AGENDA ITEM #5.1

REPORT TO CITY COUNCIL

Report Prepared by: Nancy Malecha

Date: February 5, 2019

Subject: Highway 371/County Road 29 Intersection Update

Report: At the November 14, 2018 City Council Meeting, the Council heard from concerned citizens regarding safety concerns at the Highway 371/County Road 29 intersection. The Council requested that MnDOT look into this issue further and report back. Attached is the updated Intersection Evaluation Report from MnDOT. Ken Hansen from MnDOT will be present at the Council Meeting to review and discuss this with the Council.

Council Action Requested: Council discussion with MnDOT representatives regarding the Highway 371/County Road 29 Intersection Evaluation Report.

DEPARTMENT OF TRANSPORTATION

TH 371 at Crow Wing CSAH 29

Intersection Evaluation

1/7/2019

Contents

Location

The junction of Minnesota Trunk Highway (TH) 371 at Crow Wing County State Aid Highway (CSAH) 29/Wilderness Road is located in the City of Pequot Lakes, MN. The roadway is a four-lane expressway with an Average Annual Daily Traffic (AADT) of 10,700 and a Heavy Commercial Average Annual Daily Traffic (HCAAT) of 660. The speed limit on TH 371 at this intersection is 65 miles per hour and the speed limit on CSAH 29 and Wilderness Road is statutory 55 miles per hour. Prior to 2016-2017, TH 371 was a conventional two-lane two-way roadway.

Existing Conditions

The intersection of TH 371of CSAH 29/Wilderness Road was reconstructed with SP 1810-92 which expanded the roadway to the current four-lane expressway. This project was a Design-Build project with the construction done by Mathiowetz Construction Company and the highway design by WSB & Associates.

TH 371 is on a curve at CSAH 29/Wilderness due to the presence of West Twin Lake, Lake Edna, Lower Cullen Lake, and a wetland area in the southeast quadrant of the intersection (see Figure 1). During preliminary design, there was discussion to remove/smooth out part of this curve by constructing the new TH 371 alignment over the wetland area. The wetland impact was found to be too great and ultimately the roadway was to remain and expand on the previous alignment.

Figure 1: TH 371 alignment at CSAH 29/Wilderness Rd

To accommodate the additional lanes on TH 371, the Paul Bunyan Trail needed to be relocated further to the east. A pedestrian bridge needed to be built for this relocation rather than an at-grade trail to mitigate impacts to the wetland.

Standard rural intersection highway lighting was added to SP 1810-92 to replace aging wood pole mounted lighting previously installed.

Figure 2 shows the design plan overlaying the satellite overhead view. The intersection is more clearly shown in an excerpt from the Release for Construction (RFC) in the Appendix.

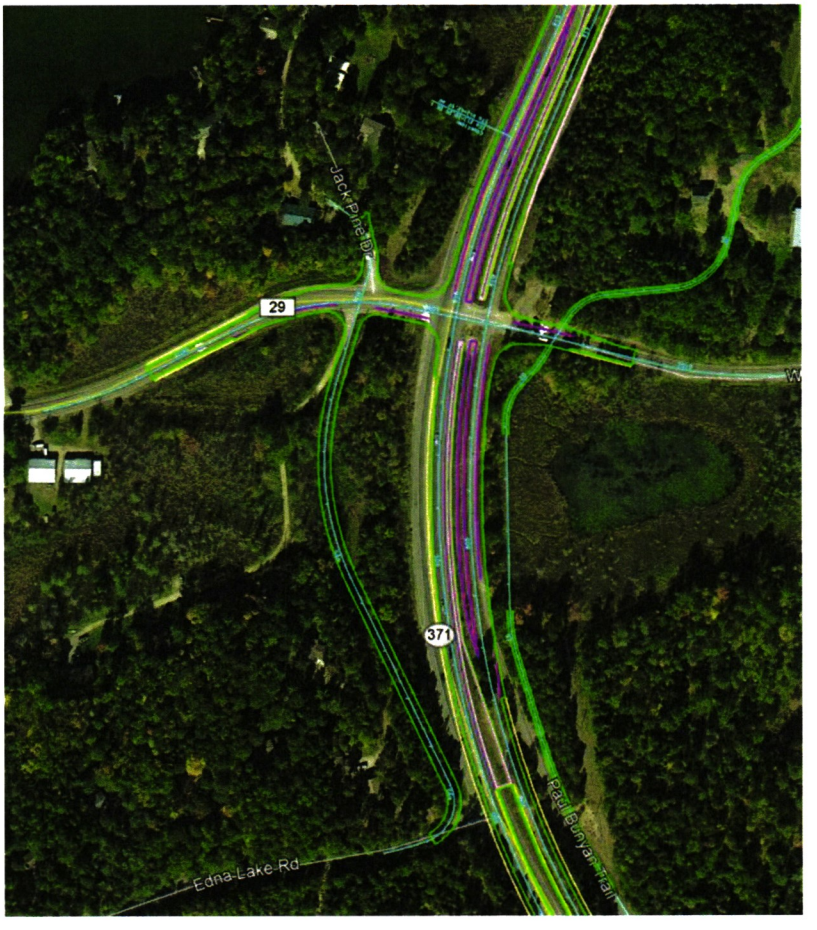


Figure 2: Design plan overlay of the intersection of TH 371 at CSAH 29/Wilderness Rd

Crash Analysis

TH 371 at CSAH 29/Wilderness Rd was reconstructed in 2016. The geometry at the intersection was changed significantly so that crash data prior to 2016 is not representative to the intersection's current state. Crash data during the construction year of 2016 is also is not representative of the intersection's final geometry. For this crash analysis, the period between January 2017 and September 2018 was used.

Note, three, five, and ten years of crash data is used to form a statistical analysis. A three year study is typically used as a minimum for reliable data. This study uses 1.75 years of data which shows trends in the crash data however may skew the crash rate higher or lower than it may actually be.

Between January 2017 and September 2018, there have been seven total crashes at the intersection but only two that could be directly attributed to the intersection. The other five included run off the road crashes more related to the curve on TH 371 as well as a deer-vehicle crash. Neither of these 2 intersection related crashes resulted in a fatal or in-capacitating/serious injuries. A breakdown of the individual crashes is shown in the Appendix.

The total crash rate of this intersection is 0.27 crashes per million entering vehicles (MEV) which is slightly above the statewide average of 0.26 crashes per MEV. However this intersection is significantly below the critical crash rate of 0.81 crashes per MEV, which means that this intersection is operating within the expected range.

Proactive Risk Assessment

MnDOT has created a Proactive Risk Assessment for intersections and highway segments that are more "at-risk" for severe crashes that do not exceed the critical crash rate as a means of prioritizing safety improvement projects. A set of risk factors were identified based on common factors present at locations with fatal and serious injury crashes.

