



STH 16

IXONIA, WISCONSIN

ROAD SAFETY AUDIT

FINAL REPORT

Prepared by:
Opus International Consultants
CH2M HILL



**WISCONSIN DEPARTMENT OF
TRANSPORTATION**

STH 16

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ROAD SAFETY AUDIT

DRAFT REPORT

CONTRACT:

TASK ORDER:

Prepared by:

Berna Sunman Sidal, P.E.
Transportation Engineer
CH2M HILL

Margaret Reed
Transportation Engineer
Opus International Consultants

Reviewed by:

Jeffrey S. Bagdade, P.E.
Vice President & Senior Transportation Engineer
Opus International Consultants Inc.

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1.0 INTRODUCTION

1.1 Background

STH 16 is a major east/west arterial located in Jefferson County, Wisconsin connecting residential agricultural and industrial areas that are located to the north of I-94. The audit section of the roadway is located in the Town of Ixonia between Oconomowoc and Watertown. It also serves as the primary connection between Watertown, Waukesha and the Milwaukee area. The area has experienced a high number of crashes recently, raising concerns regarding the safety and operation of the corridor. Several investigations have been initiated in the past evaluating this area, many of which have been site specific.

Opus International Consultants and CH2M HILL were retained by the Wisconsin Department of Transportation (WisDOT) to perform an operational stage road safety audit on the STH 16 corridor from Hilltop Road to the Oconomowoc Bypass. This report discusses the findings of the road safety audit.

1.2 Road Safety Audits

A Road Safety Audit (RSA) is a formal, independent and comprehensive safety performance review of an existing or future road or intersection by an independent RSA team. Road safety audits help to promote road safety by identifying safety issues at the design and implementation stages, promoting awareness of safe design practices, integrating multimodal safety concerns, and considering human factors through the life cycle of the project.

1.3 Reminder

The RSA team has conducted this audit to the best of its professional abilities within the time available and by referring to available information. While every attempt has been made to identify significant safety issues, WisDOT is reminded that responsibility for potential safety improvements that would be implemented for the study area remains with the engineers of record.

1.4 Audit Scope

The RSA examined the section of STH 16 between Hilltop Road and Oconomowoc Bypass, in the Town of Ixonia (shown in FIGURE 1). The Town of Ixonia is situated at the west end of the Oconomowoc Bypass, which is a high-speed facility with partial access control.



FIGURE 1 – Study Area Map

The study section of STH 16 is a two-lane undivided arterial with a rural cross section and roadside environment. FIGURE 2 presents an aerial map of the study area. The following seven unsignalized intersections along STH 16 were also reviewed as part of this study.

- Hilltop Road
- Marietta Avenue/ Highview Road
- Hawthorne Drive
- North Road

- CTH F
- River Valley Road
- Rock River Road



FIGURE 2 AERIAL PHOTO OF STUDY AREA

1.5 RSA Team and Process

The RSA Team and the project material on which the audit was based on are described below:

RSA Team Members: Jeff Bagdade, P.E. Opus International Consultants
Margaret Reed Opus International Consultants
Berna Sunman Sidal, P.E. CH2M HILL

Project Owner: Wisconsin DOT

Dates: March 25-27, 2008

Review Stage: Operational Stage (existing road)

Site Visit Conditions: Clear and dry conditions

Meetings Attended by: Town of Ixonia
Wisconsin Department of Transportation
Jefferson County Highway Department
Jefferson County Sheriff
Oconomowoc Area School District
General Public
Opus International Consultants
CH2M HILL

Project Documents Available for the Audit:

- Collision data for 2002 to 2006 and part of 2007 (2007 data for information only)
- Traffic volume data (2006 AADT) from the WisDOT and Jefferson County
- Traffic Impact Study for new developments in Town of Ixonia, conducted in 2006 by Traffic Engineering Services, Inc.
- Typical cross section and intersection details for STH 16 and CTH F
- Aerial photograph of site

Site visits were conducted on March 25-26, 2008 to gain an understanding of the existing conditions and surroundings and to identify safety concerns.

Road User Characteristics: STH 16 generally serves commuter, industrial and other local traffic. During site visits, traffic volumes were light during non-peak periods and moderate during commuter peak periods. Traffic patterns showed strong commuter trends with eastbound traffic heavier in the morning and westbound traffic heavier in the afternoon.

