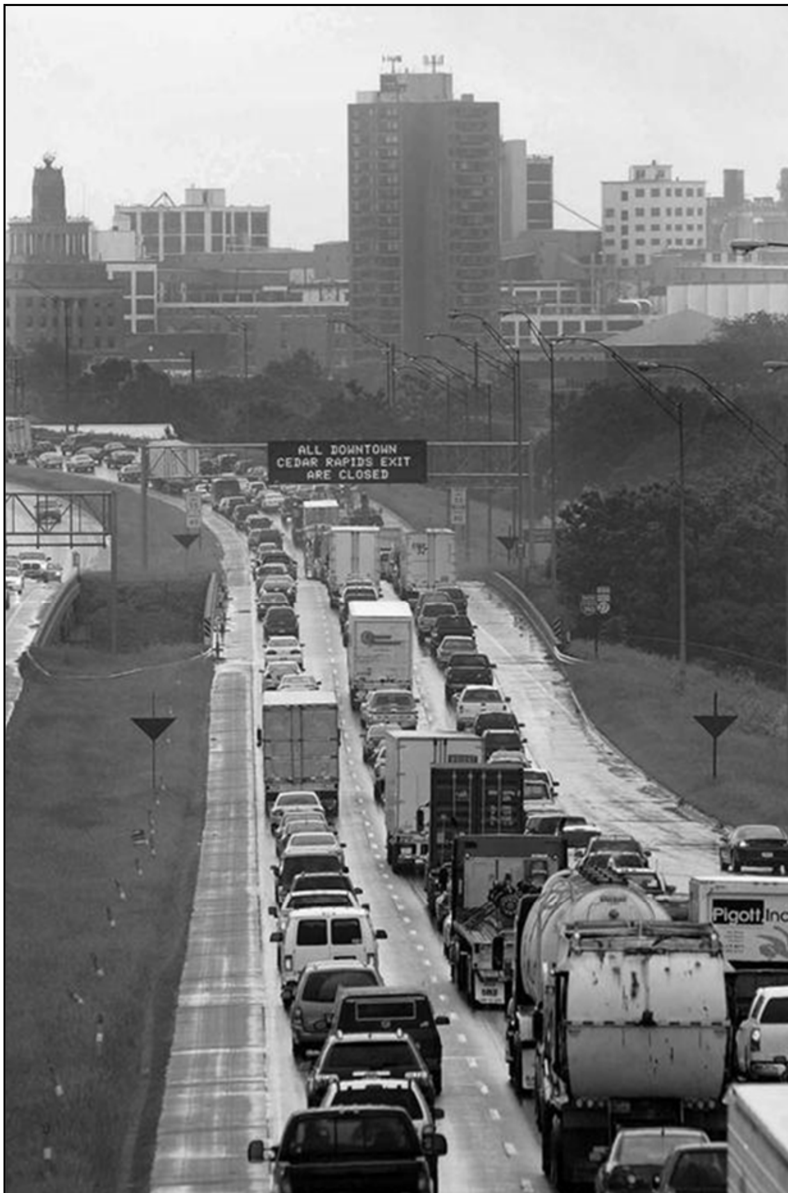


INTELLIGENT TRANSPORTATION SYSTEMS (ITS) AND COMMUNICATIONS SYSTEMS SERVICE LAYER PLAN

January 2018

IOWA DOT

Iowa Department of Transportation

Intelligent Transportation Systems (ITS) and Communications Systems Service Layer Plan

Version 1.0

Prepared for:

IOWA DOT

Office of Traffic Operations

Prepared by:

OLSSON ASSOCIATES | CAMBRIDGE SYSTEMATICS | AUREON

January 2018

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AADT	Average Annual Daily Traffic
ATDM	Active Transportation and Demand Management
ATMS	Advanced Traffic Management System
ATR	Automatic Traffic Recorders
C2C	Center-to-Center
CAT	Category
CCB	Change Control Board
CCTV	Closed-Circuit Television
CIA Triad	Confidentiality, Integrity, Availability
CTRE	Center for Transportation Research and Education
DMS	Dynamic Message Sign
DMZ	Demilitarized Zone
DOT	Department of Transportation
FAST	Fixing America's Surface Transportation
FCC	Federal Communications Commission
FIPS	Federal Information Processing Standards
GPS	Global Positioning System
HAR	Highway Advisory Radio
ICE	Interstate Condition Evaluation
ICE-OPS	Interstate Condition Evaluation-Operations
ICN	Iowa Communications Network
ICWS	Intersection Conflict Warning System
IETF	Internet Engineering Task Force
IPv4/IPv6	Internet Protocol versions 4 and 6
IRU	Indefeasible Right of Use
ISO	International Organization for Standards
ITS	Intelligent Transportation Systems
IWZ	Intelligent Work Zone
MAP-21	Moving Ahead for Progress in the 21st Century Act
MTBF	Mean Time Before Failure
MUTCD	Manual on Traffic Control Devices
MVE	Motor Vehicle Enforcement
NIST	National Institute of Standards and Technology
NMT	Network Management Team
OHDS	Over-Height Detection System
OSP	Office of Systems Planning
OTO	Office of Traffic Operations
ROW	Right of Way
RWIS	Road Weather Information Systems
SAFE	Security Architecture for Enterprise
TIM	Traffic Incident Management
TMC	Traffic Management Center
TPIMS	Truck Parking Information and Management System
TSMO	Transportation System Management and Operations
VOIP	Voice over IP
VPN	Virtual Private Network
VSL	Variable Speed Limit
VWS	Virtual Weigh Station
WIM	Weigh-in-Motion
WWDS	Wrong-Way Detection System

EXECUTIVE SUMMARY

This Intelligent Transportation Systems (ITS) and Communications Systems Service Layer Plan provides a guide for the deployment of ITS technology and solutions along with the network communications system that underpins ITS and many other services in Iowa. This service layer plan is one of the eight service layers of the Iowa Department of Transportation's (DOT) Transportation Systems Management and Operations (TSMO) program. The plan demonstrates how the specific objectives from the ITS and communications systems service layer correspond to and support the overall objectives of the TSMO program plan.

The systems and technologies addressed in this service layer plan are divided into the following three general categories:

- **Monitor** – Assessing the real-time state of the transportation system, including traffic flow, disruptive incidents, and environmental conditions.
- **Manage** – Communicate pertinent travel-related information to motorists and alleviate congestion and improve safety by advising and/or controlling traffic in real-time.
- **Connect** – Providing network communications to connect people, devices, and systems.

Stakeholder meetings were conducted throughout the state to gather input from Iowa DOT and other agency partners. All input was documented and accounted for in the development of this service layer plan. Many stakeholders indicated a need for improving data management and decision support, cyber security, inter-agency coordination, and traveler information; increasing technology to help improve operations; and preparing for the future of connected and autonomous vehicles.

Iowa DOT currently relies on many types of ITS devices and systems. These are connected by a statewide communications network that consists of a combination of state-owned and partner-owned fiber-optic infrastructure, wireless connections, leased communications, and cellular. A current inventory of these devices and systems is included in this report.

Specific strategies and tactics were developed to guide and prioritize Iowa DOT's ITS and communications systems. Where appropriate, strategies were based on the output of the Interstate Condition Evaluation for Operations (ICE-OPS) tool. This tool was developed to categorize the interstate highway system as part of the TSMO program plan, and it was enhanced to include portions of the primary road network for this service layer plan.

A special focused evaluation of the permanent dynamic message sign (DMS) deployment is included in this plan. The objective is to optimize the existing DMS fleet by relocating a small number of existing DMS from low-impact to high-impact locations. This strategy recognizes the anticipation of emerging technology that will soon provide information directly to vehicles, while still operating effectively with current technology.

A detailed analysis of the communications system is also provided, including communications infrastructure, network operations, and cyber security. A recommendation is made to establish a statewide fiber-optic network using a combination of Iowa DOT-owned and partner-owned network infrastructure. This proposed network would include three redundant rings, which will ensure the reliability and capacity needed to support the ITS program, additional TSMO service layers, and other Iowa DOT business functions. The network architecture and equipment is also considered, and it is recommended that the ITS network use enterprise-grade equipment and comply with enterprise-level standards. This includes establishing a formal network management team (NMT). An important function of the NMT will be to develop a formal network management plan, a network security policy, and a network security plan along with all the associated processes and procedures. These steps will provide the framework to maintain the needed level of service and security for all types of data transported across the ITS network.

A gap analysis was performed by determining the difference between the ultimate system (by applying the identified strategies and tactics) and the current system. The findings define system and device gaps, programmatic gaps, and provide recommendations.

A maintenance program was outlined for the existing and future ITS and communications systems devices. An effective maintenance program will help Iowa DOT to realize the operational benefits of its investment in ITS. The maintenance program should include the following components: a maintenance plan, maintenance and inventory management tools, preventative maintenance, response maintenance, and scheduled device replacement. Maintenance service center locations and maintenance staff qualifications are also recommended.

Based on gap analysis and maintenance, a budget for the service layer plan is proposed. The program allows for a build-out and maintenance of many of the systems and infrastructure discussed in this plan with an estimated budget of $10-12 million annually. This strategy employs a balanced spending program, focusing on high-priority and high-impact items first while allowing the flexibility to respond to unforeseen needs.

This plan concludes with recommendations regarding various performance measures. A description of how these measures contribute to a comprehensive performance management program is included, providing the feedback needed to allow for continuous improvement in support of effective transportation operations.

1.0 INTRODUCTION

The 2014 Iowa Department of Transportation (DOT) Strategic Plan defined the agency's vision as being smarter, simpler, and customer-driven. The Iowa DOT transportation system management and operations (TSMO) strategic and program plans build on this overall vision with a TSMO-specific vision of a safe, efficient, and reliable statewide transportation system that also supports Iowa's environmental and economic health. Iowa's TSMO plan is documented in a series of interrelated plans including the TSMO strategic plan, the TSMO program plan, and a total of eight service layer plans representing Iowa DOT's eight TSMO focus areas. The eight TSMO service layer plans are displayed in Figure 1, with this service layer plan shown in red. These plans work together to improve the capabilities of Iowa DOT to operate and proactively manage the state's transportation system.

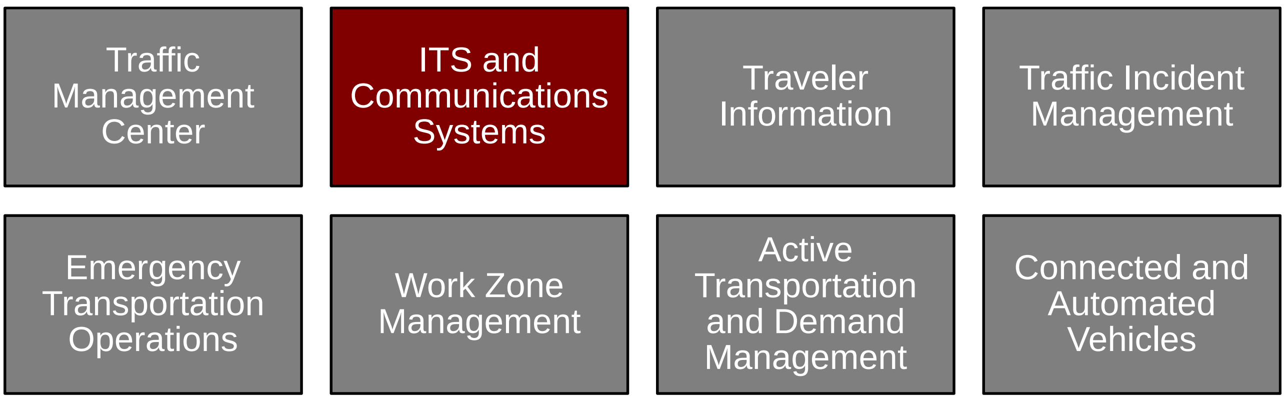


Figure 1. Iowa DOT TSMO Service Layers.

This plan will define the strategy and framework for the deployment of intelligent transportation systems (ITS) and communications systems, along with a fundamental understanding of their applications and benefits. By considering the operational benefits provided by ITS systems, Iowa DOT can integrate these systems into its design and planning processes, thereby allowing Iowa DOT to allocate resources more effectively. The emerging advanced technologies of connected and autonomous vehicles, however, are addressed in a separate service layer plan.

The current use of ITS strategies, technologies, and communications infrastructure needed to support Iowa DOT's TSMO program will be assessed in this plan. The output of this work will include guidelines to help prioritize project types and system improvements based on service level, need, benefit/cost ratio, and location to meet Iowa DOT's objectives. The ITS and Communications Systems Service Layer Plan will cover the use and upkeep of the existing system components and expansion over a five-year horizon; it is anticipated to have a three-year update cycle to keep the tactical aspects of the program current. The primary objectives of the plan are to:

- Define the goals and objectives of Iowa DOT's ITS and communications systems in support of all TSMO service layers
- Provide high-level prioritization for the geographic and functional expansion of ITS and communications systems
- Establish a strategic plan for the deployment of ITS technologies and strategies and communications infrastructure

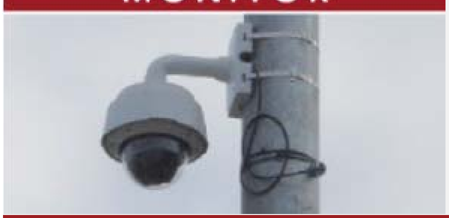
1.1 Definition of ITS and Communications Systems

ITS are defined by the U.S. DOT as “electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system” (Federal Aid Policy Guide, 23 C.F.R. § 940.1 (2002)). ITS also provides much of the transportation system monitoring information that gives real-time status on current system operations. The monitoring information is currently distributed using Iowa’s traveler information systems.

Iowa’s communications systems consist of a collection of communications networks such as wireless, leased communications networks, and fiber-optic cables that connect the ITS technologies to data servers allowing Iowa DOT to collect information about the transportation system.

The Iowa DOT manages a range of ITS and communications systems specific to the needs of the state’s transportation network. As documented in the TSMO program plan, the Iowa DOT manages over 1,000 ITS devices and approximately 350 miles of Iowa DOT owned and 400 miles of Iowa DOT indefeasible right of use (IRU) fiber-optic cable across the state. ITS devices currently managed by the DOT include everything from closed-circuit television (CCTV) cameras and dynamic message signs (DMS) to over-height detection systems (OHDS) and road weather information systems (RWIS). The Iowa DOT’s ITS and communications systems can be classified into three categories of functions: **Monitor**, **Manage**, and **Connect**, defined in Figure 2. This document is structured around these three functions. Figure 2 also provides examples of systems that fit within each category. Some of the systems may fit into multiple categories; in these situations, the category which best described the system’s functions prevailed.

MONITOR



Systems and tools that observe and assess the performance of the transportation system.

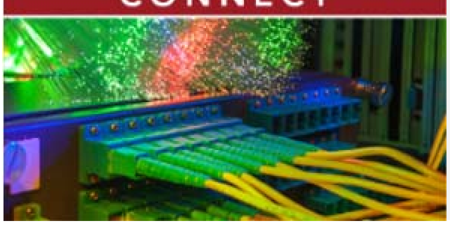
Examples: cameras, traffic sensors, RWIS

MANAGE

Systems or combinations of technologies that actively impact transportation operations through traffic control devices and traveler information.

Examples: DMS, OHDS, intersection conflict warning system (ICWS)

CONNECT



The digital communications backbone enabling all the other systems and services.

Examples: fiber-optic communications, wireless communications, cellular communications

Figure 2. Service Categories.

1.2 Service Layer Plan Development Process

Developing the ITS and Communications Systems Service Layer Plan began with identifying the challenges and needs of Iowa motorists, Iowa transportation professionals, and the needs of other Iowa TSMO service areas. This was accomplished through a series of stakeholder meetings with Iowa DOT staff and stakeholders across the state, with a goal of holding one meeting in each of the six Iowa DOT districts. Stakeholder input was then aggregated and consolidated into a summary report, which has been the foundation of this ITS and Communications Systems Service Layer Plan. That summary report can be found in Appendix A. Insights, strategies, and recommendations gathered from the stakeholder meetings are discussed in greater detail in the following sections: 2.0 Opportunities and Challenges, 4.0 ITS Strategies and Tactics, 5.0 Communications Systems Strategy, 0

Gap Analysis, and 8.0 Action Recommendations.

1.3 Relationship with other Service Layer Plans

A total of eight service layer plans will be completed as part of Iowa DOT's TSMO program. Each of these service layers rely on ITS and communication systems either directly or from the data they produce. Figure 3 describes the relationships between the ITS and communications systems service layer plan and each of the other service layer plans.

