Road Safety Audit for the Intersection of US 59 and IA 9 in Osceola County, Iowa

Final Report
March 2012

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16. Abstract

The Iowa Department of Transportation (DOT) requested a road safety audit (RSA) of the US 59/IA 9 intersection in northwestern Iowa, just south of the Minnesota border, to assess intersection environmental issues and crash history and recommend appropriate mitigation to address the identified safety issues at the intersection.

Although the number of crashes at the location has not been significantly higher than the statewide average for similar intersections, the severity of these crashes has been of concern.

This RSA was unique in that it included intersection video observation and recorded traffic conflict data analysis, along with the daylight and nighttime field reviews.

This report outlines the findings and recommendations of the RSA team for addressing the safety concerns at this intersection.

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ROAD SAFETY AUDIT FOR THE INTERSECTION OF US 59 AND IA 9 IN OSCEOLA COUNTY, IOWA

Final Report
March 2012

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Participation in the audit by staff from the Federal Highway Administration, Iowa Governor's Traffic Safety Bureau, Iowa State Patrol, Osceola County Sheriff's Office, and Iowa DOT staff provided valuable input and advice that contributed to the success of the audit.

These were the audit team members:

Roxanne Seward	District 3 Office, Iowa DOT
Tom Jungers	Maintenance Supervisor, Ashton Garage, Iowa DOT
Terry Ostendorf	Office of Traffic and Safety, Iowa DOT
Jason Dale	Office of Research, Iowa DOT
Randy Hunefeld	Iowa Governor's Traffic Safety Bureau
Chief Deputy Kevin Wollmuth	Osceola County Sheriff's Office
Sgt. Steve Hilt	Iowa State Patrol Post #6 – Spencer
Jerry Roche	Federal Highway Administration – Iowa Division
Bob Sperry	Institute for Transportation (InTrans)
Tom McDonald	InTrans

The Iowa Traffic Safety Data Service (ITSDS) at InTrans developed the crash data for this safety audit.

INTRODUCTION

As described in the National Cooperative Highway Research Program (NCHRP) Report 500, Volume 5: A Guide for Addressing Unsignalized Intersection Collisions, intersection locations, particularly in rural areas, can present potential hazards due to higher speeds and traffic exposure to conflict points. Although intersections physically represent only a small percentage of a rural highway system, crashes at these locations approximate up to 30 percent of total crashes nationally (*1*).

In California, for example, an average of 1.5 crashes per year occur at unsignalized rural intersections compared to 2.5 per year in urban areas. Overall crash severity, nationally, at these intersections reveals a low percentage of fatal crashes, but almost 36 percent are injury crashes according to data from the National Highway Traffic Safety Administration (NHTSA) (*1*).

HISTORY

IA 9 in this area was originally constructed in 1931 as a Portland cement concrete roadway, resurfaced several times, and finally reconstructed in 2009. The US 59 roadway was originally constructed of Portland cement concrete in 1937 and resurfaced several times, most recently in 2000, with 3 in. of hot-mix asphalt.

Nearby IA 60 was reconstructed as a four-lane expressway in 2008/2009, which may have had an impact on traffic volumes at the intersection of US 59 and IA 9. Figure 1 shows the intersection location (box around it) in northwest Iowa, just south of the Minnesota border.

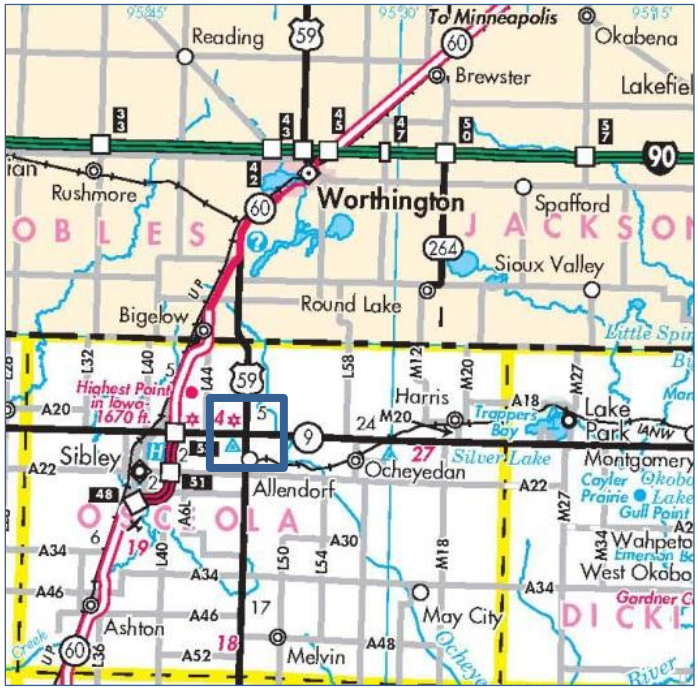

Figure 1. Location of US 59/IA 9 intersection in Osceola County, Iowa

The US 59/IA 9 intersection is a conventional four-leg, at-grade design with right turn lanes for IA 9 traffic turning onto US 59. The intersection operates with two-way stop control on the US 59 legs and IA 9 traffic flows freely through the intersection.

Although the number of crashes at the location has not been significantly higher than the statewide average for similar intersections, the severity of these crashes has been of concern.

The Iowa Department of Transportation (DOT) requested a safety review of the intersection to assess crash history and recommend appropriate mitigation to address identified safety issues. To assist in this effort, the Iowa DOT obtained an extensive volume of on-site video to permit observation of traffic operations and a review of this data was included in the audit process.

A thorough discussion of crash history and video review are included in this report.

INITIAL MEETING

The initial meeting for this road safety audit (RSA) was conducted on November 3, 2011 at the Iowa DOT maintenance garage in Ashton, Iowa (about 15 miles south southwest of the intersection).

The initial meeting participants were Terry Ostendorf, Roxanne Seward, and Tom Jungers from the Iowa DOT, Chief Deputy Kevin Wollmuth from the Osceola County Sheriff's Office, Sgt. Steve Hilt from the Iowa State Patrol, Jerry Roche from the Federal Highway Administration (FHWA) – Iowa Division, Randy Hunefeld from the Iowa Governor's Traffic Safety Bureau (GTSB), and Bob Sperry and Tom McDonald from the Institute for Transportation (InTrans) at Iowa State University.

Following initial introductions, Seward and others spoke about the reasons for requesting a review of safety concerns at this intersection, mostly relating to a recent fatal crash at the location. Deputy Wollmuth advised that some drivers may approach the intersection expecting a four-way stop when, in fact, traffic on IA 9 does not stop.

Hunefeld related that he had spoken with a former Osceola County sheriff (Mitch Waters), who recalled that many crashes at the intersection may have been related to the heavy numbers of semi-trailers that pass through the location each day, some of which may not completely stop on the US 59 legs before entering IA 9.