Risk factors (also called stars in the District and County Road Safety Plans) for rural four-lane expressway intersections include 1) skew of 10 degrees or more, 2) on/near a horizontal or vertical curve, 3) adjacent development, 4) previous stop sign on the minor approach is greater than 5 miles, 5) volume cross product (multiplication of the major and minor approach average entering ADT) is greater than 6M, 6) severe right angle density (fatal and incapacitating injury crashes per intersection per year) is greater than 0.022, 7) presence of a railroad crossing on the minor road.[1]

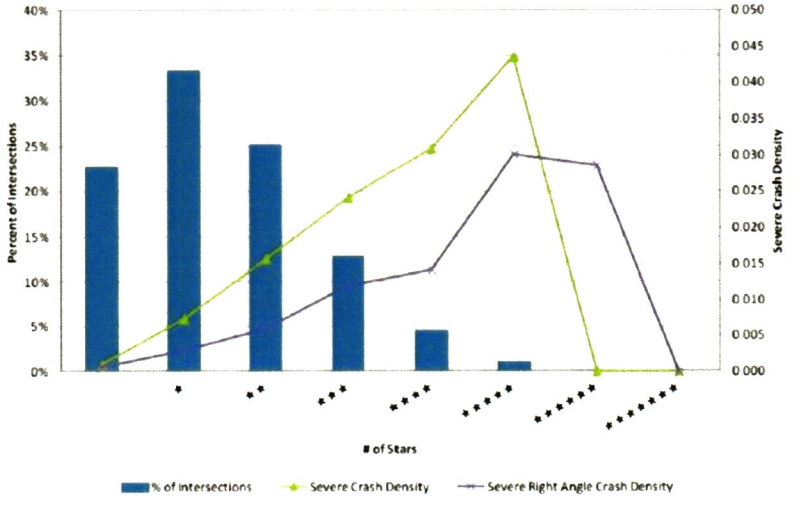


Figure 3: Severe Crash Densities for Rural Intersections – Statewide CRSP Data[1]

Figure 3 shows the relationship between the number of stars/risk factors and the severe crash density and severe right angle crash density. Intersection locations are considered for safety treatment when the star/risk factors are 4 star or greater.

Risk Factor	Intersection Characteristics		Meets Criteria
Skew of 10 Degrees	No		No
On/Near Curve	Yes		Yes
Adjacent Development	No		No
Distance from Previous Stop	CSAH 29	Wilderness	Yes
	7.5mi	2.6mi	
Volume Cross Product	8,827,500		Yes
Severe Right Angle Density	0.000		No
Railroad presence	No		No

Table 1: Proactive Risk Factors present at TH 371 at CSAH 29/Wilderness Rd.

As shown in Table 1, the intersection of TH 371 at CSAH 29/Wilderness Road exhibits 3 stars/risk factors.

Sight Distance

One of the common concerns brought forward from citizens was sight restriction at the intersection. The most common concern was regarding westbound (WB) Wilderness Rd looking to the south and the sight restriction with the Paul Bunyan Trail pedestrian bridge (Figure 4).

Figure 4: WB Wilderness Rd looking to the south

TH 371 Stopping Sight Distance

Stopping Sight Distance (SSD) is used for vehicles on TH 371 approaching the intersection with CSAH 29/Wilderness Rd. SSD is the distance traveled by a vehicle in the time it takes for a driver to perceive a conflict and for that vehicle to come to a stop under breaking.

Figure 5 shows the required stopping sight distance for a 65mph roadway (TH 371).

U.S. Customary				
Design speed (mph)	Perception / reaction distance (ft)	Braking distance (ft)	Stopping sight distance	
			Calculated (ft)	Design (ft)
30	110.3	86.4	196.7	200
35	128.6	117.6	246.2	250
40	147.0	153.6	300.6	305
45	164.4	194.6	359.8	360
50	183.8	240.0	423.8	425
55	202.1	290.3	492.4	495
60	220.5	345.5	566.0	570
65	238.9	405.5	644.4	645
70	257.3	470.3	727.6	730
75	275.6	539.9	815.5	820

Figure 5: Stopping Sight Distance on Level Terrain[2]

CSAH 29/Wilderness Rd. Decision Sight Distance

MnDOT's Road Design Manual contains Cases[3] regarding necessary sight distances a vehicle on the minor approach requires to make the decision to enter the intersection and perform a movement. Case IIIA refers to a vehicle crossing TH 371 from a stop, Case IIIB refers to a vehicle that is making a left turn from CSAH 29/Wilderness Rd onto TH 371 from a stop. Figure 6 shows the intersection of TH 371 at CSAH 29/Wilderness Rd with the widths of TH 371 used in the sight distance calculations.

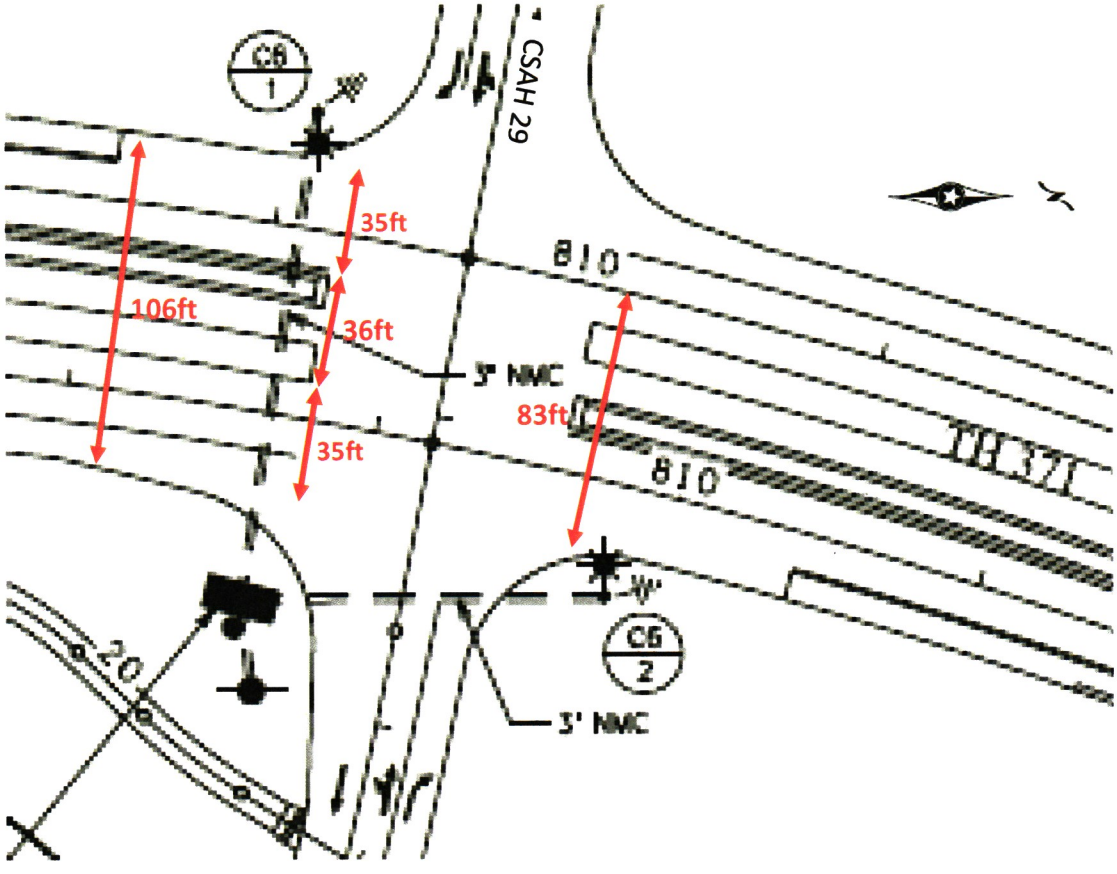


Figure 6: TH 371 Roadway Widths (W)

