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Intersection Control Evaluation

Viola Road NE (CSAH 2) and Cassidy Drive NE

in

Rochester, Minnesota

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.

Jennifer L. McCoy, P.E.	57665	8/11/21
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REVIEWED BY:

Rochester City Engineer	8/24/21
	Date

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Benjamin Johnson Digitally signed by Benjamin Johnson
Date: 2021.09.08 10:15:49 -05'00'

Olmsted County Engineer	
	Date

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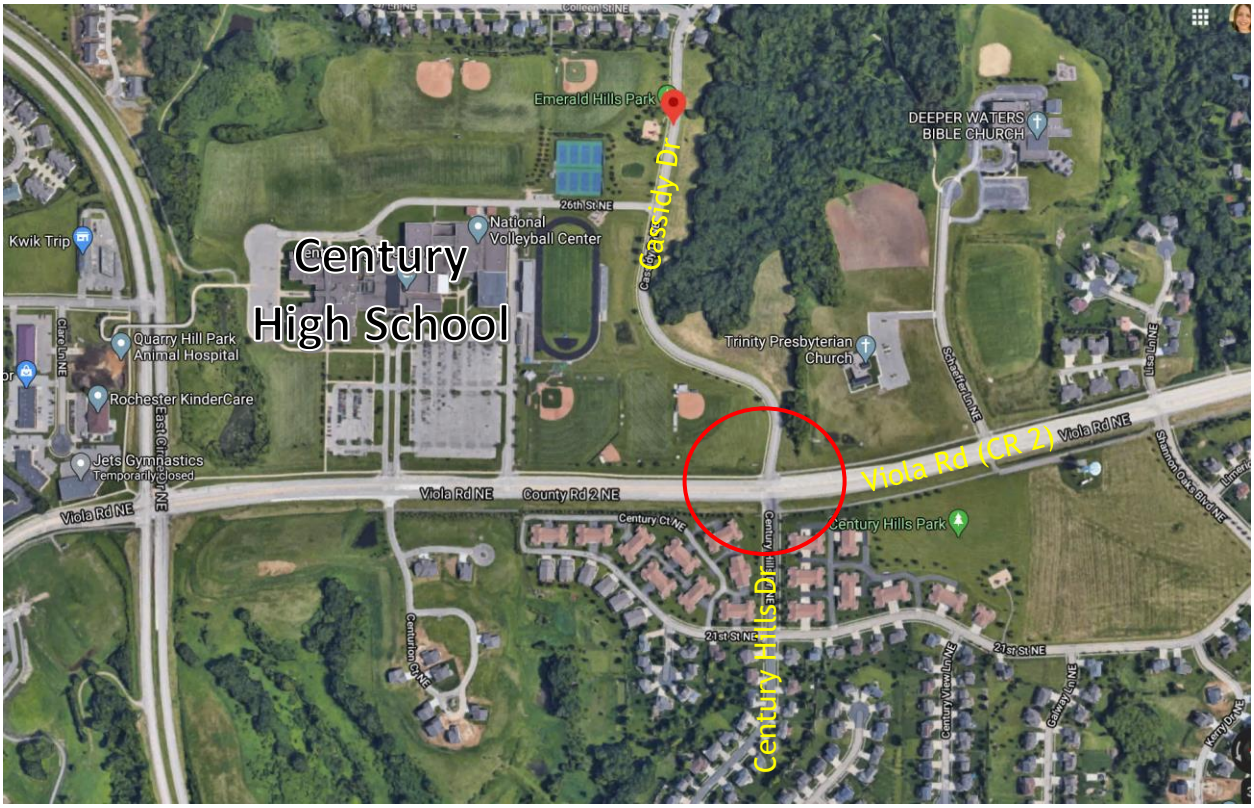
Introduction

An Intersection Control Evaluation (ICE) is being performed for the intersection of Viola Rd NE (CSAH 2) at Cassidy Dr NE. This ICE memorandum will document the analysis of existing conditions, future conditions, and potential alternatives at the intersections. The intersection is in the City of Rochester, MN in Olmsted County. See **Figure 1** for the project location map.

Figure 1: Project Location Map



Existing Conditions

Viola Rd NE/Cassidy Dr NE has the following characteristics:

- The intersection is located near the east city limits of Rochester, Minnesota.
- The intersection is in a residential area with Century High school located on the northwest corner.
- At the intersection, Viola Road NE runs east-west, but angles to the southwest as it extends west toward downtown Rochester.
- Viola Rd begins at 15th Avenue NE in Rochester and extends east into Olmsted County past Viola, MN to the County line.
- Viola Road NE is also CSAH 2, east of East Circle Drive.
- Viola Rd has a functional classification of Major Regional Arterial.
- Viola Rd NE at Cassidy Drive NE is a hybrid road with urban section on the northside and rural sections on the southside.
- The intersection is two-way stop controlled with the north-south legs required to stop and the east-west legs being free-flow.

North Leg

- The north leg of the intersection is Cassidy Drive NE.
- It is a two-lane undivided local roadway with a speed limit of 25 MPH.
- Cassidy Dr is an urban section.
- The approach to the intersection includes a 100’ left turn lane and through-right.
- It extends north of the intersection past Century High School and Emerald Hills Park ¾ mile to where it ends into Darcy Drive NE
- A sidewalk runs along the west side of Cassidy Drive NE
- There is an unmarked pedestrian crossing that crosses this north leg.

South Leg

- The south leg of the intersection is Century Hills Drive NE.
- It is a two-lane undivided minor collector roadway with a speed limit of 25 MPH.
- It has a raised median boulevard for the first block south of Viola Road NE.
- Century Hills Dr is an urban section.
- The approach to the intersection is a shared LT-TH-RT.
- Century Hills Drive NE and extends ¾ miles to the south where it ends at Century Valley Rd NE.
- A sidewalk runs along both sides of Century Hills Drive NE.
- There is an unmarked pedestrian crossing that crosses this south leg.

East Leg

- The east leg is Viola Road NE and is also CSAH 2 NE.
- Viola Road NE is a four-lane divided roadway with turn lanes at the intersection and a speed limit of 45 MPH.
- The approach to the intersection includes a 200’ left turn lane, two through lanes, and a 200’ right turn lane.
- A sidewalk is located along both sides of this leg.
- There are no pedestrian ramps present to cross the east leg.

West Leg

- The west leg is known as Viola Road NE and is also CSAH 2 NE.
- Viola Road NE is a four-lane divided roadway with turn lanes at the intersection and a speed limit of 45 MPH.
- The approach to the intersection includes a 415’ Left turn lane, two through lanes and a 245’ right turn lane.
- A sidewalk is located on the on the north side of this leg only.
- An uncontrolled crossing is painted on this leg with high visibility, continental-style markings.

Sight Distance Review

Sight distance was a concern for the stop-controlled traffic looking to the east because of a crest vertical curve. The hill crest is 850 ft east of Cassidy Drive near Schaeffer Ln. Per Figure 3.34 of the Mn/DOT Access Management Manual, the required stopping sight distance for a 45 MPH road is 360 ft. Since 850 ft is available for, the required stopping sight distance is met.

Data Collected

Due to the reduction in traffic volumes experienced during the Covid-19 pandemic, 2017 counts collected by the City of Rochester were used in this study. The daily entering vehicles were calculated as 3,250 vehicles entering eastbound, 2,300 vehicles entering westbound, 690 vehicles entering southbound, and 820 vehicles entering northbound. The intersection total was 7,060 daily entering vehicles.

Safety Review

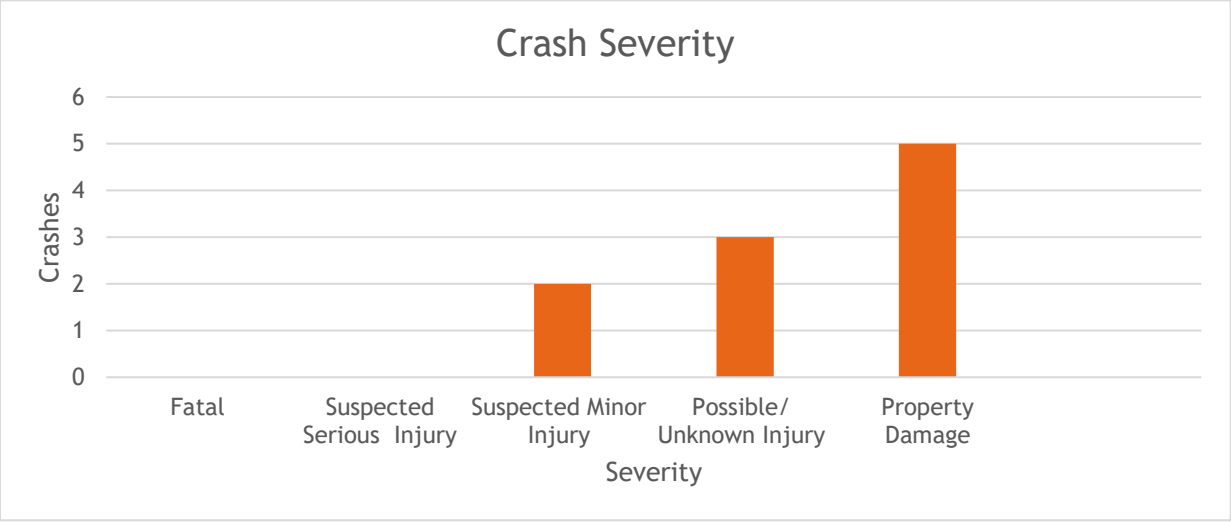
A crash review was completed for the intersection using the Minnesota Crash Mapping Analysis Tool (MnCMAT) for the years (2015-2019). There were ten total crashes. The number of crashes by year is shown in **Table 1** below.

Nine of the ten crashes were angle crashes. Three of the angle crashes were possible injuries and two were minor injuries during this period. No fatalities or serious injuries occurred during the examined years. All other crashes were property damage only (see **Figure 2**). Six of the ten collisions were a result of northbound traffic failing to yield right of way at the stop control. Six collisions occurred in non-peak hours, two occurred in the AM Peak, and two occurred in the PM peak.

Table 1: Crash Type

Crash Type									
Year	Non-Collision	Head-on	Rear-End	Angle	Broadside	Sideswipe, Same Direction	Sideswipe, Opposite Direction	Rear to Rear	Rear to side
2015				5					
2016			1						
2017				1					
2018				1					
2019				2					
Viola/Cassidy	0	0	1	9	0	0	0	0	0

Figure 2: Crash Severity



MnDOT uses a comparison of the crash rate and the critical rate when determining whether there is a safety issue at an intersection. The crash rate is the number of crashes per million entering vehicles (MEV). The critical rate is a statistical comparison based on similar intersections statewide. An observed crash rate greater than the critical rate indicates that the intersection operates outside of the expected, normal range.

The critical index compares the crash rate and the statewide critical rate. A critical index of less than one indicates that the intersection is operating within the normal range. The overall critical index for this intersection is 1.47 which implies that this intersection is operating above the statewide critical rate (see **Table 2**). No fatal/serious accidents occurred over the five-year period which yields a fatal and serious critical crash index of zero, well within normal operating conditions.

Table 2: Crash Summary

Crash Summary			
Statewide Critical Rate		0.53	
	Number of Collisions	Collision Rate	Critical Index
Total	10	0.78	1.47

Level of Service and Delay

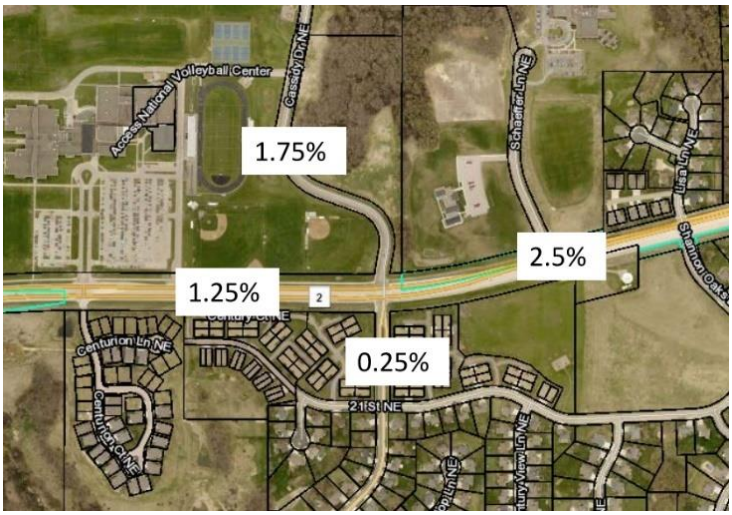
The traffic operations analysis for the intersections considers the following measures to determine the adequacy of the intersection design to meet acceptable operations: intersection delay/Level of Service (LOS) and volume-to-capacity ratios. An explanation of each of these measures is provided below:

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 Highway Capacity Manual 6th edition, 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. The control delay is modeled within the analysis software, Traffic ware Synchro. Level of Service D or higher are commonly taken as 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 quality of service when at a stop-controlled intersection (see **Table 3).**

Table 3: Level of Service Criteria

	Signalized Intersection	Unsignalized Intersection
LOS	**Control Delay per Vehicle**	**Control Delay per Vehicle**
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

Traffic Forecasting



Due to the COVID-19 pandemic, current traffic counts across Minnesota have reduced from normal levels, this combined with Century High School in remote learning mode, resulted in using historical counts and factoring accordingly. Future Traffic volumes for 2020 and 2040 were factored using the 2017 Count from the City of Rochester and applying modeled growth rates provided by the Rochester-Olmsted Council of Governments. A percent growth of 1.25% for the west, 1.75% for the north, 2.5% for the east, and 0.25% for the south were used.