McDonald then explained the proposed schedule for conducting the two-day safety review, a copy of which had been provided to the group earlier.

The Bureau of Research and Technology at the Iowa DOT, at the request of the District 3 Office, had acquired an extensive amount of observation video of traffic operations at the intersection

and had contacted InTrans for assistance in reviewing and analyzing the data on the video, which totaled 612 hours of continuous observation from a single north-facing elevated camera.

McDonald explained the proposed methodology for collecting data from the video records, primarily determining peak-hour traffic from various sources and recording the volume of traffic and number of conflicts that occur per hour within those periods. It was estimated that a minimum of about five hours of video per day would be studied for usable data.

Conflicts were defined as when two or more vehicles reach the intersection simultaneously at near right angles, which is the most common manner of collision over the past 11 years. A sample of this video was shown and comments made by the meeting participants.

When asked about the destination of the many trucks passing through this intersection, it was advised that there are several ethanol plants in the area, the largest of which is located at Hartley and that most grain trucks are probably destined for there.

A soybean processing plant is located in Brewster, Minnesota, which also generates much large truck traffic. Livestock semi-trailers are most likely destined for a packing plant in Worthington, Minnesota. Hunefeld opined that large truck traffic diminishes substantially on weekends, according to Iowa DOT Motor Vehicle Enforcement.

In addition to the large truck traffic, there is considerable vehicular traffic destined for Minnesota and the recreational areas there in the summer months.

Seward also wondered whether reduced visibility in the summer at sunrise could be contributing to the crashes. However, an examination of time of day and month of occurrence for the crashes did not indicate a high probability of vision impairment due to sunrise.

Traffic from nearby IA 60 was detoured onto US 59 in 2008 and 2009 during re-construction, but this did not seem to cause an increase in crashes at the intersection.

Traffic volumes through this intersection increased dramatically from 2005 to 2010, which may have been impacted by the opening of new IA 60 just to the west. In 2005, traffic volume on US 59 averaged about 870 vehicles per day (vpd), increasing to about 980 vpd in 2010 to the south of IA 9. Traffic volume on IA 9 in 2005 was about 1,450 vpd, but that increased to approximately 2,000 vpd in 2010.

Large commercial trucks comprise about 16 percent of the total traffic. Complete traffic volume data for 2007, including turning movements, are included in Appendix A.

The crash data for the period of 2001 through 2010 was distributed and discussed by the meeting participants. Before this final report was completed, the full year of crash data for 2011 became

available, so the analysis included in this document is based on 11 years of data (2001 through 2011).

A total of 12 crashes were recorded over the analysis period, with two fatalities, two with major injuries, three with minor injuries, two with possible injuries, and three with property only damages. The major cause of seven crashes was failure to yield the right of way from a stop sign and all other crash causes totaled only one each.

All crashes were distributed throughout daylight hours except one animal-related incident. The most prevalent manner of collision was broadside impact.

Crashes were also distributed throughout the day of week with Thursday and Friday showing the highest frequency with three each.

No patterns could be detected in the age of the 24 drivers involved in the crashes and 22 of those were judged apparently normal at the time of crash. No drivers under the age of 20 were involved in the crashes and no alcohol was detected among drivers.

The most-frequent vehicle type recorded was passenger cars with eight, followed by light trucks with six, and tractor/semi-trailers with five.

Roadway conditions at the time of crashes were most frequently dry (10 crashes) and weather conditions were clear, cloudy, or partly cloudy for 10 of the incidents.

It was interesting to note that for the vehicles involved in the crashes, 15 were licensed in Iowa, five in South Dakota, three in Minnesota, and one each in Illinois, Vermont, and Texas. Most drivers involved in these crashes were licensed in Iowa, but four had South Dakota licenses, followed by Minnesota, Illinois, Texas, and Vermont with one each.

The narratives and diagrams from the crash reports were made available for review and these data were discussed.

Jungers advised that the Stop signs mounted near the edge of the traveled way were commonly impacted, although a crash report for these incidents is generally not required. (It may be advisable to provide better markings for these near-traffic signs.)

McDonald noted that the severity rate for crashes at this intersection was quite high, even with a relatively low number of crashes over the 10 year study period. In comparison with similar intersections in Iowa, this location was ranked 654th of 40,725 total intersections and 180th of 5,415 rural primary intersections in the 2010 Safety Improvement Candidate Location (SICL) listing from the Office of Traffic and Safety.

Appendix B of this report includes complete crash data for the intersection for 11 years (2001 through 2011).

Crash rate comparisons of the intersection to those of similar design were presented, including data from Iowa and the American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM) crash prediction model for rural two-way, two lane intersections (*2*). Appendix C includes these data.

The crash rate calculation yields a rate of 1.03 total crashes per million entering vehicles (MEV), which can be compared to an Iowa DOT furnished average primary to primary rate of 1.0 crashes per MEV and a traffic volume rate of 0.9 for similar intersections.

The calculated fatal and injury crash rate was 0.85 per MEV, which is considerably higher than the predicted rate. A crash prediction model from the HSM indicates a total crash rate of 1. 09 crashes per MEV and a fatal and injury crash rate of 0. 47. (Calculations are included in Appendix C.)

Possible mitigation options were reviewed briefly including installation of a four-way stop, which was noted as not meeting the Manual on Uniform Traffic Control Devices (MUTCD) Section 2B.07 applications for a multi-way stop.

Also suggested was replacement of the overhead mounted flashing beacons (shown in Figure D.5) with red flashing beacons on the Stop signs only. This procedure was found to be more effective in a recent Minnesota study, given drivers waiting at the Stop signs may assume that vehicles approaching from right angles may also be required to stop (*3*). (Overhead beacons were also observed at other intersections in District 3 and these locations should be reviewed for crash history.)

Another option that has been deployed successfully in some other states and installed recently at two locations in Iowa is electronically-activated warning signs advising stopped vehicles that traffic is approaching on the through road and providing assistance in finding an acceptable gap in oncoming traffic to permit a safe entry onto the through road (IA 9, in this case) (*4*).

Several different designs of these devices have been used and those are described in the FHWA publication entitled Stop-Controlled Intersection Safety: Through Route Activated Warning Systems (*4*).

NCHRP Report 500, Volume 5: A Guide for Addressing Unsignalized Intersection Collisions was also studied for feasible options to improve safety at this particular intersection.

Ostendorf suggested that additional warning plaques be mounted on the back side of the Stop signs with a message such as Recheck Traffic Before Proceeding. Other low-cost improvements, including general signing upgrades, are also listed in the Conclusions and Suggestions section of this report.

DAYLIGHT FIELD REVIEW

Following the initial meeting, the entire audit team (except Deputy Wollmuth) traveled to the review site for a daylight examination of conditions and traffic operations. Stop signs have been placed for US 59 traffic, with installations in the quadrants and also adjacent to wide-turning radii.

