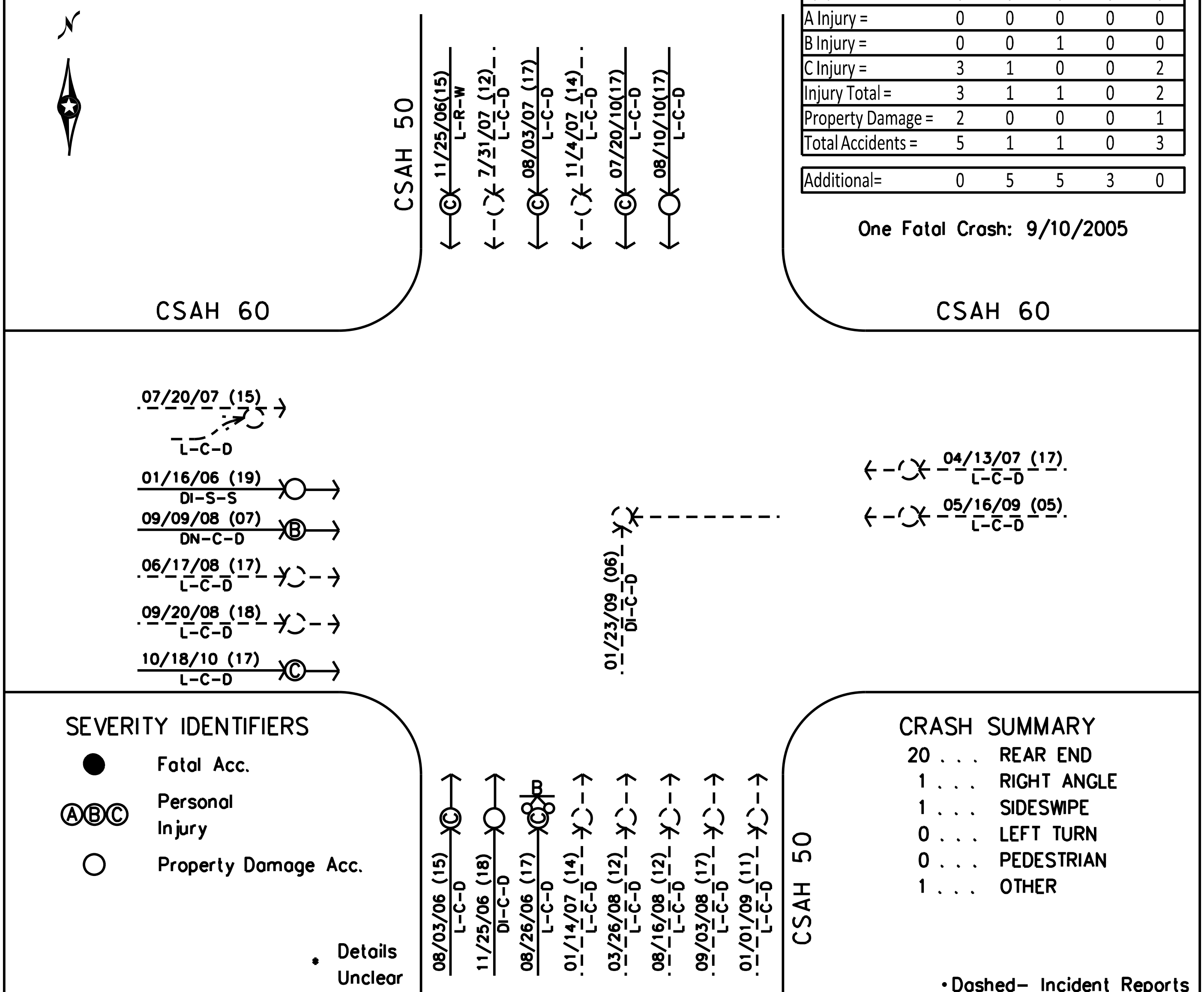
LOCATION: CSAH 50 at CSAH 60 In Lakeville, MN

TIME PERIOD: 01/01/2006 - 12/31/2010 DATE: 02/18/2011

PREPARED BY: J. Bongard

| No. of Accidents | 06 | 07 | 08 | 09 | 10 |
|---|---|---|---|---|---|
| Fatal = | 0 | 0 | 0 | 0 | 0 |
| A Injury = | 0 | 0 | 0 | 0 | 0 |
| B Injury = | 0 | 0 | 1 | 0 | 0 |
| C Injury = | 3 | 1 | 0 | 0 | 2 |
| Injury Total = | 3 | 1 | 1 | 0 | 2 |
| Property Damage = | 2 | 0 | 0 | 0 | 1 |
| Total Accidents = | 5 | 1 | 1 | 0 | 3 |
| Additional= | 0 | 5 | 5 | 3 | 0 |

One Fatal Crash: 9/10/2005




### SEVERITY IDENTIFIERS

- ● Fatal Acc.
- Ⓐ Ⓑ Ⓒ Personal Injury
- ○ Property Damage Acc.
- • Details Unclear

### CRASH SUMMARY

- 20 . . . REAR END
- 1 . . . RIGHT ANGLE
- 1 . . . SIDESWIPE
- 0 . . . LEFT TURN
- 0 . . . PEDESTRIAN
- 1 . . . OTHER

• Dashed- Incident Reports

### KEY

- Motor Vehicle Backing Up
- Motor Vehicle Out of Control
- Motor Vehicle Ahead
- Rear End
- Right Angle
- Left Turn
- Fixed Object
- Pedestrian
- Bicycle/Moped
- Motorcycle
- Deer
- School Bus
- Parking

### 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) |
| DI= 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) |

Other Vehicle — Injury Type — [Date]-[Time (hrs)]-[Light-Weather-Surface]

1 / 3 100%

# Crash Detail Report

CSAH 50 at CSAH 60

LRRB

Report Version 1.0 March 2010

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Crash ID: | 060170028 | Date: | 01/16/2006 | Time: | 1848 | Sys: | 04-CSAH |
| County: | DAKOTA | City: | LAKEVILLE | | | Route: | 19000050 001+00.310 |

| | | | |
|---|---|---|---|
| Severity: | PROPERTY DAMAGE | First Event: | ON ROADWAY |
| Road Type: | 5 LANES UNDIVIDED | To Junction: | INTERSECTION-RELATED |
| Road Char: | FREEWAY MAINLINE | Traffic Device: | TRAFFIC SIGNALS |
| Crash Type: | COLL W/MV IN TRANSPORT | Speed Limit: | 50 |
| Surf Cond: | ICE/PACKED SNOW | Diagram: | REAR END |
| Light Cond: | DARK - STREET LIGHTS ON | Officer: | |
| Weather 1: | SNOW | Reliability: | CONFIDENT |
| Weather 2: | NOT SPECIFIED | # of Vehicles: | 2.00 |

| | Unit 1 | Unit 2 | Unit 3 |
|---|---|---|---|
| Trav Dir: | EAST | E | |
| Veh Act: | LEFT TURN | LEFT TURN | |
| Veh Type: | VAN OR MINIVAN | PASSENGER CAR | |
| Age: | 54 | 17 | |
| Gender: | M | F | |
| Cond: | NORMAL | NORMAL | |
| Cont Fact | WEATHER | WEATHER | |
| Cont Fact | ILLEGAL SPEED | SKIDDING | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Crash ID: | 062160028 | Date: | 08/03/2006 | Time: | 1511 | Sys: | 04-CSAH |
| County: | DAKOTA | City: | LAKEVILLE | | | Route: | 19000050 001+00.310 |

| | | | |
|---|---|---|---|
| Severity: | POSSIBLE INJURY | First Event: | ON ROADWAY |
| Road Type: | 2 LANES UNDIV 2_WAY | To Junction: | INTERSECTION-RELATED |
| Road Char: | FREEWAY MAINLINE | Traffic Device: | TRAFFIC SIGNALS |
| Crash Type: | COLL W/MV IN TRANSPORT | Speed Limit: | 50 |
| Surf Cond: | DRY | Diagram: | REAR END |
| Light Cond: | DAYLIGHT | Officer: | |
| Weather 1: | CLEAR | Reliability: | CONFIDENT |
| Weather 2: | NOT SPECIFIED | # of Vehicles: | 3.00 |

| | Unit 1 | Unit 2 | Unit 3 |
|---|---|---|---|
| Trav Dir: | N | N | N |
| Veh Act: | STRAIGHT AHEAD | STOPPED TRAFFIC | STOPPED TRAFFIC |
| Veh Type: | SPORT UNTILITY VEHICLE | VAN OR MINIVAN | SPORT UNTILITY VEHICLE |
| Age: | 46 | 48 | 38 |
| Gender: | M | F | M |
| Cond: | NORMAL | NORMAL | NORMAL |
| Cont Fact | DISTRACTION | NO IMPROPER DRIVING | NO IMPROPER DRIVING |
| Cont Fact | NOT SPECIFIED | NOT SPECIFIED | NOT SPECIFIED |

2 / 3 100%

| | | | | | |
|---|---|---|---|---|---|
| **Crash ID:** 062390118 | **Date:** 08/26/2006 | **Time:** 1705 | **Sys:** 04-CSAH | | |
| **County:** DAKOTA | **City:** LAKEVILLE | | **Route:** 19000060 | 001+00.986 | |

| | | | |
|---|---|---|---|
| **Severity:** | POSSIBLE INJURY | **First Event:** | ON ROADWAY |
| **Road Type:** | 3 LANES UNDIVIDED | **To Junction:** | 4-LEGGED INTERSECTION |
| **Road Char:** | FREEWAY MAINLINE | **Traffic Device:** | TRAFFIC SIGNALS |
| **Crash Type:** | COLL W/PEDALCYCLE | **Speed Limit:** | 50 |
| **Surf Cond:** | DRY | **Diagram:** | RIGHT ANGLE |
| **Light Cond:** | DAYLIGHT | **Officer:** | |
| **Weather 1:** | CLEAR | **Reliability:** | CONFIDENT |
| **Weather 2:** | CLEAR | **# of Vehicles:** | 1.00 |

| | Unit 1 | Unit 2 | Unit 3 |
|---|---|---|---|
| **Trav Dir:** | NW | MC | |
| **Veh Act:** | STRAIGHT AHEAD | PED. DARTING INTO TRAFFIC | |
| **Veh Type:** | SPORT UNTILITY VEHICLE | BICYCLE | |
| **Age:** | 44 | | |
| **Gender:** | F | | |
| **Cond:** | NORMAL | | |
| **Cont Fact** | NO IMPROPER DRIVING | PEDESTRIAN ERROR | |
| **Cont Fact** | NO IMPROPER DRIVING | NO IMPROPER DRIVING | |

| | | | | |
|---|---|---|---|---|
| **Crash ID:** 063290074 | **Date:** 11/25/2006 | **Time:** 1735 | **Sys:** 04-CSAH | |
| **County:** DAKOTA | **City:** LAKEVILLE | | **Route:** 19000050 | 001+00.310 |

| | | | |
|---|---|---|---|
| **Severity:** | PROPERTY DAMAGE | **First Event:** | ON ROADWAY |
| **Road Type:** | 4_6 LANES UNDIV 2_WAY | **To Junction:** | 4-LEGGED INTERSECTION |
| **Road Char:** | FREEWAY MAINLINE | **Traffic Device:** | TRAFFIC SIGNALS |
| **Crash Type:** | COLL W/MV IN TRANSPORT | **Speed Limit:** | 50 |
| **Surf Cond:** | DRY | **Diagram:** | REAR END |
| **Light Cond:** | DARK - STREET LIGHTS ON | **Officer:** | |
| **Weather 1:** | CLEAR | **Reliability:** | CONFIDENT |
| **Weather 2:** | NOT SPECIFIED | **# of Vehicles:** | 2.00 |

| | Unit 1 | Unit 2 | Unit 3 |
|---|---|---|---|
| **Trav Dir:** | N | N | |
| **Veh Act:** | STRAIGHT AHEAD | STOPPED TRAFFIC | |
| **Veh Type:** | SPORT UNTILITY VEHICLE | SPORT UNTILITY VEHICLE | |
| **Age:** | 21 | 31 | |
| **Gender:** | M | M | |
| **Cond:** | NORMAL | NORMAL | |
| **Cont Fact** | FAIL TO YIELD ROW | NO IMPROPER DRIVING | |
| **Cont Fact** | DISTRACTION | NOT SPECIFIED | |

3 / 3 100%

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Crash ID: | 072180007 | Date: | 08/03/2007 | Time: | 1656 | Sys: | 04-CSAH |
| County: | DAKOTA | City: | LAKEVILLE | | | Route: | 19000050 001+00.310 |

| | | | |
|---|---|---|---|
| Severity: | POSSIBLE INJURY | First Event: | ON ROADWAY |
| Road Type: | 2 LANES UNDIV 2_WAY | To Junction: | NON-JUNCTION |
| Road Char: | FREEWAY MAINLINE | Traffic Device: | NOT APPLICABLE |
| Crash Type: | COLL W/MV IN TRANSPORT | Speed Limit: | 50 |
| Surf Cond: | DRY | Diagram: | REAR END |
| Light Cond: | DAYLIGHT | Officer: | |
| Weather 1: | CLEAR | Reliability: | CONFIDENT |
| Weather 2: | CLEAR | # of Vehicles: | 2.00 |

| | Unit 1 | Unit 2 | Unit 3 |
|---|---|---|---|
| Trav Dir: | MC | MC | |
| Veh Act: | STOPPED TRAFFIC | STRAIGHT AHEAD | |
| Veh Type: | SPORT UNTILITY VEHICLE | PASSENGER CAR | |
| Age: | 44 | 17 | |
| Gender: | M | F | |
| Cond: | NORMAL | NORMAL | |
| Cont Fact | NO IMPROPER DRIVING | DISTRACTION | |
| Cont Fact | NO IMPROPER DRIVING | FOLLOWING TOO CLOSELY | |

**Selection Filter:**

WORK AREA: COUNTY_CODE('20','19') - FILTER: CRASH_YEAR('2006','2007','2008','2009','2010') - SPATIAL FILTER APPLIED

**Analyst:**

Jacob Bongard

**Notes:**

Lakeville, MN 2006-2010

# 2k5-2k10 Dakota CSAH 50-60 - created on 01-21-2011 by Drew1Nat

Crash data is managed by the Mn/DOT Office of Traffic, Safety, and Operations.