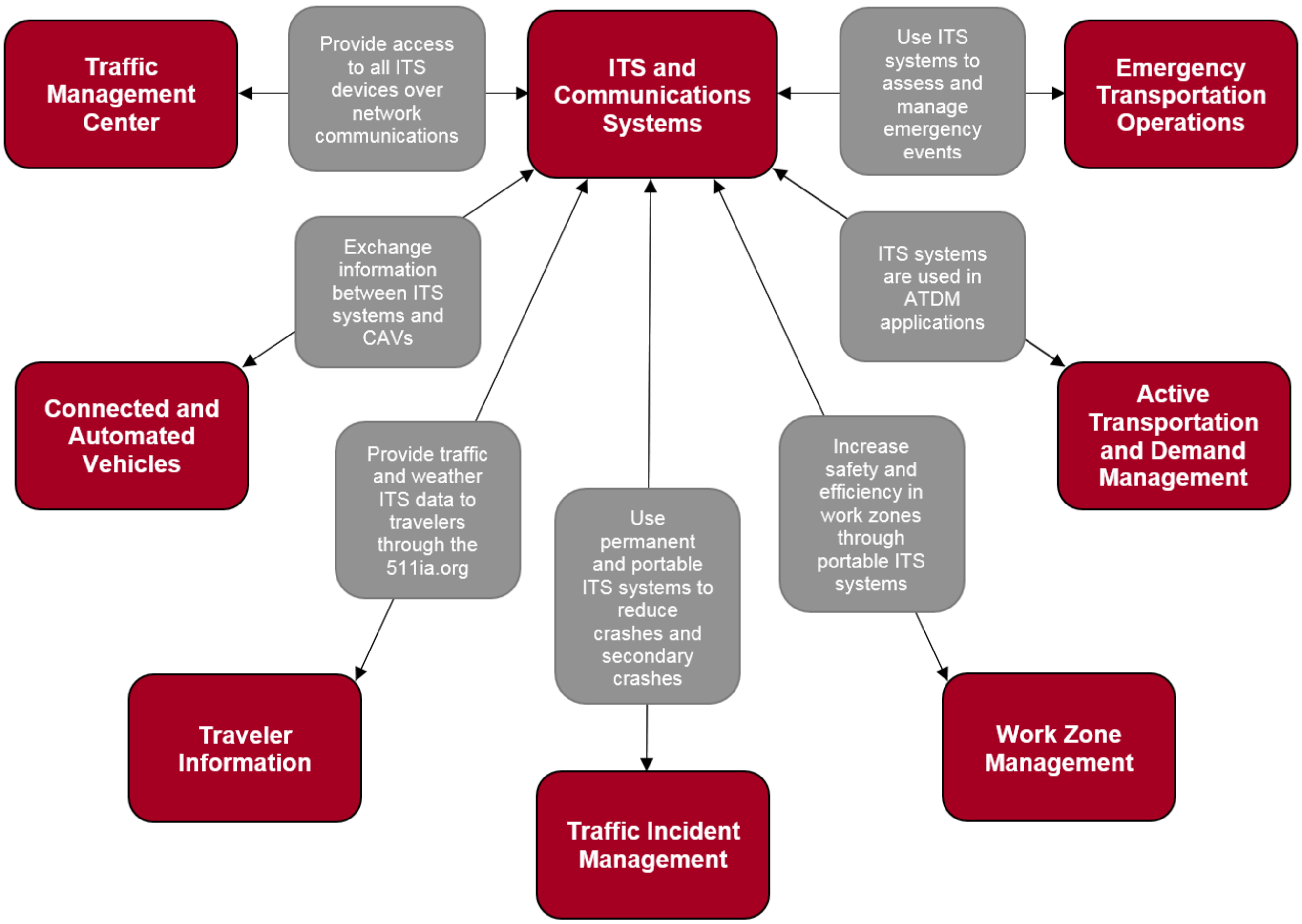


Figure 3. ITS and Communications Systems Relationships with other Service Layer Plans.

1.4 Document Content and Intended Use

This document serves as a tactical plan for managing the ITS and communications systems in a way that is consistent with, and supportive of, the Iowa DOT TSMO strategic and program plans. This plan will outline the strategic deployment and integration of ITS, which will enable a higher level of multiagency regional operational coordination and will help meet the increasing demands for real-time information from agency partners, freight system providers, and all other motorists. The content will be used by Iowa DOT to guide operations, procurements, partnerships, developments, and deployments to help accomplish the objectives defined.

Following this introduction, the remaining sections are organized as follows:

- **2.0 Opportunities and Challenges** – Outlines the key opportunities and challenges for advancing ITS and communications systems in Iowa, as identified by stakeholders, as well as the ITS and communications systems service layer's objectives in relation to Iowa DOT's larger TSMO goals and objectives.
- **3.0 Existing Systems and Inventory** – Provides a brief history and timeline of Iowa's existing ITS and communications systems, describes the ITS service layer's three categories: Monitor, Manage, and Connect, and reviews the existing system's inventory.
- **4.0 ITS Strategies and Tactics** – Presents the service layer plan's general ITS strategies for each category of ITS systems as well as focused strategies for DMS and motor vehicle enforcement (MVE) technologies.
- **5.0 Communications Systems Strategy** – Presents the service layer plan's strategies specific to the communications system, particularly communication infrastructure, equipment and services, and network security.
- **6.0 Gap Analysis –** Looks across all ITS and communications systems deployment strategies provided in sections 4.0 ITS Strategies and Tactics and 5.0 Communications Systems Strategy to determine the ultimate build-out conditions and evaluates the difference (gap) between the ultimate build-out conditions and the existing system, described in section 3.0 Existing Conditions and Systems. Infrastructure gaps as well as programmatic gaps are analyzed.
- **7.0 System Maintenance** – Identifies maintenance strategies for ITS and communications systems, including technology life cycles and staffing considerations.

8.0 Action Recommendations – Summarizes recommendations and actions for the implementation of the strategies discussed in sections 4.0 ITS Strategies and Tactics and 5.0 Communications Systems Strategy and to close the gaps identified in section 0

- Gap Analysis.
- **9.0 Service Layer Cost Estimate –** Provides a cost estimate for the deployment, maintenance, and recapitalization of the ITS and communications systems and strategies detailed in the service layer plan.
- **10.0 Performance Management –** Details performance measures related to the ITS and communications systems to assist Iowa DOT in tracking and continually improving the operations of these systems.

2.0 OPPORTUNITIES AND CHALLENGES

2.1 Challenges Facing Iowa Transportation

Most congestion in Iowa is categorized as nonrecurring – meaning disruptions that prevent motorists from having full use of the roadway are temporary. The top causes of nonrecurring congestion in Iowa are adverse weather, traffic incidents, work zones, and special events, shown in Figure 4. Nonrecurring congestion can be improved by managing and operating roadways more effectively with better technology, information, and collaboration among all the agencies responsible for different parts of the transportation network.

The Iowa DOT's TSMO plan is designed to coordinate and enhance highway management and operations practices that Iowa DOT has been conducting for years, and to build upon these practices with new technologies and approaches to continually improve the operations of Iowa's roadways. ITS and communications systems are key to this advancement – equipping Iowa with the technologies to continue improving highway operations and providing the means of communication, coordination, and decision-making for many other TSMO strategies included in Iowa's comprehensive TSMO plan.

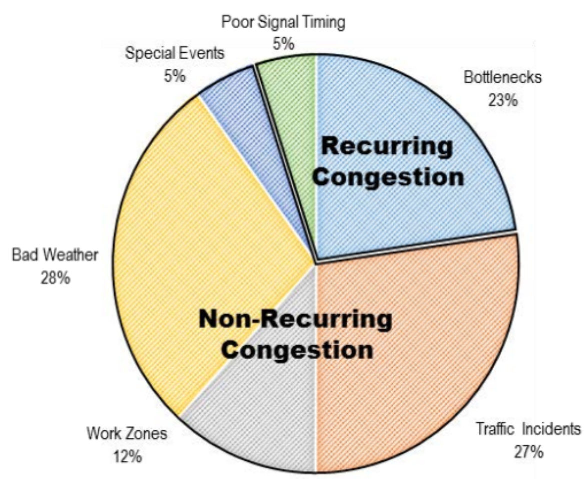


Figure 4. Sources of Congestion in Iowa.

2.2 Stakeholder Outreach

One of the first steps in gathering baseline information for this planning effort was to collect inputs and user needs from within the DOT and its collaborative partners. Meetings were scheduled with all DOT districts, the majority of which were held in the fall of 2016, to discuss current operational resources and systems along with technologies and advancements on the horizon. A list of stakeholders who attended each meeting is provided in Appendix A. The objectives of these stakeholder meetings were to understand the needs and challenges from those working with ITS and communication systems; define and categorize the ITS and communication systems provided; gather inputs on prioritizing future investments in ITS and communications systems; and to generally share information on current resources available.

The series of stakeholder meetings contributing to the ITS and Communications Systems Service Layer Plan highlighted challenges that stakeholders across the state see as a top priority. These priority challenges covered issues ranging from data, traveler information, and network security to both interagency and intra-agency communication and the impact of connected vehicles on the ITS systems and technologies currently managed by the DOT. Figure 5 provides a high-level summary of the challenges (aggregated and summarized across all meetings) identified at the stakeholder meetings. Detailed summaries from each of the stakeholder meetings can be found in Appendix A.

Data

- There is too much data and too little time for people to make sense of it.
- Data is currently stored in many locations – need better way to organize.
- Need better systems to help with decisions, and more GIS resources.

Inter/Intra-Agency Communications

- Broad desire to improve interagency and intra-agency communciations for operations planning and real-time event managment.
- Need for consistency throughout the state in terms of common goals, technology/purchasing, training, diversion routes, signage, etc.

General Services

- Future technologies will change how data and information are gathered/dissemianted; need to balance investments essential for operations today versus the future.
- Need to ensure that the full spectrum of drivers continues to be served.

Network Security

- Security concerns are growing and changing, requiring constant adaptation.
- Cyber security of end devices needs to be addressed.

Traveler Information

- Concerns about the usability and awareness of existing services
- Need to disseminate information to motorists in the way they want it (get feedback) and without the information being distracting
- Need to make sure Iowa is maximizing partnerships with potential third-party providers (e.g., Waze, etc.)

Technologies

- Stakeholders discussed challenges and needs specific to individual technologies (DMS; cameras; traffic data, RWIS; and communications infrastructure).

Specific Technologies to Pursue, Expand, or Consider

- Stakeholders indentified specific technologies to pursue, expand, or consider – namely integrated corridor management, ramp metering, signal control, over-height warning systems, predictive data analysis, variable speed limits (VSL), rail crossings, highway helper along critical corridors, border bridge monitoring, falling rock warning, intersection conflict warning, wrong-way detection warning, and drones for emergency management.

Figure 5. Priority Challenges for ITS and Communications Identified during Stakeholder Meetings.

2.3 ITS and Communications Systems Objectives

To address the challenges identified in the previous section, the ITS and communications systems service layer will work together with the other TSMO service layers so the Iowa transportation system can be collectively managed and operated. A series of objectives have been defined specifically for the ITS and communications systems service layers, rooted in the overarching goals and objectives outlined in the TSMO strategic and program plans. Table 1 presents the ITS and communications systems objectives that support the Iowa DOT TSMO strategic goals and objectives. Specific tactics for individual systems and device types that help accomplish these objectives are outlined in sections 4.0 ITS Strategies and Tactics and 5.0 Communications Systems Strategy.

Table 1. ITS and Communications Systems Objectives.

TSMO Strategic Goals	TSMO Strategic Objectives	TSMO Program Objectives	ITS and Communications Systems Objectives
Safety	Reduce crash frequency and severity.	• Reduce the number of overall major crashes. • Reduce the number of secondary crashes caused by traffic incidents. • Reduce the number of work zone related traffic incidents.	• Detect and inform motorists and responders of hazardous conditions. • Detect and inform motorists and responders of incidents.
Reliability	Improve transportation system reliability, increase system resiliency, and add highway capacity in critical corridors.	• Improve travel time reliability. • Increase the resilience of the transportation system to floods, winter weather, and other extreme weather events. • Work with special event generators to actively manage traffic during large scale events that impact the highway network.	• Improve travel time reliability. • Inform maintenance personnel of road weather conditions. • Identify optimum time for non-emergency lane closures. • Inform motorists of optimum routes. • Use ITS to support special event traffic.
Efficiency	Minimize traffic delay and maximize system efficiency to keep traffic moving.	• Maximize use of existing roadway capacity. • Respond to and clear traffic incidents as quickly as possible.	• Detect traffic incidents as quickly as possible. • Maximize the volume/capacity of the full system.
Convenience	Provide ease of access and mobility choices to customers.	• Provide timely, accurate and comprehensive information to customers. • Provide high quality, machine ready data in open formats.	• Inform motorists of optimum routes. • Provide traffic information to motorists enabling them to make informed travel decisions.
Coordination	Engage all DOT disciplines and external agencies and jurisdictions to proactively manage and operate the transportation system.	• Provide staff knowledge and management resources to enable adaptation to rapidly changing technology.	• Provide a robust communications system throughout the state to connect devices, systems, organizations, and people.
Integration	Incorporate TSMO strategies throughout DOT's transportation planning, design, construction, maintenance, and operations activities.	• Implement integrated corridor management strategies to manage traffic across multiple jurisdictions.	• Deploy devices that support integrated corridor management applications. • Share resources such as systems, data, and devices with transportation partners.

3.0 EXISTING CONDITIONS AND SYSTEMS

Iowa DOT has deployed and operates a variety of ITS and communications systems across the state. ITS systems evolved from simple monitoring devices and DMS to the elements of comprehensive transportation management systems that improve the capacity and reliability of the roadways. Over the past decade, Iowa DOT, its partners, and the public have come to rely on these resources for information on which to base travel decisions, deploy resources, and develop strategies to reduce congestion and improve safety. Deploying these systems has become easier because of the increased availability and capacity of the communications systems that tie them together. This section outlines the current ITS and communications systems, which serves as a starting point and the foundation on which the future direction will be established.

3.1 Iowa DOT Background in ITS and Communications Systems

Iowa's first ITS was deployed in 1988 in the form of RWIS sensors, well before the term "ITS" had been coined. RWIS have been deployed in strategic locations around the state. These electronic sensors provided valuable road condition information to support and optimize winter maintenance operations.

Additional ITS elements were introduced as a traffic management strategy during the 2003 reconstruction project of Interstate 235 (I-235). Cameras, traffic sensors, and DMS were connected by wireless communications and deployed as a temporary solution to monitor I-235, I-35 / I-80, and the Iowa State Route 5 / U.S. 65 bypass route, along with Highway Helper services. Once operational, Iowa DOT quickly recognized the system's value for overall traffic management and operations, and it became a service that the public and the media expected.

After testing the ITS systems as temporary devices for the I-235 project, Iowa DOT began to deploy permanent ITS systems starting with Iowa City and the Quad Cities in 2006. Council Bluffs and Sioux City followed in 2009; then Waterloo; Cedar Rapids; U.S. 30 through Boone, Ames, and Nevada; I-35 from Des Moines to Ames; and along I-80 in Newton. The Des Moines area system was upgraded from temporary to permanent in 2010.

A project traffic management center (TMC) was originally established for the I-235 project, but it was dismantled upon project completion. Iowa DOT then pursued operating a system without a central TMC by providing full access to maintenance supervisors and local partner agencies, with a focus on law enforcement. A TMC was formally established in Ames in 2008 to provide more proactive and uniform operations throughout the state. In 2015, the TMC was relocated to a larger facility in Ankeny.

Figure 6 illustrates a timeline of Iowa DOT's ITS efforts over the last 30 years.

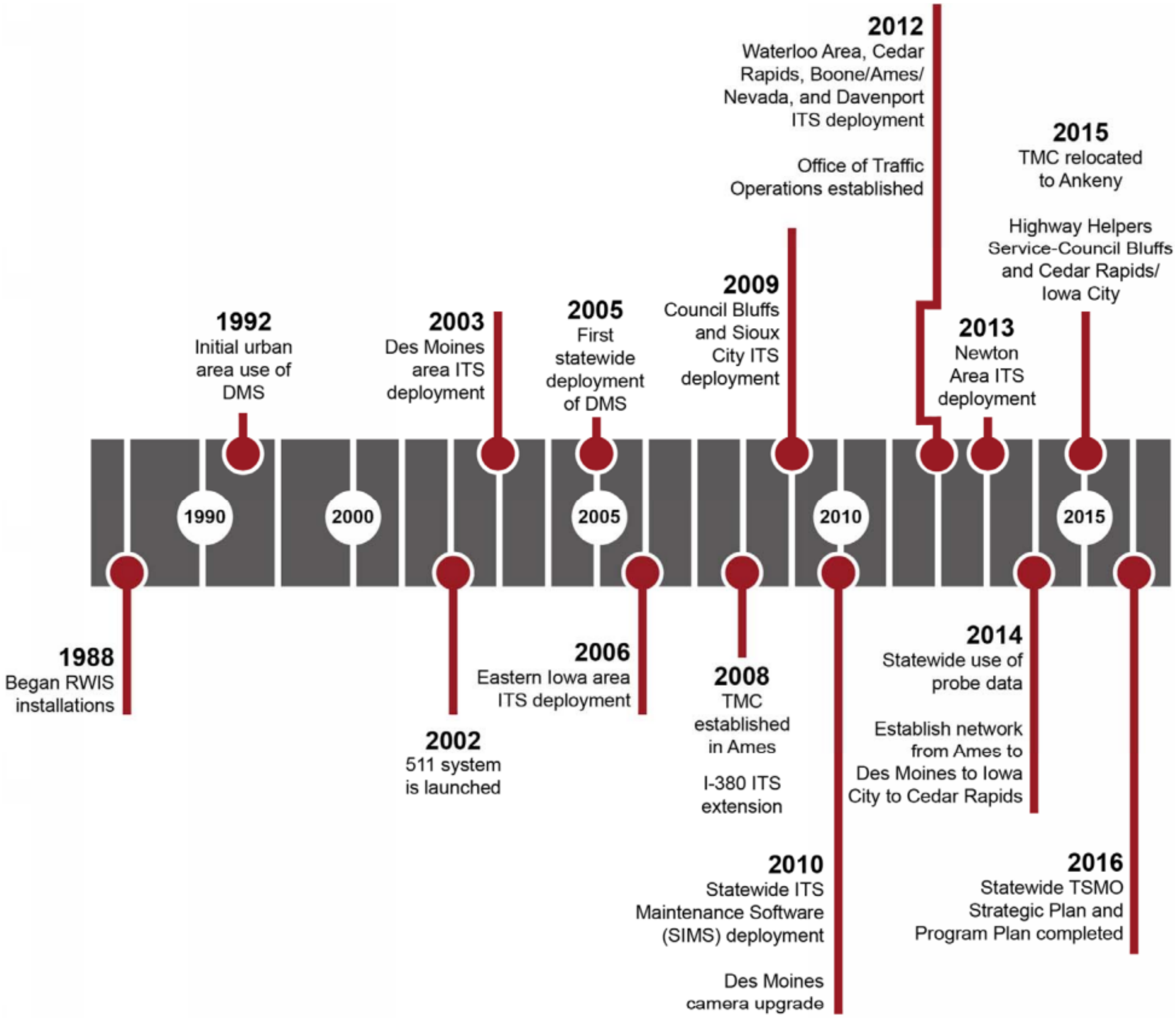


Figure 6. Iowa ITS Timeline.