It was observed that a shadow from the adjacent intersection lighting pole was cast across the northbound Stop sign at the time of the review. Cross Traffic Does Not Stop plaques with fluorescent yellow sheeting were mounted below some of the Stop signs. All of these signs appeared in good condition, although the installation date for some signs indicated an extensive service life (some of approximately 20 years).

Some of the guide signs advising drivers of destinations appeared to be in poor condition and should be considered for replacement (Figure D.9). However, route markers appeared to be in excellent condition (Figure D.12).

An approximate 2 ft paved shoulder with rumble strips had been placed along US 59 approaching the intersection (Figure D.13).

A twin 10 x 10 ft reinforced box culvert extends through the intersection on a diagonal alignment (Figure D.6). The unshielded inlet and outlet of this culvert are within the clear zone.

Conventional intersection lighting has also been provided at the intersection (Figure D.14).

During the review, one large commercial vehicle was observed to "roll" through a stop sign, but most drivers showed extra caution, possibly influenced by the Iowa State Patrol vehicle parked nearby.

Numerous images were taken of field conditions and many of these are included in Appendix D.

NIGHTTIME FIELD REVIEW

Following dinner, a nighttime review of the intersection was conducted by the team (except for Deputy Wollmuth). Conspicuity of signs was satisfactory and pavement markings were quite visible (Figure D.15).

Traffic volume was higher than expected, particularly for large commercial vehicles, and compliance with existing traffic controls was good. However, some of the lamps in the intersection lighting were burned out and should be replaced.

Numerous images were again taken during this review and samples are included in the final records for this audit.

WRAP-UP MEETING

A wrap-up meeting was conducted on November 4, 2011 at the Iowa DOT Ashton maintenance garage. Participants in the meeting were Seward, Jungers, Ostendorf, Wollmuth, Roche, Hunefeld, Sperry, and McDonald.

McDonald explained that improving safety at this intersection could be approached on a reactive basis, addressing concerns raised by the crash data and video review, but also with a proactive approach by improving potential hazards that may not as yet resulted in significant crashes.

Suggestions for addressing safety issues at this intersection will include elements of all feasible alternatives. Installation of activated approaching traffic warning signs (as shown on US 151 at Anamosa, Iowa in Figure D.16) could also be considered a reactive option to possibly reduce failure to yield from Stop sign crashes. Proactive options might include replacement of the overhead beacons with flashing beacons mounted on the Stop signs, possibly supplemented with advance warning signs on IA 9 advising of entering truck traffic or a similar message.

These warning signs could also benefit from the mounting of amber flashing beacons on the signs. Solar power for all beacons should be considered to reduce costs and need for transmission poles.

Needed upgrading of all deficient signs could also be a proactive option, including mounting of additional warning plaques on the back of existing Stop signs, as well as increasing the size of the current Cross Traffic Does Not Stop plaques.

Another example of a proactive improvement would be extension of the existing large culvert ends beyond the clear zone. This improvement, in addition to removal of the overhead beacons, would remove several existing obstacles in the intersection, resulting in improved visibility and safety for drivers. Another less costly option would be to install grates on the culvert ends, but trapping of debris could result.

It was noted that other potential improvement options might be determined following review of the video records and an in-depth examination of the references discussed in the initial meeting.

SUPPLEMENTAL FIELD REVIEW

Following the wrap-up meeting, Roche, Ostendorf, Sperry, and McDonald re-visited the US 59/IA 9 intersection to gather additional information, including installation dates for many of the existing signs. Some signs, however, did not have dates on them, including the Stop Ahead warning signs on US 59, and, on other signs, the date stickers had faded to the point of illegibility, making installation-date determination impossible.

Some 4 x 6 in. support posts were observed that did not appear to be drilled to render them crashworthy. (This condition should be checked and addressed as needed by District maintenance staff.)

Evidence of semi-tractor trailer parking along the US 59 shoulders near the intersection was observed, although the crash records did not indicate any direct safety hazards due to this practice, possibly due to greatly-reduced traffic volumes at night in this area.

VIDEO REVIEW METHODOLOGY

As a prelude to a formal RSA, the Iowa DOT District 3 Office requested the Bureau of Research and Technology to obtain an extensive video log of traffic operations at this intersection to determine if driver behavior or other traffic patterns could be having an impact on safety. In response to this request, 30 days of mostly-continuous video was taken during the months of April and May 2011 and 25.5 days of video were provided to researchers at InTrans for analysis.

Because the video log contained more than 600 hours of data, it was decided to adopt a sampling methodology that would provide a valid sampling of the observations within the time constraints established for project completion.

The sampling procedure selected is supported by several factors, as follows:

- Because most recorded crashes at the intersection involved multiple vehicles, the number of recorded conflicts among traffic was of most interest. (For the purposes of this analysis, a traffic conflict was defined as occurring when two or more vehicles reach the intersection simultaneously at approximate right angles, whether by initial directions of travel or by turning movements.)
- Given the 2007 Iowa DOT traffic volumes (and hence potential conflicts) were much reduced during nighttime and early morning hours, observation of the log during these low-traffic times would not be fruitful.
- The crash data revealed that most crashes were recorded during certain daylight time periods, indicating that most potentially-problematic conflicts also occur at those times.
- Several major truck-generating facilities operate in this surrounding area, such as ethanol-producing facilities and a meat-packing plant. Most hauling into and from these traffic generators occurs during weekday and daylight hours.
- Peak-hour-only traffic observations have been utilized successfully on past InTrans research projects.
- The project completion date would not allow for extensive time to efficiently observe and analyze the total volume of data collected.

The major data desired to be gleaned from the complete video log was number of conflicts within established time periods, given this would represent a measurement of potentially-hazardous conditions.

To substantiate this methodology, two 15 hour periods (7 a.m. to 10 p.m.) on Saturday, April 16 and Thursday, April 21, 2011 were randomly selected to be viewed and conflicts per hour were noted.

Peak hours for conflicts based on those two day totals were 9 to 12 a.m., 1 to 2 p.m., and 4 to 6 p.m. In addition, a review of the midnight to 3 a.m. period recorded on April 21, 2011 showed no conflicts during the three-hour period.

Therefore, these peak daytime-only hours (six hours per day) were viewed for all days that had data available and a summary of that data is included in the next section of this report.

VIDEO OBSERVATION RESULTS

The selected methodology for sampling the observation video of the US 59/IA 9 intersection was undertaken during the month of November and yielded the following results.

The total video log reviewed (174 hours) contained data recorded for 25.5 days between the dates of noon on April 14 to midnight on May 12, 2011 and included approximately 612 hours of observation data. Note that the video observations did not begin until the afternoon of April 14 and that no data was available for three other days (April 17, 18, and 20) within that period.

The sampling methodology yielded approximately 150 hours of assessment viewing over the 25.5 days, with six hours of daylight viewing per day.