| SYS | NUM | REF_POINT | GIS_ROUTE | GIS_TM | RD_DIR | ELEM | RELY | INV | R_U | ATP |
|---|---|---|---|---|---|---|---|---|---|---|
| 04 | 19000050 | 001+00.310 | 0419000050 | 1.310 | Z | | 1 | 3 | U | 5 |
| 04 | 19000050 | 001+00.310 | 0419000050 | 1.310 | Z | 951 | 1 | 1 | U | 5 |
| 04 | 19000060 | 001+00.986 | 0419000060 | 1.986 | Z | | A | 3 | U | 5 |
| 04 | 19000050 | 001+00.310 | 0419000050 | 1.310 | Z | | 1 | 0 | U | 5 |
| 04 | 19000050 | 001+00.310 | 0419000050 | 1.310 | Z | | 1 | 3 | U | 5 |
| 04 | 19000050 | 001+00.310 | 0419000050 | 1.310 | S | | 1 | 3 | U | 5 |
| 04 | 19000060 | 001+00.986 | 0419000060 | 1.986 | Z | | 1 | 3 | U | 5 |
| 04 | 19000050 | 001+00.310 | 0419000050 | 1.310 | Z | | 1 | 3 | U | 5 |
| 04 | 19000050 | 001+00.215 | 0419000050 | 1.215 | Z | | 2 | 3 | U | 5 |
| 04 | 19000050 | 001+00.310 | 0419000050 | 1.310 | Z | | 1 | 3 | U | 5 |
| 04 | 19000060 | 002+00.080 | 0419000060 | 2.080 | E | | 3 | 3 | U | 5 |
| 04 | 19000050 | 001+00.347 | 0419000050 | 1.347 | Z | | 1 | 3 | U | 5 |
| 04 | 19000050 | 001+00.310 | 0419000050 | 1.310 | Z | | 1 | 3 | U | 5 |
| 04 | 19000050 | 001+00.310 | 0419000050 | 1.310 | Z | | 1 | 98 | U | 5 |

| CO | CITY | DOW | MONTH | DAY | YEAR | TIME | SEV | NUM_KILLED | NUM_VEH | JUNC |
|---|---|---|---|---|---|---|---|---|---|---|
| 19 | 2150 | 3-Tue | 2 | 15 | 2005 | 1436 | N | 0 | 2 | 4 |
| 19 | 2150 | 2-Mon | 5 | 2 | 2005 | 0250 | N | 0 | 2 | 1 |
| 19 | 2150 | 7-Sat | 9 | 10 | 2005 | 1239 | K | 1 | 2 | 4 |
| 19 | 2150 | 4-Wed | 10 | 12 | 2005 | 1009 | N | 0 | 2 | 0 |
| 19 | 2150 | 2-Mon | 1 | 16 | 2006 | 1848 | N | 0 | 2 | 7 |
| 19 | 2150 | 5-Thu | 8 | 3 | 2006 | 1511 | C | 0 | 3 | 7 |
| 19 | 2150 | 7-Sat | 8 | 26 | 2006 | 1705 | C | 0 | 1 | 4 |
| 19 | 2150 | 7-Sat | 11 | 25 | 2006 | 1735 | N | 0 | 2 | 4 |
| 19 | 2150 | 2-Mon | 11 | 6 | 2006 | 1525 | C | 0 | 3 | 7 |
| 19 | 2150 | 6-Fri | 8 | 3 | 2007 | 1656 | C | 0 | 2 | 1 |
| 19 | 2150 | 3-Tue | 9 | 9 | 2008 | 0724 | B | 0 | 3 | 7 |
| 19 | 2150 | 3-Tue | 7 | 20 | 2010 | 1638 | C | 0 | 3 | 7 |
| 19 | 2150 | 3-Tue | 8 | 10 | 2010 | 1634 | N | 0 | 3 | 4 |
| 19 | 2150 | 2-Mon | 10 | 18 | 2010 | 1645 | C | 0 | 2 | 0 |

| SL | TYPE | DIAG | LOC1 | TCD | LIT | WTHR1 | WTHR2 | SURF | CHAR | DESGN |
|---|---|---|---|---|---|---|---|---|---|---|
| 45 | 1 | 6 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 8 |
| 50 | 1 | 90 | 1 | 98 | 4 | 2 | 0 | 1 | 1 | 8 |
| 50 | 1 | 98 | 1 | 1 | 1 | 1 | 0 | 1 | 2 | 5 |
| 50 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| 50 | 1 | 1 | 1 | 1 | 4 | 4 | 0 | 5 | 1 | 7 |
| 50 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 8 |
| 50 | 6 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 |
| 50 | 1 | 1 | 1 | 1 | 4 | 1 | 0 | 1 | 1 | 5 |
| 50 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 2 | 0 | 5 |
| 50 | 1 | 1 | 1 | 98 | 1 | 1 | 1 | 1 | 1 | 8 |
| 45 | 1 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 2 | 5 |
| 50 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 8 |
| 50 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 5 |
| 45 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 |

| ACC_NUM | PERSON1 VTYPE | DIR | ACT | FAC1 | FAC2 | POSN | INJ | EQP | PHYS | AGE | SEX |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 050460533 | 7 | S | 11 | 1 | 1 | 1 | N | 4 | 1 | 48 | F |
| 052210144 | 1 | E | 1 | 90 | 18 | 1 | N | 4 | 2 | 21 | M |
| 052780285 | 1 | E | 1 | 5 | 41 | 1 | A | 4 | 99 | 50 | F |
| 053390208 | 1 | 0 | 0 | 0 | 0 | 1 | N | 0 | 0 | 893 | M |
| 060170028 | 4 | E | 6 | 61 | 3 | 1 | N | 4 | 1 | 54 | M |
| 062160028 | 3 | N | 11 | 1 | 0 | 1 | N | 4 | 1 | 38 | M |
| 062390118 | 3 | NW | 1 | 1 | 1 | 1 | N | 4 | 1 | 44 | F |
| 063290074 | 3 | N | 1 | 2 | 15 | 1 | N | 4 | 1 | 21 | M |
| 063450273 | 4 | S | 11 | 1 | 0 | 1 | N | 4 | 1 | 40 | F |
| 072180007 | 1 | 0 | 1 | 15 | 4 | 1 | N | 4 | 1 | 17 | F |
| 082530150 | 1 | E | 1 | 15 | 32 | 1 | N | 99 | 1 | 23 | M |
| 102030127 | 1 | SE | 10 | 15 | 16 | 1 | N | 4 | 1 | 18 | F |
| 102230056 | 1 | S | 1 | 3 | 15 | 1 | N | 4 | 1 | 36 | F |
| 102990141 | 4 | E | 0 | 0 | 0 | 1 | N | 0 | 0 | 26 | F |

| PERSON2 | | | | | | | | | | | PERSON3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| VTYPE | DIR | ACT | FAC1 | FAC2 | POSN | INJ | EQP | PHYS | AGE | SEX | VTYPE |
| 1 | NW | 5 | 3 | 16 | 1 | N | 4 | 1 | 16 | M | |
| 1 | E | 1 | 1 | 0 | 1 | N | 4 | 1 | 27 | M | |
| 11 | S | 1 | 1 | 0 | 1 | K | 11 | 99 | 50 | M | |
| 3 | SE | 1 | 0 | 0 | 1 | N | 0 | 0 | 32 | F | |
| 1 | E | 6 | 61 | 46 | 1 | N | 4 | 1 | 17 | F | |
| 3 | N | 1 | 15 | 0 | 1 | N | 4 | 1 | 46 | M | 4 |
| 53 | 9NW | 33 | 17 | 1 | 25 | C | 98 | 98 | 13 | M | |
| 3 | N | 11 | 1 | 0 | 1 | N | 4 | 1 | 31 | M | |
| 31 | S | 11 | 1 | 0 | 1 | N | 4 | 1 | 43 | M | 2 |
| 3 | 0 | 11 | 1 | 1 | 1 | C | 4 | 1 | 44 | M | |
| 2 | E | 11 | 1 | 0 | 1 | N | 4 | 1 | 38 | M | 3 |
| 1 | SE | 11 | 1 | 1 | 1 | C | 4 | 1 | 55 | F | 1 |
| 1 | S | 11 | 1 | 0 | 1 | N | 4 | 1 | 45 | F | 1 |
| 1 | E | 11 | 0 | 0 | 1 | C | 4 | 0 | 23 | F | |

| | | | | | | | | | | PERSON4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIR | ACT | FAC1 | FAC2 | POSN | INJ | EQP | PHYS | AGE | SEX | VTYPE | DIR | ACT |
| N | 11 | 1 | 0 | 1 | N | 4 | 1 | 48 | F | | | |
| S | 1 | 15 | 18 | 1 | C | 4 | 2 | 44 | M | | | |
| E | 11 | 1 | 0 | 1 | B | 4 | 1 | 45 | F | | | |
| SE | 1 | 1 | 1 | 1 | N | 4 | 1 | 48 | F | | | |
| S | 11 | 1 | 0 | 1 | N | 4 | 0 | 56 | F | | | |

# Attachment C

# Economic Evaluation

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# MEMORANDUM

**Date:** July 1, 2011

**To:** Technical Advisory Committee

**From:** Bryan Nemeth

**Subject:** CP 50-17: CSAH 50 and CSAH 60 Intersection Study, Economic Evaluation

---

This document compares the costs and benefits (benefit-cost analysis) of the proposed improvement alternatives at the intersection of Kenwood Trail (CSAH 50) and 185th Street (CSAH 60). The effects of each proposed investment is converted into monetary terms. This analysis takes into account both the costs of the alternatives but also the incremental benefits of each alternative over time in terms of travel time savings and safety savings.

Throughout this analysis the signal and roundabout improvement alternatives have an estimated build year of 2013 and an opening year of 2014.

The attached Costs and Benefits spreadsheets includes the total costs and benefits of the proposed signal and roundabout improvements over the base condition (existing lanes and signal) in terms of capital cost, maintenance, delay, and safety over the 20-year project life of either improvement. The guidance for the calculations is based on "User Benefit Analysis for Highways", AASHTO, August 2003 and the Benefit/Cost Analysis for Transportation Projects by the Minnesota Department of Transportation (MnDOT). The fiscal year 2011 recommended standard values for the occupancy rates, discount rate, value of time, and crash values used in the calculations were taken from the Mn/DOT Office of Capital Programs and Performance Measures Benefit-Cost Analysis Standard Value Tables and are included below.

| **SFY2011 Recommended Standard Values *(a)*** | |
|---|---|
| **Discount Rate** *(b)* | **Percent** |
| Real | 2.8 |
| **Value of Time *(c)*** | **Dollars per person hour** |
| Auto | $13.80 |
| Truck | $17.46 |
| **Variable Operating Costs *(d)*** | **Dollars per mile** |
| Auto | $0.28 |
| Truck | $0.78 |
| **Mn/DOT Crash Values *(e)*** | **Dollars per crash** |
| Fatal | $7,100,000 |
| Injury Type A only | $415,000 |
| Injury Type B only | $137,000 |
| Injury Type C only | $91,000 |
| Property damage only | $12,000 |

**SFY2011 Recommended Remaining Capital Value Factors *[a, b, c]***

| Expected life (years) | 25 | 30 | 35 | 40 | 50 | 60 | 100 |
|---|---|---|---|---|---|---|---|
| Analysis: 20 years | 0.26 | 0.43 | 0.55 | 0.64 | 0.75 | 0.83 | 0.95 |
| Analysis: 25 | 0.00 | 0.23 | 0.39 | 0.51 | 0.67 | 0.77 | 0.93 |
| Analysis: 30 | 0.00 | 0.00 | 0.21 | 0.36 | 0.57 | 0.70 | 0.91 |

**Minnesota Automobile Occupancy Rates(a)**

| Project Area | Off-Peak | Peak | Daily |
|---|---|---|---|
| **TBI: 7 County Metro Area(b)** | 1.43 | 1.28 | 1.35 |
| **NHTS: Urban Areas(c)** | 1.46 | 1.47 | 1.46 |
| **NHTS: Rural Areas(c)** | 1.6 | 1.36 | 1.49 |

(a) People per vehicle. Vehicle occupancy weighted by vehicle-miles traveled.

(b) Source: 2001 Twin Cities Metropolitan Council Travel Behavior Inventory (TBI).

(c) Source: 2001/2002 National Household Travel Survey (NHTS).

The calculations tables for each cost or benefit are included in the appendices, but an explanation of the methodology is included as follows. Project costs consider the capital and maintenance costs of each alternative. These are expressed in terms of 2011 dollars. The capital cost of the traffic signal improvement includes all of the improvements as designated in the concept layout for the project. The roundabout capital costs include the initial investment of the multi-lane roundabout. The maintenance costs of the alternatives are approximately equal based on the following assumptions.

The maintenance and operating costs for a traffic signal intersection is approximately $1,500 per year for maintenance, $40 per month for signal power, and $12 per month for maintenance and power for the two lights attached to the signal. This equates to a sum of $2,124 per year for operation and maintenance for the signalized intersection alternative.

The maintenance and operating costs for a roundabout intersection is approximately $17 per month for maintenance and power of eight lighting unit poles, one on each entrance and exit of the roundabout. This equates to a sum of $1,632 per year for operation and maintenance for the roundabout intersection alternative. Overall, the difference in operating and maintenance costs of the alternatives is minimal over the 20 year time frame of analysis and was not added into the project costs for the benefit cost calculations.

The travel time (or operating cost) savings are calculated based on the difference in between the Base Case and each Alternative. Travel time is expressed as vehicle-hours traveled (VHT). The VHT is estimated using delay estimation models (i.e. Synchro and Rodel) to develop delay per vehicle estimates for each hour of the day. The estimation of travel time savings includes both the driver and passengers in the vehicle (i.e., vehicle occupancy rates). The valuation of travel time savings is calculated using the standardized cost-per-hour-per-person figures for different vehicles (auto or truck). The operating costs for the roundabout option does not include a free-right, as that improvement is only estimated to be needed near the end of the 20-year design. If a free-right turn lane is added for some movements there will be additional benefit.

The safety benefits were calculated using average crash rates and crash reduction factors obtained from Mn/DOT and FHWA as designated in the Highway Safety Improvement Program (HSIP). The crash reduction factors for the signal were taken from the FHWA Desktop Reference for Crash Reduction Factors while the roundabout reduction factors were taken from the HSIP Criteria for January 2011. These were then summarized in separate tables for consistency with the other calculations.

A summary of the costs and benefits is provided below. The benefit to cost (B/C) ratio presented is the total benefit of the improvement over its cost. Generally, a B/C ratio of 1.00 is needed to substantiate a project.

**Cost and Benefit Summary Table (in 2011 dollars)**

| | **Signal Improvements** | **Multi-Lane Roundabout** |
|---|---|---|
| **Project Costs (A)** | $8,300,000 | $3,500,000 |
| **Vehicle Operating Cost Savings (B)** | $49,024,000 | $73,300,000 |
| **Safety Benefits (C)** | $1,916,000 | $5,106,000 |
| **Total Benefit (B+C)** | *$50,940,000* | *$78,406,000* |
| **Benefit-Cost Ratio ((B+C)/A)** | **6.1** | **22.4** |

Both alternatives do provide vehicle cost savings and safety benefits as compared to the project cost, resulting in a positive project benefit in terms of the benefit-cost ratio. The most significant difference in the costs and benefits between the two alternatives is the vehicle operating cost savings. The roundabout provides a larger delay benefit over the 20-year project life than the signal alternative, which is a result of the lower delay experienced by vehicles at a roundabout. Taking into account all of the costs and benefits as calculated in this study the roundabout alternative provides a larger cost benefit of approximately $27.5 million over the signal improvement alternative and results in a higher benefit to cost ratio.

**Appendix A: Project Costs Calculations**

**Signal Improvements Project Costs**
**CP50-17: CSAH 50 and CSAH 60 Intersection Study**
**Lakeville, Dakota County, MN**

| | | Capital Cost in 2011 Dollars | | |
|---|---|---|---|---|
| | **Year** | **BASE CASE** | **Signal Alternative** | **Present Value** |
| **2013** | **0** | $ - | $ 8,300,000.00 | $ 8,300,000.00 |
| **2014** | **1** | $ - | $ - | $ - |
| **2015** | **2** | $ - | $ - | $ - |
| **2016** | **3** | $ - | $ - | $ - |
| **2017** | **4** | $ - | $ - | $ - |
| **2018** | **5** | $ - | $ - | $ - |
| **2019** | **6** | $ - | $ - | $ - |
| **2020** | **7** | $ - | $ - | $ - |
| **2021** | **8** | $ - | $ - | $ - |
| **2022** | **9** | $ - | $ - | $ - |
| **2023** | **10** | $ - | $ - | $ - |
| **2024** | **11** | $ - | $ - | $ - |
| **2025** | **12** | $ - | $ - | $ - |
| **2026** | **13** | $ - | $ - | $ - |
| **2027** | **14** | $ - | $ - | $ - |
| **2028** | **15** | $ - | $ - | $ - |
| **2029** | **16** | $ - | $ - | $ - |
| **2030** | **17** | $ - | $ - | $ - |
| **2031** | **18** | $ - | $ - | $ - |
| **2032** | **19** | $ - | $ - | $ - |
| **2033** | **20** | $ - | $ - | $ - |
| | **Present Value of Costs (2011 Dollars)** | | | **$ 8,300,000.00** |

**Multi-Lane Roundabout Project Costs**
**CP50-17: CSAH 50 and CSAH 60 Intersection Study**
**Lakeville, Dakota County, MN**

| | | Capital Cost in 2011 Dollars | | |
|---|---|---|---|---|
| | **Year** | **BASE CASE** | **Roundabout Alternative** | **Present Value** |
| **2013** | **0** | $ - | $ 3,500,000.00 | $ 3,500,000.00 |
| **2014** | **1** | $ - | $ - | $ - |
| **2015** | **2** | $ - | $ - | $ - |
| **2016** | **3** | $ - | $ - | $ - |
| **2017** | **4** | $ - | $ - | $ - |
| **2018** | **5** | $ - | $ - | $ - |
| **2019** | **6** | $ - | $ - | $ - |
| **2020** | **7** | $ - | $ - | $ - |
| **2021** | **8** | $ - | $ - | $ - |
| **2022** | **9** | $ - | $ - | $ - |
| **2023** | **10** | $ - | $ - | $ - |
| **2024** | **11** | $ - | $ - | $ - |
| **2025** | **12** | $ - | $ - | $ - |
| **2026** | **13** | $ - | $ - | $ - |
| **2027** | **14** | $ - | $ - | $ - |
| **2028** | **15** | $ - | $ - | $ - |
| **2029** | **16** | $ - | $ - | $ - |
| **2030** | **17** | $ - | $ - | $ - |
| **2031** | **18** | $ - | $ - | $ - |
| **2032** | **19** | $ - | $ - | $ - |
| **2033** | **20** | $ - | $ - | $ - |
| | **Present Value of Costs (2011 Dollars)** | | | **$ 3,500,000.00** |