This approach was based on the following:

1. Collecting new counts during the COVID-19 pandemic would result in data that is not reflective of normal traffic patterns
2. A comparison of MnDOT ADT counts from their Mapping Tool to ADTs factored using the 2017 PM count show the difference is close to the typical acceptable change for recounting that MnDOT uses, +/- 20%. (See **Table 4** below)
3. A review of aerials of the area showed that there have not been large development/redevelopment projects since 2017 that would have dramatically changed the traffic volumes at this intersection.

Table 4: Count Comparison

Leg	MnDOT 2018 ADT	Factored ADT using 2017 PM Count	Difference	Typical Acceptable Change for recounts
East	4,300	3,990	- 10%	+/- 20%
South	2,100	1,660	- 23%	+/- 20%

Turns32 was used to determine the turn movement volumes at the intersection due to the different growth rates on each leg. It utilized the existing turning movements and ADT to determine the 2020 and 2040 future turn movements.

Operational Analysis

The factored 2020 turning movement counts were used to model the intersection to determine existing traffic operations during the 2020 peak hours. The operations results are shown in **Table 5** below. The intersection is operating at LOS C and LOS A in the AM and PM peak hours, respectively. The northbound right exceeds an acceptable delay at LOS F in the AM peak. The northbound approach is a shared LT-TH-RT so the northbound right turns often get stuck behind a vehicle trying to go left or through causing delay for the right turning vehicles.

Table 5: Existing 2020 No Build Traffic Operations

Intersection	Peak Hour	Intersection Delay (1.)		Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
							Direction	Average Queue (ft)	Max Queue (ft)
Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 AM	15	C	90	F	NBR	NBL/T/R	125	375
Stop Controlled	2020 PM	3	A	15	C	NBT	SBT/R	50	100

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Future No Build Conditions

The factored 2040 turning movement counts were used to model the intersection to determine traffic operations for the 2040 peak hours with the existing side-street stop.

Operational Analysis

The 2040 No Build scenarios analyzed the existing roadway geometry to determine any deficiencies. **Table 6** illustrates the results. With the existing side street stop configuration and no other geometric changes, the intersection is anticipated to operate at LOS E and LOS A in the AM and PM peak hours, respectively. The northbound movement continues have long delays leading to LOS E or F. The northbound approach is a shared LT-TH-RT so the northbound right turns often get stuck behind a vehicle trying to go left or through causing delay for the right turning vehicles.

Table 6: Projected 2040 No Build Traffic Operations

Intersection	Peak Hour	Intersection Delay (1.)		Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
							Direction	Average Queue (ft)	Max Queue (ft)
Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2040 AM	45	E	356	F	NBR	SBT/R	175	575
Stop Controlled	2040 PM	4	A	36	E	NBT	SBT/R	50	125

Analysis of Intersection Alternatives

Alternatives Considered

The following alternatives were considered at the Viola Rd and Cassidy Dr intersection:

Signal	
Single Lane Roundabout	
Single Lane Roundabout with EB/WB Right Turn Drop Lanes	
Multi-Lane Roundabout **2x1**	

All-Way Stop	

Warrant Analysis

Traffic signal and all-way stop warrants were performed to assess the potential for a traffic control changes. Warrants have been developed as national guidelines to promote continuity of traffic control devices to ensure that traffic signals or all-way stops are installed at intersections that would benefit from their use.

The MUTCD states that the investigation of the need for a traffic signal control shall include an analysis of the applicable factors contained in the following traffic signal warrants:

- Warrant 1: Eight-Hour Vehicular Volume
- Warrant 2: Four-Hour Vehicular Volume
- Warrant 3: Peak Hour
- Warrant 4: Pedestrian Volume
- Warrant 5: School Crossing
- Warrant 6: Coordinated Signal System
- Warrant 7: Crash Experience
- Warrant 8: Roadway Network
- Warrant 9: Intersection Near a Grade Crossing

Traffic signal warrants are based on a variety of situations listed above. Our review focuses on the volume-based warrants.

A traffic signal shall not be installed unless one or more of the warrants can be met. Furthermore, a signal shall not be installed unless an engineering study indicates that the signal will improve the overall safety and operation of the intersection. Finally, the signal should not disrupt the progressive flow of traffic.

The City of Rochester 2017 counts only included six hours of count data, therefore, there are not enough data hours to meet the requirements for warrants 1A,1B,7, or All Stop. See **Table 7**.

Table 7: Signal and All Stop Warrant Analysis

Viola Rd & Cassidy Dr						
Warrant	2020			2040		
	Met (Hr)	Required (Hr)		Met (Hr)	Required (Hr)	
1A	1	8	Not satisfied	1	8	Not satisfied
1B	1	8	Not satisfied	3	8	Not satisfied
2	1	4	Not satisfied	1	4	Not satisfied
3	0	1	Not satisfied	1	1	Satisfied*
5	-	-	Unable to Measure	-	-	-
7	3	8	Not satisfied	4	8	Not satisfied
All Way	0	8	Not satisfied	1	8	Not satisfied

*Using linear interpolation Warrant 3 will likely be obtained in 2026.

Warrant 3 is intended for use at a location where traffic conditions are such that for a minimum of 1 hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street. Per the Section 4C.4 of the MnMUTCD, this signal warrant "shall be applied only in unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time". Century High School attracts and discharges a large number of vehicles over a short time during arrival and dismissal periods, therefore, the peak hour warrant can be considered for this intersection. The Peak Hour signal warrant is met by 2040. Using linear interpolation, this warrant would likely be met in 2026.

Information for Warrant 5, the School Crossing warrant, was unable to be measured for this intersection. This warrant examines the need for a traffic signal based on the number of schoolchildren crossing and available gaps in the traffic stream during the period of time they are crossing. Due to the COVID-19 pandemic, Century High School was in remote learning mode with no students attending class in the building, therefore, there were no schoolchildren crossings to measure.

While the volume information is not enough to determine if warrant 7 can be met, there are five angle crashes that could be remedied by a traffic signal based on the 2015 crash experience. However, this could be an outlier year as the number of crashes per years prior to this year was two or less annually.

All-way stops are designed and perform best for low traffic-volume and are often put in place when a traffic signal is not warranted. This option was not reviewed further since it is not warranted.

Future Build Alternatives

Multiple scenarios were ran to test different traffic control alternatives for the intersection using 2020 and 2040 volumes to determine maximum delay and maximum queues.

Operations Analysis

Signal

As this location met Warrant 3, the peak hour warrant, and is located next to a high school which attracts and discharges a large number of vehicles over a short time during arrival and dismissal times, a signal alternative was analyzed at this location to determine how it would operate.

2020 AM

Adding a signal to existing lane configuration provides a similar intersection delay as the existing conditions but reduces the maximum delay to 20 seconds and changes the maximum delay approach to the eastbound left during AM peak hours. Maximum queues are now occurring in the westbound direction instead of the northbound direction. The northbound direction has a max queue of 175 ft. (see **Table 8**).

2020 PM

Adding a signal to existing lane configuration provides an increase in the intersection delay from 3 seconds to 12 seconds and an increase in the maximum delay to 17 seconds and changes the maximum delay approach to the westbound through during PM peak hours. Maximum queue occurred in the westbound through direction with a max of 150 ft.

2040 AM

Adding a signal to existing lane configuration provides a reduction in intersection delay from 45 seconds to 21 seconds and a reduction of maximum delay from 356 seconds in the northbound to 28 seconds in the westbound through direction during AM peak hours. Maximum queue occurred in both westbound through lanes with a max of 300 ft.

2040 PM

Adding a signal to existing lane configuration provides an increase in the intersection delay from 4 seconds to 13 seconds and a decrease in the maximum delay to 21 seconds for the eastbound left during PM peak hours. Maximum queue occurred in the westbound through direction with a max of 150 ft.

Overall, the signal improves the LOS/Delay and queues in the AM Peak, but increases the intersection LOS/Delay and queues in the PM Peak when compared to the 2020 and 2040 No Build Scenarios. In the PM Peak with the signal, the LOS changes from LOS A to LOS B and the queues increase by up to 50 additional feet.

Table 8: Projected 2020 & 2040 Signalized Traffic Operations

Intersection	Peak Hour	Intersection Delay (1.)		Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
							Direction	Average Queue (ft)	Max Queue (ft)
Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE *Signalized Intersection*	2020 Signal AM	15	B	20	C	EBL	WBT	100	175
	2020 Signal PM	12	B	17	B	WBT	WBT	75	150
	2040 Signal AM	21	C	28	C	WBT	WBT	150	300
	2040 Signal PM	13	B	21	C	EBL	WBT	75	150

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Roundabout

An alternative to signalization is the construction of a roundabout. Roundabouts have been found to perform as good as or better than traffic signals during peak hours and are significantly more efficient than traffic signals during the off-peak hours. As a roundabout is an alternative form of intersection control to traffic signals, they should be considered only when other intersection control types are warranted. As a signal was warranted here, two different roundabout alternatives were analyzed for this intersection: a single-lane and a 2x1 multi-lane roundabout.

Single-Lane

This single-lane roundabout alternative has single lane approach and departures. There is one circulating lane. The eastbound and westbound approaches on Viola Road (CSAH 2) merge on the approach to the roundabout and widen back to two lanes after departing the roundabout.

2020 AM

Adding a single-lane roundabout provides a decrease of intersection delay from 15 seconds to 7 seconds when compared to the existing side-street stop. The maximum delay reduces from 90 seconds in the northbound to 9 seconds in the westbound direction. Maximum queues reduce from 375 ft in the northbound direction to 75 ft in the westbound direction with the single-lane roundabout (see **Table 9).**

2020 PM

Adding a single lane roundabout provides an increase of intersection delay from 3 second to 5 seconds and maximum delay reduction from 15 seconds in the northbound to 6 seconds in the eastbound direction. Maximum queues reduce from 50’ in the northbound direction to 25 ft with the single-lane roundabout.

2040 AM

Adding a single lane roundabout provides a decrease of intersection delay from 45 second to 14 seconds and a maximum delay reduction from 356 seconds in the northbound to 19 seconds in the westbound direction during the AM peak hour. Maximum queues occur in the westbound direction instead of the northbound direction, with a max of 225 ft. This westbound queue is due to the number of eastbound left turns in the roundabout providing less gaps for the westbound movement in the AM peak hour.

2040 PM

Adding a single lane roundabout provides an increase of intersection delay from 4 second to 7 seconds and maximum delay reduction from 36 second in the northbound to 7 seconds in the eastbound direction during the PM peak hour. Maximum queues occur in the westbound direction instead of the southbound direction, with a max of 50 ft.

Overall, the single-lane roundabout improves or maintains LOS/Delay in both the AM and PM Peaks, when compared to the no-build scenarios. The side street queues reduce substantially, however, the westbound experiences some queuing with the single-lane roundabout, with a max of 225 ft.

Table 9: Projected 2020 & 2040 Single-Lane Roundabout Traffic Operations

Intersection	Peak Hour	Intersection Delay (1.)		Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
							Direction	Average Queue (ft)	Max Queue (ft)
Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 Roundabout AM	7	A	9	A	WBL	WBL/T/R	-	75
	2020 Roundabout PM	5	A	6	A	EBT	WBL/T/R	-	25
	2040 Roundabout AM	14	B	19	B	WBL	WBL/T/R	-	225
Roundabout	2040 Roundabout PM	7	A	7	A	EBT	WBL/T/R	-	50

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

** With 50 peds/hours Max Delay increases to 20 sec/veh in the AM and 8 sec/veh in the PM.*

Single-Lane with EB/WB Right Turn Drop Lanes

This single lane roundabout alternative has two approaching lanes eastbound and westbound on Viola (CSAH 2) with the right/curb lane becoming a right turn drop lane at the roundabout and one lane departing on Viola (CSAH 2). Cassidy Dr/Century Hills Drive has one entering and one departing lane. There is one circulating lane around the roundabout.

2020 AM

Adding a Single-Lane roundabout with eastbound and westbound right turn drop lanes provides a decrease of intersection delay from 15 seconds to 7 seconds when compared to the existing side-street stop. The maximum delay reduces from 90 seconds for the northbound approach to 8 seconds on the westbound approach. Maximum queues reduce from 375ft in the northbound direction to 50 ft in the westbound direction (see **Table 10).**

2020 PM

Adding a Single-Lane roundabout with eastbound and westbound right turn drop lanes provides an increase of intersection delay from 3 second to 5 seconds when compared to the existing side-street stop. The maximum delay reduction from 15 seconds in the northbound to 5 seconds in both east and westbound approaches during PM peak hours. Maximum queues expected are in the east and westbound directions with a max of 25 ft.

2040 AM

Adding a Single-Lane roundabout with eastbound and westbound right turn drop lanes provides a decrease of intersection delay from 45 second to 11 seconds and a maximum delay reduction from 356

seconds in the northbound to 14 seconds in the westbound direction during AM peak hours. Maximum queues occur in the westbound direction instead of the northbound direction, with a max of 150 ft.

2040 PM

Adding a Single-Lane roundabout with eastbound and westbound right turn drop lanes provides an increase of intersection delay from 4 second to 6 seconds and maximum delay reduction from 36 seconds in the northbound to 6 seconds in the eastbound and westbound direction during PM peak hours. Maximum queues occur in the eastbound direction with a max of 50 ft.