Township staff reported that traffic volumes are typically higher during morning (7:00 AM – 8:00 AM) and afternoon (3:00 PM – 4:00 PM) school arrival and dismissal periods when Ixonia Elementary School is in session (school was on spring break at the time of site visits). A substantial proportion of truck traffic was observed along the corridor, most of which appeared to be associated with businesses located at the Ixonia Industrial Park. Seasonal presence of grain trucks and tractors with trailers in the study area was reported. A few pedestrians and cyclists were also observed within the study area.



Different travel modes observed along STH 16

Based on year 2004 data, annual average daily traffic volume is 9600 along STH 16 and 3600 along CTH F.

Road and Roadside Physical Characteristics: STH 16 is an undivided arterial with one through lane in each direction. The length of the corridor is approximately three miles. All intersections in the study area are unsignalized (stop-control for the side roads) “Type C” or “Type D” intersections. CTH F is a modified Type B intersection with bypass lanes. Three foot paved and seven foot unpaved shoulders are provided along STH 16. Pipe culverts and ditches are utilized for mainline drainage. Side roads intersecting STH 16 generally exhibit rural roadside characteristics with unpaved shoulders and open drainage. The Canadian Pacific railroad runs parallel to STH 16 through Ixonia (on the south side of mainline).

A majority of STH 16 is on a horizontal curve through Ixonia. Vertical alignment is relatively flat; however sections near the Rock River bridge and Kanow Park riverside facilities feature some changes in topography.



Two-lane rural cross section on STH 16

Adjacent Network and Connectivity: STH 16 is a major east/west arterial connecting existing and planned residential areas in Ixonia to Oconomowoc to the east and Watertown to the west. Connecting roadways are mostly collector roads that provide access to commercial, agricultural and residential developments. CTH F is the main ingress and egress point into the business area of Ixonia and also serves as a primary connection between I-94 and STH 16.

Five new developments totaling 613 single family home lots and 45 acres of industrial development are planned within the Town of Ixonia. These developments are at different stages of construction and will have access from Town of Ixonia or Jefferson County roadways.

Other Observations: Posted speed limit on STH 16 is 55 miles per hour. North Road and CTH F have posted speeds of 30 miles per hour at the intersection areas (North Road has a School Zone 15 mph posted speed when school children are present). There are no marked pedestrian crossings or formal bicycle facilities present within the study area.



STH 16 and North Road intersection



STH 16 and CTH F intersection

Presence of high mounds near many of the intersections combined with horizontal curvature and skewed angles limit the sight distance to the intersections along the roadway.

RSA Process: A RSA framework was applied in both the analysis and presentation of findings. The expected frequency and severity of crashes caused by each safety issue have been identified and rated according to categories shown in TABLES 1 and 2. These two risk elements were then combined to obtain a risk assessment on the basis of the matrix shown in TABLE 3. Consequently, each safety issue is assessed on the basis of a ranking between F (highest risk and highest priority) and A (lowest risk and lowest priority). For each safety issue identified, possible mitigation measures have been suggested.

TABLE 1 – Frequency Rating

<i>Frequency Rating</i>	<i>Expected Crash Frequency (per audit item)</i>
<i>Frequent</i>	<i>10 or more crashes per year</i>
<i>Occasional</i>	<i>1 to 9 crashes per year</i>
<i>Infrequent</i>	<i>Less than 1 crash per year, but more than 1 crash every 10 years</i>
<i>Rare</i>	<i>Less than 1 crash every 10 years</i>

TABLE 2 – Severity Rating

Severity Rating	Expected Crash Severity	Typical Crashes Expected (per audit item)
<i>High</i>	<i>Probable fatality or severe (incapacitating) injury</i>	<i>Involve high speeds or heavy vehicles, pedestrians, or bicycles</i>
<i>High Moderate</i>	<i>Moderate to severe injury</i>	<i>Involve medium to high speed, head-on, crossing, or off-road crashes</i>
<i>Low Moderate</i>	<i>Minor to moderate injury</i>	<i>Involve medium to low speeds, left-turn and right-turn crashes</i>
<i>Low</i>	<i>Property damage only or minor injury</i>	<i>Involve low to medium speeds; rear-end or sideswipe crashes</i>