Communications systems have also evolved since the original Iowa DOT-owned wireless deployments in Des Moines. Iowa DOT has installed its own fiber-optic communications in many areas and has leveraged this investment by partnering with other state and local agencies and private companies to share infrastructure, which greatly expanded Iowa's coverage at a minimal cost. This infrastructure is supplemented with licensed wireless Ethernet communications for "last mile" connectivity to many devices. Cellular and leased communications are also used for devices and facilities outside the reach of Iowa DOT-owned communications.

As Iowa DOT has realized the increasing value of ITS and communications systems in improving transportation operations, greater investment has been made in field systems, personnel, programs, and partner relationships. As part of this evolution, the Office of Traffic Operations (OTO) was formally established in 2012.

PARTNERSHIPS

Since the initial ITS deployment in Des Moines, Iowa DOT has promoted and facilitated the establishment of strong partnerships for transportation operations. For ITS and communications systems, these partnerships are manifested through sharing infrastructure, data, and, where appropriate, integration between systems. These partnerships have strengthened relationships with other agencies and organizations and improved the overall experience for travelers as they move through the full transportation system. Partners include local municipalities such as cities and counties, other state agencies such as the Iowa Communications Network (ICN), and private telecommunications providers. Examples of shared infrastructure include shared conduit, fiber-optics, cameras, DMS, and traffic sensors.

3.2 Existing ITS and Communications Systems

Iowa's focus on improving safety and capacity of the roadway has led to growth of the ITS and communications systems programs. ITS devices are located throughout the entire state; however, there are greater concentrations of devices in the metropolitan areas because of higher populations and more congested roadways. Table 2 below specifies the total number of ITS and communications systems devices owned by the OTO within Iowa DOT, as of June 2017, not including portable ITS devices or specialty DMS.

Table 2. Existing Permanent ITS and Communications Inventory.

Category	System	Inventory
Monitor	Cameras	418
	Traffic Sensors	504
	Road Weather Information Systems	74
	Weigh-In-Motion	45
Manage	Dynamic Message Signs*	115
	Over-Height Detection Systems	2
	Intersection Conflict Warning Systems	5
	Lane Closure Planning Tool	N/A
	Travel Time Display	N/A
Connect	Miles of Fiber-Optic Cable - Iowa DOT Owned	340
	Miles of Fiber-Optic Cable – Iowa DOT IRU	380
	Microwave Ethernet Radios	408
	Cellular Data Modems	265

* Not including specialty or portable DMS

In the following subsections, the existing ITS and communications systems that the TMC uses are listed along with descriptions, their locations, and quantities. Maps are provided giving a visual representation of where each existing system's devices are located, and detailed maps are provided in Appendix B. In addition, the following general items are of note:

TMC Oversight – Iowa's traffic operations and ITS devices are overseen, reviewed, and controlled from the state's TMC. As a core function of the OTO, the TMC works with Iowa DOT headquarters and each district to make Iowa's transportation system safer and to alleviate congestion.

Portable ITS Devices – Iowa DOT has used many portable devices to meet temporary needs in work zones, for special events, and during emergency situations such as during flooding. These devices have included cameras, sensors, DMS, and highway advisory radio (HAR). Some of these devices are owned by Iowa DOT, and others are rented from traffic control device suppliers. The TMC monitors and controls all of the Iowa DOT-owned devices, and some of the rented devices, depending on the specific device needs and project requirements. In addition, most of the Iowa DOT-owned devices use a global positioning system (GPS) device to provide real-time location, which helps in the system management.

Motor Vehicle Enforcement – In May 2017, the OTO began maintaining the cameras, blank-out signs, and sensors located at MVE weigh stations to take advantage of the existing skills and contracts for the maintenance of these types of ITS devices already managed by the OTO. MVE continues to maintain the scales and weigh-in-motion (WIM) sensors at each weigh station.

Office of Systems Planning – The Office of Systems Planning (OSP) maintains various traffic data collection devices throughout the state (traffic sensors, WIM sensors, etc.). The systems have historically had slightly different purposes – the OSP focusing on historical data for planning purposes, and the OTO collecting current data for real-time operations purposes. However, the two offices have collaborated throughout the years to share data, to use the sensors for both real-time and historical purposes, and to mutually plan the locations of new sensors.

Cameras

Cameras provide a visual perspective of the transportation system, displaying real-time traffic conditions and enabling faster and more accurate incident response. Cameras also enable Iowa DOT to monitor and proactively manage traffic operations in real time on Iowa's highways and within work zones.

Since 2003, Iowa DOT has deployed cameras in many areas of the state. Deployments were first focused on the larger metropolitan areas to monitor congestion. Multiple partnerships were established with local municipalities to share each organization's cameras, expanding coverage without increasing costs. Once camera coverage had been installed in the largest metropolitan areas, Iowa DOT also installed cameras in rural locations. These have included installations on RWIS towers to provide visual verification of road-weather conditions, as well as critical rural locations. Iowa DOT also worked with Illinois DOT to install three cameras on the Illinois side of I-74 in the Quad Cities. These cameras continue to be accessed and controlled through Iowa DOT's ATMS system, though they are owned and maintained by Illinois DOT.

Most cameras are permanent; however, Iowa DOT also has several portable cameras for use in monitoring work zones or other temporary applications. The OTO has also recently begun to work with MVE to support and maintain cameras currently deployed at weigh stations.

All of Iowa's cameras have the pan tilt zoom feature, allowing the camera's view to be changed. The video capabilities depend on the type connection, either through a high-bandwidth connection or through a cellular modem. Cameras on a high-bandwidth connection allow video from the device to be streamed continuously. Cameras connected over a cellular modem only allow periodic snapshots, or low-resolution video streams for short periods of time. Some of these also record video directly in the camera that can be downloaded locally.

Cameras are installed in many different areas around the state, including:

- *Urban Areas / Interstates*. Cameras are installed to allow the TMC to monitor roadway and traffic conditions, typically over high-bandwidth connections.
- *Border Bridges*. Cameras that are positioned to provide a view of the bridge deck. This allows the TMC and responders to quickly respond if any hazards occur on the bridge. They can use a high-bandwidth connection if available, or a cellular modem.
- *Rest / Parking Areas*. Cameras positioned in order to monitor the parking lots of full service rest areas and parking only rest areas. Snapshots are provided over the 511ia.org website as well as the mobile app to allow truck operators to see if parking is available. Most are connected over cellular modem except for a small number with access to fiber-optic communications.
- *Rural Cameras*. These cameras are located at strategic locations along two types of roadways:
  - Freeway locations, to monitor traffic, weather, and incidents.
  - Rural intersections, to locally record video that can be reviewed later if there is an incident. Most ICWS installations include such a camera.

- *Weigh Stations.* Cameras provided at MVE weigh stations, that allow scale operators to monitor trucks coming in and out of the weighing area.
- *RWIS Sites.* Located on RWIS sites, these cellular modem cameras provide a visual verification of the site's weather conditions.
- *Portable Cameras*. Several cameras are installed on trailers, are powered by solar panels and batteries, and are typically connected by a cellular modem. These are valuable for short-term needs such as construction or emergency situations such as flooding.

A list of the cameras supplied in each district and metropolitan area of Iowa is provided in Table 3. Figure 7 displays the locations of the cameras throughout the state. It should be noted that RWIS cameras provide only snapshots of the roadway, supplying a limited view of the transportation system compared to many of the other pan tilt zoom cameras. The three cameras located in Illinois were not included in the inventory or map since Iowa DOT does not own or maintain these cameras.

Table 3. Existing Camera Inventory.

Camera Type	Des Moines / Newton	Boone / Ames / Nevada	Council Bluffs	Sioux City	Iowa City	Quad Cities	Cedar Rapids	Waterloo	Dubuque	Rural District 1	Rural District 2	Rural District 3	Rural District 4	Rural District 5	Rural District 6	Total
Permanent	93	29	43	27	24	15	52	27	-	5	5	-	1	2	1	**324**
Border Bridge	-	-	3	1	-	6	-	-	-	-	-	-	-	-	-	**10**
Rest / Parking Areas	-	-	-	-	-	-	-	-	-	2	5	-	-	7	-	**14**
ICWS	1	-	-	-	-	-	-	-	-	2	-	-	-	1	3	**7**
Weigh Stations	1	-	-	-	-	-	-	-	-	1	1	1	2	2	2	**10**
RWIS	1	-	-	-	-	1	2	1	1	5	7	10	8	10	7	**53**
Total	**96**	**29**	**46**	**28**	**24**	**22**	**54**	**28**	**1**	**15**	**18**	**11**	**11**	**22**	**13**	**418**
Portable	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**7**

*Note: The rows highlighted in red were not counted in the overall total for cameras.

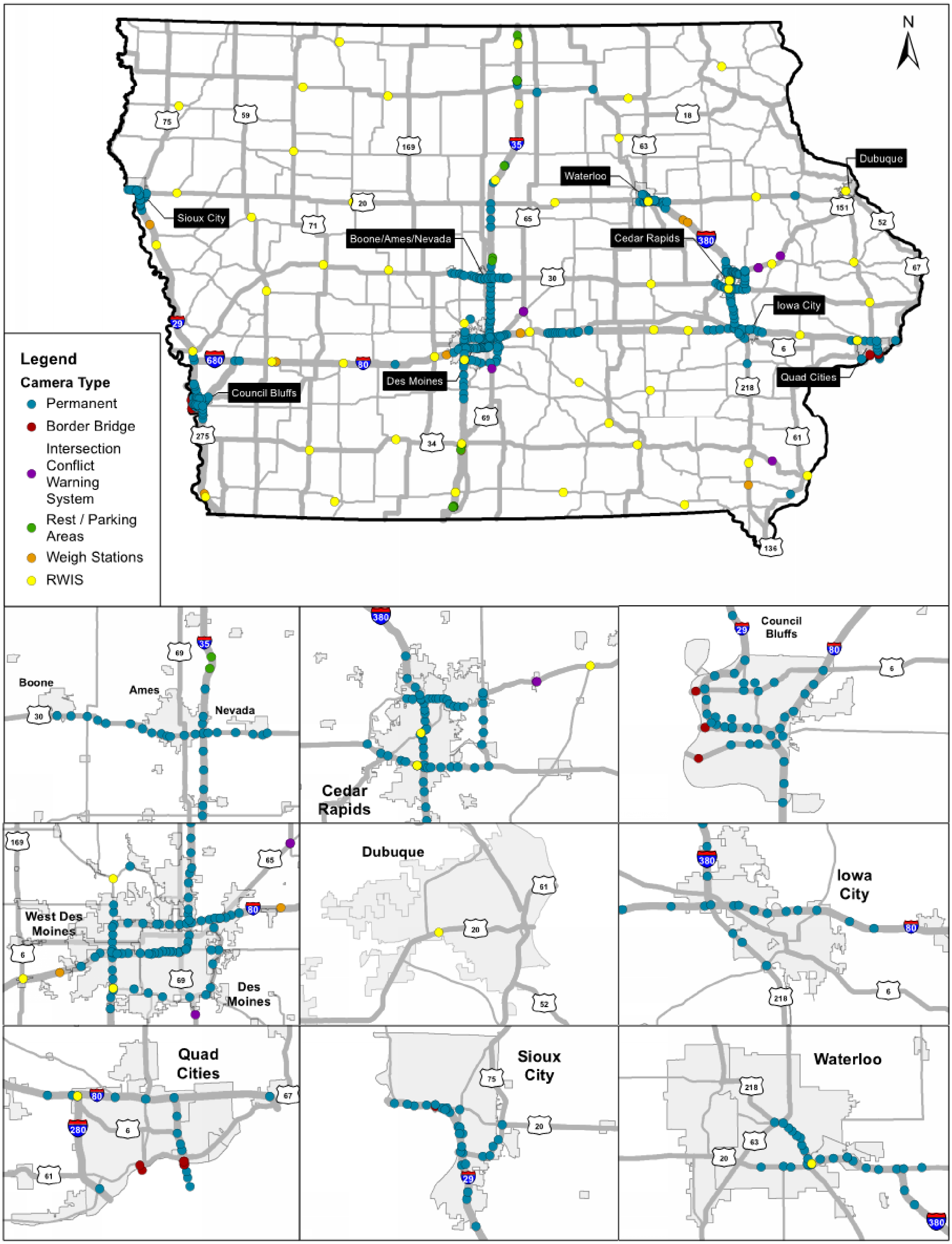


Figure 7. Existing Statewide and Metropolitan Area Camera Inventory.

Traffic Data

Traffic technology gives Iowa DOT the ability to automatically gather and quantify traffic flow information. Real-time information is used to monitor and manage day-to-day operations, while historical information is used for analysis and planning. Traffic data are collected using several types of traffic sensors and, more recently, through probe data.

Prior to the availability of sufficiently accurate probe data, Iowa DOT installed traffic sensors in many locations. To support real-time operations, many were installed at approximately 1-mile spacing along urban freeways and interstates. A majority are side-mounted radar sensors with eight video image detection sensors installed on the I-74 bridge in the Quad Cities. Side-mounted radar sensors are also installed on many of the RWIS sites throughout the state; however, these sensors are currently not connected to Iowa DOT's ATMS. It is recommended that these devices be connected to the ATMS, ultimately providing more monitoring coverage of the transportation system. In addition, the OSP has many sensors located in strategic locations throughout the state that collect historical data to support planning efforts. These consist of some side-mounted radar sensors and some in-pavement inductive loop detectors.

In 2013, Iowa DOT began supplementing the DOT-owned traffic sensors with probe data through a data vendor (INRIX). This additional data provides speed and travel-time information along the interstates and many highways throughout the state where there is a sufficient volume of probe vehicles (primarily consisting of commercial fleet vehicles).

In addition to the sensors owned and maintained by the OTO, the OSP has 132 automatic traffic recorders (ATR) located throughout the state. While many of these ATR sensors are the same model that is used for real-time operations, the field controllers and central software are purpose-built for data collection only and are not compatible with the ATMS software used by the TMC. Efforts have been made in the past establish data sharing between these two systems so that the sensors may be used for both purposes, however this integration is not yet complete. Notwithstanding, the OTO and the OSP continue to work together to agree on the locations of future devices in the anticipation that they will all eventually be shared between both offices.

Each traffic data collection technology has different characteristics and collects different types of data. For example, side-mounted radar detectors provide lane-by-lane volumes, speeds, occupancy, direction, and classification data in 20-second intervals. However, they can only provide this information at a single location. In contrast, vehicle probe data can be available on any highway with sufficient probe vehicle volume, including most multilane highways and freeways throughout the state. Still, this data includes speeds and travel times only, and is provided with a latency range of four to eight minutes. The data captured from the traffic sensors is transferred to a “Data Portal” where many different agencies have access to the information. Table 4 describes the general characteristics of each type of traffic data detection technology.

Table 4. Traffic Data Capability Matrix.

	Traffic Sensors	Probe Data	Crowd-Sourced Data
Speed	X	X	X
Travel Times		X	X
Volume	X		
Occupancy	X		
Classification	X		
By Lane	X		
Coverage	Spot	Continuous	Continuous
Latency	~20-30 sec	~5 min	~5 min
Accuracy	High	Medium	Medium
Cost per Mile	High	Low	Very Low
Sample Size	All Vehicles	Fleet Vehicles	App Users
Maintenance Required	Yes	None	None

A list of the traffic sensors supplied in each district and metropolitan area of Iowa is provided below. Figure 8 displays the locations of the traffic sensors throughout the state.

The RWIS radar sensors were included in the overall traffic sensors total since these sensors operate properly and merely need to be connected to the ATMS.

Table 5. Existing Traffic Sensor Inventory.

Traffic Sensor Type	Des Moines / Newton	Boone / Ames / Nevada	Council Bluffs	Sioux City	Iowa City	Quad Cities	Cedar Rapids	Waterloo	Dubuque	Rural District 1	Rural District 2	Rural District 3	Rural District 4	Rural District 5	Rural District 6	Total
Side Fire Radar Detection	97	34	43	25	27	7	58	19	1	4	7	9	8	9	6	**354**
Video Image Detection	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	**8**
Weigh Stations	1	-	-	-	-	-	-	-	-	1	1	2	1	2	2	**10**
Automatic Traffic Recorders	8	3	3	4	2	3	4	3	2	15	17	21	21	15	11	**132**
Total	**106**	**37**	**46**	**29**	**29**	**18**	**62**	**22**	**3**	**20**	**25**	**32**	**30**	**26**	**19**	**504**
Portable	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7

*Note: The items in red were not counted in the overall total for traffic sensors.