Overall, the Single-Lane roundabout with eastbound and westbound right turn drop lanes improves or maintains LOS/Delay in both the AM and PM Peaks, when compared to the existing side-street stop. Queues reduce substantially.

Table 10: Projected 2020 & 2040 Single-lane with EB/WB right turn drop lanes Roundabout Traffic Operations

Intersection	Peak Hour	Intersection Delay (1.)		Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
							Direction	Average Queue (ft)	Max Queue (ft)
Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 Roundabout AM	7	A	8	A	WBT/L	WBT/R	-	50
	2020 Roundabout PM	5	A	5	A	WBT/L	WBT/L	-	25
Single-Lane with EB/WB Right Turn Drop Lanes	2040 Roundabout AM	11	B	14	B	WBT/L	WBT/L	-	150
	2040 Roundabout PM	6	A	6	A	EBT/L	EBT/L	-	50

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Multi-Lane

The multi-lane roundabout alternative examined is a 2x1 with two entering and two departing lanes on Viola (CSAH 2) and one entering and one departing lane on Cassidy Dr/Century Hills Dr.

2020 AM

Adding a 2x1 multi-lane roundabout provides a decrease of intersection delay from 15 seconds to 5 seconds when compared to the existing side-street stop. The maximum delay reduces from 90 seconds for the northbound approach to 7 seconds. Maximum queues reduce from 375' in the northbound direction to 25 ft with the single-lane roundabout (see **Table 11).**

2020 PM

Adding a 2x1 multi-lane roundabout provides an increase of intersection delay from 3 second to 5 seconds when compared to the existing side-street stop. The maximum delay reduction from 15 seconds

in the northbound to 5 seconds in all directions during PM peak hours. Maximum queues expected are in the eastbound direction with a max of 25 ft.

2040 AM

Adding a 2x1 multi-lane roundabout provides a decrease of intersection delay from 45 second to 9 seconds and a maximum delay reduction from 356 seconds in the northbound to 10 seconds in the eastbound direction during AM peak hours. Maximum queues occur in the westbound direction instead of the northbound direction, with a max of 75 ft.

2040 PM

Adding a 2x1 multi-lane roundabout provides an increase of intersection delay from 4 second to 6 seconds and maximum delay reduction from 36 seconds in the northbound to 6 seconds in the eastbound direction during PM peak hours. Maximum queues occur in the eastbound direction with a max of 25 ft.

Overall, the 2x1 multi-lane roundabout improves or maintains LOS/Delay in both the AM and PM Peaks, when compared to the existing side-street stop. Queues also reduce substantially.

Table 11: Projected 2020 & 2040 Multi-lane Roundabout Traffic Operations

Intersection	Peak Hour	Intersection Delay (1.)		Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
							Direction	Average Queue (ft)	Max Queue (ft)
Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 Roundabout AM	6	A	7	A	WBT/R	WBT/R	-	25
	2020 Roundabout PM	5	A	5	A	EBT/R	EBT/R	-	25
2x1 Multi-Lane Roundabout	2040 Roundabout AM*	9	A	10	B	WBT/R	WBT/R	-	75
	2040 Roundabout PM*	6	A	6	A	EBT/R	EBT/R	-	25

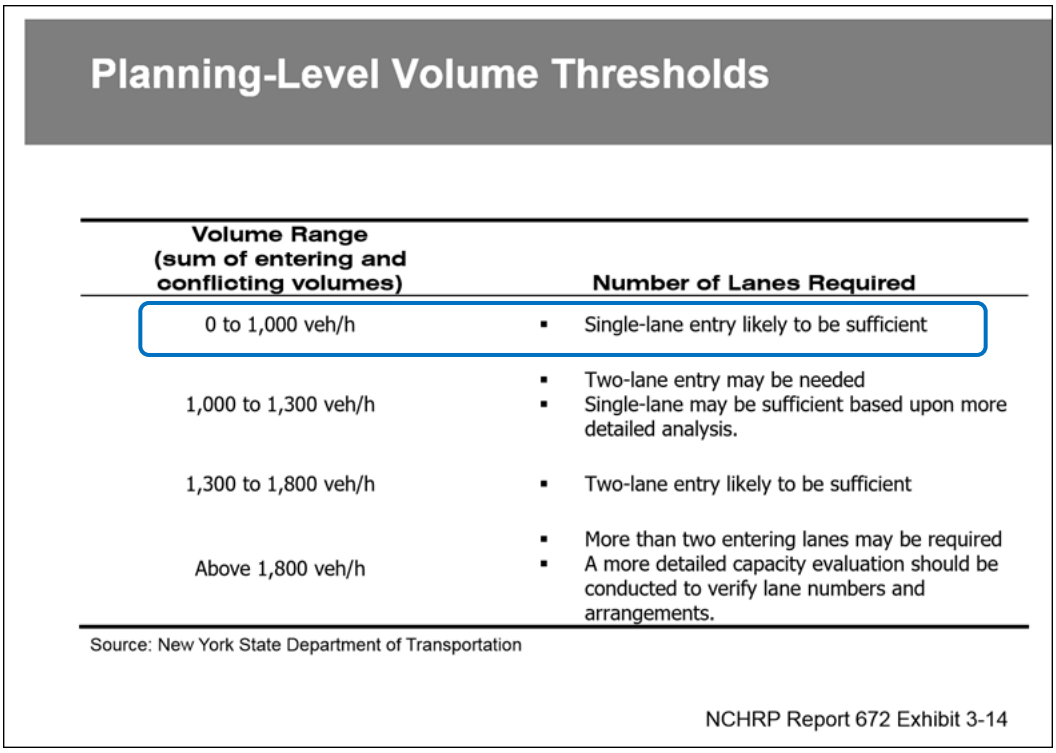
1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

**Note: With 50 peds/hours Max Delay increases to 12 sec/veh in the AM and 7 sec/veh in the PM.*

Single-Lane Vs. Multi-Lane Roundabout

A single lane roundabout is sufficient to handle the volumes at the intersection both now and in 2040.

A review of volumes shows that the entry + circulating volumes are no greater than 800 which means single-lane entry is likely to be sufficient per NCHRP Report 672.



Planning-Level Volume Thresholds

Volume Range (sum of entering and conflicting volumes)	Number of Lanes Required
0 to 1,000 veh/h	▪ Single-lane entry likely to be sufficient
1,000 to 1,300 veh/h	▪ Two-lane entry may be needed ▪ Single-lane may be sufficient based upon more detailed analysis.
1,300 to 1,800 veh/h	▪ Two-lane entry likely to be sufficient
Above 1,800 veh/h	▪ More than two entering lanes may be required ▪ A more detailed capacity evaluation should be conducted to verify lane numbers and arrangements.

Source: New York State Department of Transportation

NCHRP Report 672 Exhibit 3-14

Roundabout professionals at the Federal Highway Administration (FHWA) and the Institute of Transportation Engineers (ITE) stress the importance of not over designing the roundabout. Over designing can lead to increased speeds, poor yielding behavior, more conflict points, and increases in Property Damage type crashes. The goal should be to have the least number of lanes to achieve function.

Single-lane roundabouts will be more easily understood initially than multi-lane roundabouts. With the location next to Century High School, the simplicity the single-lane roundabout provides vs. a multi-lane roundabout is something to be considered. A single-lane roundabout also has a crossing that is up to 15 ft less than a 2x1 roundabout.

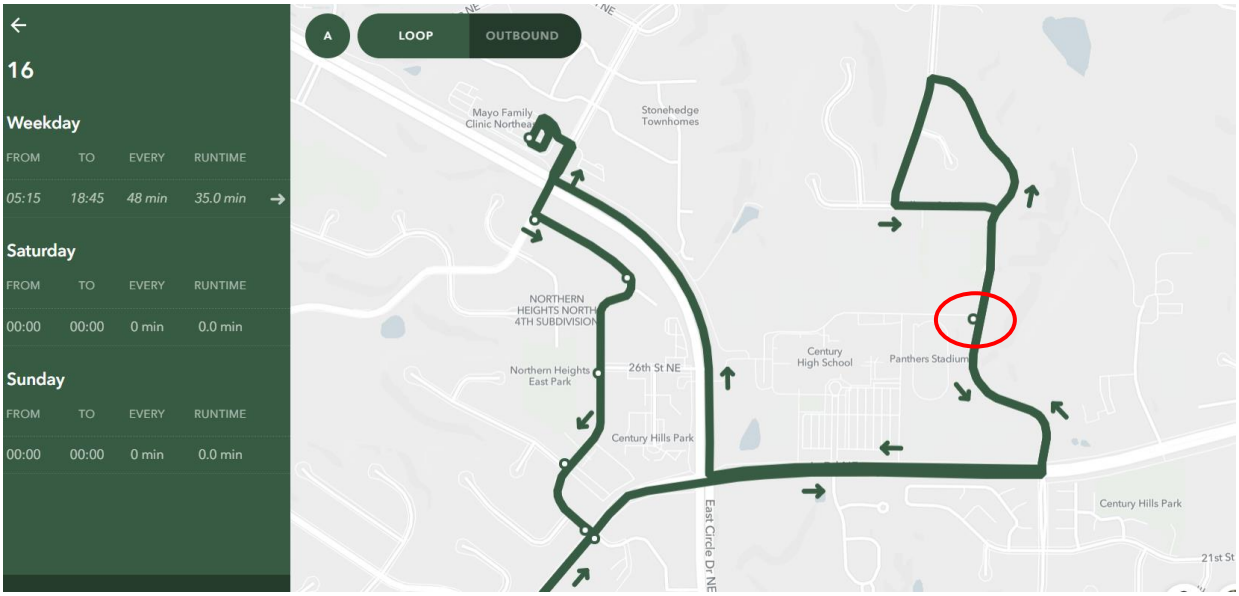
Multimodal Review

Pedestrian/Bicycle Facilities

Currently pedestrian crossings are striped on west and north legs of the intersection. An existing bike trail runs parallel to Viola Rd. A sidewalk is provided along the west side of Century Hills Dr NE connecting to the Century High School and into Emerald Hills Park and the Emerald Hills residential area to the north.

Transit

This area is served by Route 16. A bus stop is provided at the Century High School Drive entrance.



Connectivity

Century High School is on the northwest corner of the intersection. Residential development exists south of Viola Road, with Cassidy Drive being the main way to cross Viola Road. As these intersection crossings are improved with different intersection control, an increase in pedestrian traffic could be expected during peak hours as students move to and from school.

Whereas pedestrian volumes were not able to be confirmed for 2020, an examination of the 2017 counts collected by the city show that there were three pedestrians crossing the west leg in the AM Peak and eight in the afternoon. This number of pedestrians has little to no impact on LOS/Delay, however, a longer crossing distance does increase the exposure time in the roadway for a student crossing.

Conclusion & Recommendations

Alternative Safety Benefit

The signal controlled and two roundabout alternatives were analyzed for safety benefits. Crash modification factors from the Highway Safety Manual 1st Edition (HSM) and 2017 MnDOT "A Study of the Traffic Safety at Roundabouts in Minnesota" Report were used.

A "Study of the Traffic Safety at Roundabouts in Minnesota", published in October 2017, reviewed existing roundabouts across the state of Minnesota. They calculated the average crash rates for roundabouts by type on all roads as shown in **Table 12**. This information was used to calculate the number of crashes anticipated with the different roundabout types analyzed for this intersection.

Table 12: Average Crash Rates by Roundabout Type from 2017 Traffic Safety at Roundabouts Report

Type of Roundabouts	Number of Sites	Crash Rate (CR)	Fatal and Serious Injury Rate (FAR)
Single Lane	104	0.32	0.31
Unbalanced (2 lanes x 1 lane)	34	0.76	0.15
Full Multi-Lane	6	2.18	0.00
Total (All Roundabouts)	**144**	**0.600**	**0.24**

**Note:* Per MnDOT, the number of roundabouts studied that were single lane is far greater, with far more exposure then the unbalanced at the time the 2017 report was published. Hence, small numbers may be affecting the FAR rate. Looking at the actual crash numbers, unbalanced roundabouts had 1 severe crash (A injury), if there had been 2 severe crashes, the FAR rates for the single lane and unbalanced roundabouts would be close to identical.

Crash modification factors from the HSM state that converting a two-way stop-controlled intersection into a signal-controlled intersection is expected to decrease total crashes by 5%. Crash modification factors from the "2017 Traffic Safety at Roundabouts in Minnesota" Report show that converting a two-way stop-controlled intersection into a single-lane or multi-lane roundabout is expected to decrease total crashes by 68% and 24%, respectively. The predicted number of crashes per year with each alternative is provided in **Table 13**.

Table 13: Projected 2020 & 2040 Multi-lane Roundabout Traffic Operations

2020 Annual Traffic Entering Traffic (MEV)		**2.48 MEV**
Traffic Control Type	**Crash Rate***	**Predicted Number of Crashes per Year**
No Build	0.81	2.01
Signal	0.77	1.91
Roundabout- Single Lane	0.26	0.64
Roundabout- Single Lane with EB/WB Drop Lane	0.26	0.64
Roundabout- 2x1	0.62	1.53
* Crash Rates calculated based on 2015-2019 data combined with relevant CMF from below.		
Crash Modification Factors (CMFs) from the HSM 1st edition and the 2017 Traffic Safety at Roundabouts in Minnesota Report. For purposes of this analysis, the Roundabout with the EB/WB right turn drop lanes were assumed to have the same crash rate as a single lane roundabout as it has only on circulating lane		

Alternative Evaluation

The 2040 alternatives were compared in an evaluation matrix shown in **Table 15**. An all-way stop was not included in the evaluation matrix since it was not warranted.

