IOWA DOT
I-80 Planning Study

INTERSTATE 80
PLANNING STUDY

Existing Systems Needs Analysis: Today & Tomorrow

Office of Location and Environment | January 2018

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Executive Summary

As part of the Interstate (I-80) Planning Study, the Iowa DOT is studying the rural portions of I-80 across the state. The study evaluates the corridor at a system level. As the Iowa DOT undertakes individual projects along I-80, the study provides an understanding of each project's contributions and impacts on the wider system. This technical memorandum is an existing conditions assessment of the rural I-80 corridor.

The analysis looks at both current and future year (2040) anticipated performance conditions for the I-80 study area. This existing system assessment will inform the types of potential improvements that will be recommended for I- 80. This study is informed by the latest available data and tools, and provides a summary of the existing conditions.

Traffic Capacity

Traffic operations and the capacity of I-80 were assessed in five study segment areas for an existing year (taken as year 2015) and a future planning horizon year (2040). The evaluation of traffic operations/capacity serves the purpose of establishing if the existing configuration of I-80 adequately handles current and future traffic or if reconfiguration/widening is needed. Traffic operations are measured by Level of Service (LOS), which range from LOS A (free-flow traffic conditions) to LOS F (congested, gridlock conditions). Results indicate under existing conditions, all representative I-80 segments were found to operate at LOS B or better. LOS B or better is the target for the I-80 Planning Study. However, under 2040 no-build conditions, all segments except segment 1 were found to operate at LOS C or worse in both directions in at least the PM peak hour. By crossing the LOS B/C threshold, the rural I-80 corridor can be expected to experience average speeds slowing below free-flow levels, meaning there will be some peak hour delays/congestion. The finding of LOS C and reduced average speeds at dispersed locations across most segments of the I-80 corridor suggest the need for statewide improvements/strategies to ease congestion and raise the LOS.

Transportation Systems Management and Operations

Transportation System Management and Operations (TSMO) is an approach that seeks to optimize existing infrastructure through improved integration, coordination, and systematic implementation of strategies like Traffic Incident Management, Work Zone Management, and Traveler Information Systems. TSMO was assessed for current conditions and the future planning horizon year of 2040. The evaluation will assist in addressing areas with poor reliability across I-80 due to recurring and non-recurring congestion. TSMO was evaluated for five performance measures: hours of congestion, bottleneck occurrences, bottleneck duration, reliability, and incident rate. The TSMO results indicate issue areas that should be addressed through both management of the system and future construction to improve the corridor's designed capacity and resiliency.

Traffic Safety

The existing and future year 2040 conditions of I-80 were assessed for traffic safety performance. Existing traffic safety conditions were completed for five rural freeway segments expected to represent the typical (or average) freeway segment, by examining the past five years of crash data. Crashes that involved fatal and major injuries are of particular concern and accounted for approximately 2.5 percent of all crashes in the study area. Additionally, existing crash conditions were summarized for five “hot spot” segments to provide a comparison to the typical segments. Crashes are anticipated to increase between today and 2040 mostly due to increased traffic volumes on I-80.

Geometrics and Physical Conditions Analysis

The existing conditions were evaluated for pavement and bridge conditions, geometric analysis including minimum horizontal radius, maximum vertical grades, and minimum stopping sight distance. Each feature was evaluated on a “good”, “fair”, and “poor” rating scale. The results of the bridge and pavement condition along the I-80 corridor indicate well maintained infrastructure. The majority of the corridor is rated good while less than two percent of the elements received a poor rating. Route continuity and lane balance concerns are limited to one location in the study area. Since the construction of the interstate system in the late 1950s, speed limits have increased and the corresponding design criterion has changed. These changes are most prevalent at the horizontal curve locations. Over 40 percent of the horizontal curves within the study area are rated poor due to the radius and superelevation not being suitable for the increased design speeds.

Environmental Resources

Study area environmental resources were evaluated based on readily-available electronic data. The resources were identified as potential constraints for consideration in planning improvements to I-80. This evaluation focused on resources that influence environmental permitting, coordination, and engineering design. Environmental resources were identified in each county across I-80.

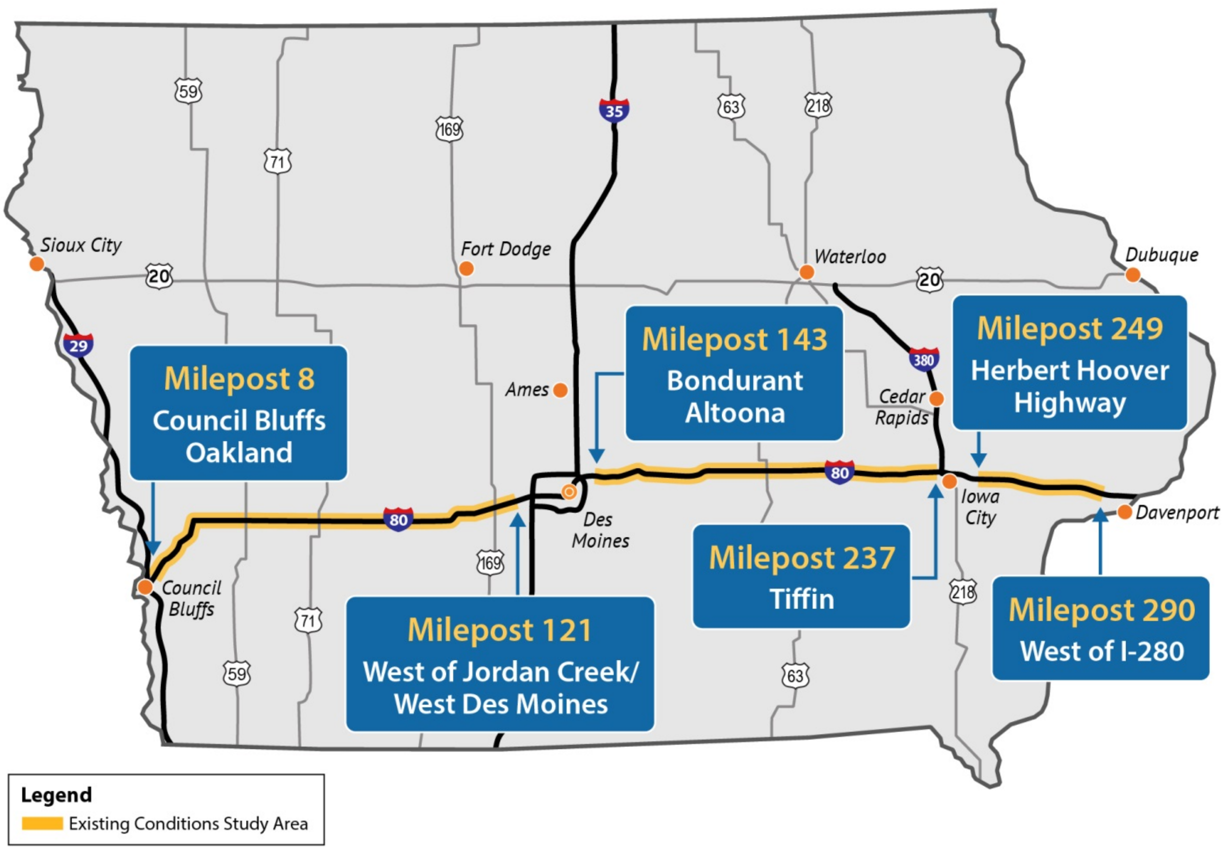
This report provides a summary of the current and anticipated future needs and resources along the existing rural portions of the I-80 system. As the DOT undertakes individual projects along I-80, the information provided in this report should inform decision-making.

Introduction

Study Background

As part of the I-80 Planning Study, the Iowa DOT is studying the rural portions of I-80 across the state. The study uses a Planning Environmental Linkages (PEL) approach, to evaluate the corridor at a system level and prioritize individual projects. As the Iowa DOT undertakes individual projects along I-80, this systematic approach will provide a comprehensive understanding of each project's contributions and impacts on the wider system. **Figure 1** illustrates the rural portions of I-80 that are included in the PEL study, which do not include the urban portions of the Council Bluffs, Des Moines, Iowa City, and Davenport areas.

Figure 1. I-80 PEL Study Area



This document is one in a series of technical memorandums encompassing various topics to communicate different aspects of the study.

Report Purpose

This existing conditions report identifies corridor resources and the performance of I-80 study area segments. This includes assessments from a variety of perspectives, and is documented in the following sections:

- Traffic Capacity
- Transportation System Management & Operations
- Traffic Safety
- Geometrics and Physical Conditions Analysis
- Environmental Resources

This assessment looks at both current and future year (2040) anticipated performance conditions for the I-80 study area. This existing system assessment will inform the types of potential improvements that will be recommended for I-80. This study uses the latest available data and tools, and provides a summary of existing conditions. More detailed technical information is available in the appendices at the end of this report.

Traffic Capacity Analysis

INTRODUCTION

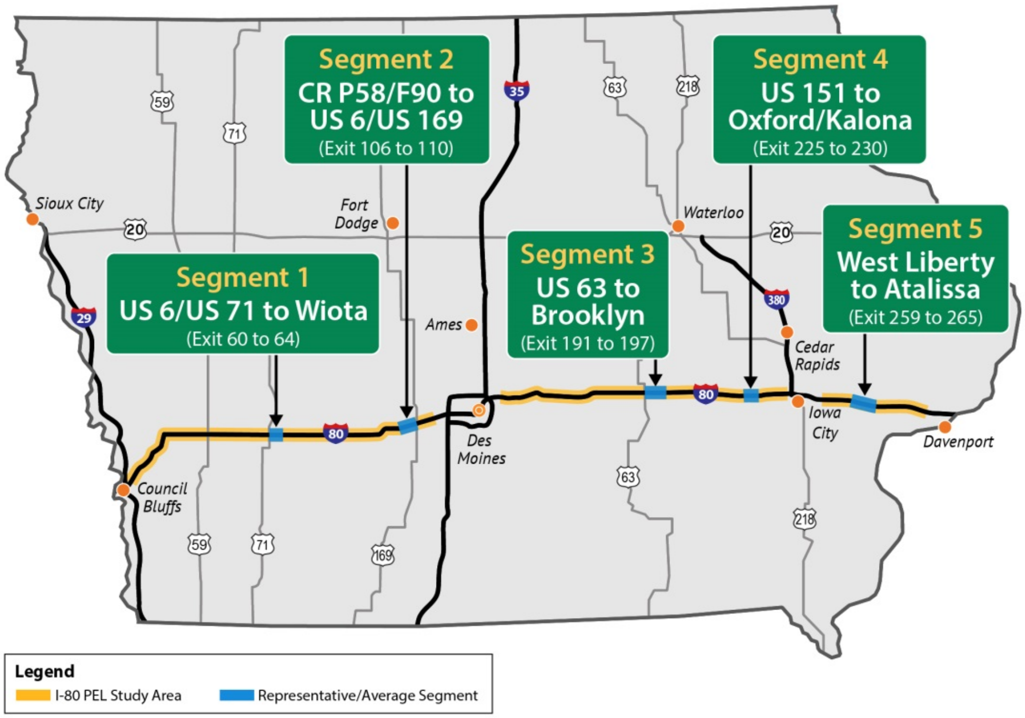
Traffic operations and the capacity of I-80 were assessed for an existing year (taken as year 2015) and a future planning horizon year (2040). The evaluation of traffic operations/capacity identifies how well the existing configuration of I-80 adequately handles current and future traffic or if reconfiguration/widening is needed. The I-80 traffic operations/capacity analysis is documented herein, using the following structure: methodology, development of existing conditions models and model results, development of future "no-build" conditions models and model results, and findings.

METHODOLOGY

Typical Segment Selection

Traffic capacity analysis was conducted to support long-term planning for 248 miles of I-80 within the study area. Given the expansive project scope, full analysis of each segment's individual traffic operating characteristics was deemed not appropriate for this planning stage. In the place of detailed analysis for hundreds of I-80 segments, the project team chose a number of representative freeway segments to analyze that would have similar operating characteristics to dozens of nearby segments. **Figure 2** depicts the study generalized, or "typical" I-80 segments chosen for this traffic capacity analysis. Further explanation of segment selection is covered in **Appendix A.**

Figure 2. Typical I-80 Segments Analyzed in Study



Traffic Volume Development

Once the typical I-80 segments were identified, the next step in traffic capacity analysis was to develop traffic volumes. The traffic volume development process required detailed investigation of existing count data to capture vehicle peaking characteristics (i.e., "what are the busiest times of the day?") and vehicle fleet mix on the studied roadway sections. The following concepts are important in the I-80 capacity analysis:

- **Peak hour volumes**: In a given direction, how much of the daily traffic volume occurs in the AM and PM peak hours?
- **Design hour volume**: How much higher are peak hour volumes on the 30th highest day of the year versus the average day? The 30th highest peak hour volume in a given year is known in engineering as the design hour volume, and is practical way to make sure a designed facility can handle a reasonably high level of traffic that would occur under typical conditions.
- **Vehicle fleet mix**: What component of the vehicle fleet on I-80 are automobiles (cars, pickups, SUVs), and what component are delivery trucks and semi-trucks? How big are those delivery trucks and semi-trucks, and how many are there in comparison to the automobiles?

After reviewing traffic data, we could establish when the traffic peaks, and what the vehicle mix was during that peak on I-80 in the existing condition. To forecast future 2040 traffic conditions, a more simplified approach was applied. The future conditions volume development considered daily traffic growth for passenger car and truck trips, and assumed similar peaking characteristics to the present day conditions. By applying the existing peaking characteristics to future daily volumes, the traffic volumes for future analysis used a conservative approach. As traffic volumes increase in future years and traffic operations begin to degrade, Iowa DOT will begin to start designing more detailed, project-level improvements in the I-80 corridor. These future project-level traffic analyses will investigate how traffic peaking characteristics may change in the future and how those changes may impact design needs.

Modeling Tool

Another key aspect of the study methodology is the use of an appropriate traffic modeling tool. More discussion about the traffic capacity modeling tool is provided in **Appendix A**.

The traffic capacity analysis used segment-specific inputs such as traffic volumes, speed information, and roadway geometry (roadway geometry includes number of travel lanes and the presence of interchange ramps). The traffic capacity analysis calculated one primary performance measure: segment density, which can be correlated to a level of service (LOS). Density is a measure of how many passenger cars (pc) are located within a mile (mi) of freeway lane (ln) at a given time. For the basic freeway analyses conducted in this study, the conversion from density to LOS is completed using **Table 1** with LOS A and B serving as the study's target performance levels.

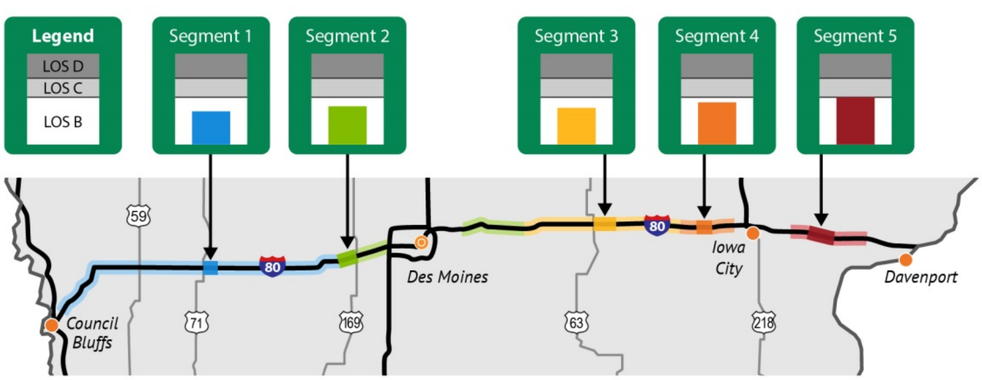
Table 1. Freeway Level of Service by Density Ranges

Level of Service (LOS)	Density (pc / mi / ln)
A	≤ 11
B	> 11 - 19
C	> 18 - 26
D	> 26 - 35
E	> 35 - 45
F	Demand exceeds capacity OR density > 45

EXISTING CONDITIONS MODELS

Existing conditions traffic models were developed to determine the existing LOS on I-80 segments. Details of key model parameters are included in the **Appendix A**. The segment density and LOS are based on the geometric, traffic volume, and base speed conditions along each segment. **Figure 3** shows the existing conditions traffic analysis LOS results for the worst peak direction by segment.

Figure 3. Existing Conditions Traffic Capacity Results by Segment



The existing conditions traffic operations analysis shows that all 5 representative study segments exhibit LOS B or better in both directions in both AM and PM peak hours. At the LOS A and B levels of congestion, average segment speeds remain at the segment free-flow speed, meaning there is no congestion during the design hour volume, which is very desirable for travelers. As LOS B has been set as the target for the I-80 Planning Study Guiding Principles, no rural segments of I-80 currently exhibit a mobility need based on existing LOS alone. The detailed results from the existing conditions traffic capacity analysis are provided in **Appendix A**.

FUTURE NO-BUILD CONDITIONS MODELS

Future no-build conditions traffic capacity models were developed to assess whether the growth in traffic along I-80 might lead to poor operations. In the 2040 no-build models, only the design hour volumes are modified to account for corridor traffic growth. The no-build condition assumes no roadway improvements or widening has taken place by 2040. Annual traffic volume growth rates were used to factor up the design hour volumes using a compounded growth equation. The annual traffic volume growth rates and a resulting total growth rate are shown in **Table 2**.

Table 2. Traffic Volume Growth Rates by Segment, Existing 2015 to No-Build 2040

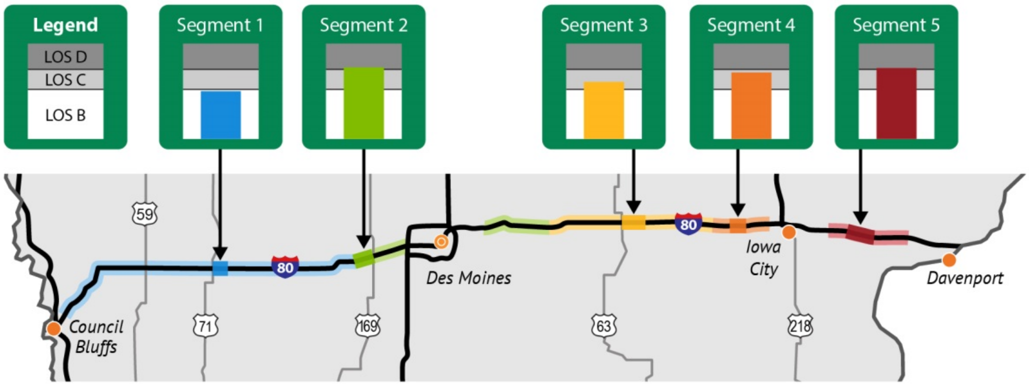
Location	Annual Growth Rate Existing vs. Future Conditions (%) 2015-2040	Total Growth Rate (%) 2015-2040
Exit 60 (US 6/US 71) to Exit 64 (Wiota)	1.4%	42%
Exit 106 (CR P58/F90) to Exit 110 (US 6/US 169)	1.8%	57%
Exit 193 (US 63) to Exit 197 (Brooklyn)	1.6%	47%
Exit 225 (US 151) to Exit 230 (Oxford/Kalona)	1.6%	48%
Exit 259 (West Liberty) to Exit 265 (Atalissa)	1.7%	52%

Source: Iowa DOT Systems Planning, I-80 Planning Study Forecasts, 2017 (unpublished)

Detailed traffic forecast data are provided in **Appendix A.**

Applying these growth rates to the existing (2015) design hour volumes, the project team derived 2040 no-build condition design hour volumes. The increased future volumes were evaluated for the 2040 no-build condition, which used the same posted speed and geometric characteristics as existing conditions. **Figure 4** depicts the 2040 no-build condition LOS results for the worst peak direction by segment.

Figure 4. Future 2040 No-Build Conditions Traffic Capacity Results by Segment



The 2040 no-build condition traffic analysis shows that the growth in peak hour volumes is expected to lead to degraded quality of traffic service. Most locations drop one letter grade on the LOS scale, with LOS C or worse conditions in the PM peak hour on four of the five study segments. Segment 2 drops to a LOS D and Segment 5 sits just on the threshold of LOS D during the worst-case peak hour. Given the I-80 Planning Study guiding principle of maintaining mobility at LOS B or better, the 2040 no-build conditions fails to meet the desirable target for LOS. This finding is similar to the Diversion Strategies tech memo that found daily traffic operations for 23 percent of the corridor to be in the fair range (LOS C) and 61percent of the corridor to operate in the poor range (LOS D or worse). The primary difference between these two findings being the more stringent LOS criteria applied for classifying daily operations. The detailed results from the Future No-Build conditions traffic capacity analysis are provided in **Appendix A**.

The result of entering the LOS C range in the peak hours is that congestion on the segment reaches a breakpoint where average vehicle speeds start to dip from drivers' preferred free-flow speed. In urban areas, this dip in speeds is expected during peak hours, but traditionally rural corridors have assumed a higher standard of service (LOS B) that keep average segment speeds at the segment free-flow speed.

Additionally, further study is needed to identify the detailed lane needs for the area just west and east of Des Moines, with volumes on the west being slightly higher. As volumes in this region begin to increase substantially and take on a more urban characteristic, peak hour service for through I-80 travelers will see substantially reduced speeds. The results for Segments 3 and 5 are representative of portions of I-80 that will remain predominately rural in nature through the year 2040. The sections of I-80 closer to the metro areas of Des Moines and Iowa City may require either more substantial widening than the other studied regions or may require alternative forms of improvement.

FINDINGS

Traffic operations analysis was conducted for five representative freeway segments along rural I-80. The traffic operations analysis looked at the LOS for existing conditions (2015) and future no-build conditions (2040). Based on the I-80 Planning Study guiding principles, acceptable traffic operations are LOS B or better. Under existing conditions, all representative I-80 segments were found to operate at LOS B or better during the peak hour. Under 2040 no-build conditions, Segments 3 and 4 were found to operate at LOS C in both directions in at least the PM peak hour. By crossing the LOS B/C threshold, the rural I-80 corridor can be expected to experience average speeds slowing below free-flow levels, meaning there will be some design hour delays/congestion. The finding of LOS C and reduced average speeds at dispersed locations across most segments of the I-80 corridor suggests the need for statewide improvements to ease congestion and raise the LOS.

The most critical segments for future study and design appears to be Segment 2, representing the growing urban influence of Des Moines to the west and to the east, and Segment 5 representing the rural area between Iowa City and the Quad Cities. Segment 2 reaches a LOS D, but represents roughly 11 miles west of the Des Moines metro and 21 miles east of the metro that experience more significant traffic volume growth than the rest of the study area. No-Build conditions in these two regions would likely approach LOS D or worse, meaning traffic would be slowed by congestion significantly in the peak hours. To mitigate the safety concerns and user cost of slow traffic on I-80, the regions just west and east of the Des Moines metro area should be studied in greater detail, particularly in regards to traffic volume growth and how that growth impacts design.

The segment in greatest need of near term improvements is Segment 5. Segment 5 operates at an acceptable LOS B today, but is nearing the LOS C threshold. By 2040, Segment 5 will just enter the LOS D level, which makes it the second worst operating segment in the future and considered poor condition by the expectations set in this study. In prioritizing improvements to I-80, the area east of Iowa City to Walcott should be considered a high priority location based on traffic capacity.

Transportation System Management & Operations

INTRODUCTION

Transportation System Management and Operations (TSMO) is a cross-cutting approach to optimize existing infrastructure through better integration, coordination, and systematic implementation of key operational strategies like Traffic Incident Management, Work Zone Management, and Traveler Information Systems. TSMO differs from traditional methods by changing the question from, “Can I-80 move enough traffic at a desirable quality level?” to, “Can I-80 be operated more efficiently to give travelers the best possible quality of service using the existing roadway?”. In this study, TSMO was assessed for existing years (2013-2015) and a future planning horizon year (2040). The evaluation of TSMO will assist in addressing areas with poor reliability across I-80 during recurring and non-recurring congestion. The TSMO analysis conducted for I-80 is documented herein and describes the methodology and results.

METHODOLOGY

The TSMO analysis was completed for the entire study area. Five TSMO performance measures were selected for evaluation:

1. **Hours of Congestion –** measures the amount of time where travelers are moving at 45 miles per hour or slower. Captures both daily rush hour slowdowns and those related to bad weather and crashes.
2. **Bottleneck Occurrences –** measures congestion conditions severe enough that vehicles must slow to nearly a stop causing a queue of vehicles to build back toward upstream interchanges. This metric most commonly identifies ramps that are no longer adequate to handle their function

of allowing traffic to efficiently enter/exit the freeway with minimal impact to travelers already on the freeway.

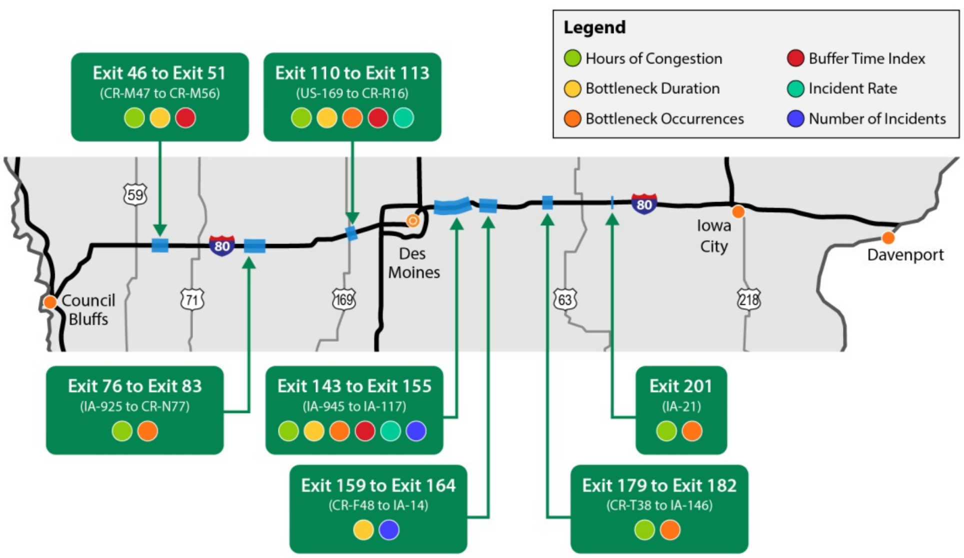
3. **Bottleneck Duration –** measures the time taken to return to normal conditions when a bottleneck occurs. This metric most commonly identifies areas that are not resilient to unexpected congestion. Examples might include a freeway segment on the fringe of an urban area where first responders have difficulty reaching an incident or crash, but the demand for the freeway segment is high. These freeway segments may not experience congestion or incidents often enough to receive dedicated monitoring and management, but could benefit from emergency response and system operator response planning.
4. **Buffer Time Index (Reliability) –** measures the extra time or “buffer time” a traveler needs to leave early to be sure of on-time arrival to a destination. The buffer time addresses the issue of reliable travel times, which are highly valued by freight shippers and truck drivers, business travelers, and social/recreational travelers. The penalty for arriving late can often lead to very early departures that can result in a loss of productivity and or time that could be spent on other activities.
5. **Incident Rate –** measures the number of randomly occurring incidents like bad weather, maintenance activities and crashes. Areas with a greater likelihood of incidents may highlight needed spot improvements to maintain efficient traveler mobility.