Sight distance is calculated using the following formula.

$$d = (velocity)(time) = 1.47V(J + t_a)$$

Where:
d = minimum sight distance along the major highway from the intersection (ft)
V = design speed on major highway (mph). Posted speed limit is 65mph
J = perception-reaction time (sec). MnDOT uses 2.0sec
t_a = time (sec) required to traverse distance S to clear the major highway pavement
S = D+W+L
D = distance from the near edge of the pavement to the front of the stopped vehicle (ft) MnDOT uses 10ft
W = width of the pavement along the path of the crossing vehicle (ft). See Figure 6.
L = Overall length of the vehicle (ft). MnDOT uses 30ft for passenger vehicle, 30ft for single unit truck, and 69ft for a WB-62 semi-truck

$$S = \frac{a}{2}(t_a)^2 + v_0(t_a) + D_0$$

a = acceleration of the vehicle from stop. Assumed at 3.8 (ft/sec^2)[4]
v_0 = initial velocity of the vehicle. Since vehicle is at rest, 0 (mph)
D_0 = initial distance at stop bar is considered 0 (ft)

Case IIIA – Crossing maneuver, Enabling a Stopping Vehicle to Cross a Major Highway

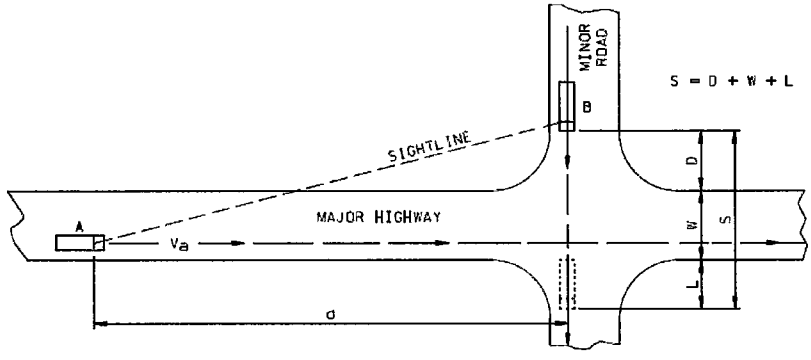


Figure 7: Sight Distance Diagram for Case IIIA

W = Full Pavement width = 106ft

S = D+W+L = 10ft+106ft+30ft = 146ft

$$S = \frac{a}{2}(t_a)^2 + v_0(t_a) + D_0 = \frac{3.8}{2}(t_a)^2 + 0t_a + 0 = 146ft$$

$$t_a = \sqrt{\frac{2}{3.8}(146)} = 8.77sec$$

$$d = 1.47V(J + t_a) = 1.47(65)(2.0 + 8.77) = 1029.1ft$$

Case IIIB – Turning Left onto a Major Highway, Enabling a Stopped Vehicle to Make a Left-Turn

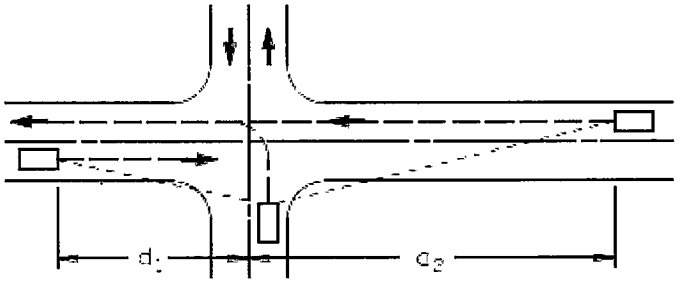


Figure 8: Sight Distance Diagram for Case IIIB

- Sight Distance for NB 371, d_1
  W = Pavement width from outside edge of shoulder to NB TH 371 left turn lane buffer = 35ft

  S = D+W+L = 10ft+35ft+30ft = 75ft

  $$S = \frac{a}{2}(t_a)^2 + v_0(t_a) + D_0 = \frac{3.8}{2}(t_a)^2 + 0t_a + 0 = 75ft$$

  $$t_a = \sqrt{\frac{2}{3.8}(75)} = 6.28sec$$

  $$d_1 = 1.47V(J + t_a) = 1.47(65)(2.0 + 6.28) = 791.2ft$$

- Sight Distance for SB 371, d_2
  W = Pavement width from outside edge of shoulder to SB TH 371 centerline between inside and outside through lanes = 83ft

  S = D+W+L = 10ft+83ft+30ft = 123ft

  $$S = \frac{a}{2}(t_a)^2 + v_0(t_a) + D_0 = \frac{3.8}{2}(t_a)^2 + 0t_a + 0 = 123ft$$

  $$t_a = \sqrt{\frac{2}{3.8}(123)} = 8.05sec$$

  $$d_2 = 1.47V(J + t_a) = 1.47(65)(2.0 + 8.05) = 960.3ft$$

Sight Distance Measurements

Sight distance was measured using a 12 inch diameter paddle 4 foot tall. The vehicle used to take was a 2016 Chevrolet Equinox with an eye height of 4.25 feet to account for the prevalence of SUV and pickup trucks in the area.

Measured sight distances are shown alongside the minimum calculated sight distance for TH 371 in Table 2 and both CSAH 29 and Wilderness Rd in Table 3.

	NB TH 371			SB TH 371	
	Minimum	Measured		Minimum	Measured
SSD (ft)	645	800		645	1500

Table 2: Minimum SSD and field measured SSD

	Wilderness Rd (WB)			CSAH 29 (EB)	
	Minimum	Measured		Minimum	Measured
d (ft)	1029.1	1050		1029.1	1075
d1 (ft)	791.2	800		791.2	1500
d2 (ft)	960.3	1050		960.3	1075

Table 3: Minimum calculated decision sight distance and field measured decision sight distance

The intersection of TH 371 at CSAH 29/Wilderness road meets SSD and decision sight distance.

The Paul Bunyan pedestrian bridge does create a blind spot for both NB TH 371 drivers and WB Wilderness Road drivers in two locations. The blind spot occurs when NB TH 371 vehicles are 500-570ft from the intersection and 660-760ft from the intersection. At the posted speed limit, these blind spots equate to 1.05 sec and 0.73 sec respectively. Both are shorter duration than the perception-reaction time of 2.0 seconds.

Gap Analysis

The sight restriction from CSAH 29/Wilderness Rd. was measured by the time period (gap) between seeing an approaching vehicle and that vehicle entering the intersection. Drivers select an acceptable gap in which to cross the roadway. Research shows the 50th percentile gap selection (gap at which 50 percent of drivers will accept and enter the intersection) is 6.5 seconds and 85th percentile gap selection is 8.25 seconds[5].

Gap data was collected from TH 371 at CSAH 29/Wilderness Rd in four different locations (see Figure 9). The referenced locations in the figure correspond with the Gap Collection Locations shown in Table 3. The minimum observed gap (8.19 seconds) and smallest average observed gap (10.02 seconds) occurred for eastbound CSAH 29 looking to the north for southbound TH 371 vehicles (Location 1). Location 3, westbound Wilderness Rd looking to the south for northbound TH 371 vehicles, was the location of most concern which had a minimum observed gap of 9.60 seconds and an average observed gap of 11.18 seconds.

Note that the gap at Location 3 was taken from the first sight of an approaching vehicle to the intersection. The pedestrian bridge did block the view of an approaching vehicle as noted in the Sight Distance section of this report.