**Appendix B: Vehicle Operating Cost Savings Calculations**

**Vehicle Operating Cost Savings**
**CP50-17: CSAH 50 and CSAH 60 Intersection Study**
**Lakeville, Dakota County, MN**

**Traffic Signal Improvements**

| | Year | BASE VHT | Signal VHT | VHT Difference | Annual Savings | Present Value |
|---|---|---|---|---|---|---|
| **2014** | **1** | 331.6453439 | 186.6113178 | 145.034026 | $ 984,985.39 | *$ 958,156.99* |
| **2015** | **2** | 368.3873861 | 198.6848088 | 169.7025773 | $ 1,152,519.61 | *$ 1,090,591.46* |
| **2016** | **3** | 405.1294284 | 210.7582998 | 194.3711285 | $ 1,320,053.83 | *$ 1,215,100.78* |
| **2017** | **4** | 441.8714706 | 222.8317908 | 219.0396798 | $ 1,487,588.05 | *$ 1,332,018.40* |
| **2018** | **5** | 478.6135129 | 234.9052818 | 243.708231 | $ 1,655,122.27 | *$ 1,441,665.51* |
| **2019** | **6** | 515.3555551 | 246.9787728 | 268.3767823 | $ 1,822,656.49 | *$ 1,544,351.45* |
| **2020** | **7** | 552.0975974 | 259.0522638 | 293.0453335 | $ 1,990,190.72 | *$ 1,640,374.06* |
| **2021** | **8** | 588.8396396 | 271.1257548 | 317.7138848 | $ 2,157,724.94 | *$ 1,730,020.16* |
| **2022** | **9** | 625.5816819 | 283.1992458 | 342.382436 | $ 2,325,259.16 | *$ 1,813,565.86* |
| **2023** | **10** | 662.3237241 | 295.2727368 | 367.0509873 | $ 2,492,793.38 | *$ 1,891,276.98* |
| **2024** | **11** | 767.2879107 | 323.0647005 | 444.2232102 | $ 3,016,901.51 | *$ 2,226,572.65* |
| **2025** | **12** | 872.2520972 | 350.8566642 | 521.395433 | $ 3,541,009.64 | *$ 2,542,200.11* |
| **2026** | **13** | 977.2162838 | 378.6486279 | 598.5676559 | $ 4,065,117.77 | *$ 2,838,982.01* |
| **2027** | **14** | 1082.18047 | 406.4405915 | 675.7398788 | $ 4,589,225.89 | *$ 3,117,710.82* |
| **2028** | **15** | 1187.144657 | 434.2325552 | 752.9121017 | $ 5,113,334.02 | *$ 3,379,149.79* |
| **2029** | **16** | 1292.108843 | 462.0245189 | 830.0843246 | $ 5,637,442.15 | *$ 3,624,034.00* |
| **2030** | **17** | 1397.07303 | 489.8164826 | 907.2565474 | $ 6,161,550.28 | *$ 3,853,071.32* |
| **2031** | **18** | 1502.037217 | 517.6084462 | 984.4287703 | $ 6,685,658.41 | *$ 4,066,943.32* |
| **2032** | **19** | 1607.001403 | 545.4004099 | 1061.600993 | $ 7,209,766.54 | *$ 4,266,306.21* |
| **2033** | **20** | 1711.96559 | 573.1923736 | 1138.773216 | $ 7,733,874.67 | *$ 4,451,791.71* |
| | **Total Benefits During 20 Year Project Life (2011 Dollars)** | | | | | **$ 49,023,883.60** |

**Multi-Lane Roundabout**

| | Year | BASE VHT | Roundabout VHT | VHT Difference | Annual Savings | Present Value |
|---|---|---|---|---|---|---|
| **2014** | **1** | 331.6453439 | 29.46018102 | 302.1851628 | $ 2,052,263.03 | *$ 1,996,364.82* |
| **2015** | **2** | 368.3873861 | 31.06469267 | 337.3226934 | $ 2,290,896.38 | *$ 2,167,800.02* |
| **2016** | **3** | 405.1294284 | 32.66920431 | 372.460224 | $ 2,529,529.72 | *$ 2,328,415.29* |
| **2017** | **4** | 441.8714706 | 34.27371596 | 407.5977547 | $ 2,768,163.06 | *$ 2,478,672.85* |
| **2018** | **5** | 478.6135129 | 35.8782276 | 442.7352853 | $ 3,006,796.40 | *$ 2,619,017.79* |
| **2019** | **6** | 515.3555551 | 37.48273925 | 477.8728159 | $ 3,245,429.74 | *$ 2,749,878.62* |
| **2020** | **7** | 552.0975974 | 39.0872509 | 513.0103465 | $ 3,484,063.08 | *$ 2,871,667.86* |
| **2021** | **8** | 588.8396396 | 40.69176254 | 548.1478771 | $ 3,722,696.43 | *$ 2,984,782.61* |
| **2022** | **9** | 625.5816819 | 42.29627419 | 583.2854077 | $ 3,961,329.77 | *$ 3,089,605.04* |
| **2023** | **10** | 662.3237241 | 43.90078583 | 618.4229383 | $ 4,199,963.11 | *$ 3,186,502.98* |
| **2024** | **11** | 767.2879107 | 66.14621087 | 701.1416998 | $ 4,761,740.05 | *$ 3,514,320.95* |
| **2025** | **12** | 872.2520972 | 88.3916359 | 783.8604613 | $ 5,323,516.99 | *$ 3,821,917.15* |
| **2026** | **13** | 977.2162838 | 110.6370609 | 866.5792228 | $ 5,885,293.93 | *$ 4,110,149.96* |
| **2027** | **14** | 1082.18047 | 132.882486 | 949.2979844 | $ 6,447,070.87 | *$ 4,379,845.99* |
| **2028** | **15** | 1187.144657 | 155.127911 | 1032.016746 | $ 7,008,847.82 | *$ 4,631,801.19* |
| **2029** | **16** | 1292.108843 | 177.373336 | 1114.735507 | $ 7,570,624.76 | *$ 4,866,781.92* |
| **2030** | **17** | 1397.07303 | 199.6187611 | 1197.454269 | $ 8,132,401.70 | *$ 5,085,525.93* |
| **2031** | **18** | 1502.037217 | 221.8641861 | 1280.17303 | $ 8,694,178.64 | *$ 5,288,743.39* |
| **2032** | **19** | 1607.001403 | 244.1096111 | 1362.891792 | $ 9,255,955.58 | *$ 5,477,117.82* |
| **2033** | **20** | 1711.96559 | 266.3550362 | 1445.610554 | $ 9,817,732.52 | *$ 5,651,307.03* |
| | **Total Benefits During 20 Year Project Life (2011 Dollars)** | | | | | **$ 73,300,219.22** |

| | |
|---|---|
| **Roundabout Versus Signal Improvement Alternatives Delay Benefits in 2011 Dollars** | **$ 24,276,335.62** |

**Vehicle Operating Cost Savings Calculations (Base and Signal Improvement)**
**CP50-17: CSAH 50 and CSAH 60 Intersection Study**
**Lakeville, Dakota County, MN**

| BASE | Year | Time Period | # of hours in Time Period | Volume | Delay per veh | Daily VHT |
|---|---|---|---|---|---|---|
| | **2013** | AM Peak | 1 | 2080 | 39.2 | 22.6 |
| | **2013** | PM Peak | 3 | 2590 | 53.8 | 116.1 |
| | **2013** | AM2 | 6 | 1469 | 27.9 | 68.3 |
| | **2013** | PM2 | 3 | 1568 | 27 | 35.3 |
| | **2013** | PM3 | 2 | 1960 | 36.6 | 39.9 |
| | **2013** | LATE | 6 | 210 | 12.4 | 4.3 |
| | **2013** | LATE2 | 2 | 420 | 14.9 | 3.5 |
| | **2013** | LATE3 | 1 | 915 | 19.2 | 4.9 |
| | | **SUM** | | | | **294.9** |
| | **2023** | AM Peak | 1 | 2810 | 73.1 | 57.1 |
| | **2023** | PM Peak | 3 | 3440 | 107.9 | 309.3 |
| | **2023** | AM2 | 6 | 2017 | 37.8 | 127.1 |
| | **2023** | PM2 | 3 | 2117 | 38.6 | 68.1 |
| | **2023** | PM3 | 2 | 2646 | 55.2 | 81.1 |
| | **2023** | LATE | 6 | 288 | 12.6 | 6.1 |
| | **2023** | LATE2 | 2 | 576 | 17.4 | 5.6 |
| | **2023** | LATE3 | 1 | 1235 | 23.4 | 8.0 |
| | | **SUM** | | | | **662.3** |
| | **2033** | AM Peak | 1 | 3776 | 152.9 | 160.4 |
| | **2033** | PM Peak | 3 | 4452 | 233.9 | 867.8 |
| | **2033** | AM2 | 6 | 2754 | 62.8 | 288.3 |
| | **2033** | PM2 | 3 | 2783 | 64.5 | 149.6 |
| | **2033** | PM3 | 2 | 3479 | 111.5 | 215.5 |
| | **2033** | LATE | 6 | 393 | 14.3 | 9.4 |
| | **2033** | LATE2 | 2 | 787 | 17.7 | 7.7 |
| | **2033** | LATE3 | 1 | 1624 | 29.5 | 13.3 |
| | | **SUM** | | | | **1712.0** |

| Signal | Year | Time Period | # of hours in Time Period | Volume | Delay per veh | Daily VHT |
|---|---|---|---|---|---|---|
| | **2013** | AM Peak | 1 | 2080 | 23.7 | 13.7 |
| | **2013** | PM Peak | 3 | 2590 | 25.8 | 55.7 |
| | **2013** | AM2 | 6 | 1469 | 18.8 | 46.0 |
| | **2013** | PM2 | 3 | 1568 | 19 | 24.8 |
| | **2013** | PM3 | 2 | 1960 | 20.7 | 22.5 |
| | **2013** | LATE | 6 | 210 | 12.1 | 4.2 |
| | **2013** | LATE2 | 2 | 420 | 14.2 | 3.3 |
| | **2013** | LATE3 | 1 | 915 | 16.6 | 4.2 |
| | | **SUM** | | | | **174.5** |
| | **2023** | AM Peak | 1 | 2810 | 34.1 | 26.6 |
| | **2023** | PM Peak | 3 | 3440 | 32.6 | 93.5 |
| | **2023** | AM2 | 6 | 2017 | 24.4 | 82.0 |
| | **2023** | PM2 | 3 | 2117 | 22.4 | 39.5 |
| | **2023** | PM3 | 2 | 2646 | 24.7 | 36.3 |
| | **2023** | LATE | 6 | 288 | 12.2 | 5.9 |
| | **2023** | LATE2 | 2 | 576 | 16.3 | 5.2 |
| | **2023** | LATE3 | 1 | 1235 | 18.3 | 6.3 |
| | | **SUM** | | | | **295.3** |
| | **2033** | AM Peak | 1 | 3776 | 54.8 | 57.5 |
| | **2033** | PM Peak | 3 | 4452 | 49.7 | 184.4 |
| | **2033** | AM2 | 6 | 2754 | 39.5 | 181.3 |
| | **2033** | PM2 | 3 | 2783 | 25.8 | 59.8 |
| | **2033** | PM3 | 2 | 3479 | 32.9 | 63.6 |
| | **2033** | LATE | 6 | 393 | 15.7 | 10.3 |
| | **2033** | LATE2 | 2 | 787 | 16.7 | 7.3 |
| | **2033** | LATE3 | 1 | 1624 | 19.9 | 9.0 |
| | | **SUM** | | | | **573.2** |

**Vehicle Operating Cost Savings Calculations (Roundabout Improvement)**
**CP50-17: CSAH 50 and CSAH 60 Intersection Study**
**Lakeville, Dakota County, MN**

| Roundabout | Year | Time Period | # of hours in Time Period | Volume | Delay per veh | Daily VHT |
|---|---|---|---|---|---|---|
| | **2013** | AM Peak | 1 | 2080 | 3.5 | 2.0 |
| | **2013** | PM Peak | 3 | 2590 | 4.5 | 9.7 |
| | **2013** | AM2 | 6 | 1469 | 2.8 | 6.9 |
| | **2013** | PM2 | 3 | 1568 | 2.9 | 3.8 |
| | **2013** | PM3 | 2 | 1960 | 3.4 | 3.7 |
| | **2013** | LATE | 6 | 210 | 2 | 0.7 |
| | **2013** | LATE2 | 2 | 420 | 2.1 | 0.5 |
| | **2013** | LATE3 | 1 | 915 | 2.3 | 0.6 |
| | | **SUM** | | | | **27.9** |
| | **2023** | AM Peak | 1 | 2810 | 5.1 | 4.0 |
| | **2023** | PM Peak | 3 | 3440 | 6 | 17.2 |
| | **2023** | AM2 | 6 | 2017 | 3 | 10.1 |
| | **2023** | PM2 | 3 | 2117 | 2.9 | 5.1 |
| | **2023** | PM3 | 2 | 2646 | 3.6 | 5.3 |
| | **2023** | LATE | 6 | 288 | 1.8 | 0.9 |
| | **2023** | LATE2 | 2 | 576 | 1.9 | 0.6 |
| | **2023** | LATE3 | 1 | 1235 | 2.2 | 0.8 |
| | | **SUM** | | | | **43.9** |
| | **2033** | AM Peak | 1 | 3776 | 15.5 | 16.3 |
| | **2033** | PM Peak | 3 | 4452 | 57 | 211.5 |
| | **2033** | AM2 | 6 | 2754 | 3.7 | 17.0 |
| | **2033** | PM2 | 3 | 2783 | 3.6 | 8.4 |
| | **2033** | PM3 | 2 | 3479 | 5.3 | 10.2 |
| | **2033** | LATE | 6 | 393 | 1.8 | 1.2 |
| | **2033** | LATE2 | 2 | 787 | 1.9 | 0.8 |
| | **2033** | LATE3 | 1 | 1624 | 2.3 | 1.0 |
| | | **SUM** | | | | **266.4** |

**Appendix C: Safety Benefits Calculations**

**Crash Types Safety Analysis**
**CP50-17: CSAH 50 and CSAH 60 Intersection Study**
**Lakeville, Dakota County, MN**

**Crash Type Distribution for High Volume and High Speed Signalized Intersections** *From Mn/DOT for 2009

| | Fatal (K) | Incapacitating Injury (A) | Non-Incapacitating Injury (B) | Possible Injury (C) | Property Damage Only (PD) | Total Crashes |
|---|---|---|---|---|---|---|
| **# of Crashes Statewide** | ***32*** | ***86*** | ***731*** | ***2258*** | ***5911*** | ***9018*** |
| **% of Total Crashes** | 0.4% | 1.0% | 8.1% | 25.0% | 65.5% | 100.0% |

**Base (Existing Signalized Intersection)**

| | Fatal (K) | Incapacitating Injury (A) | Non-Incapacitating Injury (B) | Possible Injury (C) | Property Damage Only (PD) | Total Crashes |
|---|---|---|---|---|---|---|
| **Build** | 0 | 0 | 1 | 2 | 4 | 7 |
| **50% Planned Growth** | 0 | 0 | 1 | 2 | 6 | 9 |
| **Full Planned Growth** | 0 | 0 | 1 | 3 | 7 | 11 |

**Signalized Improvements Alternative**

| | Fatal (K) | Incapacitating Injury (A) | Non-Incapacitating Injury (B) | Possible Injury (C) | Property Damage Only (PD) | Total Crashes |
|---|---|---|---|---|---|---|
| **Build** | 0 | 0 | 0 | 2 | 4 | 6 |
| **50% Planned Growth** | 0 | 0 | 0 | 2 | 6 | 8 |
| **Full Planned Growth** | 0 | 0 | 1 | 2 | 7 | 10 |

**Crash Reduction Factors** *From FHWA Desktop Reference for Crash Reduction Factors

| | | |
|---|---|---|
| Install Median Islands (physical): | Fatal/Injury | 0.25 |

**Roundabout Alternative**

| | Fatal (K) | Incapacitating Injury (A) | Non-Incapacitating Injury (B) | Possible Injury (C) | Property Damage Only (PD) | Total Crashes |
|---|---|---|---|---|---|---|
| **Build** | 0 | 0 | 0 | 1 | 4 | 5 |
| **50% Planned Growth** | 0 | 0 | 0 | 1 | 6 | 7 |
| **Full Planned Growth** | 0 | 0 | 0 | 1 | 7 | 8 |

**Crash Reduction Factors** *From Mn/DOT

| | | |
|---|---|---|
| Signalized to Multi-Lane Roundabout: | Injury Only | 0.65 |