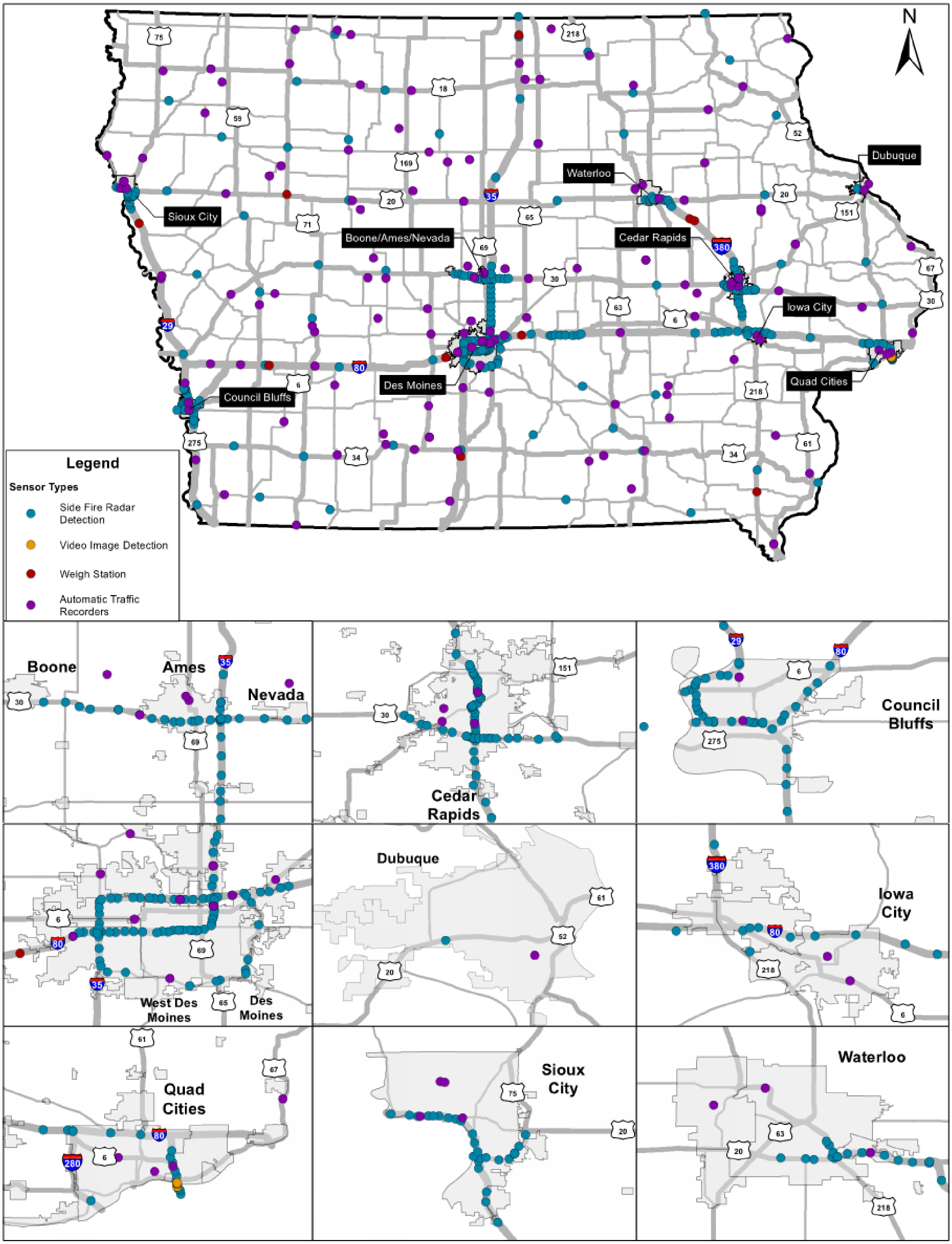


Figure 8. Existing Statewide and Metropolitan Area Traffic Sensor Inventory.

RWIS

RWIS was the first type of ITS device deployed by Iowa DOT, with the first installed in 1988. RWIS provide real-time and historical atmospheric and pavement condition information. Real-time information supports maintenance efforts just prior to and during storm events by allowing maintenance personnel to monitor conditions at remote locations in their maintenance areas. Real-time and historical information are used to develop refined weather and pavement condition forecasts. RWIS provide decision support to maintenance personnel, resulting in more effective winter roadway maintenance, optimized deployment of personnel, and efficient use of anti-icing and deicing material.

RWIS typically consist of a combination of atmospheric sensors (temperature, humidity, wind speed and direction, visibility, precipitation) and a roadway sensor (surface temperature, subsurface temperature, and occasionally surface liquid chemical composition). Specific sensors are typically selected based on the specific needs of the area and overall site cost. Iowa DOT often includes a traffic sensor and a camera at each RWIS location.

RWIS are placed either to provide representative pavement conditions or to monitor unique locations with recurring issues (e.g., low-lying areas, bridges, curves, etc.). To date, Iowa DOT's overall target for RWIS installations has been to place representative RWIS in an approximate grid across the state at 30-mile spacing, adjusting to optimize placement within each maintenance area.

Iowa DOT currently shares RWIS data with surrounding states. As neighboring states install new RWIS sites near Iowa's border, Iowa DOT should work with the states to gain access to and incorporate the RWIS data into their system.

A list of RWIS devices supplied in each district and metropolitan area of Iowa is provided in Table 6. Figure 9 displays the relative locations of RWIS devices throughout the state. These are shown with a radius indicating the approximate area for which they provide representative data.

Table 6. Existing RWIS Inventory.

RWIS Type	Des Moines / Newton	Boone / Ames / Nevada	Council Bluffs	Sioux City	Iowa City	Quad Cities	Cedar Rapids	Waterloo	Dubuque	Rural District 1	Rural District 2	Rural District 3	Rural District 4	Rural District 5	Rural District 6	Total
RWIS	7	1	2	1	2	2	2	1	1	8	9	11	8	11	8	**74**

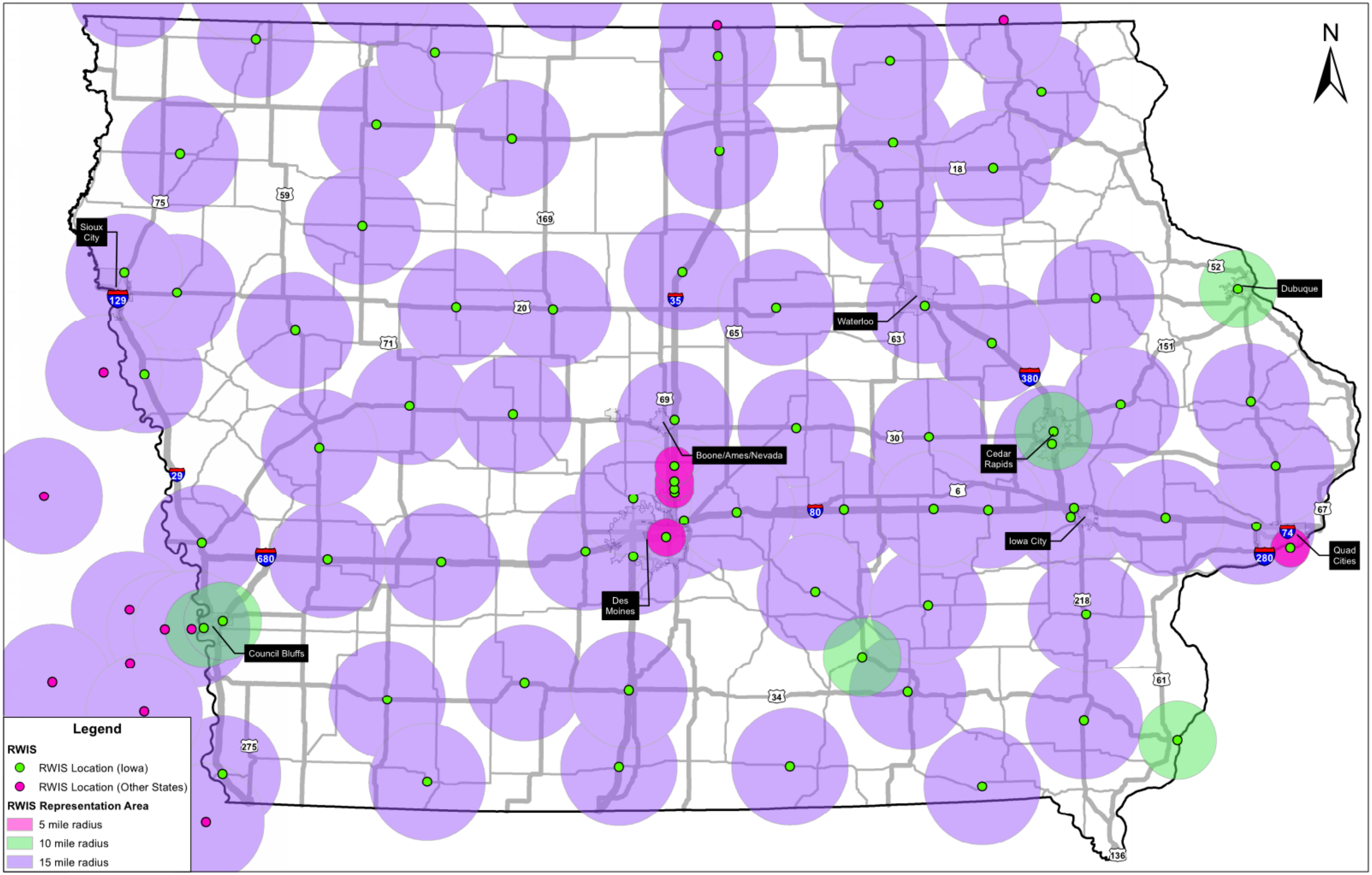


Figure 9. Existing Statewide RWIS Inventory.

Weigh-In-Motion

WIM devices consist of one or more in-road sensors that can measure a vehicle's approximate axle weight at highway speeds. While various technologies can be used, Iowa DOT uses piezoelectric sensors.

Iowa DOT currently uses two grades of WIM devices. The MVE division has three units, each used to screen vehicles within weigh stations. These specific units provide a precision of approximately 2 percent of actual axle weight. The OSP also has 42 WIM units located throughout the state. Theirs are less expensive than the MVE's sensors and are used for vehicle counts and to give an approximate axle weight roughly within 20 percent.

A list of the MVE and OSP WIM are provided in Table 7. Figure 10 displays the relative locations of the MVE WIM throughout the state.

Table 7. Existing WIM Inventory.

WIM Type	Des Moines / Newton	Boone / Ames / Nevada	Council Bluffs	Sioux City	Iowa City	Quad Cities	Cedar Rapids	Waterloo	Dubuque	Rural District 1	Rural District 2	Rural District 3	Rural District 4	Rural District 5	Rural District 6	Total
MVE WIM	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-	**3**
OSP WIM	1	-	-	1	-	2	-	-	-	5	6	3	4	9	11	**42**
Total	**1**	**-**	**-**	**1**	**-**	**2**	**-**	**-**	**-**	**6**	**6**	**3**	**6**	**9**	**11**	**45**

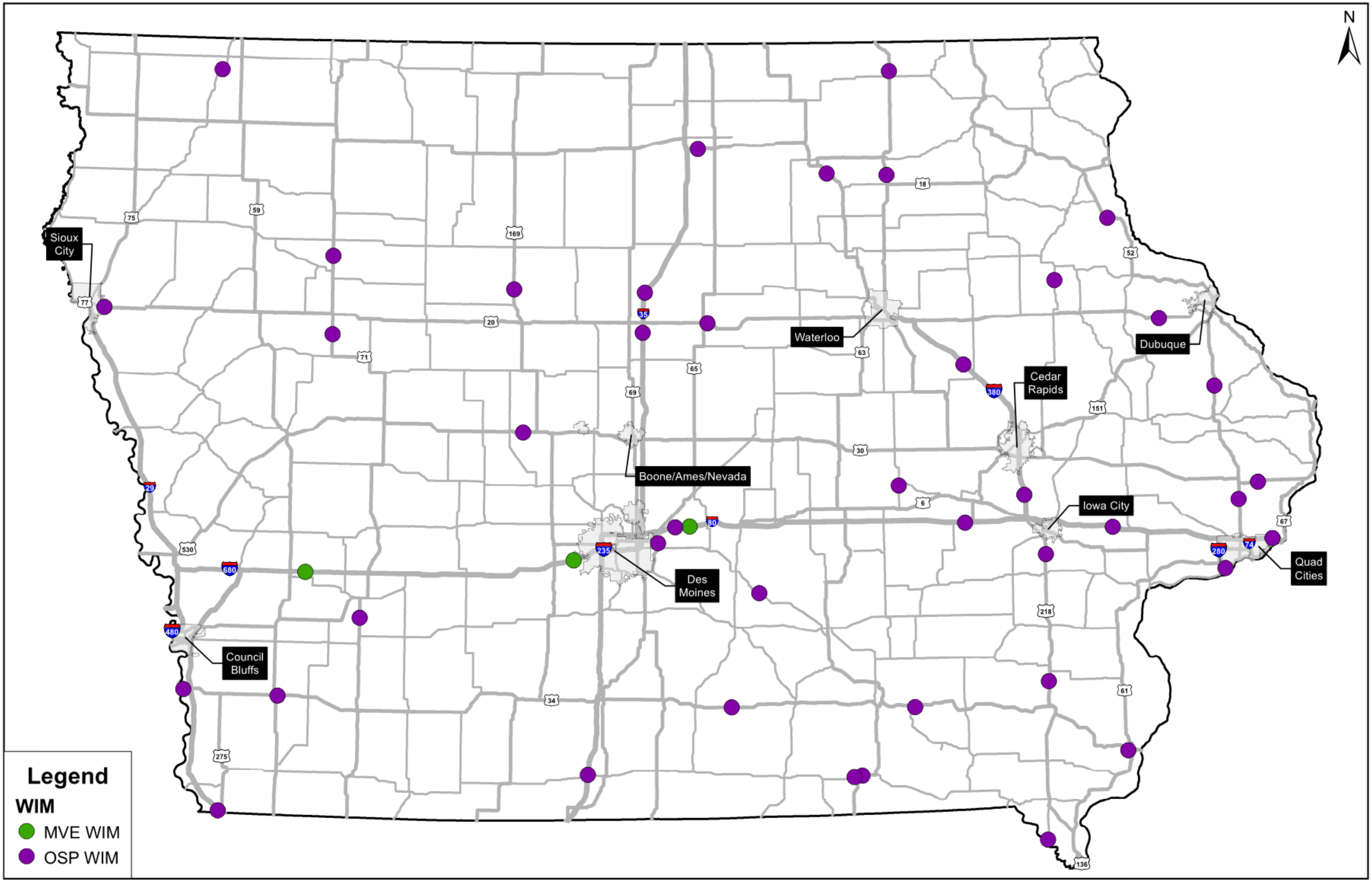


Figure 10. Existing Statewide Motor Vehicle Enforcement Weigh-in-Motion Inventory.

DMS

DMS provide a means for Iowa DOT to inform and manage roadway conditions by communicating directly to motorists. DMS are used to provide real-time information about downstream issues motorists need to be aware of such as incidents, roadwork, or weather, etc. Other general information can also be provided about planned events, public information messages, or amber alerts. Most installed DMS are monochrome (amber); multicolor DMS are planned for several installations and will be able to display signs that are compliant with the Manual on Uniform Traffic Control Devices (MUTCD) along with text-based messages. All permanent and many portable DMS are monitored and operated by the TMC. Iowa DOT uses multiple types of DMS, including the following:

- Overhead DMS – This type of DMS is mounted directly above the roadway with supports on the shoulder and in the center median. Mounting DMS over the road has multiple advantages. It puts the signs more directly into a driver's line-of-sight, which increases the amount of time a driver has to view a message, which maximizes the amount of information the driver can ingest. Because of sign size, location, and required large structures, these DMS are the most expensive to install and maintain.
- Side-Mounted DMS – This type of DMS is significantly smaller than an overhead DMS, and it is mounted on the roadside shoulder. Iowa DOT has installed numerous side-mounted DMS throughout the state as a lower-cost alternative to overhead DMS. There are various limitations to the use of these signs, however, which may outweigh the cost savings. A major limitation is in the viewing angle, which reduces the amount of reading time and introduces possible occlusion for vehicles traveling in inside lanes. In addition, the number of characters (three lines by eight characters) significantly reduces the types of messages and amount of information that can be conveyed. For example, the TMC can rarely use them for "pre-warning" messages because these types of messages generally require more characters than are available on side-mounted DMS (e.g., anticipated roadwork or other warnings). Other messages must be shortened or even split between two phases, often reducing overall message clarity.
- Portable DMS – While portable DMS have many of the same characteristics as side-mounted DMS, their portability makes them valuable for predictable short-term needs or unanticipated medium-term needs. Such events may include construction, maintenance, special events, road damage, road closures, and other temporary applications. These DMS are trailer-mounted and solar-powered, so they can be placed wherever needed. However, they are relatively small, which limits the amount of information that can be conveyed to drivers. Being near the roadway, the signs and their trailers are subject to heavy wear and tear and, therefore, require frequent maintenance. Iowa DOT has a fleet of around 80 portable DMS, stored and deployed from maintenance facilities throughout the state. This fleet is regularly supplemented by rented units.
- Color DMS – In recent years, DMS manufacturers have added color to their DMS for ITS portfolios. Color DMS have the distinction of being able to replicate the color, shape, and size of standard MUTCD highway signs. These sign images can convey immediate information and meaning without requiring drivers to read and comprehend a word-based message. In addition, replicated highway signs are enforceable, whereas word-based messages (e.g., advised speeds vs. speed limits) may not be. The increased cost of color DMS vs. traditional amber

monochrome DMS is approximately $65,000 for overhead DMS over a three-lane road and $25,000 for side-mounted DMS.