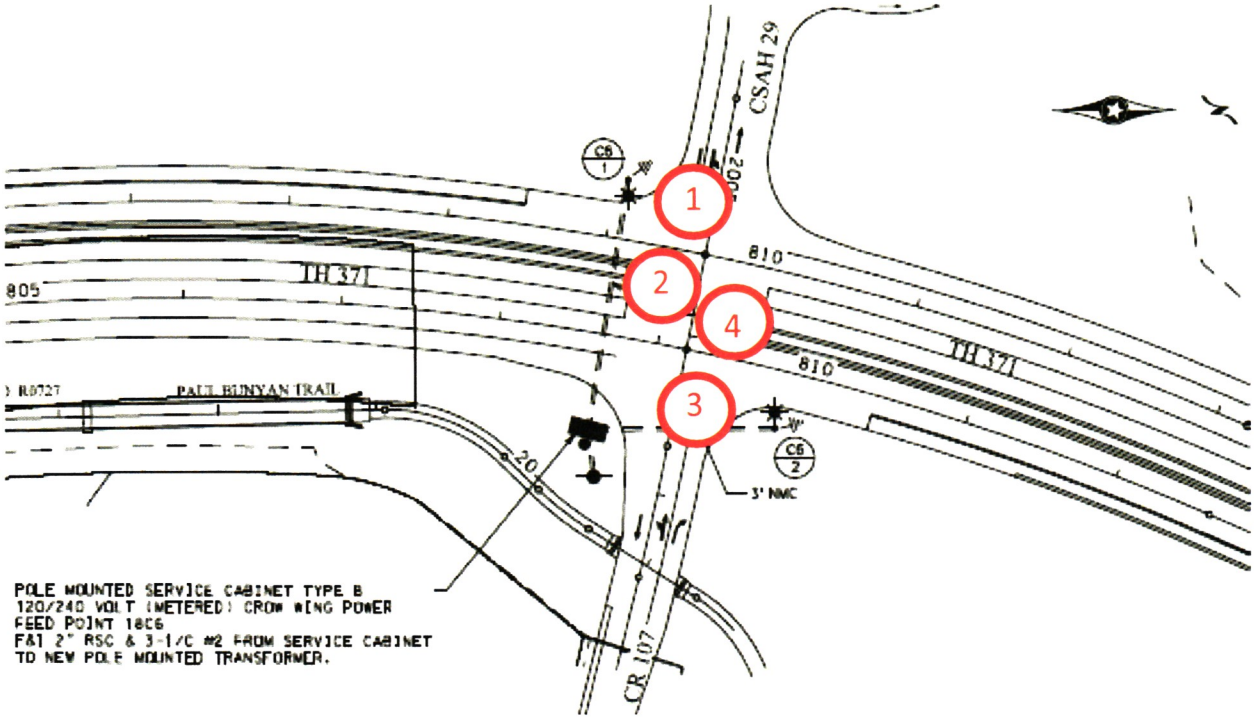


Figure 9: Plan Sheet with Gap Collection Locations

		Gap (seconds)			
Gap Collection Location	Description	Min	Max	Average	Standard Deviation
1	EB CSAH 29 looking North for SB TH 371	8.19	12.20	10.02	0.92
1	EB CSAH 29 looking South for NB TH 371	13.00	16.97	15.20	1.01
2	EB CSAH 29 looking South from median for NB TH 371	10.37	12.07	11.25	0.67
3	WB Wilderness looking South for NB TH 371	9.60	12.54	11.18	0.87
3	WB Wilderness looking North for SB TH 371	12.66	15.47	13.73	0.98
4	WB Wilderness looking North from Median for SB TH 371	12.92	14.64	13.73	0.66

Table 3: Measured Gaps in Traffic

Pedestrians

Pedestrians were considered in the pre-design process for SP 1810-92. MnDOT's Traffic Engineering Manual (TEM) gives guidance and recommendations to pedestrian facility treatments (shown in the Appendix).

- The Unsignalized Marked Crosswalk Installation Flowchart shows "No Action" required due to low pedestrian volumes at this intersection.
- Table 13-1 Pedestrian Facility Treatments show Treatment "D. Do not install marked crosswalk" based on TH 371 roadway configuration, volume, and design speed.

The rural expressway nature of the intersection, the super-elevation (banking necessary for vehicles to drive the curve at the design speed), and the very low volume of pedestrians weighed into the decision not to include pedestrian ramps at the intersection. This decision was validated during the volumetric data collection period, as only one pedestrian was observed.

The roadway features a small median of six feet from front of curb to front of curb due to geometric constraints. While not designed originally for pedestrians, the median does meet the minimum acceptable median width to provide pedestrian refuge.

Speed Limit

The section of TH 371 between Nisswa and Jenkins was set to a 65 miles per hour speed limit following completion of SP 1810-92 based on MN Statue 169.14 Subd. 2. (2) for non-interstate expressways.

A speed study will be conducted on TH 371 to verify 65 miles per hour is the appropriate speed limit.

Analysis of Alternatives

Traffic Signal

A traffic signal warrant analysis was conducted and shown in the Appendix. The analysis concluded that a signal system is not warranted due to the low volumes on CSAH 29 and Wilderness Road.

Further analysis of the roadway geometry suggests this location is a poor location for a traffic signal. The intersection is on a curve in super-elevation on TH 371. Stopped traffic on TH 371, due to a signal, would not be expected nor have good visibility which would lead to high speed rear end crashes and an increase in fatal and/or serious injuries.

Roundabout

Roundabouts can be used where volumes meet all-way STOP or signal warrants however work best when the entering roadways have similar volumes. Since CSAH 29 and Wilderness Road have much lower volumes than TH 371, a roundabout would cause significant delay to the intersection.

Similar to the concern for a traffic signal, the slow moving or even stopped traffic on TH 371 due to a roundabout would lead to high speed rear end crashes.

Reduced Conflict Intersection (RCI)

There are currently no warrants available for the analysis of RCI intersections. To date RCI intersections have been installed at location were safety has been a concern especially where cross street traffic has difficulty entering or crossing the major roadway.

RCIs can allow left turning traffic from the major road however if the mainline left turning traffic is low, the median can be closed entirely. Left turning vehicles without a median opening would use the turnaround areas. This configuration is being planned for TH 169 at Mille Lacs CSAH 12 and 13.

MnDOT is using RCIs as a corridor approach to safety on TH 371. Currently RCIs have been installed on TH 371 at both north and south Patriot Ave intersections in Pequot Lakes. RCIs are currently planned for installation on TH 371 at Crow Wing CSAH 125 (Gull Dam Rd) and 126 (Green Gables Rd). RCI would be a good safety strategy for this intersection.

Two-way Stop Controlled

Two-way Stop Controlled is the intersection of TH 371 at CSAH 29/Wilderness Rd's current configuration. The current crash rate is below the critical rate. There has not been a fatal or incapacitating/serious injury crash at this intersection.

Recommendations

Short Term (present – 5yrs)

Continue to operate as a Two-way Stop Controlled intersection. Crashes will be monitored; if the crash rate reaches the critical crash rate, a long term safety improvement can be implemented in an accelerated manner.

Pedestrian ramps and a cut through of the existing six foot median could be planned.

A speed study will been conducted on TH 371 between Nisswa and Pequot Lakes.