**Safety Analysis**
**CP50-17: CSAH 50 and CSAH 60 Intersection Study**
**Lakeville, Dakota County, MN**

| | Build Year | | 50% Planned Growth | | Full Planned Growth | |
|---|---|---|---|---|---|---|
| **Annual Average Daily Traffic (AADT) Volume** | **30,150** | | **40,200** | | **52,000** | |
| | **crashes per year** | **crash rate** | **crashes per year** | **crash rate** | **crashes per year** | **crash rate** |
| **Base (Existing Signalized Intersection)** | 7 | 0.60 | 9 | 0.60 | 11 | 0.60 |
| **Signalized Improvements Alternative** | 6 | 0.55 | 8 | 0.55 | 10 | 0.55 |
| **Roundabout Alternative** | 5 | 0.44 | 7 | 0.44 | 8 | 0.44 |

**Signal Improvements Safety Benefits**
**CP50-17: CSAH 50 and CSAH 60 Intersection Study**
**Lakeville, Dakota County, MN**

**Traffic Signal Improvements**

| | Year | BASE Crashes | K | A | B | C | PD | Signal Crashes | K | A | B | C | PD | Crash Difference | K | A | B | C | PD | Annual Savings | Present Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2014** | **1** | 7 | 0 | 0 | 1 | 2 | 4 | 6 | 0 | 0 | 0 | 2 | 4 | 1 | 0 | 0 | 1 | 0 | 0 | $ 137,000.00 | *$ 137,000.00* |
| **2015** | **2** | 8 | 0 | 0 | 1 | 2 | 5 | 7 | 0 | 0 | 0 | 2 | 5 | 1 | 0 | 0 | 1 | 0 | 0 | $ 137,000.00 | *$ 137,000.00* |
| **2016** | **3** | 8 | 0 | 0 | 1 | 2 | 5 | 7 | 0 | 0 | 0 | 2 | 5 | 1 | 0 | 0 | 1 | 0 | 0 | $ 137,000.00 | *$ 137,000.00* |
| **2017** | **4** | 8 | 0 | 0 | 1 | 2 | 5 | 7 | 0 | 0 | 0 | 2 | 5 | 1 | 0 | 0 | 1 | 0 | 0 | $ 137,000.00 | *$ 137,000.00* |
| **2018** | **5** | 8 | 0 | 0 | 1 | 2 | 5 | 7 | 0 | 0 | 0 | 2 | 5 | 1 | 0 | 0 | 1 | 0 | 0 | $ 137,000.00 | *$ 137,000.00* |
| **2019** | **6** | 8 | 0 | 0 | 1 | 2 | 5 | 7 | 0 | 0 | 0 | 2 | 5 | 1 | 0 | 0 | 1 | 0 | 0 | $ 137,000.00 | *$ 137,000.00* |
| **2020** | **7** | 8 | 0 | 0 | 1 | 2 | 5 | 7 | 0 | 0 | 0 | 2 | 5 | 1 | 0 | 0 | 1 | 0 | 0 | $ 137,000.00 | *$ 137,000.00* |
| **2021** | **8** | 8 | 0 | 0 | 1 | 2 | 5 | 7 | 0 | 0 | 0 | 2 | 5 | 1 | 0 | 0 | 1 | 0 | 0 | $ 137,000.00 | *$ 137,000.00* |
| **2022** | **9** | 9 | 0 | 0 | 1 | 2 | 6 | 8 | 0 | 0 | 0 | 2 | 6 | 1 | 0 | 0 | 1 | 0 | 0 | $ 137,000.00 | *$ 137,000.00* |
| **2023** | **10** | 9 | 0 | 0 | 1 | 2 | 6 | 8 | 0 | 0 | 0 | 2 | 6 | 1 | 0 | 0 | 1 | 0 | 0 | $ 137,000.00 | *$ 137,000.00* |
| **2024** | **11** | 9 | 0 | 0 | 1 | 2 | 6 | 9 | 0 | 0 | 1 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | $ - | *$ -* |
| **2025** | **12** | 9 | 0 | 0 | 1 | 2 | 6 | 9 | 0 | 0 | 1 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | $ - | *$ -* |
| **2026** | **13** | 9 | 0 | 0 | 1 | 2 | 6 | 9 | 0 | 0 | 1 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | $ - | *$ -* |
| **2027** | **14** | 9 | 0 | 0 | 1 | 2 | 6 | 9 | 0 | 0 | 1 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | $ - | *$ -* |
| **2028** | **15** | 11 | 0 | 0 | 1 | 3 | 7 | 10 | 0 | 0 | 1 | 2 | 7 | 1 | 0 | 0 | 0 | 1 | 0 | $ 91,000.00 | *$ 91,000.00* |
| **2029** | **16** | 11 | 0 | 0 | 1 | 3 | 7 | 10 | 0 | 0 | 1 | 2 | 7 | 1 | 0 | 0 | 0 | 1 | 0 | $ 91,000.00 | *$ 91,000.00* |
| **2030** | **17** | 11 | 0 | 0 | 1 | 3 | 7 | 10 | 0 | 0 | 1 | 2 | 7 | 1 | 0 | 0 | 0 | 1 | 0 | $ 91,000.00 | *$ 91,000.00* |
| **2031** | **18** | 11 | 0 | 0 | 1 | 3 | 7 | 10 | 0 | 0 | 1 | 2 | 7 | 1 | 0 | 0 | 0 | 1 | 0 | $ 91,000.00 | *$ 91,000.00* |
| **2032** | **19** | 11 | 0 | 0 | 1 | 3 | 7 | 10 | 0 | 0 | 1 | 2 | 7 | 1 | 0 | 0 | 0 | 1 | 0 | $ 91,000.00 | *$ 91,000.00* |
| **2033** | **20** | 11 | 0 | 0 | 1 | 3 | 7 | 10 | 0 | 0 | 1 | 2 | 7 | 1 | 0 | 0 | 0 | 1 | 0 | $ 91,000.00 | *$ 91,000.00* |
| | **Total Benefits During 20 Year Project Life (2011 Dollars)** | | | | | | | | | | | | | | | | | | | | **$ 1,916,000.00** |

## Multi-Lane Roundabout Safety Benefits
## CP50-17: CSAH 50 and CSAH 60 Intersection Study
## Lakeville, Dakota County, MN

**Multi-Lane Roundabout**

| | Year | BASE Crashes | K | A | B | C | PD | Roundabout Crashes | K | A | B | C | PD | Crash Difference | K | A | B | C | PD | Annual Savings | Present Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2014** | **1** | 7 | 0 | 0 | 1 | 2 | 4 | 5 | 0 | 0 | 0 | 1 | 4 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2015** | **2** | 8 | 0 | 0 | 1 | 2 | 5 | 6 | 0 | 0 | 0 | 1 | 5 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2016** | **3** | 8 | 0 | 0 | 1 | 2 | 5 | 6 | 0 | 0 | 0 | 1 | 5 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2017** | **4** | 8 | 0 | 0 | 1 | 2 | 5 | 6 | 0 | 0 | 0 | 1 | 5 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2018** | **5** | 8 | 0 | 0 | 1 | 2 | 5 | 6 | 0 | 0 | 0 | 1 | 5 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2019** | **6** | 8 | 0 | 0 | 1 | 2 | 5 | 6 | 0 | 0 | 0 | 1 | 5 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2020** | **7** | 8 | 0 | 0 | 1 | 2 | 5 | 6 | 0 | 0 | 0 | 1 | 5 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2021** | **8** | 8 | 0 | 0 | 1 | 2 | 5 | 6 | 0 | 0 | 0 | 1 | 5 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2022** | **9** | 9 | 0 | 0 | 1 | 2 | 6 | 7 | 0 | 0 | 0 | 1 | 6 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2023** | **10** | 9 | 0 | 0 | 1 | 2 | 6 | 7 | 0 | 0 | 0 | 1 | 6 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2024** | **11** | 9 | 0 | 0 | 1 | 2 | 6 | 7 | 0 | 0 | 0 | 1 | 6 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2025** | **12** | 9 | 0 | 0 | 1 | 2 | 6 | 7 | 0 | 0 | 0 | 1 | 6 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2026** | **13** | 9 | 0 | 0 | 1 | 2 | 6 | 7 | 0 | 0 | 0 | 1 | 6 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2027** | **14** | 9 | 0 | 0 | 1 | 2 | 6 | 7 | 0 | 0 | 0 | 1 | 6 | 2 | 0 | 0 | 1 | 1 | 0 | $ 228,000.00 | *$ 228,000.00* |
| **2028** | **15** | 11 | 0 | 0 | 1 | 3 | 7 | 8 | 0 | 0 | 0 | 1 | 7 | 3 | 0 | 0 | 1 | 2 | 0 | $ 319,000.00 | *$ 319,000.00* |
| **2029** | **16** | 11 | 0 | 0 | 1 | 3 | 7 | 8 | 0 | 0 | 0 | 1 | 7 | 3 | 0 | 0 | 1 | 2 | 0 | $ 319,000.00 | *$ 319,000.00* |
| **2030** | **17** | 11 | 0 | 0 | 1 | 3 | 7 | 8 | 0 | 0 | 0 | 1 | 7 | 3 | 0 | 0 | 1 | 2 | 0 | $ 319,000.00 | *$ 319,000.00* |
| **2031** | **18** | 11 | 0 | 0 | 1 | 3 | 7 | 8 | 0 | 0 | 0 | 1 | 7 | 3 | 0 | 0 | 1 | 2 | 0 | $ 319,000.00 | *$ 319,000.00* |
| **2032** | **19** | 11 | 0 | 0 | 1 | 3 | 7 | 8 | 0 | 0 | 0 | 1 | 7 | 3 | 0 | 0 | 1 | 2 | 0 | $ 319,000.00 | *$ 319,000.00* |
| **2033** | **20** | 11 | 0 | 0 | 1 | 3 | 7 | 8 | 0 | 0 | 0 | 1 | 7 | 3 | 0 | 0 | 1 | 2 | 0 | $ 319,000.00 | *$ 319,000.00* |
| | **Total Benefits During 20 Year Project Life (2011 Dollars)** | | | | | | | | | | | | | | | | | | | | **$ 5,106,000.00** |

| Roundabout Versus Signal Improvement Alternatives Safety Benefits in 2011 Dollars | |
|---|---|
| **Roundabout Versus Signal Improvement Alternatives Safety Benefits in 2011 Dollars** | **$ 3,190,000.00** |

# Attachment D

# Double-Lane Roundabout State of the Practice

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# M E M O R A N D U M

**Date:** June 8, 2011

**To:** Technical Advisory Committee

**From:** Bryan Nemeth

**Subject:** Double-Lane Roundabout Capacity State of the Practice
CP 50-17: CSAH 50/Kenwood Trail and CSAH 60/185th Street Intersection Study
Lakeville, Dakota County, MN

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To fully evaluate the intersection of Kenwood Trail (CSAH 50) and 185th Street (CSAH 60) in Lakeville, Dakota County, a review of the capacity of the proposed double-lane roundabout was completed. While this analysis indicated that the double-lane roundabout would operate acceptably with forecasted traffic volumes, there is a need to understand if there are other roundabouts in the United States operating at or near the existing and forecasted traffic volumes. This memorandum is a State of the Practice of the traffic volume capacity of a double-lane roundabout, analysis methods, reports, and real-life examples.

Roundabouts, expecially modern roundabouts, in the United States are relatively new, and consequently there is a learning curve associated with driving them. With any roundabout design, it becomes important to understand the capacity of the design and to understand when the traffic control will no longer operate effectively. This can help determine if a roundabout is an effective traffic control option at an intersection based on the operations, safety, cost, and right-of-way available or if additional capacity will be needed.

There are few double-Lane roundabout examples in Minnesota, especially ones that are currently operating at traffic volumes near or at capacity. Nationally, there are more double-lane roundabouts, but again there are few operating at or near capacity today. Assessment of the intersection of CSAH 50/60 was completed using multiple methods to evaluate operations and the capacity of the proposed roundabout.

***Rodel Capacity Analysis***

Analysis using Rodel software was used to evaluate the roundabout capacity. Rodel is a roundabout design software tool that can provide roundabout lane entry and capacity analysis, similar to Synchro software as used for signalized and stop sign controlled intersection analysis. Rodel is recommended by the Minnesota Department of Transportation in the Mn/DOT Road Design Manual, for analysis of roundabouts.

Rodel was developed in Europe and as such is based off of European roundabouts and drivers. Since roundabouts have been in service longer in Europe than the United States, these tools have stated higher capacity ranges than have been noted in the United States. To account for these capacity reductions of roundabouts in the United States, at least until drivers are more comfortable with them, a reduction on the capacity does have merit. The typical way to account for this capacity reduction in Rodel is through the use of altering what is designated the Confidence Level. Based on Rodel analysis of roundabouts within MN, a confidence level of 85 is deemed to be appropriate and was used in the analysis of the CSAH 50/60 intersection evaluation.

The proposed design of the roundabout at CSAH 50 and CSAH 60 in Lakeville was analyzed using Rodel software. The maximum delay threshold for acceptable service levels for a roundabout is the same as other unsignalized intersections at 35 seconds per vehicle (Level of Service D to E threshold).

The Rodel analysis indicates that a double-lane roundabout design can handle the forecasted AM Peak Hour Full Planned Growth traffic volumes (see Table 1 and Figure 1).

**Table 1: Rodel Intersection Delay (seconds per vehicle) and Level of Service (LOS) for the AM Peak Hour**

| Intersection Leg | Build Year | Full Planned Growth (see Fig. 1) |
|---|---|---|
| **North Leg** | 3 sec. per veh. / LOS A | 4 sec. per veh. / LOS A |
| **West Leg** | 3 sec. per veh. / LOS A | 5 sec. per veh. / LOS A |
| **South Leg** | 4 sec. per veh. / LOS A | 21 sec. per veh. / LOS C |
| **East Leg** | 4 sec. per veh. / LOS A | 26 sec. per veh. / LOS D |
| **Entire Intersection** | **4 sec. per veh. / LOS A** | **16 sec. per veh. / LOS C** |

During the PM Peak Hour, the Full Planned Growth traffic volumes indicate that there some approaches operate at unacceptable service levels with the full double-lane roundabout (two lane approaches and two lanes circulating). An eastbound (EB) free right turn lane is necessary to accommodate this volumes (see Table 2 and Figure 2).