- Specialty DMS – Through the years, Iowa DOT has piloted several initiatives for specific applications and sizes of DMS signs. Among these are the following:
  - *Rest Area DMS*. These are located within each rest area, and they provide information to stopped motorists.
  - *Falling-Rock DMS*. Several DMS are in northeastern Iowa along the bluffs near the Mississippi River where falling rock is common. These DMS alert drivers to the presence of rocks on the road until the rocks can be removed.
  - *School Zone Speed Limit DMS*. Two-color DMS signs are located along U.S. 30 between Ames and Boone. They display an MUTCD-compliant enforceable speed limit sign with flashing beacons along this segment to warn motorists to slow down.
  - *Blank-out Signs*. While not a true DMS that can display a variety of messages, blank-out signs are simple, purpose-built (typically with placed LEDs) signs with one or two messages that can be switched on and off. One example is the “Open” / “Closed” signs placed ahead of weigh stations.

The locations for permanent DMS were selected along the most congested corridors, as well as many other key locations throughout the state that were identified with input from District personnel. Iowa DOT also either owns or helps operate a total of 10 DMS in bordering states. One sign, located in Omaha along I-80, is owned and operated by Iowa DOT and provides a mechanism to inform drivers as they enter the state from Nebraska. Additionally, Iowa DOT helped plan, design, and procure nine DMS located on the Illinois side of the Quad Cities. This agreement has allowed both Iowa and Illinois DOT to post messages on the signs; Illinois DOT is responsible for their maintenance. The signs are controlled through Iowa DOT’s advanced traffic management system (ATMS). Because these signs are not owned by Iowa DOT, they are not included in Iowa DOT’s DMS inventory.

A summary of the DMS device types supplied in each district and metropolitan area of Iowa are provided in Table 8. Table 8 provides inventory of general and special DMS device types used throughout Iowa. The special DMS device types were not included in the overall DMS inventory total since these devices are used for a specific purpose and are not multifunctional.

Figure 11 displays the locations of the DMS throughout the state.

Table 8. Existing DMS Inventory.

DMS Type	Des Moines / Newton	Boone / Ames / Nevada	Council Bluffs	Sioux City	Iowa City	Quad Cities	Cedar Rapids	Waterloo	Dubuque	Rural District 1	Rural District 2	Rural District 3	Rural District 4	Rural District 5	Rural District 6	Total	Illinois
General DMS																	
Overhead	19	2	7	4	6	6	12	5	1	4	1	-	4	-	-	**71**	5
Side-Mounted	9	1	2	4	7	4	-	-	3	2	4	-	6	-	2	**44**	4
Total	**28**	**3**	**9**	**8**	**13**	**10**	**12**	**5**	**4**	**6**	**5**	**-**	**10**	**-**	**2**	**115**	**9**
Other DMS																	
Portable	-	-	-	-	-	-	-	-	-	14	18	11	14	16	9	**82**	-
Rest Area	2	4	2	2	2	2	2		-	-	1	2	2	6	3	**30**	4
School Zone Speeds	-	2	-	-	-	-	-		-	-	-	-	-	-	-	**2**	-
Falling-Rock	-	-	-	-	-	-	-		-	-	-	4	-	-	-	**4**	-
Blank-out Signs (scale sites)	1	-	-	-	-	-	-		-	-	1	1	2	2	2	**9**	2
Under Construction or Planned	3	1	1	-	-	-	-		-	-	-	-	-	-	-	**5**	-

*Note: The items in red were not counted in the overall total for DMS.

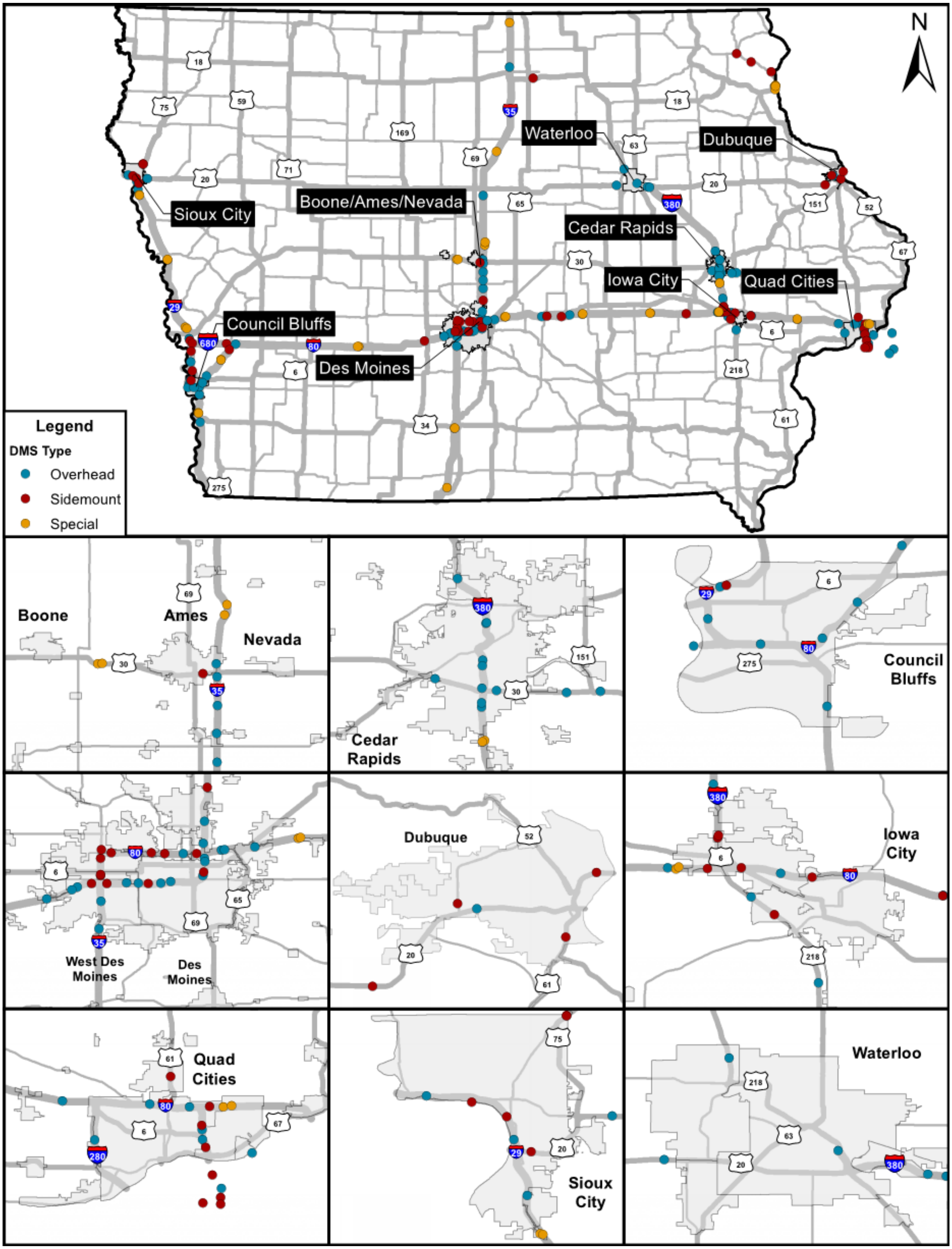


Figure 11. Existing Statewide and Metropolitan Area DMS Inventory.

Over-Height Detection Systems

OHDS are placed ahead of height-restricted bridges or structures. They are coupled with a warning mechanism that will alert an over-height vehicle of an imminent collision with the structure they are approaching. OHDS are only provided in locations with a history of high-load collisions. A list of the systems installed in each district and metropolitan area of Iowa is provided in Table 9.

Over time, Iowa DOT has been systematically reducing the number of height-restricted structures to comply with current standards. Because of this, it is anticipated OHDS will no longer be needed.

Intersection Conflict Warning System

Intersection conflict warning systems (ICWS) are installed at locations where a high-speed rural road (typically a four-lane divided highway), intersects with a minor road in a two-way stop configuration. ICWS are effective in alerting drivers on the intersecting local road to the presence of high-speed oncoming traffic along the highway. These systems help reduce these types of crashes, which are often severe. ICWS are only provided in spot locations, listed in Table 9.

Table 9. Existing Warning Devices Inventory.

Warning Device Type	Des Moines / Newton	Boone / Ames / Nevada	Council Bluffs	Sioux City	Iowa City	Quad Cities	Cedar Rapids	Waterloo	Dubuque	Rural District 1	Rural District 2	Rural District 3	Rural District 4	Rural District 5	Rural District 6	Total
OHDS	1	-	-	-	-	1	-	1	-	-	-	-	-	-	-	**3**
ICWS	1	-	-	-	-	-	-	-	-	1	-	-	-	1	2	**5**

Figure 12 displays the relative locations of the warning devices throughout the state.

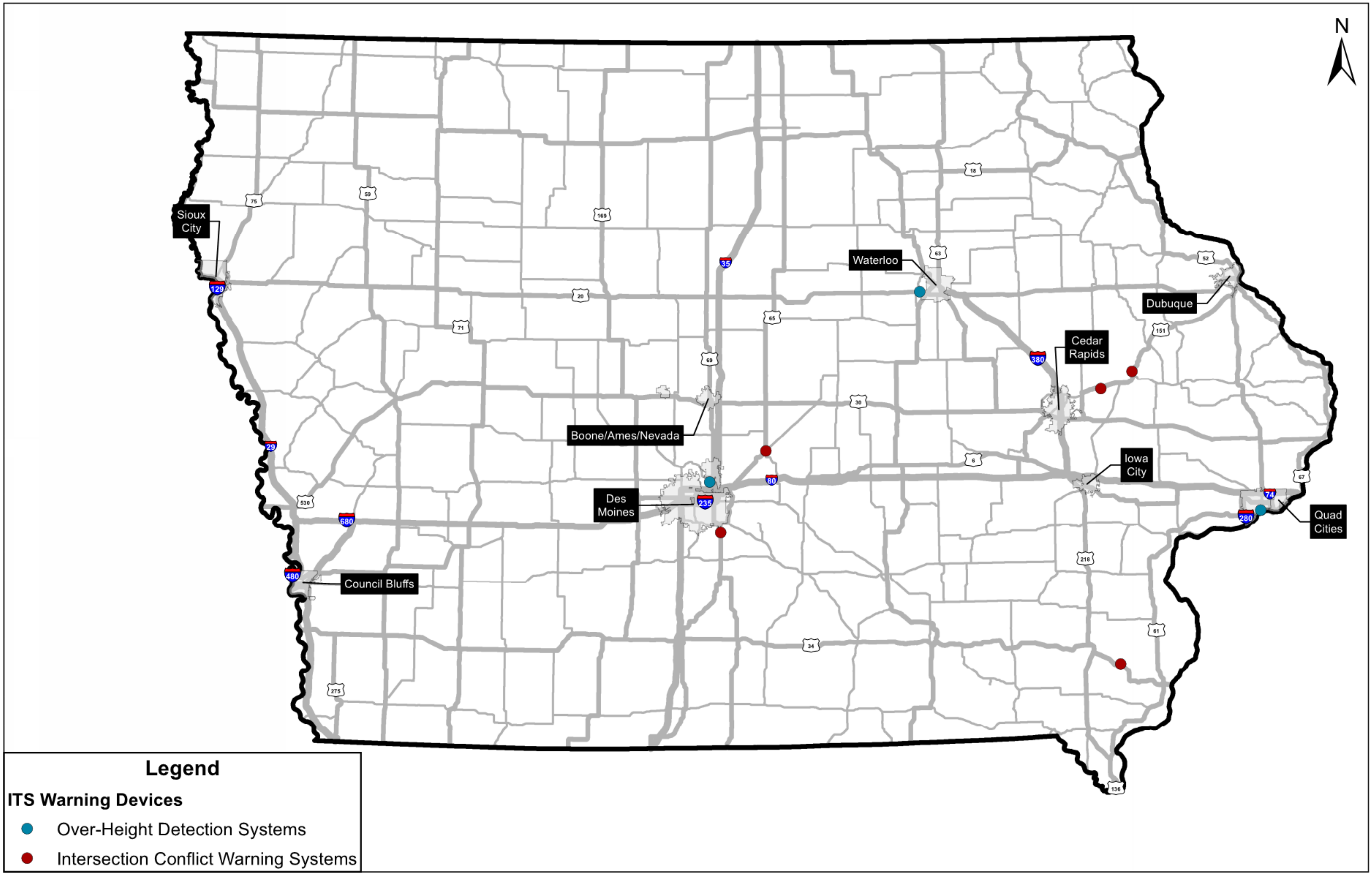


Figure 12. Existing Statewide Warning Devices Inventory.

Lane Closure Planning Tool

The Iowa DOT has developed a lane closure planning tool to aide in determining when a lane can be closed, for non-emergency reasons, on a multi-lane highway facility without causing traffic queues.

The lane closure planning tool utilizes traffic volume and classification information from the Office of Systems Planning's ATRs to calculate passenger car equivalents. This information is tracked and stored by time-of-day, day-of-the-week, and month.

When a need to close a lane of a multi-lane highway arises, the lane closure planning tool is queried for the passenger car equivalent information for that location and time period. This information is compared with preset thresholds for traffic queue generation to determine if the closure can be allowed.

Presently, if the requested closure location is not in close proximity to an ATR, the DOT interpolates between the nearest ATRs to determine the feasibility for a lane closure.

Travel Time Displays

One of the means Iowa DOT has used to provide its users with meaningful information about travel conditions, is to display travel times on DMS signs. Currently there are only corridors in the state that are using this application of ITS technology, consisting of the I-235 and I-35/80 corridors in the Des Moines area.

This information gives travelers an indication of current congestion levels by providing the estimated time to travel from the DMS sign to a specific downstream location. For motorists traveling between the East and West I-235 and I-35/80 interchanges in the Des Moines area, it also gives them a travel time comparison between each route which helps make the most efficient use of the system as a whole.

The system works by using speed data from the installed traffic sensors that are spaced along each corridor. The ATMS software then normalizes and smooths this data to calculate estimated travel times, which it displays on each DMS sign.

Communications

A key component of any ITS system lies in the digital communications that connect devices to systems and systems to people. The mechanisms used for transmitting this data consist of a combination of fiber-optic cable, wireless Ethernet links, leased communications circuits, and cellular communications. Multiple types of routing and switching equipment are used to manage the network traffic and keep it secure.

Since 2003, Iowa DOT's ITS network has been growing and evolving. Originally scoped as a temporary, wireless-only network installed in the Des Moines area, the network was enhanced by sharing infrastructure with local and statewide partners. As additional metropolitan areas were added, additional fiber and sharing agreements were established, and each metro was considered a stand-alone deployment. Later, they were all connected into one large network, but was and continues to be separate from the Iowa DOT's department network. During each stage of this evolution, more sophisticated networking has been required to add these legacy stand-alone deployments into a robust statewide network. The general architecture of Iowa DOT's ITS network is illustrated in Figure 13.

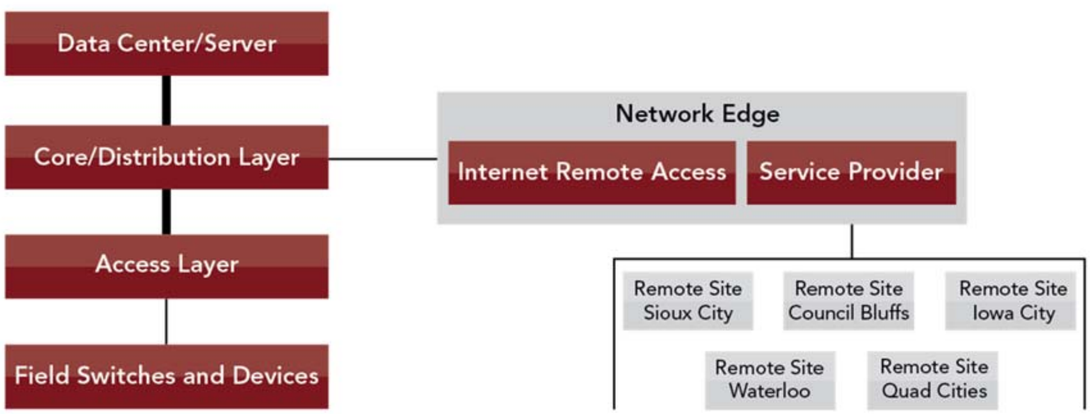


Figure 13. ITS Network High-Level Architecture.

As the system was deployed, there were some opportunities that presented themselves to provide service to nearby Iowa DOT district or maintenance facilities. Because of this, there are several instances where Iowa DOT facilities are connected to the central office network and to the internet over the ITS network. In this role, the reliability of the ITS network has become even more critical to the operation of the department.