Mid/Long Term (5-20yrs)

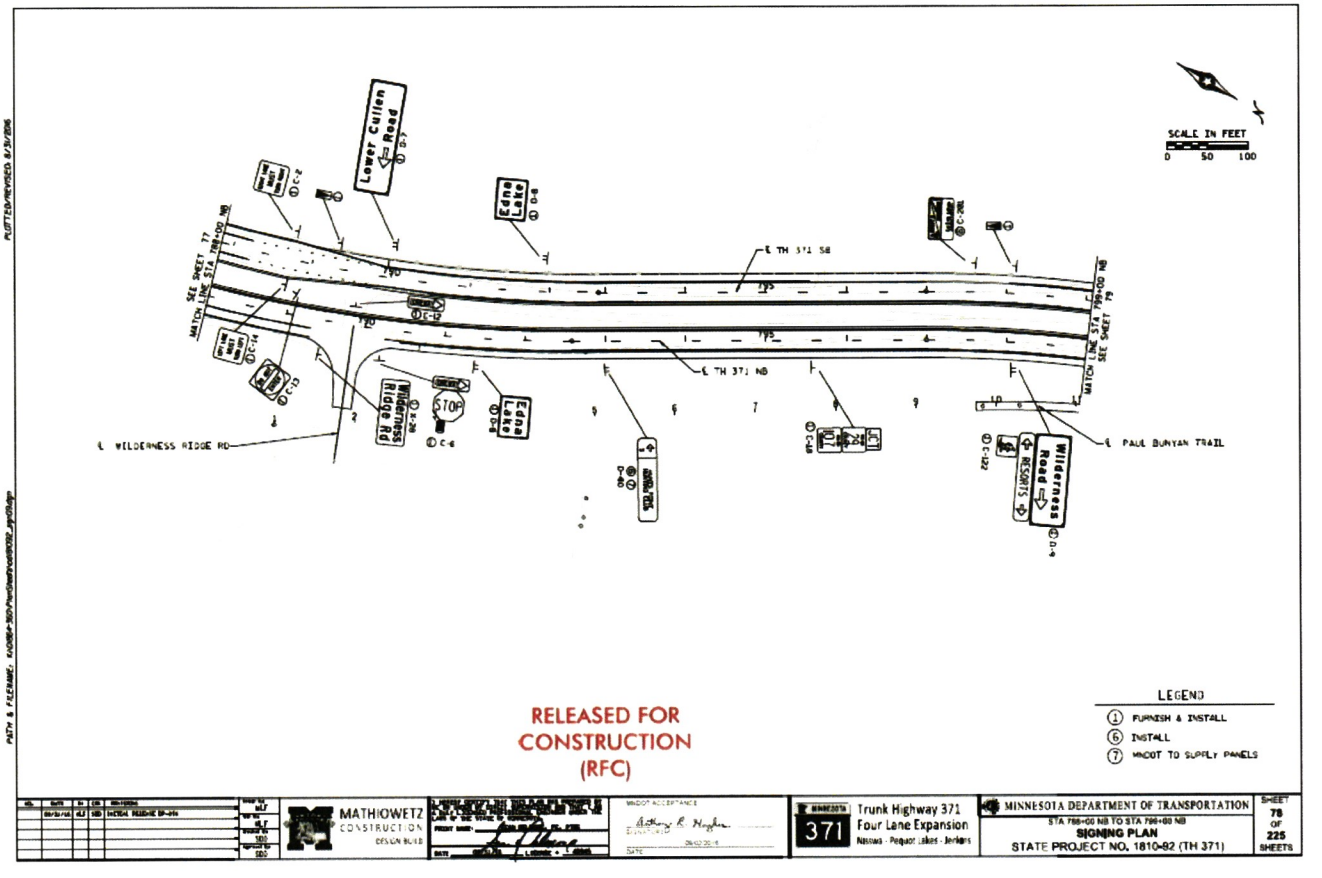
Convert the intersection to a RCI. Since this intersection was reconstructed in 2016, a project likely wont be planned until the pavement needs rehabilitation which could be in 20 years.

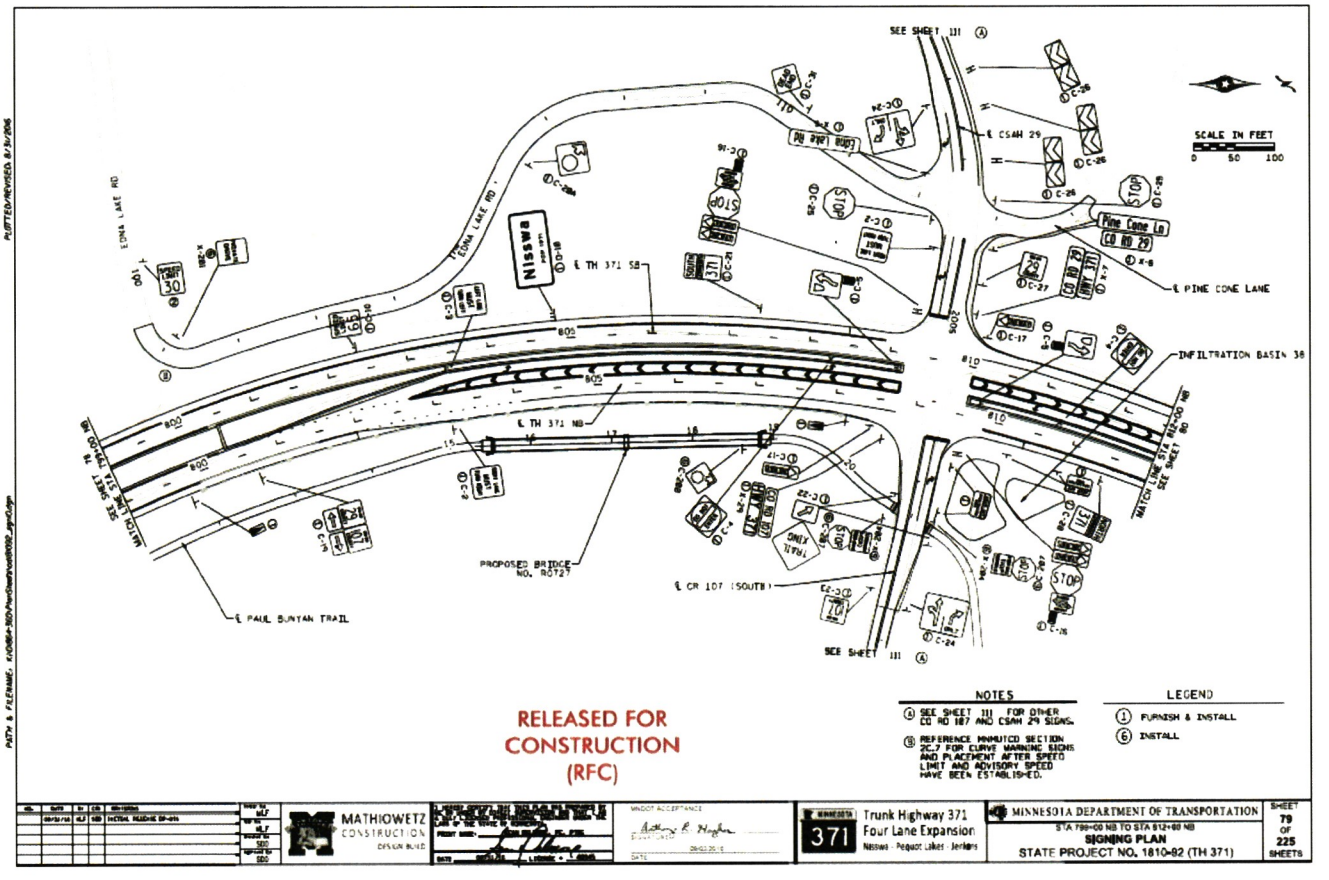
If safety needs require immediate action/treatment, the median can be closed completely and turn arounds can utilize Lower Cullen Rd (2600ft south) and Olson Rd (6100ft north) with added signing.