TABLE 3 – Crash Risk Assessment

Risk Category		Severity Rating			
		<i>Low</i>	<i>Low Moderate</i>	<i>High Moderate</i>	<i>High</i>
Frequency Rating	<i>Frequent</i>	<i>C</i>	<i>D</i>	<i>E</i>	<i>F</i>
	<i>Occasional</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>
	<i>Infrequent</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
	<i>Rare</i>	<i>A</i>	<i>A</i>	<i>B</i>	<i>C</i>

Crash Risk Ratings

<i>A</i>	<i>Lowest risk level</i>	<i>D</i>	<i>Moderate – High risk level</i>
<i>B</i>	<i>Low risk level</i>	<i>E</i>	<i>High risk level</i>
<i>C</i>	<i>Moderate – Low risk level</i>	<i>F</i>	<i>Highest risk level</i>

1.6 Overview of Collision History

Crash data and collision summary reports for 2002 through 2006 were provided by the Wisconsin DOT and the Town of Ixonia (available 2007 data was incomplete, therefore was not used for statistical analysis). Over these five years, 57 collisions were recorded in the study area. Two of the collisions (approximately 5% of total) resulted in fatalities. Approximately 15% of the collisions (7) resulted in incapacitating injury, 40% of the collisions (24) resulted in minor or moderate injuries and 40 % of the collisions (24) resulted in property damage only. Collision type distributions are summarized in Table 4.

Calculated crash rate for total crashes in the study area (averaged for 2002-2006) is 104 crashes/100 million vehicle-miles, which is comparable to the statewide average total crash rate of 114 crashes/100 million vehicle-miles (averaged for 2002-2006; deer crashes excluded). However, average crash rate for combined fatal and non-fatal injury crashes for the study area, 66 crashes/100 million vehicle-miles, is significantly higher than the statewide average of 46 crashes/100 million vehicle-miles for rural state trunk highways (averaged for 2002-2006).

TABLE 4 – Summary of Collision Types in Study Area

Location	Injury	Fatal	Right angle	Rear-end	Side-swipe	Head-on	Other (Fixed object, Non-collision, etc.)	TOTAL
Hilltop Rd	1	-	-	-	2	-	1	3
Marietta Ave/ Highview Rd	-	-	-	1	-	-	2	3
Hawthorne Dr	2	-	1	-	-	-	1	2
North Rd	8	1	6	1	3	-	5	15
CTH F	10	1	6	4	5	2	3	20
River Valley Rd	4	-	3	-	1	1	0	5
Rock River Rd	5	-	2	-	-	2	4	8
Other	1	-	-	1	-	-	-	1
TOTAL	31	2	18	7	11	5	16	57

A review of the collision types indicated the following trends:



- Right-angle collisions were the most prevalent collision type at the intersections (18 out of 57), accounting for 32% of all crashes.
- Fixed object and non-collision related incidents were the second most prevalent type (16 out of 57), accounting for 28% of all crashes. Run-of-road type crashes involving vehicles running into ditches, culverts, sign posts, bridge piers, etc. are included in this category.
- More than one third of all crashes occurred at the intersection of STH 16 and CTH F.
- STH 16 and North Road intersection was the second high in terms of crash frequency (26%).
- The two crashes which resulted in fatalities occurred at the CTH F and North Road intersections.
- There was one pedestrian crash that was recorded in the study area between 2002 and 2006. It occurred at CTH F intersection and resulted in a Type A injury.



2.0 RSA FINDINGS

2.1 Existing Safety Measures

Several safety measures detailed in TABLE 5 have already been implemented along STH 16 to improve safety.