When compared to a side street stop:

- Signal decreases delay 90% for a signal in AM Peak, but increases 25% in the PM Peak.
- Single-lane roundabout decreases delay 93% in the AM Peak and 30% in the PM Peak.
- Multi-lane roundabout decreases delay 95% in the AM Peak and 37% in the PM Peak

The other main differences between the signal and the roundabouts are the distance pedestrians need to cross the street and the anticipated crash rate.

The roundabout has lower delay and decreases pedestrian crossing distances, therefore, a installing a roundabout is preferred over installation of a traffic signal. Installing roundabouts are one of several proven FHWA safety countermeasures.

The intersection traffic can be handled well with a single-lane roundabout and the goal should be to have the least number of lanes to achieve function. Over designing can lead to increased speeds, poor yielding behavior, more conflict points, and increases in Property Damage type crashes.

The single-lane roundabout has a higher crash modification factor, but the existing four-lane roadway would have to merge on the approach and diverge after the departure which could lead to a potential increase in sideswipe crashes.

A multi-lane roundabout has a longer pedestrian crossing distances than a single-lane roundabout and could be more confusing to drivers than a single-lane roundabout which is something to be considered adjacent to a high school with several young drivers.

Based on the review of unbalanced (2x1) roundabouts before-after analysis in the "2017 Traffic Safety at Roundabouts in Minnesota", unbalanced roundabouts are not having the same success as the single-lane roundabouts. Many of the sites saw an increase in the frequency of crashes, and the overall total crash rates. However, unbalanced roundabouts are still achieving a noticeable reduction in fatal, serious injury, and other injury crashes.

Some of the highlights from the unbalanced roundabout analysis include:

- No reported fatal crashes at any of the sites.
- A 78% reduction in Serious Injury Crashes
- Right Angle crashes, typically the most deadly type of crash in Minnesota, had a total reduction of 25% of all crash severities.
- Left Turn into Traffic crashes had an 83% reduction.

Some of the results to note for future considerations of unbalanced roundabouts include:

- The total crashes rate is up about 44%
- Sideswipe Same Direction crash rate is up 774%
- Multi-vehicle crashes had a 22% increase. (See **Table 14)**

Table 14: Crash data from Unbalanced Roundabouts with before construction and after construction crash data based on Severity

Description	Vehicles Entering	Total Crashes	K	A	B	C	PDO
Before Crashes	998,943,195	524	0	7	42	124	351
Before Crash Rate	NA	0.525	0.000	0.007	0.042	0.124	0.351
After Crashes	664,905,712	502	0	1	18	74	409
After Crash Rate	NA	0.755	0.000	0.002	0.027	0.111	0.615
Percent Increase/ Decrease (By Rate)	**-33.4%**	**+43.9%**	**0.0%**	**-78.5%**	**-35.6%**	**-10.3%**	**+75.1%**

Source: Study of the Traffic Safety at Roundabouts in Minnesota, October 2017

Table 15: Evaluation Matrix

Performance Measure		Side Street Stop		Signalized Intersection		Single-Lane Roundabout*		Single-Lane Roundabout with right turn drop lanes		2x1 Multi-Lane Roundabout	
Vehicle Delay on Viola Rd (CSAH 2) (sec/veh)	AM	12	B	27	C	19	C	8	A	10	B
	PM	5	A	21	C	7	A	5	A	6	A
Vehicle Delay on Cassidy Dr/Century Hills Dr (sec/veh)	AM	356	F	17	B	13	B	14	B	11	B
	PM	36	E	16	B	6	A	6	A	6	A
Total Delay (veh-min)	AM	2339		254		176		152		132	
	PM	155		197		104		95		98	
Pedestrian Crossing Distance (ft)		100		100		51		63		77	
Crash Rate Reduction		-		5%		68%		68%		24%	
CMF Table				HSM 14-7		2017 MN Report		2017 MN Report		2017 MN Report	
Expected Crash Rate		0.81		0.77		0.26		0.26		0.62	
Statewide Average Crash Rate of Side Street Stop		0.19									
Total Cost		N/A		$397,500		$2,818,000		$2,112,000		$2,185,000	
Preferred Engineering Option		No		No		No		Yes		No	

**Note:* This is the most expensive option. This single-lane roundabout requires transition from a two-lane section to a single lane prior to it. This needs to be done with a reconstruction and not just striping as the curb line must be tapered in to reduce speeds and direct traffic into the roundabout. The multi-lane roundabout has two lanes, so the reconstruction does not need to extend as far east and west. The multi-lane roundabout cost estimate does include reconstructing the curb lines to accommodate the roundabout.

Rectangular Rapid Flashing Beacon (RRFB)

The need for an RRFB on the west leg crossing was evaluated. The National Cooperative Highway Research Program (NCHRP) Report 572 "Roundabouts in the United States", published by TRB in 2007, indicates that the expected yield rate of vehicles at a two-lane entry/exit is 57%. The 57% yield rate is the average driver yield rate for the overall crossing of a two-lane entry/exit. Adding a rectangular rapid-flash beacon (RRFB) can improve the two-stage crossing by increasing the driver yield rate to 84%. An "Assessment of Driver Yield Rates Pre- and Post-RRFB Installation, Bend, Oregon", published by the

Oregon Department of Transportation, in 2011 showed an 84% driver yield rate at staged pedestrian crossings at roundabouts with RRFBs.

Table 16 shows the pedestrian LOS and delay at the different driver yield rates. As shown in **Table 16**, the AM peak for the west leg is at LOS D. Per the HCM, a delay at LOS D is noticeable/irritating which could lead to an increased chance of risk-taking. When pedestrians feel that the delay is too great, they may become impatient and take more risks in crossing.

All detailed pedestrian LOS worksheets are included in the **Appendix**.

Table 16. Pedestrian LOS and Delay

Average Yield Rate	Peak Hour	Location	West Leg Crossing Two Lanes
57% TWO LANE	AM	Delay (sec)	23
		LOS	D
	PM	Delay (sec)	18
		LOS	C
84% TWO LANE w/RRFB	AM	Delay (sec)	15
		LOS	C
	PM	Delay (sec)	15
		LOS	C

Recommendation

The preferred engineering option is to convert the intersection to a single-lane roundabout with eastbound and westbound right turn drop lanes. This will achieve good operations, eliminate the merge on the approach, provide for less tapers on the east and west legs, and offer crash reduction. This alternative reduces the width and complexity of the pedestrian crossings when compared to the 2x1 roundabout by having a single lane departure.

The need for an RRFB with this preferred engineering option was evaluated for the west leg. With the addition of RRFBs on the west leg, the pedestrian delay and LOS can be improved and additional attention to the pedestrian crossing provided. The preferred engineering option has the benefit of reducing the pedestrian crossing with a two-lane approach and single lane departure, however, due to the proximity of the roundabout to Century High School, a higher pedestrian generator with less experienced drivers, an RRFB for this west leg crossing is recommended for further consideration.

Although not needed today based upon current 2040 projections, the splitter islands on the north and south legs of this preferred engineering option should be designed so that the roundabout could be retrofitted into a full 2x1 in the future if needed.

Appendix

CITY OF ROCHESTER

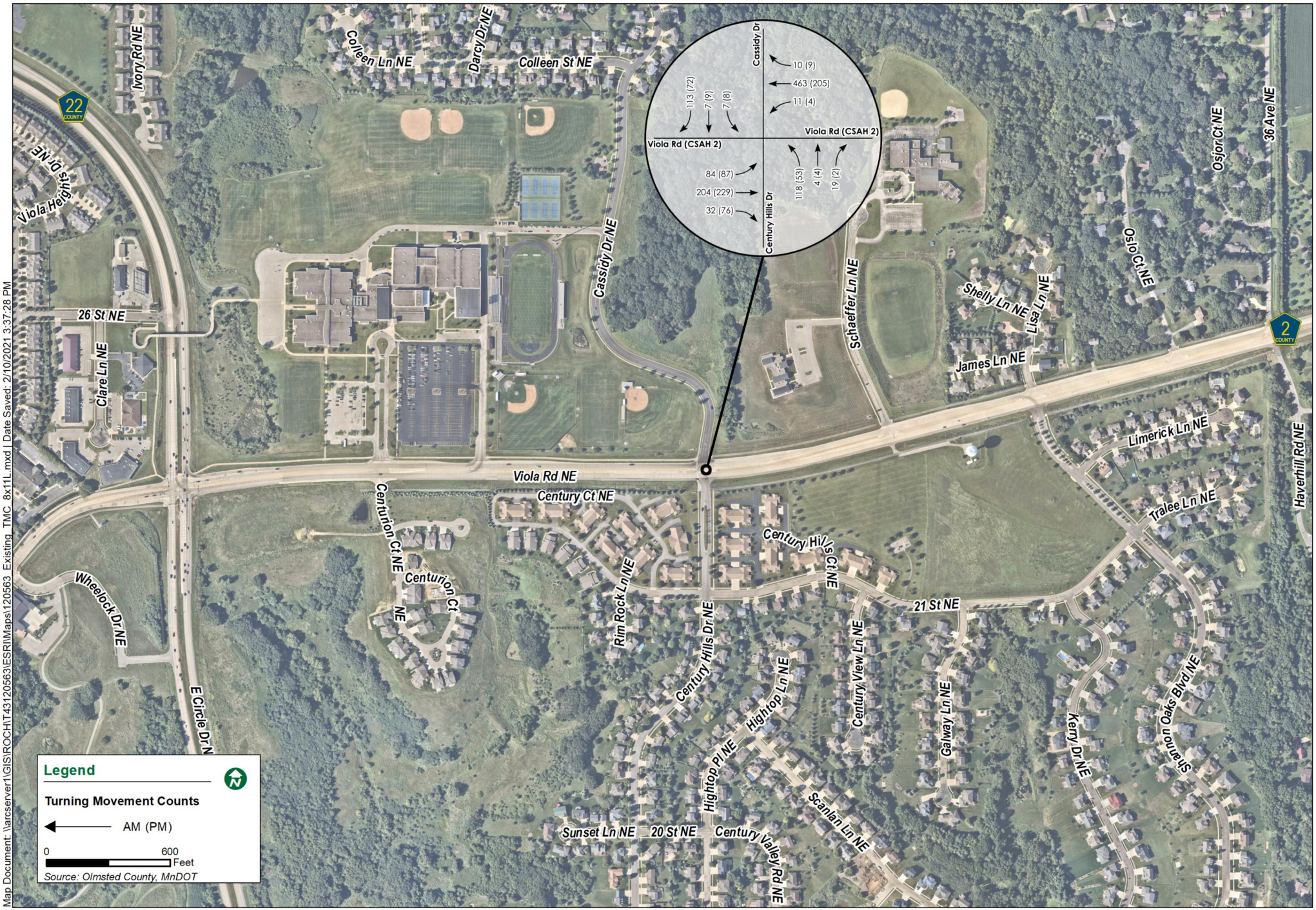
Viola Rd and Cassidy Dr ICE

Rochester, MN

2020 Turning Movement Counts

February 2021

BOLTON & MENK
Real People. Real Solutions.



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CITY OF ROCHESTER

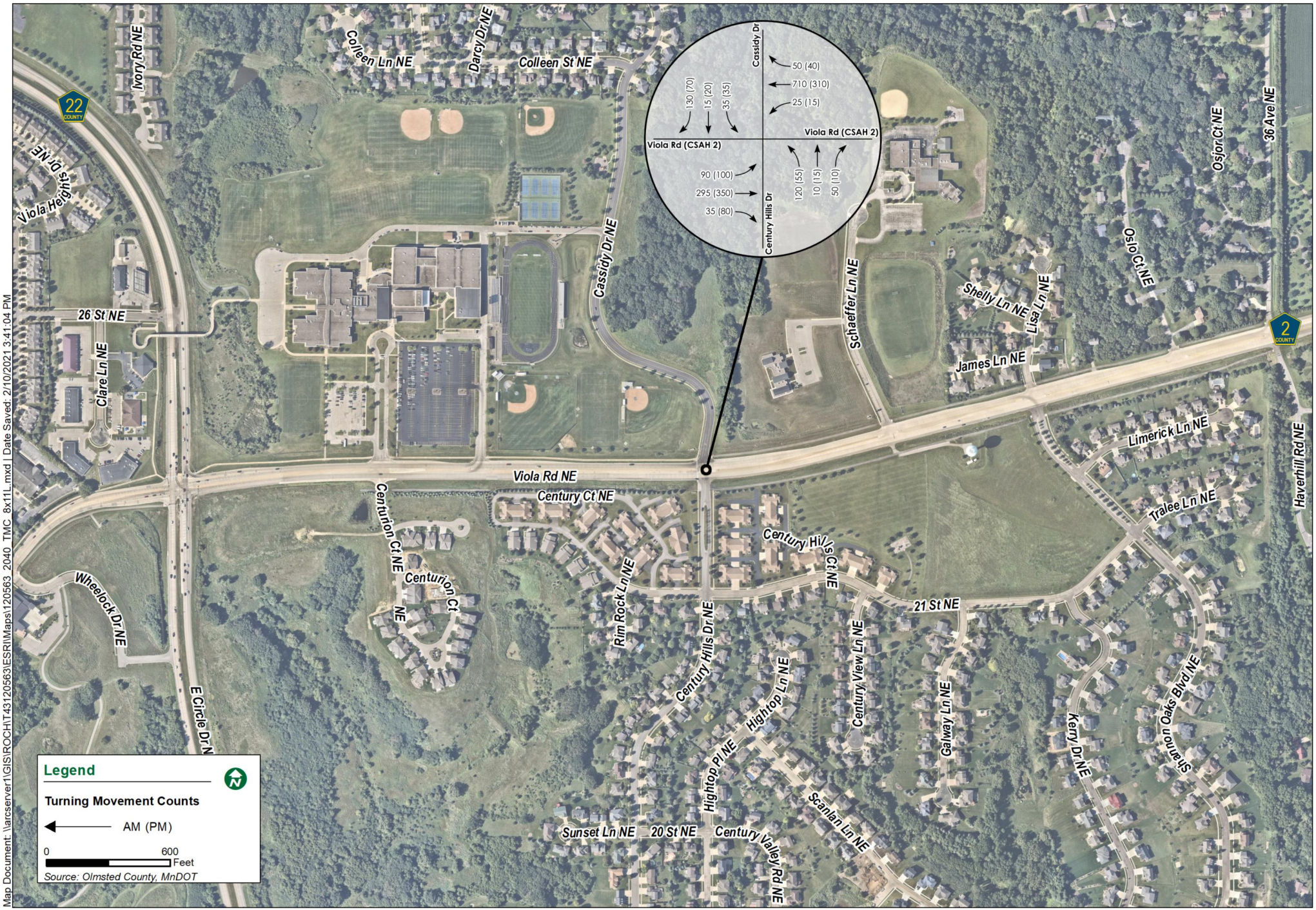
Viola Rd and Cassidy Dr ICE

Rochester, MN

2040 Turning Movement Counts

February 2021

BOLTON & MENK
Real People. Real Solutions.