**Table 2: Rodel Intersection Delay (seconds per vehicle) and Level of Service (LOS) for the PM Peak Hour**

| Intersection Leg | Build Year | Full Planned Growth with Free EBR (see Fig. 2) |
|---|---|---|
| **North Leg** | 5 sec. per veh. / LOS A | 15 sec. per veh. / LOS B |
| **West Leg** | 5 sec. per veh. / LOS A | 11 sec. per veh. / LOS B |
| **South Leg** | 4 sec. per veh. / LOS A | 23 sec. per veh. / LOS C |
| **East Leg** | 3 sec. per veh. / LOS A | 8 sec. per veh. / LOS A |
| **Entire Intersection** | **5 sec. per veh. / LOS A** | **14 sec. per veh. / LOS B** |

All approaches operate with minimal delay as highlighted in Figure 1: AM Peak Hour Double-Lane Roundabout and Figure 2: PM Peak Hour Double-Lane Roundabout with EB Free Right.

```
--------------------------------------------------------------------------------
|                                                                              |
|   2:6:11              CSAH 50 at CSAH 60 Full Growth 4-L ken           188   |
|                                                                              |
|------------------------------------------------------------------------------|
|                                                  |                           |
| E     (m)     8.00    8.00    8.00    8.00        | TIME PERIOD     min    90 |
| L'    (m)    45.72   45.72   45.72   45.72        | TIME SLICE      min    15 |
| V     (m)     7.32    7.32    3.66    7.32        | RESULTS PERIOD  min 15 75 |
| RAD   (m)    28.96   28.96   28.96   28.96        | TIME COST      $/hr 15.00 |
| PHI   (d)    30.00   30.00   30.00   30.00        | FLOW PERIOD     min 15 75 |
| DIA   (m)    58.00   58.00   58.00   58.00        | FLOW TYPE   pcu/veh   VEH |
| GRAD SEP         0       0       0       0        | FLOW PEAK   am/op/pm   AM |
|                                                  |                           |
|------------------------------------------------------------------------------|
| LEG NAME  |PCU  | TURNS (1st exit, 2nd..U)   |FLOF|CL|     DIRECT     |FLOWS    |
|           |     |                            |    |  |                |         |
|CSAH 50 SB|1.02|    23   419    96   0       |1.00|85|   Press F7 to| edit    |
|CSAH 60 EB|1.02|   309   606    61   0       |1.00|85|   the  direct| flow    |
|CSAH 50 NB|1.02|    56   879   251   0       |1.00|85|                |         |
|CSAH 60 WB|1.02|   341   590   157   0       |1.00|85|  Direct flows| / leg   |
|           |     |                            |    |  |  must = FLOWS| / leg   |
|           |     |                            |    |  |                |         |
|           |     |                            |    |  |                |         |
|------------------------------------------------------------------------------|
|                                                            |                 |
| FLOW        veh      538     975    1186    1087            | AVEDEL  s  15.5 |
| CAPACITY    veh     1497    1726    1408    1362            | LOS    SIG    B |
| AVE DELAY   secs     3.9     4.6    20.5    25.6            | LOS UNSIG     C |
| MAX DELAY   secs     7.4     6.9    34.6    50.4            |                 |
| AVE QUEUE   veh      0.6     1.3     7.0     7.7            | VEHIC HRS  16.3 |
| MAX QUEUE   veh      0.9     1.4    10.7    13.5            | COST     $  245 |
|                                                            |                 |
--------------------------------------------------------------------------------
```

Figure 1. Full Planned Growth AM Rodel Analysis

```
--------------------------------------------------------------------------------
|                                                                              |
|   2:6:11          CSAH 50 at CSAH 60 Full Growth 4-L ken w/EBR        196    |
|                                                                              |
|------------------------------------------------------------------------------|
|                                                  |                           |
| E    (m)    8.00   8.00   8.00   8.00            | TIME PERIOD      min    90 |
| L'   (m)   45.72  45.72  45.72  45.72            | TIME SLICE       min    15 |
| V    (m)    7.32   7.32   3.66   7.32            | RESULTS PERIOD  min 15 75 |
| RAD  (m)   28.96  28.96  28.96  28.96            | TIME COST      $/hr 15.00 |
| PHI  (d)   30.00  30.00  30.00  30.00            | FLOW PERIOD     min 15 75 |
| DIA  (m)   58.00  58.00  58.00  58.00            | FLOW TYPE    pcu/veh   VEH |
| GRAD SEP       0      0      0      0            | FLOW PEAK  am/op/pm    PM |
|                                                  |                           |
|------------------------------------------------------------------------------|
| LEG NAME  |PCU | TURNS (1st exit, 2nd..U)    |FLOF|CL|     DIRECT    |FLOWS    |
|           |    |                             |    |  |               |         |
|CSAH 50 SB|1.02|    98  757  306  0           |1.00|85|   Press F7 to| edit    |
|CSAH 60 EB|1.02|     0  966   56  0           |1.00|85|   the  direct| flow    |
|CSAH 50 NB|1.02|    46  493  306  0           |1.00|85|               |         |
|CSAH 60 WB|1.02|   206  723   96  0           |1.00|85|  Direct flows| / leg   |
|           |    |                             |    |  |  must = FLOWS| / leg   |
|           |    |                             |    |  |               |         |
|           |    |                             |    |  |               |         |
|------------------------------------------------------------------------------|
|                                                             |                |
| FLOW         veh     1160    1023     845    1026            | AVEDEL  s  13.6 |
| CAPACITY     veh     1407    1389    1040    1597            | LOS    SIG     B |
| AVE DELAY    secs     14.9    10.5    22.9     7.5           | LOS UNSIG      B |
| MAX DELAY    secs     38.5    14.5    36.6    16.8           |                |
| AVE QUEUE    veh       5.8     3.0     5.3     2.2           | VEHIC HRS  15.3 |
| MAX QUEUE    veh      11.7     4.3     8.1     4.8           | COST     $   229 |
|                                                             |                |
--------------------------------------------------------------------------------
```

Figure 2. Full Planned Growth PM Rodel Analysis

***National Cooperative Highway Research Program (NCHRP) Roundabout Capacity Analysis***

Current research into the capacity of roundabouts in the United States is ongoing. The most definitive research completed to date has been NCHRP Report 672: Roundabouts: An Informational Guide, Second Edition. This guide builds off of and includes previous research from NCHRP Report 572: Roundabouts in the United States and is the basis for the capacity analysis presented in the latest edition of the Highway Capacity Manual (HCM). Based on the research the general consensus of the capacity of double-lane roundabouts in the United States is approximately 45,000 entering vehicles per day. This is lower than previous estimates for double-lane roundabout capacity which has been stated at 55,000 entering vehicles per day which was largely established through the analysis of roundabouts in Europe.

NCHRP 572 and 672 analysis does not take into account design parameters of individual roundabouts, and only evaluates capacity based on number of lanes and traffic volumes. As such, this analysis is different than Rodel. The most important difference of Rodel to evaluate capacity as compared to the NCHRP equations, is that it accounts for roundabout geometry and volume variability during the time period.

The research completed in NCHRP 572 and 672 is based upon evaluation of roundabout approaches operating at or near capacity, and not the entire roundabout. A roundabout approach operating at or near capacity was identified by observations of persistent queuing. This data was translated into hourly flows and applied to graphs of the entry flow of the critical lane versus the total conflicting flow as shown in Figure 3. Figure 3 also shows a plot of the entry versus circulating volume of the proposed double-lane roundabout in Lakeville at the Build year and at Full Planned Growth.

The existing intersection at CSAH 50 (Kenwood Trail) and CSAH 60 (185$^{th}$ Street) in Lakeville, MN has the following traffic volume characteristics.

**Table 3: Intersection Traffic Volumes**

| | Existing | Build Year | Full Planned Growth |
|---|---|---|---|
| **AM Entering** | 1,930 | 2,080 | 3,820 |
| **PM Entering** | 2,420 | 2,590 | 4,490 |
| **Daily (ADT) Entering** | 28,250 | 30,300 | 54,500<br>52,000 with Free EBR |

The entry versus circulating volumes for the Build Year and Full Planned Growth are also shown in Appendix A at the end of this memorandum for reference.

A review of the data points on the graph indicates that the capacity is different depending on the entry versus circulating flow. Figure 3 indicates that the proposed roundabout is close to or exceeding the capacity of the double-lane roundabout on the east leg of the intersection in the AM peak hour and on the north and west legs of the intersection in the PM peak hour. A reduction of approximately 50 vehicles on the entry lane or a reduction of 100 vehicles on the conflicting flow (over 2 lanes) would be expected to bring all approaches below the regression curve. This is within the confidence level of the future forecasts for the Full Planned Growth scenario. If traffic volumes are 93% of the Full Planned Growth Traffic Volumes, all of the entry versus circulating volume data points are under the capacity curve.

There are multiple data points shown above the curve of average values. These are noted as “Higher Volume Roundabouts” on Figure 3. Roundabouts with high volume characteristics similar to the proposed roundabout in Lakeville are attributed to three roundabouts in the United States, two of which are located within Baltimore, Maryland: MD 139 at Bellona Avenue and MD 45 at MD 146/Joppa Road; and one of which is located in Brattleboro, Vermont: RT 9 at RT 5. All of these are roundabouts have two lane entries and two lanes circulating. Delay and queues were measured at each entry and these measurements indicated acceptable operations with momentary high delays during the peak hour. The data points indicate that these roundabout entries are operating acceptably at capacity ranges above the curve.

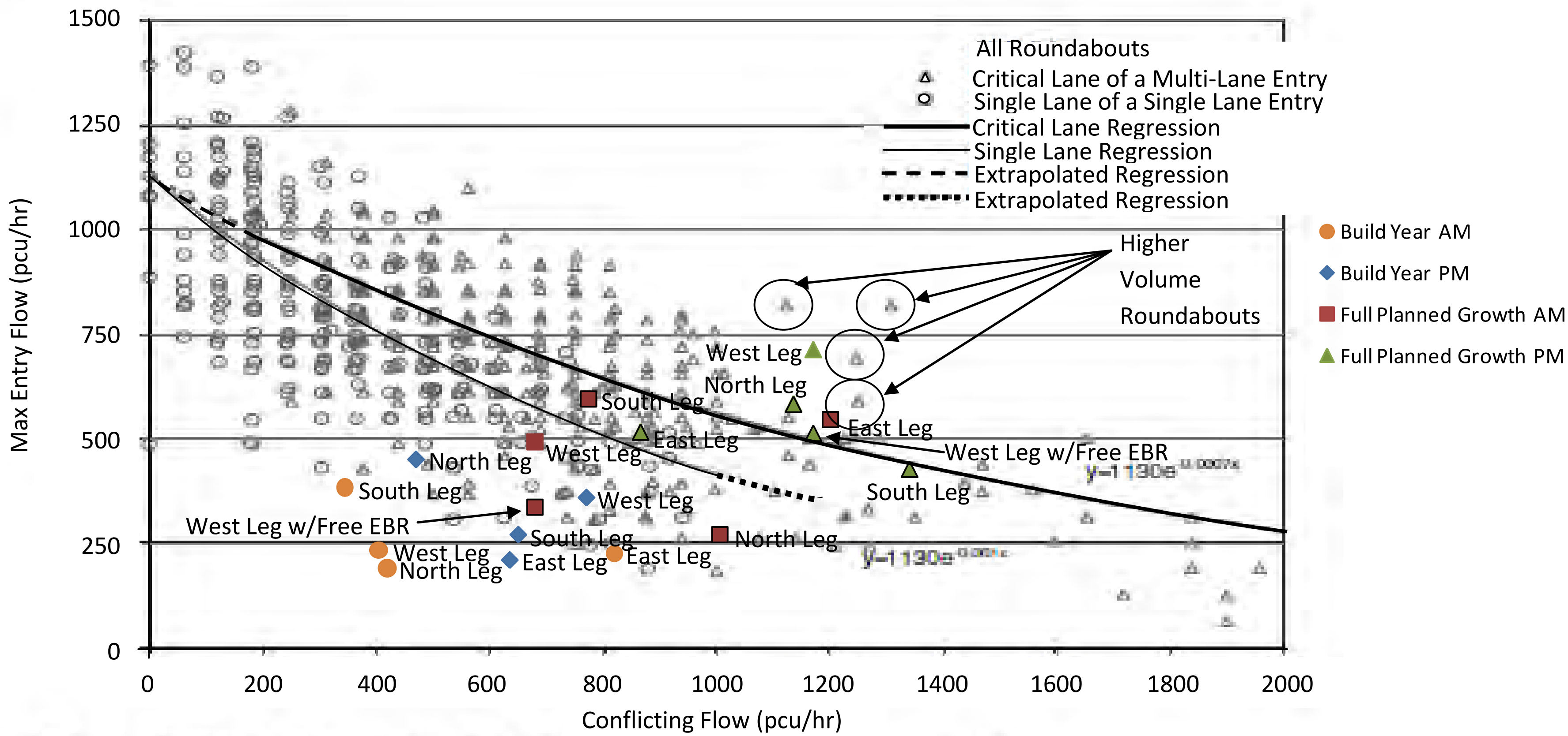



**Figure 3. Single-lane and adjusted multilane critical-lane regression**

***Multi-Lane Roundabout Examples in Minnesota and Nationwide***

Traffic volumes of some similar roundabouts in MN and the United States were collected to get a frame of reference in comparison to the traffic volumes of the proposed roundabout in Lakeville. While the above analysis does provide an evaluation of the capacity, it is also advantageous to review and understand how other roundabouts in the United States, and Canada, are operating with traffic volumes similar to volumes proposed at the CSAH 50/60 intersection in Lakeville. The following are examples of multi-lane roundabouts operating in the United States operating at high traffic volumes. The Annual Average Daily Traffic (AADT) volumes shown are the existing year entering traffic volumes. Many of these examples are included in Appendix B with pictures.

**Table 4A: Roundabout Example Entry Volume Characteristics**

| Roundabout | Existing Traffic Volume (Entering AADT) | Design Year Forecasted Traffic Volume (Entering AADT) |
|---|---|---|
| **Proposed CSAH 50 and CSAH 60 Lakeville, MN** | 28,250<br>2,420 Peak Hr | 52,000<br>4,490 Peak Hr |
| **66th Street and Richfield Parkway Richfield, MN** | 16,900 | 37,100 |
| **66th Street and Portland Avenue Richfield, MN** | 29,300 | 39,700 |
| **Diffley Road (CSAH 30) and Rahn Road Eagan, MN** | 21,500<br>1,852 Peak Hr | 39,000<br>2,180 Peak Hr |
| **Bailey Road and Radio Drive Woodbury, MN** | 16,500 | 44,000<br>70,000 for Triple Lane Rbt |
| **Hayden Bridge and Martin Luther King Jr. Parkway/Pioneer Parkway Springfield, OR** | 26,000 | 57,000 |
| **Avon Road and Beaver Creek Boulevard Avon, CO** | 40,000<br>2,190 Peak Hr | 57,000<br>2,725 Peak Hr |
| **Olympic Way and 4th Avenue/5th Avenue Olympia, WA** | 29,800<br>2,950 Peak Hr | 59,800<br>5,900 Peak Hr |
| **Briton Parkway and Haydon Run Hilliard, OH** | 35,000 | - |

**Table 4B: Roundabout Example Entry Volume Characteristics Continued**

| Roundabout | Existing Traffic Volume (Entering AADT) |
|---|---|
| **Proposed CSAH 50 and CSAH 60**<br>**Lakeville, MN** | 28,250<br>2,420 Peak Hr |
| **Marvin Road SE/Pacific Avenue SE**<br>**Lacey, WA** | 30,500 |
| **Marvin Road NE and Willamette Dr/Britton Parkway**<br>**Lacey, WA** | 28,500 |
| **Columbia Park Trail and Steptoe Street**<br>**Richland, WA** | 32,000 |
| **Springdale Street and 8th Street**<br>**Mount Horeb, WI** | 30,000<br>3,000 Peak hr |
| **Carefree Circle S and New Center Point**<br>**Colorado Springs, CO** | 26,200 |
| **Cony Street and Bangor Street/Stone Street**<br>**Augusta, ME** | 38,000 |
| **Rue Notre Dame/Rue Sherbrooke**<br>**Montreal, Quebec** | 38,000 |
| **Lakewood Blvd (SR 19) and Pacific Coast Hwy (SR 1)**<br>**Long Beach, CA** | 53,000 |
| **I-80/Camonix Road**<br>**Vail, CO** | 30,000 |
| **Hwy 85 and Hwy 17**<br>**Waterloo, Ontario** | 30,000 |
| **Erb Street and Ira Needles Blvd**<br>**Waterloo, Ontario** | 40,000 |
| **Ira Needles Corridor**<br>**Waterloo, Ontario** | 28,000 |
| **Townline Road and Can-Amera Blvd**<br>**Cambridge, Ontario** | 32,000 |
| **Happy Valley Road and I-17**<br>**Phoenix, AZ** | 38,000 |

The example roundabouts shown in Tables 4A and 4B are all multi-lane roundabouts with at least three approaches with two or more lanes. These provide a good comparison to the proposed roundabout in Lakeville at CSAH 50 and CSAH 60. There is only one known roundabout in MN, at the intersection of 66th Street and Portland Avenue in Richfield, operating at volumes near the existing traffic volumes of the CSAH 50/60 intersection. There are at least another 18 roundabouts within the United State and Canada that are operating with traffic volumes either near or higher than the existing traffic volume at CSAH 50/60. This indicates that the proposed roundabout is not unusual and it will be able to operate effectively. While many of the example roundabouts are not operating at traffic volumes as high as the Full Planned Growth forecasted traffic volumes at CSAH 50/60, the expectation is that traffic will continue to increase at all of these roundabouts. Most of them are located in areas where future growth expansion is planned and there is open land available. With these traffic volumes it is anticipated that most of these intersections would operate with traffic volumes either near or higher than the forecasted traffic volumes at CSAH 50/60 of 52,000 to 54,500 vehicles per day based on the existing traffic volumes.

***Conclusions***

Evaluation of the proposed roundabout at CSAH 50/Kenwood Trail and CSAH 60/185th Street in Lakeville, Dakota County, MN through Rodel software indicates that a double lane roundabout will operate effectively until the traffic volumes at Full Planned Growth are met. This includes the addition of an eastbound free right turn lane to address the high PM Peak Hour volumes based on Full Planned Growth of the area.

The analysis provided in NCHRP Reports 572 and 672 indicate that some approaches of the CSAH 50/60 intersection are close to the capacity threshold for a roundabout. While this analysis does provide a quick evaluation it does not account for traffic variables (i.e. lane widths, entry angles, Size of the roundabout (diameter), traffic arrivals (platoons), and traffic variability during the peak hour (peak hour factor)). Additionally, there are multiple roundabouts in the NCHRP study that are operating effectively at traffic volumes higher than the forecasted CSAH 50/60 traffic volumes. Also, when taking into account traffic forecast variability, it appears that the proposed roundabout will operate effectively.