As part of this evolution, Iowa DOT has recognized that the system has outgrown the capability of the current equipment. Because of this, the OTO is currently in the process of upgrading the system architecture, equipment, and security elements to meet current needs. This upgrade designed around the efficiency of the future network, rather than designing around legacy operations. This upgrade will position Iowa DOT for effective operations for approximately seven years, the current industry-recommended maximum life for network routing, switching, and security devices.

Since 2003, Iowa DOT has deployed these types of communications infrastructure as part of its metro and rural ITS deployments. Much of this infrastructure is owned and maintained by Iowa DOT or leased directly from private communications providers. Some, however, have been made available by sharing agreements with other public organizations (IRU agreements).

Quantities for existing Iowa DOT fiber-optics are provided in Table 10 and Table 11 provides quantities for existing Ethernet radios and cellular modems. An additional list of the connection speeds of leased circuits at specific Iowa DOT locations is provided in Table 12. Figure 14 displays the relative locations of the miles of fiber in the nine largest metropolitan areas.

Table 10. Existing Fiber-Optics Quantities.

Communications Infrastructure Type	Des Moines / Newton	Boone / Ames / Nevada	Council Bluffs	Sioux City	Iowa City	Quad Cities	Cedar Rapids	Waterloo	Dubuque	Rural District 1	Rural District 2	Rural District 3	Rural District 4	Rural District 5	Rural District 6	Total
Iowa DOT Owned (miles)	30	25	35	10	10	-	45	-	-	70	-	10	35	-	70	**340**
Iowa DOT IRU (miles)	85	15	5	20	10	10	5	-	-	140	-	20	5	-	75	**390**
Total	**115**	**40**	**40**	**30**	**20**	**10**	**50**	**-**	**-**	**210**	**-**	**30**	**40**	**-**	**145**	**730**

Table 11. Existing Ethernet Radios and Cellular Modems Quantities.

Communications Infrastructure Type	Rural District 1	Rural District 2	Rural District 3	Rural District 4	Rural District 5	Rural District 6	Total
Microwave Ethernet Radios	186	24	29	57	19	93	**408**
Cellular Data Modems	53	55	29	44	16	68	**265**

Table 12. Existing Leased Circuits Speeds.

Leased Circuits	Newton Maintenance Garage	Cedar Rapids District Office	Waterloo (via radio from Community College)	Ankeny MVE	Iowa DOT Ames	Oakdale Maintenance Garage	Council Bluffs (North Maintenance Garage)
Connection Speed (MB)	15	50	15	50	50	15	50

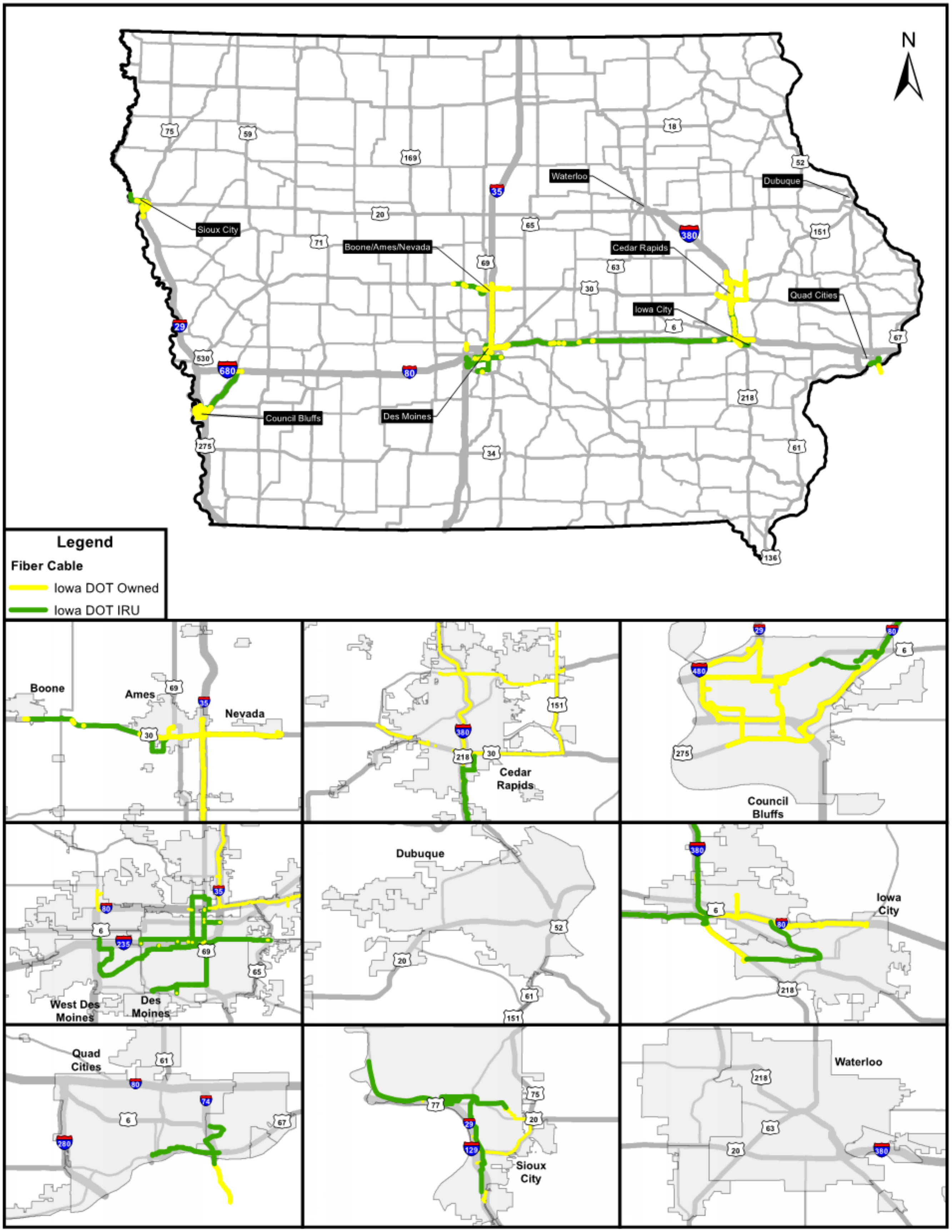


Figure 14. Existing Statewide and Metropolitan Area Fiber.

4.0 ITS STRATEGIES AND TACTICS

This section outlines specific strategies and tactics that will guide the implementation of ITS devices and technologies along Iowa's roadways. The recommended implementation is based on the premise that technologies should be deployed where they are most effective, and that it is cost-prohibitive to install all technologies along every mile of roadway. To this end, the ICE-OPS tool, described below, is used to help guide the implementation of several ITS technologies.

The strategies in this section are presented within their functional groupings outlined in section 1.1 Definition of ITS and Communications Systems (Monitor, Manage, and Connect). Three specific strategies are separated into their own subsections because they are treated with additional detail, including sections: 4.3 Dynamic Message Signs, 4.4 Motor Vehicle Enforcement, and 5.0 Communications Systems Strategy.

4.1 ICE-OPS Tool for Prioritization

The ICE-OPS tool, introduced in Part 6 of the TSMO program plan, was developed in cooperation with the OSP for use in evaluating the operational efficiency of Iowa's roadways. The tool uses a total of nine criteria to rank each roadway segment according to its operational efficiency. These criteria capture volume, congestion, crashes, special events, weather sensitivity, and the ICE rating (used by the OSP to prioritize roadways for infrastructure condition).

The original analysis in the TSMO program plan included 21 interstate segments. As part of the evolution and improvement of this tool, the interstates were further divided for this analysis into 54 segments to give better granularity in the metropolitan areas. For this study, the tool was expanded to also include 85 primary municipal and primary rural roadway segments. As the ICE-OPS tool continues to be refined and expanded, this plan should be updated accordingly to incorporate these changes.

The results of the ICE-OPS tool are used in this plan in conjunction with the roadway facility priorities defined in Part 2 of the TSMO program plan. Those priorities are:

1. Interstate Highways
2. Primary Municipal Network
3. Primary Rural Network
4. Border Bridges

These priority corridors are illustrated in Figure 15. All segments are shown for the primary municipal and primary rural networks. In addition, the border bridges were prioritized according to the Roadway Facility Priorities and were not subdivided according to the ICE-OPS segment rankings. The full list of segment rankings is included in Appendix C.

The ICE-OPS rankings provide a basis which can guide Iowa DOT in prioritizing locations to evaluate the expansion of ITS systems. Lower value ICE-OPS rankings represent segments with greater operational challenges, and may benefit from appropriate ITS systems or applications, and should be given priority.

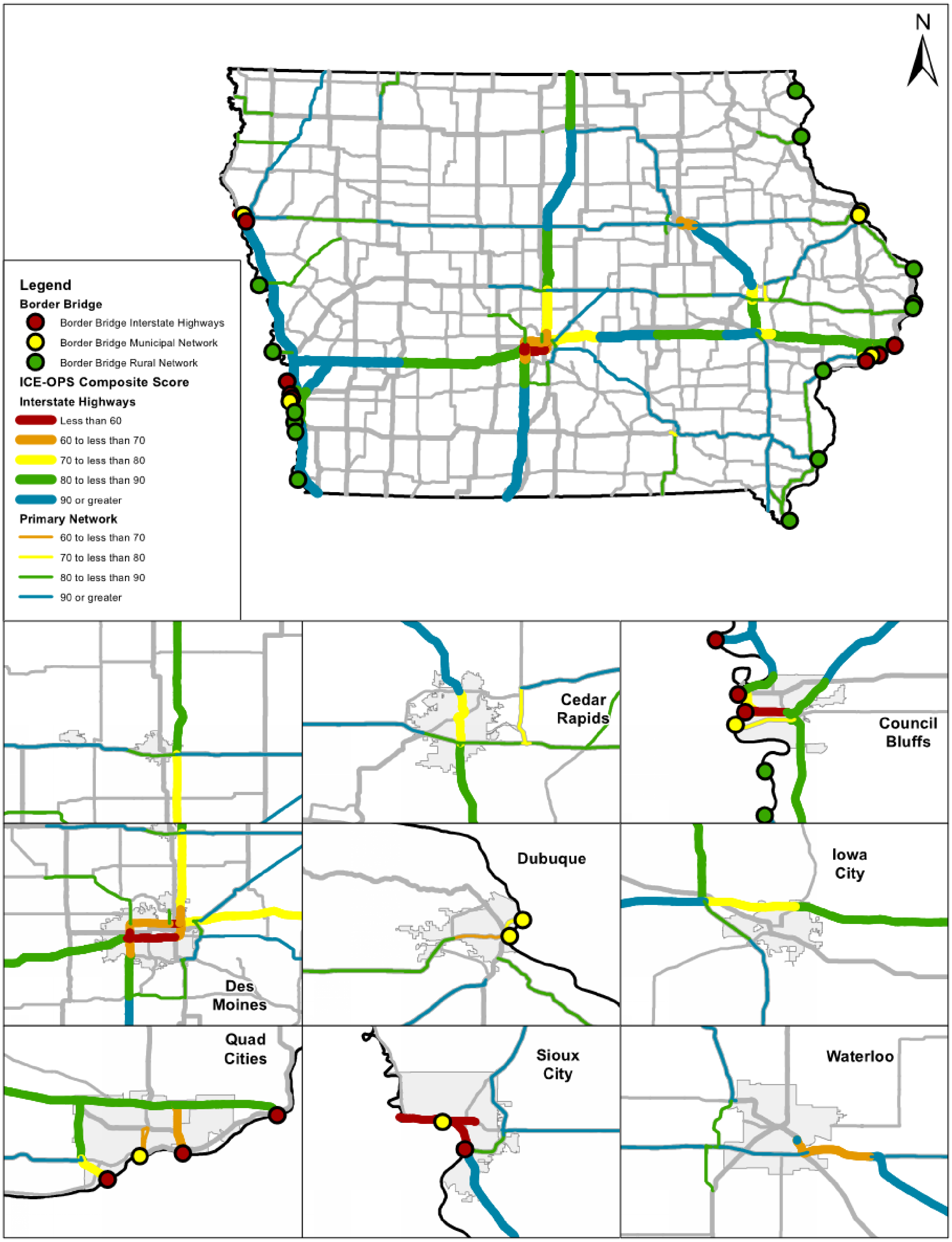


Figure 15. ICE-OPS Segment Rankings.

4.2 ITS Infrastructure

Iowa DOT's existing ITS infrastructure was deployed primarily based on existing needs and projects in the area. This section as well as 5.0 Communications Systems Strategy will provide strategies and tactics for deploying ITS and communication systems. These strategies provide a link between the placement of the existing infrastructure and the conceptual plan for each of the ITS and communications systems in the future.

MONITOR

A review of the monitor service category is outlined below. The monitor service category is divided into four systems: visual monitoring, traffic data monitoring, weather monitoring, and security monitoring. Each system allows Iowa DOT to review real-time information; however, each analyzes different aspects of the transportation system.

- *Visual Monitoring* – Provides an optical perspective of the system.
- *Traffic Data Monitoring* – Enables the automatic gathering and quantifying of traffic flow information.
- *Weather Monitoring* – Provides a means to monitor pavement temperatures along the roadway and on bridge decks.
- *Security Monitoring* – Is optical monitoring-specific for valuable state facilities, such as border bridges, rest areas, and DOT buildings.

The systems defined in this section provide strategies and tactics that should be reviewed before the systems are installed. Also defined are quantifiable factors that correspond with each strategy. Benefits and limitations are described for each system, and examples of the systems are provided.

Table 13 illustrates each of the systems provided under the monitor service category and the specific TSMO strategic goals and ITS and communications supporting objectives that each system meets.

Table 13. Goals and Objectives Met by the Monitor Systems.

TSMO Strategic Goals	ITS and Communications Systems Objectives	Visual	Traffic Data	Weather	Security
Safety	Detect and inform motorists and responders of hazardous conditions.	x	x	x	x
	Detect and inform motorists and responders of incidents.	x	x	x	
Reliability	Improve travel time reliability.	x	x	x	x
	Inform maintenance personnel of road weather conditions.	x		x	x
	Help determine optimum time for lane closures.	x	x		
	Inform motorists of optimum routes.	x	x	x	x
	Use ITS to support special event traffic.	x	x		
Efficiency	Detect traffic incidents as quickly as possible.	x	x		x
	Maximize the volume/capacity of the full system.	x	x	x	x
Convenience	Inform motorists of optimum routes.	x	x	x	x
	Provide traffic information to motorists enabling them to make informed travel decisions.	x	x		
Coordination	Provide a robust communications system throughout the state to connect devices, systems, organizations, and people.				
Integration	Deploy devices that support integrated corridor management applications.	x	x		
	Share resources such as systems, data, and devices with transportation partners.	x	x	x	x

Visual Monitoring

Description

Visual monitoring provides operators and motorists with a real-time optical view of the transportation system by means of cameras. Cameras allow the TMC and other departments to visually monitor hazardous conditions or incidents on the roadway as well as within work zones. Cameras also provide recording capability, allowing for post-incident analysis. They are generally most effective in areas where traffic volume and density (volume/capacity) are high, as these locations typically have more congestion and incidents.

Benefits

- Quickly identify hazardous conditions and incidents along the roadway.
- Identify congestion in real-time.
- Reduce time for incident verification, leading to faster response times.
- Enable post-incident analysis through recorded video.

Limitations

- Only provided in spot locations.
- Some blind spots exist from roadway and other structures.
- Requires access to power and relatively high-bandwidth communications.
- Camera image quality is degraded by inclement weather and at night.

Table 14. Visual Monitoring Deployment Tactics.

Tactic	Description
ICE-OPS Priority Segments	o Comprehensive camera coverage should be provided in areas of high volume and density, whereas less dense coverage may be provided along roadways with lower volume and density.
Interstates	o Comprehensive camera coverage should be provided along interstates.
Key Locations	o Some locations may have a greater need for cameras for various factors. These may include locations with high incident rates, regular specific weather concerns, seasonal or event traffic, or decision points. o Cameras may be provided in certain areas because of easy access to power and communications and the opportunity to provide coverage of an area of interest.
Temporary Uses	o Portable cameras can be used in areas with temporary needs, including the following examples: • Work zones • Special events • Accident investigation or other safety concerns • Observing a new traffic pattern or operational concerns • Design support (recorded or live as needed)
Security	o See Security Monitoring in this section on page 42.

TRAFFIC DATA MONITORING

Description

Traffic data monitoring systems are used to review traffic delay and other conditions through data sets and statistics. The following systems are considered traffic data monitoring systems:

- Traffic sensors – provides low-latency, detailed, and relatively accurate spot information.
- Probe data – provides speeds and travel times for a section of roadway.
- Crowd-sourced data – allows highway users to report incidents and conditions directly.

Benefits

- Supports planning and traffic analysis efforts.
- Sensor data helps detect hazardous conditions and incidents.
- Crowd-sourced data allows motorists to actively identify real-time roadway hazards.
- Speed information can help indicate road conditions during winter weather.

Limitations

- Traffic sensors have reduced value at detecting congestion along signalized corridors.
- Traffic sensors are used in spot locations, causing gaps in coverage.
- Traffic sensors can be relatively expensive to install along a continuous segment of roadway.
- Traffic sensors require regular maintenance and calibration.
- Traffic sensors require power, communications, and cabinet equipment.
- Probe data provides speeds only for a sample of vehicles (typically fleet vehicles).
- Probe data is dependent on traffic being present.
- Crowd-sourced events are often not immediately verifiable.