The data observed indicated 2,240 total conflicts or about 89.6 per six-hour day, which reduces to about 14.9 conflicts per hour. The conflict rate for the 25.5 days ranged from a low of 13.32 per hour for the 10 to 11 a.m. hour to a high of 16.38 per hour for the 4 to 5 p.m. hour.

This range of rates can be further reduced to a low of 1 conflict per 4.5 minutes to a high of 1 conflict per 3.7 minutes.

Throughout a given week, average conflicts per six-hour day indicated the totals shown in Table 1.

Table 1. Average conflicts per six-hour day

Day of Week	Average Number of Conflicts per 6 Hrs
Monday **	84
Tuesday	86
Wednesday **	89
Thursday *	96
Friday	109
Saturday	73
Sunday **	72

4 full days of data were recorded on Tuesdays, Fridays, and Saturdays
* 4.5 days of data
** 3 days of data

From Table 1, it would appear that the number of conflicts is quite consistent throughout the work week, building to a high on Fridays, and decreasing over the weekends when traffic volumes are lower.

For the two methodology verification days of Saturday, April 16 and Thursday, April 21, the traffic conflict data in Table 2 were gleaned.

Table 2. Traffic conflict data for two methodology verification days

Date	Total Conflicts for 15 Hrs	Conflicts per Hour (15 Hrs)	Conflicts for Six-Hour Sampling Period	Conflicts per Hour (6 Hrs)
Saturday, April 16	122	8.13	71	11.83
Thursday, April 21	197	13.13	106	17.67

Observation hours for these two verification days extended from 7 a.m. until 10 p.m. for a total of 15 hours per day. Note that three hours of observation from 12 a.m. to 3 a.m. on Thursday, April 21 were not included, given no conflicts were found during those hours.

For comparative purposes, conflicts for the selected six-hour observation time are shown in the far-right column.

SUMMARY OF OBSERVATION VIDEO

To aid in studying the data contained on the observation video for the selected six one-hour daily periods, short video clips were made of selected observations where erratic driver behavior, traffic violations, and near-misses were recorded. These clips, along with the entire observation video records are on file at InTrans.

Recorded observations include the following:

- Running Stop signs and failure to come to a complete stop
- Stopping several feet in advance of the Stop sign locations and then proceeding through the intersection unimpeded
- Turning left through a restricted area
- Passing quite closely to on-coming or stopped vehicles
- Passing other vehicles within the intersection

These clips included some overly-cautious drivers and others that exhibited insufficient patience when proceeding from the Stop signs. While most of these possibly unsafe driving practices could only be addressed by increased enforcement effort, a few might be addressed with engineering improvements such as milled-in stop bars.

All suggested improvements are listed in the next section of this report.

CONCLUSIONS AND SUGGESTIONS

A thorough review of available crash history and observation video records did not reveal any dominant factor that could contribute to crashes occurring at this intersection, other than possible driver error. The major cause of the recorded crashes was failure to yield the right of way from a Stop sign, with 7 of 12 crashes.

A fatal crash in 2005 occurred when a stopped commercial vehicle proceeded into the intersection into the path of an on-coming vehicle. An additional fatal crash occurred in 2011 when a large commercial vehicle entered IA 9 from a stopped position and was impacted by a passenger vehicle.

Large, combination trucks were overrepresented in these crashes. Although contributing about 16 percent to the total traffic volume, approximately 42 percent of the crashes involved a large truck.

It could be concluded that drivers involved in the major crash cause at this intersection exhibited poor judgment when departing from a Stop sign, probably due to either distraction, inattentiveness, impatience, deficient gap acceptance, or a hampering of vision. A successful reduction in crashes will need to address driver behavior in some manner.

After reviewing and considering available data including observation video, crash history, traffic volumes and mix, and roadway conditions, as well as field reviews and input from audit team members, the following suggestions were formulated.

The teams suggests that the low-cost options be addressed initially, followed by higher-cost alternatives as warranted.

Low-Cost Options

1. Remove the existing overhead flashing beacons and replace with flashing red beacons mounted over the Stop signs on the US 59 approaches. In addition to improving effectiveness, this step would also result in the removal of several utility poles and span wires, which would improve visibility and eliminate some roadside obstacles.

2. Review the condition of all signs in the area of the intersection and replace as needed according to retroreflectivity performance, installation date, and current sheeting condition, with special attention to the destination sign on the eastbound IA 9 approach leg. These improvements may prove especially beneficial in advising drivers on IA 9 of the location of the US 59 intersection after removal of the overhead beacons described in option 1 above.

3. Consider installation of fluorescent yellow intersection warning signs (MUTCD W2-1), on IA 9 to provide additional notice of the US 59 intersection and the possibility of entering traffic.

4. Review all existing sign supports and replace or drill all existing 4 x 6 in. wood supports to assure crashworthiness.

5. Consider the installation of additional fluorescent-yellow warning signs on the back of the existing Stop signs with the message to Recheck Traffic Before Proceeding or similar language.

6. Install milled-in, extra-width (24 in.) stop lines as close as practical to the IA 9 pavement edge to encourage drivers to stop at a location where maximum visibility of approaching traffic would be achieved. This action may relieve the propensity of some drivers to stop several feet in advance of the Stop signs as observed in the traffic operations video.

7. Work with the Iowa State Patrol and Osceola County Sheriff's Office to provide law enforcement presence at this intersection on a periodic but routine basis, as it appeared that traffic performance improved significantly when a law enforcement vehicle was observed.

8. Another low-cost, but potentially-effective tool could be a public information/education effort to advise local news media of safety concerns and statistics at the intersection and perhaps sharing the results of this road safety audit report.

Higher-Cost Options

1. Consider the installation of an automated through-route activated warning system to advise stopped vehicles on US 59 of approaching traffic on IA 9 as shown in Figure D.16. These applications have proven successful in other states and have also been deployed in two locations in Iowa.

2. Lower-cost, experimental procedures have been undertaken in other states using passive warning devices such as pavement markings and/or roadside markers, together with explanatory signing to advise stopped vehicles of acceptable gaps in approaching traffic before entering the intersection.

3. Program extension of the existing culvert to relocate structure ends beyond the clear zone, thus providing an improved sight triangle and an enhanced roadside safety environment.

REFERENCES

1. Neuman, Timothy R., Pfefer, Slack, Hardy, Harwood, Potts, Trobic, and Rabbani. 2003. *Guidance for Implementation of the AASHTO Strategic Highway Safety Plan.* National Cooperative Highway Research Program (NCHRP) Report 500, Volume 5: A Guide for Addressing Unsignalized Intersection Collisions. Washington, DC: Transportation Research Board.
2. American Association of State Highway and Transportation Officials (AASHTO). 2010. *Highway Safety Manual*.
3. Minnesota Department of Transportation (MnDOT). Removal of Overhead Red/Yellow Intersection Control Beacons. Engineering Services Division. Technical Memorandum No. 08-12-T-03.
4. Bryer, Tom. February 2011. *Stop-Controlled Intersection Safety: Through Route Activated Warning Systems*. Federal Highway Administration (FHWA). Office of Safety.