These metrics are defined and assessed in a data driven manner. The data analysis and detailed findings are described in **Appendix B**.

EXISTING RESULTS

The results of the TSMO performance measures are summarized below. A Top 10 Worst list was created for each TSMO performance measure. Locations appearing more than once on the TSMO Top 10 worst lists are noted in **Figure 5**.

Figure 5: Worst TSMO Segments



Many factors may contribute to the locations that experience poor TSMO performance measures. The following factors were reviewed for possible causation:

- Bad weather
- Road work
- Overnight driving
- High crash frequency locations
- Geometrics (horizontal radii, vertical grade, and stopping sight distance)
- Infrastructure (pavement and bridge conditions)
- Operational features (capacity analysis)

The five TSMO performance measures indicate areas that are recommended for additional TSMO review in the design process. These issue areas should be addressed through both management of the system and future construction to improve the corridor's designed capacity and resiliency. Separate from any consideration of corridor capacity, recommended improvements in system management would stem from Iowa DOT efforts to utilize some of the following strategies: Highway Helper, Traffic Incident Management (TIM), Maintenance Decision Support Systems (MDSS) for winter weather, Intelligent Work Zones (IWZ), and identification and implementation of spot improvements (bottleneck removal). Future additional capacity has the potential to reduce work zone impacts on I-80 and ease bottlenecks corridor-wide through better balance between travel demand and available capacity and improved design of freeway access locations.

FUTURE NO-BUILD RESULTS

Future TSMO conditions were not quantified but can be addressed by general trends. The most significant variable affecting TSMO is traffic volumes. From 2015 to 2040, traffic is expected to grow approximately 50 percent throughout the study corridor. The traffic growth will result in worse TSMO conditions. I-80 westbound between Exit 110 and Exit 113 exhibits poor TSMO conditions and is expected to experience the highest projected traffic growth (60 percent). This location will benefit the most from future widening in order to handle the future increased traffic.

Other variables that affect TSMO are crashes, incidents, and weather. Crashes and incidents are expected to increase in the future due to increased traffic volumes and congestion. Iowa DOT will benefit most from utilizing the following strategies: Highway Helper, Traffic Incident Management (TIM), and Intelligent Work Zones (IWZ), Integrated Corridor Management (ICM), and use of alternative modes (like bus and rail travel). Additionally, future TSMO on I-80 will be impacted by industry development of automated vehicles (AVs) and how Iowa DOT operates I-80 in relation to AVs, which is discussed in the I-80 Automated Vehicles Tech Memo. In regards to weather, Iowa DOT is developing a separate Resiliency and Vulnerability Technical Memorandum that will address the potential effects of inclement weather. A detailed illustration of the TSMO results is available in **Appendix B.**

Traffic Safety Analysis

INTRODUCTION

The existing conditions of I-80 were assessed for traffic safety performance using 2012–2016 crash records. An additional analysis was completed for a future planning horizon year (2040) to evaluate no-build conditions. This provides insight about the future safety conditions if no future expansion were to occur on I-80. The traffic safety analysis completed for existing conditions and 2040 no-build for I-80 is documented using the following structure: methodology, summary of existing crash records, and future no-build condition (i.e, 2040 no-build) model results.

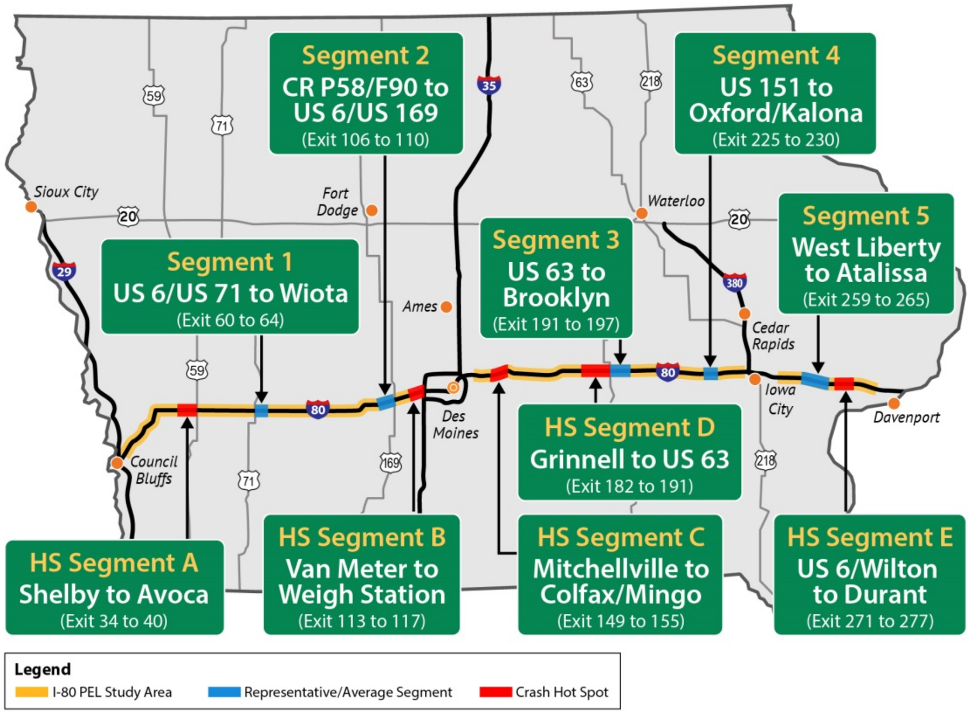
METHODOLOGY

Hot Spot and Typical Segment Identification

Like the traffic capacity analysis, the documentation of existing traffic safety conditions was completed for five rural freeway segments expected to represent the typical (or average) freeway segment. Additionally, existing crash conditions were summarized for five hot spot segments to provide a comparison to the typical segments.

A Geographic Information System (GIS) based analysis technique was used to identify if there were statistically higher than expected concentrations of crashes in an area, such as a freeway segment. Initial geographic analysis mostly identified interchanges as hot spots. To focus the evaluation on the rural mainline segments of I-80; crashes on ramps and between the exit and entrance ramps at an interchange were removed through a simple visual selection of the crash points. The geographic crash assessment results (see **Appendix C, Figures C1-C12**) were used to identify five typical and five hot spot segments (**Figure 6**). The selection of typical segments was coordinated with the traffic capacity analysis for consistency. To confirm that the crash activity on these segments was typical (segments with blue or tan colors in **Figures C1-C12**), the segments were visually scanned in GIS for any out of the ordinary crash concentrations. Since none were found, the segments were used to assess the corridor's typical crash activity. In addition, eight candidate hot spot segments were initially identified for the study by scanning the corridor for crash concentrations (segments with orange or red colors in **Figures C1-C12**). To narrow down to the final five hot spot segments; the number of severe crashes (those crashes that resulted in a fatal or major injury) was identified for those rural freeway segments that had a notable hot spot (segments with red in **Figures C1-C12**). Selection of the five hot spot segments considered the size and intensity of hot spots as well as the number of severe crashes.

Figure 6. Study Typical and Crash Hot Spot I-80 Segments Analyzed



Future No-Build Conditions Modeling

Evaluation of the 2040 no-build safety conditions used a modeling approach where key traffic volume and roadway geometric characteristics such as number of lanes, lane width, shoulder width, median width, horizontal roadway alignment, and location and distance to traffic barriers were used to estimate future crash frequency by severity. The traffic capacity and safety analyses used the same traffic volumes. The crash prediction model output reports are provided in **Appendix C**.

EXISTING CONDITIONS

Crash Patterns for Hot Spot and Typical Segments

For the five typical and five hot spot segments, the crash records for each segment were evaluated to identify patterns in the crash records. Between 2012 and 2016, there were a total of 8,636 crashes in the I-80 study area, of which 63 were fatal and 157 were major injury (a combined total of 2.5 percent of crashes in the study area). There were 505 crashes throughout the typical segments and 665 crashes in the hot spot segments, which is over 13 percent of all crashes in the study area.

Most hot spot segments had at least 4 severe crashes, those crashes involving a fatal or major injury (HS Segment B was the exception with a single severe crash), while most typical segments had fewer than 4 severe crashes (Hot Spot Segment C was the exception with 6 severe crashes). Overall, hot spot segments had twice the number of severe crashes (fatal plus major injury crashes) when compared to typical segments. In total, the 37 severe crashes in the ten study segments are nearly 17 percent of all severe crashes in the I-80 study area.

Crash rates were also computed for this evaluation. Crash rates adjust the number of crashes along a segment by how much travel occurs on that segment. The amount of travel is measured in vehicle miles traveled, simply how much traffic a segment has multiplied by its length. The crash rates for the typical segments range from 35.8 crashes per 100 million vehicle miles traveled (100M VMT) to 54.0. The hot spot segment crash rates ranged from 20.3 to 52.7. Overall, the crash rates for the typical and freeway hot spot segments have no noticeable differences. When compared to the Iowa statewide average crash rate for rural interstates (47.8 crashes per 100M VMT), one typical segment (Segment 5) and one hot spot segment (Hot Spot Segment C) have a crash rate that exceeds the statewide average (**Figure 7**). The crash rates indicate that while the hot spot segments have a concentration of crashes within the segment, that overall the hot spots have a rate of crashes similar to typical segments.

The crash rate for fatal and major injury crashes (severe crashes) was also computed for the ten segments. The severe crash rate for two typical and three hot spot segments is above the statewide average (1.4 severe crashes per 100M VMT). However, only the crash rate for Segment 3 and Hot Spot Segment A is noticeably above the statewide average.

Figure 7. Crash Rates for Typical and Hot Spot Segments

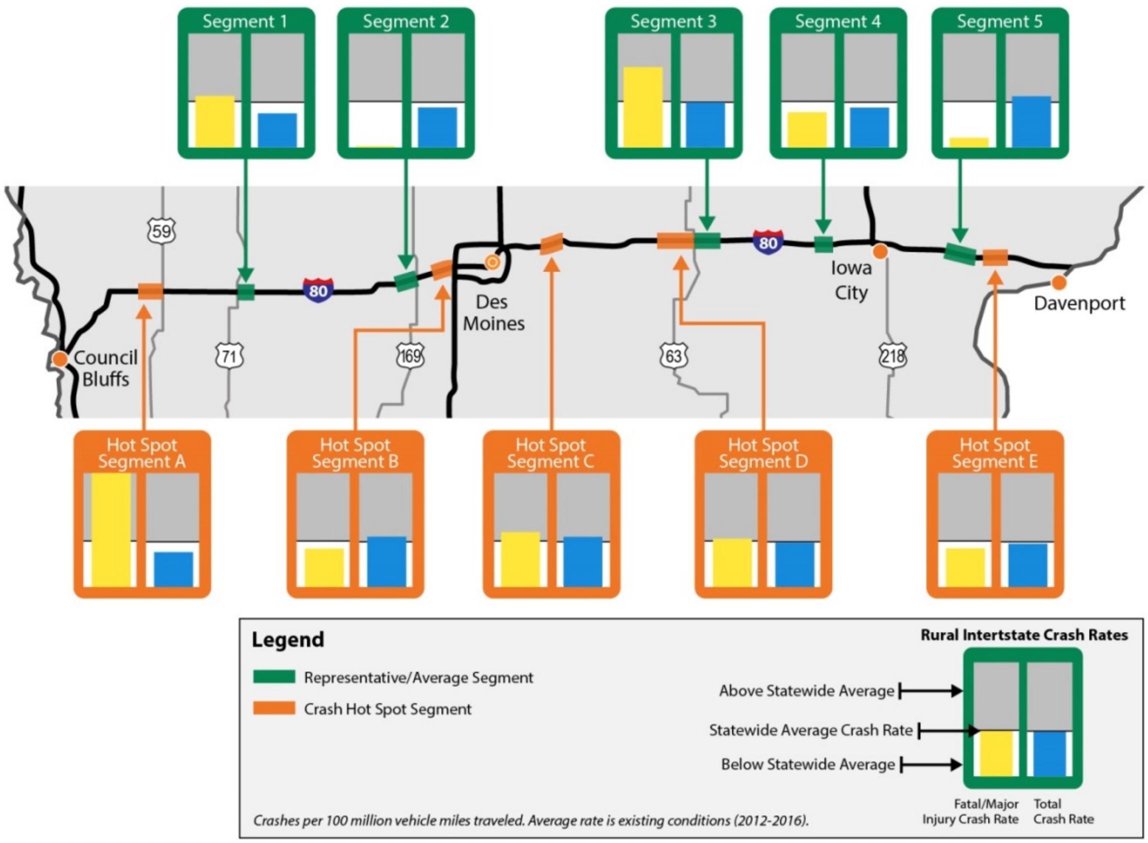


Table 3 summarizes the top five reported major causes for the crashes in the typical and hot spot segments (individual segment summaries are availabe in **Appendix C**.

Table 3. Top 5 Reported Major Causes by Segment Type

Major Cause	Typical Segments	Hot Spot Segments
Animal	23%	16%
Ran off road – left	17%	16%
Driving too fast for conditions	11%	14%
Ran off road – right	11%	10%
Swerving/evasive action	11%	11%

Source: Iowa DOT, 2012-2016, webSAVER accessed on July 10, 2017

Animal crashes are the most frequently reported major cause for both typical and hot spot segments, which is common for rural segments. In total, the top five reported major causes (animal, ran of road – left, driving too fast for conditions, ran off road – right, and swerving/evasive action) account for 73 percent of all crashes in the typical segments and 67 percent of the crashes in hot spot segments (**Table 3**). Most of the difference is explained by animal crashes, which accounted for 23 percent of crashes in the typical segments and only 16 percent of hot spot segment crashes. The percentage of crashes for the other top 4 major causes changed only a few percentage points between typical and hot spot segments and overall the other top 4 major causes summed to nearly the same total. The lower percentage of animal crashes on hot spot segments is reflected in slightly higher percentages across multiple other major causes.

In the hot spot segments, the majority of reported major causes for severe crashes involved some form of driver behavior (**Table 4**). This included 14 of the 25 crashes where the major cause referenced were speed, swerving, following too close or driving in a reckless manner. Seven crashes reported ran off road and one crash cited equipment failure. Driver behavior may contribute to run off road crashes, but there is insufficient information to know how driver behavior contributed to the seven crashes

Table 4. Top 5 Reported Major Causes for Severe Crashes in Hot Spot Segments

Major Cause	Number Reported
Swerving/evasive action	4
Ran off road – right	4
Ran off road – left	3
Driving too fast for conditions	3
Operating vehicle in an reckless, erratic, careless, negligent manner	3
Exceeded authorized Speed	2
Followed too close	2
Equipment failure	1

Source: Iowa DOT, 2012-2016, webSAVER accessed on July 10, 2017

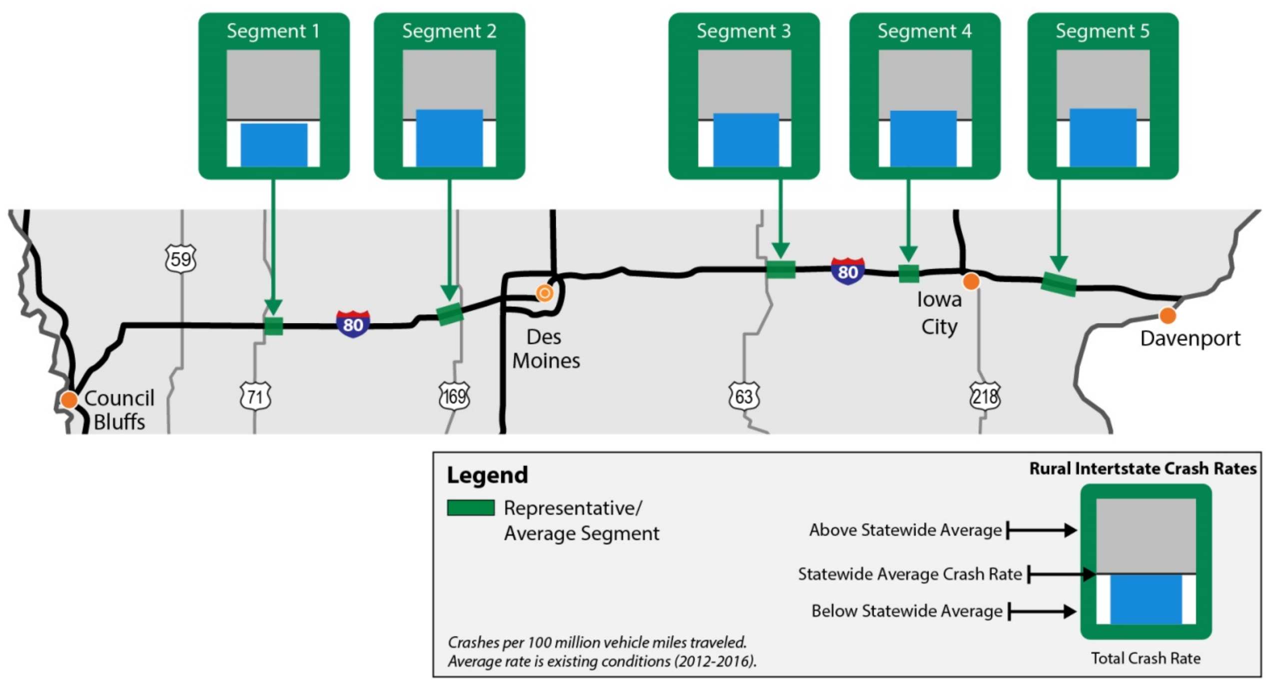
Crash Predictions for Typical Segments

Only the five freeway segments selected to represent the typical condition were evaluated for future crash predictions. See **Appendix C** for the details of this analysis. For the 2040 no-build condition, it was assumed the freeway geometric conditions remain unchanged while traffic volumes continue to grow.

When compared to existing crashes, total crashes per year in the typical segments increased from 101 observed crashes per year (2012-2016 average per year) to 189 predicted crashes per year, an 87 percent increase in the total number of crashes. Between 2012 and 2016, the five typical rural freeway segments averaged approximately 20 fatal and injury crashes per year and 81 property damage only (PDO) crashes per year. The 2040 predicted crash frequency increases to approximately 35 fatal and injury crashes in a single year, a 75 percent increase when compared to the existing conditions. Property damage only crashes are predicted to increase by 77 percent. The crashes in 2040 are anticipated to increase mostly due to higher traffic volumes in 2040.

The future analysis results in a 2040 predicted crash rate for all typical segments (**Figure 8**) that is higher than the existing crash rates. Based on the analysis, all segments except for Segment 1 are anticipated to have a crash rate that exceeds the current rural interstate average crash rate. In comparison, only Segment 5 has an existing crash rate that exceeds the statewide average.

Figure 8. Predicted 2040 Crash Rates for Typical Segments



Geometrics and Physical Conditions Analysis

INTRODUCTION

The existing conditions evaluated were pavement and bridge conditions, geometric analysis including minimum horizontal radius, maximum vertical grades, and minimum stopping sight distance. Each feature was evaluated as “good”, “fair”, and “poor”. Features or measures rated “good” meet or exceed current design standards or guidelines. A rating of “fair” reflects characteristics that are near or close to minimum standards or guidelines. A rating of “poor” indicates that the feature is substandard with respect to the standards or guidelines. Data used in this geometric and physical conditions analysis can be located in **Appendix D.**

PAVEMENT CONDITIONS

The quality of the roadway surface is determined by the International Roughness Index (IRI) which measures the smoothness of the pavement along the longitudinal wheel path, and the Pavement Condition Index (PCI) for the interstate system which is based on pavement surface distress. The breakdown of the measured scale for these conditions is shown below in **Table 5**.

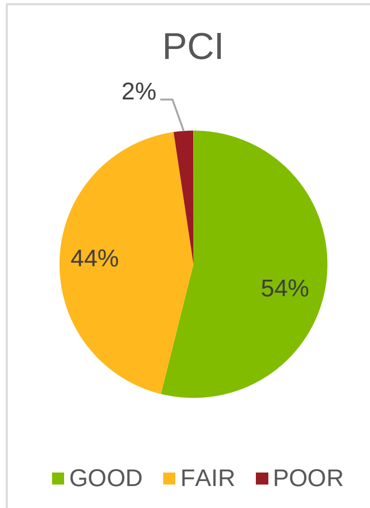
Table 5. Criteria for Interstate Pavement Condition

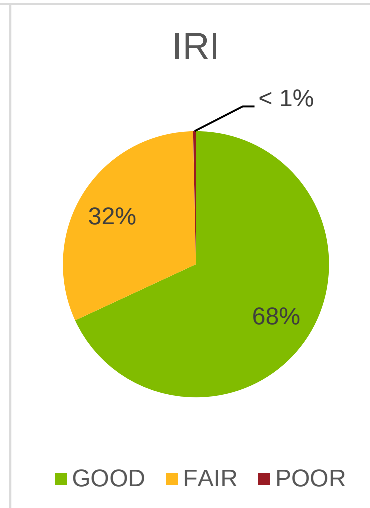
Rating	Pavement Condition Index (PCI) (Interstate)	International Roughness Index (IRI)
Good	76 – 100	0 – 94
Fair	51 – 75	95 – 170
Poor	0 – 50	171 +

The results are summarized below based on lengths of pavement. The total length of pavement reviewed was 496 miles, which includes both the eastbound and westbound directions (248 miles in each direction). For the PCI criteria, the majority of the pavement is classified as good and fair, and for the IRI criteria, the only pavement classified as poor is located in Dallas County. The pavement classified as fair for both criteria is concentrated in Dallas, Polk, and Jasper counties with a large section located in Cass County. The only locations of pavement classified as poor based on PCI are in Adair and Dallas Counties (see **Table 6**).

Table 6. Existing Pavement Conditions Results

Rating	PCI (miles)	IRI (miles)
Good	265	336
Fair	219	158
Poor	12	2



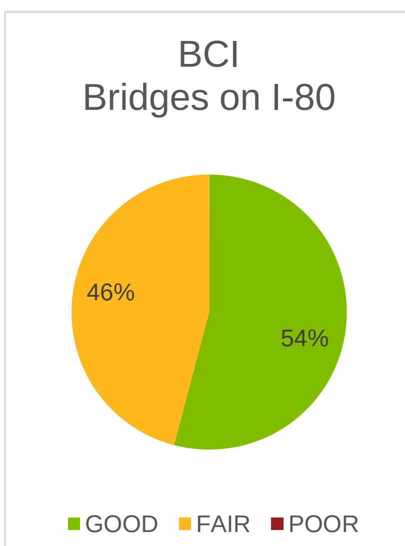


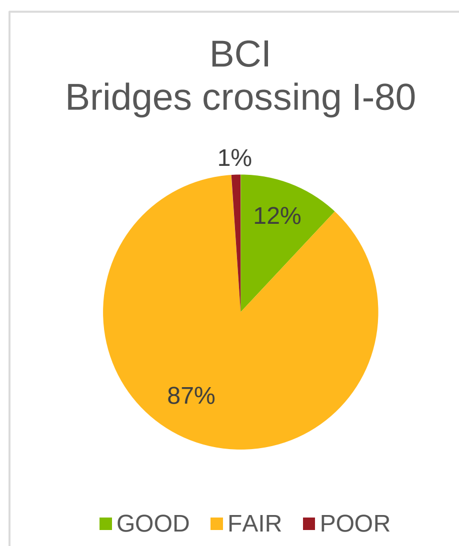
BRIDGE CONDITIONS

Bridge conditions are determined by the Bridge Condition Index (BCI) which measures the overall structure condition, taking into account structural condition, load carrying capacity, horizontal and vertical clearances, width, traffic levels, type of roadway it serves, and the length of out-of-distance travel if the bridge were closed. A bridge rated as poor is not considered unsafe, but should be considered for repair, replacement, restriction posting, weight limits, or continued monitoring on a more frequent basis. If a bridge is considered unsafe, it is closed to the traveling public. The breakdown for this condition is shown below in **Table 7**.

Table 7. Criteria for Interstate Bridge Conditions

Rating	Bridge Condition Index (BCI)
Good	70 – 100
Fair	37.5 – 70
Poor	0 – 37.5





There were 238 bridges evaluated in the study area, including bridges on I-80 and bridges that cross I-80. The results are broken down by number of bridges carrying I-80 traffic versus bridges that cross over I-80 and summarized below. The results of the bridge condition analysis show that almost all of the bridges are in good to fair condition, with only one bridge classified as poor, crossing over I-80 and located in Cedar County (see **Table 8**).

Table 8. Existing Bridge Condition Results

Rating	Bridges on I-80	Bridges Crossing I-80
Good	79	11
Fair	67	80
Poor	0	1

GEOMETRIC ANALYSIS

The analysis of all geometric criteria was based on the *2011 AASHTO Policy on Geometric Design of Highways and Streets*. The design speed of I-80 was evaluated at 75 mph.

Existing conditions were evaluated as “good”, “fair”, and “poor”. Features or measures rated “good” meet or exceed current design standards or guidelines. A rating of “fair” reflects characteristics that are near or close to minimum standards or guidelines. A rating of “poor” indicates that the feature is clearly substandard with respect to the standards or guidelines.

Minimum Horizontal Radii

The minimum required radius for horizontal curves is based on the design speed, existing superelevation rate, and a maximum superelevation rate of eight percent. Superelevation is the banking of a roadway along a horizontal curve so motorists can safely and comfortably maneuver the curve at reasonable speeds. The existing horizontal radius and superelevation for each curve was compared to the minimum required radius to determine the ratings for each curve. These ratings are based on design speed and are broken down in the table below in **Table 9**.

Table 9. Criteria for Elements Based on Design Speed

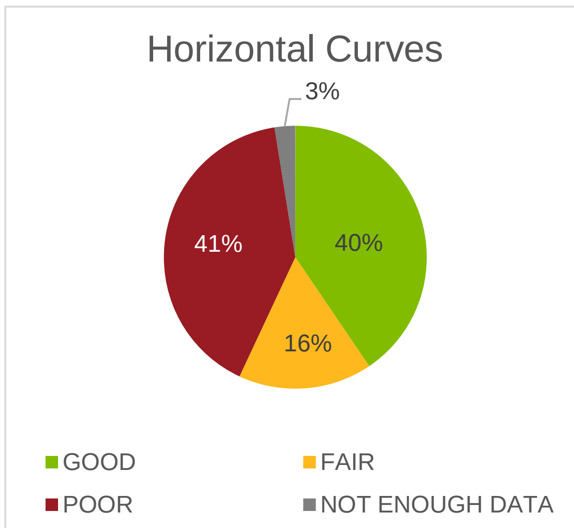
Rating	Based on design speed (mph)	
Good	≥ 75	Meets or exceeds design speed
Fair	65 – 75	0 – 10 mph below design speed
Poor	< 65	> 10 mph below design speed

The results of the 158 horizontal curves analyzed in the study area are shown in the table and graph below. Four curves located in Pottawattamie County at the I-80/I- 680 interchange did not have enough data provided to fully analyze the geometrics. The curves classified as poor are scattered fairly evenly along the interstate, with the heaviest concentration located in Johnson County.

Of the 248 miles of I-80 analyzed, 32 miles consisted of horizontal curves. Ten miles were rated as good, 6 miles as fair, and 16 miles as poor (see Table 10).