Legend

Turning Movement Counts

AM (PM)

0 600 Feet

Source: Olmsted County, MnDOT

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Table 1: 2020 No Build Traffic Operations Analysis - Viola Rd & Cassidy Dr

Intersection ID	Intersection	Peak Hour	Intersection Delay (1.)		Movement Delay (sec/veh)																						Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
					NBL		NBT		NBR		SBL		SBT		SBR		EBL		EBT		EBR		WBL		WBT		WBR				Direction	Average Queue	Max Queue (ft)
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 AM	15	C	88	F	20	C	90	F	40	E	45	E	10	B	6	A	1	A	1	A	3	A	2	A	1	A	90	F	NBR	NBL/T/R	125	375
	Stop Controlled	2020 PM	3	A	14	B	15	C	2	A	10	B	14	B	5	A	3	A	1	A	1	A	3	A	1	A	1	A	15	C	NBT	SBT/R	50	100

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Table 2: Peak Hour Queues By Movement - 2020 No Build Geometry

Intersection ID	Intersection	Peak Hour	Queue Lengths															
			EBL		EBR		WBL		WBT		WBR		NBL/T/R		SBL		SBT/R	
			Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 No_Build AM	25	100	0	25	25	25	0	25	-	-	125	375	25	50	50	125
	Stop Controlled	2020 No_Build PM	25	75	0	25	25	25	-	-	0	25	50	75	25	50	50	100

Table 3: 2040 No Build Traffic Operations Analysis - Viola Rd & Cassidy Dr

Intersection ID	Intersection	Peak Hour	Intersection Delay (1.)		Movement Delay (sec/veh)																						Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
					NBL		NBT		NBR		SBL		SBT		SBR		EBL		EBT		EBR		WBL		WBT		WBR				Direction	Average Queue	Max Queue (ft)
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2040 AM	45	E	322	F	209	F	356	F	325	F	168	F	68	F	12	B	1	A	0	A	6	A	2	A	1	A	356	F	NBR	SBT/R	175	575
	Stop Controlled	2040 PM	4	A	24	C	36	E	10	B	31	D	22	C	5	A	5	A	1	A	1	A	3	A	1	A	1	A	36	E	NBT	SBT/R	50	125

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Table 4: Peak Hour Queues By Movement - 2040 No Build Geometry

Intersection ID	Intersection	Peak Hour	Queue Lengths													
			EBL		EBR		WBL		WBR		NBL/T/R		SBL		SBT/R	
			Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	ry Hills Dr NE/Cassidy Dr NE & Viola	40 No_Build A	50	125	-	-	25	50	25	25	325	575	75	125	175	575
	Stop Controlled	40 No_Build P	25	75	0	25	25	50	25	25	50	125	25	100	50	125

Table 5: 2020 Build Signal Traffic Operations Analysis - Viola Rd & Cassidy Dr

Intersection ID	Intersection	Peak Hour	Intersection Delay (1.)		Movement Delay (sec/veh)																						Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
					NBL		NBT		NBR		SBL		SBT		SBR		EBL		EBT		EBR		WBL		WBT		WBR				Direction	Average Queue	Max Queue (ft)
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 AM	15	B	16	B	14	B	8	A	13	B	16	B	5	A	20	C	11	B	2	A	18	B	20	C	4	A	20	C	EBL	WBT	100	175
	Signalized Intersection	2020 PM	12	B	15	B	14	B	5	A	17	B	15	B	3	A	16	B	11	B	3	A	17	B	17	B	4	A	17	B	WBT	WBT	75	150

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Table 6: Peak Hour Queues By Movement - 2020 Build Signal Geometry

Intersection	Peak Hour	Queue Lengths																					
		EBL		EBT 1		EBT 2		EBR		WBL		WBT 1		WBT 2		WBR		NBL/T/R		SBL		SBT/R	
		Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 Signal AM	50	125	50	125	25	75	25	50	25	50	100	175	75	175	25	50	50	175	25	50	50	100
Signalized Intersection	2020 Signal PM	50	125	50	100	25	100	25	75	25	25	75	150	25	75	25	50	25	75	25	50	25	75

Table 7: 2040 Build Signal Traffic Operations Analysis - Viola Rd & Cassidy Dr

Intersection ID	Intersection	Peak Hour	Intersection Delay (1.)		Movement Delay (sec/veh)																						Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
					NBL		NBT		NBR		SBL		SBT		SBR		EBL		EBT		EBR		WBL		WBT		WBR				Direction	Average Queue	Max Queue (ft)
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2040 AM	21	C	16	B	13	B	8	A	16	B	17	B	7	A	27	C	14	B	3	A	25	C	28	C	7	A	28	C	WBT	WBT	150	300
	Signalized Intersection	2040 PM	13	B	14	B	16	B	5	A	13	B	12	B	4	A	21	C	11	B	3	A	14	B	19	B	6	A	21	C	EBL	WBT	75	150

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Table 8: Peak Hour Queues By Movement - 2040 Build Signal Geometry

Intersection ID	Intersection	Peak Hour	Queue Lengths																			
			EBL		EBT 1		EBT 2		EBR		WBL		WBT 1		WBT 2		WBR		NBL/T/R		SBL		SBT/R	
			Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2040 Signal AM	50	150	75	175	50	150	25	50	25	175	150	300	125	300	25	75	50	125	25	75	50	100
	Signalized Intersection	2040 Signal PM	50	150	75	125	50	100	25	75	25	50	75	150	50	100	25	75	25	75	25	75	25	100

Table 9: 2020 Single Lane Roundabout Traffic Operations Analysis - Viola Rd & Cassidy Dr

Intersection ID	Intersection	Peak Hour	Intersection Delay (1.)		Movement Delay (sec/veh)								Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
					NBL/T/R		SBL/T/R		EBL/T/R		WBL/T/R					Direction	Average Queue (ft)	Max Queue (ft)
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 Roundabout AM	7	A	5	A	8	A	5	A	9	A	9	A	WBL/T/R	WBL/T/R	-	75
	Single Lane Roundabout	2020 Roundabout PM	5	A	4	A	5	A	6	A	5	A	6	A	EBL/T/R	WBL/T/R	-	25

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Table 10: Peak Hour Queues By Movement - 2020 Single Lane Roundabout Geometry

Intersection ID	Intersection	Peak Hour	Queue Lengths							
			EBL/T/R		WBL/T/R		NBL/T/R		SBL/T/R	
			Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 Roundabout AM	-	25	-	75	-	25	-	25
	Roundabout	2020 Roundabout PM	-	25	-	25	-	0	-	0
	1. Max queue from 95th percentile									

Table 11: 2040 Roundabout Traffic Operations Analysis - Viola Rd & Cassidy Dr

Intersection ID	Intersection	Peak Hour	Intersection Delay (1.)		Movement Delay (sec/veh)								Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
					NBL/T/R		SBL/T/R		EBL/T/R		WBL/T/R					Direction	Average Queue (ft)	Max Queue (ft)
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2040 Roundabout AM	14	B	7	A	13	B	6	A	19	C	19	C	WBL/T/R	WBL/T/R	-	225
	Single Lane Roundabout	2040 Roundabout PM	7	A	6	A	6	A	7	A	7	A	7	A	EBL/T/R	EBL/T/R	-	50

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Table 12: Peak Hour Queues By Movement - 2040 Single Lane Roundabout Geometry

Intersection ID	Intersection	Peak Hour	Queue Lengths							
			EBL/T/R		WBL/T/R		NBL/T/R		SBL/T/R	
			Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2040 Roundabout AM	-	50	-	225	-	25	-	50
	Roundabout	2040 Roundabout PM	-	50	-	50	-	0	-	25
	1. Max queue from 95th percentile									

Table 13: 2020 Multi-Lane Roundabout Traffic Operations Analysis - Viola Rd & Cassidy Dr

Intersection ID	Intersection	Peak Hour	Intersection Delay (1.)		Movement Delay (sec/veh)								Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
					NBL/T/R		SBL/T/R		EBL/T/R		WBL/T/R					Direction	Average Queue (ft)	Max Queue (ft)
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 Roundabout AM	6	A	6	A	7	A	5	A	7	A	8	A	WBL/T/R	WBL/T/R	-	25
	Multi-Lane Roundabout	2020 Roundabout PM	6	A	6	A	5	A	6	A	6	A	6	A	WBL/T/R	WBL/T/R	-	25

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Table 14: Peak Hour Queues By Movement - 2020 Multi-Lane Roundabout Geometry

Intersection ID	Intersection	Peak Hour	Queue Lengths							
			EBL/T/R		WBL/T/R		NBL/T/R		SBL/T/R	
			Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2040 Roundabout AM	-	25	-	25	-	25	-	25
	Multi-Lane Roundabout	2040 Roundabout PM	-	25	-	25	-	0	-	25

1. Max queue from 95th percentile

Table 15: 2020 Multi-Lane Roundabout Traffic Operations Analysis - Viola Rd & Cassidy Dr

Intersection ID	Intersection	Peak Hour	Intersection Delay (1.)		Movement Delay (sec/veh)								Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
					NBL/T/R		SBL/T/R		EBL/T/R		WBL/T/R					Direction	Average Queue (ft)	Max Queue (ft)
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2040 Roundabout AM	9	A	7	A	11	B	6	A	10	B	11	B	SBL/T/R	WBL/T/R	-	75
	Multi-Lane Roundabout	2040 Roundabout PM	6	A	6	A	6	A	6	A	6	A	6	A	EBL/T/R	EBL/T/R	-	25

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Table 14: Peak Hour Queues By Movement - 2040 Multi-Lane Roundabout Geometry

Intersection ID	Intersection	Peak Hour	Queue Lengths							
			EBL/T/R		WBL/T/R		NBL/T/R		SBL/T/R	
			Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2040 Roundabout AM	-	25	-	75	-	25	-	25
	Multi-Lane Roundabout	2040 Roundabout PM	-	25	-	25	-	0	-	25

1. Max queue from 95th percentile

Table17: 2020 Single Lane Roundabout with EB/WB Right Drop Lanes Traffic Operations Analysis - Viola Rd & Cassidy Dr

Intersection ID	Intersection	Peak Hour	Intersection Delay (1.)		Movement Delay (sec/veh)								Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
					NBL/T/R		SBL/T/R		EBL/T/R		WBL/T/R					Direction	Average Queue (ft)	Max Queue (ft)
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 Roundabout AM	7	A	5	A	8	A	4	A	8	A	8	A	WBL/T/R	WBL	-	50
	Single Lane Roundabout with EB/WB Right Turn drop lanes	2020 Roundabout PM	5	A	4	A	5	A	5	A	5	A	5	A	WBL/T/R	EBL	-	50

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Table 18: Peak Hour Queues By Movement - 2020 Single Lane with EB/WB Right Drop Lanes Roundabout Geometry

Intersection ID	Intersection	Peak Hour	Queue Lengths							
			EBL/T/R		WBL/T/R		NBL/T/R		SBL/T/R	
			Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2020 Roundabout AM	-	25	-	50	-	25	-	25
	Single Lane Roundabout with EB/WB Right Turn drop lanes	2020 Roundabout PM	-	25	-	25	-	0	-	0

Table 19: 2040 Single Lane Roundabout with EB/EB Right Turn Drop Lanes Traffic Operations Analysis - Viola Rd & Cassidy Dr

Intersection ID	Intersection	Peak Hour	Intersection Delay (1.)		Movement Delay (sec/veh)								Maximum Delay-LOS (2.)		Limiting Movement (3.)	Max Approach Queue		
					NBL/T/R		SBL/T/R		EBL/T/R		WBL/T/R					Direction	Average Queue (ft)	Max Queue (ft)
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2040 Roundabout AM	11	B	7	A	13	B	6	A	14	B	14	B	WBL/T/R	WBL	-	150
	Single Lane Roundabout with EB/WB Right Turn drop lanes	2040 Roundabout PM	6	A	6	A	6	A	6	A	6	A	6	A	EBL/T/R	EBL	-	50

1. Delay in seconds per vehicle
2. Maximum delay and LOS on any approach and/or movement
3. Limiting Movement is the highest delay movement.