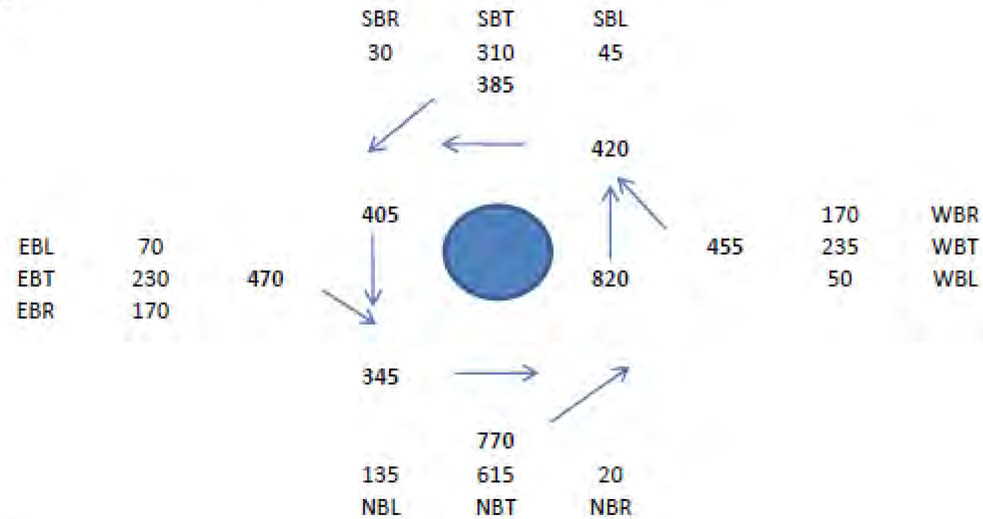
There are multiple multi-lane and double lane roundabouts throughout MN, the United States, and Canada that are operating acceptably with traffic volumes higher than the current traffic volumes at the intersection of CSAH 50/Kenwood Trail and CSAH 60/185th Street in Lakeville, Dakota County, MN. While many of the example roundabouts are not operating at traffic volumes as high as the Full Planned Growth forecasted traffic volumes at CSAH 50/60, the expectation is that traffic will continue to increase at all of these roundabouts to levels of 50,000 to 55,000 vehicles per day.

Based on the Rodel analysis, NCHRP analysis, and national examples of roundabouts at these higher volumes, the proposed roundabout at CSAH 50/60 in Lakeville can manage the proposed traffic volumes and is anticipated to operate acceptably.

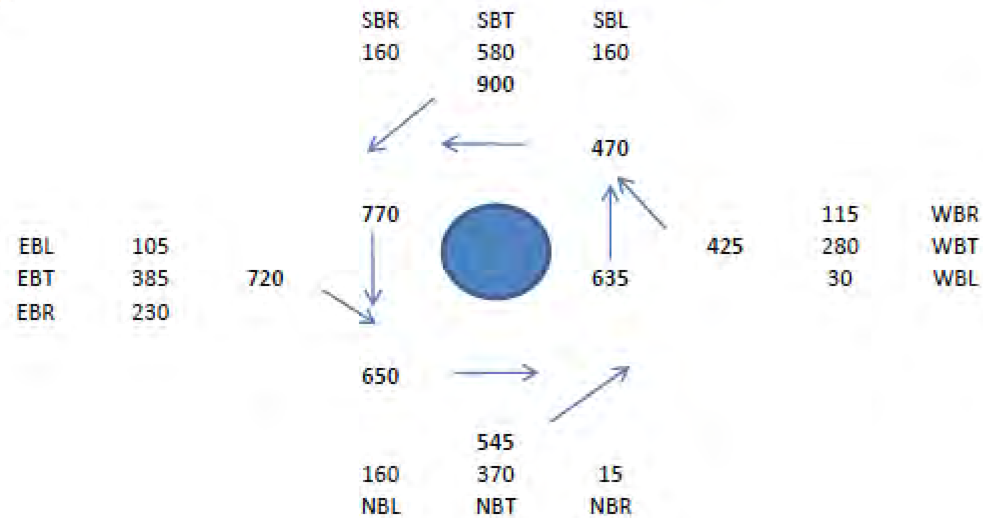
**Appendix A: Entry Versus Circulating Traffic Volumes**

**Entry Verus Circulating Traffic Volumes**
**Proposed Roundabout at CSAH and CSAH 60**
**Lakeville, Dakota County, MN**

Build Year AM

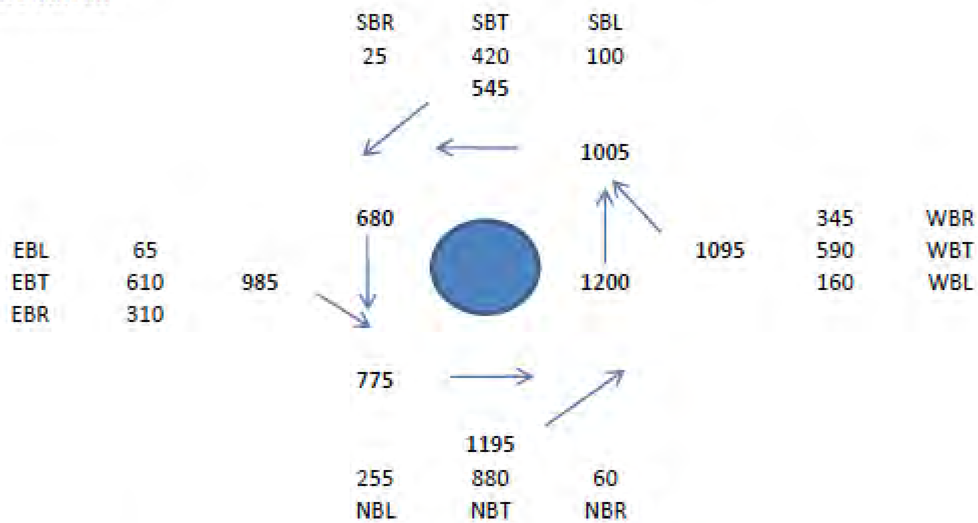



Build Year PM

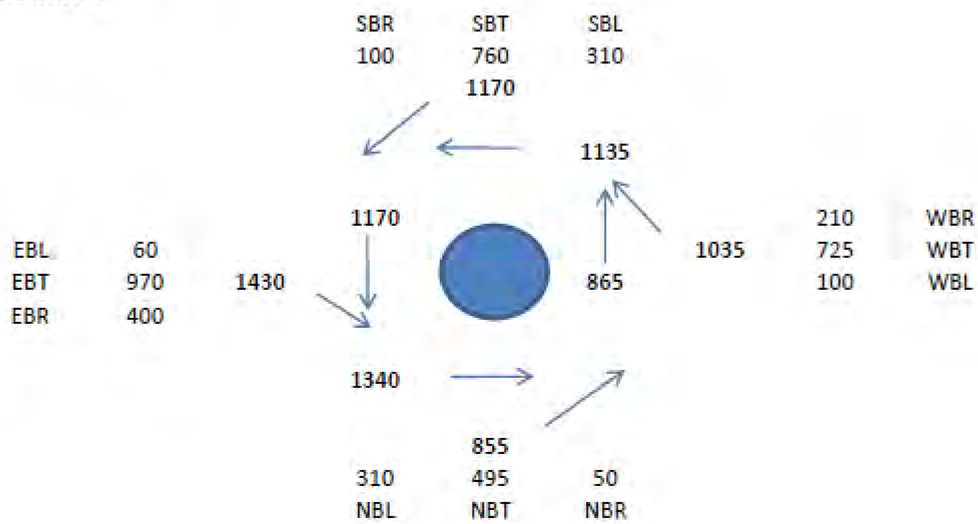


**Entry Verus Circulating Traffic Volumes**
**Proposed Roundabout at CSAH and CSAH 60**
**Lakeville, Dakota County, MN**

Full Planned Growth AM



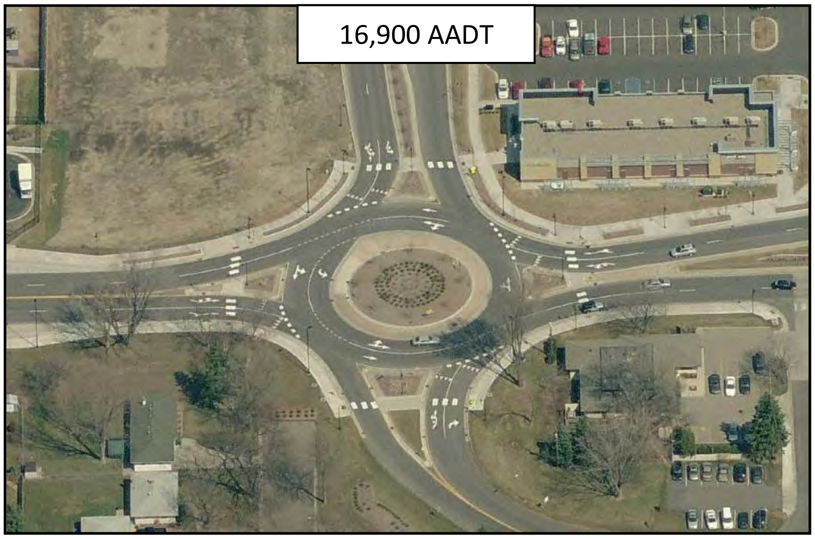

Full Planned Growth PM



**Appendix B: Roundabout Examples**

Most recent existing year AADT shown on roundabout picture.

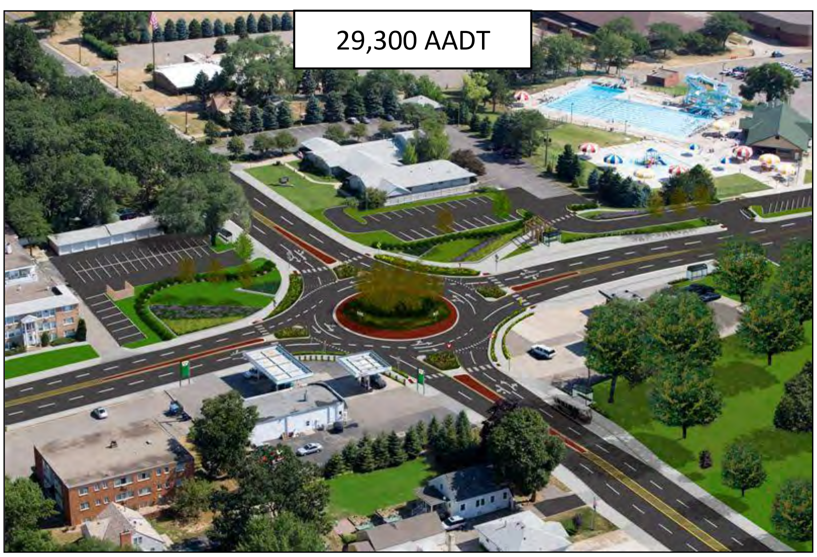
**Richfield, MN (66th Street and Richfield Parkway)**




Opened in October 2007

2027 Projected AADT: 37,100

**Richfield, MN (66th Street and Portland Avenue)**




Opened in Fall 2008

2027 Projected AADT: 39,700

**Springfield, OR (Hayden Bridge and Martin Luther King Jr. Parkway/Pioneer Parkway)**

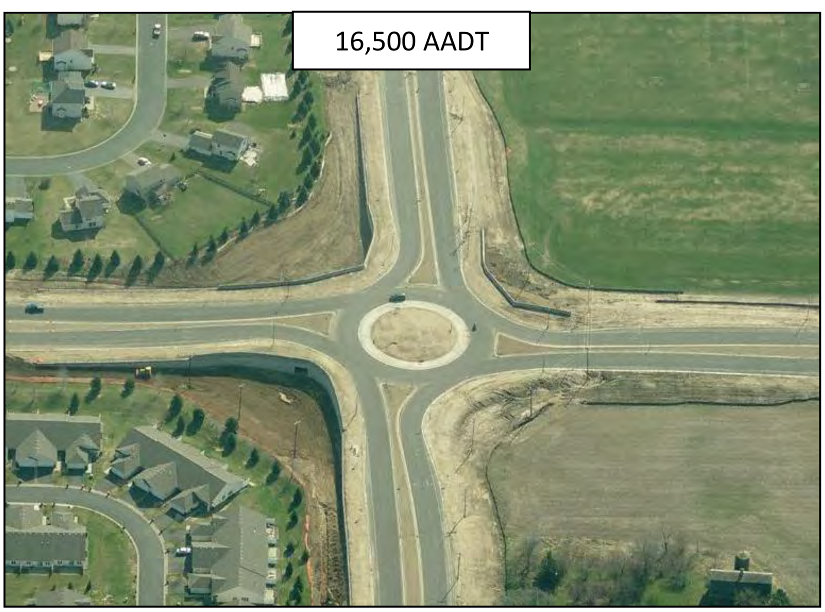

20 Year Projected AADT: 57,000

N-S Speed Limit: 45 mph

E-W Speed Limit: 35 mph

No yielding problems at entering.