Table 10. Horizontal Curve Results

Rating	Number of Curves
Good	64
Fair	26
Poor	64
Not Enough Data	4



Maximum Vertical Grades

The roadway grades, or slope of the roads, were compared to the recommended values. This criterion, shown below, is based on the speed reduction of heavy trucks due to the grade and length of the tangent. The tangents classified as fair based on grade were analyzed further based on length using Figure 3-28 from the *2011 AASHTO Policy on Geometric Design of Highways and Streets* (see **Table 11**).

Table 11. Criteria for Vertical Grade Alignment

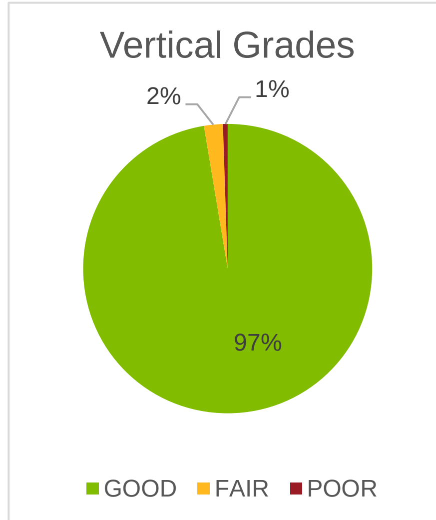
Rating	Grade	Effect of grade on speed
Good	≤ 3%	Reduction in speed less than 10 mph
Fair	3% - 5%	Reduction in speed between 10 and 15 mph
Poor	> 5%	Reduction in speed greater than 15 mph

The results of the vertical grade analysis are summarized below based on each tangent grade and length. The results of the 570 vertical tangents analyzed are shown in the table and chart below. Even though there are no vertical grades above 5 percent in the study area, there are three tangents classified as poor. This is due to the long length of each tangent which results in speed reduction greater than 15 mph (see **Table 12**).

Of the 248 miles of I-80 analyzed, 175 miles consisted of vertical tangents. One hundred and seventy one miles were rated as good, 2 miles as fair, and 2 miles as poor.

Table 12. Vertical Grade Results

Rating	Number of Vertical Tangents
Good	555
Fair	12
Poor	3



Minimum Stopping Sight Distance

Analyzing the adequacy of the vertical curves of the roadway is based on sight distance. Sight distance is the length of roadway ahead that is visible to the driver. Minimum sight distance should be sufficient for a vehicle traveling at the design speed to stop before reaching a stationary object. The controlling criteria for crest vertical curves is the geometry of the roadway itself, while the controlling criteria for sag vertical curves is the amount of roadway that the headlights illuminate while driving at night (where roadway lighting is not present). Sag curves with appropriate lighting can be analyzed based on comfort criteria.

The minimum stopping sight distance for each vertical curve was calculated based on the design speed, tangent (or curve) grades, and length of curve. This results in a "K" value, which is the length of curve divided by the difference in grades of the beginning and end of the curve. This value can be compared to the "K" value ranges shown in the table below in **Table 13**.

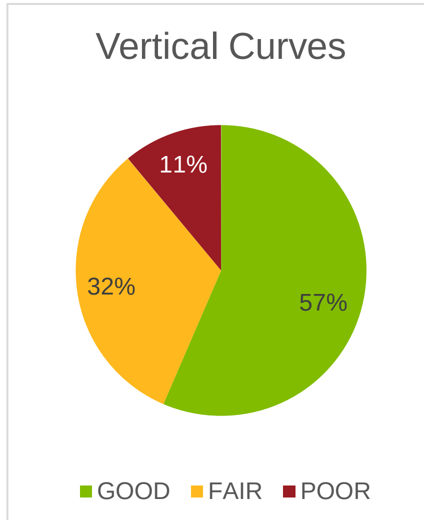
Table 13. Criteria for Stopping Sight Distance

Rating	K Value		Speed (mph)
	Crest Curve	Sag Curve	
Good	≥ 312	≥ 206	≥ 75
Fair	312 - 193	206 - 157	65 – 75
Poor	< 193	< 157	< 65

The results of the 570 curves analyzed are shown below. A majority of vertical curves are classified as good. The highest concentration of fair and poor are in Adair, Dallas, and Jasper Counties. There are a total of 63 vertical curves listed as poor; 56 of them are sag curves and 7 of them are crest curves. Of the 56 sag curves, 55 of them meet comfort criteria and could be corrected with proper lighting of the curve. One sag vertical curve does not meet comfort criteria and would require reconstruction to rectify the insufficiency (see **Table 14**). Of the 248 miles of I-80 analyzed, 78 miles consisted of vertical curves. Forty one miles were rated as good, 29 miles were rated as fair, and 8 miles were rated as poor.

Table 14. Vertical Curve Results

Rating	Number of Vertical Curves	
Good	322	
Fair	185	
Poor	63	
	Sag Curve	Crest Curve
	56	7



SUMMARY OF EXISTING CONDITIONS AND GEOMETRICS ANALYSIS

The results of the bridge and pavement condition along the I-80 corridor indicate a well maintained infrastructure. The majority of the infrastructure is rated good while less than two percent of the elements received a poor rating. The 12 miles of poor pavement are located in Adair and Dallas Counties. The only poor-rated bridge crosses over I-80 and is located in Cedar County.

The results of the geometrics analysis reveal shortcomings in expected areas. Since the construction of the interstate system in the late 1950s, speed limits have increased and the corresponding design criterion has changed. These changes are most prevalent at the horizontal and vertical curve locations. Over 40 percent of the horizontal curves within the study area are rated poor due to the radius and superelevation not being suitable for the increased design speeds. While over 10 percent of the vertical curves received a poor rating due to inadequate sight distance, less than two percent would require reconstruction to improve the rating. The remaining poor-rated locations could be mitigated with the addition of lighting at the sag locations.

Route Continuity and Lane Balance

Additional geometric elements which may have an effect on the operations of the roadway are route continuity and lane balance.

Route continuity was evaluated by reviewing each directional path (e.g., eastbound I-80) to determine if through vehicles in either of the two basic lanes provided are required to change lanes to continue on the intended path and if the through vehicles could remain to the left of the other traffic in operations such as merging, diverging, weaving, etc.

In general, route continuity is maintained throughout the study area for each directional path. The only exceptions to this are the left side exits and entrances contained within the I-80/I-680 interchange. The exit from eastbound I-80 to westbound I-680 is a left hand exit and the entrance from eastbound I-680 to eastbound I-80 is a left hand entrance.

Lane balance reflects the need to provide access to and from a freeway while minimizing disruption to through traffic by requiring unnecessary lane changing.

Overall, lane balance is generally maintained throughout the study area. There is only a single location where lane balance is not maintained. The right lane of eastbound I-80 drops and vehicles are required to merge with the adjacent lane after the merge from eastbound I-680.

Environmental Evaluation

INTRODUCTION

This section presents the results of an evaluation of readily available electronic data to identify environmental resources present within the Study Area as potential constraints for consideration in planning improvements to I-80.

METHODOLOGY

This evaluation focuses on resources that influence environmental permitting, coordination, and engineering design. The following resources were evaluated:

- Cultural Resources
- Parks and Trails
- Floodplains
- Ungrazed and Planted Grasslands
- Regulated Materials
- Streams
- Threatened & Endangered (T&E) Species
- Conservation Lands, including Wildlife Management Areas
- Unique Landforms
- Wetlands
- Woodlands
- Businesses
- Cemeteries
- Religious Places
- Farmland

To identify known resources present within the Study Area (0.25 mile on either side of I-80), available geographic information system (GIS) data were compiled for the Study Area. A descriptive list of sources used for each environmental resource is included in **Appendix E**.

Once the GIS data were compiled, GIS analysis was completed to quantify the resources present in the Study Area and by county. Data were reviewed for potential duplication between data layers to avoid double-counting a resource. These data were then used to identify the relative distribution of resources by county, and determine the county containing the largest acreage or number of each resource. The businesses and threatened and endangered species resources represent the number of businesses and the number of occurrences, respectively. Next, since the miles of interstate varies by county, the data were normalized to show the amount of each resource per mile. This was necessary to identify higher concentrations of resources per county. For example, Cedar County only has 5,313 acres of farmland while Pottawattamie has 9,162 acres of farmland, but when looking at acres of farmland per mile of interstate, Cedar County has 217.0 acres per mile while Pottawattamie County has only 218.9 acres per mile. So while the total acreage of farmland is higher in Pottawattamie County, the concentration is approximately the same in both counties.

ENVIRONMENTAL RESOURCES IN STUDY AREA

The identified Study Area for the planning improvements to I-80 includes 0.25 mile on either side of I-80 within each county from west to east across Iowa (**Figure 9**). The resources described above are the known resources present in the Study Area, but only a small fraction of these would be impacted by improvements along I-80. **Table 15** portrays the resources present and amount of each resource per mile in the Study Area by county from west to east across Iowa.

Figure 9. Counties Across I-80 Study Area

Each resource evaluated has been assigned a symbol, if the resource is not present in the county, the symbol is not included. The numbers in the figure represent the acreage of the resource per mile of interstate in the county, with five exceptions: trails, streams, threatened and endangered species, religious places and businesses. Trails and streams were identified by linear feet, and threatened and endangered species, religious places and businesses by the number of resources. The sections following **Table 15** describe the presence of each resource in more detail. **Tables E1** and **E2** in **Appendix E** provide total amounts of resources per county and resource/mile by county.

Table 15: Environmental Resources per Mile by County

County*	Resource Density																
	Cultural Resources *Acres/Mile*	Parks *Acres/Mile*	Trails *Acres/Mile*	Floodplains *Acres/Mile*	Ungrazed Grasslands *Acres/Mile*	Planted Grasslands *Acres/Mile*	Regulated Materials *Acres/Mile*	Streams *Linear Ft/Mile*	Threatened & Endangered Findings *Resources/Mile*	Conservation Lands *Acres/Mile*	Unique Landforms *Acres/Mile*	Wetlands *Acres/Mile*	Woodlands *Acres/Mile*	Businesses *Resources/Mile*	Cemeteries *Acres/Mile*	Religious Places *Resources/Mile*	Farmland *Acres/Mile*
Pottawattamie *41.9 miles*	1.2		184.1	74.4	67.3	8.0	11.0	5,350.2		< 0.1	39.6	3.3	10.7	0.8	0.7		219.0
Cass *23.6 miles*	0.5		457.2	30.7	56.3	38.2	4.6	5,650.9				5.8	13.7	0.1			221.5
Adair *23.9 miles*	1.3	0.2			59.5	11.8		5,448.1				4.2	9.4	1.8	1.1	0.1	242.6
Madison *2.0 miles*				27.2	60.3	2.9		6,199.0									283.0
Dallas *21.9 miles*	4.8			26.3	61.9	29.5	7.2	7,012.0		1.8		11.3	57.4	4.4	< 0.1	< 0.1	129.4
Polk *6.8 miles*	1.0	0.1	327.2		62.2	8.4		1,508.2				2.2	10.3	5.2			229.8
Jasper *30.7 miles*	2.6	1.4	514.3	81.5	55.6	21.4	10.5	5,225.7		16.2		17.6	43.5	2.4		< 0.1	154.5
Poweshiek *24.1 miles*	0.8				46.1	12.6	6.3	3,735.6	< 0.1			1.5	9.2	0.6	0.1		224.1
Iowa *24.1 miles*	0.2			20.9	52.6	10.0	12.0	3,437.2		0.5		1.2	3.1	1.5	0.2	< 0.1	243.3
Johnson *15.7 miles*	0.2		122.8	15.1	79.6	25.3	5.1	3,856.6				4.6	14.4	2.4			210.9
Cedar *24.5 miles*	6.3		32.4	39.0	65.8	10.8	11.1	2,796.9	0.1	0.1		2.8	22.6	1.7	0.1	0.1	217.0
Scott *11.4 miles*	1.4			35.8	72.5	0.3	12.2	836.7		3.8		0.8	0.1	2.7		0.2	243.0

**Counties are listed from west to east across the state.*

Cultural Resources

Cultural resources are aspects of the environment that are deemed culturally valuable, such as historic properties or archaeological sites. The average acreage of known or previously recorded cultural resources per mile in the Study Area is 1.7 acres/mile (ac/mi) with counties ranging from 0.0 ac/mi in Madison County to 6.3 ac/mi in Cedar County. The rest of the counties in the Study Area have 1.3 ac/mi or less of cultural resources with the exception of Dallas County (5.6 ac/mile) and Jasper County (2.6 ac/mi). The 130-acre Herbert Hoover National Historic Site in Cedar County is adjacent to I-80 in the town of West Branch and is the largest single area of cultural resources in the Study Area. The Hoover National Historic site is a unit of the National Park System and includes the former President’s childhood home.

Parks and Trails

Parks are areas, often large public green spaces, devoted to a specific purpose, such as recreation. Trails are planned and maintained paths that are marked out for a particular purpose. Common uses for trails include walking, biking, hiking, or for the use of motorized vehicles such as all-terrain vehicles or snowmobiles. Only three counties have parks within the Study Area: Adair, Polk, and Jasper. Adair and Polk County have 0.1 ac/mile and 0.2 ac/mile, while Jasper County has 1.4 ac/mile.

Pottawattamie (Rock Island Old Stone Arch Nature Trail), Cass (T-Bone Trail), Polk (Greenway Trail), Jasper (South Newton Hike and Bike Trail), Johnson (Clear Creek Trail), and Cedar County (Hoover Nature Trail) all contain trails within the Study Area. The average linear feet of trails per mile in the Study Area is 136.5 linear feet/mile. Jasper County and Cass County contain the largest concentration of trails with 514.3 linear feet/mile and 457.2 linear feet/mile, respectively. Adair, Madison, Dallas, Poweshiek, Iowa, and Scott have no mapped trails within the Study Area.

Floodplains

Floodplains are low-lying areas adjacent to a creek, river or water body that are subject to flooding. The average density of mapped 100-year floodplains in the Study Area is 29.2 ac/mile. Jasper County and Pottawattamie County contain the highest concentrations of floodplains with 81.5 ac/mi and 74.4 ac/mi, respectively. Both contain large areas of floodplains associated with a single waterway (South Skunk River in Jasper County and Mosquito Creek in Pottawattamie County) in addition to smaller areas of floodplain associated with other waterways. Adair, Polk, and Poweshiek Counties have no mapped floodplains in the Study Area.

Ungrazed and Planted Grasslands

Grasslands are large, open areas often devoid of large concentrations of trees. Most prairies within the state of Iowa have been converted for agricultural purposes or development. Areas identified as ungrazed grasslands appear to be unmanaged with native grass characteristics. Planted grasslands are areas of dense grasses where field observations suggest they have been planted with native grasses or areas of brome grass. Ungrazed grasslands (average 61.6 ac/mi) are more abundant throughout the Study Area than planted grasslands (average 15.0 ac/mi). Ungrazed grasslands range from 46.1 ac/mi in Poweshiek County to 79.6 ac/mi in Johnson County. Planted grasslands range from 0.3 ac/mi in Scott County to 38.2 ac/mi in Cass County.

Regulated Materials

Regulated materials are hazardous substances or petroleum products that have been determined to be capable of posing an unreasonable risk to human health, safety, and the environment if improperly treated, stored, transported, disposed of, or otherwise managed. The majority of the known, regulated materials sites in the Study Area are located near existing interchanges and developed areas, and have an average density of 6.7 ac/mi. Petroleum products associated with gas along I-80 throughout most counties are the largest source of regulated materials. Other potential sources within the Study Area include landfills and farmsteads containing storage tanks for pesticides, petroleum, or other chemicals. Scott County contains the largest concentration of regulated materials sites at 12.2 ac/mi., followed by Iowa (12.0 ac/mi), Cedar (11.1 ac/mi), and Pottawattamie (11.0 ac/mi) Counties.

Streams

Streams are classified as moving bodies of water ranging in size from creek to river. Within the Study Area, Dallas County contains the largest concentration of streams at 7,012.0 linear feet/mi, while Scott County has the smallest concentration at 836.7 linear feet/mi. The remaining counties range from 1,500 linear feet/mi to 5,700 linear feet/mi.

Threatened and Endangered Species

Threatened and endangered (T&E) species are any species that are likely or in danger of becoming extinct throughout all or a significant portion of its range within the foreseeable future. There are both federal and state-listed T&E species. The unit of measurement for T&E species along the Study Area was the number of documented occurrences. Within the Study Area, only Poweshiek and Cedar County had documented occurrences of T&E species. Poweshiek County had two documented occurrences, one of the endangered barn owl and one of the endangered spotted skunk. Cedar County had listed three occurrences of the threatened meadow beauty (plant). While these are the only documented occurrences, multiple species are listed in each county in the Study Area. The U.S. Fish and Wildlife Service's County Distribution of Federally Threatened, Endangered, and Candidate Species for Iowa and the Iowa DNR's County List of Species Considered Endangered, Threatened, and of Special Concern are included in **Appendix E**.

Conservation Lands

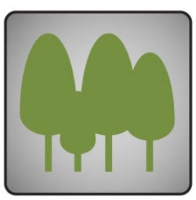
Conservation lands is a broad category encompassing Iowa Department of Natural Resources Wildlife Management Areas (WMAs), parks, historical markers, research areas, sovereign waters and other public lands. Many of the conservation land types have recreational functions. The Study Area averages 1.9 ac/mi but ranges from 0.0 ac/mi in Cass, Adair, Madison, Polk, Poweshiek, and Johnson Counties to 16.2 ac/mi in Jasper County. Jasper County contains the largest area of WMAs within the Study Area at approximately 385 acres, of which the majority is the Colfax WMA east and west near Colfax, Iowa. Within the Study Area, the Cedar River in Cedar County and Mississippi River in Scott County are designated as meandered sovereign rivers.

Unique Landforms

Unique landforms are naturally formed features on Earth's surface with recognizable geographical features that are distinct from the surrounding topographical landscape. The only unique landform within the Study Area is the Loess Hills located in Pottawattamie County. The approximately 42 miles of I-80 through Pottawattamie County spans through approximately 1,657 acres of the Loess Hills within the Study Area, or 39.6 ac/mi. The Loess Hills were formed approximately 14,000 to 24,000 years ago when retreating glaciers and strong westerly winds resulted in silt from the Missouri River floodplain to deposit on the Iowa side of the Missouri River, creating the bluffs observed today (U.S. Geological Survey 1999).

Wetlands

Wetlands are defined as areas where water is present either at or near the surface of the soil all year or for varying periods of time during the year, which promotes the growth of specially adapted plants and characteristic soils. Wetlands are classified according to *Classification of Wetlands and Deepwater Habitats of the United States (*Cowardin et al., December 1979). Wetlands present in the study area include emergent (grassy), scrub-shrub, forested, and lacustrine (pond fringe) wetlands. A complete list of wetland types identified within the Study Area and their respective acreage amounts per county are described in **Table N1**. The Study Area averages 4.6 ac/mi of wetlands and ranges from 0.0 ac/mi in Madison County to 17.6 ac/mi in Jasper County. The only other county with more than 10 ac/mi of wetlands is Dallas County. A large portion of the wetlands within Jasper County are associated with the North and South Skunk River, its numerous creek tributaries, or other creeks under I-80 within the county.



Woodlands

Woodlands are characterized as low-density forests containing ample sunlight for understory growth, limited shade, and open habitats. The Study Area averages 16.2 ac/mi of woodland area but varies substantially between counties. Scott County has 0.1 ac/mi of woodlands and Madison County has no identified woodlands within the Study Area, while Dallas County has 57.4 ac/mi and Jasper County has 43.5 ac/mi.

Businesses

Businesses were identified and divided into five categories to assess the primary types of business in the Study Area: Agriculture, Mining and Construction (AMC); Transportation, Communications and Utilities (TCU); Retail; Office and Service; and Unclassified. The average number of businesses per mile in the Study Area is 2.0, and ranges from zero businesses per mile in Madison County to 5.2 businesses per mile in Polk County and 4.4 businesses per mile in Dallas County. The majority of businesses in the Study Area were concentrated near interchanges and comprised of Office and Service businesses.

Cemeteries

While not common, there are a number of cemeteries within the Study Area that average 0.2 ac/mi. Adair and Pottawattamie County have the highest concentrations of cemetery acreage per mile at 1.1 ac/mi and 0.7 ac/mi, respectively.

Religious Places

A religious place is a designated area of worship, including a specified structure or space where people go to perform religious acts or study. Ten churches were the sole type of religious places identified within the Study Area. Adair, Dallas, Cedar, and Scott County all contain two churches, with Iowa and Jasper County each containing one church within the Study Area.

Farmland

The predominant form of land use in the Study Area is agricultural production. Unsurprisingly, each county contains large farmland acreage totals with an overall average of 218.2 ac/mi. While nine of the counties are average 200 to 250 ac/mi, the following counties are notably higher or lower than the average: Madison (283.0 ac/mi), Jasper (154.5 ac/mi), and Dallas (129.4 ac/mi).

SUMMARY

The most prevalent environmental resources for the Study Area and each county is farmland. Farmland acreage ranges from 129.4 ac/mi in Dallas County to 283.0 ac/mi in Madison County. High farmland acreage within the Study Area is expected based on the Interstate's route through Iowa and the dominance of agricultural land use throughout the region.

When looking at **Table 15**, Jasper County has the largest concentration of resources per mile in different categories compared to all other counties (see **Appendix E**, **Table E2**), followed by Scott, Dallas, Pottawattamie and Cedar Counties. Jasper County has the highest concentration of parks, trails, floodplains, conservation lands, and wetlands; and higher concentrations than most counties of cultural resources, regulated materials, streams, woodlands, and religious places. Dallas County has the highest concentration of woodlands and streams, and higher concentrations than most counties of cultural resources, ungrazed and planted grasslands, wetlands, and religious places. Pottawattamie County has the highest concentration of unique landforms and higher concentrations than most counties of floodplains, ungrazed grasslands, regulated materials, and cemeteries.

Cedar County has the highest concentration of cultural resources and documented occurrences of threatened and endangered species, and higher concentrations that most counties of floodplains, ungrazed grasslands, regulated materials, woodlands, and religious places. Scott County has the highest concentrations of regulated materials, and religious places, but has below average concentrations of the majority of the resources reviewed.

Cass, Adair, Poweshiek, Iowa and Johnson County lack high levels of resource concentrations compared to the other counties, but have resource concentrations near the average for the entire Study Area. Madison and Polk County contain few environmental resources relative to adjacent counties and in low concentration. While the overall concentrations of resources in Madison County are low, the county has the highest concentration of streams. Polk County has the lowest concentration of resources among all of the counties in the Study Area, but has a higher concentration of businesses than most counties.

The number and/or acreage of resources per mile for each county can be used to approximate which counties would require more intensive environmental review; design for avoidance, minimization, and mitigation; and more complex permitting. Counties with low concentrations of resources would be expected to have less complex environmental review and permitting while those with high concentrations would likely be more complex.

As proposed improvements are defined and separated into manageable pieces for design and construction additional environmental analysis will be required. Further evaluation will include the completion of field studies to confirm resources present and coordination with designers to avoid/minimize resource impacts. Additional environmental resources, such as environmental justice and noise impacts, will be evaluated in later phases of the project. Resource agency coordination will also need to occur to review projects and confirm permitting requirements including National Environmental Policy Act document preparation; permit application development and submittal; and identification of specific mitigation measures required.

Conclusion

This report provides a summary of the current and anticipated future needs and resources along the existing system. As the Iowa DOT undertakes individual projects along I-80, the information included in this report should inform decision-making. The major findings of each analysis area are provided in the bullets below.

- **Traffic Capacity***:* Traffic operations and the capacity of I-80 were assessed in five study segment areas for an existing year (taken as year 2015) and a future planning horizon year (2040). Results indicate under existing conditions, all representative I-80 segments were found to operate at LOS B or better. LOS B or better is the target for the I-80 Planning Study. However, under 2040 no-build conditions, Segments 3, 4, and 5 were found to operate at LOS C in both directions in at least the PM peak hour, indicated that these segments are expected to experience some design hour delays/congestion. The finding of LOS C and reduced average speeds at dispersed locations across most segments of the I-80 corridor suggest the need for statewide improvements to ease congestion and raise the LOS.
- **Transportation Systems Management and Operations (TSMO)**: TSMO was evaluated for five performance measures: hours of congestion, bottleneck occurrences, bottleneck duration, reliability, and incident rate. The TSMO results indicate a widespread pattern of poor conditions that should be addressed through both management of the system and future construction to improve the corridor's designed capacity and resiliency.
- **Traffic Safety**: Existing traffic safety conditions were completed for five rural freeway segments expected to represent the typical (or average) freeway segment. Additionally, existing crash conditions were summarized for five "hot spot" segments to provide a comparison to the typical segments. Crashes are anticipated to increase between today and 2040 mostly due to increased traffic volumes on I-80.
- **Geometrics and Physical Conditions Analysis**: The existing conditions were evaluated for pavement and bridge conditions, geometric analysis including minimum horizontal radius, maximum vertical grades, and minimum stopping sight distance. Each feature was evaluated on a "good", "fair", and "poor" rating scale. The results of the bridge and pavement condition along the I-80 corridor indicate well maintained infrastructure. The majority of the corridor is rated good while less than two percent of the elements received a poor rating. Many of the locations rated

poor sight distance could be mitigated with improved lighting, and route continuity and lane balance concerns are limited to one location in the Study Area.

- **Environmental Resources**: Study Area environmental resources were evaluated based on readily-available electronic data. The resources were identified as potential constraints for consideration in planning improvements to I-80. This evaluation focused on resources that influence environmental permitting, coordination, and engineering design. Environmental resources were identified in each county across I-80.

Glossary

AMC – Agriculture, Mining and Construction

Conservation Land – A broad category encompassing Iowa Department of Natural Resources Wildlife Management Areas (WMAs), parks, historical markers, research areas, sovereign waters and other public lands.

Cultural Resource –Aspects of the environment that are deemed culturally valued, such as historic properties. Historic properties are any prehistoric or historic districts, sites, buildings, structures, or objects that are eligible for listing or already listed in the National Register of Historic Places. This also includes artifacts, records, and remains that are related to and located within historic properties and any properties of traditional religious and cultural importance to Tribes or Native Hawaiian Organizations.

Curve Radius – how gradually a curve changes direction**.**

Design Hour Volume - Traffic volumes during the peak hour of the 30th highest day of the year.

Floodplains – Geographic low-lying areas adjacent to a creek, river, or water body that the Federal Emergency Management Agency has defined according to varying levels of flood risk.

Grasslands – Large, open areas often devoid of large concentrations of trees.

Horizontal Curve – the alignment of the roadway, essentially indicating how straight or curved a roadway segment is.

Level of Service (LOS) – A measure of the quality of traffic operations, measured in letter grades from LOS A (free-flow traffic conditions) to LOS F (congested, gridlock conditions

Meandered Sovereign River – “those rivers which, at the time of the original federal government surveys, were surveyed as navigable and important water bodies and were transferred to the states upon their admission to the union to be transferred or retained by the public in accordance with the laws of the respective states upon their admission to the union.” (571 Iowa Administrative Code Chapter 13)

Parks – Areas, often large public green spaces, devoted to a specific purpose, such as recreation.