Table 15. Traffic Data Deployment Tactics.

Tactic	Description
General Travel Conditions	o Probe and crowd-sourced data should be used on all interstate and primary network roadways. Except in the cases identified below, no traffic sensors are recommended.
ITS Applications	o Deploy traffic sensors in support of ITS applications such as travel time display, queue detection, ICWS, and the non-emergency lane closure system.
Active Traffic Management	o Some active traffic management strategies such as intelligent work zones (IWZ), integrated corridor management, real-time travel time information corridors, ramp merge systems, ramp metering, and others require low-latency, detailed, accurate roadway data. Appropriate traffic sensors should be installed to support these systems and strategies.
Spot Locations	o Vehicle sensors should be installed in specific locations where the higher accuracy, low-latency, or additional data types are needed.
Automatic Traffic Recorder Support	o The Iowa DOT has approximately 130 permanent ATRs located strategically throughout the state to gather detailed traffic data. This is used to identify trends and support DOT planning processes. Wherever these ATRs are located, shared-use should be considered to supplement both planning and real-time information efforts.

WEATHER MONITORING

Description

RWIS provide real-time atmospheric and roadway-related weather conditions. They support forecasting efforts and provide information to support winter operations decisions. They are installed in representative areas and in trouble-spot locations.

Benefits

- Assists with general forecasting efforts (atmospheric data).
- Quickly detects ice, pavement temperature, subsurface temperature, and chemical content for the roadway.
- Higher-resolution forecasting and road condition data can save money by allowing more accurate scheduling of field crews and providing better data to enable the optimization of anti-icing materials.
- Pavement and ice sensors can be placed near bridge decks for problem bridges.
- Can use mobile RWIS on maintenance vehicles.
- (Future) connected vehicle data:
    - Wipers, anti-lock brakes, headlights

Limitations

- Provides spot information only and is assumed to represent general conditions in an area.
- Optimal placement in Iowa is distributed in diverse and often remote areas throughout the state.
- Often provides only little benefit from co-locating other devices in areas that are optimal for RWIS.

Table 16. Weather Monitoring Deployment Tactics.

Tactic	Description
Representative Locations	o Install RWIS in the largest gaps in the state where RWIS is currently not provided, at approximately 30-mile spacing.
Trouble Spots	o Provide in low-lying areas where fog and ice may be present. Provide in wind-prone areas and on problem bridges where ice may be a factor.
Co-location with Other Devices or Facilities	o If an existing device or facility is near an optimum location (defined by 1 or 2 above), consider installing to share communications, power, and poles and to minimize the cost of installation. o Work with neighboring states to share RWIS information that represents conditions on both sides of the state line.
Mobile RWIS / Connected Vehicle Data	o Begin pilot program for mobile RWIS installed in Iowa DOT maintenance trucks.

Security Monitoring

Description

The 24-7 TMC provides security monitoring to critical infrastructure such as border bridges, bridges with scour potential, and many other state facilities. Security monitoring systems can detect dangerous activities involving border bridges, such as stopped vehicles, pedestrians on the superstructure or substructure, or those with scour alarms.

Benefits

- Quickly detect hazardous activities at border bridges.
- TMC operators are in position 24-7 to respond to emergency alarms throughout the state.
  - Respond to panic buttons installed at various locations, including welcome centers

Limitations

- Needs a designated security monitoring system to trigger activity alarms.
- Many bridges are in remote areas with limited communications options.

Table 17. Security Monitoring Deployment Tactics.

Tactic	Description
Border Bridge Locations	o All border bridge locations. The current direction is to provide monitoring, including visual monitoring, of the bridge surface at either end with no monitoring of the substructure or piers unless specifically warranted. Currently, only the I-74 bridge in the Quad Cities has substructure and pier security monitoring.
Bridge Scour Monitoring	o Interface with the Bridge Watch scour monitoring system for alarms.
Other DOT Facilities	o Anywhere Iowa DOT personnel regularly interface with the public.

MANAGE

ITS devices can be used individually or combined into systems and strategies to support the effective management of traffic operations. Several strategies are outlined in this section and are organized into two groups: safety and traffic management. Additional strategies are also referenced.

Safety Systems

- *Intersection Conflict Warning System (ICWS)* – Alerts motorists approaching rural at-grade intersections of the presence of approaching traffic on the crossing highway. Newer systems provide a means to alert travelers on the major roadway as well.
- *Truck Parking Information and Management System (TPIMS)* – Collect and transmit truck parking availability to freight operators.
- *Wrong-way Detection System (WWDS)* – Detects wrong-way vehicles and alerts the motorists of the error.
- *Queue Detection* – Sensors and signs that work together to alert motorists of stopped or slow-moving traffic ahead, helping prevent incidents.

Traffic Management Systems

- *Non-Emergency Lane Closure System* – provides guidance on the timing of lane closures on interstates, freeways, and expressways to avoid causing congestion.
- *Travel Time Display* – Provides motorists with estimated travel times along a corridor.

As mentioned previously, DMS will be addressed separately in section 4.3 Dynamic Message Signs. Similarly, ITS devices that are deployed as part of MVE systems will be addressed in their own section 4.4 Motor Vehicle Enforcement. These include virtual weigh stations (VWS) and WIM systems.

The deployment of each strategy is guided by one or more deployment tactics that are identified.

Portable HAR

The OTO also maintains two portable AM (amplitude modulation) HAR, which can be used to address temporary needs, primarily in support emergency management activities. The benefit of these units is that they have a broadcast range of up to 8 miles, which gives the opportunity to provide motorists with a significant amount of detailed information. Either static signs or DMS signs must be used in conjunction with the portable HAR to alert motorists of the radio frequency and presence of a message.

Additional Management Applications

In addition to the specific strategies identified above, the following ITS-related transportation management strategies are addressed in detail in other service layer plans or efforts.

Active Transportation and Demand Management Service Layer Plan

This plan addresses advanced strategies for managing traffic flow, which may include (but not be limited to) the following:

- *Ramp Metering* – Traffic signals located at the ends of onramps to freeways that break up platoons of traffic entering the freeway to reduce instability in traffic flow.

- *Dynamic Speed Limits* – Automatic adjustment of enforceable speed limits based on roadway and congestion conditions.
- *Traffic Signal Control Strategies* – Advanced control of traffic signals such as traffic adaptive, traffic responsive, and multijurisdictional coordination.
- *Integrated Corridor Management* – Dynamic routing recommendations for drivers using multimodal and parallel roadways.
- *Lane Management / Lane Utilization* – Active management of individual traffic lanes, which may include technologies like reversible lanes for directional demand during commutes.

<u>*Work Zone Management Service Layer Plan*</u>

- *Intelligent Work Zones (IWZ)* – Concentrated monitoring and traveler information applied specifically to work zone applications including work zone TIM, portable DMS, and sensors.
- *Dynamic Late Merge Systems* – In areas where general travel information is adequate and a sufficient number of participants are present to provide data, probe or crowd-sourced data should be considered.

<u>*Traffic Incident Management Service Layer Plan*</u>

- *Highway Helper Program* – Mobile resources that aid with traffic control during incidents as well as assistance to stranded motorists.
- *Response Agency Coordination* – Multiagency communications to provide coordinated responses to incident management.
- *Accident Investigation Sites* – Training and equipment to allow personnel to perform accident investigations from safe locations.
- *Traffic Incident Management (TIM) Alternate Route Management* – Identify designated alternate routes and manage traffic when in use.

<u>*Data and Performance Management Program*</u>

- *Shared Data Warehouse* – A common data storage location for all aspects of traffic operations that allows data management within and between programs.
- *Performance Management Program* – A data driven program that provides performance feedback into all aspects of traffic management to drive performance improvement.
- *Center-to-Center (C2C) Applications* – Common data exchanged and shared between different applications; can be a real-time function of the shared data warehouse.

These strategies are included because they use one or more ITS and communications elements integrated together as a system designed for a specific application. A high-level summary of these elements is summarized in Table 18.

TSMO Strategic Goals and Supporting Objectives

ITS-enabled traffic management strategies support the TSMO strategic goals and ITS and communications objectives. Table 19 illustrates the relationship between each of the systems provided under the manage service category and the specific objective met by each system.

Table 18. ITS Devices used in Management and Operations Strategies.

	Cameras	Traffic Sensors	Specialized Sensors	Probe Data	Dynamic Message Signs (appropriate style)	Flashing Beacon	Road Weather Information Systems	Traffic Signals	Connected and Autonomous Vehicle Applications (future)	Weigh in Motion	Virtual Weigh Stations
Safety Applications											
• Intersection Conflict Warning System	x	x			x	x			x		
• Truck Parking Information and Management System	x		x						x		
• Wrong-way Detection	x	x			x	x			x		
• Queue Detection	x	x		x	x						
• High Wind Warnings							x				
• Flood Detection							x				
• Motor Vehicle Applications										x	x
Traffic Management Strategies											
• Non-Emergency Lane Closure System		x									
• Travel Time Display		x		x	x						
Active Transportation Demand Management											
• Ramp Metering		x		x				x			
• Dynamic Speed Limits		x			x				x		
• Traffic Signal Control Strategies		x						x			
• Integrated Corridor Management		x		x	x				x		
• Lane Management / Lane Utilization		x			x						
Work Zone Management											
• Intelligent Work Zones	x	x		x	x				x		
• Dynamic Late Merge System		x			x	x					
Traffic Incident Management											
• Highway Helper Program											
• Response Agency Coordination											
• Accident Investigation Sites											
• TIM Alternate Route Management					x			x			
Data and Performance Management											
• Shared Data Warehouse							x				
• Performance Management Program							x				
• C2C Applications							x				

*Note: Services in red will be addressed in other service layer plans. These are mentioned here since they all use ITS devices.

Table 19. Goals and Objectives Met by the Manage Systems.

TSMO Strategic Goals	ITS and Communications Systems Objectives	DMS	Safety				Traffic Management	
			ICWS	TPIMS	WWDS	Queue Detection	Non-Emergency Lane Closure System	Travel Time Display
Safety	Detect and inform motorists and responders of hazardous conditions.	x	x		x	x	x	x
Safety	Detect and inform motorists and responders of incidents.	x				x		x
Reliability	Improve travel time reliability.							x
Reliability	Inform maintenance personnel of road weather conditions.							
Reliability	Help determine optimum time for lane closures.						x	
Reliability	Inform motorists of optimum routes.	x						x
Reliability	Use ITS to support special event traffic.	x						x
Efficiency	Detect traffic incidents as quickly as possible.					x		
Efficiency	Maximize the volume/capacity of the full system.	x	x			x		x
Convenience	Inform motorists of optimum routes.	x						x
Convenience	Provide traffic information to motorists enabling them to make informed travel decisions.	x	x		x	x		x
Coordination	Provide a robust communications system throughout the state to connect devices, systems, organizations, and people.							
Integration	Deploy devices that support integrated corridor management applications.	x	x	x	x		x	x
Integration	Share resources such as systems, data, and devices with transportation partners.	x						

INTERSECTION CONFLICT WARNING SYSTEM

Management Strategy Group
Safety Applications

Description
ICWS can be installed at locations where a high-speed rural road (typically a four-lane divided highway) intersects with a minor road in a two-way stop configuration. Crashes at these types of intersections are frequently severe and often result from drivers being unaware of other vehicles on the crossing roads. ICWS are effective in alerting (1) drivers on the intersecting local road to the presence of high-speed oncoming traffic along the highway; and (2) drivers on the main highway to the presence of vehicles that may be entering from the local road. ICWS typically consist of the following components:

- *Traffic Sensors* – Installed along the highway to detect the presence of oncoming traffic and along side streets.
- *Warning Devices* – Installed on both the major and minor road approaches to warn of the presence of entering and oncoming traffic; may consist of flashing beacons, blank-out signs, modified stop signs with LEDs, or other similar devices.
- *Local Communications* – Wireless or wired communications between the vehicle presence sensors and the warning devices.
- *CCTV Cameras* – Cameras often installed in conjunction with these systems to monitor system operations.

Benefits
- Reduces severe crashes at specific types of rural at-grade intersections.
- Can be installed as a stand-alone device; not connected to the overall network if communications are not feasible.

Limitations
- Limited to a single intersection.
- Requires access to power.

Table 20. Intersection Conflict Warning System Deployment Tactics.

Tactic	Description
Rural Intersection Collisions	o Install at four-lane, divided two-way-stop rural intersections with a history of severe accidents.

TRUCK PARKING INFORMATION AND MANAGEMENT SYSTEM

Management Strategy Group
Safety Applications

Description
The Iowa DOT provides information specific to motor carriers to improve the mobility and safety of their movements and the transportation system.

Currently, the DOT has cameras installed at many of its rest areas. These cameras capture snapshots of the current parking areas, and these snapshots are uploaded to 511ia.org as well as to the 511ia mobile application. While some commercial vehicle operators are not allowed to use phones while driving their truck, these technologies can use the snapshots to allow vehicle operators to make their own assessment about parking availability.

In addition, the Iowa DOT received a TIGER grant as part of MAASTO's application for a regional truck parking information management system (TPIMS). TPIMS detect the presence of available truck parking and transmit that information to freight vehicle operators. As part of its TIGER grant application, Iowa committed to collecting truck parking information in the truck parking areas of DOT-owned rest areas and private truck stops on I-80. Truck parking information will be disseminated via numerous methods, all focused on getting it to motor carrier operators as timely as possible.

The Iowa DOT is in the detailed design stage of the project with implementation occurring in 2018. As part of the grant award, Iowa DOT will maintain the TPIMS for three years.

At the completion of the 3-year TPIMS deployment, the Iowa DOT will evaluate the effectiveness of the service with respect to the cost of the program. Based on that evaluation, Iowa will a) expand the service to other interstate routes; b) maintain the service as is; or c) terminate the service.

If the DOT decides to maintain or expand the TPIMS program, the cost of operating the program will require funding from either the DOT's operating budget or the ITS program.

Benefits

- Reduces operator time spent searching for available parking, minimizing driver fatigue.

Limitations

- Some designs require frequent calibration.
- Currently planned at DOT-owned facilities only.

Table 21. Truck Parking Information and Management Deployment Tactics.

Tactic	Description
Iowa DOT Rest Areas	o Once the current project demonstrates successful operation and benefit, extend to other Iowa DOT rest areas along I-35 and I-29.

Wrong-way Detection System

Management Strategy Group

Safety Applications

Description

WWDS can detect wrong-way vehicles, alert drivers of this mistake (as well as possibly alerting oncoming vehicles), and provide alarms to traffic management and/or law enforcement personnel. There are no national standards for WWDS; however, several states have tested or deployed or are in the process of testing or deploying systems using various technologies and strategies. WWDS have been shown to reduce the number of wrong-way drivers by up to 88 percent.

Table 22. Wrong-way Detection Deployment Tactics.

Tactic	Description
Lighting and Signing Treatments	o If there are specific instances where signing, lighting, or flashing beacons do not address wrong-way issues, Iowa DOT may investigate technology-based WWDS.

QUEUE DETECTION

Management Strategy Group
Safety Applications

Description
A queue detection system provides motorists warning of traffic slow-downs and congestion.

On Iowa interstates and freeways, recurring congestion occurs in only a handful of locations. These locations are in the larger metropolitan areas, all of which have existing ITS deployments that include cameras, side-fire radar traffic sensors, and DMS.

The predominant sources of nonrecurring congestion are traffic crashes and construction work. While it is difficult to anticipate when and where crashes will occur, construction activities are planned, and their traffic impacts are predictable. The DOT's IWZ program provides for the placement of portable cameras, traffic sensors, and DMS in advance of and through construction areas.

These technologies, integrated into the traffic management system, provide the ability to know when and where traffic queueing occurs and to provide warnings to motorists before they encounter the slow and stopped traffic.

Benefits

- Provides motorists real-time information of upcoming traffic slow-downs so they can safely take appropriate actions.
- Assists motorists in making route choices, which may help maximize overall roadway capacity utilization.
- Raises driver awareness to prepare for congested conditions.

Limitations

- The ITS technologies needed to support queue detection are not generally positioned at nonrecurring congestion locations.

Table 23. Queue Detection Deployment Tactics.

Tactic	Description
Metropolitan Interstates and Freeways	o Use existing ITS technologies (traffic sensors, cameras, and DMS) to detect and provide motorists warnings of recurring and nonrecurring traffic queues.
Construction Projects on Interstates, Freeways, and Expressways	o Install portable ITS technologies (traffic sensors, cameras, and DMS) in advance of and through construction projects to detect and provide motorists warnings of traffic queues.

NON-EMERGENCY LANE CLOSURE SYSTEM

Management Strategy Group
Safety Applications and Traffic Management Strategies

Description
Emergency events (e.g.: traffic crashes, winter weather) occur at unpredictable times and require responses appropriate to the event. In many instances, these events require the closure of traffic lanes and, at times, the entire highway facility. These closures typically result in traffic queueing, delays, and secondary crashes.

Non-emergency lanes closures typically result from construction and maintenance activities, utility work, and/or towing operations. These closures are anticipated and usually can be planned to occur at times when the traffic impacts are negligible.