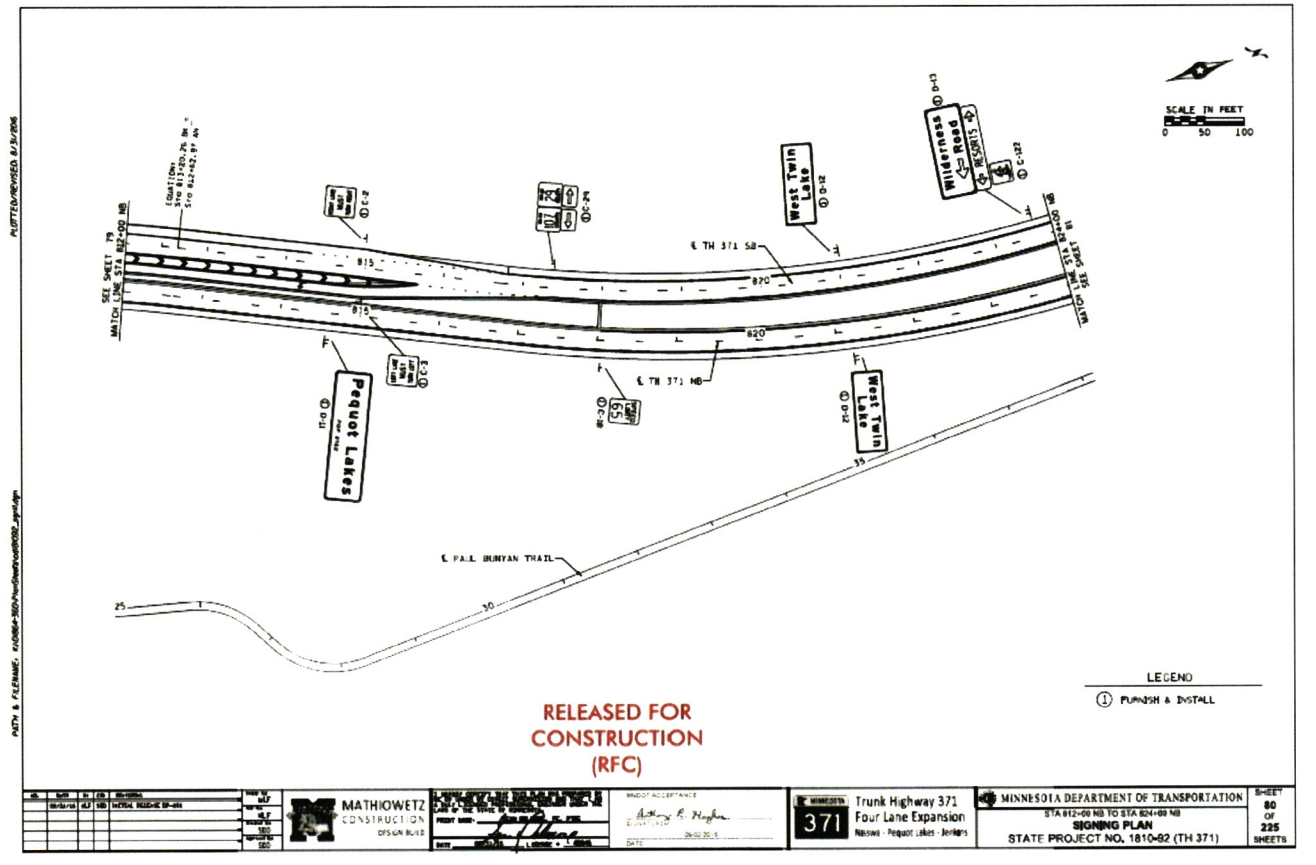
Future planned RCI would identify if the median left turns from TH 371 should be closed or open based on traffic volumes. Turn arounds are typically planned for roughly 800-1000ft from the intersection – MnDOT Design and Geometrics will determine the exact location during preliminary design.

Appendices

SP 1810-92 Release for Construction Plan Excerpt




SEE SHEET 111 (A)
SCALE IN FEET
0 50 100
℄ CSAH 29
Pine Cone Ln
CO RD 29
℄ PINE CONE LANE
INFILTRATION BASIN 38
EDNA LAKE RD
℄ TH 371 SB
℄ TH 371 NB
PROPOSED BRIDGE NO. 80727
℄ CR 107 (SOUTH)
℄ PAUL BUNYAN TRAIL
MATCH LINE STA 812+00 NB SEE SHEET 80
MATCH LINE STA 799+00 NB SEE SHEET 78
SEE SHEET 111 (A)
RELEASED FOR CONSTRUCTION (RFC)
NOTES
(A) SEE SHEET 111 FOR OTHER CO RD 107 AND CSAH 29 SIGNS.
(B) REFERENCE MNMUTCD SECTION 2C.7 FOR CURVE WARNING SIGNS AND PLACEMENT AFTER SPEED LIMIT AND ADVISORY SPEED HAVE BEEN ESTABLISHED.
LEGEND
(1) FURNISH & INSTALL
(6) INSTALL
MATHIOWETZ CONSTRUCTION
371 Trunk Highway 371 Four Lane Expansion
Nisswa - Pequot Lakes - Jenkins
MINNESOTA DEPARTMENT OF TRANSPORTATION
STA 799+00 NB TO STA 812+60 NB
SIGNING PLAN
STATE PROJECT NO. 1810-82 (TH 371)
SHEET 79 OF 225 SHEETS