APPENDIX A. TRAFFIC VOLUME AND TURNING MOVEMENTS

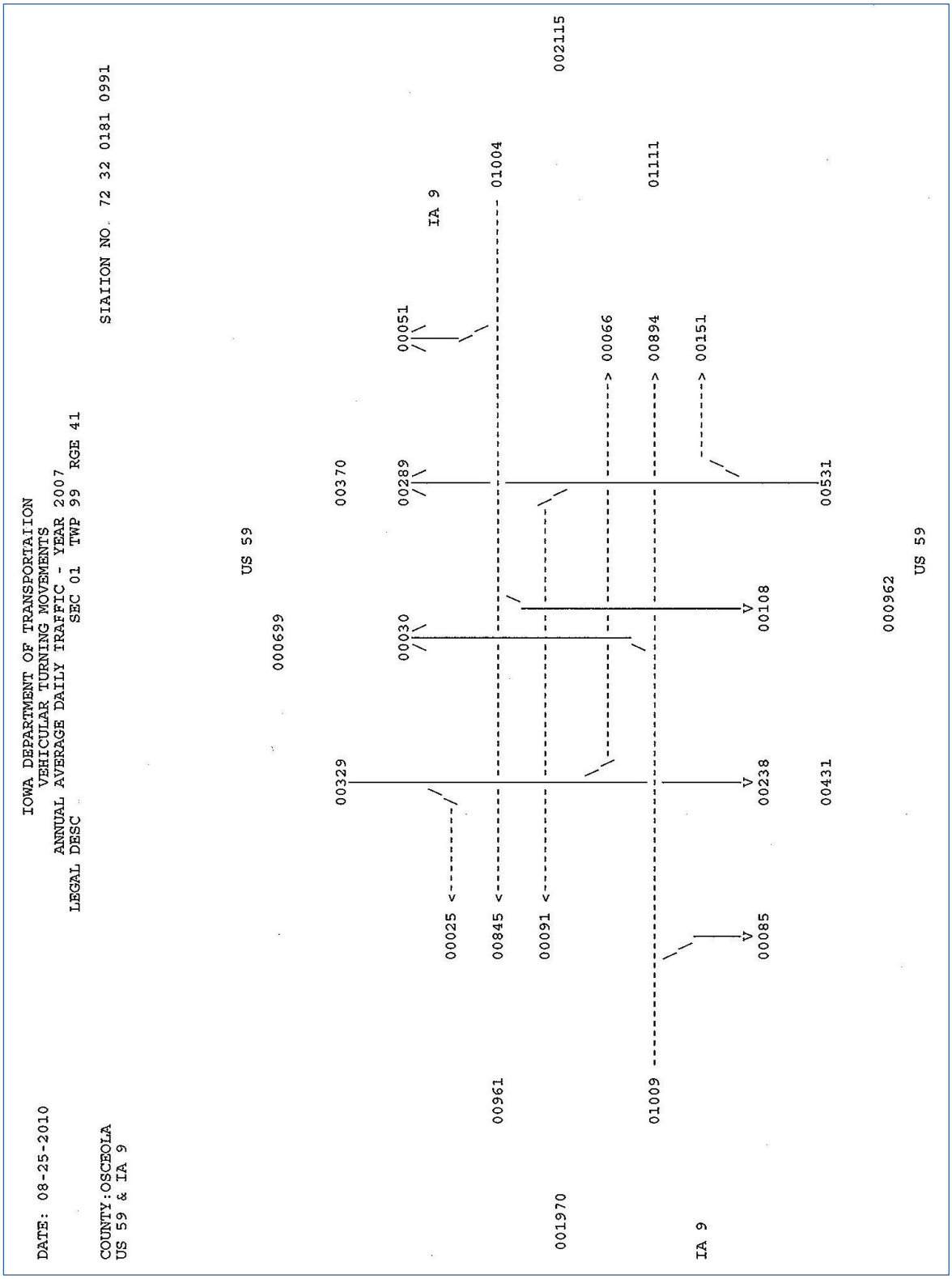

Figure A.1. 2007 US 59 and IA 9 intersection vehicular turning movements

APPENDIX B. CRASH DATA

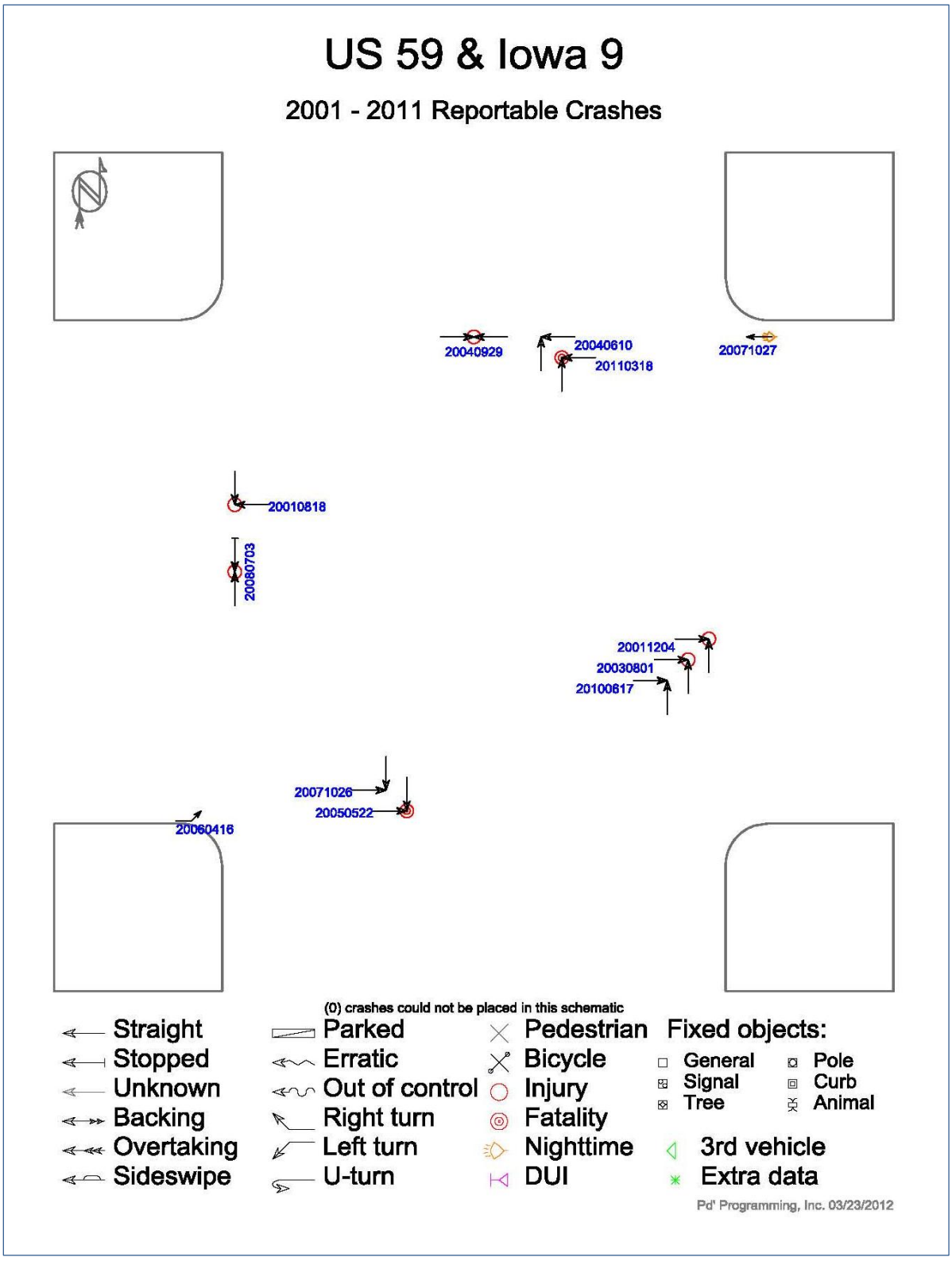

Figure B.1. 2001-2011 US 59 and IA 9 intersection crash diagram

Table B.1. 2001-2011 US 59 and IA 9 intersection crashes by major cause

Major Cause	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Animal							1					1
Crossed centerline				1								1
FTYROW: From stop sign	1			1	1		1	1		1	1	7
Other: No improper action			1									1
Other: Vision obstructed	1											1
Unknown						1						1
Total	2	0	1	2	1	1	2	1	0	1	1	12

Table B.2. 2001-2011 US 59 and IA 9 intersection crashes by manner of collision

Manner of Collision	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Broadside	2		1	1	1		1	1		1	1	9
Head-on				1								1
Non-collision						1	1					2
Total	2	0	1	2	1	1	2	1	0	1	1	12

Table B.3. 2001-2011 US 59 and IA 9 intersection crashes by time of day

Time of Day	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
8:00 a.m. to 9:59 a.m.	1			1							1	3
10:00 a.m. to 11:59 a.m.										1		1
Noon to 1:59 p.m.				1		1						2
2:00 p.m. to 3:59 p.m.	1		1									2
4:00 p.m. to 5:59 p.m.							1	1				2
6:00 p.m. to 7:59 p.m.							1					1
8:00 p.m. to 9:59 p.m.					1							1
Total	2	0	1	2	1	1	2	1	0	1	1	12

Table B.4. 2001-2011 US 59 and IA 9 intersection crashes by day of week

Day of Week	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Sunday					1	1						2
Monday												0
Tuesday	1											1
Wednesday				1								1
Thursday				1				1		1		3
Friday			1				1				1	3
Saturday	1						1					2
Total	2	0	1	2	1	1	2	1	0	1	1	12

Table B.5. 2001-2011 US 59 and IA 9 intersection crashes by month of year

Month	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
March											1	1
April						1						1
May					1							1
June				1						1		2
July								1				1
August	1		1									2
September				1								1
October							2					2
December	1											1
Total	2	0	1	2	1	1	2	1	0	1	1	12

Table B.6. 2001-2011 US 59 and IA 9 intersection crashes by severity

Crash Severity	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Fatal					1						1	2
Major Injury	1							1				2
Minor Injury	1		1	1								3
Possible/Unknown				1			1					2
Property Damage Only						1	1			1		3
Total	2	0	1	2	1	1	2	1	0	1	1	12

Table B.7. 2001-2011 US 59 and IA 9 intersection crashes by driver age

Driver Age	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