TABLE 5 EXISTING SAFETY MEASURES

EXISTING SAFETY MEASURE	PHOTO
<p><i>Paved shoulders</i></p> <p>Three-foot paved shoulders (in addition to seven-foot aggregate shoulders) are provided along STH 16. Paved shoulders contribute to safety by a moderate reduction in crash frequency and a high reduction in crash severity due to the recovery room. Primarily, paved shoulders are beneficial to prevent run-of-road type crashes.</p>	
<p><i>Rumble strips</i></p> <p>Shoulder rumble strips are provided to the east of Rock River Road intersection, at the terminus of the Oconomowoc Bypass. Rumble strips add sound and vibration to the visual benefits of painted markings to alert drivers who have left the travel lane and entered the shoulder. Therefore, shoulder rumble strips reduce the likelihood of fixed object and run-off-road collisions.</p>	

EXISTING SAFETY MEASURE	PHOTO
<p><i>Lighting</i> Lighting is provided at STH 16 and CTH F. All other intersections have light poles illuminating the side road approaches. Lighting improves intersection conspicuousness, so that approaching drivers are more aware of the intersection and the potential for conflicting movements. Lighting also improves the visibility of other road users, including pedestrians and bicyclists, at night.</p>	
<p><i>Advance Street Name Signing</i> Advance street name signing is currently provided along STH 16 prior to CTH F and Rock River Road intersections. This signing provides additional guidance for unfamiliar and older drivers, and reduces the likelihood of sudden braking or evasive maneuvers near the intersection.</p>	
<p><i>Pavement markings and delineation</i> Pavement markings and flexible delineators along STH 16 appear to be in good condition, providing adequate retro-reflectivity. This results in an increased guidance for drivers particularly during nighttime hours.</p>	

2.2 RSA Findings

On the basis of the reviews summarized in Section 1.0, issues dealing with specific conditions observed during the site visit and RSA analysis were identified. In total, five issues were identified, which range from moderate-low risk rating to moderate-high risk rating. These five issues and suggested mitigation measures are described in detail below.

Issue 1: Intersection Sight Distance

During the site visits, high embankments/mounds were observed on both sides of STH 16 approaching the intersections at River Valley Road, North Road, Hilltop Road and Hawthorn Drive. These intersections also happen to be located on curved segments of STH 16. Presence of mounds combined with horizontal curvature and intersection skew obstruct the visibility at the intersections. Drivers making turns from side streets onto STH 16 may be forced to pull further up onto the mainline in order to get a better vision angle. Due to this limited visibility of the intersections, drivers traveling on STH 16 may not fully perceive that they are approaching an intersection. These factors may contribute to the angle and sideswipe conflicts at the intersections.



Expected Crash Types: crossing and turning collisions, sideswipe collisions

Expected Frequency: occasional

Expected Severity: high moderate

Risk Rating: D (moderate-high risk level)

Opportunities for Improvement:

- Consider additional grading for mounds in order to increase intersection sight distance and visibility. At the intersection of North Road and STH 16 (by Ixonia Elementary School) a retaining wall could be installed if cross section is not wide enough to provide room for additional grading.
- Consider providing enhanced lighting at the intersections, especially over the mainline approaches.
- Provide advance street name signs at the River Valley Road and North Road intersections.
- Consider upgrading existing street name signs to current standards. Existing signs display 4" letters with no retro reflectivity. 6" - 8" minimum letters on reflective background is recommended. Signs with larger font will be more conspicuous and easier for approaching drivers to read.
- Consider mowing /clearing of excessive vegetation on the mounds beyond the 10' strip recommended per WisDOT policy.

Issue 2: Lane Departure Crashes

Lane departure crashes involving fixed-objects are the second most prevalent type of crashes reported in the study area between 2002 and 2006 (accounting for 28% of all crashes). Some examples include vehicles running into ditches, culverts, sign posts and bridge piers. There were also a notable number of head-on collisions (5 out of 57) that had occurred within the study area. During the site visits, it was observed that paved shoulders that are currently provided on the mainline do not continue through the taper portion of the roadway at the intersections. It was also noted that rumble strips that are provided along the Oconomowoc Bypass terminate at the Rock River Road intersection and do not continue through the study area.



Paved shoulders not carried through taper sections at the intersections



Rumble strips terminate to the east of Rock River Road intersection

Expected Crash Types:	run-of-road crashes, head-on collisions, sideswipe (opposite direction) collisions
Expected Frequency:	occasional
Expected Severity:	high moderate
Risk Rating:	D (moderate-high risk level)

Opportunities for Improvement:

- Consider extending paved shoulders at the taper portions of STH 16 through the intersection areas.
- Consider extending shoulder rumble strips beyond the Rock River Road and River Valley Road intersections.
- Consider providing centerline rumble strips at the curved segments of STH 16 to prevent head-on crashes.
- Investigate opportunities for utilizing the “safety edge” as a shoulder treatment. The safety edge provides a bevel that cars can traverse, therefore helps errant vehicles to maintain stability, particularly on roadway re-entry.