Planted grasslands – grasslands with dense grasses where field observations suggest they have been planted with native grasses or areas of brome grass.

Regulated Material – A hazardous substance or petroleum product that has been determined to be capable of posing an unreasonable risk to human health, safety, and the environment if improperly treated, stored, transported, disposed of, or otherwise managed.

Religious Place – A designated area of worship, including a specified structure or space where people go to perform religious acts or study. Examples of religious places include churches, temples, mosques, synagogues, or sacred grounds.

Roadway Grades – the slope of the road, measured as the increase in elevation compared to the change in horizontal distance (rise compared to run).

Route Continuity – the level to which through vehicles are required to change lanes to continue on the intended path.

Sight Distance - the length of roadway ahead that is visible to the driver

Superelevation - The banking of a roadway along a horizontal curve so motorists can safely and comfortably maneuver the curve at reasonable speeds.

TCU – Transportation, Communications and Utilities

Threatened and Endangered Species (T&E) – Any species that is likely or in danger of becoming extinct throughout all or a significant portion of its range in the foreseeable future.

Trails – An established path or route for travel or recreation. Common uses for trails include biking, jogging, or walking.

Transportation System Management and Operations (TSMO) – a transportation approach that seeks to optimize existing infrastructure through improved integration, coordination, and systematic implementation of multiple strategies.

Travel Reliability – the level of travel time consistency or dependability through a corridor from day to day.

Ungrazed Grasslands – grasslands that appear to be unmanaged with native grass characteristics and include areas "rural road and ditch complexes, grassed waterways, some grassland/forest edge areas, and some tracts of greases that are spectrally separable" (Iowa DNR 2002).

Unique Landform – Naturally formed feature on Earth's surface that is distinct from the surrounding topographical landscape. The recognizable geographical feature has a characteristic shape and can include attributes such as plains, plateaus, mountains, valleys, or unique composition.

Vertical Curve – how a roadway changes in elevation, essentially indicated how flat or steep a roadway is.

Wetlands – Areas where water is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. The prolonged presence of water creates environmental conditions favorable for the growth of specially adapted plants and promotes the development of characteristic wetland soils.

Wildlife Management Area (WMA) – Land managed by Iowa DNR with the goal of developing and restoring wildlife species habitat for public hunting and other wildlife dependent recreational activity use.

Woodland – Low-density forests, providing ample sunlight, limited shade, and open habitats. The availability of sunlight supports an understory composed of shrubs and herbaceous plants.

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Appendix A: Traffic Capacity Analysis

SUPPLEMENTAL METHODOLOGY DETAILS

Typical segment selection

A number of factors influenced the identification of typical segments: 1) existing and projected traffic volumes, 2) availability of supporting count data, and 3) average crash rate (identified as part of the traffic safety analysis)

1. **Existing and projected traffic volumes** were provided to the project team by Iowa DOT Systems Planning group. The project team reviewed those volumes for both 2015 and 2040 identifying routes crossing I-80 that represented significant increases or decreases in either existing or projected traffic volumes. The best typical segments are segments that within these subdivisions of the corridor represent an average volume of traffic.
2. **Available supporting count data** were critical to establishing appropriate relationships between documented average daily traffic volumes and required model parameters (peak hour volumes, peak flow rate/peak hour factor, directional split). Iowa DOT operates a number of continuous traffic count stations along I-80. Proximity to robust count data was a primary factor in choosing typical segments for analysis.
3. **Average crash density** was also considered in selecting segments for detailed analysis. The crash rate is not considered in the traffic operations analysis, but the project team preferred consistency in locations between traffic capacity and safety analysis segments. For further discussion on crash density see the traffic safety section of the **Existing Conditions Tech Memo**.

Details behind the selection of the five typical segments are as follows:

- **Segment 1** (Rural Council Bluffs to Des Moines) – I-80 traffic volumes in both 2014 and projected out to 2040 are at a low point east of US Highway 6 in Council Bluffs all the way east to Dallas County. In this region average daily traffic volumes never exceed 24,000 vehicles per day in existing conditions and show limited variability. Any particular segment in this region would likely lead to similar conclusions, so the study team focused on two segments with available continuous traffic count data. As a tie breaker between the two segments, crash patterns were considered in conjunction with the related crash study, and led to the selection of the segment between Exit 60 (US 6/US 71) and Exit 64 (Wiota).
- **Segment 2** (West of Des Moines) – The first place traffic volumes start to climb along I-80 is just to the west of the Des Moines metropolitan area. Today's urban boundary for the Des Moines metro area stops outside of Van Meter, but a review of the projected traffic volumes for 2040 show a sharp uptick in traffic volumes across most of Dallas County that suggests a growing impact to I-80 from a western shift in urban growth. By choosing the segment between Exit 106 (County Road P58) – Exit 110 (US 6/US 169) the traffic capacity analysis could assist in determining if a closer look should be taken into developing a separate plan for addressing the areas just west of Des Moines. Results of the analysis of this western urban growth area likely impact areas just east of Des Moines as well.
- **Segment 3** (Des Moines to Iowa City) – Central Jasper County east to Central Iowa County is a portion of I-80 that has limited urban influence. Traffic volumes here are much higher than the

region east of Council Bluffs, approximately 35percent higher by 2040. Still, volumes in this region are at second lowest level of the study corridor. To represent this region, a segment was chosen between Exit 191 (US 63) and Exit 197 (Brooklyn). This segment is adjacent to a continuous traffic counter at approximately mile marker 190. The segment just east of US 63 was chosen to avoid high crash density locations just west of US 63.

- **Segment 4** (West of Iowa City) – Johnson County is another high growth county that warranted additional consideration as a study segment. Like the Des Moines metro area, volumes within the core of Iowa City are projected to grow at extremely high levels over the next 25 years, but in the Iowa City area, that growth does not drive as much growth for outlying communities along I-80. All considered, analysis of the area west of Iowa City can help provide further insight as to the best balance of addressing the needs of I-80 on this border condition between rural and urban interstate. For this region, Exit 225 (US 151) to Exit 230 (Oxford/Kalona) was the chosen segment. This segment is adjacent to a continuous traffic counter at approximately mile marker 222. The segment just east of US 151 was chosen to avoid a high crash density locations on the segment west of US 151.
- **Segment 5** (Iowa City to Walcott) – East of Iowa City the truly isolated rural portions of I-80 reach their highest level. Traffic from Interstate 380 and Iowa City producers joins with I-80 freight traffic and heads to markets east of the state's borders and proximity to large markets like Chicago and nationally significant features like the Great Lakes draw increased business and recreational travelers alike. The traffic on the east side of Iowa City all the way to Walcott even surpasses western Johnson County traffic volumes, making this segment a critical location for determining if rural I-80 will need improvements to maintain high quality traffic operations. In this region, the studied segment was Exit 259 (West Liberty) to Exit 265 (Atalissa) since this segment experienced average crash densities and is home to a continuous traffic counter.

Traffic Volume Development

Once the typical I-80 segments were identified, the next step in traffic capacity analysis was to develop traffic volumes.

The steps used in the existing volume development process include:

1. Examine hourly traffic volumes at all count sites by hour of the day for the full year. For all sites, select the single AM hour of the day and single PM hour of the day that exhibits the highest traffic volumes. Data were available in hourly observation periods, such as midnight to 1 AM and 1 AM to 2 AM, with no sub-hourly details available. In this rural setting, the AM peak hour was selected at 10 AM to 11 AM and the PM peak hour was selected as 4 PM to 5 PM.
   Note: some continuous count sites are several interchanges away from the chosen study segment, which is handled in steps 3 and 4.
   Note: the selected analysis period is practical since the entire corridor has similar peaking characteristics today, and most corridor locations will continue to be most sensitive to midday and PM peak hour volumes in the future. However, one notable exception is Segment 2 and the area it represents west and east of the Des Moines urban area. In these regions, an AM peak hour of 7 AM to 8 AM would provide a more appropriate worst-case for segment traffic

operating conditions, particularly in the eastbound direction, where would be heading inbound to Des Moines.

2. Within the hour selected, examine daily volume variation for each freeway segment to obtain the 30th highest observed traffic volume, which is a recommended procedure for determining the design hour volume per AASHTO's *A Policy on Geometric Design of Highways and Streets*.
3. For locations where the analysis site is adjacent to the count site, factor the peak hour volumes from step 2 based on the ratio of the daily volumes of the analysis site over the adjacent count site. The daily volumes used in this step are the 2015 average daily traffic volumes published on **Iowa DOT's GIS web site** (http://iowadot.maps.arcgis.com/apps/MapSeries/index.html?appid=0cce99afb78e4d3b9b24f8263717f910).
4. In the case of an analysis site between two count sites that are several interchanges away from either count site, existing peak hour volumes for the analysis site should be developed from a weighted average of the two count sites. The weights are based on the ratio of the absolute percent difference in daily traffic volume of the analysis site to the daily traffic volume of each respective count site versus the sum of the absolute percent difference of both count sites. This procedure can be repeated to compare forecast year volumes of the analysis site to existing volumes of the count sites to account for the possibility of analysis sites transitioning to more closely resemble one of the count sites over time.
5. Once the design hour level of traffic was determined, an assessment was made to the peaking present within the design hour. For this assessment, 15-minute count data, that was available upon request from Iowa DOT for August to December of 2015, was used. Peak hour factors were calculated for a single day that exhibited an equivalent level of traffic to the design hour volumes.
6. At the same time as the peaking assessment, design volumes were segmented into the three vehicle classes: passenger vehicles, single-unit trucks, and semi trucks. All count sites provided either 3-class or 13-class counting capabilities with the 13-class system based on the FHWA vehicle classification system. The 3-class sites directly counted vehicles by the needed volume classes. The 13-class volumes were converted to a 3-class system using the following groupings: passenger vehicles include FHWA classes 1-3, single-unit trucks included FHWA classes 4-7, and semi trucks included FHWA classes 8-13. For a complete breakdown of the FHWA vehicle classification system, please visit **FHWA web site** (https://www.fhwa.dot.gov/policyinformation/tmguide/tmg_2013/vehicle-types.cfm).
7. The results of Step 4 should be utilized to develop weighted average peak hour factors and heavy vehicle traffic volumes for analysis sites not located at or adjacent to count sites.

After establishing how traffic peaks on I-80 in the existing condition, a more simplified approach was applied to future conditions, considering only daily growth in passenger car and truck trips that experiences similar peaking to the present day. By applying the existing peaking characteristics to future daily volumes, the traffic volumes for future analysis may potentially overestimate future peaking demand due to the use of conservative assumptions. Future project-level traffic analyses will investigate how traffic peaking characteristics may change in the future and how those changes may impact design needs.

Modeling Tool

Another key aspect of the study methodology is the use of an appropriate traffic modeling tool. For this study, the software modeling package Highway Capacity Software version 7.3 (HCS 7) from McTrans was chosen. HCS 7 is a software package that faithfully implements the methods and calculations in the sixth edition of the Highway Capacity Manual (HCM), an industry standard reference on traffic analysis. HCS 7 uses analytical relationships based on national research of field measured relationships between traffic volume, speed, and segment density. In this study, volumes derived from traffic counts (existing conditions) and from travel demand modeling (future conditions) coupled with geometric data and free-flow speed data were used as input for HCS 7 to calculate performance measures. The primary performance measure used in this study was segment density, which can be correlated to a level of service (LOS). Density is a measure of how many passenger cars (pc) are located within a mile (mi) of freeway lane (ln) at a given time. For the basic freeway analyses conducted in this study, the conversion from density to LOS is completed using **Table A1** with LOS A and B serving as the study's target performance levels.

Table A1. Freeway Level of Service by Density Ranges

LOS	Density (pc / mi / ln)
A	≤ 11
B	$> 11 - 18$
C	$> 18 - 26$
D	$> 26 - 35$
E	$> 35 - 45$
F	Demand exceeds capacity OR density > 45

Existing Conditions Models

Development

HCS 7 geometric input data were collected from aerial images from Google Earth, including: number of lanes, lane width, right-side clearance, and total ramp density. In the situation of rural I-80, these geometric inputs were fairly consistent between segments and direction of travel. In addition to these cross-sectional and horizontal elements, Iowa DOT As-Built roadway plans were used to estimate segment grades and length of grade. Grades are of particular concern on I-80 due to the potential extreme impact of low speed semi trucks on steep uphill grades. **Table A2** records the controlling grade and length of grade identified for each segment. At these controlling grade locations, demand is systematically increased to account for heavy vehicles occupying larger amounts of space than passenger vehicles, using passenger car equivalents. Additionally, the latest advances in the HCM for understanding the impact of heavy vehicle flow were utilized. The mixed car and truck speed prediction models account for the fact that at certain truck percentages and especially in the presence of upgrade conditions, passenger car speeds become constrained to the prevailing truck speed. These mixed vehicle class speeds are more realistic, and when combined with the HCM procedure for estimating passenger car equivalent volume, lead to a better estimate of peak hour density and LOS.

Table A2. Controlling Roadway Grade by Segment

	Eastbound		Westbound	
Location	**Grade (%)**	**Length of Grade (ft)**	**Grade (%)**	**Length of Grade (ft)**
Exit 60 (US 6/US 71) to Exit 64 (Wiota)	3.0%	4,750	3.4%	1,850
Exit 106 (CR P58/F90) to Exit 110 (US 6/US 169)	2.9%	1,400	2.8%	1,450
Exit 193 (US 63) to Exit 197 (Brooklyn)	1.8%	3,300	1.5%	2,450
Exit 225 (US 151) to Exit 230 (Oxford/Kalona)	2.2%	1,900	3.0%	2,200
Exit 259 (West Liberty) to Exit 265 (Atalissa)	2.9%	1,450	2.9%	1,750

* Iowa DOT, Various As-built plans, Various dates (unpublished)

After identifying the geometry of the study areas, homogenous portions of roadway were modeled as individual study segments. HCS 7's Facilities module allows for modeling a sequence of linked segments to reflect the impact of individual segments on corridor performance.

Aside from grade, each segment varied only by the volume of traffic at the peak time and travelers' preferred speed, in low volume conditions, or free-flow speed. Based on an assessment of study area travel volumes, traffic analysis was conducted for an AM peak hour of 10 to 11 AM and a PM peak hour of 4 to 5 PM. Within those periods, the traffic volume characteristics shown in **Table A3** were identified from continuous count station data using the data processing rules explained in the methodology section.

Table A3. Design Hour Volume, Peak Hour Factor, and Truck Percentage by Segment and Analysis Period

Location	Direction	Time Period	Design Hour Volume	Peak Hour Factor	Truck Percentage (Single Unit / Tractor Trailer)
Exit 60 (US 6/US 71) to Exit 64 (Wiota)	East Bound	AM	1,045	0.89	27% (5% / 22%)
		PM	1,030	0.97	21% (4% / 17%)
	West Bound	AM	841	0.97	30% (5% / 25%)
		PM	1,080	0.92	22% (4% / 18%)
Exit 106 (CR P58/F90) to Exit 110 (US 6/US 169)	East Bound	AM	1,268	0.94	15% (3% / 12%)
		PM	1,276	0.92	18% (3% / 15%)
	West Bound	AM	1,161	0.95	24% (4% / 20%)
		PM	1,660	0.96	11% (2% / 9%)
Exit 193 (US 63) to Exit 197 (Brooklyn)	East Bound	AM	1,199	0.96	24% (5% / 19%)
		PM	1,340	0.97	21% (5% / 16%)
	West Bound	AM	1,172	0.94	26% (4% / 22%)
		PM	1,436	0.90	22% (6% / 16%)
Exit 225 (US 151) to Exit 230 (Oxford/Kalona)	East Bound	AM	1,278	0.89	18% (4% / 14%)
		PM	1,549	0.96	13% (2% / 11%)
	West Bound	AM	1,344	0.89	15% (2% / 13%
		PM	1,643	0.89	13% (3% / 10%)
Exit 259 (West Liberty) to Exit 265 (Atalissa)	East Bound	AM	1,299	0.96	35% (5% / 30%)
		PM	1,704	0.96	23% (4% / 19%)
	West Bound	AM	1,350	0.97	31% (4% / 27%)
		PM	1,523	0.97	22% (2% / 20%)

* Iowa DOT, Continuous Count Station Data, 2013-2015 (unpublished)

The HCS models were also populated with a free-flow speed. INRIX data was used to look at historical speed data, particularly looking at speed patterns on days matching the day when the design hour volume was counted. The results from the INRIX assessment of free flow speed are shown below in **Table A4**.

Table A4. Free Flow Speed by Segment

Location	Free Flow Speed (miles per hour)
Exit 60 (US 6/US 71) to Exit 64 (Wiota)	69
Exit 106 (CR P58/F90) to Exit 110 (US 6/US 169)	68
Exit 193 (US 63) to Exit 197 (Brooklyn)	69
Exit 225 (US 151) to Exit 230 (Oxford/Kalona)	70
Exit 259 (West Liberty) to Exit 265 (Atalissa)	69

* Inrix, Speed Profiles, 2015 (unpublished)

EXISTING CONDITIONS RESULTS

HCS estimates the segment density and related LOS based on the geometric, traffic volume, and base speed inputs. **Table A5** shows the existing conditions traffic analysis results.

Table A5. Existing Conditions Density and LOS by Segment

Location	Direction	Time Period	Design Hour Volume	Density (pc / mi / ln)	LOS
Exit 60 (US 6/US 71) to Exit 64 (Wiota)	East Bound	AM	1,045	12.4	B
		PM	1,030	10.5	A
	West Bound	AM	841	9.0	A
		PM	1,080	11.3	B
Exit 106 (CR P58/F90) to Exit 110 (US 6/US 169)	East Bound	AM	1,268	11.7	B
		PM	1,276	12.4	B
	West Bound	AM	1,161	11.5	B
		PM	1,660	14.7	B
Exit 193 (US 63) to Exit 197 (Brooklyn)	East Bound	AM	1,199	11.3	B
		PM	1,340	12.3	B
	West Bound	AM	1,172	11.3	B
		PM	1,436	14.1	B
Exit 225 (US 151) to Exit 230 (Oxford/Kalona)	East Bound	AM	1,278	12.6	B
		PM	1,549	13.6	B
	West Bound	AM	1,344	13.5	B
		PM	1,643	16.2	B
Exit 259 (West Liberty) to Exit 265 (Atalissa)	East Bound	AM	1,299	18.2	C
		PM	1,704	16.3	B
	West Bound	AM	1,350	14.0	B
		PM	1,523	14.6	B

* Volumes - Iowa DOT, Continuous Count Station Data, 2013-2015 (unpublished)
*2040 Volumes/Density/LOS-HDR, 2017

The existing conditions traffic operations analysis shows that all 5 representative study segments exhibit LOS B or better in both directions in both AM and PM peak hours. At the LOS A and B levels of congestion, average segment speeds remain at the segment free-flow speed, which is very desirable for travelers. As LOS B has been set as the target for I-80 mobility in the I-80 Planning Study Guiding Principles, no rural segments of I-80 exhibit a mobility need based on LOS alone.

FUTURE NO-BUILD CONDITIONS MODELS

Development

Future no-build conditions HCS models were developed to assess if growth in traffic along I-80 might lead to poor operations. In the 2040 no-build models, only the design hour volumes are modified to account for corridor growth. Corridor growth was estimated by the Iowa DOT System Planning group using the statewide travel demand model (iTRAM). Future daily traffic volumes for study segments and annual traffic volume growth rates are shown in **Table A6**.

Table A6. Traffic Volumes and Growth Rates by Segment, Existing 2015 to No-Build 2040 Conditions

Location	2014 Daily Traffic Volume	2040 No-Build Traffic Volume	Annual Growth Rate Existing vs. No-Build Conditions (%) 2015-2040	Total Growth Rate (%) 2015-2040
Exit 60 (US 6/US 71) to Exit 64 (Wiota)	20,100	28,944	1.4%	42%
Exit 106 (CR P58/F90) to Exit 110 (US 6/US 169)	28,100	44,960	1.8%	57%
Exit 193 (US 63) to Exit 197 (Brooklyn)	26,300	39,319	1.6%	47%
Exit 225 (US 151) to Exit 230 (Oxford/Kalona)	30,600	45,900	1.6%	48%
Exit 259 (West Liberty) to Exit 265 (Atalissa)	33,500	51,925	1.7%	52%

* Iowa DOT Systems Planning, I-80 Planning Study Forecasts, 2017 (unpublished)

No-Build Condition Model Results

Applying these growth rates to the existing (2015) design hour volumes, the project team derived 2040 no-build condition design hour volumes. Applying these increased volumes with all other traffic, speed, and geometric characteristics treated as equivalent to existing conditions, the future traffic operations modeling yielded estimates for density and LOS. **Table A7** depicts the 2015 existing condition and 2040 no-build condition design hour volumes, 2040 no-build condition density, and 2040 no-build condition LOS by segment, time of day, and direction.

Table A7. No-Build Condition Model Results

Location	Direction	Time Period	2015 Existing Condition Design Hour Volume	2040 No-Build Condition Design Hour Volume	2040 No-Build Condition Density (pc / mi / ln)	2040 No-Build Condition LOS
Segment 1 Exit 60 (US 6/US 71) to Exit 64 (Wiota)	East Bound	AM	1,045	1,484	17.5	B
		PM	1,030	1,463	14.9	B
	West Bound	AM	841	1,194	12.8	B
		PM	1,080	1,534	16.1	B
Segment 2 Exit 106 (CR P58/F90) to Exit 110 (US 6/S 169)	East Bound	AM	1,268	1,992	18.3	C
		PM	1,276	2,004	20.3	C
	West Bound	AM	1,161	1,824	18.1	C
		PM	1,660	2,608	26.3	D
Segment 3 Exit 193 (US 63) to Exit 197 (Brooklyn)	East Bound	AM	1,199	1,765	16.7	B
		PM	1,340	1,972	18.1	C
	West Bound	AM	1,172	1,725	16.7	B
		PM	1,436	2,115	20.9	C
Segment 4 Exit 225 (US 151) to Exit 230 (Oxford/Kalona)	East Bound	AM	1,278	1,887	18.6	C
		PM	1,549	2,288	20.1	C
	West Bound	AM	1,344	1,984	20.0	C
		PM	1,643	2,426	24.4	C
Segment 5 Exit 259 (West Liberty) to Exit 265 (Atalissa)	East Bound	AM	1,299	1,980	21.1	C
		PM	1,704	2,597	26.0	C
	West Bound	AM	1,350	2,058	21.5	C
		PM	1,523	2,321	22.6	C

* 2015 Volumes - Iowa DOT, Continuous Count Station Data, 2013-2015 (unpublished)
* 2040 Volumes/Density/LOS – HDR, 2017

The 2040 no-build condition traffic analysis shows that the growth in peak hour volumes has led to a degradation in quality of traffic service. Most locations drop one letter grade on the LOS scale, with LOS C present for at least the PM peak hour on four of the five study segments. Given the I-80 Planning Study guiding principle of maintaining mobility at LOS B or better, the 2040 no-build conditions fails to meet the desirable target for LOS. The result of entering the LOS C range is that congestion on the segment reaches a breakpoint where average vehicle speeds start to dip from drivers' preferred free-flow speed. In urban areas, this dip in speeds is expected during peak hours, but traditionally rural corridors have assumed a higher standard of service (LOS B) that according to the HCM method would keep average segment speeds at the segment free-flow speed.

FINDINGS

Traffic operations analysis was conducted for five representative freeway segments along rural I-80. The traffic operations analysis utilized HCS as a modeling tool to look at the key performance measures of LOS (based on density) and average segment speed for existing conditions (2015) and future no-build conditions (2040). Based on the I-80 Planning Study guiding principles, acceptable traffic operations are based on a freeway segment LOS of LOS B or better. Under existing conditions, all representative freeway segments were found to operate at LOS B or better. Under 2040 no-build conditions, Segments 3 and 4 were found to operate at LOS C or worse in both directions in at least the PM peak hour. By crossing the LOS B/C threshold, the rural I-80 corridor can be expected to experience average speeds slowing below free-flow levels. The finding of LOS C and reduced average speeds at dispersed locations across the corridor suggests the need for corridor-wide improvements to ease congestion and raise the LOS. Segments 2 and 5 were found to operate at LOS D in at least one direction during the peak hour. LOS D conditions can lead to significant slow downs and conditions where drivers have limited opportunity to make lane changes. The resulting congestion on all I-80 segments from Dallas County to the eastern border of the state would adversely impact travelers and shippers doing business in Iowa.

Appendix B: Transportation Systems Management & Operations Analysis and Results

PERFORMANCE MEASURES

1. **Hours of Congestion –** The hours of congestion performance measure conveys the amount of time where travelers are moving at lower than preferable speed due to recurrent congestion (e.g. congestion resulting from peak period traffic demand), non-recurrent congestion (e.g. congestion resulting from weather or incidents), or a combination of recurrent and non-recurrent congestion. The hours of congestion metric helps identify areas in Iowa that exhibit poor traffic operations outside of the typical peak hours. The use of hours of congestion also emphasizes the effects of bad weather and traffic incidents which are some of the biggest obstacles that Iowa travelers face.

2. **Bottleneck occurrences –** Bottlenecks occur in instances of over capacity conditions severe enough that vehicles must slow to nearly a stop causing queuing (or spillback) until such time that the travel demand falls back below the available capacity of the roadway. When analyzing TSMO performance, capacity constraints could result from design features or nonrecurring congestion factors (e.g. weather, incidents). Analysis of bottleneck occurrences focuses remediation strategies on the most frequently occurring bottlenecks, which are typically locations with inadequate base capacity to serve the facility’s demand.

3. **Bottleneck duration –** Bottleneck duration is another performance measure that can isolate roadway segments for a more in-depth review to determine if countermeasures to improve operations are necessary. Bottleneck duration looks at locations that are experiencing the greatest loss of time when a bottleneck occurs. In some cases, the bottleneck duration may last around 20 minutes and occur most weekdays. In other cases the duration may be longer than 2 hours, but the bottleneck may have occurred only once every few months. Bottleneck duration focuses on the latter of those two examples in order to focus analysis on areas that may be lacking design or operational resiliency to nonrecurring congestion. By using both bottleneck occurrence and bottleneck duration, the analysis methodology seeks to capture locations that experience the worst recurring congestion as well as locations that experience the worst nonrecurring congestion.

4. **Buffer Time Index (Reliability) –** Part of providing high quality traffic operations is addressing travelers’ needs to arrive at their destination on time. Research has shown that the reliability of on-time arrival to a destination is nearly as important in the mind of travelers as the average travel time for that trip. Even without widely available measures for reliability, travelers leave a buffer above their average trip time to make sure they arrive on-time. The buffer time index seeks to identify corridors where this additional buffer time is high in comparison to the average travel time on the corridor. Locations with a high buffer time to average travel time ratio, or buffer time index, have design and/or operational flaws making them less resilient to deal with nonrecurring congestion factors. The buffer time is based on the 95th percentile travel time on a corridor when determining the buffer time index.

5. **Incident Rate** – Freeway operations can be heavily affected by randomly occurring incidents like bad weather, maintenance activities and accidents. In particular, incidents can be tracked and analyzed to determine locations along a corridor that are hot spots for incidents. Closer review of these hot spots can often lead to the source of a problem. For instance, a stretch of highway with a high number of incidents may be further investigated to gain a better understanding of the root causes for those incidents.