**Woodbury, MN (Bailey Road and Radio Drive)**




2017 Projected AADT: 44,000

2027 Projected AADT: 70,000

**Avon, CO (Avon Road and Beaver Creek Boulevard)**


Picture provided by Ourston Roundabouts

Opened in 1997

20 Year Projected AADT: 57,000

Winter Volumes

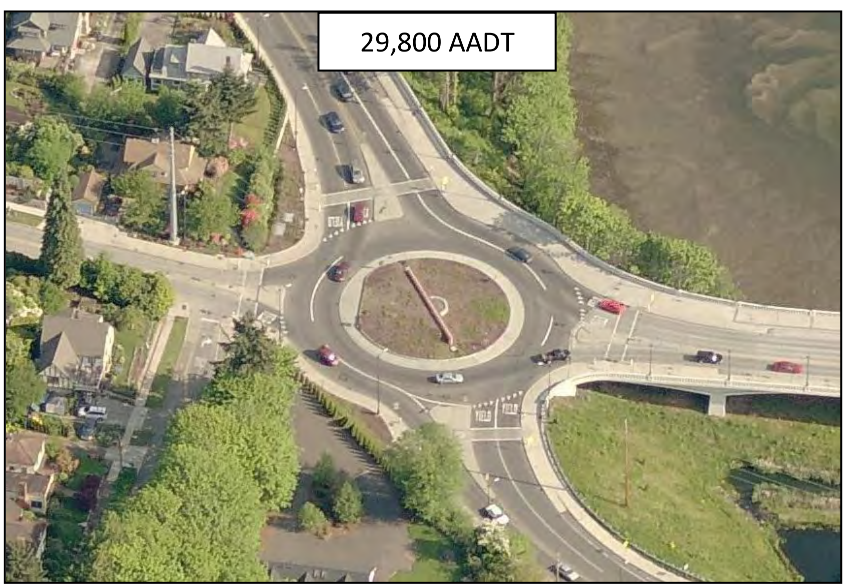
Existing AM Peak Hr: 1,410

Existing PM Peak Hr: 2,190

20-Year AM Peak Hr: 2,220

20-Year PM Peak Hr: 2,725

**Olympia, WA (Olympic Way and 4th Avenue/5th Avenue)**



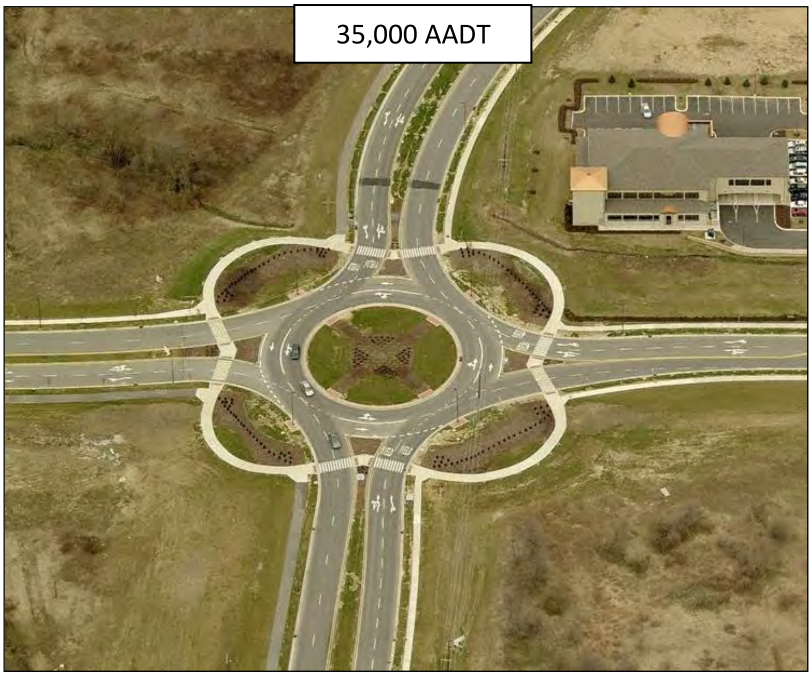

Opened in 2004

2031 Projected AADT: ~59,800

Existing Peak Hour: 2,950

2031 Peak Hour: 5,900

**Hilliard, OH (Briton Parkway and Haydon Run)**




**Richland, WA (Columbia Park Trail and Steptoe Street)**

**Lacey, WA (Marvin Road SE/Pacific Avenue SE)**


**Lacey, WA (Marvin Road NE and Willamette Dr/Britton Parkway)**

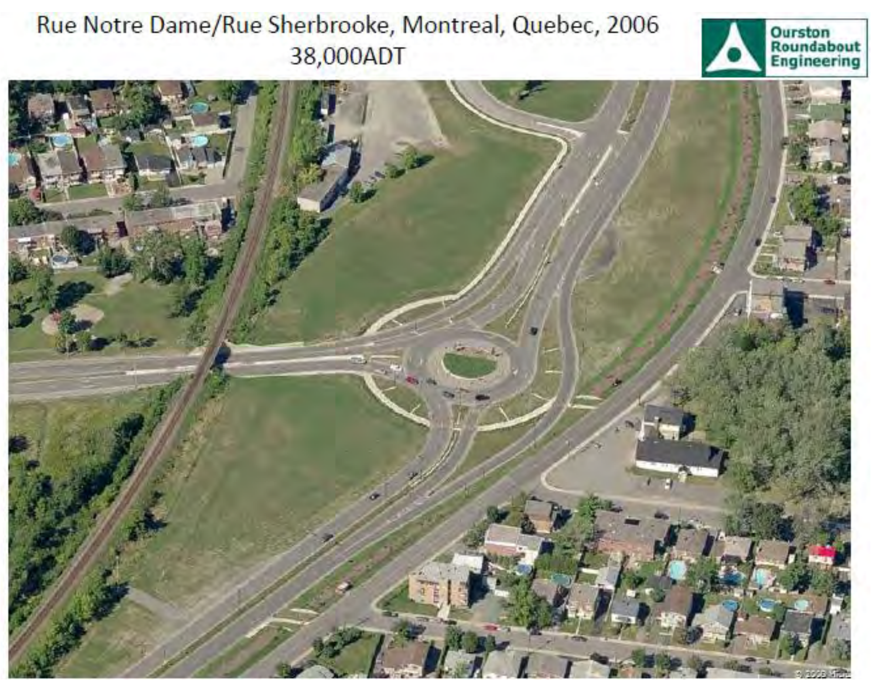
**Mount Horeb, WI (Springdale Street and 8th Street)**


Existing Peak Hour Entering Volume: 3,000

~approximate AADT

**Colorado Springs, CO (Carefree Circle S and New Center Point)**

**Augusta, ME (Cony Street and Bangor Street/Stone Street)**

Long Beach, CA
53,000ADT

Ourston Roundabout Engineering

I-70/Chamonix Rd, Vail, CO, 1995
30,000ADT

Ourston Roundabout Engineering

Hwy. 85/Hwy. 17, Waterloo, ON, 2006
30,000ADT

Ourston Roundabout Engineering

Erb Street/Ira Needles Blvd, 2005
40,000ADT

Ourston Roundabout Engineering

## Ira Needles Corridor, 28,000ADT

## Townline Road Can-Amera Blvd, Cambridge, ON 2005 32,000ADT

Happy Valley/I17 T.I., AZ, 2005
38,000ADT

Ourston Roundabout Engineering

## Appendix C: Additional MN Intersection Comparison Traffic Volume Information

| | | Volume on Each approach | | | | |
|---|---|---|---|---|---|---|
| **Intersection Exist/Proj.** | **Year** | **North** | **South** | **East** | **West** | **Total Ent. Vol.** |
| Kenwood trail & 185th Dakota County | 2010 | 17,200 | 15,900 | 9,500 | 13,900 | 28,500 (2,400 peak hour) |
| | Full Planned Growth | 27,000 | 27,000 | 24,000 | 31,000 | 54,500 (4,700 peak hour) |
| Rahn & Diffley Dakota County | 2009 | 8400 | 3600 | 15700 | 15,200 | 21,500 (1852 pm peak hr.) |
| | 2025 | 10,000 | 4500 | 31700 | 31700 | 39,000 (2180 pm peak hour) |
| Radio & Bailey Washington Co. | 2009 | 9400 | 8300 | 7700 | 7600 | 16,500 |
| | 2017 | 25,000 | 24,000 | 19,000 | 20,000 | 44,000 |
| | 2027 | 35000 | 34,000 | 34,000 | 37,000 | 70,000 |
| 66th & Portland Richfield | 2009 | 13,000 | 13,000 | 16,300 | 16,300 | 29,300 |
| | 2027 | 22,900 | 22,900 | 16,805 | 16,805 | 39,700 |
| 66th & Richfield Parkway | 2027 | 10,700 | 10,700 | 26,400 | 26,400 | 37,100 |
| CH 16/Lynn Scott County | 2009 | 7,800 | 7,000 | 12,500 | 12,500 | 19,900 |
| | 2030 | 10,600 | 9,500 | 16,900 | 16,900 | 26,950 |

# Attachment E

# CSAH 50 and CSAH 60 Delay Study

# Dakota County Delay Study Summary

CSAH 50 (Kenwood Trail) and CSAH 60 (185th Street)
Date: 05/06/2011
Analyzed by: KC, PV
Date Collected: April – May 2011

**Reason for study:**
CP 50-17, the study of the hwy 60 & 50 intersection is being conducted by Dakota County Transportation staff to assess alternatives to handle traffic now and in the future. An open house was held as part of the study. At the open house several citizens commented about prolonged delays at existing side streets near the CSAH 50 and CSAH 60 intersection during peak hours.

The County performed PM delay studies and 24hr side road counts at the following intersections: (see attached Figure A)

- CSAH 50 and 188th Street
- CSAH 50 and Jaguar Path
- CSAH 60 and Jaeger Path
- CSAH 60 and Jamaica Path
- CSAH 60 and Jasmine Way

(the five intersections above: Three Leg Approach)

- CSAH 60 and Orchard Trail – Four Leg Approach

**Study Findings:**
Table 1 details the AM & PM peak hour traffic & PM delay based on the delay and level of service (LOS) assignment as shown.

**Table 1**

| Intersection | Side Road ADT Entering & Exiting: AM Peak | Side Road ADT Entering & Exiting: PM Peak | PM Exiting | PM Delay (s) | LOS |
|---|---|---|---|---|---|
| CSAH 50 & 188th St | 68 | 81 | 27 | 30 | D |
| CSAH 50 & Jaguar Path | 74 | 112 | 46 | 11 | B |
| CSAH 60 & Jaeger Path | 25 | 35 | 12 | 8.8 | A |
| CSAH 60 & Jamaica Path | 65 | 58 | 20 | 5.3 | A |
| CSAH 60 & Jasmine Way | 34 | 44 | 5 | 15 | B |
| CSAH 60 & Orchard Tr | | | 23 | 22 | C |

PM peak observations were made during the time of each study.

- Traffic on side streets operated well and with acceptable low to minimal delay.
- No major delay or queue was observed during delay studies.
- Gaps were sufficient in length of time and frequency.
- No impatient or risky driver maneuvers were observed.

Figure A


182ND ST W
JANNEVAR CT
JAGUAR PATH
183RD ST W
JAEGER PATH
JASPER PATH
JAMAICA PATH
JAMBEAU CT
JASPER CT
JAMAICA CT W
JAVA TRL
185TH ST W
ORCHARD TRL
JASPER WAY
JASMINE WAY
KENWOOD TRL
JONESBORO CT
KALMAR CT
KALMAR TRL
KABERA TRL
188TH ST W
JORDAN TRL
JOPLIN AVE
ORCHARD TR
N

# DAKOTA COUNTY TRANSPORTATION

TRAFFIC

TRAFFIC COUNT DATA

Road: : 188th Street | Site: 2011008

Location: : West of CSAH 50 | Date: 05/02/11

Notes: : | Directiorboth

| Interval Begin | Mon 5/2 | Tue 5/3 | Wed 5/4 | Thu 5/5 | Fri 5/6 | Sat 5/7 | Sun 5/8 | Weekday Avg | Week Avg |
|---|---|---|---|---|---|---|---|---|---|
| 12:AM | * | * | 1 | 3 | * | * | * | 2 | 2 |
| 1:00 | * | * | 0 | 0 | * | * | * | 0 | 0 |
| 2:00 | * | * | 0 | 3 | * | * | * | 1 | 1 |
| 3:00 | * | * | 1 | 2 | * | * | * | 1 | 1 |
| 4:00 | * | * | 2 | 2 | * | * | * | 2 | 2 |
| 5:00 | * | * | 12 | 14 | * | * | * | 13 | 13 |
| 6:00 | * | * | 51 | 44 | * | * | * | 47 | 47 |
| 7:00 | * | * | 64 | 72 | * | * | * | 68 | 68 |
| 8:00 | * | * | 56 | 54 | * | * | * | 55 | 55 |
| 9:00 | * | * | 40 | 50 | * | * | * | 45 | 45 |
| 10:00 | * | 60 | 50 | 70 | * | * | * | 60 | 60 |
| 11:00 | * | 42 | 50 | * | * | * | * | 46 | 46 |
| 12:PM | * | 48 | 39 | * | * | * | * | 43 | 43 |
| 1:00 | * | 60 | 60 | * | * | * | * | 60 | 60 |
| 2:00 | * | 78 | 78 | * | * | * | * | 78 | 78 |
| 3:00 | * | 48 | 65 | * | * | * | * | 56 | 56 |
| 4:00 | * | 84 | 69 | * | * | * | * | 76 | 76 |
| 5:00 | * | 52 | 64 | * | * | * | * | 58 | 58 |
| 6:00 | * | 79 | 84 | * | * | * | * | 81 | 81 |
| 7:00 | * | 48 | 70 | * | * | * | * | 59 | 59 |
| 8:00 | * | 63 | 40 | * | * | * | * | 51 | 51 |
| 9:00 | * | 28 | 15 | * | * | * | * | 21 | 21 |
| 10:00 | * | 16 | 13 | * | * | * | * | 14 | 14 |
| 11:00 | * | 3 | 0 | * | * | * | * | 1 | 1 |
| Totals | 0 | 709 | 924 | 314 | 0 | 0 | 0 | 938 | 938 |
| | | | | | | | | | |
| AM Peak | * | 10:00 | 7:00 | 7:00 | * | * | * | 7:00 | 7:00 |
| Volume | * | 60 | 64 | 72 | * | * | * | 68 | 68 |
| | | | | | | | | | |
| PM Peak | * | 4:00 | 6:00 | * | * | * | * | 6:00 | 6:00 |
| Volume | * | 84 | 84 | * | * | * | * | 81 | 81 |

# DAKOTA COUNTY TRANSPORTATION

TRAFFIC

TRAFFIC COUNT DATA

Road: : Jaguar Path | Site: 2011007

Location: : East of CSAH 50 | Date: 05/02/11

Notes: : DirectiorBoth

| Interval Begin | Mon 5/2 | Tue 5/3 | Wed 5/4 | Thu 5/5 | Fri 5/6 | Sat 5/7 | Sun 5/8 | Weekday Avg | Week Avg |
|---|---|---|---|---|---|---|---|---|---|
| 12:AM | * | * | 8 | 8 | * | * | * | 8 | 8 |
| 1:00 | * | * | 4 | 6 | * | * | * | 5 | 5 |
| 2:00 | * | * | 0 | 1 | * | * | * | 0 | 0 |
| 3:00 | * | * | 3 | 1 | * | * | * | 2 | 2 |
| 4:00 | * | * | 9 | 5 | * | * | * | 7 | 7 |
| 5:00 | * | * | 13 | 13 | * | * | * | 13 | 13 |
| 6:00 | * | * | 61 | 47 | * | * | * | 54 | 54 |
| 7:00 | * | * | 67 | 81 | * | * | * | 74 | 74 |
| 8:00 | * | * | 70 | 56 | * | * | * | 63 | 63 |
| 9:00 | * | * | 52 | 80 | * | * | * | 66 | 66 |
| 10:00 | * | 61 | 46 | 76 | * | * | * | 61 | 61 |
| 11:00 | * | 48 | 43 | * | * | * | * | 45 | 45 |
| 12:PM | * | 64 | 56 | * | * | * | * | 60 | 60 |
| 1:00 | * | 60 | 58 | * | * | * | * | 59 | 59 |
| 2:00 | * | 76 | 74 | * | * | * | * | 75 | 75 |
| 3:00 | * | 104 | 87 | * | * | * | * | 95 | 95 |
| 4:00 | * | 122 | 99 | * | * | * | * | 110 | 110 |
| 5:00 | * | 113 | 112 | * | * | * | * | 112 | 112 |
| 6:00 | * | 106 | 100 | * | * | * | * | 103 | 103 |
| 7:00 | * | 77 | 85 | * | * | * | * | 81 | 81 |
| 8:00 | * | 70 | 79 | * | * | * | * | 74 | 74 |
| 9:00 | * | 46 | 51 | * | * | * | * | 48 | 48 |
| 10:00 | * | 24 | 27 | * | * | * | * | 25 | 25 |
| 11:00 | * | 10 | 12 | * | * | * | * | 11 | 11 |
| Totals | 0 | 981 | 1,216 | 374 | 0 | 0 | 0 | 1,251 | 1,251 |
| AM Peak | * | 10:00 | 8:00 | 7:00 | * | * | * | 7:00 | 7:00 |
| Volume | * | 61 | 70 | 81 | * | * | * | 74 | 74 |
| PM Peak | * | 4:00 | 5:00 | * | * | * | * | 5:00 | 5:00 |
| Volume | * | 122 | 112 | * | * | * | * | 112 | 112 |

# DAKOTA COUNTY TRANSPORTATION

TRAFFIC

TRAFFIC COUNT DATA

Road: : Jaeger Path
Location: : North of CSAH 60
Notes: : DirectiorBoth

Site: 2011003
Date: 05/02/11

| Interval Begin | Mon 5/2 | Tue 5/3 | Wed 5/4 | Thu 5/5 | Fri 5/6 | Sat 5/7 | Sun 5/8 | Weekday Avg | Week Avg |
|---|---|---|---|---|---|---|---|---|---|
| 12:AM | * | * | 1 | 1 | * | * | * | 1 | 1 |
| 1:00 | * | * | 1 | 2 | * | * | * | 1 | 1 |
| 2:00 | * | * | 1 | 0 | * | * | * | 0 | 0 |
| 3:00 | * | * | 0 | 0 | * | * | * | 0 | 0 |
| 4:00 | * | * | 2 | 0 | * | * | * | 1 | 1 |
| 5:00 | * | * | 1 | 2 | * | * | * | 1 | 1 |
| 6:00 | * | * | 13 | 13 | * | * | * | 13 | 13 |
| 7:00 | * | * | 27 | 24 | * | * | * | 25 | 25 |
| 8:00 | * | * | 23 | 27 | * | * | * | 25 | 25 |
| 9:00 | * | 21 | 40 | 14 | * | * | * | 25 | 25 |
| 10:00 | * | 12 | 18 | * | * | * | * | 15 | 15 |
| 11:00 | * | 14 | 16 | * | * | * | * | 15 | 15 |
| 12:PM | * | 14 | 12 | * | * | * | * | 13 | 13 |
| 1:00 | * | 12 | 6 | * | * | * | * | 9 | 9 |
| 2:00 | * | 24 | 26 | * | * | * | * | 25 | 25 |
| 3:00 | * | 20 | 24 | * | * | * | * | 22 | 22 |
| 4:00 | * | 34 | 36 | * | * | * | * | 35 | 35 |
| 5:00 | * | 36 | 34 | * | * | * | * | 35 | 35 |
| 6:00 | * | 22 | 24 | * | * | * | * | 23 | 23 |
| 7:00 | * | 27 | 29 | * | * | * | * | 28 | 28 |
| 8:00 | * | 9 | 21 | * | * | * | * | 15 | 15 |
| 9:00 | * | 15 | 17 | * | * | * | * | 16 | 16 |
| 10:00 | * | 12 | 5 | * | * | * | * | 8 | 8 |
| 11:00 | * | 3 | 5 | * | * | * | * | 4 | 4 |
| Totals | 0 | 275 | 382 | 83 | 0 | 0 | 0 | 355 | 355 |
| AM Peak | * | 9:00 | 9:00 | 8:00 | * | * | * | 7:00 | 7:00 |
| Volume | * | 21 | 40 | 27 | * | * | * | 25 | 25 |
| PM Peak | * | 5:00 | 4:00 | * | * | * | * | 4:00 | 4:00 |
| Volume | * | 36 | 36 | * | * | * | * | 35 | 35 |