Safety edge

Issue 3: Speed Related Crashes

The Town of Ixonia is situated at the west end of the Oconomowoc Bypass, a four-lane divided highway with posted speed of 55 miles per hour. As noted in Section 1.5, posted speed limit on STH 16 remains at 55 miles per hour through the study area. During site visits, speeds of about 55 to 60 mph were observed on STH 16. Law enforcement officials indicated that drivers exceeding the speed limit on the Bypass most likely continue onto STH 16 without reducing their speed. Due to proximity to the high-speed facility and presence of unsignalized intersections reducing the posted speed on this segment of STH 16 is unlikely to reduce the prevailing speeds.



STH 16 at Oconomowoc Bypass



Posted speed is 55 mph on STH 16

Expected Crash Types:	rear-end collisions, angle collisions
Expected Frequency:	occasional
Expected Severity:	moderate
Risk Rating:	C (moderate-low risk level)

Opportunities for Improvement:

- Opportunities for targeted speed enforcement could be considered.
- Consider installing permanent speed feedback signs for westbound STH 16 right after the Rock River Road intersection to capture drivers traveling with high speeds upon exiting the Oconomowoc Bypass.

Issue 4: Left Turns to/from STH 16

Vehicles approaching the intersections to make left turns may have limited sight visibility due to the intersection skew and high volumes of trucks. Due to limited visibility, drivers turning left may be braking when vehicles following are not expecting them to stop. Following vehicles, who are typically looking at the through traffic, may fail to see the vehicle in front stop suddenly, increasing the risk of rear-end conflicts. Drivers turning left may also be experiencing difficulty in judging the speed of oncoming vehicles, therefore choosing unsuitable gaps.



This issue specifically occurs at the intersection of STH 16 and CTH F, which displays the highest crash location on the study corridor. A schematic layout of STH 16 and CTH F is shown in FIGURE 3.



High volume of left turn movements observed at the intersection of STH 16 and CTH F