20				1								1
21-24	2						1	1				4
25-29					1							1
30-34	1										1	2
35-39							1				1	2
40-44					1	1				1		3
45-49							1	2				3
50-54			1	1								2
55-59	1									1		2
60-64	1			1								2
80-84			1									1
85-89				1								1
Total	5	0	2	4	2	1	3	3	0	2	2	24

Table B.8. 2001-2011 US 59 and IA 9 intersection crashes by driver condition

Driver Condition	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Apparently normal	5		2	4	1	1	2	3		2	2	22
Not Reported					1							1
Other							1					1
Total	5	0	2	4	2	1	3	3	0	2	2	24

Table B.9. 2001-2011 US 59 and IA 9 intersection crashes by vehicle type

Vehicle Type	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Four-tire light truck (pick-up/panel)	2			1	1					1	1	6
Passenger car	1			2	1	1	1	2				8
Sport utility vehicle			2				1			1		4
Tractor/semi-trailer	2			1				1			1	5
Van or mini-van							1					1
Total	5	0	2	4	2	1	3	3	0	2	2	24

Table B.10. 2001-2011 US 59 and IA 9 intersection crashes by road surface conditions

Roadway Condition	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Dry	1		1	1	1	1	2	1		1	1	10
Wet	1			1								2
Total	2	0	1	2	1	1	2	1	0	1	1	12

Table B.11. 2001-2011 US 59 and IA 9 intersection crashes by weather conditions

Weather Conditions	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Clear			1	1	1		1	1		1		6
Cloudy						1						1
Fog/smoke	1											1
Mist				1								1
Partly cloudy	1						1				1	3
Total	2	0	1	2	1	1	2	1	0	1	1	12

Table B.12. 2001-2011 US 59 and IA 9 intersection crashes by light conditions

Light Conditions	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Darkness							1					1
Daylight	2		1	2	1	1	1	1		1	1	11
Total	2	0	1	2	1	1	2	1	0	1	1	12

Disclaimer: The information contained in these tables was derived from the February 3, 2012 Iowa DOT crash database. The 2011 data are considered unedited, incomplete, and preliminary. In addition, the data may not contain all crashes that occurred during 2001 (i.e., ~ 5,000 old form crashes). If errors or odd cases are found, please communicate the case number or send a printed crash report to Michael Pawlovich, Iowa DOT, Office of Traffic and Safety (Michael.Pawlovich@dot.iowa.gov, 515-239-1428). Given the database is actively being updated, edited, and reviewed, some of the fatality totals may differ from the Fatality Analysis Reporting System (FARS).

APPENDIX C. COMPARABLE CRASH RATES

Crash rate computations and comparisons for this intersection and those of similar design are included in this appendix.