# DAKOTA COUNTY TRANSPORTATION

TRAFFIC

TRAFFIC COUNT DATA

Road: : Jamaica Path | Site: 2011004

Location: : North of CSAH 60 | Date: 05/02/11

Notes: :

| Interval | Mon 2 | | Tue 3 | | Wed 4 | | Thu 5 | | Fri 6 | | Sat 7 | | Sun 8 | | Weekday Avg. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Begin | | Both | | Both | | Both | | Both | | Both | | Both | | Both | | Both |
| 12:AM | * | * | * | * | 0 | 1 | 0 | 2 | * | * | * | * | * | * | 0 | 1 |
| 01:00 | * | * | * | * | 0 | 0 | 0 | 1 | * | * | * | * | * | * | 0 | 0 |
| 02:00 | * | * | * | * | 0 | 0 | 0 | 0 | * | * | * | * | * | * | 0 | 0 |
| 03:00 | * | * | * | * | 0 | 0 | 0 | 0 | * | * | * | * | * | * | 0 | 0 |
| 04:00 | * | * | * | * | 0 | 4 | 0 | 2 | * | * | * | * | * | * | 0 | 3 |
| 05:00 | * | * | * | * | 0 | 4 | 0 | 9 | * | * | * | * | * | * | 0 | 6 |
| 06:00 | * | * | * | * | 0 | 36 | 0 | 36 | * | * | * | * | * | * | 0 | 36 |
| 07:00 | * | * | * | * | 0 | 67 | 0 | 63 | * | * | * | * | * | * | 0 | 65 |
| 08:00 | * | * | * | * | 0 | 36 | 0 | 37 | * | * | * | * | * | * | 0 | 36 |
| 09:00 | * | * | 0 | 44 | 0 | 50 | 0 | 38 | * | * | * | * | * | * | 0 | 44 |
| 10:00 | * | * | 0 | 53 | 0 | 28 | * | * | * | * | * | * | * | * | 0 | 40 |
| 11:00 | * | * | 0 | 28 | 0 | 31 | * | * | * | * | * | * | * | * | 0 | 29 |
| 12:PM | * | * | 0 | 28 | 0 | 16 | * | * | * | * | * | * | * | * | 0 | 22 |
| 01:00 | * | * | 0 | 28 | 0 | 28 | * | * | * | * | * | * | * | * | 0 | 28 |
| 02:00 | * | * | 0 | 34 | 0 | 20 | * | * | * | * | * | * | * | * | 0 | 27 |
| 03:00 | * | * | 0 | 44 | 0 | 47 | * | * | * | * | * | * | * | * | 0 | 45 |
| 04:00 | * | * | 0 | 50 | 0 | 53 | * | * | * | * | * | * | * | * | 0 | 51 |
| 05:00 | * | * | 0 | 68 | 0 | 48 | * | * | * | * | * | * | * | * | 0 | 58 |
| 06:00 | * | * | 0 | 42 | 0 | 30 | * | * | * | * | * | * | * | * | 0 | 36 |
| 07:00 | * | * | 0 | 42 | 0 | 33 | * | * | * | * | * | * | * | * | 0 | 37 |
| 08:00 | * | * | 0 | 44 | 0 | 30 | * | * | * | * | * | * | * | * | 0 | 37 |
| 09:00 | * | * | 0 | 28 | 0 | 19 | * | * | * | * | * | * | * | * | 0 | 23 |
| 10:00 | * | * | 0 | 4 | 0 | 1 | * | * | * | * | * | * | * | * | 0 | 2 |
| 11:00 | * | * | 0 | 2 | 0 | 4 | * | * | * | * | * | * | * | * | 0 | 3 |
| **Totals** | 0 | 0 | 0 | 539 | 0 | 586 | 0 | 188 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 629 |
| **Combined** | 0 | | 539 | | 586 | | 188 | | 0 | | 0 | | 0 | | 629 | |
| **Split %** | 0.0 | .0 | 0.0 | 100 | 0.0 | 100 | 0.0 | 100 | 0.0 | .0 | 0.0 | .0 | 0.0 | .0 | 0.0 | 100 |
| **AM** | | | | | | | | | | | | | | | | |
| **Peak Hr** | * | * | -1:00 | 10:00 | 10:00 | 07:00 | 07:00 | 07:00 | * | * | * | * | * | * | 07:00 | 07:00 |
| **Volume** | * | * | 0 | 53 | 0 | 67 | 0 | 63 | * | * | * | * | * | * | 0 | 65 |
| **PM** | | | | | | | | | | | | | | | | |
| **PeakHr** | * | * | -1:00 | 05:00 | 05:00 | 04:00 | * | * | * | * | * | * | * | * | 04:00 | 05:00 |
| **Volume** | * | * | 0 | 68 | 0 | 53 | * | * | * | * | * | * | * | * | 0 | 58 |

# DAKOTA COUNTY TRANSPORTATION

TRAFFIC

TRAFFIC COUNT DATA

Road: : Jasmine Way | Site: 2011005

Location: : South of CSAH 60 | Date: 05/02/11

Notes: : | DirectiorBoth

| Interval Begin | Mon 5/2 | Tue 5/3 | Wed 5/4 | Thu 5/5 | Fri 5/6 | Sat 5/7 | Sun 5/8 | Weekday Avg | Week Avg |
|---|---|---|---|---|---|---|---|---|---|
| 12:AM | * | * | 2 | 2 | * | * | * | 2 | 2 |
| 1:00 | * | * | 0 | 0 | * | * | * | 0 | 0 |
| 2:00 | * | * | 0 | 0 | * | * | * | 0 | 0 |
| 3:00 | * | * | 0 | 1 | * | * | * | 0 | 0 |
| 4:00 | * | * | 2 | 2 | * | * | * | 2 | 2 |
| 5:00 | * | * | 8 | 9 | * | * | * | 8 | 8 |
| 6:00 | * | * | 21 | 20 | * | * | * | 20 | 20 |
| 7:00 | * | * | 30 | 38 | * | * | * | 34 | 34 |
| 8:00 | * | * | 19 | 18 | * | * | * | 18 | 18 |
| 9:00 | * | 17 | 17 | 17 | * | * | * | 17 | 17 |
| 10:00 | * | 16 | 17 | * | * | * | * | 16 | 16 |
| 11:00 | * | 22 | 16 | * | * | * | * | 19 | 19 |
| 12:PM | * | 16 | 20 | * | * | * | * | 18 | 18 |
| 1:00 | * | 18 | 20 | * | * | * | * | 19 | 19 |
| 2:00 | * | 20 | 18 | * | * | * | * | 19 | 19 |
| 3:00 | * | 30 | 22 | * | * | * | * | 26 | 26 |
| 4:00 | * | 35 | 53 | * | * | * | * | 44 | 44 |
| 5:00 | * | 28 | 33 | * | * | * | * | 30 | 30 |
| 6:00 | * | 30 | 26 | * | * | * | * | 28 | 28 |
| 7:00 | * | 29 | 23 | * | * | * | * | 26 | 26 |
| 8:00 | * | 11 | 10 | * | * | * | * | 10 | 10 |
| 9:00 | * | 8 | 5 | * | * | * | * | 6 | 6 |
| 10:00 | * | 10 | 3 | * | * | * | * | 6 | 6 |
| 11:00 | * | 3 | 0 | * | * | * | * | 1 | 1 |
| Totals | 0 | 293 | 365 | 107 | 0 | 0 | 0 | 369 | 369 |
| AM Peak | * | 11:00 | 7:00 | 7:00 | * | * | * | 7:00 | 7:00 |
| Volume | * | 22 | 30 | 38 | * | * | * | 34 | 34 |
| PM Peak | * | 4:00 | 4:00 | * | * | * | * | 4:00 | 4:00 |
| Volume | * | 35 | 53 | * | * | * | * | 44 | 44 |

# DAKOTA COUNTY TRANSPORTATION

TRAFFIC

TRAFFIC COUNT DATA

Road: : Jasper Path | Site: 2011006

Location: : North of CSAH 60 | Date: 05/02/11

Notes: : DirectiorBoth

| Interval Begin | Mon 5/2 | Tue 5/3 | Wed 5/4 | Thu 5/5 | Fri 5/6 | Sat 5/7 | Sun 5/8 | Weekday Avg | Week Avg |
|---|---|---|---|---|---|---|---|---|---|
| 12:AM | * | * | 0 | 3 | * | * | * | 1 | 1 |
| 1:00 | * | * | 0 | 2 | * | * | * | 1 | 1 |
| 2:00 | * | * | 2 | 0 | * | * | * | 1 | 1 |
| 3:00 | * | * | 0 | 0 | * | * | * | 0 | 0 |
| 4:00 | * | * | 2 | 0 | * | * | * | 1 | 1 |
| 5:00 | * | * | 3 | 4 | * | * | * | 3 | 3 |
| 6:00 | * | * | 17 | 16 | * | * | * | 16 | 16 |
| 7:00 | * | * | 26 | 36 | * | * | * | 31 | 31 |
| 8:00 | * | * | 30 | 30 | * | * | * | 30 | 30 |
| 9:00 | * | * | 27 | 40 | * | * | * | 33 | 33 |
| 10:00 | * | 22 | 17 | 18 | * | * | * | 19 | 19 |
| 11:00 | * | 6 | 26 | * | * | * | * | 16 | 16 |
| 12:PM | * | 24 | 21 | * | * | * | * | 22 | 22 |
| 1:00 | * | 24 | 14 | * | * | * | * | 19 | 19 |
| 2:00 | * | 48 | 36 | * | * | * | * | 42 | 42 |
| 3:00 | * | 24 | 34 | * | * | * | * | 29 | 29 |
| 4:00 | * | 32 | 52 | * | * | * | * | 42 | 42 |
| 5:00 | * | 31 | 54 | * | * | * | * | 42 | 42 |
| 6:00 | * | 48 | 15 | * | * | * | * | 31 | 31 |
| 7:00 | * | 19 | 20 | * | * | * | * | 19 | 19 |
| 8:00 | * | 21 | 21 | * | * | * | * | 21 | 21 |
| 9:00 | * | 14 | 5 | * | * | * | * | 9 | 9 |
| 10:00 | * | 7 | 2 | * | * | * | * | 4 | 4 |
| 11:00 | * | 4 | 2 | * | * | * | * | 3 | 3 |
| Totals | 0 | 324 | 426 | 149 | 0 | 0 | 0 | 435 | 435 |
| AM Peak | * | 10:00 | 8:00 | 9:00 | * | * | * | 9:00 | 9:00 |
| Volume | * | 22 | 30 | 40 | * | * | * | 33 | 33 |
| PM Peak | * | 2:00 | 5:00 | * | * | * | * | 2:00 | 2:00 |
| Volume | * | 48 | 54 | * | * | * | * | 42 | 42 |

## DELAY STUDY

**Location:** CSAH 50 & 188th Street
**Approach:** EB All Movements
**Date:** 04/21/11, Wednesday
**Time:** 4:30 to 5:30 PM
**Weather:** Cloudy, 48F
**Observer:** KC, PV

188th Street West of CSAH 50, EB All Movements

| Time | Period | EB All Movements | Number of Cars Stopped | Sampling Interval | Total Delay | Average Delay |
|---|---|---|---|---|---|---|
| 16:30 | 16:44 | 6 | 13 | 15 | 195 | 32.5 |
| 16:45 | 16:59 | 8 | 21 | 15 | 315 | 39.4 |
| 17:00 | 17:14 | 9 | 16 | 15 | 240 | 26.7 |
| 17:15 | 17:29 | 4 | 4 | 15 | 60 | 15.0 |
| | **Total** | **27** | **54** | | **810** | **30.0** |

Average Delay Per Approach Vehicle is 30.0 seconds.

## DELAY STUDY

**Location:** CSAH 50 & Jaguar Path
**Approach:** WB All Movements
**Date:** 04/20/11, Wednesday
**Time:** 4:30 to 5:30 PM
**Weather:** Cloudy, 38F
**Observer:** KC, PV

Jaguar Path East of CSAH 50, WB All Movements

| Time | Period | WB All Movements | Number of Cars Stopped | Sampling Interval | Total Delay | Average Delay |
|---|---|---|---|---|---|---|
| 16:30 | 16:44 | 14 | 13 | 15 | 195 | 13.9 |
| 16:45 | 16:59 | 10 | 9 | 15 | 135 | 13.5 |
| 17:00 | 17:14 | 10 | 7 | 15 | 105 | 10.5 |
| 17:15 | 17:29 | 12 | 6 | 15 | 90 | 7.5 |
| | **Total** | **46** | **35** | | **525** | **11.4** |

Average Delay Per Approach Vehicle is 11.4 seconds.

# DELAY STUDY

**Location:** CSAH 60 & Jaeger Path
**Approach:** SB All Movements
**Date:** 04/27/11, Wednesday
**Time:** 4:30 to 5:30 PM
**Weather:** Cloudy, 48F
**Observer:** KC, PV

Jaeger Path North of CSAH 60, SB All Movements

| Time | Period | SB All Movements | Number of Cars Stopped | Sampling Interval | Total Delay | Average Delay |
|---|---|---|---|---|---|---|
| 16:30 | 16:44 | 3 | 2 | 15 | 30 | 10.0 |
| 16:45 | 16:59 | 3 | 0 | 15 | 0 | 0.0 |
| 17:00 | 17:14 | 5 | 4 | 15 | 60 | 12.0 |
| 17:15 | 17:29 | 1 | 1 | 15 | 15 | 15.0 |
| | **Total** | **12** | **7** | | **105** | **8.8** |

Average Delay Per Approach Vehicle is 8.8 seconds.

## DELAY STUDY

**Location:** CSAH 60 & Jamaica Path
**Approach:** SB All Movements
**Date:** 04/28/11, Thursday
**Time:** 4:30 to 5:30 PM
**Weather:** Overcast, 50F
**Observer:** KC, PV

Jamaica Path North of CSAH 60, SB All Movements

| Time | Period | SB All Movements | Number of Cars Stopped | Sampling Interval | Total Delay | Average Delay |
|---|---|---|---|---|---|---|
| 16:30 | 16:44 | 3 | 0 | 15 | 0 | 0.0 |
| 16:45 | 16:59 | 4 | 1 | 15 | 15 | 3.8 |
| 17:00 | 17:14 | 7 | 4 | 15 | 60 | 8.6 |
| 17:15 | 17:29 | 6 | 2 | 15 | 30 | 5.0 |
| | **Total** | **20** | **7** | | **105** | **5.3** |

Average Delay Per Approach Vehicle is 5.3 seconds.

## DELAY STUDY

**Location:** CSAH 60 & Jasmine Way
**Approach:** NB All Movements
**Date:** 05/03/11, Tuesday
**Time:** 4:30 to 5:30 PM
**Weather:** Sunny, 60F
**Observer:** KC, PV

Jasmine Way South of CSAH 60, NB All Movements

| Time | Period | NB All Movements | Number of Cars Stopped | Sampling Interval | Total Delay | Average Delay |
|---|---|---|---|---|---|---|
| 16:30 | 16:44 | 2 | 2 | 15 | 30 | 15.0 |
| 16:45 | 16:59 | 0 | 0 | 15 | 0 | 0.0 |
| 17:00 | 17:14 | 0 | 0 | 15 | 0 | 0.0 |
| 17:15 | 17:29 | 3 | 3 | 15 | 45 | 15.0 |
| | **Total** | **5** | **5** | | **75** | **15.0** |

Average Delay Per Approach Vehicle is 15.0 seconds.

# DELAY STUDY

**Location:** CSAH 60 & Orchard Tr
**Approach:** NB All Movements
**Date:** 05/04/11, Wednesday
**Time:** 4:30 to 5:30 PM
**Weather:** Sunny, 65F
**Observer:** KC, PV

Orchard Tr South of CSAH 60, NB All Movements

| Time | Period | NB All Movements | Number of Cars Stopped | Sampling Interval | Total Delay | Average Delay |
|---|---|---|---|---|---|---|
| 16:30 | 16:44 | 8 | 6 | 15 | 90 | 11.3 |
| 16:45 | 16:59 | 6 | 2 | 15 | 30 | 0.0 |
| 17:00 | 17:14 | 4 | 8 | 15 | 120 | 0.0 |
| 17:15 | 17:29 | 5 | 17 | 15 | 255 | 51.0 |
| | **Total** | **23** | **33** | | **495** | **21.5** |

Average Delay Per Approach Vehicle is 21.5 seconds.