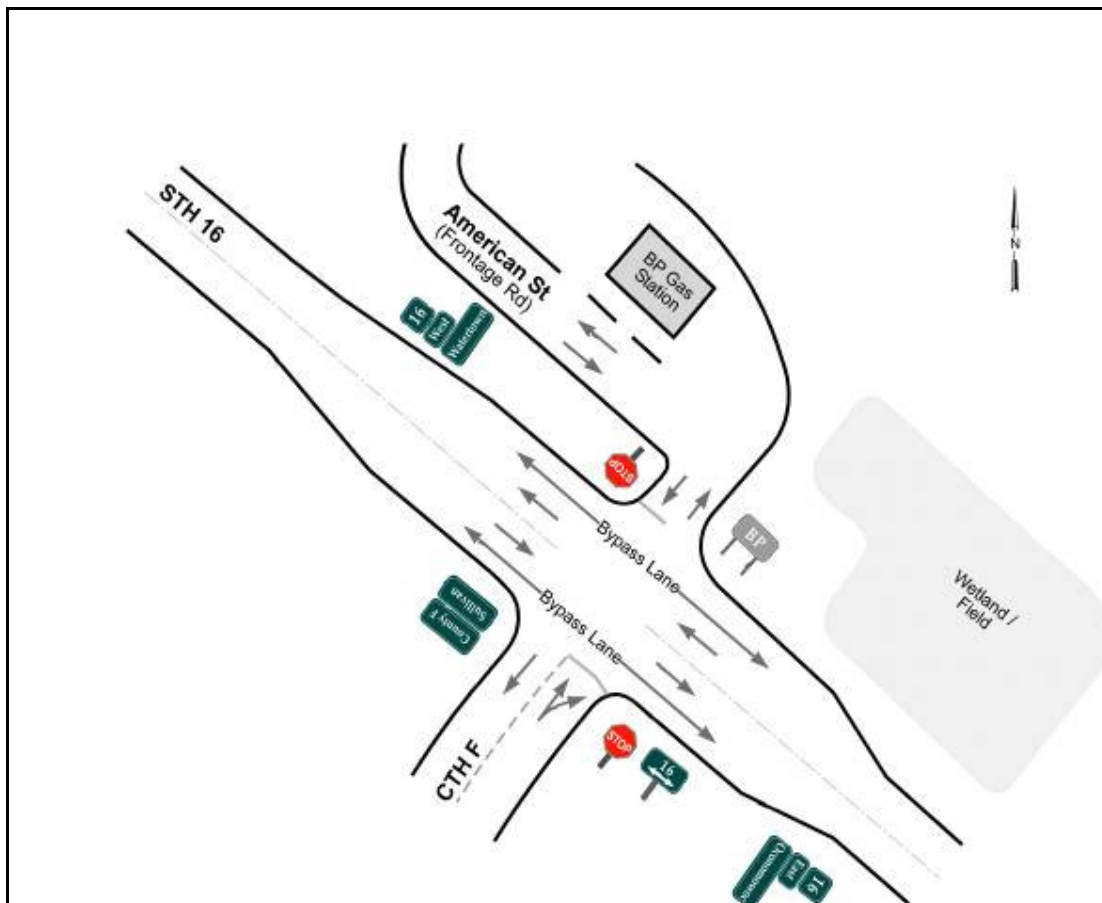


FIGURE 3 – Schematic layout of existing conditions at STH 16 and CTH F

Expected Crash Types: rear-end collisions, angle collisions

Expected Frequency: occasional

Expected Severity: high moderate

Risk Rating: D (moderate-high risk level)

Opportunities for Improvement for the STH 16 and CTH F intersection:

1. Consider providing exclusive left turn lanes (separated from through lane with striping or raised median) as well as channelized right turn lanes on STH 16. This would isolate the turning vehicles from the through lane and provide better visibility for the drivers. FIGURE 4 presents a schematic layout of the suggested improvement.