Iowa DOT Crash Rate Computation and Comparable Rates

Iowa DOT Equation

R = 2(A) 1,000,000/TV

where:
R = Crash Rate
A = Number of Crashes for the Study Period
T = Length of Analysis Period in Days
V = Total Entering Vehicles per Day

Calculation for US 59/IA 9 Intersection

A = Number of Crashes for the Study Period = 12 crashes
T = Length of Analysis Period in Days = 11 years x 365 days/year
V = Total Entering Vehicles per Day = 5,790 vehicles/day

R = 2(12) x 1,000,000/11 x 365 x 5,790 or 24,000,000/23,246,850

Intersection Crash Rate = 1.03 crashes per MEV

Iowa DOT Comparable Rates

The crash rate calculation yielded a rate of 1.03 crashes per MEV, which could be compared to an Iowa DOT furnished average primary to primary rate of 1.0 crashes per MEV and a traffic volume rate of 0.9 for similar intersections.

The calculated fatal and injury crash rate was 0.85 per MEV, which is considerably higher than the predicted rate.

Comparable Crash Rate Computations Using HSM Worksheets

A crash prediction model from the HSM for rural two-way, two lane intersections indicated a total crash rate of 1.09 crashes per MEV and a fatal and injury crash rate of 0.47 (as shown in the following tables) for comparison purposes.

Worksheet 2A -- General Information and Input Data for Rural Two-Lane Two-Way Roadway Intersections

General Information		Location Information	
Analyst	JLR	Roadway	
Agency or Company	FHWA	Intersection	US 59/IA 9
Date Performed	10/25/11	Jurisdiction	Iowa
		Analysis Year	2011

Input Data				Base Conditions	Site Conditions			
Intersection type (3ST, 4ST, 4SG)				--	4ST			
$AADT_{major}$ (veh/day)	$AADT_{MAX}$ =	14,700	(veh/day)	--	2,000			
$AADT_{minor}$ (veh/day)	$AADT_{MAX}$ =	3,500	(veh/day)	--	950			
Intersection skew angle (degrees)	[If 4ST, does skew differ for minor legs?]		No	0	Skew for Leg 1 (All):	0	Skew for Leg 2 (4ST only):	0
Number of signalized or uncontrolled approaches with a left-turn lane (0, 1, 2, 3, 4)				0	0			
Number of signalized or uncontrolled approaches with a right-turn lane (0, 1, 2, 3, 4)				0	0			
Intersection lighting (present/not present)				Not Present	Present			
Calibration Factor, C_i				1.00	1.00			

Worksheet 2B -- Crash Modification Factors for Rural Two-Lane Two-Way Roadway Intersections

(1)	(2)	(3)	(4)	(5)
CMF for Intersection Skew Angle	CMF for Left-Turn Lanes	CMF for Right-Turn Lanes	CMF for Lighting	Combined CMF
CMF_{1i}	CMF_{2i}	CMF_{3i}	CMF_{4i}	CMF_{COMB}
from Equations 10-22 or 10-23	from Table 10-13	from Table 10-14	from Equation 10-24	(1)*(2)*(3)*(4)
1.00	1.00	1.00	0.91	0.91

Worksheet 2C -- Intersection Crashes for Rural Two-Lane Two-Way Roadway Intersections

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crash Severity Level	$N_{spf\ 3ST,\ 4ST\ or\ 4SG}$	Overdispersion Parameter, k	Crash Severity Distribution	$N_{spf\ 3ST,\ 4ST\ or\ 4SG}$ by Severity Distribution	Combined CMFs	Calibration Factor, C_i	Predicted average crash frequency, $N_{predicted\ int}$
	from Equations 10-8, 10-9, or 10-10	from Section 10.6.2	from Table 10-5	$(2)_{TOTAL}$ * (4)	from (5) of Worksheet 2B		(5)*(6)*(7)
Total	1.201	0.24	1.000	1.201	0.91	1.00	1.089
Fatal and Injury (FI)	--	--	0.431	0.518	0.91	1.00	0.470
Property Damage Only (PDO)	--	--	0.569	0.683	0.91	1.00	0.620