Table 20: Peak Hour Queues By Movement - 2040 Single Lane Roundabout with EB/WB Right Turn Drop Lanes Geometry

Intersection ID	Intersection	Peak Hour	Queue Lengths							
			EBL/T/R		WBL/T/R		NBL/T/R		SBL/T/R	
			Avg	Max	Avg	Max	Avg	Max	Avg	Max
1	Century Hills Dr NE/Cassidy Dr NE & Viola Rd NE	2040 Roundabout AM	-	25	-	150	-	25	-	50
	Single Lane Roundabout with EB/WB Right Turn drop lanes	2040 Roundabout PM	-	50	-	25	-	0	-	25

Crash Summary

Report Version 1.0
February 2020

Crash Severity/Crash Year

Crash Severity	Total	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
K - Fatal	0	0	0	0	0	0	0	0	0	0	0	0
A - Serious Injury	0	0	0	0	0	0	0	0	0	0	0	0
B - Minor Injury	2	0	0	0	0	0	0	0	1	0	1	0
C - Possible Injury	3	0	0	0	0	0	3	0	0	0	0	0
N - Prop Dmg Only	5	0	0	0	0	0	2	1	0	1	1	0
U - Unkown	0	0	0	0	0	0	0	0	0	0	0	0
Total	10	0	0	0	0	0	5	1	1	1	2	0

Crash Severity/Number of Vehicles

Crash Severity	Total	0	1	2	3+
K - Fatal	0	0	0	0	0
A - Serious Injury	0	0	0	0	0
B - Minor Injury	1	0	0	1	0
C - Possible Injury	3	0	0	3	0
N - Prop Dmg Only	5	0	0	5	0
U - Unkown	0	0	0	0	0
Total	9	0	0	9	0

Basic Type Summary

Basic Type Summary	Total	%
Pedestrian	0	0.0
Bike	0	0.0
Single Vehicle Run Off Road	0	0.0
Single Vehicle Other	0	0.0
Sideswipe Same Direction	0	0.0
Sideswipe Opposing	0	0.0
Rear End	1	10.0
Head On	0	0.0
Left Turn	0	0.0
Angle	8	80.0
Other	1	10.0
Total	10	100.0

First Harmful Event Summary

First Harmful Event Summary	Total	%
Pedestrian	0	0.0
Bicyclist	0	0.0
Motor Vehicle In Transport	10	100.0
Parked Motor Vehicle	0	0.0
Train	0	0.0
Deer/Animal	0	0.0
Other - Non Fixed Object	0	0.0
Collision Fixed Object	0	0.0
Non-Collision Harmful Events	0	0.0
Non-Harmful Events	0	0.0
Other/Unknown	0	0.0
Total	10	100.0

Relationship to Intersection Summary

Relationship to Intersection Summary	Total	%
Not at Intersection/Interchange	0	0.0
Four-Way Intersection	9	90.0
T or Y Intersection	0	0.0
Five-Way Intersection or More	0	0.0
Roundabout	0	0.0
Intersection Related	1	10.0
Driveway Access Related	0	0.0
At School Crossing	0	0.0
Railway Grade Crossing	0	0.0
Shared Use Path or Trail	0	0.0
Interchange or Ramp	0	0.0
Crossover Related	0	0.0
Acceleration/Deceleration Lane	0	0.0
Other/Unknown	0	0.0
Total	10	100.0

Weather 1 Summary

Weather 1 Summary	Total	%
Clear	7	70.0
Cloudy	1	10.0
Rain	2	20.0
Snow	0	0.0
Sleet, Hail (Freezing Rain/Drizzle)	0	0.0
Fog/Smog/Smoke	0	0.0
Blowing Sand/Soil/Dirt/Snow	0	0.0
Severe Crosswinds	0	0.0
Other/Unknown	0	0.0
Total	10	100.0

Light Condition Summary

Light Condition Summary	Total	%
Daylight	8	80.0
Sunrise	0	0.0
Sunset	0	0.0
Dark (Str Lights On)	2	20.0
Dark (Str Lights Off)	0	0.0
Dark (No Str Lights)	0	0.0
Dark (Unknown Light)	0	0.0
Other/Unknown	0	0.0
Total	10	100.0

Crash Summary

Time of Day/Day of Week

From To	00:00 01:59	02:00 03:59	04:00 05:59	06:00 07:59	08:00 09:59	10:00 11:59	12:00 13:59	14:00 15:59	16:00 17:59	18:00 19:59	20:00 21:59	22:00 23:59	Total	%
SUN	0	0	0	0	0	0	1	0	0	0	0	0	1	10.0
MON	0	0	0	0	0	0	1	0	0	0	0	0	1	10.0
TUE	0	0	0	0	0	0	0	0	1	0	0	0	1	10.0
WED	0	0	0	1	0	0	0	0	0	0	0	0	1	10.0
THU	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
FRI	0	0	0	1	0	0	0	1	1	0	0	0	3	30.0
SAT	0	0	0	0	0	1	0	0	0	1	1	0	3	30.0
Total	0	0	0	2	0	1	2	1	2	1	1	0	10	100.0
%	0.0	0.0	0.0	20.0	0.0	10.0	20.0	10.0	20.0	10.0	10.0	0.0	100.0	100.0

Driver & Non-Motorist Age/Gender Summary

Age	M	F	NR	No Value	Total	%
<14	0	0	0	0	0	0.0
14	0	0	0	0	0	0.0
15	0	0	0	0	0	0.0
16	1	1	0	0	2	10.0
17	2	1	0	0	3	15.0
18	0	1	0	0	1	5.0
19	0	0	0	0	0	0.0
20	0	0	0	0	0	0.0
21-24	2	1	0	0	3	15.0
25-29	2	0	0	0	2	10.0
30-34	1	0	0	0	1	5.0
35-39	0	1	0	0	1	5.0
40-44	1	1	0	0	2	10.0
45-49	1	2	0	0	3	15.0
50-54	0	0	0	0	0	0.0
55-59	0	0	0	0	0	0.0
60-64	0	0	0	0	0	0.0
65-69	0	0	0	0	0	0.0
70-74	1	0	0	0	1	5.0
75-79	1	0	0	0	1	5.0
80-84	0	0	0	0	0	0.0
85-89	0	0	0	0	0	0.0
90-94	0	0	0	0	0	0.0
95+	0	0	0	0	0	0.0
No Value	0	0	0	0	0	0.0
Total	12	8	0	0	20	100.0
%	60.0	40.0	0.0	0.0	100.0	100.0

Month Summary

Month Summary	Total	%
January	0	0.0
February	2	20.0
March	1	10.0
April	1	10.0
May	1	10.0
June	0	0.0
July	0	0.0
August	0	0.0
September	1	10.0
October	3	30.0
November	0	0.0
December	1	10.0
Total	10	100.0

Physical Condition Summary

Physical Condition Summary	Total	%
Apparently Normal (Including No Drugs/Alcohol)	18	90.0
Physical Disability (Short Term or Long Term)	0	0.0
Medical Issue (Ill, Sick or Fainted)	0	0.0
Emotional (Depression, Angry, Disturbed, etc.)	0	0.0
Asleep or Fatigued	0	0.0
Has Been Drinking Alcohol	0	0.0
Has Been Taking Illicit Drugs	0	0.0
Has Been Taking Medications	0	0.0
Other/Unknown	0	0.0
Not Applicable	2	10.0
Total	20	100.0

Selection Filter:

WORK AREA: County('659500') - FILTER: Year('2015','2016','2017','2018','2019') - SPATIAL FILTER APPLIED

Analyst: Jennifer McCoy

Notes:

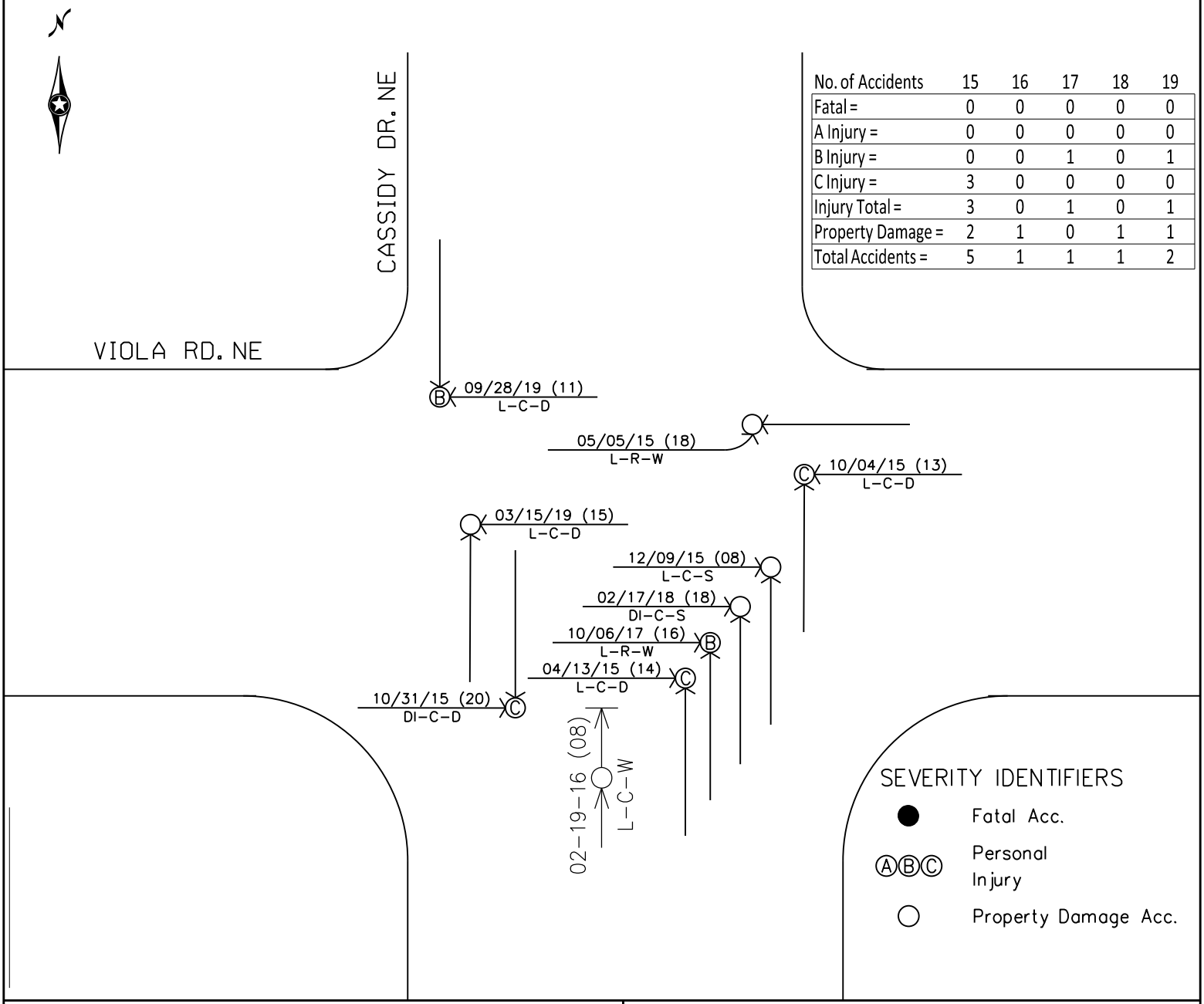
COLLISION DIAGRAM

BOLTON & MENK, INC.

LOCATION: Viola Rd NE & Cassidy Dr NE - Rochester, MN

TIME PERIOD: 01/01/15 - 12/31/2019 DATE: 05/28/2020

PREPARED BY: M. WALL



No. of Accidents	15	16	17	18	19
Fatal =	0	0	0	0	0
A Injury =	0	0	0	0	0
B Injury =	0	0	1	0	1
C Injury =	3	0	0	0	0
Injury Total =	3	0	1	0	1
Property Damage =	2	1	0	1	1
Total Accidents =	5	1	1	1	2

SEVERITY IDENTIFIERS

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

KEY

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

NOTES

[1] ADT = 6,790

[2] CR = 0.54 CI = 1.50

[3] SR = 0.00

Light:
L= Daylight (1)
DN= Dawn (2)
DU= Dusk (3)
DI= Dark, Lighted (4)
Do= Dark, Lights Off (5)
D= Dark, Unlighted (6)
X= Unknown (99)

Weather:
C= Clear or Cloudy (1 or 2)
R= Rain (3)
S= Snow or Sleet (4 or 5)
F= Fog, Smog, Smoke (6)
B= Blowing Sand/Dust (7)
W= Severe Crosswinds (8)
X= Other or Unknown (99)

Surface:
D= Dry (1)
W= Wet (2)
S= Snow or Ice (3 or 4)
M= Muddy (5)
DB= Debris (6)
O= Oily (7)
X= Other or Unknown (99)

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

Highway Capacity Manual (HCM)

Pedestrian Level of Service (LOS) at Uncontrolled Crossing Locations

Intersection and Mid-Block Crossings

Crossing Location:	E. leg Viola & Cassidy	Date:	5/5/2021
City, State:	Rochester, MN	Scenario:	2020 AM Peak 2x1
Reviewer(s):	Jennifer McCoy	Agency:	Bolton & Menk
Project Number:	T43120563	ID #:	RRFB

The following is the base information needed to complete the analysis.
If this is a one-stage crossing, use only Crossing 1.
If this is a two-stage crossing, each stage must be evaluated separately using Crossing 1 and Crossing 2.