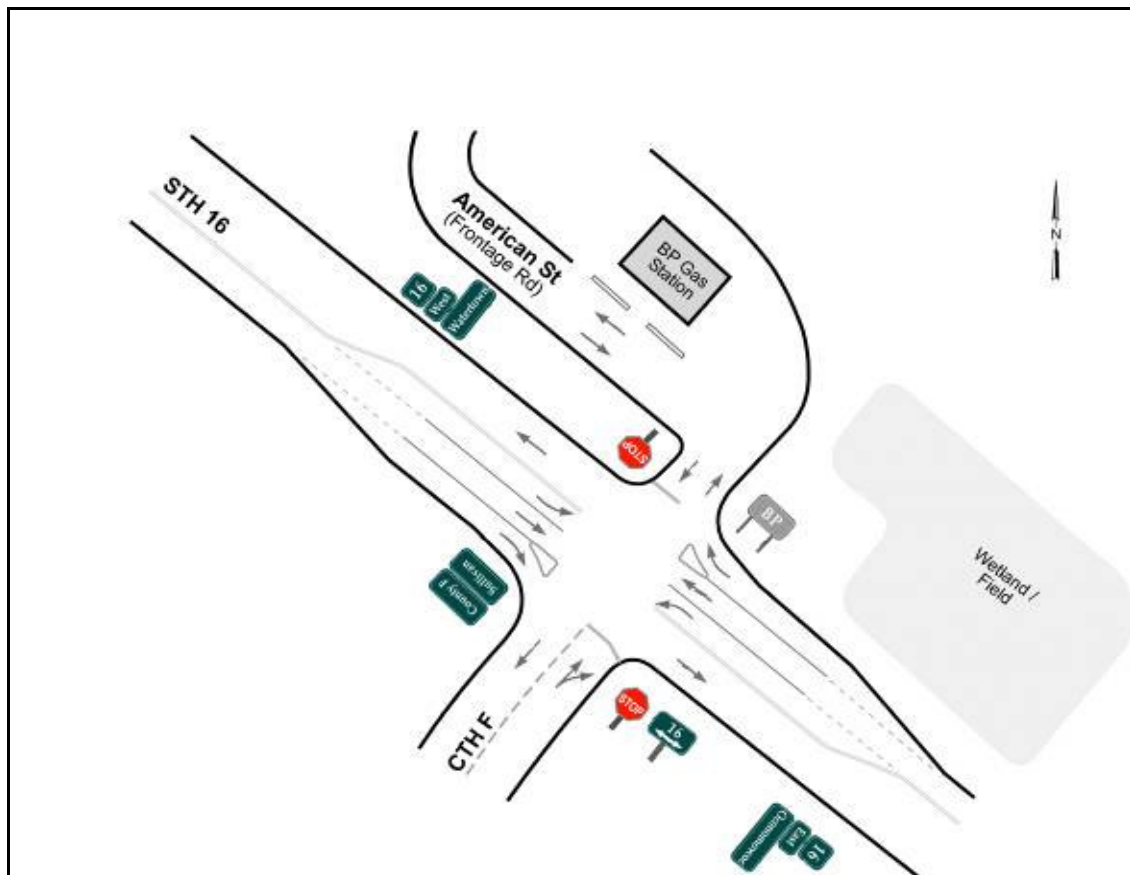


FIGURE 4 – Schematic layout for dedicated turn lanes at STH 16 and CTH F

Left-turn lanes remove vehicles waiting to turn left from the through-traffic stream, thus reducing the potential for rear-end collisions. Left turn lanes also provide a sheltered location for drivers to wait for a gap in opposing traffic, which may encourage drivers to be more selective in choosing a gap to complete the maneuver. This, in return, may reduce the potential for collisions between left-turn vehicles and opposing through vehicles. Right-turn lanes remove slow vehicles that are decelerating to turn right from the through-traffic stream, thus reducing the potential for rear-end collisions.

Estimated right-of-way impact of the suggested improvement would be minimal compared to the existing configuration of the intersection.

2. Consider opportunities for converting the intersection to a rural single-lane three-legged roundabout (see Figure 5).

The physical configuration of the modern roundabout forces drivers to reduce their speed during the approach, entry, and movement within the roundabout. Another important safety factor is that the only movement at the entry and exit of a roundabout is a right turn, which reduces the potential frequency and severity of crashes compared to those involving left turns or crossing maneuvers.

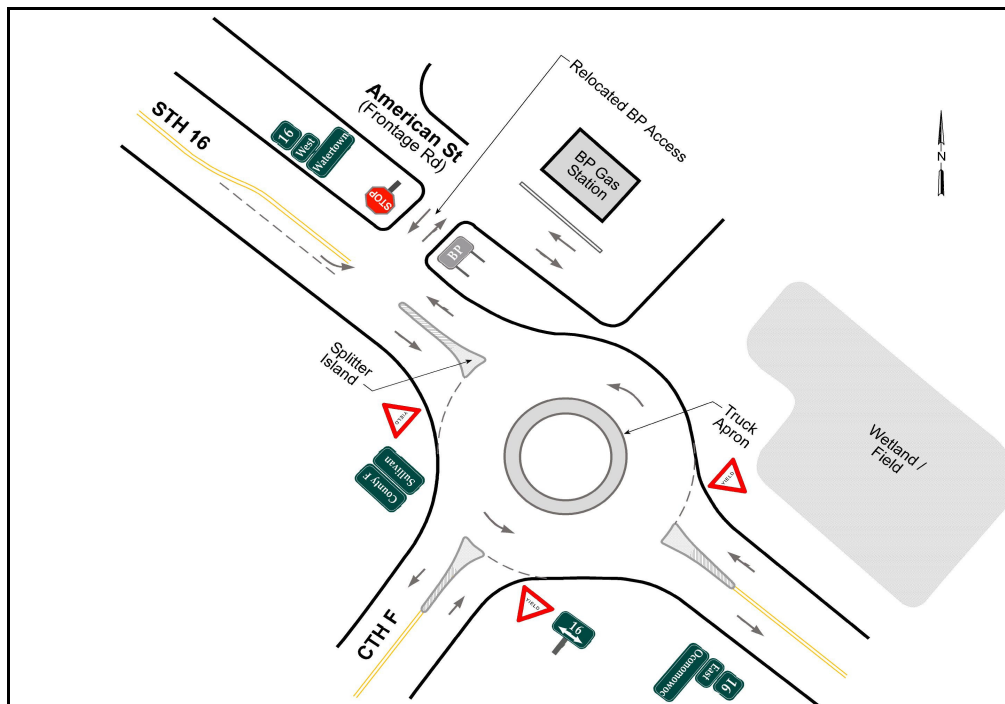


FIGURE 5 – Schematic layout for three-legged roundabout at STH 16 and CTH F

Per FHWA guidelines, a 115-130 ft inscribed circle diameter and 25 mph entry design speed is typically recommended for single-lane rural roundabouts.