SCALE IN FEET
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West Twin Lake
Pequot Lakes
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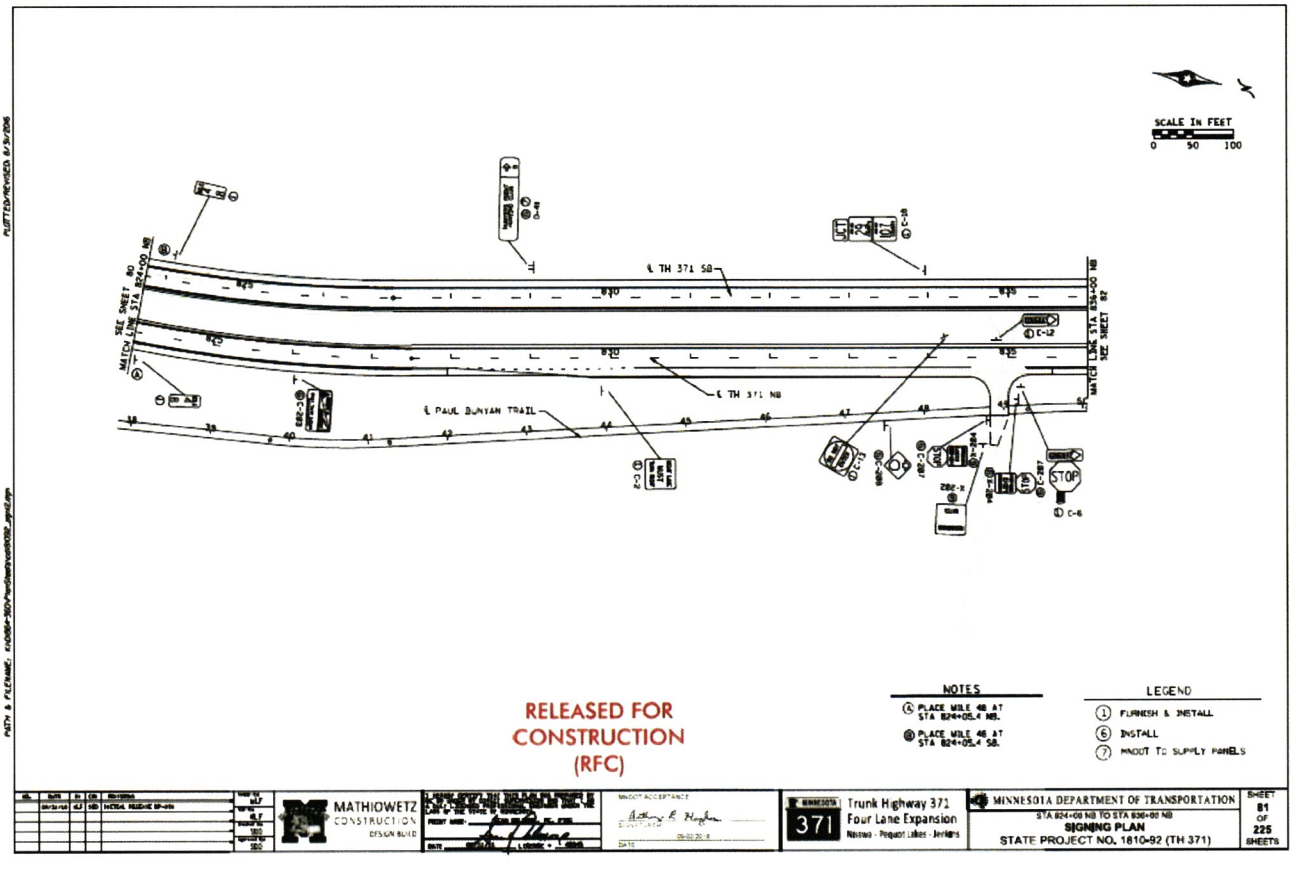
℄ PAUL BUNYAN TRAIL
LEGEND
① FURNISH & INSTALL
RELEASED FOR CONSTRUCTION (RFC)
MATHIOWETZ CONSTRUCTION
Trunk Highway 371
Four Lane Expansion
Nisswa - Pequot Lakes - Jenkins
MINNESOTA DEPARTMENT OF TRANSPORTATION
SIGNING PLAN
STATE PROJECT NO. 1810-82 (TH 371)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℄ TH 371 SB
℄ TH 371 NB
℄ PAUL BUNYAN TRAIL
STOP
RELEASED FOR CONSTRUCTION (RFC)
NOTES
LEGEND
MATHIOWETZ CONSTRUCTION
Trunk Highway 371 Four Lane Expansion
MINNESOTA DEPARTMENT OF TRANSPORTATION
SIGNING PLAN
STATE PROJECT NO. 1610-92 (TH 371)

Intersection Safety Screening

Intersection: TH 371 at Crow Wing CSAH 29/Wilderness Rd

Crash Data, Jan 2017- Sept 2018.

Crashes by Crash Severity	
Fatal	0
Incapacitating Injury	0
Non-incapacitating Injury	0
Possible Injury	1
Property Damage	1
Total Crashes	2

Intersection Characteristics	
Entering Volume	11,525
Traffic Control	Thru / stop
Environment	Rural
Speed Limit	65 mph

Annual crash cost = $51,771

Statewide Comparison *Rural Thru / Stop*

Total Crash Rate	
Observed	0.27
Statewide Average	0.26
Critical Rate	0.81
Critical Index	**0.33**

Fatal & Serious Injury Crash Rate	
Observed	0.00
Statewide Average	1.06
Critical Rate	12.72
Critical Index	**0.00**

The observed 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 the expected, normal range. The critical index reports the magnitude of this difference.

The observed total crash rate for this period is 0.27 per MEV; this is 67% below the critical rate. Based on similar statewide intersections, an additional 4 crashes over the three years would indicate this intersection operaters outside the normal range.

The observed fatal and serious injury crash rate for this period is 0.00 per 100 MEV; this is 100% below the critical rate. The intersection operates within the normal range.

Crash Data from January 2017 to September 2018

Local ID	Month	Day	Year	DayWk	Time	Severity	Diagram	Contributing Factor
17800318	2	10	2017	Friday	8:34	Property Damage Only	Right Angle	Failure to Yield Right of Way
18801009	6	10	2018	Sunday	14:47	Possible Injury Crash (C)	Sideswipe - Opposing	Failure to Yield Right of Way

Crashes in Proximity of the Intersection from January 2017 to September 2018*

Local ID	Month	Day	Year	DayWk	Time	Severity	Diagram	Contributing Factor
17802354	12	21	2017	Thursday	10:51	Property Damage Only	Run off Road	Medical Emergency
17802423	12	29	2017	Friday	10:51	Property Damage Only	Run off Road	Too Fast for Conditions
18800367	3	5	2018	Monday	15:53	Property Damage Only	Run off Road	Snowy Road
18006578	5	5	2018	Saturday	1:41	Property Damage Only	Other	Struck Deer
18801750	9	18	2018	Tuesday	16:32	Possible Injury Crash (C)	Run off Road	Medical Emergency

*Crashes not attributed to the intersection

Signal Warrant Analysis

LOCATION: TH371 & CR 29
COUNTY: Crow Wing
REF. POINT:
DATE: 10/18/2018
OPERATOR: Ken Hansen

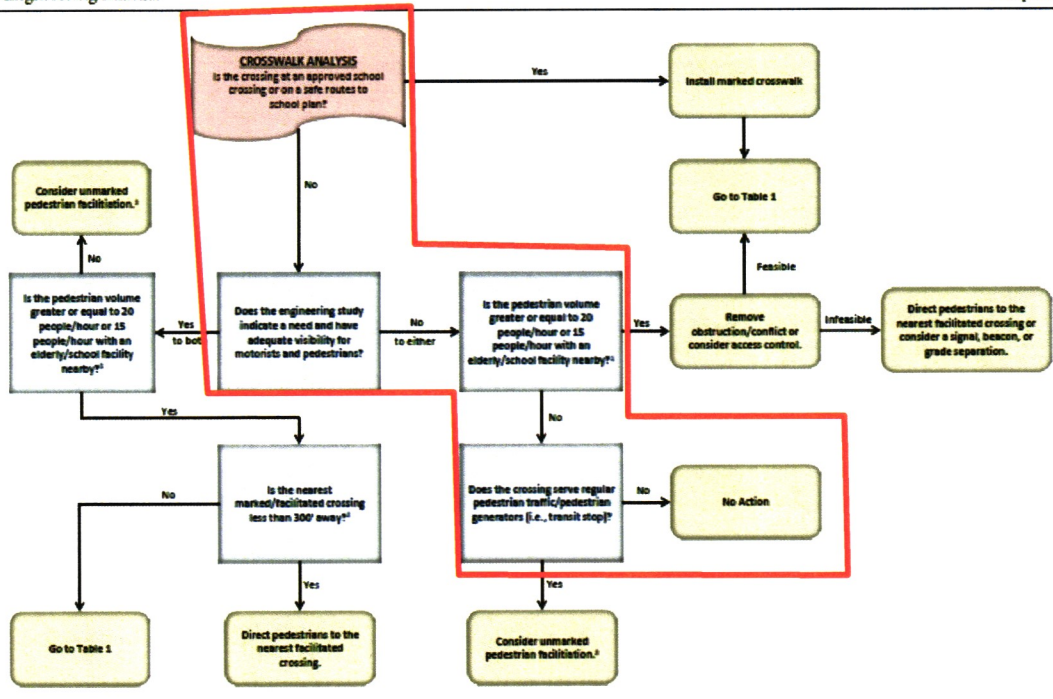
Speed	Approach Description		Lanes
65	Major App1:	TH 371 NB	2
65	Major App3:	TH 371 SB	2
55	Minor App2:	Wilderness Rd	1
55	Minor App4:	CR 29	1