TSMO METHODOLOGY

Methodologies were developed for analyzing each of the TSMO performance measures. The following sections present the analysis period, performance measure data and analysis process, and evaluation ratings.

Analysis Period

A major consideration for analyzing each performance measure is selecting an appropriate length of time for analysis. Ideally, the time period captures the natural cycle of some nonrecurring congestion factors (e.g. all four seasons for weather impacts). Years 2013-2015 were selected as the timeframe for the existing analysis.

One careful consideration was to avoid long duration events of significant impact that occur atypically (e.g. construction projects). Congestion of this nature is not representative of the baseline existing operations for the corridor and periods containing such events should be avoided, if possible, when selecting the analysis period. Using three years of data (2013-2015) reduces the work zone impact and allows for a consistent analysis period.

Performance Measure Data and Analysis Process

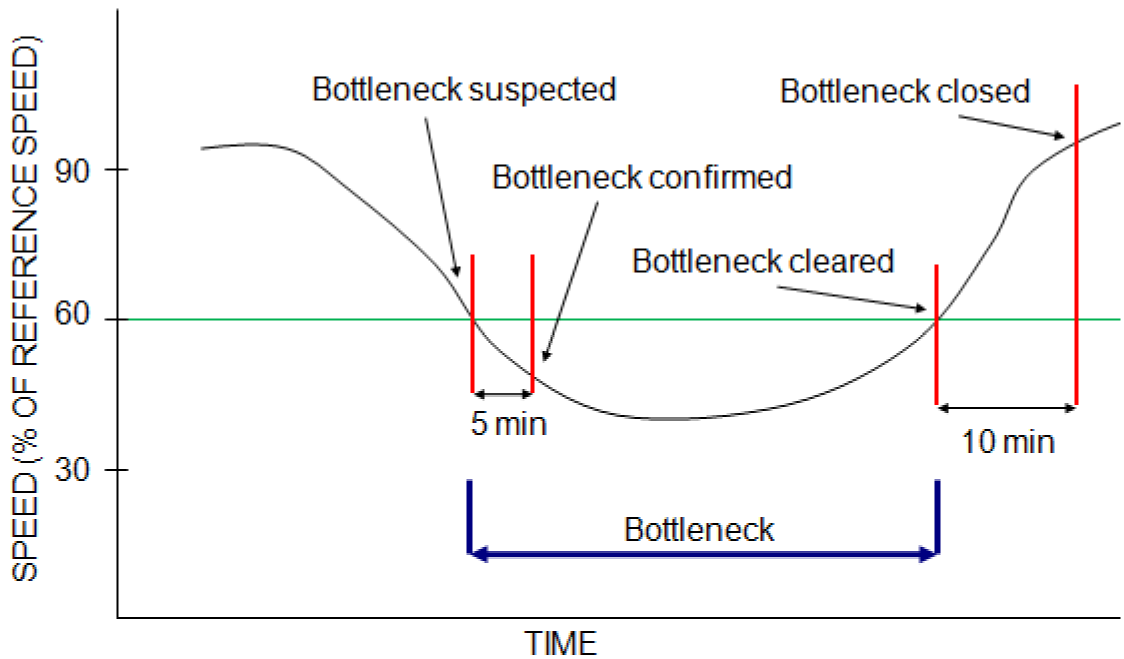
Four of the selected performance measures rely on the use of real-time speed data. These are the hours of congestion, bottleneck occurrences, bottleneck duration and buffer time index performance measures. The fifth selected performance measure, incidents, requires a robust database of incidents that occurred within the study area during the analysis period. The data and analysis process for each of the five selected performance measures are summarized below:

1. **Hours of Congestion –** The data used for hours of congestion was INRIX real-time speed data in 1-minute intervals provided by CTRE. The data was summarized on the INRIX traffic message channel (TMC) segment level. INRIX TMC segments typically represent a single direction of the roadway between logical termini (e.g. ramps, major intersections) and can range from less than one mile up to ten miles in length. Forty five miles per hour was used as the threshold for the minimum preferable speed on the Interstate based on similar assumptions made by neighboring states and previous reviews of Iowa interstate speed data. This is consistent with the work conducted by CTRE that was documented in the *Iowa DOT Office of Traffic Operations Mobility Report*. The hours of congestion measure was taken a step further and broken down into three timeframes: by month, day of week, and part of day. This helps show any congestion issues with a specific temporal component, for example: higher recreational travel demand during summer, higher congestion during warm weather road work, higher congestion during inclement weather during winter, and congestion overnight versus congestion during the commuter peaks.

2. **Bottleneck Occurrences –** Data and tools available to Iowa DOT via their agreement with INRIX were used to determine bottleneck occurrences. Here is an excerpt from INRIX describing the bottleneck procedure:

How are bottleneck conditions tracked?
Bottleneck conditions are determined by comparing the current reported speed to the reference speed for each segment of road. Reference speed values were provided for each segment and represent the 85th percentile observed speed for all time periods with a maximum value of 65 mph. If the reported speed falls below 60 percent of the reference, the road segment is flagged as a potential bottleneck. If the reported speed stays below 60 percent for five minutes, the segment is confirmed as a bottleneck location. Adjacent road segments meeting this condition are merged to form the bottleneck queue. When reported speeds on every segment associated with a bottleneck queue have returned to values greater than 60 percent of their reference values and remained that way for 10 minutes, the bottleneck is considered cleared. The total duration of a bottleneck is the difference between the time when the congestion condition was first noticed (prior to the 5 minute lead in) and the time when the congestion condition recovered (prior to the 10 minute lead out). Bottlenecks whose total queue length, determined by adding the length of each road segment associated with the bottleneck, is less than 0.3 miles are ignored.

Figure B1. The Life of a Bottleneck by Speed and Time



Source: INRIX Analytics FAQs

The INRIX bottleneck tool reports the number of bottleneck occurrences originating at the same location, the average duration of those bottlenecks and the average queue length associated with bottlenecks originating at a common location.

- GIS tools were used to conduct a spatial analysis to aggregate multiple overlapped INRIX bottlenecks. While combining the bottlenecks that share a location, the spatial analysis procedure also dynamically splits the INRIX bottleneck records, so a very long bottleneck may be combined with smaller bottleneck sections. The combining and splitting of bottlenecks leads to bottleneck segments of variable length unlike the analysis of the INRIX TMC data for hours of congestion.

- Once bottleneck segments where generated, the frequency of occurrences for each contributing bottleneck to the segment were summed to determine total bottleneck occurrences per year. In instances where the bottleneck segment did not match the start/end points of the associated TMC segment, the highest bottleneck occurrence value within the limits of the TMC segment was chosen.

3. **Bottleneck Duration –** The data and analysis process for the bottleneck duration measure was very similar to that described above for the bottleneck occurrences. The total duration of bottlenecks on each of the segments was calculated by summing the product of average duration and number of occurrences for individual bottlenecks. The average duration for each bottleneck segment was calculated by dividing the total duration of bottlenecks by the total number of bottleneck occurrences. Each bottleneck segment was then associated with an overlapping TMC segment. As multiple bottleneck segments might correspond to one TMC segment, the highest observation for bottleneck duration associated with a TMC segment was chosen.

4. **Buffer Time Index (Reliability) –** Similar to hours of congestion, buffer time index was calculated utilizing 1-minute interval INRIX data provided via data transfer from CTRE. The following steps were used to calculate the buffer time index:
   - Determine the analysis time period to use. For this project, buffer time indices from the AM peak period from 7 AM to 9 AM and PM peak period from 4 PM to 6 PM were reviewed to determine the analysis reporting time period. The 15-minute interval (5:15 – 5:30 PM) resulted in the greatest buffer time index for the majority of the sections and was selected as the reporting time period. Fifteen minutes was selected because travel times were less volatile than those summarized in a 5 or 10-minute interval, while still capturing the peak within the peak hours.
   - Utilize statistical functions to determine the average travel time and the 95th percentile travel time for each analysis reporting time period.
   - Subtract the average travel time from the 95th percentile travel time to obtain the buffer time.
   - Divide the buffer time by the average travel time to obtain the buffer time index.

5. **Incident Rate –** Incident data from 2015 was provided in a database from Iowa DOT's traffic management center. The incident data was spatially assigned and related to the TMC segments. The number of incidents were summed for each TMC segments and then adjusted into a rate of the number of incidents per hundred million vehicle miles traveled (HMVMT). For the calculation of the incident rate, the length of the TMC segment and year 2014 annual average daily traffic (AADT) volumes from the I-80 strip maps provided by Iowa DOT were utilized.

Evaluation Ratings

The Top 10 Worst locations for each performance measure were identified. This helps focus Iowa DOT's attention to the worst locations that could benefit the most from system improvements.

Existing TSMO Results

The Top 10 Worst locations for each performance are listed below:

Hours of Congestion

1. I-80 WB at Exit 201 (IA-21) – 46.6
2. I-80 WB from Exit 83 (CR-N77) to Exit 76 (IA-925) – 37.0
3. I-80 WB from Exit 149 (112^{th} St.) to Exit 143 (IA-945) – 36.9
4. I-80 WB from Exit 113 (CR-R16) to Exit 110 (US-169) – 31.4
5. I-80 EB at Exit 284 (CR-Y40) – 30.6
6. I-80 WB from Exit 51 (CR-M56) to Pottawattamie/Cass Co. Border – 30.6
7. I-80 WB at Exit 51 (CR-M56) – 30.2
8. I-80 WB at Exit 143 (IA-945) – 29.9
9. I-80 WB from Exit 182 (IA-146) to Exit 179 (CR-T38) – 29.9
10. I-80 EB from Exit 143 (IA-945) to Exit 149 (112^{th} St.) – 29.0

Bottleneck Occurrences

1. I-80 WB at Exit 201 (IA-21) – 119
2. I-80 WB at Exit 143 (IA-945) – 80
3. I-80 WB from Exit 83 (CR-N77) to Exit 76 (IA-925) – 78
4. I-80 WB at Exit 117 (CR-R22) – 76
5. I-80 WB at Exit 179 (CR-T38) – 72
6. I-80 WB at Exit 76 (IA-925) – 70
7. I-80 WB at Exit 110 (US-169) – 66
8. I-80 EB at Exit 83 (CR-N77) – 63
9. I-80 WB from Exit 182 (IA-146) to Exit 179 (CR-T38) – 58
10. I-80 WB at Exit 284 (CR-Y40) – 56

Bottleneck Duration

1. I-80 EB from Exit 70 (IA-148) to Exit 75 (CR-G30) – 81
2. I-80 WB from Exit 51 (CR-M56) to Pottawattamie/Cass Co. Border – 79
3. I-80 EB from Exit 149 (112^{th} St.) to Exit 155 (IA-117) – 78
4. I-80 WB from Exit 155 (IA-117) to Exit 149 (112^{th} St.) – 72
5. I-80 EB from Exit 60 (US-71) to Exit 64 (CR-N28) – 71
6. I-80 WB from Exit 164 (IA-14) to Exit 159 (CR-F48) – 65
7. I-80 EB from Exit 83 (CR-N77) to Exit 86 (IA-25) – 65
8. I-80 WB from Exit 46 (505^{th} St.) to Exit 40 (US-59) – 64
9. I-80 EB at Exit 230 (Black Hawk Ave.) – 64
10. I-80 WB from Exit 113 (CR-R16) to Exit 110 (US-169) – 63

Buffer Time Index (Reliability)

1. I-80 WB at Exit 51 (CR-M56) – 1.272
2. I-80 WB from Exit 113 (CR-R16) to Exit 110 (US-169) – 1.196
3. I-80 EB at Exit 149 (112^{th} St.) – 1.193
4. I-80 EB at Exit 155 (IA-117) – 1.178
5. I-80 WB at Exit 143 (IA-945) – 1.167

6. I-80 WB at Exit 159 (CR-F48) – 1.161
7. I-80 EB from Exit 155 (IA-117) to Exit 159 (CR-F48) – 1.151
8. I-80 EB from Exit 149 (112th St.) to Exit 155 (IA-117) – 1.145
9. I-80 WB at Exit 113 (CR-R16) – 1.142
10. I-80 WB at Exit 155 (IA-117) – 1.141

Incident Rate

1. I-80 WB at Exit 70 (IA-148) – 537.80
2. I-80 EB at Exit 27 (I-680) – 394.57
3. I-80 WB at Exit 143 (IA-945) – 370.85
4. I-80 WB at Exit 155 (IA-117) – 339.58
5. I-80 WB at Exit 149 (112th St.) – 307.08
6. I-80 WB at Exit 182 (IA-146) – 303.68
7. I-80 WB at Exit 271 (US-6) – 302.32
8. I-80 WB at Exit 110 (US-169) – 269.80
9. I-80 WB at Exit 64 (CR-N28) – 267.09
10. I-80 WB at Exit 168 (Iowa Speedway Dr.) – 261.54

The Top 10 Worst incident rates were all at interchanges and not on long segments. This is caused by a high amount of incidents within a short segment length. The total number of incidents (not factored by ADT or segment length) will show long segments with high number of incidents. The Top 10 Worst locations for number of incidents are:

Number of Incidents

1. I-80 EB from Exit 159 (CR-F48) to Exit 164 (IA-14) – 36
2. I-80 WB from Exit 149 (112th St.) to Exit 143 (IA-945) – 28
3. I-80 WB from Exit 191 (US-63) to Exit 182 (IA-146) – 25
4. I-80 WB from Exit 164 (IA-14) to Exit 159 (CR-F48) – 22
5. I-80 EB from Exit 149 (112th St.) to Exit 155 (IA-117) – 21
6. I-80 WB from Exit 155 (IA-117) to Exit 149 (112th St.) – 21
7. I-80 WB from Exit 237 (Ireland Ave.) to Exit 230 (Black Hawk Ave.) – 20
8. I-80 EB from Exit 249 (Herbert Hoover Hwy.) to Exit 254 (CR-X30) – 19
9. I-80 EB from Exit 173 (IA-224) to Exit 179 (CR-T38) – 18
10. I-80 EB from Exit 143 (IA-945) to Exit 149 (112th St.) – 18
11. I-80 EB from Exit 230 (Black Hawk Ave.) to Exit 237 (Ireland Ave.) – 18
12. I-80 WB at Exit 143 (IA-945) – 18

Locations that show up more than once on the TSMO Top 10 Worst lists:

- I-80 WB from Exit 51 (CR-M56) to Pottawattamie/Cass Co. Border
- I-80 WB at Exit 51 (CR-M56)
- I-80 WB from Exit 83 (CR-N77) to Exit 76 (IA-925)
- I-80 WB at Exit 110 (US-169)
- I-80 WB from Exit 113 (CR-R16) to Exit 110 (US-169)
- I-80 WB at Exit 143 (IA-945)
- I-80 EB from Exit 143 (IA-945) to Exit 149 (112th St.)

- I-80 WB from Exit 149 (112th St.) to Exit 143 (IA-945)
- I-80 EB from Exit 149 (112th St.) to Exit 155 (IA-117)
- I-80 WB from Exit 155 (IA-117) to Exit 149 (112th St.)
- I-80 WB at Exit 155 (IA-117)
- I-80 WB from Exit 164 (IA-14) to Exit 159 (CR-F48)
- I-80 WB from Exit 182 (IA-146) to Exit 179 (CR-T38)
- I-80 WB at Exit 201 (IA-21)

Locations that were the Top 10 Worst for any of the five metrics were reviewed for several potential indicators of causation. The first potential indicators focused on reviewing time frames that experienced the peak of activity (lowest speeds, highest occurrence of incidents). Often the timing of this activity would be during an individual season, recurrent throughout the year with heavy periods at night, or clustered in a short period of time. These indicators are particularly useful for the metrics of hours of congestion, reliability, and incidents. Trends from these indicators were common to most poor locations, including:

- **Bad weather –** Month by month review of locations with high hours of congestion and buffer time indices revealed that the congestion was heavily weighted to the period between November and February; the peak of winter weather. Winter weather poses a statewide issue, but as these locations stand out against peer locations that also face the same weather challenges, the following locations may be candidates for design improvements to provide greater resilience:
    - I-80 WB from Exit 83 (CR-N77) to Exit 76 (IA-925)
    - I-80 WB at Exit 143 (IA-945)
    - I-80 EB & WB from Exit 143 (IA-945) to Exit 149 (112th St.)
    - I-80 WB from Exit 182 (IA-146) to Exit 179 (CR-T38)
    - I-80 WB at Exit 201 (IA-21)
    - I-80 EB at Exit 284 (CR-Y40)

- **Road work –** Iowa DOT's incident database provided some insight into areas where operations were poor by logging occurrences of road work. Road work was cited from Iowa DOT's records as impacting multiple incidents throughout the I-80 corridor. The following locations were more heavily impacted by road work than peer locations:
    - I-80 EB at Exit 27 (1-680)
    - I-80 WB at Exit 110 (US-169)
    - I-80 EB & WB from Exit 143 (IA-945) to Exit 155 (IA-117)
    - I-80 EB from Exit 159 (CR-F48) to Exit 164 (IA-14)
    - I-80 WB at Exit 182 (IA-146)

- **Overnight driving –** Overnight driving is not typically considered a cause of congestion, but for some segments in the study area, traffic operations were significantly impacted during the overnight hours. The segments impacted mostly by overnight hours had rest areas within the segments or major truck stops at the interchanges. As overnight rest area and truck stop traffic largely consists of heavy trucks, it appears the combination of nighttime conditions, heavy trucks, and the presence of the rest areas and truck stops add to the congestion of these areas. The locations that had high hours of congestion in the overnight hours are:

- I-80 WB from Exit 83 (CR-N77) to Exit 76 (IA-925)
- I-80 EB & WB from Exit 143 (IA-945) to Exit 149 (112th St.)
- I-80 WB from Exit 182 (IA-146) to Exit 179 (CR-T38)
- I-80 WB at Exit 201 (IA-21)
- I-80 EB at Exit 284 (CR-Y40)

The previous indicators discussed provide a rationale behind some of the documented operational challenges. To get a deeper understanding into the operational challenges of the corridor, the TSMO data was compared with the safety, geometry, infrastructure, and operational feature assessments also conducted as part of this study. This cross-sectional review allows for identifying trends relating corridor operations to design hot spots.

- **Safety –** The crash rate analysis was compared against TSMO analysis results. Locations identified as crash hot spot segments and poor TSMO metrics:
  - I-80 WB from Exit 113 (CR-R16) to Exit 110 (US-169)
  - I-80 EB from Exit 143 (IA-945) to Exit 149 (112th St.)
  - I-80 WB from Exit 149 (112th St.) to Exit 143 (IA-945)
  - I-80 EB from Exit 149 (112th St.) to Exit 155 (IA-117)
  - I-80 WB from Exit 155 (IA-117) to Exit 149 (112th St.)
  - I-80 WB at Exit 155 (IA-117)
  - I-80 WB from Exit 182 (IA-146) to Exit 179 (CR-T38)

- **Geometry –** Horizontal radii, vertical grades and stopping sight distance were evaluated and rated as good, fair, and poor. Few conclusions could be drawn from the relationship of roadway alignment and TSMO since most of the corridor was assessed to have a good grade for alignment elements. Locations with a combination of poor grades for TSMO and geometry features are listed below:
  - I-80 WB from Exit 51 (CR-M56) to Pottawattamie/Cass Co. Border
  - I-80 WB from Exit 83 (CR-N77) to Exit 76 (IA-925)
  - I-80 EB from Exit 143 (IA-945) to Exit 149 (112th St.)
  - I-80 WB from Exit 149 (112th St.) to Exit 143 (IA-945)
  - I-80 EB from Exit 149 (112th St.) to Exit 155 (IA-117)
  - I-80 WB from Exit 155 (IA-117) to Exit 149 (112th St.)
  - I-80 WB from Exit 164 (IA-14) to Exit 159 (CR-F48)

- **Infrastructure** – Only a few locations were flagged as poor pavement or bridge conditions along I-80. The two locations that overlap with poor TSMO results are:
  - I-80 WB from Exit 83 (CR-N77) to Exit 76 (IA-925)
  - I-80 WB from Exit 113 (CR-R16) to Exit 110 (US-169)

- **Operational Features –** The existing capacity analysis showed the study corridor operates with little or no congestion so no conclusions can be made between operational features and TSMO measures. The operational methodology for this planning study did not consider the influence of interchange and system ramp design, which could have implications for TSMO.

Synthesizing the results of the multitude of contributing factors, the study corridor shows existing poor operations from a TSMO perspective. The five TSMO performance measures indicate a widespread pattern of poor conditions that should be addressed through both management of the system and future construction to improve the corridor's designed capacity and resiliency. Improvements in system management would stem from Iowa DOT efforts to utilize some of the following strategies: Highway Helper, Traffic Incident Management (TIM), Maintenance Decision Support Systems (MDSS) for winter weather, and Intelligent Work Zones (IWZ), Integrated Corridor Management (ICM), and use of alternative modes (like bus and rail travel). Additionally, future TSMO on I-80 will be impacted by industry development of automated vehicles (AVs) and how DOT operates I-80 in relation to AVs, which is discussed in the I-80 Automated Vehicles Tech Memo. Future construction has the potential to reduce work zone impacts on I-80 and ease bottlenecks corridor-wide through additional mainline capacity and improved design of freeway access locations.

FUTURE NO-BUILD TSMO PERFORMANCE MEASURE RESULTS

Future TSMO conditions were not quantified but can be assessed relative to general trends. The most significant variable affecting TSMO is the relationship between traffic volumes and roadway capacity. From 2015 to 2040, traffic is expected to grow approximately 50 percent throughout the study corridor. The traffic growth will result in worse TSMO conditions. I-80 WB between US-169 and CR-R16 exhibits poor TSMO conditions and is expected to experience the highest projected traffic growth (60 percent). This location will benefit the most from future widening in order to handle the future increased traffic.

Other variables that affect TSMO are crashes, incidents, and weather. Crashes and incidents are expected to increase in the future due to increased traffic volumes and congestion. Iowa DOT will benefit most from utilizing the following strategies: Highway Helper, Traffic Incident Management (TIM), and Intelligent Work Zones (IWZ). In regards to weather, Iowa DOT is developing a separate Resiliency and Vulnerability tech memo that will comment on the potential effects of inclement weather.

Appendix C: Traffic Safety Analysis Methodology

HOT SPOT AND TYPICAL SEGMENT IDENTIFICATION

A Geographic Information System (GIS) based analysis technique known as Getis-Ord GI* statistic (known as GI*) was used to identify typical and hot spot freeway segments. Application of the GI* statistic identifies if there were statistically higher than expected concentrations of crashes in an area, such as a freeway segment. Initial application of GI* mostly identified interchanges as hot spots. To focus the evaluation on the rural mainline segments of I-80 crashes on ramps and on the mainline between the exit and entrance ramps were removed through a simple visual selection of the crash points. The revised GI* results were used to identify eligible typical and hot spot segments.

The selection of typical segments (segments with blue or tan colors) was coordinated with the traffic capacity analysis for consistency. Initially, eight candidate hot spot segments were identified for the study. To narrow down to the final hot spot segments; the number of severe crashes (those crashes that resulted in a fatal or major injury) was identified for the rural freeway segments that had a notable hot spot (those areas shown in red in **Figures C1-C12**). The eight candidate hot spot segments and the number of fatal and major injury crashes are summarized in **Table C1**. Selection of the five hot spot segments considered the size and intensity of hot spots as well as the number of severe crashes. When candidate segments were located near another candidate, preference was given to the segment with the greatest number of fatal and major injury crashes. For example, the first and second candidate locations in **Table C1** are located only five miles apart. However, the second candidate had a total of seven severe crashes compared to a single severe crash in the first candidate. Therefore, the first segment was dismissed and the second segment was selected as a hot spot segment. The final selection of typical and hot spot segments is summarized in **Table C2**.

Table C1. I-80 Rural Study Segments – Hot Spot Candidates

I-80 Segment Description	Fatal Crashes (2012-2016)	Major Injury Crashes (2012-2016)
Exit 27 (I-680) to Exit 29 (Minden)	0	1
Exit 34 (Shelby) to Exit 40 (Avoca)	2	6
Exit 113 (Van Meter) to Weigh Station (west of Exit 117, Ute Ave)	0	1
Exit 149 (Mitchellville) to Exit 155 (Colfax/Mingo)	1	5
Exit 179 (Lynnville) to Exit 182 (Grinnell)	0	2
Exit 182 (Grinnell) to Exit 191 (US 63)	1	5
Exit 249 (County Road F44) to Exit 254 (West Branch)	0	3
Exit 271 (US 6 / Wilton) to Exit 277 (Durant)	3	1

Table C2. I-80 Rural Study Segments

I-80 Segment Number	I-80 Segment Description
Typical Segments	
Segment 1:	Exit 60 (US 6/US 71) to Exit 64 (Wiota)
Segment 2:	Exit 106 (County Rd P58/County Rd F90) to Exit 110 (US 6/US 169)
Segment 3:	Exit 191 (US 63) to Exit 197 (Brooklyn)
Segment 4:	Exit 225 (US 151) to Exit 230 (Oxford/Kalona)
Segment 5:	Exit 259 (West Liberty) to Exit 265 (Atalissa)
Hot Spot Segments	
HS Segment 1:	Exit 34 (Shelby) to Exit 40 (Avoca)
HS Segment 2:	Exit 113 (Van Meter) to Weigh Station (west of Exit 117, Ute Ave)
HS Segment 3:	Exit 149 (Mitchellville) to Exit 155 (Colfax/Mingo)
HS Segment 4:	Exit 182 (Grinnell) to Exit 191 (US 63)
HS Segment 5:	Exit 271 (US 6/Wilton) to Exit 277 (Durant)

SUMMARY OF EXISTING CRASHES

Crashes records for I-80 were summarized for the entire study area (i.e., rural I-80) and for the 10 study segments, including the five typical segments and the five hot spot segments. Crash frequency by severity is summarized in **Table C3** and crash rates are summarized **Table C4**.