Suggested improvement would include relocating access to American Street (frontage road and driveway to BP gas station) further to the west of the existing intersection (by approximately 300-400 ft). Opportunities to minimize the potential right-of-way impacts of this improvement could be investigated.

If traffic volumes increase significantly in the future and further development to the north of the intersection is anticipated, a four-legged roundabout may prove to be more efficient. A four-legged roundabout would also reduce the conflicts that could result from having relocated American Street access within close proximity of the suggested three-legged roundabout.

Opportunities for Improvement at the other intersections:

- Consider providing left turn lanes (separated from through lane with striping) on STH 16 at North Road and River Valley Road intersections.
- Consider implementing improvement options mentioned under **Issue 1 – Intersection Sight Distance**.

Issue 5: Weather Factors

During the site visits, flooding near the ditches was observed along STH 16 from Oconomowoc Bypass to the River Valley Road intersection. This area is generally at a lower elevation compared to the roadway and can be characterized as marshland. Based on input received from town residents, foggy conditions are often observed near the banks of Rock River and adjacent Kanow Park.



Expected Crash Types:	run-of-road crashes, head-on collisions
Expected Frequency:	rare
Expected Severity:	high
Risk Rating:	C (moderate-low risk level)

Opportunities for Improvement:

- Consider extending shoulder rumble strips beyond the Rock River Road and River Valley Road intersections to prevent lane departure crashes involving vehicles running off the road and ending up in the flooded areas.
- Consider providing centerline rumble strips to prevent head-on crashes.

Other Opportunities for Improvement for STH 16:

- Provide advance school zone signs for Ixonia Elementary School at the intersection of STH 16 and North Road.
- Consider implementing a no passing zone prior to intersections with heavier turn volumes such as CTH F and North Road.
- Continue to monitor the need for a traffic signal at STH 16 and CTH F intersection. Current traffic volumes would not warrant a traffic signal at this location, however, with future development in the area, a traffic signal warrant study could be recommended to determine when a traffic signal is warranted.

2.3 Conclusion

Improvements that could be considered to enhance safety along STH 16 corridor have been identified by this road safety audit, and are described in this report. A summary of the safety issues and suggestions are presented in Table 5. To complete the audit process, WisDOT may prepare a short written response to the issues and options outlined in this report.

Safety Issue		Risk Rating	Opportunities for Improvement
1	Intersection sight distance	D	<ul style="list-style-type: none"> • Additional grading for mounds near the intersections • Enhanced lighting at the intersections • Advance street name signs for River Valley Road and North Road prior to intersection • Upgrade existing street name signs per current standards • Additional mowing /clearing of excessive vegetation at mound locations near the intersections
2	Lane departure crashes	D	<ul style="list-style-type: none"> • Extend paved shoulders at taper sections through the intersection • Extend shoulder rumble strips to the west of Rock River Road intersection • Provide centerline rumble strips at curved segments of STH 16 • Investigate opportunities for utilizing the “safety edge”
3	Speed related crashes	C	<ul style="list-style-type: none"> • Consider targeted speed enforcement • Consider installing speed feedback signs for westbound STH 16 near Rock River Road intersection
4	Left turns to/from STH 16	D	<ul style="list-style-type: none"> • Provide left turn lanes at CTH F, North Road and River Valley Road intersections • Consider providing a single-lane three-legged roundabout at CTH F intersection
5	Weather factors	C	<ul style="list-style-type: none"> • Extend shoulder rumble strips to the west of Rock River Road intersection • Provide centerline rumble strips at curved segments of STH 16

Note: Risk rating ranges from A (lowest risk) to F (highest risk).