APPENDIX D. IMAGES FROM FIELD REVIEWS

Figure D.1. Eastbound approach to US 59/IA9 intersection

Figure D.2. Right-turn lane on IA 9

Figure D.3. Northbound approach to US 59/IA 9 intersection

Figure D.4. Southbound approach to US 59/IA 9 intersection

Figure D.5. Existing Stop signs and overhead beacons

Figure D.6. Large reinforced concrete box culvert

Figure D.7. Looking east from Stop sign on northbound US 59

Figure D.8. Numerous utility poles near intersection

Figure D.9. Destination guide sign on eastbound IA 9

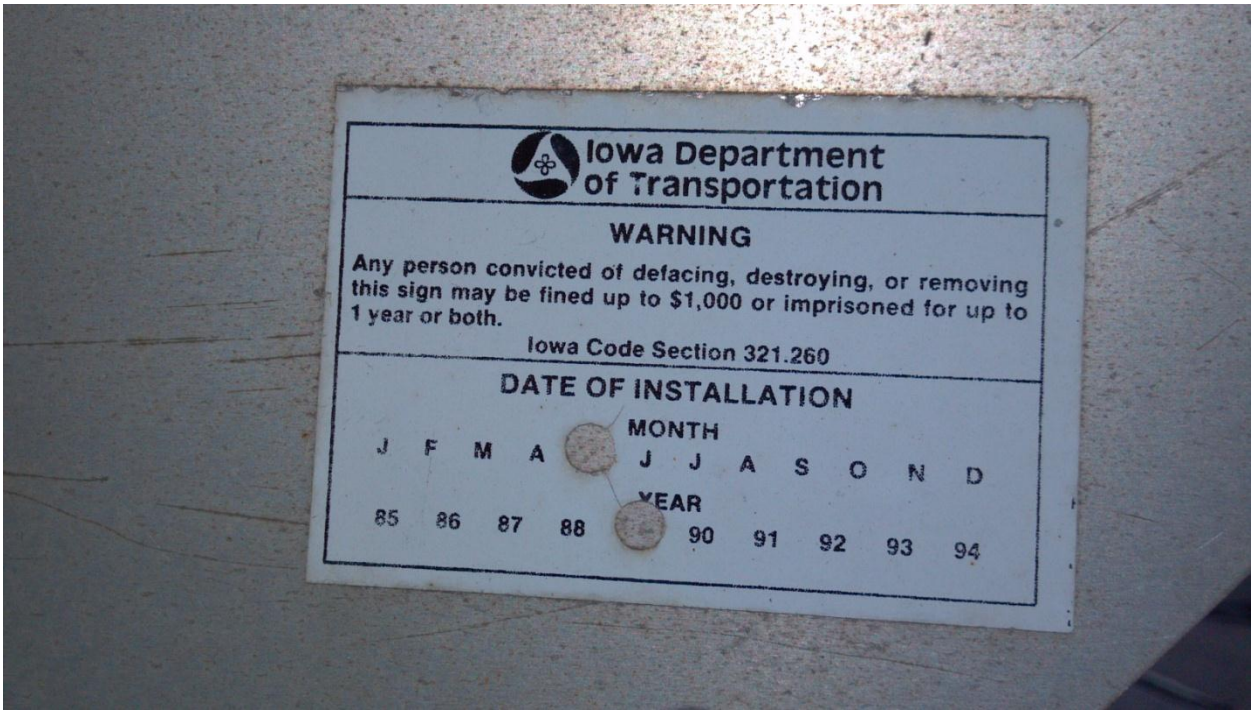

Figure D.10. Installation date sticker on existing sign

Figure D.11. Truck parking evidence on granular shoulder

Figure D.12. Route markers at intersection

Figure D.13. Shoulder rumble strips at intersection

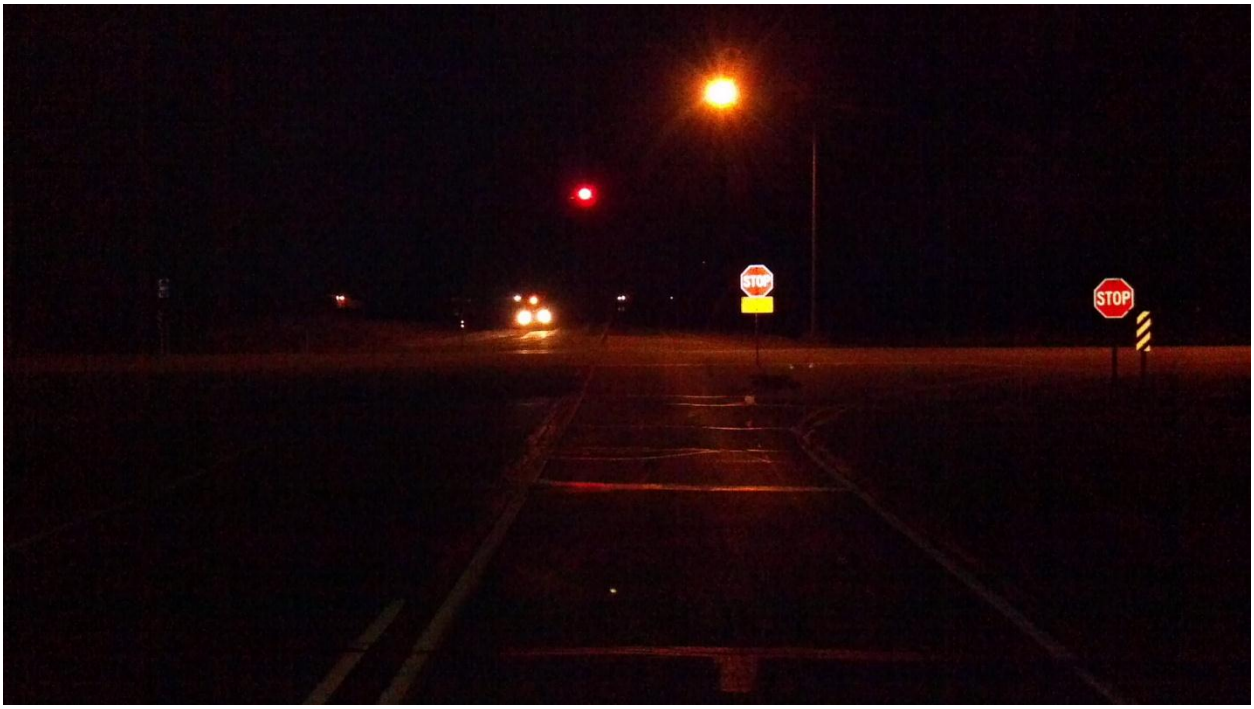

Figure D.14. Nighttime view of intersection

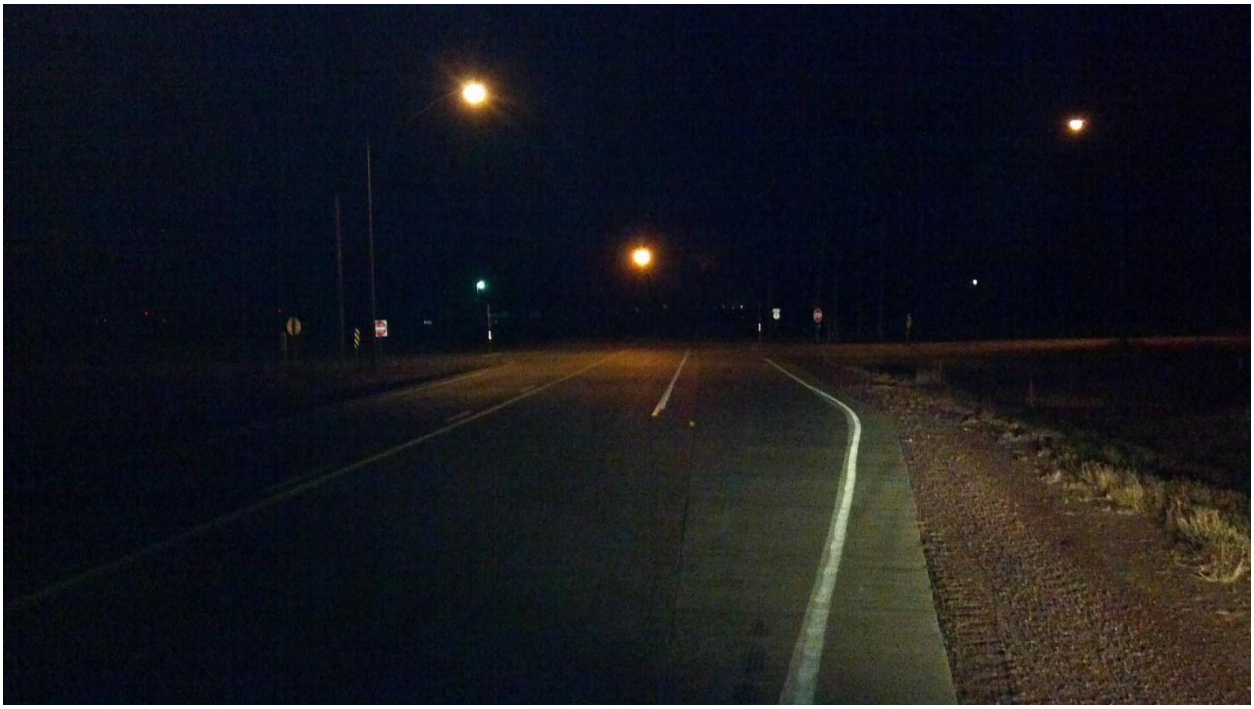

Figure D.15. Painted edge line at night

Figure D.16. Activated warning sign advising of approaching traffic on US 151 at Anamosa, Iowa