Table C3. Crash Frequency by Severity for I-80 Rural Segments (2012-2016)

I-80 Segment	Crashes by Severity					Total Crashes
	Fatal	Major Injury	Minor Injury	Possible Injury	Property Damage Only	
Typical Segments						
Segment 1: Exit 60 (US 6/US 71) to Exit 64 (Wiota)	1	1	4	6	33	45
Segment 2: Exit 106 (County Rd P58/County Rd F90) to Exit 110 (US 6/US 169)	0	0	4	6	58	68
Segment 3: Exit 191 (US 63) to Exit 197 (Brooklyn)	1	5	6	11	90	113
Segment 4: Exit 225 (US 151) to Exit 230 (Oxford/Kalona)	0	3	5	9	101	118
Segment 5: Exit 259 (West Liberty) to Exit 265 (Atalissa)	1	0	13	23	124	161
Total – Typical Segments	**3**	**9**	**32**	**55**	**406**	**505**
Crash Hot Spot (HS) Segments						
HS Segment A: Exit 34 (Shelby) to Exit 40 (Avoca)	2	6	8	8	59	83
HS Segment B: Exit 113 (Van Meter) to Weigh Station (west of Exit 117, Ute Ave)	0	1	0	5	39	45
HS Segment C: Exit 149 (Mitchellville) to Exit 155 (Colfax/Mingo)	1	5	16	19	151	192
HS Segment D: Exit 182 (Grinnell) to Exit 191 (US 63)	1	5	11	9	167	193
HS Segment E: Exit 271 (US 6/Wilton) to Exit 277 (Durant)	3	1	8	19	121	152
Total – Crash Hot Spot Segments	**7**	**18**	**43**	**60**	**537**	**665**
I-80 Study Area	**63**	**157**	**643**	**919**	**6,854**	**8,636**

Table C4. Crash Rates for I-80 Rural Segments (2012-2016)

I-80 Segment	2014 ADT*	Segment Length (mi.)	No. Crashes+	Fatal and Major Injury Crashes+	Segment Crash Rate (100M VMT)	Fatal and Major Injury Segment Crash Rate (100M VMT)
Typical Segments						
Segment 1: Exit 60 (US 6/US 71) to Exit 64 (Wiota)	20,100	3.43	45	2	35.8	1.6
Segment 2: Exit 106 (County Rd P58/County Rd F90) to Exit 110 (US 6/US 169)	28,100	3.14	68	0	42.2	0.0
Segment 3: Exit 191 (US 63) to Exit 197 (Brooklyn)	26,300	4.98	113	6	47.3	2.5
Segment 4: Exit 225 (US 151) to Exit 230 (Oxford/Kalona)	30,600	5.03	118	3	42.0	1.1
Segment 5: Exit 259 (West Liberty) to Exit 265 (Atalissa)	33,500	4.88	161	1	54.0	0.3
Crash Hot Spot Segments						
HS Segment A: Exit 34 (Shelby) to Exit 40 (Avoca)	23,300	5.34	83	8	36.6	3.5
HS Segment B: Exit 113 (Van Meter) to Weigh Station (west of Exit 117, Ute Ave)	35,700	3.40	45	1	20.3	0.5
HS Segment C: Exit 149 (Mitchellville) to Exit 155 (Colfax/Mingo)	34,700	5.75	192	6	52.7	1.7
HS Segment D: Exit 182 (Grinnell) to Exit 191 (US 63)	26,500	8.50	193	6	46.9	1.5
HS Segment E: Exit 271 (US 6 Wilton) to Exit 277 (Durant)	32,400	5.63	152	4	45.7	1.2
Statewide Average – Rural Interstates					**47.8**	**1.4**

** Source: Iowa DOT Systems Planning, I-80 Planning Study Forecasts, 2017 (unpublished)*

+ Source: Iowa DOT, 2012-2016, webSAVER accessed on July 10, 2017

Figure C1. Existing Conditions – Crash Hot Spot Analysis 1 of 12

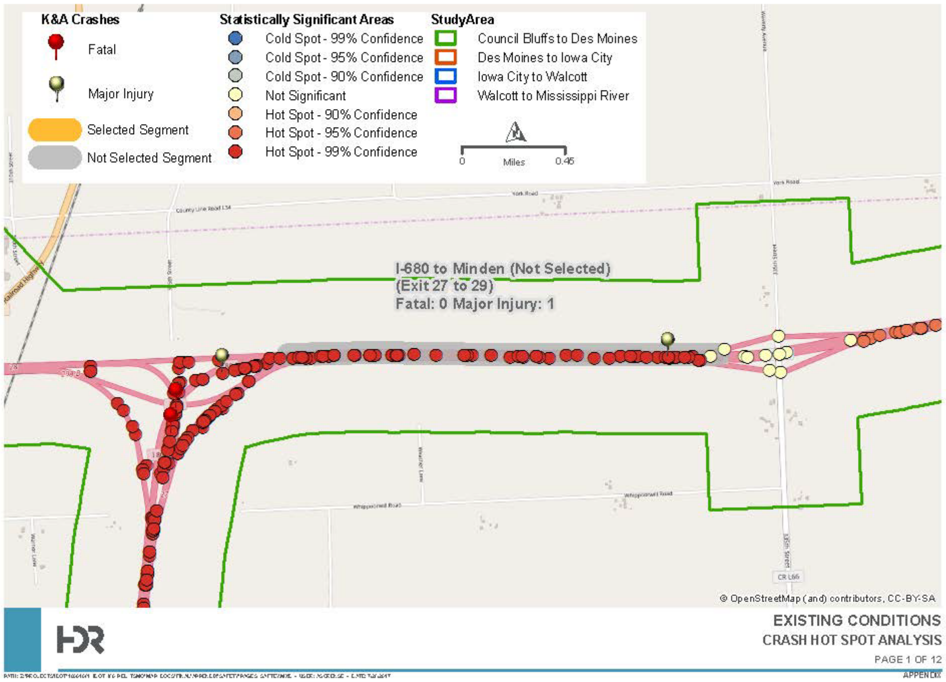


Figure C2. Existing Conditions – Crash Hot Spot Analysis 2 of 12

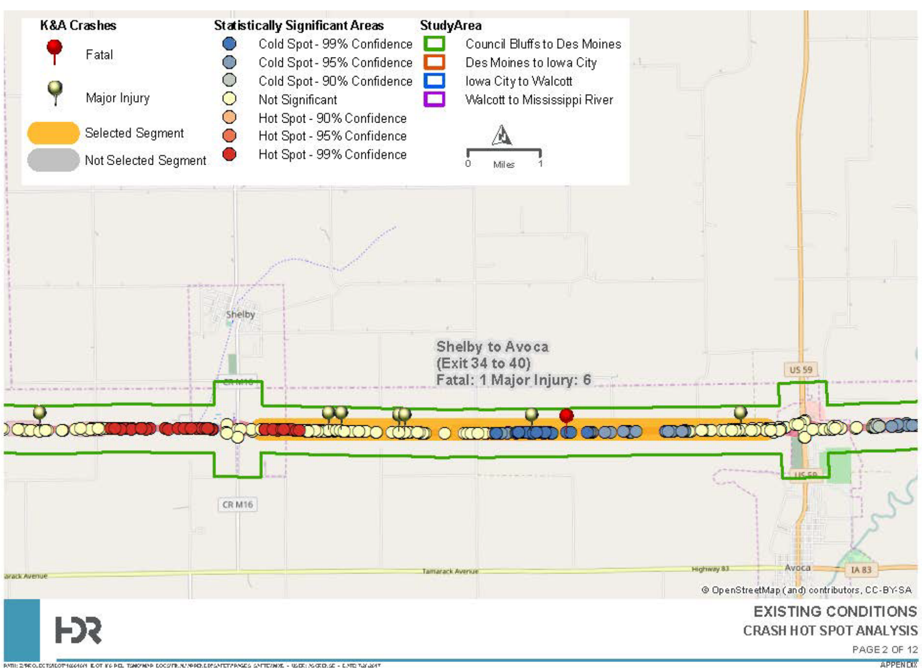


Figure C3. Existing Conditions – Crash Hot Spot Analysis 3 of 12

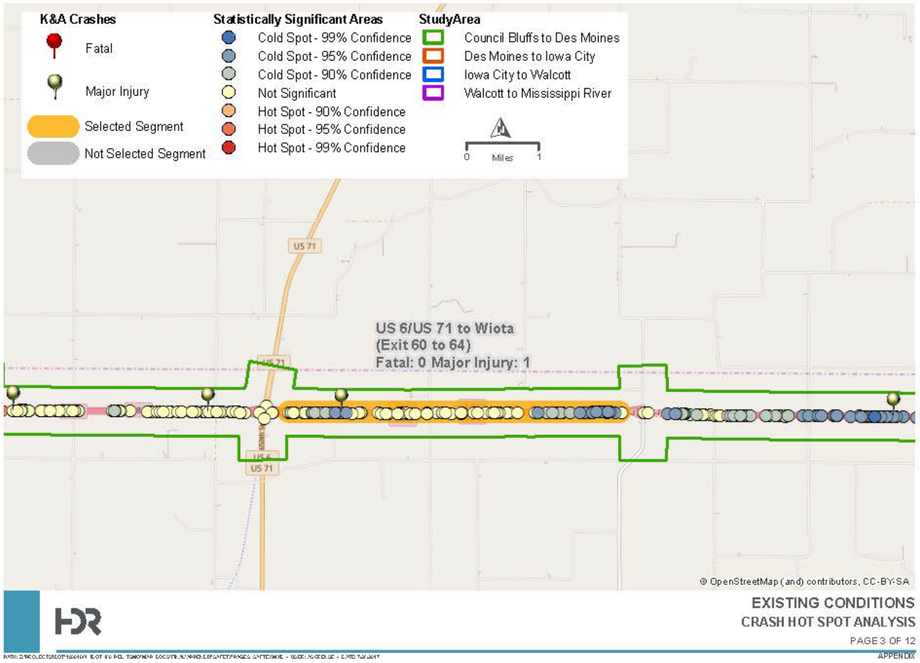


Figure C4. Existing Conditions – Crash Hot Spot Analysis 4 of 12

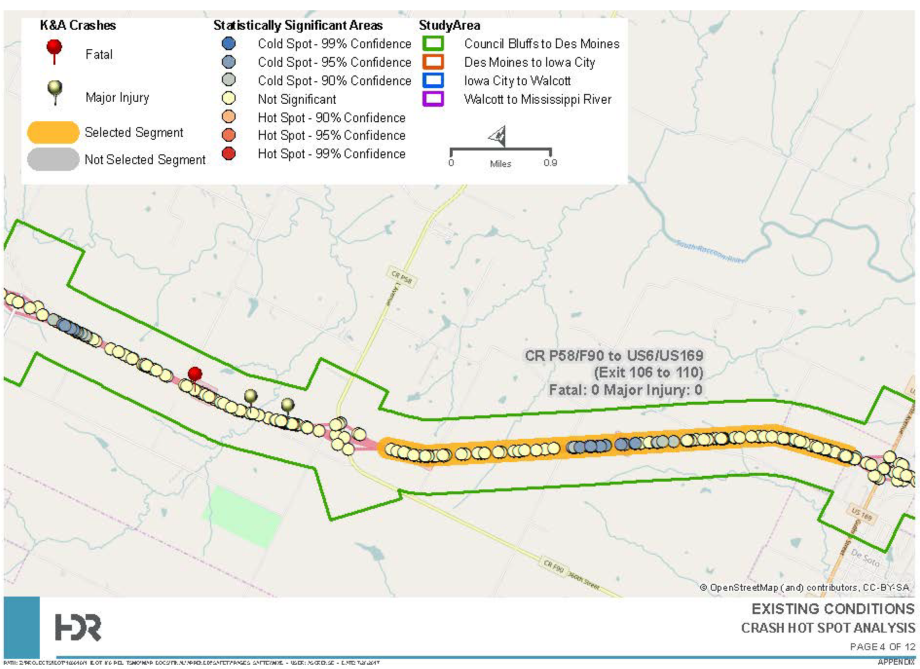


Figure C5. Existing Conditions – Crash Hot Spot Analysis 5 of 12

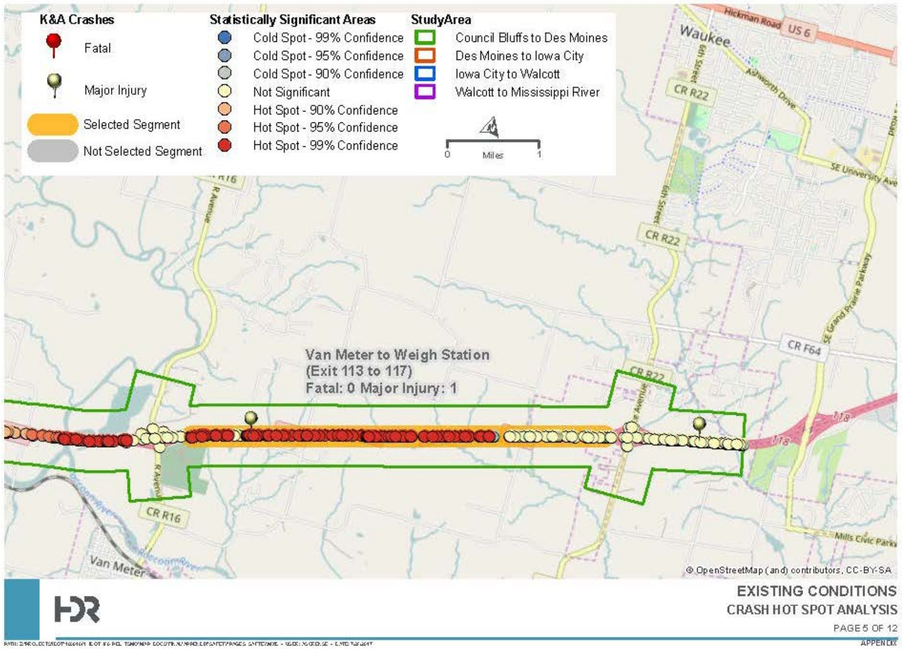


Figure C6. Existing Conditions – Crash Hot Spot Analysis 6 of 12

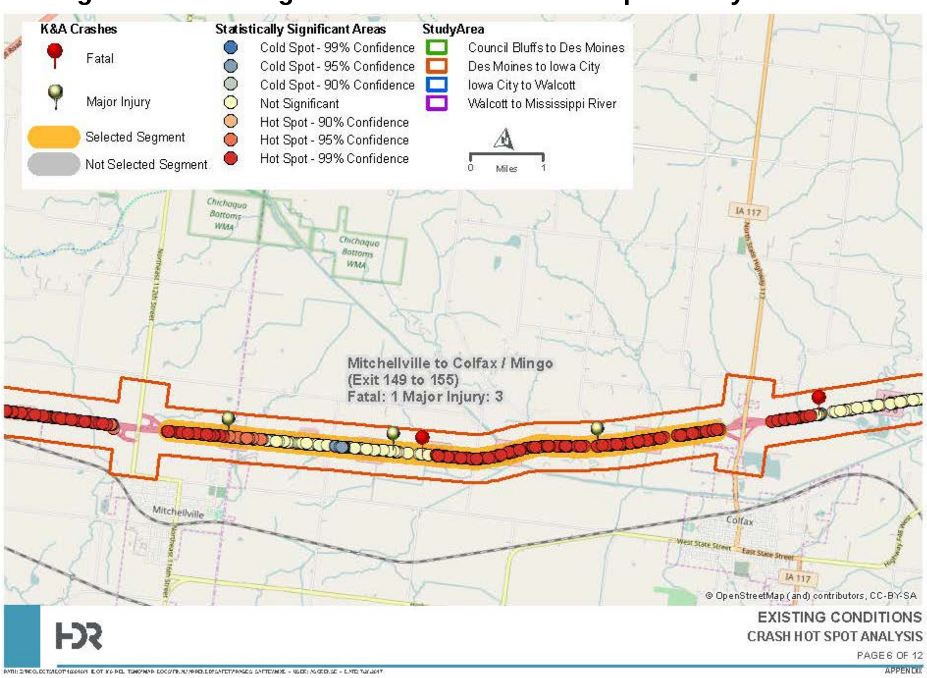


Figure C7. Existing Conditions – Crash Hot Spot Analysis 7 of 12

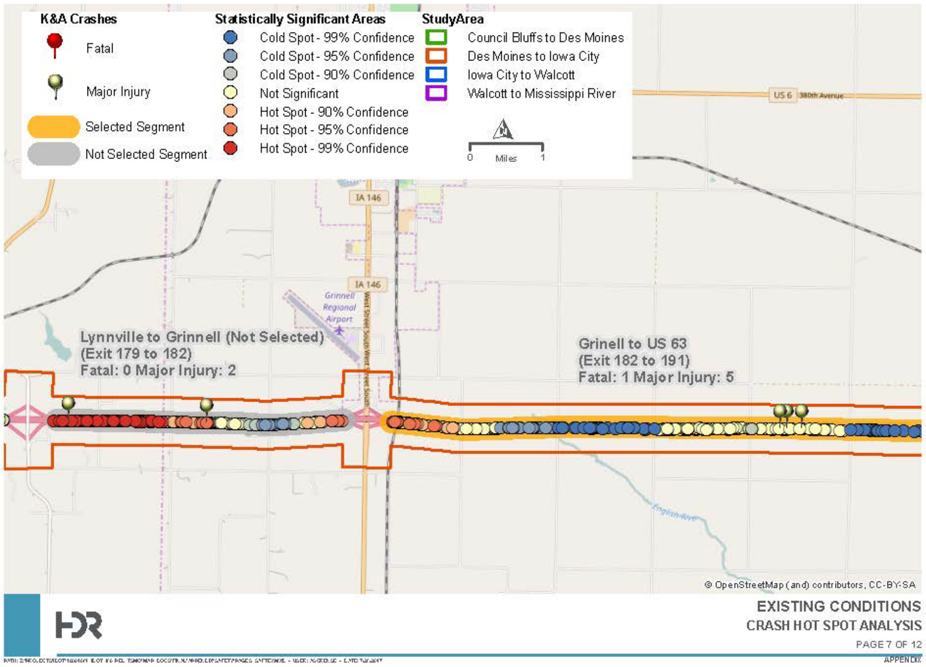


Figure C8. Existing Conditions – Crash Hot Spot Analysis 8 of 12

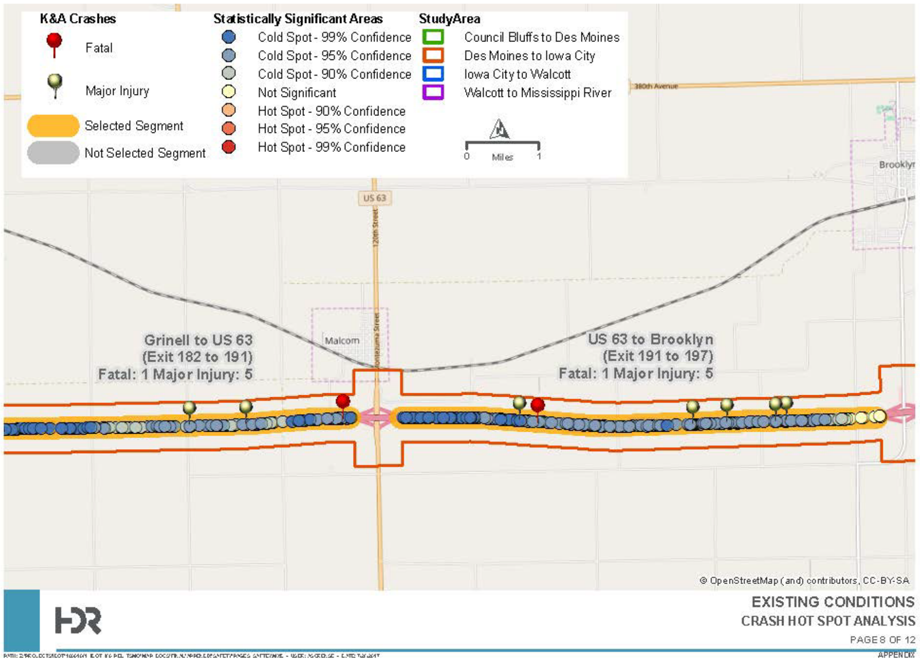


Figure C9. Existing Conditions – Crash Hot Spot Analysis 9 of 12

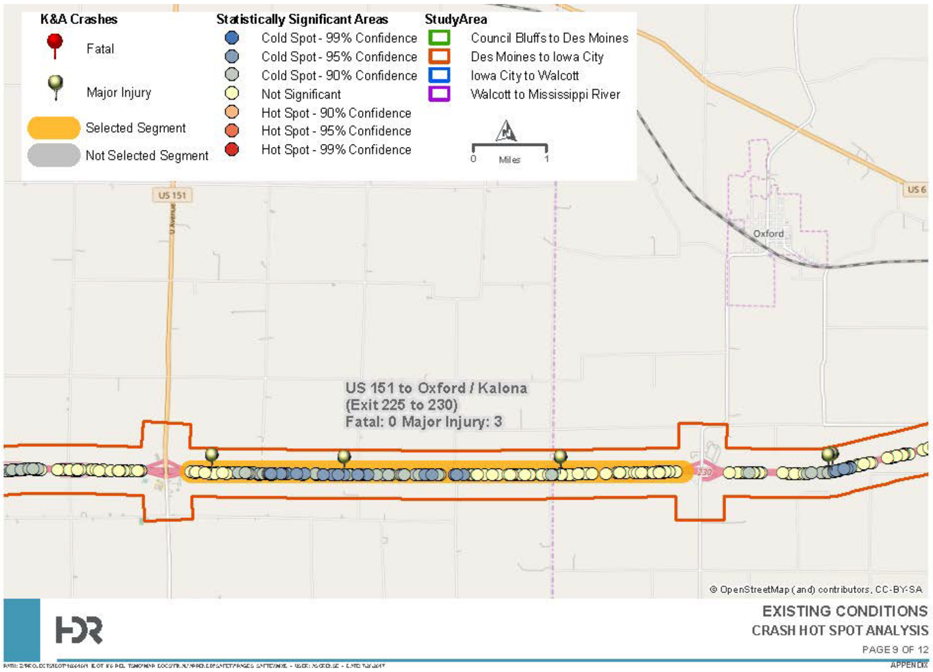


Figure C10. Existing Conditions – Crash Hot Spot Analysis 10 of 12

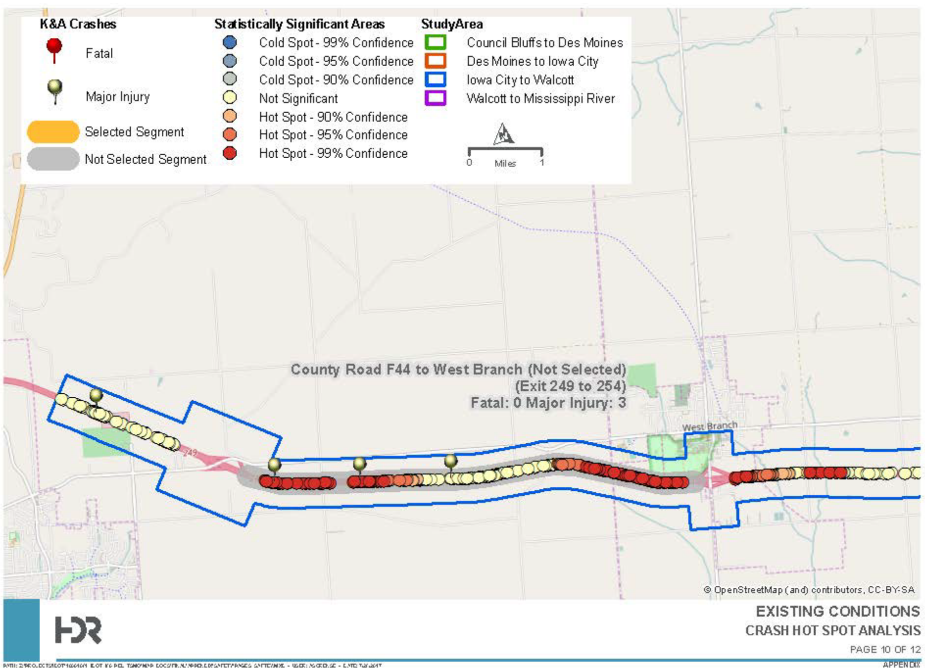


Figure C11. Existing Conditions – Crash Hot Spot Analysis 11 of 12

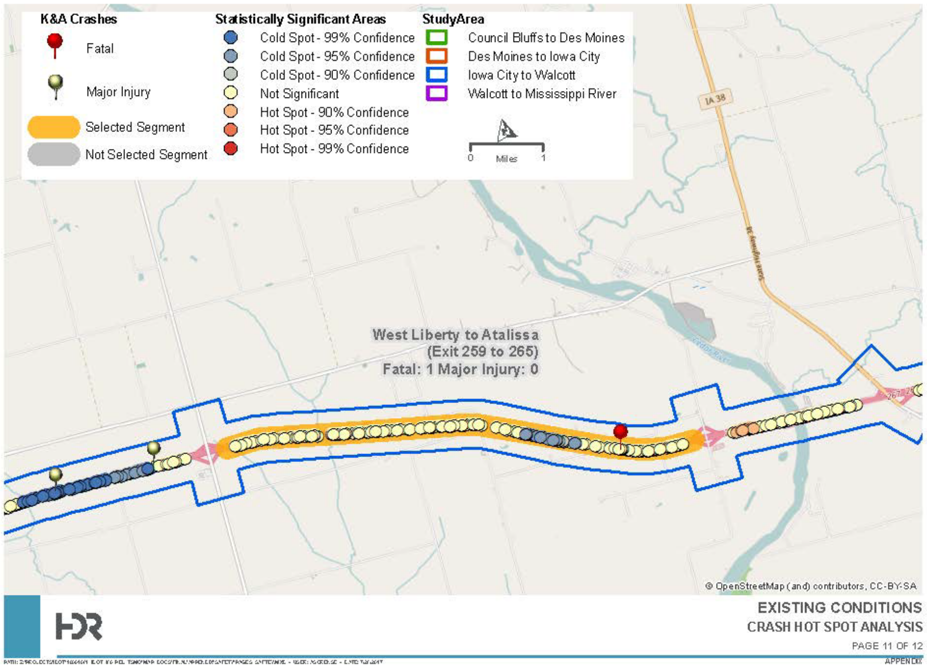
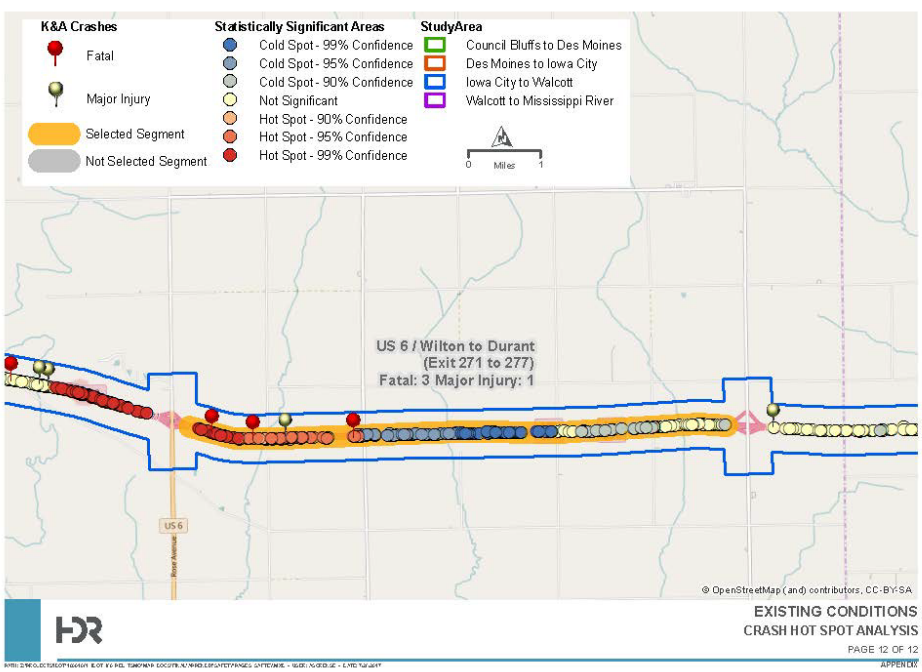


Figure C12. Existing Conditions – Crash Hot Spot Analysis 12 of 12



FUTURE NO-BUILD CONDITION MODELING

Evaluation of the future no-build condition safety performance used a modeling approach where key traffic volume and roadway geometric characteristics such as number of lanes, lane width, shoulder width, median width, horizontal roadway alignment, and location and distance to traffic barriers were used to estimate future crash frequency by severity. The analysis relied on safety performance functions (SPFs) for rural freeway segments from the Highway Safety Manual (HSM). The traffic capacity and safety analyses used the same traffic volumes. The program Interactive Highway Safety Design Model (IHSDM) (version 12.1.0) was chosen to perform the crash prediction.