Crossing 1:

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	3.5
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	484
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.134
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing 2:

(only used for two-stage crossings)

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	4
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	230
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.064
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing Treatment Yield Rate

	Input Table:	
M_y = motorist yield rate (decimal)	M_y =	84%

Entering data into the tables above will populate the evaluation tables in Microsoft Excel.

Results:

Average Delay	**16.2**	**sec/ped**
LOS	**C**	

Highway Capacity Manual (HCM)

Pedestrian Level of Service (LOS) at Uncontrolled Crossing Locations

Intersection and Mid-Block Crossings

Crossing Location:	E. leg Viola & Cassidy	Date:	5/5/2021
City, State:	Rochester, MN	Scenario:	2020 AM Peak 2x1
Reviewer(s):	Jennifer McCoy	Agency:	Bolton & Menk
Project Number:	T43120563	ID #:	Signs and Striping

The following is the base information needed to complete the analysis.
If this is a one-stage crossing, use only Crossing 1.
If this is a two-stage crossing, each stage must be evaluated separately using Crossing 1 and Crossing 2.

Crossing 1:

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	3.5
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	484
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.134
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing 2:

(only used for two-stage crossings)

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	4
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	230
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.064
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing Treatment Yield Rate

	Input Table:	
M_y = motorist yield rate (decimal)	M_y =	57%

Entering data into the tables above will populate the evaluation tables in Microsoft Excel.

Results:

Average Delay	**19.0**	**sec/ped**
LOS	**C**	

Highway Capacity Manual (HCM)

Pedestrian Level of Service (LOS) at Uncontrolled Crossing Locations

Intersection and Mid-Block Crossings

Crossing Location:	W. leg Viola & Cassidy	Date:	5/5/2021
City, State:	Rochester, MN	Scenario:	2020 AM Peak 2x1
Reviewer(s):	Jennifer McCoy	Agency:	Bolton & Menk
Project Number:	T43120563	ID #:	RRFB

The following is the base information needed to complete the analysis.
If this is a one-stage crossing, use only Crossing 1.
If this is a two-stage crossing, each stage must be evaluated separately using Crossing 1 and Crossing 2.

Crossing 1:

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	3.5
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	694
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.193
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing 2:

(only used for two-stage crossings)

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	4
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	320
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.089
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing Treatment Yield Rate

	Input Table:	
M_y = motorist yield rate (decimal)	M_y =	84%

Entering data into the tables above will populate the evaluation tables in Microsoft Excel.

Results:

Average Delay	**15.1**	**sec/ped**
LOS	**C**	

Highway Capacity Manual (HCM)

Pedestrian Level of Service (LOS) at Uncontrolled Crossing Locations

Intersection and Mid-Block Crossings

Crossing Location:	W. leg Viola & Cassidy	Date:	5/5/2021
City, State:	Rochester, MN	Scenario:	AM Peak 2x1
Reviewer(s):	Jennifer McCoy	Agency:	Bolton & Menk
Project Number:	T43120563	ID #:	Signs/Stripes Only

The following is the base information needed to complete the analysis.
If this is a one-stage crossing, use only Crossing 1.
If this is a two-stage crossing, each stage must be evaluated separately using Crossing 1 and Crossing 2.

Crossing 1:

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	3.5
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	694
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.193
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing 2:

(only used for two-stage crossings)

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	4
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	320
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.089
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing Treatment Yield Rate

	Input Table:	
M_y = motorist yield rate (decimal)	M_y =	57%

Entering data into the tables above will populate the evaluation tables in Microsoft Excel.

Results:

Average Delay	**22.8**	**sec/ped**
LOS	**D**	

Highway Capacity Manual (HCM)

Pedestrian Level of Service (LOS) at Uncontrolled Crossing Locations

Intersection and Mid-Block Crossings

Crossing Location:	E. leg Viola & Cassidy	Date:	5/5/2021
City, State:	Rochester, MN	Scenario:	2020 PM Peak 2x1
Reviewer(s):	Jennifer McCoy	Agency:	Bolton & Menk
Project Number:	T43120563	ID #:	RRFB

The following is the base information needed to complete the analysis.
If this is a one-stage crossing, use only Crossing 1.
If this is a two-stage crossing, each stage must be evaluated separately using Crossing 1 and Crossing 2.

Crossing 1:

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	3.5
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	218
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.061
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing 2:

(only used for two-stage crossings)

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	4
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	239
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.066
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing Treatment Yield Rate

	Input Table:	
M_y = motorist yield rate (decimal)	M_y =	84%

Entering data into the tables above will populate the evaluation tables in Microsoft Excel.

Results:

Average Delay	**15.7**	**sec/ped**
LOS	**C**	

Highway Capacity Manual (HCM)

Pedestrian Level of Service (LOS) at Uncontrolled Crossing Locations

Intersection and Mid-Block Crossings

Crossing Location:	E. leg Viola & Cassidy	Date:	5/5/2021
City, State:	Rochester, MN	Scenario:	2020 PM Peak 2x1
Reviewer(s):	Jennifer McCoy	Agency:	Bolton & Menk
Project Number:	T43120563	ID #:	Signs and Striping

The following is the base information needed to complete the analysis.
If this is a one-stage crossing, use only Crossing 1.
If this is a two-stage crossing, each stage must be evaluated separately using Crossing 1 and Crossing 2.

Crossing 1:

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	3.5
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	218
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.061
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing 2:

(only used for two-stage crossings)

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	4
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	239
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.066
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing Treatment Yield Rate

	Input Table:	
M_y = motorist yield rate (decimal)	M_y =	57%

Entering data into the tables above will populate the evaluation tables in Microsoft Excel.

Results:

Average Delay	**14.3**	**sec/ped**
LOS	**C**	

Highway Capacity Manual (HCM)

Pedestrian Level of Service (LOS) at Uncontrolled Crossing Locations

Intersection and Mid-Block Crossings

Crossing Location:	W. leg Viola & Cassidy	Date:	5/5/2021
City, State:	Rochester, MN	Scenario:	2020 PM Peak 2x1
Reviewer(s):	Jennifer McCoy	Agency:	Bolton & Menk
Project Number:	T43120563	ID #:	RRFB

The following is the base information needed to complete the analysis.
If this is a one-stage crossing, use only Crossing 1.
If this is a two-stage crossing, each stage must be evaluated separately using Crossing 1 and Crossing 2.

Crossing 1:

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	3.5
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	330
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.092
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing 2:

(only used for two-stage crossings)

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	4
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	392
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.109
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing Treatment Yield Rate

	Input Table:	
M_y = motorist yield rate (decimal)	M_y =	84%

Entering data into the tables above will populate the evaluation tables in Microsoft Excel.

Results:

Average Delay	**15.5**	**sec/ped**
LOS	**C**	

Highway Capacity Manual (HCM)

Pedestrian Level of Service (LOS) at Uncontrolled Crossing Locations

Intersection and Mid-Block Crossings

Crossing Location:	W. leg Viola & Cassidy	Date:	5/5/2021
City, State:	Rochester, MN	Scenario:	PM Peak 2x1
Reviewer(s):	Jennifer McCoy	Agency:	Bolton & Menk
Project Number:	T43120563	ID #:	Signs/Stripes Only

The following is the base information needed to complete the analysis.
If this is a one-stage crossing, use only Crossing 1.
If this is a two-stage crossing, each stage must be evaluated separately using Crossing 1 and Crossing 2.

Crossing 1:

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	3.5
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	330
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.092
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing 2:

(only used for two-stage crossings)

Evaluation Inputs:

	defaults:		Input Table:	
L = crosswalk length (ft)			L =	31
S_p = average pedestrian walking speed (ft/s)	S_p =	3.5	S_p =	4
t_s = pedestrian start-up and end clearance time (s)	t_s =	3.0	t_s =	3
V = vehicular hourly volume (veh/hr)			V =	392
v_p = pedestrian flow rate (ped/s)	v_p =	0*	v_p =	0.00
v = vehicular flow rate (veh/s) = V/3600	v =	V/3600	v =	0.109
W_c = crosswalk width (ft)	W_c =	8.0	W_c =	8.0
N = number of through lanes crossed (Integer)	N =	INT(L/11)	N =	2

*no platooning observed

Crossing Treatment Yield Rate

	Input Table:	
M_y = motorist yield rate (decimal)	M_y =	57%

Entering data into the tables above will populate the evaluation tables in Microsoft Excel.

Results:

Average Delay	**17.9**	**sec/ped**
LOS	**C**	

CASSIDY DR. NE

VIOLA RD. NE

CENTURY HILLS DR. NE

N

30

SCALE IN FEET

BOLTON & MENK

VIOLA RD AND CASSIDY DR
ROCHESTER, MINNESOTA

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CASSIDY DR. NE

CENTURY HIGH SCHOOL

TRINITY PRESPYTERIAN CHURCH

SCHAEFFER LN NE

VIOLA RD. NE

CENTURY HILLS DR. NE

120

SCALE IN FEET

For these concepts, a WB-62 was assumed for all turning movements, an ICD of 130' for the single lane and an ICD of 160' for the 2x1 roundabout. These factors result in a 58' diameter interior circle for both the single lane and 2x1 roundabout, although this interior diameter is likely to change as the design progresses.

As for the approach curves, these will be better defined in preliminary design. They will not have a big impact on the overall cost and footprint of each concept, but will need further design information to detail out.