0.70 FACTOR USED? YES
POPULATION < 10,000? No
EXISTING SIGNAL ? No
THRESHOLDS 1A/1B:

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			0						
1:00 - 2:00			0						
2:00 - 3:00			0						
3:00 - 4:00			0						
4:00 - 5:00			0						
5:00 - 6:00			0						
6:00 - 7:00	280	144	424	Y / -	10	- / -	13	- / -	- / -
7:00 - 8:00	456	276	732	Y / Y	14	- / -	32	- / -	- / -
8:00 - 9:00	408	318	726	Y / Y	23	- / -	23	- / -	- / -
9:00 - 10:00	412	298	710	Y / Y	10	- / -	20	- / -	- / -
10:00 - 11:00	503	230	733	Y / Y	14	- / -	14	- / -	- / -
11:00 - 12:00	427	266	693	Y / Y	13	- / -	17	- / -	- / -
12:00 - 13:00									
13:00 - 14:00	380	504	884	Y / Y	10	- / -	23	- / -	- / -
14:00 - 15:00	401	477	878	Y / Y	5	- / -	29	- / -	- / -
15:00 - 16:00	455	564	1019	Y / Y	4	- / -	20	- / -	- / -
16:00 - 17:00	397	570	967	Y / Y	9	- / -	39	- / -	- / -
17:00 - 18:00	360	606	966	Y / Y	11	- / -	39	- / -	- / -
18:00 - 19:00			0						
19:00 - 20:00			0						
20:00 - 21:00			0						
21:00 - 22:00			0						
22:00 - 23:00			0						
23:00 - 24:00			0						

	Met (Hr)	Required (Hr)	
Warrant 1A	0	8	Not satisfied
Warrant 1B	0	8	Not satisfied
Warrant 2	0	4	Not satisfied
Warrant 3	0	1	Not satisfied
Warrant 7		8	Not satisfied

Unsignalized Marked Crosswalk Installation Flowchart



Notes
1. Urban, suburban, and rural locations may vary in this classification. Urban may want to use locations that have higher volumes than the surrounding crossings. Rural locations may want to mark locations that have regular pedestrian crossings but may never meet the 20 pedestrians/hour minimum.
2. A reasonable walking distance is 660' in some suburban/rural applications, urban marked crossings should never be closer than 150'.
3. See the "Additional Treatment Considerations" section for more information.

November 2014	UNSIGNALIZED MARKED CROSSWALK INSTALLATION FLOWCHART	FIGURE 10

Pedestrian Facility Treatment

Table 13-1 Pedestrian Facility Treatments

Roadway Configuration[1,2]	Vehicle ADT ≤ 9000				Vehicle ADT > 9000 - 12,000				Vehicle ADT > 12,000 - 15,000				Vehicle ADT > 15,000			
	≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph
2 lanes (with or without a raised median)	A	A	B	D	A	A	B	D	A	A	C	D	A	B	C	D
3 lanes with raised median	A	A	C	D	A	B	C	D	A	C	C	D	B	C	C	D
3 lanes without raised median	A	B	C	D	A	B	C	D	B	B	C	D	B	C	C	D
Multilane (4 or more lanes) with raised median[2]	A	A	C	D	A	B	C	D	A	B	C	D	C	C	C	D
Multilane (4 or more lanes) without raised median[3]	A	C	C	D	B	C	C	D	C	C	C	D	C	C	C	D

Treatment Descriptions:

A. Consider marked crosswalk and signs

Guidance: Consider installing marked crosswalk with advance warning signs (W11-2); use S1-1 signs for school crossings. Consider in-roadway (R1-6) or overhead (R1-9b) signs.

B. Consider marked crosswalk with enhanced signs (R1-6 or R1-9b) and/or geometric improvements

Guidance: Consider installing treatment options from Type A treatments. Add curb extensions or median refuge islands.

C. Consider marked crosswalk with signs, geometric improvements, and pedestrian activated warning devices[4]

Guidance: Consider installing a raised median refuge island if one is not present. Consider installing marked crosswalk and appropriate crossing signs along with a pedestrian activated

D. Do not install marked crosswalk. [5]

Guidance: Consider pedestrian hybrid beacon, pedestrian traffic signal, or grade separated crossing.

Specific Notes:

1. Advanced stop lines and signing (R1-5b or c) should be used whenever possible if a multiple threat crash issue is present. Overhead signing, RRFBs or other overhead treatments should be used to mitigate multiple threat crash risks.
2. Do not install a marked crosswalk where there are 3 or more through lanes per direction. Consider a pedestrian hybrid beacon, pedestrian traffic signal, or grade separated crossing.
3. Traffic calming measures should be considered to reduce speed.
4. If a median cannot be or is not currently installed go to Treatment Type D.
5. Minimum acceptable median width to provide a refuge is 6 feet.

General Notes:

1. Adding crosswalks alone will not make crossings safer, result in more vehicles stopping for pedestrians, nor will they necessarily create a false sense of security.
2. Crosswalks have not been proven to create a false sense of security - research shows that pedestrians scan the road more at marked crosswalks.
3. Whether a crosswalk is marked or not, additional crossing enhancements should be considered. See the "Additional Treatment Considerations" section.
4. See MUTCD Section 3B.18 for additional guidance on using this table.
5. Lanes are total cross section.

References

1. CH2M HILL Safety Team. "MnDOT District Safety Plans – District 3 Evaluation Plan". September 17, 2015. Minnesota Department of Transportation. pp. 20, 27.
2. *Road Design Manual.* Chapter 2, Minnesota Department of Transportation, 1982.
3. *Road Design Manual.* Chapter 5, Minnesota Department of Transportation, 1982.
4. Wang et al. Normal Acceleration Behavior of Passenger Vehicles Starting from Rest at All-Way Stop-Controlled Intersections. *Transportation Research Record: Journal of the Transportation Research Board,* 1883(2004). pp. 158-166.
5. K. Fitzpatrick. Gap Accepted at Stop-Controlled Intersections. In *Transportation Research Record 1303,* TRB, National Research Council, Washington DC, 1991, pp. 103-112.