Predictions of 2040 crashes for a single year by segment are summarized in **Table C5**.

Table C5. Crash Predictions for I-80 Segments (2040 No-Build)

I-80 Segment	2040 ADT	Segment Length (mi.)	Predicted Crash Frequency			Segment Crash Rate (100M VMT)
			Fatal and Injury Crashes	Property Damage Only Crashes	Total Crashes	
Segment 1: Exit 60 (US 6/US 71) to Exit 64 (Wiota)	28,944	3.43	3.5	12.7	16.1	44.5
Segment 2: Exit 106 (County Rd P58/County Rd F90) to Exit 110 (US 6/US 169)	44,960	3.14	5.6	24.6	30.2	58.7
Segment 3: Exit 191 (US 63) to Exit 197 (Brooklyn)	39,318	4.98	7.4	31.8	39.2	54.8
Segment 4: Exit 225 (US 151) to Exit 230 (Oxford/Kalona)	45,900	5.03	8.8	39.7	48.5	57.6
Segment 5: Exit 259 (West Liberty) to Exit 265 (Atalissa)	51,926	4.88	10.2	45.0	55.1	59.6
Total Predicted Crashes			**35.5**	**153.7**	**189.2**	

EXISTING CONDITIONS

Figure C13 summarizes reported major casue for the 5 typical segments while **Figure C14** is the reported major causes for the 5 hot spot segments. **Figures C13 - C24** summarize the reported major cause for the crashes for both typical and hot spot freeway segments.

Figure C13. Major Cause Reported I-80 Rural Freeway Typical Segments (2012-2016)

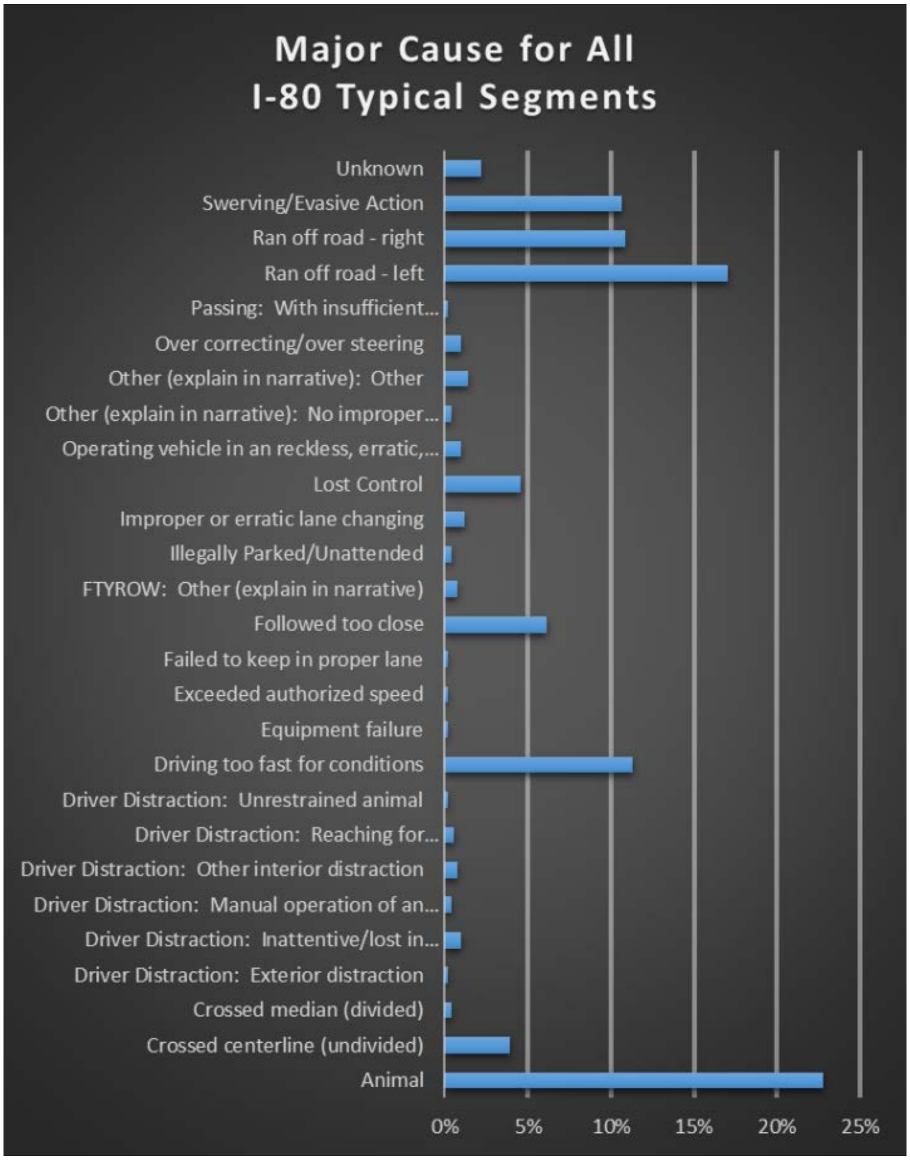


Figure C14. Major Cause Reported I-80 Rural Freeway Crash Hot Spot Segments (2012-2016)

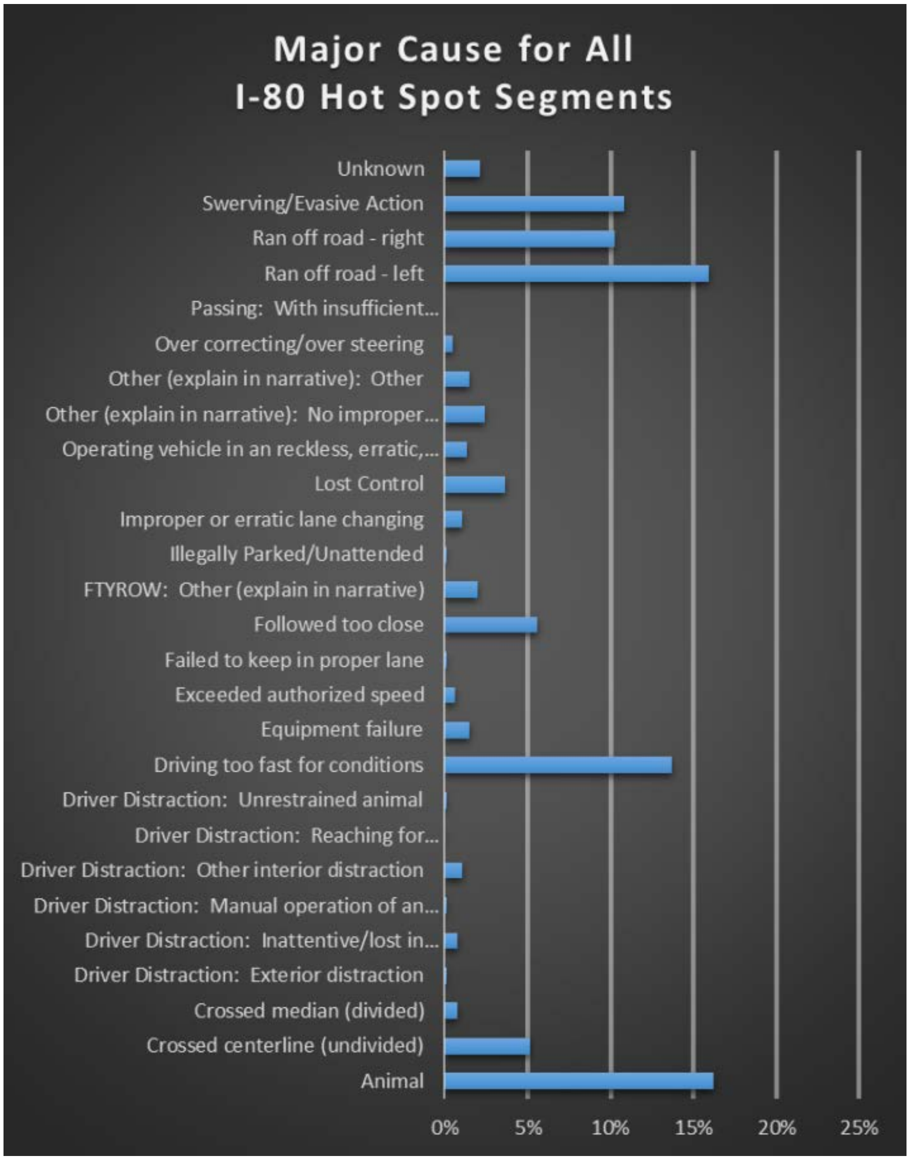


Figure C15. Major Cause Reported I-80 Rural Freeway Typical Segment 1: Exit 60 to Exit 64 (2012-2016)

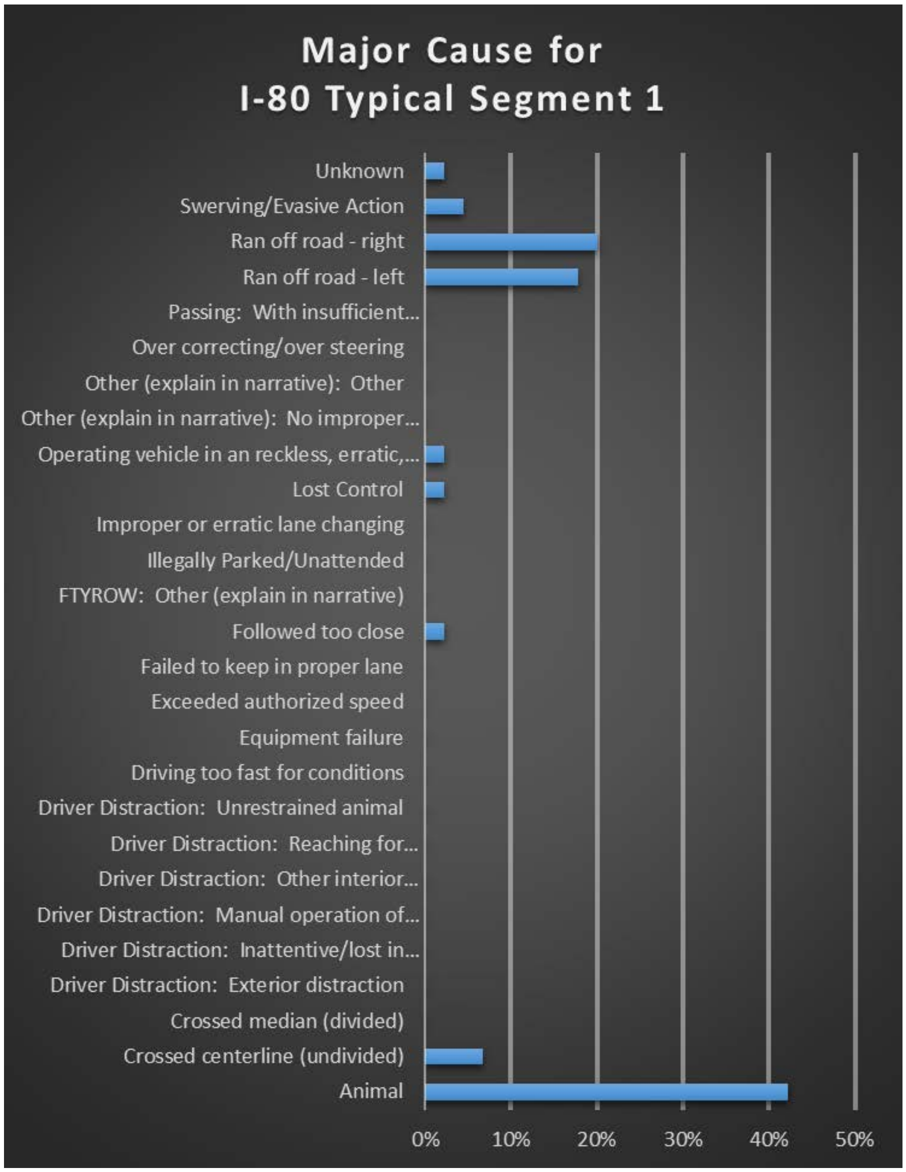


Figure C16. Major Cause Reported I-80 Rural Freeway Typical Segment 2: Exit 106 to Exit 110 (2012-2016)

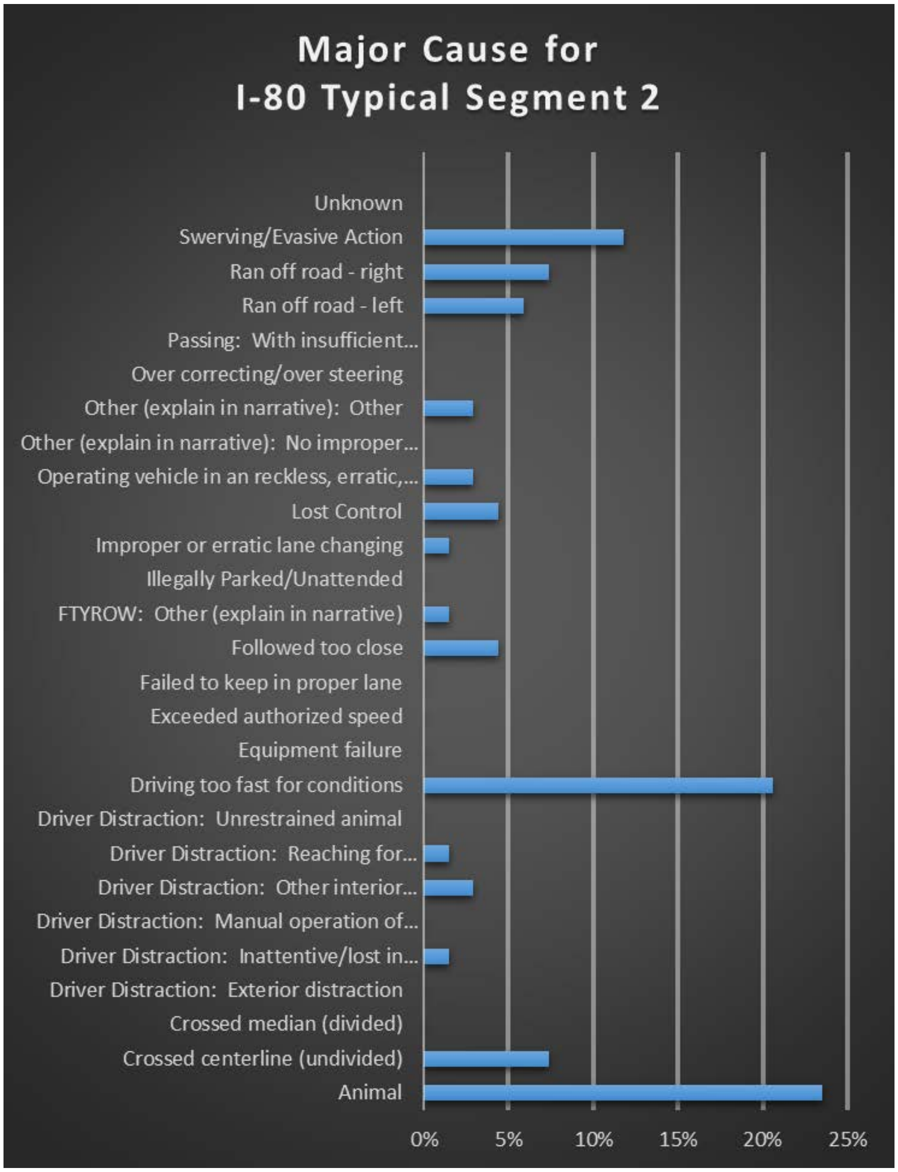


Figure C17. Major Cause Reported I-80 Rural Freeway Typical Segment 3: Exit 191 to Exit 197 (2012-2016)

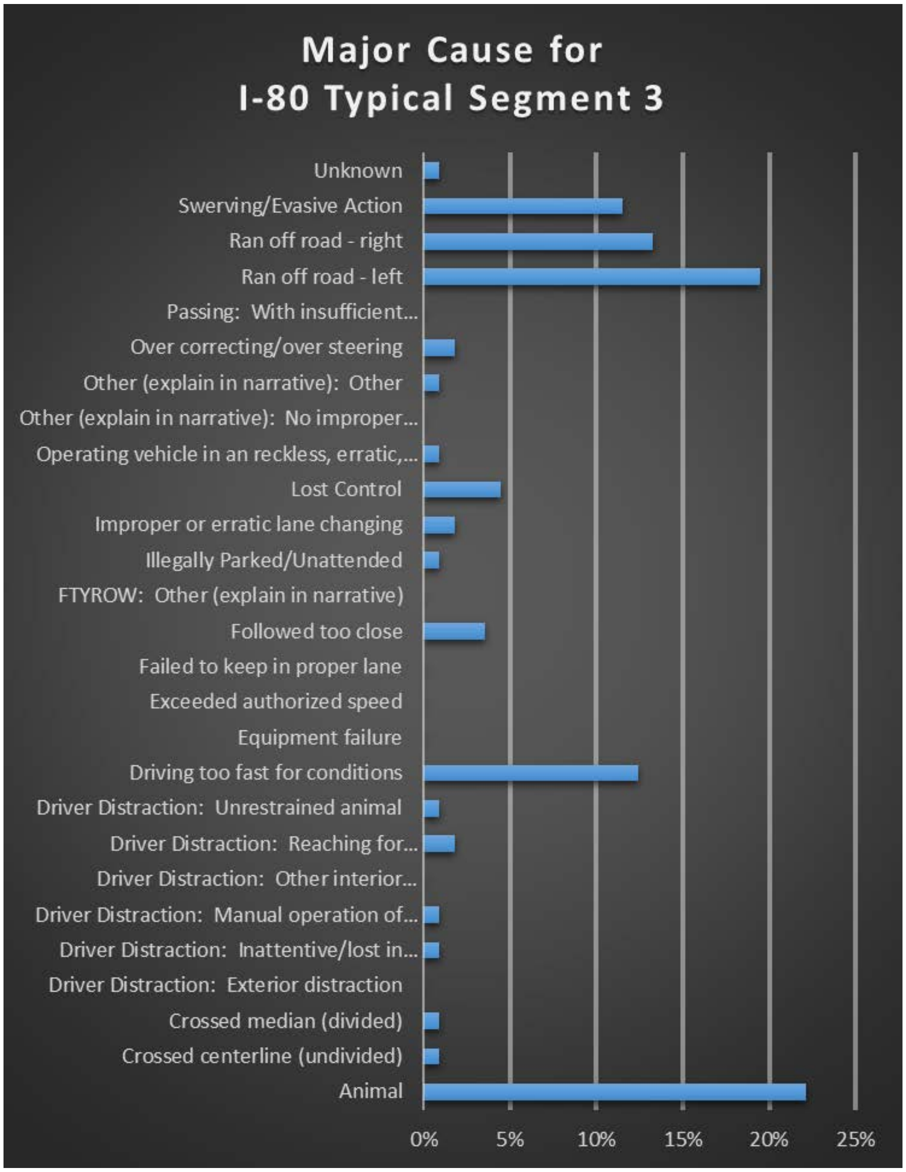


Figure C18. Major Cause Reported I-80 Rural Freeway Typical Segment 4: Exit 225 to Exit 230 (2012-2016)

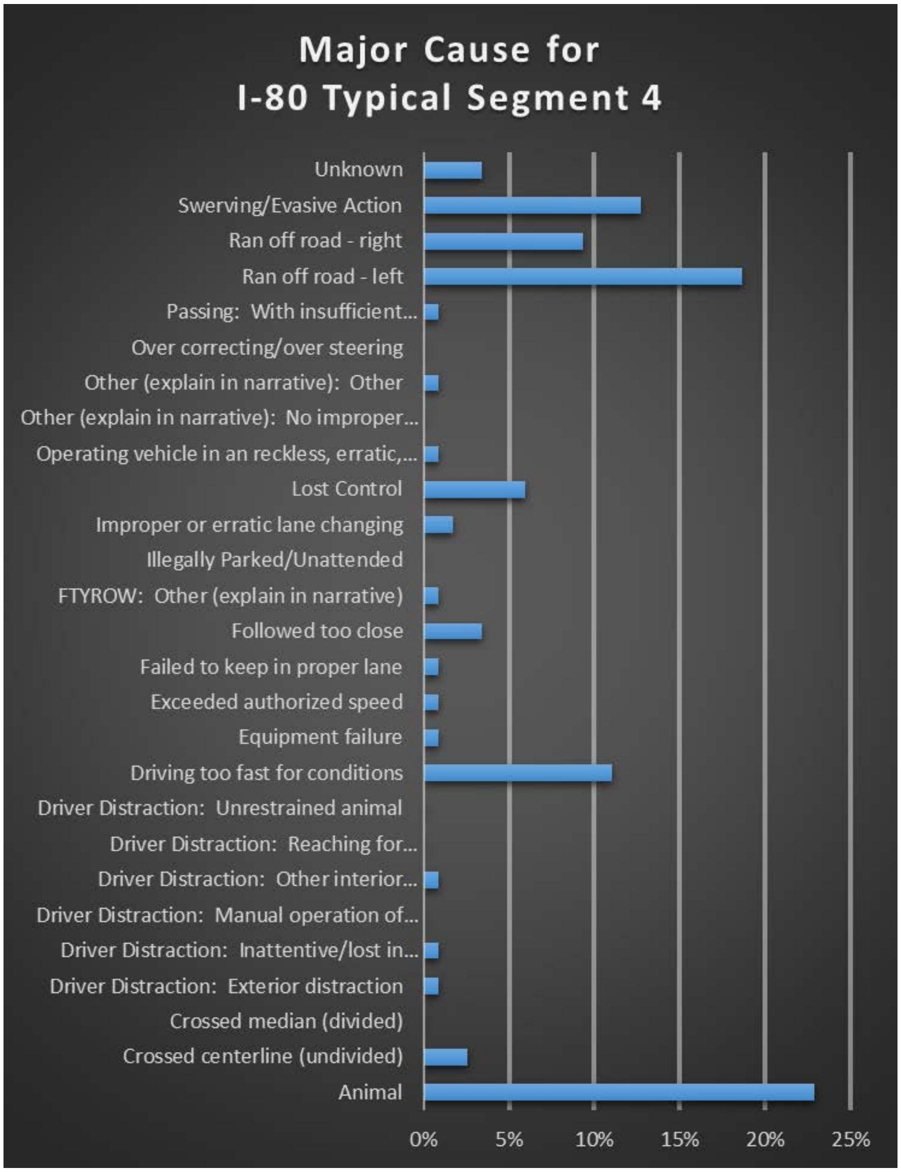


Figure C19. Major Cause Reported I-80 Rural Freeway Typical Segment 5: Exit 259 to Exit 265 (2012-2016)

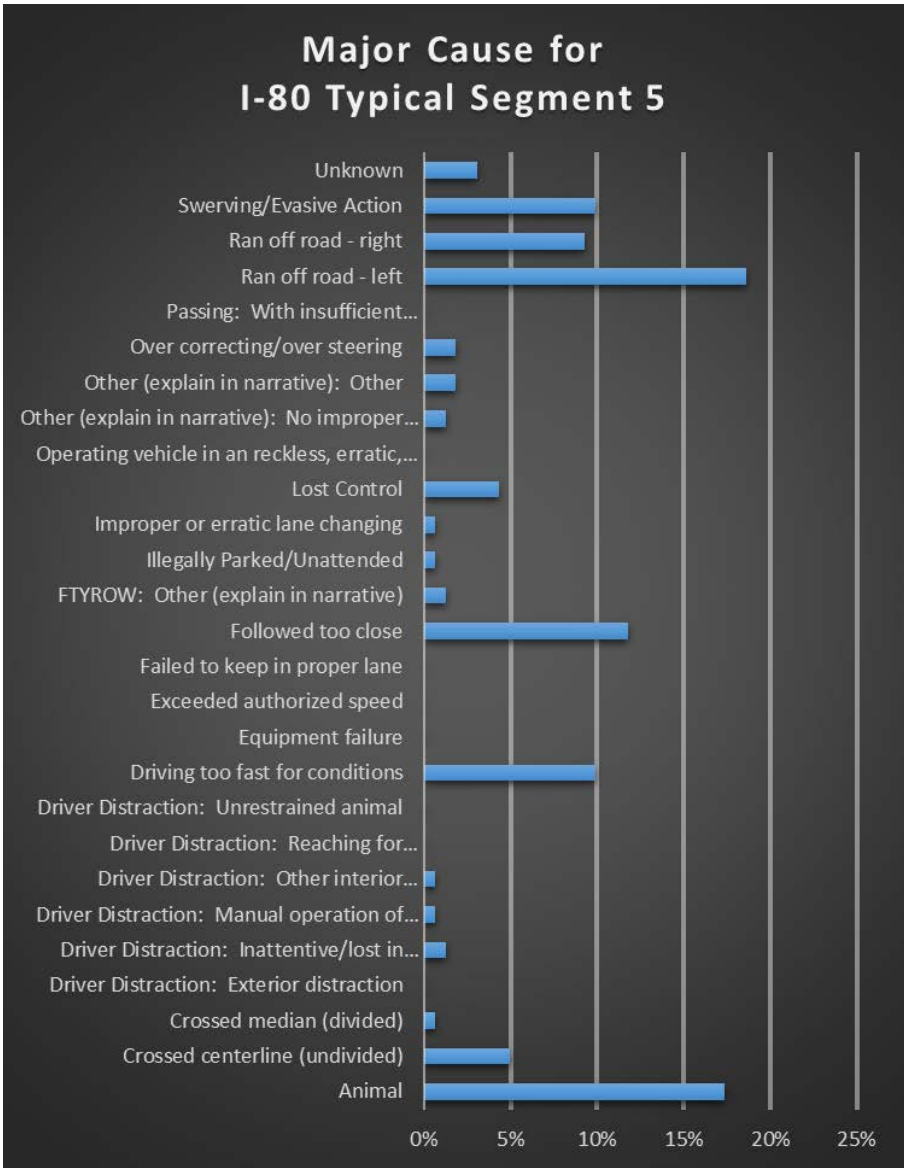


Figure C20. Major Cause Reported I-80 Rural Freeway Hot Spot Segment 1: Exit 34 to Exit 40 (2012-2016)