LEGEND

- ROADWAY
- TURF
- SIDEWALK
- RAISED CONC. MEDIAN, CURB & GUTTER
- TRAIL
- TRUCK APRON
- PARCEL LINES

BOLTON & MENK

VIOLA RD AND CASSIDY DR
ROCHESTER, MINNESOTA

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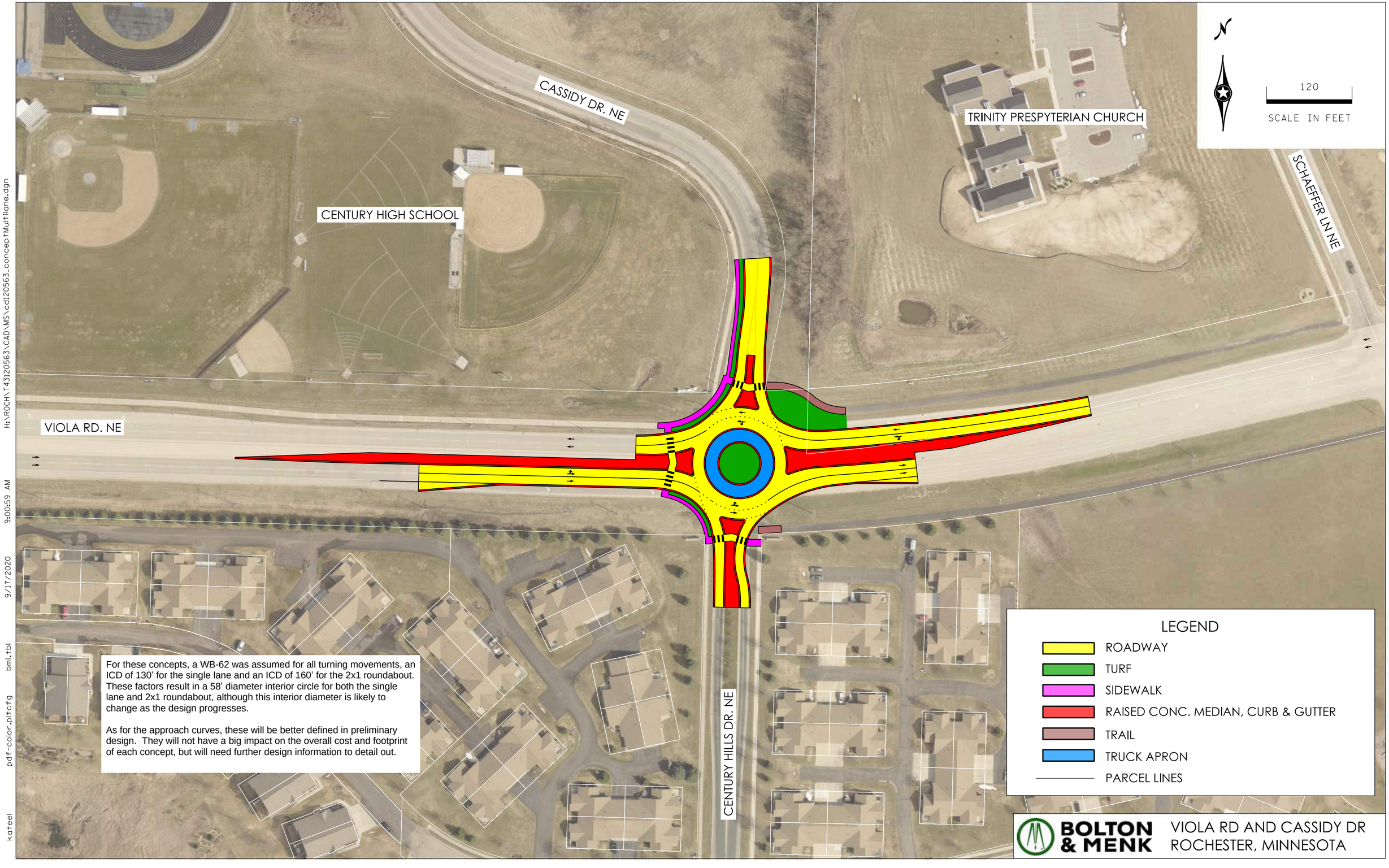
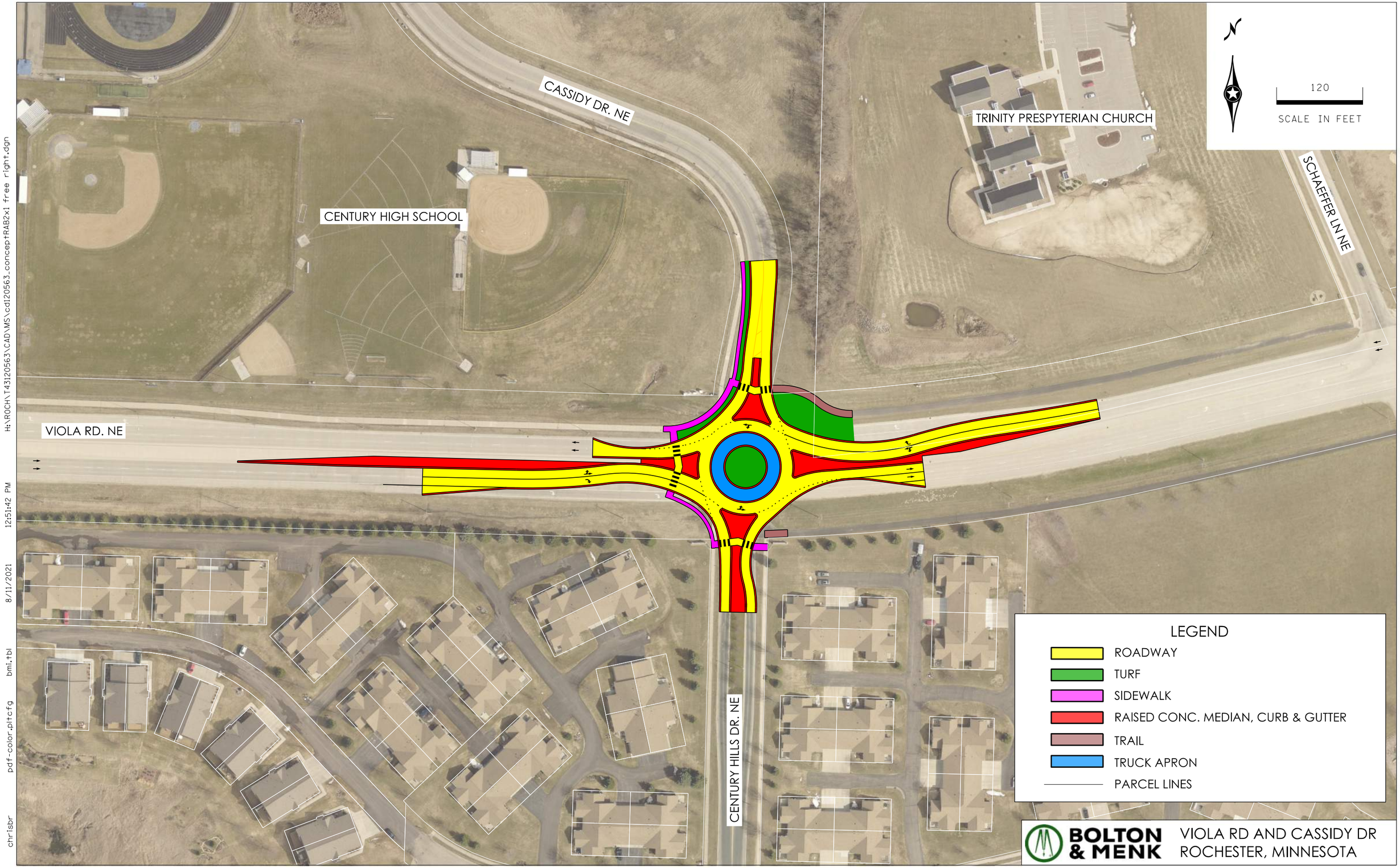


For these concepts, a WB-62 was assumed for all turning movements, an ICD of 130' for the single lane and an ICD of 160' for the 2x1 roundabout. These factors result in a 58' diameter interior circle for both the single lane and 2x1 roundabout, although this interior diameter is likely to change as the design progresses.

As for the approach curves, these will be better defined in preliminary design. They will not have a big impact on the overall cost and footprint of each concept, but will need further design information to detail out.

BOLTON & MENK

VIOLA RD AND CASSIDY DR
ROCHESTER, MINNESOTA



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Preliminary Design Opinion of Probable Cost

Viola Rd and Cassidy Dr - Signal Option

MNDOT

8/11/2021

Item		Unit	Total Qty	Unit Price	Total Cost
MAJOR ROADWAY AND TRAIL					
	TRAFFIC SIGNAL SYSTEM	LS	1	$ 250,000.00	$ 250,000
	4" SOLID LINE PAINT	LIN FT	500	$ 1.00	$ 500
	PAVEMENT MESSAGE PAINT	SF	580	$ 3.00	$ 1,700
	Subtotal				$ 252,200
PRECENTAGE ITEMS					
	MOBILIZATION	5%		of all	$ 12,600
	TRAFFIC CONTROL	5%		of all	$ 12,600
	CONTINGENCY FOR MISSING ITEMS	20%		of all	$ 50,400
	Subtotal				$ 79,000
				Construction Cost (2020 Dollars)	$ 331,200
				Anticipated Right-of-Way Cost (2020 Dollars)	$ -
				Engineering Cost (2020 Dollars)	$ 66,240
				Total Cost (2020 Dollars)	**$ 397,440**

Preliminary Design Opinion of Probable Cost

Viola Rd and Cassidy Dr - Single Lane Roundabout Option

MNDOT

7/16/2021

Item		Unit	Total Qty	Unit Price	Total Cost
MAJOR ROADWAY AND TRAIL (NOTE 1)					
	REMOVE BITUMINOUS PAVEMENT	SY	5,600	$ 6.00	$ 33,600
	REMOVE CONCRETE PAVEMENT	SY	11,000	$ 8.00	$ 88,000
	REMOVE CURB AND GUTTER	LIN FT	5,100	$ 5.00	$ 25,500
	EXCAVATION - COMMON	CY	4,970	$ 10.00	$ 49,700
	AGGREGATE BASE (CV) CLASS 5 (Roadway)	CY	2,000	$ 36.00	$ 72,000
	AGGREGATE BASE (CV) CLASS 5 (Trail)	CY	10	$ 36.00	$ 400
	SELECT GRANULAR EMBANKMENT (CV)	CY	2,330	$ 25.00	$ 58,300
	TYPE SP BITUMINOUS MIX (Roadway)	TON	570	$ 70.00	$ 39,900
	TYPE SP BITUMINOUS MIX (Trail/Driveway)	TON	20	$ 70.00	$ 1,400
	4" CONCRETE WALK/MEDIAN	SF	26,000	$ 11.00	$ 286,000
	6" CONCRETE WALK (Ped Ramps)	SF	790	$ 15.00	$ 11,900
	9" CONCRETE PAVEMENT	SY	5,700	$ 100.00	$ 570,000
	CURB AND GUTTER	LIN FT	6,600	$ 20.00	$ 132,000
	Subtotal				$ 1,369,000
OTHER ROADWAY ITEMS					
	DRAINAGE	LS	1	$ 274,000	$ 270,000
	LIGHTING	LS	1	$ 100,000	$ 100,000
	Subtotal				$ 370,000
PRECENTAGE ITEMS					
	MOBILIZATION	5%		of all	$ 87,000
	MISC REMOVALS (CURB, SIGNS, TREES, ETC.)	2%		of all	$ 34,800
	SIGNING & PAVEMENT MARKINGS	3%		of all	$ 52,200
	TRAFFIC CONTROL	5%		of all	$ 87,000
	CONTINGENCY FOR MISSING ITEMS	20%		of all	$ 347,800
	Subtotal				$ 609,000
				Construction Cost (2020 Dollars)	$ 2,348,000
				Anticipated Right-of-Way Cost (2020 Dollars)	$ -
				Engineering Cost (2020 Dollars)	$ 470,000
				Total Cost (2020 Dollars)	**$ 2,818,000**

Notes:

Preliminary Design Opinion of Probable Cost

Viola Rd and Cassidy Dr - 2x1 Roundabout Option

MNDOT

7/16/2021

Item		Unit	Total Qty	Unit Price	Total Cost
MAJOR ROADWAY AND TRAIL (NOTE 1)					
	REMOVE BITUMINOUS PAVEMENT	SY	2,900	$ 6.00	$ 17,400
	REMOVE CONCRETE PAVEMENT	SY	5,800	$ 8.00	$ 46,400
	REMOVE CURB AND GUTTER	LIN FT	2,900	$ 5.00	$ 14,500
	EXCAVATION - COMMON	CY	4,080	$ 10.00	$ 40,800
	AGGREGATE BASE (CV) CLASS 5 (Roadway)	CY	1,700	$ 36.00	$ 61,200
	AGGREGATE BASE (CV) CLASS 5 (Trail)	CY	40	$ 36.00	$ 1,400
	SELECT GRANULAR EMBANKMENT (CV)	CY	1,910	$ 25.00	$ 47,800
	TYPE SP BITUMINOUS MIX (Roadway)	TON	550	$ 70.00	$ 38,500
	TYPE SP BITUMINOUS MIX (Trail/Driveway)	TON	20	$ 70.00	$ 1,400
	4" CONCRETE WALK/MEDIAN	SF	19,100	$ 11.00	$ 210,100
	6" CONCRETE WALK (Ped Ramps)	SF	870	$ 15.00	$ 13,100
	9" CONCRETE PAVEMENT	SY	4,400	$ 100.00	$ 440,000
	CURB AND GUTTER	LIN FT	5,300	$ 20.00	$ 106,000
	Subtotal				$ 1,039,000
OTHER ROADWAY ITEMS					
	DRAINAGE	LS	1	$ 208,000	$ 210,000
	LIGHTING	LS	1	$ 100,000	$ 100,000
	Subtotal				$ 310,000
PRECENTAGE ITEMS					
	MOBILIZATION	5%		of all	$ 67,500
	MISC REMOVALS (CURB, SIGNS, TREES, ETC.)	2%		of all	$ 27,000
	SIGNING & PAVEMENT MARKINGS	3%		of all	$ 40,500
	TRAFFIC CONTROL	5%		of all	$ 67,500
	CONTINGENCY FOR MISSING ITEMS	20%		of all	$ 269,800
	Subtotal				$ 472,000
				Construction Cost (2020 Dollars)	$ 1,821,000
				Anticipated Right-of-Way Cost (2020 Dollars)	$ -
				Engineering Cost (2020 Dollars)	$ 364,000
				Total Cost (2020 Dollars)	**$ 2,185,000**

Notes:

Preliminary Design Opinion of Probable Cost

Viola Rd and Cassidy Dr - 2x1 Free Right Roundabout Option

MNDOT

8/11/2021

	Item	Unit	Total Qty	Unit Price	Total Cost
MAJOR ROADWAY AND TRAIL (NOTE 1)					
	REMOVE BITUMINOUS PAVEMENT	SY	2,900	$ 6.00	$ 17,400
	REMOVE CONCRETE PAVEMENT	SY	5,800	$ 8.00	$ 46,400
	REMOVE CURB AND GUTTER	LIN FT	3,000	$ 5.00	$ 15,000
	EXCAVATION - COMMON	CY	3,900	$ 10.00	$ 39,000
	AGGREGATE BASE (CV) CLASS 5 (Roadway)	CY	1,600	$ 36.00	$ 57,600
	AGGREGATE BASE (CV) CLASS 5 (Trail)	CY	40	$ 36.00	$ 1,400
	SELECT GRANULAR EMBANKMENT (CV)	CY	1,820	$ 25.00	$ 45,500
	TYPE SP BITUMINOUS MIX (Roadway)	TON	600	$ 70.00	$ 42,000
	TYPE SP BITUMINOUS MIX (Trail/Driveway)	TON	20	$ 70.00	$ 1,400
	4" CONCRETE WALK/MEDIAN	SF	19,000	$ 11.00	$ 209,000
	6" CONCRETE WALK (Ped Ramps)	SF	870	$ 15.00	$ 13,100
	9" CONCRETE PAVEMENT	SY	4,100	$ 100.00	$ 410,000
	CURB AND GUTTER	LIN FT	5,300	$ 20.00	$ 106,000
	Subtotal				$ 1,004,000
OTHER ROADWAY ITEMS					
	DRAINAGE	LS	1	$ 201,000	$ 200,000
	LIGHTING	LS	1	$ 100,000	$ 100,000
	Subtotal				$ 300,000
PRECENTAGE ITEMS					
	MOBILIZATION	5%		of all	$ 65,200
	MISC REMOVALS (CURB, SIGNS, TREES, ETC.)	2%		of all	$ 26,100
	SIGNING & PAVEMENT MARKINGS	3%		of all	$ 39,100
	TRAFFIC CONTROL	5%		of all	$ 65,200
	CONTINGENCY FOR MISSING ITEMS	20%		of all	$ 260,800
	Subtotal				$ 456,000
				Construction Cost (2020 Dollars)	$ 1,760,000
				Anticipated Right-of-Way Cost (2020 Dollars)	$ -
				Engineering Cost (2020 Dollars)	$ 352,000
				Total Cost (2020 Dollars)	**$ 2,112,000**