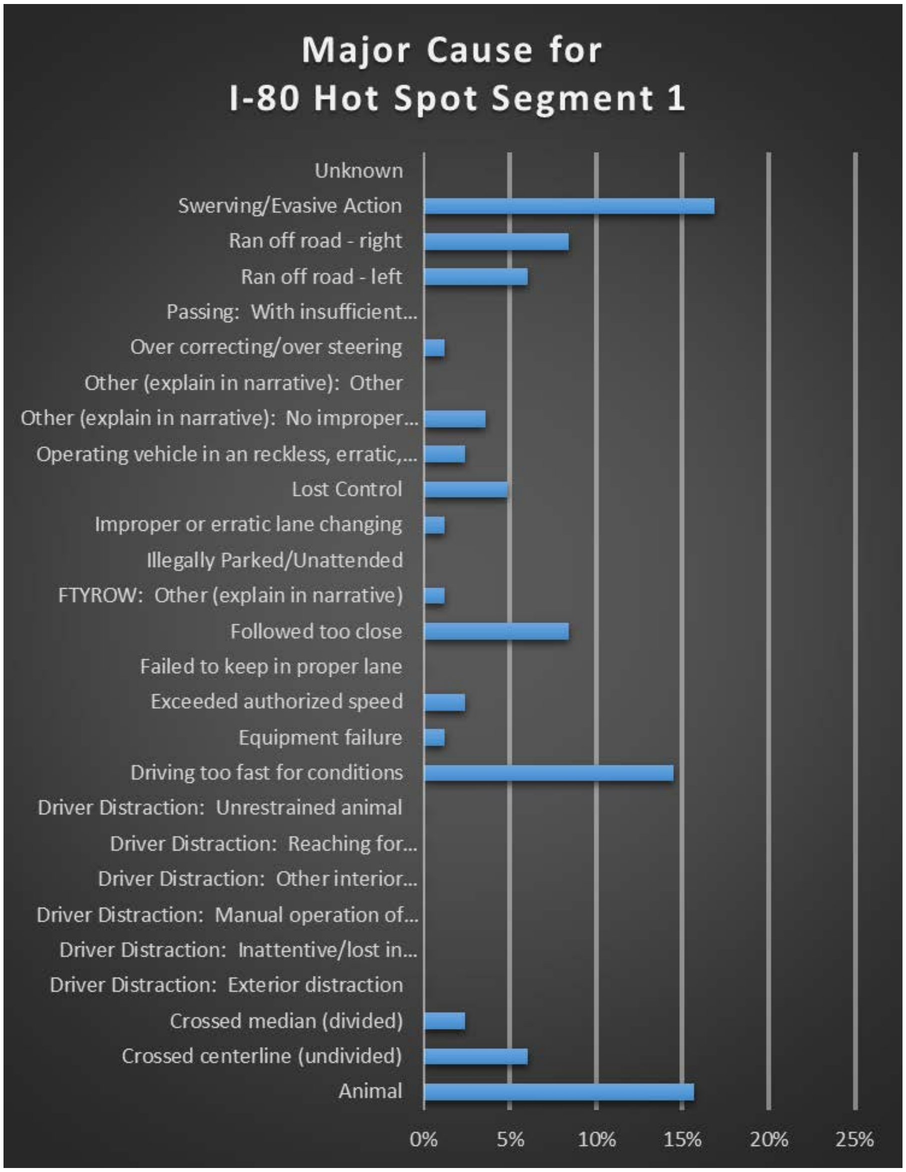


Figure C21. Major Cause Reported I-80 Rural Freeway Hot Spot Segment 2: Exit 113 to Weigh Station west of Exit 117 (2012-2016)

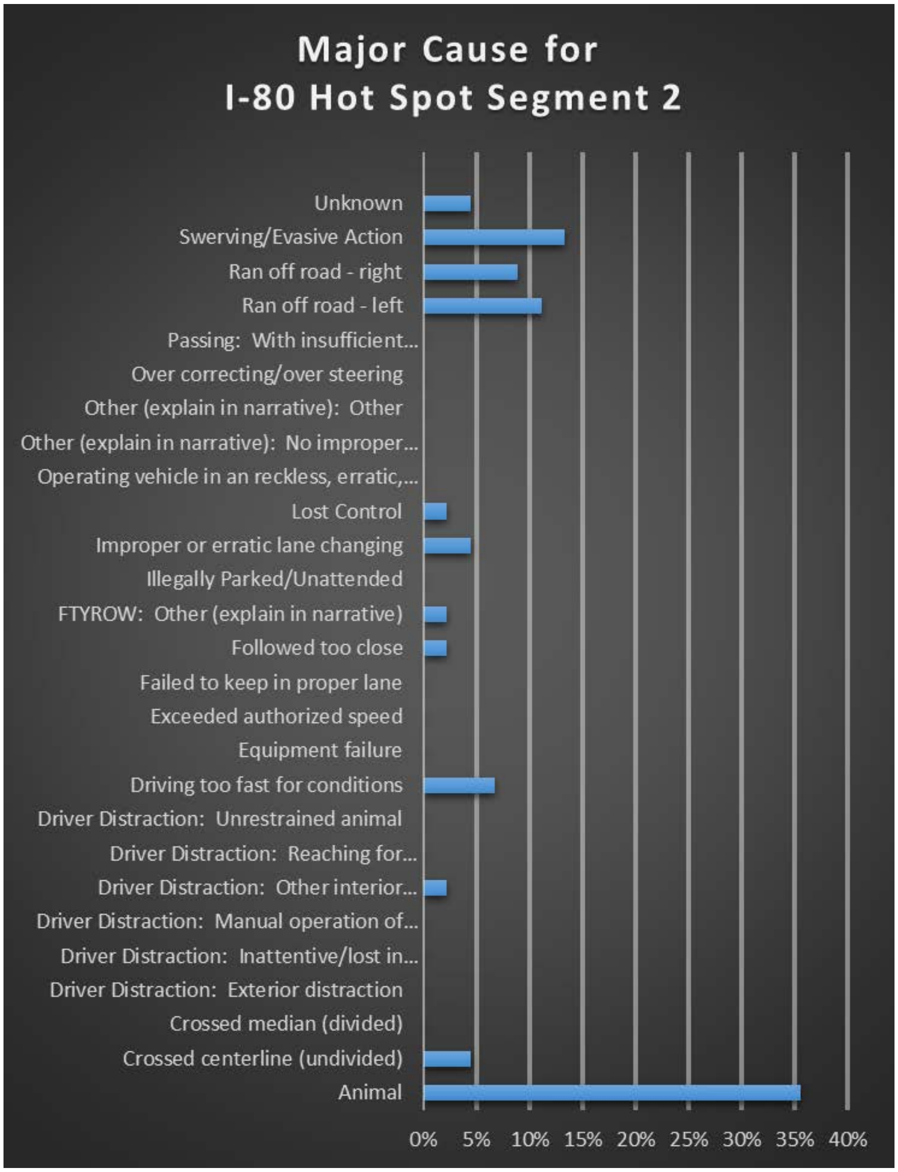


Figure C22. Major Cause Reported I-80 Rural Freeway Hot Spot Segment 3: Exit 149 to Exit 155 (2012-2016)

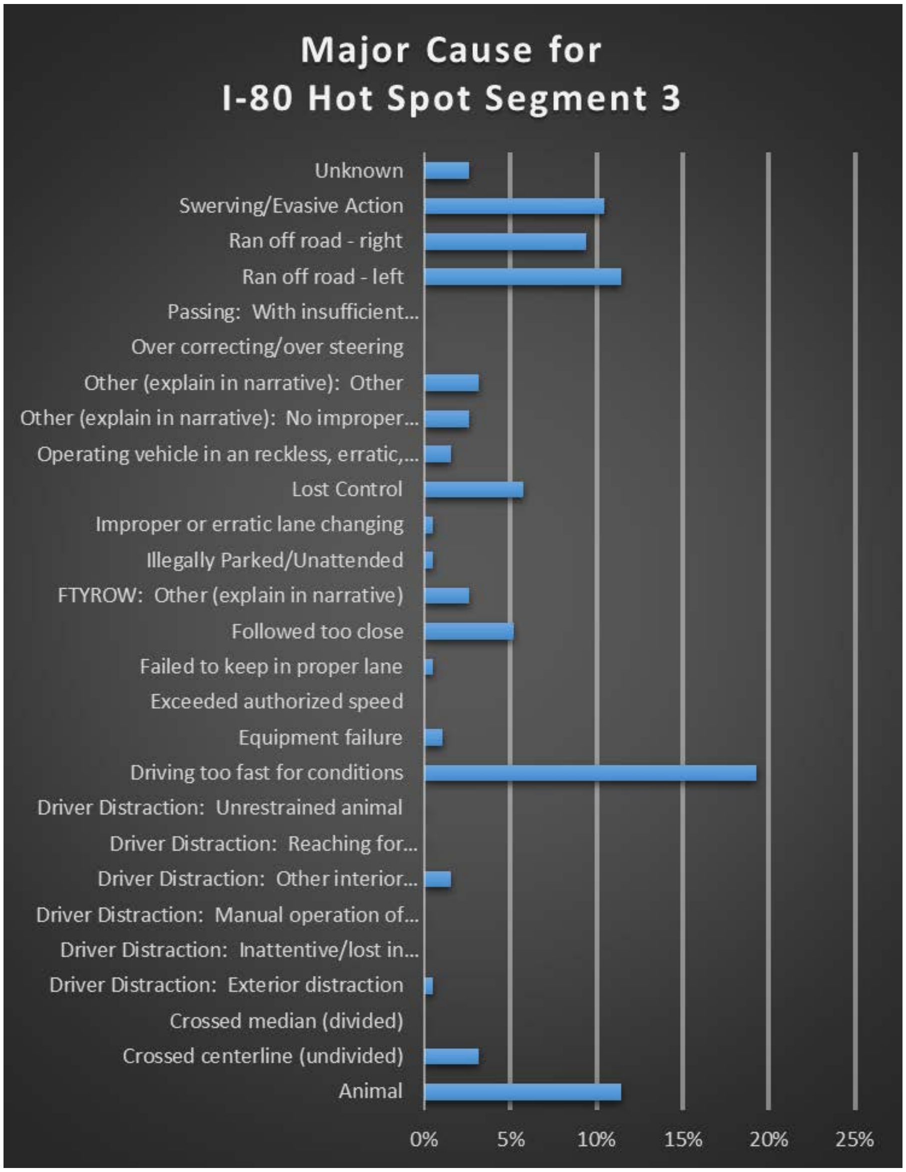


Figure C23. Major Cause Reported I-80 Rural Freeway Hot Spot Segment 4: Exit 182 to Exit 191 (2012-2016)

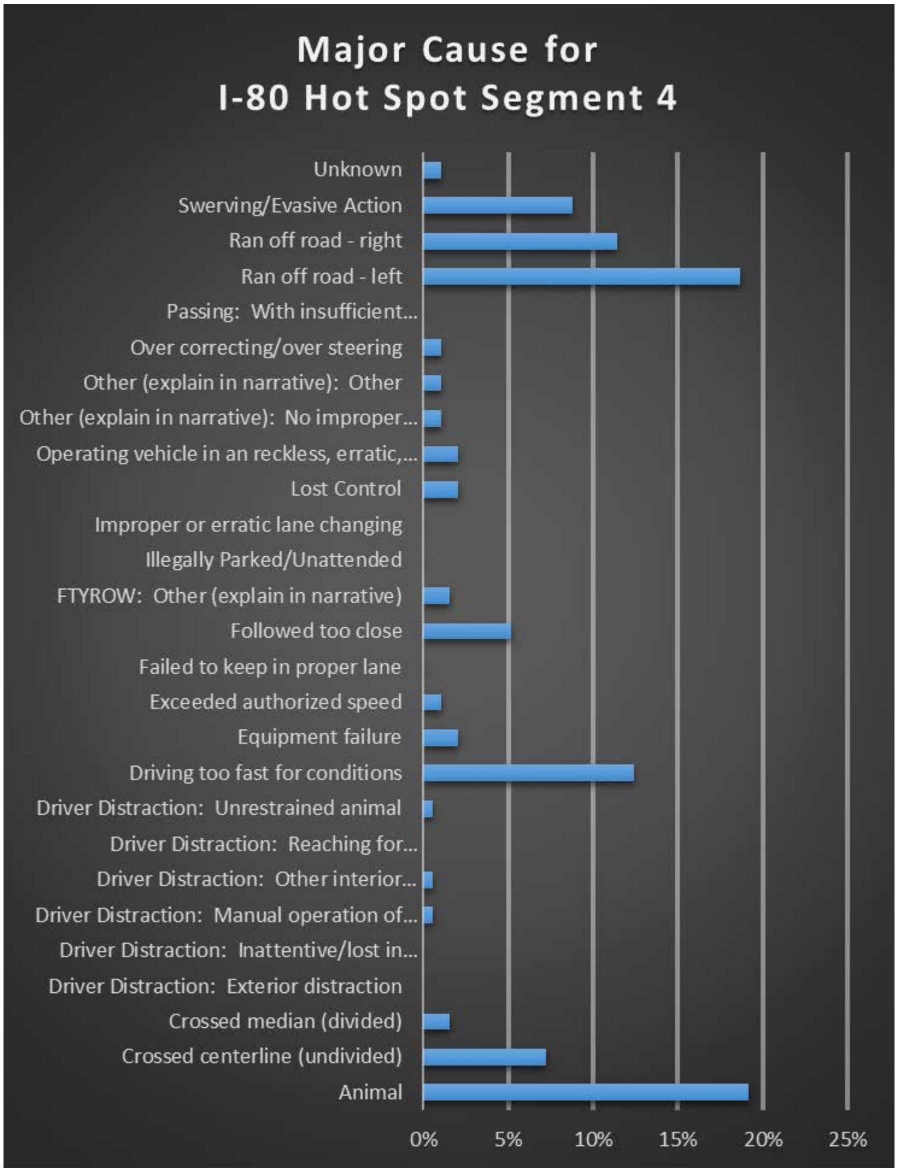
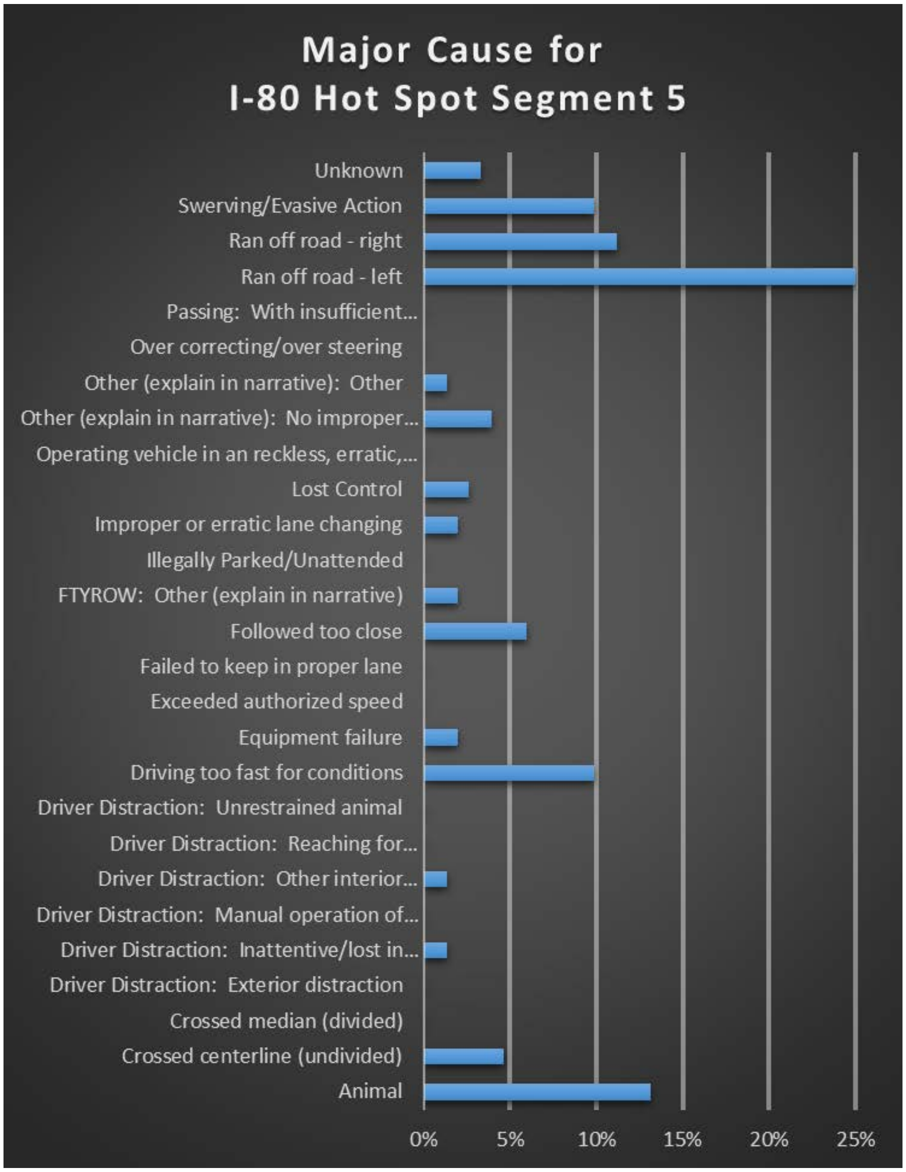


Figure C24. Major Cause Reported I-80 Rural Freeway Hot Spot Segment 5: Exit 271 to Exit 277 (2012-2016)



Appendix D: Geometric Analysis Data Sets

2014 Pavement Condition Index, http://data.iowadot.gov/datasets/2014-pavement-condition-index

The Pavement Management Information Systems (PMIS) from 2011 through 2015 contains various levels of data on the pavement condition and history of Iowa Interstate and Primary routes. The data was collected by a 3rd party vendor and processed by the Iowa Department of Transportation.

2015 International Roughness Index, http://data.iowadot.gov/datasets/2015-international-roughness-index

The Pavement Management Information Systems (PMIS) from 2011 through 2015 contains various levels of data on the pavement condition and history of Iowa Interstate and Primary routes. The data was collected by a 3rd party vendor and processed by the Iowa Department of Transportation.

Application for the 2017 Iowa legislature with information on the condition of Iowa's bridges, http://iowadot.maps.arcgis.com/home/item.html?id=db6cb43313354a4f85505089ab317e7a

Note that data is the best available data as of 6/5/2017 and may be different than what was submitted to FHWA for our most recent submission. Data and application will be updated on an as-needed basis.

All information for the geometric analysis was provided by the Iowa DOT as of June of 2017.

Appendix E: Environmental Resources Analysis

To identify known resources present within the Study Area (0.25 mile on either side of I-80), available geographic information system (GIS) data were compiled for the Study Area from the following sources:

- United States Department of Agriculture CropScape data
- University of Iowa land cover data for grasslands
- United States Census Bureau TIGER data
- Iowa DOT Open Data Portal interstate data
- Iowa DNR cemeteries data
- Iowa DOT conservation lands, cultural resources, floodplains, regulated materials, streams, threatened and endangered species, unique landforms, wetlands, WMA, and woodland data

The CropScape – Cropland Data Layer, maintained by the U.S. Department of Agriculture, are satellite images depicting agricultural land cover. The images are useful for monitoring crop rotation patterns, land use changes, water resources and carbon emissions. Topographically Integrated Geographic Encoding and Referencing (TIGER) products produced by the U.S. Census Bureau are line and boundary files from their database that provide features such as roads, railroads, rivers and legal and statistical geographic areas such as counties. Other GIS data were acquired from the Iowa Department of Transportation GIS Services' Open Data Portal

Table E1 presents the resources present and amount of each resource per mile by county. For each resource in the table, the row is color coded using a scale by resource that goes from grey (smallest concentration of resource) to orange (largest concentration of resource). For example, for cultural resources, Madison County, the county with the greyest cell, has the smallest acreage of known cultural resources sites per mile, while Cedar County, with the most orange cell, has the largest acreage of known cultural resources sites per mile. This color coded scale visually helps determine the county with the largest or smallest concentration of each environmental resource as well as counties that have high or low concentrations of numerous environmental resources based on the number of orange or grey cells they contain. **Table E2** identifies the concentration of each resource per mile to identify the counties that have higher concentrations.

Table E1: Resources in the 0.5 mile wide Study Area by County

Resource (acres unless otherwise noted)	Pottawattamie	Cass	Adair	Madison	Dallas	Polk	Jasper	Poweshiek	Iowa	Johnson	Cedar	Scott	total
Miles of Interstate	41.9	23.6	23.9	2.0	21.9	6.8	30.7	24.1	24.1	15.7	24.5	11.4	250.6
Cultural Resources	49	12	31	-	105	7	80	19	4	4	153	16	479
Parks	-	-	6	-	-	1	44	-	-	-	-	-	50
Trails (linear feet)	7,704	10,785	-	-	-	2,209	15,808	-	-	1,930	794	-	39,229
Floodplains	3,114	724	<0.1	53	577	-	2,506	-	504	237	956	406	9,078
Ungrazed Grasslands	2,818	1,327	1,423	118	1,356	420	1,709	1,114	1,270	1,250	1,612	823	15,240
Planted Grasslands	336	902	283	6	647	57	658	304	242	398	265	3	4,100
Regulated Materials	462	108	-	-	158	-	324	151	289	80	271	138	1,982
Streams (linear feet)	223,908	133,302	130,381	12,091	153,702	10,181	160,637	90,210	82,986	60,587	68,479	9,505	1,135,968
T&E (documented findings)	-	-	-	-	-	-	-	2	-	-	3	-	5
Federally-Listed	6	3	5	4	5	5	4	3	4	6	4	6	-
State-Listed	26	7	12	25	15	37	29	26	29	80	39	52	377
Conservation Lands	-	-	-	-	39	-	496	-	13	-	2	43	593
WMA	-	-	-	-	39	-	385	-	13	-	-	21	458
Historic Marker	-	-	-	-	-	-	1	-	-	-	-	-	1
Research Area	-	-	-	-	-	-	8	-	-	-	-	-	8
Sovereign Waters	-	-	-	-	-	-	-	-	-	-	2	22	24
Other Public Land	-	-	-	-	-	-	102	-	-	-	-	-	102
Unique Landforms	1,657	-	-	-	-	-	-	-	-	-	-	-	1,657
Wetlands	139	136	100	-	247	15	541	36	28	72	69	9	1,392
Palustrine	139	136	100	-	201	15	458	36	28	72	69	9	1,263
Emergent	72	54	35	-	21	1	86	16	7	35	12	3	342
Scrub-Shrub	9	4	-	-	24	-	30	1	-	1	-	-	69
Forested	50	31	32	-	104	10	296	-	5	18	46	-	592
Unconsolidated Bottom	8	47	33	-	52	4	43	19	16	18	11	6	257
Unconsolidated Shore	-	-	-	-	-	-	3	-	-	-	-	-	3
Aquatic Bed (Dike/Impounded)	-	-	-	-	-	-	-	<0.1	-	-	-	-	<0.1
Lacustrine	-	-	-	-	46	-	83	-	-	-	-	-	129
Unconsolidated Bottom	-	-	-	-	46	-	77	-	-	-	-	-	123
Unconsolidated Shore	-	-	-	-	-	-	6	-	-	-	-	-	6
Woodlands	447	324	225	-	1,258	69	1,336	223	75	225	554	1	4,738
Businesses (number)	33	2	44	-	96	35	73	15	37	37	42	31	445
AMC	-	-	1	-	8	3	6	1	2	4	1	-	26
MTC	-	-	5	-	10	3	2	-	8	5	13	3	49
Retail	5	1	9	-	6	3	10	-	7	6	8	5	60
Service	24	-	26	-	56	23	46	10	12	17	16	21	251
Unclassified	4	1	3	-	16	3	9	4	8	5	4	2	59
Cemeteries	29	-	27	-	1	-	-	3	6	-	4	-	68
Religious Places (number)	-	-	2	-	2	-	1	-	1	-	2	2	10
Farmland	9,164	5,226	5,805	552	2,837	1,551	4,749	5,412	5,874	3,313	5,312	2,760	52,555

Table E2: Resources per mile in the 0.5 mile wide Study Area by County

Resource (acres unless otherwise noted)	Pottawattamie	Cass	Adair	Madison	Dallas	Polk	Jasper	Poweshiek	Iowa	Johnson	Cedar	Scott	total
Miles of Interstate	41.9	23.6	23.9	2.0	21.9	6.8	30.7	24.1	24.1	15.7	24.5	11.4	250.6
Cultural Resources	49	12	31	-	105	7	80	19	4	4	153	16	479
Parks	-	-	6	-	-	1	44	-	-	-	-	-	50
Trails (linear feet)	7,704	10,785	-	-	-	2,209	15,808	-	-	1,930	794	-	39,229
Floodplains	3,114	724	<0.1	53	577	-	2,506	-	504	237	956	406	9,078
Ungrazed Grasslands	2,818	1,327	1,423	118	1,356	420	1,709	1,114	1,270	1,250	1,612	823	15,240
Planted Grasslands	336	902	283	6	647	57	658	304	242	398	265	3	4,100
Regulated Materials	462	108	-	-	158	-	324	151	289	80	271	138	1,982
Streams (linear feet)	223,908	133,302	130,381	12,091	153,702	10,181	160,637	90,210	82,986	60,587	68,479	9,505	1,135,968
T&E (documented findings)	-	-	-	-	-	-	-	2	-	-	3	-	5
Federally-Listed	6	3	5	4	5	5	4	3	4	6	4	6	-
State-Listed	26	7	12	25	15	37	29	26	29	80	39	52	377
Conservation Lands	-	-	-	-	39	-	496	-	13	-	2	43	593
WMA	-	-	-	-	39	-	385	-	13	-	-	21	458
Historic Marker	-	-	-	-	-	-	1	-	-	-	-	-	1
Research Area	-	-	-	-	-	-	8	-	-	-	-	-	8
Sovereign Waters	-	-	-	-	-	-	-	-	-	-	2	22	24
Other Public Land	-	-	-	-	-	-	102	-	-	-	-	-	102
Unique Landforms	1,657	-	-	-	-	-	-	-	-	-	-	-	1,657
Wetlands	139	136	100	-	247	15	541	36	28	72	69	9	1,392
Palustrine	139	136	100	-	201	15	458	36	28	72	69	9	1,263
Emergent	72	54	35	-	21	1	86	16	7	35	12	3	342
Scrub-Shrub	9	4	-	-	24	-	30	1	-	1	-	-	69
Forested	50	31	32	-	104	10	296	-	5	18	46	-	592
Unconsolidated Bottom	8	47	33	-	52	4	43	19	16	18	11	6	257
Unconsolidated Shore	-	-	-	-	-	-	3	-	-	-	-	-	3
Aquatic Bed (Dike/Impounded)	-	-	-	-	-	-	-	<0.1	-	-	-	-	<0.1
Lacustrine	-	-	-	-	46	-	83	-	-	-	-	-	129
Unconsolidated Bottom	-	-	-	-	46	-	77	-	-	-	-	-	123
Unconsolidated Shore	-	-	-	-	-	-	6	-	-	-	-	-	6
Woodlands	447	324	225	-	1,258	69	1,336	223	75	225	554	1	4,738
Businesses (number)	33	2	44	-	96	35	73	15	37	37	42	31	445
AMC	-	-	1	-	8	3	6	1	2	4	1	-	26
MTC	-	-	5	-	10	3	2	-	8	5	13	3	49
Retail	5	1	9	-	6	3	10	-	7	6	8	5	60
Service	24	-	26	-	56	23	46	10	12	17	16	21	251
Unclassified	4	1	3	-	16	3	9	4	8	5	4	2	59
Cemeteries	29	-	27	-	1	-	-	3	6	-	4	-	68
Religious Places (number)	-	-	2	-	2	-	1	-	1	-	2	2	10
Farmland	9,164	5,226	5,805	552	2,837	1,551	4,749	5,412	5,874	3,313	5,312	2,760	52,555