To determine the times when non-emergency lane closures can safely occur on an interstate, freeway or high-speed expressway highway segment, the DOT needs specific traffic data on each of these highway segments (i.e.: speeds, traffic volumes, classifications, time of day, day of week). This information can be ingested into programming (Non-Emergency Lane Closure System) which determines specific traffic metrics (passenger car equivalent rates) for each hour of the day and reflect weekly, monthly, and seasonal fluctuations.

The development of the Non-Emergency Lane Closure System will require DOT to establish traffic sensor locations on all interstate, freeway, and high-speed expressway segments where real-time traffic information is not presently available. The additional traffic sensor information will supplement the DOT's existing ATR information and be processed by the DOT's lane closure planning tool.

The programming for the Non-Emergency Lane Closure System will need to be developed to incorporate the lane closure planning tool, automatically provide data as to when non-emergency lane closures can safely occur on these highway segments, establish a lane-closure application process for internal and external use, provide for issuance of Non-Emergency Lane Closure permits.

Benefits
- Maintain traffic mobility and safety on Iowa's high-speed, high-volume highway network.

Limitations
- Requires the development of the Non-Emergency Lane Closure System.
- Requires installation of traffic sensors on additional rural interstate, freeway and expressway segments.
- Requires changes to the State of Iowa's Administrative Rules to allow for the establishment and enforcement of the Non-Emergency Lane Closure policy.

Table 24. Non-Emergency Lane Closure System Deployment Tactics.

Tactics	Description
Programming	o Program funding for the installation of 40-50 traffic sensors on rural interstate, freeway, and high-speed expressway highway segments.
Traffic Sensor Installation	o Install side-fire radar traffic sensors at designated highway locations.
Administrative Rule Changes	o Propose changes to the State of Iowa’s Administrative rules to support the Non-Emergency Lane Closure policy.

TRAVEL TIME DISPLAY

Management Strategy Group

Traffic Management Strategies

Description

Travel time display systems are used to convey traffic delay condition information to motorists along commuter corridors. This helps set driver expectations and can help drivers make travel route decisions when congestion is present. Travel time systems consist of:

- *Traffic Data Monitoring* – Either probe data systems or regularly spaced traffic sensors (typically 0.5 to 1 mile) along the corridor.
- *Traveler Information Systems* – DMS, supported by other travel information sources such as DOT-provided mobile applications, the 511ia.org website, or information provided through private services.
- *Communications* – Near real-time information that is conveyed between the traffic data monitoring, the ATMS software, and the DMS signs as well as the other traveler information services in order maintain required accuracy.

The effectiveness of Travel Time Displays depends on distances from the DMS sign to each designated target location. If the distances are too short, and the travel times may not provide enough information to be useful in that short of a time. If the distances are too long, there is too much opportunity for conditions to change before the drivers arrive at the target location. Minimum and maximum distances have been estimated at greater than 12 miles and less than 25 miles, which values were used in the consideration of candidate corridors throughout the state.

Benefits

- Provides real-time travel condition information to motorists.
- Assists motorists in making route choices, which may help maximize overall roadway capacity utilization.
- Raises driver awareness to prepare for congested conditions.

Limitations

- Requires traffic data monitoring, DMS, and ATMS software.

Table 25. Travel Time Display Deployment Tactics.

Tactics	Description
Commuter Corridors	Corridors with high commuter volumes within a metropolitan area greater than 12 miles or between two metropolitan areas with a maximum distance of 25 miles. These include: o I-235 (Des Moines) o I-35/80 (Des Moines) o I-35 from Des Moines to Ames o I-380 from Cedar Rapids to Iowa City o I-80 through Council Bluffs and Omaha (only if the Nebraska Department of Transportation (NDOT) is willing to partner)

CONNECT

Communications systems are the backbone to the ITS devices provided along the roadway. The communications systems are what allow the ITS systems, discussed in this service layer plan, to provide data to motorists and operators.

For the purposes of this plan, a separate section was completed to discuss the strategy and tactics for communications systems, section 5.0 Communications Systems Strategy. Section 5.0 provides detailed information about fiber, cellular, wireless, and leased communications.

DISCONTINUED ITS SYSTEMS AND TECHNOLOGIES

Within any organization, an important component of a successful future is the ability to learn from experience. As Iowa's ITS program has evolved, several specific technologies have been explored and lessons learned. Most of these have been successful, and this plan itself reflects the great benefit these efforts have produced. Some initiatives have outgrown their effectiveness and have been retired or decommissioned. It is anticipated that as the ITS program continues to evolve, more of the current systems and technologies will be discontinued as better and more effective strategies and technologies are implemented. Highlights of these retired initiatives are included below.

Permanent HAR

For many years, Iowa DOT used permanent HAR to broadcast traveler information over AM radio in several metro areas. Some consistent challenges plagued these units and are discussed below:

- Keeping fresh content and the right amount of content broadcasting consistently was challenging, especially during normal travel conditions. Attempts were made to automate messages using data from 511ia, but these attempts often resulted in insufficient detail for some items and too much for others.
- Some technical difficulties were consistently experienced, especially where a metropolitan area required two units (e.g., Des Moines and Quad Cities). For these installations, the two units required near-perfect synchronization so that drivers in range of both would not hear an echo. In Des Moines, this was accomplished by installing a dedicated party line through the local telephone provider that was in constant operation; however, this was not an option in other areas.
- As mobile applications have grown in popularity, fewer and fewer motorists tune in to listen to the messages.

Automated Freeway Gates

Several automated gates were installed along freeway mainline sections (for winter closures) and on arterials in the Quad Cities to prevent drivers from entering I-74 toward the Mississippi River bridge when it was closed or restricted. The devices were connected to the ATMS software, and operators had the ability to raise and lower the gates remotely. Listed below are several lessons that came from the use of these devices:

- Mainline freeway gates
    - Interstate closures require the presence of Iowa DOT and the Iowa State Patrol to be on-site, making the remote functionality unnecessary.

    - The purchased gates were lightweight and did not require a counterweight. For freeway applications, however, they were typically needed during winter storms that included winds strong enough to break them off once they were out of the cradles.
- Quad Cities I-74 Ramp Gates
    - The gates were originally purchased from a small business, which was later sold to another company. Once sold, the knowledge needed for parts and support was lost.
    - Coordination with local law enforcement on how and when to use the gates proved difficult because of their staff turnover and infrequent use, resulting in the gates being underused.
    - The gate lowering mechanism was very slow, allowing vehicles time to drive under the gate while it was lowering. This caused it to pause for several seconds before beginning to lower again, and after three interruptions to stop the lowering process and raise again.

High-Bandwidth Licensed Wireless

Three high-bandwidth licensed wireless links were installed in the Council Bluffs area along I-29, north and south of the metropolitan area. These links operated successfully for several years; however, they were deemed unnecessary for the following reasons:

- While the links provided uninterrupted, high-bandwidth operation (100 megabits per second with capability of up to 300 megabits per second), they were used to backhaul three to five cameras and sensors each, which only required a fraction of the available bandwidth.
- Advancements in unlicensed wireless technology has improved significantly in recent years. Unlicensed links currently can provide service levels similar to that of the licensed links for bandwidth and reliability without the expense or administrative burden required for Federal Communications Commission (FCC) licensing.
- The cost of purchasing and replacing the systems was very high relative to the benefit it provided. With lower cost systems available, the high-bandwidth licensed wireless system was determined unnecessary.

4.3 Dynamic Message Signs

DMS are used to convey messages to drivers already on the roadway, and they are an important element of Iowa's ITS program for many reasons. They are treated separately in this ITS and Communications Service Layer Plan because of the maturity of the DMS system and the unique issues surrounding their use in the state of Iowa. Specifically, DMS are a highly visible component of the transportation system and have a direct impact on the perceptions and opinions of all motorists, including government officials, businesses, and the general public about Iowa DOT. Also, DMS are expensive to install and maintain relative to other ITS devices.

Iowa DOT has been using DMS since 1999. Currently there are 115 permanent, 82 portable, and 50 specialty DMS located around the state. The locations of these DMS have largely been driven by input from each district to address specific issues in each area. DMS distribution is generally denser within metropolitan areas because of increased congestion and the number of accidents.

In 2015, Iowa DOT published the "Iowa DOT Dynamic Message Sign Deployment Plan." This plan tied DMS use back to the Iowa DOT Strategic Plan. Since that time, the OTO published the TSMO Strategic and Program Plans. The guiding principles for DMS use and placement are therefore being revised from the 2015 plan to be consistent with the TSMO plans. Table 26 provides some benefits and limitations of DMS.

Table 26. Benefits and Limitations of DMS.

Uses & Benefits	Limitations
• Messages alert drivers to imminent hazards o Incidents, congestion, debris, adverse weather conditions, and other similar hazardous conditions • Reduces the risk of incidents by raising driver's alertness as they approach the condition areas • Provides information to allow drivers to divert to an alternate route and avoid the hazard • Provides information on special events and general travel conditions o Travel time, construction information, and public service messages • Provides information to drivers in an area without having to rely on secondary communications such as radio or electronic devices • Provides Amber Alert information to motorists	• DMS are only deployable in spot locations • Drivers can only comprehend and read a small amount of information while driving • DMS are expensive to install o Overhead: $250,000 o Side-mounted: $125,000

GENERAL STRATEGY FOR DMS USAGE

DMS have long been recognized as an important and efficient tool for providing immediate location-specific information to motorists. Message requests and new sign locations are frequently received by OTO from Iowa DOT central and district personnel as well as local transportation and law enforcement partners.

The current state of mobile technology along with the anticipated introduction of connected vehicles will have a direct impact on the usefulness of fixed DMS. This is because each of these technologies provides the ability to send notifications directly to drivers in their vehicles. These messages can be customized for each driver based on location and other factors. It is recognized that as this in-vehicle technology becomes more widespread, the need to convey information using fixed DMS to drivers will diminish.

Currently, many drivers still do not use alert-capable mobile devices or applications while driving. In addition, some estimates indicate that it may take up to 20 years before most vehicles on the roadway are equipped with connected vehicle technology. Therefore, because the benefits of DMS are sufficiently great and the needed in-vehicle technology is not adequately widespread among the traveling public, it is recommended to continue Iowa's DMS program for the time being. Consistent with this perspective, the agency intends to maintain the current total number of DMS for now, a strategy the agency calls "holding the fleet steady". It is also recommended that this approach be revisited and updated in three to five years, depending on the state of technology at that time.

Given this direction, the effort of this plan is to establish a set of criteria to rank the relative value of a DMS, then to apply these criteria to:

- Identify any additional locations where a DMS would have an immediate positive impact
- Evaluate the current fleet of DMS to identify any locations where existing DMS provide minimal impact

This process provides a basis for the OTO to optimize the current DMS deployment without increasing the fleet size by relocating a small number of signs from low-impact to high-impact locations.

DMS PLACEMENT CRITERIA

The following criteria have been identified to guide the placement of DMS and to assign a relative value to a DMS in a specific location.

Location Type

DMS can be used to provide different types of information based on location. Strategically placed, DMS may serve multiple categories, which increases its relative value. These categories were assigned to each sign in consultation with TMC and OTO personnel. These include four primary categories:

1) Major interchanges and decision points
2) At the entrance or exit of a metro area, and at state of Iowa entrance points
3) Prior to routinely congested corridors
4) Other key metro locations placed to support frequent special events, incident management routes, or other specific local needs

Traffic Volumes

Volumes are included because there is a direct correlation between the amount of traffic and the number of traffic-related issues that benefit from advanced notification from DMS messages. Average annual daily traffic (AADT) at each sign was used for the analysis.

Crash History

Crash data immediately downstream of each DMS is also included as a separate criterion because of the direct safety benefit of messaging for downstream crashes. For this analysis, the total number of downstream crashes per mile over a three-year period was considered. The approximate number of miles of downstream influence for each sign was estimated at between 2 and 9 miles based on its location (metropolitan area or rural location), the proximity of other downstream DMS, and other geometric characteristics.

Existing DMS Usage History

For existing DMS, the number of messages posted for the year 2016 was included in the analysis as a direct measure of the sign's value.

Iowa DOT Staff Value

One subjective criterion was included in the analysis to account for local experience, knowledge of future growth and construction plans, and other considerations that are not captured in the other numeric criteria. This input was gathered from TMC, OTO, traffic and safety departments, and district personnel.

PRIORITIES FOR DMS OPTIMIZATION

The criteria above were applied to the existing fleet of permanent DMS, excluding specialty signs and DMS located in other states. A total of 51 potential additional locations were included in the analysis to assess their values relative to the existing DMS. Maps showing the locations of all analyzed existing and potential DMS are included in Appendix D along with the full analysis results.

Because of the much greater effectiveness of overhead DMS over side-mounted DMS, no new side-mounted DMS are proposed except on arterials. In addition, full-matrix, color DMS provides a great amount of flexibility in message options and driver clarity for a marginal cost increase. Therefore, it is recommended that any future freeway installations consist of full-matrix, color, overhead-mounted DMS unless there are specific reasons to consider alternatives.

MAINTAINING THE EXISTING DMS FLEET

The strategy of maintaining the existing DMS fleet relatively constant also implies that effort is needed ensure that the existing fleet remains operational and maintainable. Many of the existing signs are nearing or have exceeded their anticipated useful life, and some need to be modified to meet current standards for maintenance safety (specifically, electrical shut-off locations and catwalk configurations). It is recommended that the OTO undertake an effort to develop a detailed inventory and maintenance plan specifically targeted to DMS that will identify required steps to bring signs into compliance with safety standards, and to upgrade, replace, or retrofit signs with aging components to ensure that they provide reliable operations for the next decade.

4.4 Motor Vehicle Enforcement

Like most state agencies in Iowa and other states, the Iowa DOT's MVE staffing and resources have declined over the last 20 years. At the same time, the highway system has expanded to include additional multilane highway corridors, and it provides greater mobility for commercial vehicle traffic. Presently, the MVE maintains 12 permanent scale sites statewide. Ten of these sites are located on the interstate highway system, while the remaining two are located on the primary road system.

In 2013, the DOT commissioned a study of the state of the existing enforcement scales capabilities. This study included recommendations and strategies for the future enforcement motor carrier laws and regulations. The overall recommendations in the scale study were to provide technology to supplement the MVE operation to target their resources strategically to maximize effectiveness.

The recommendations from the 2013 scale study have been reviewed and updated. The following specific recommendations are carried forward to the ITS and Communications Systems Service Layer Plan:

1. Deploy VWS technology at nine designated locations to enhance the existing fixed-scale facility and patrol operations. The VWS will assist in locating overweight commercial vehicles and provide increased effectiveness of enforcement operations.
2. Deploy WIM technology at 12 designated locations to monitor and record the movements and trends of overweight commercial vehicle traffic. This data can be used to strategically target mobile MVE activities to better anticipate overweight traffic movement and more effectively enforce commercial motor vehicle regulations.
3. Upgrade four existing Iowa DOT OSP WIM sites with high-quality piezoelectric sensors to enable higher accuracy measurements of commercial motor vehicle weights. These four sites will supplement the 12 new WIM deployments.
4. Incorporate maintenance of technology (cameras, sensors, dynamic message signs) at existing MVE scale sites into the existing ITS maintenance program. This action will provide for routine preventative maintenance of devices and repair, when necessary, to maintain maximum uptime.
5. Where possible, connect existing scale sites to the DOT's ITS fiber-optic network to provide access to the statewide ITS network and high-speed access to statewide MVE databases.

The implementation of these recommendations will provide for improved effectiveness of the commercial motor vehicle regulations and the improved safety of the interstate and primary road system in Iowa.

5.0 COMMUNICATIONS SYSTEMS STRATEGY

A reliable communications network is the backbone that enables TSMO strategies, linking people, systems, and devices together. Providing a reliable and secure communications system not only is a strategy for transportation operations, but also to help other Iowa DOT functions across the state. This section addresses both the infrastructure and the program levels of establishing and maintaining a communications system, including a detailed cyber security plan.

5.1 Communications Infrastructure

Various methods of both digital and analog communications are used in ITS applications, each with its own benefits and limitations according to the specific application. In addition, there are various communications infrastructure ownership strategies, including Iowa DOT-owned, leased, public-public partnerships, and public-private partnerships. Strategies for the uses of each major type of communications media (i.e. fiber, wireless, copper, leased, etc.) and for each ownership strategy are presented. Lastly, there are several programmatic and other considerations that are also addressed.

COMMUNICATIONS INFRASTRUCTURE STRATEGIES

The communications discussed in this section reference longer range communications, approximately greater than 0.25 miles. There are many applications for short-range communications, many times addressed through copper communications using twisted pair copper wire cables, which include CAT 5, 5e, or 6, or coaxial cables. However, this type of short-range communication is typically addressed at the detailed design level; therefore, these technologies are not included in this discussion.

In this section, the following definitions are used:

- *Backbone* – A communications backbone is a high-bandwidth, primary communications path that typically stretches over long distances and transports data back to a central location.
- *Backhaul* – A backhaul includes all the information being transmitted over the backbone.
- *Bandwidth* – The data flow rate, sometimes referred to as throughput.
- *Distribution* – A distribution is a communications path that connects individual or smaller groups of devices or facilities to the backbone.
- *Resiliency* – The ability of a network to recover quickly from service interruptions. This is typically achieved through a combination of physical and network redundancy along with automatic failover capability (all described below).
- *Redundant Ring* (path redundancy) – It is advantageous to provide communications to devices and facilities in a “ring” structure, giving two separate paths between each device and a central location. In this way, if one path is damaged, communications continue uninterrupted.
- *Network Redundancy* – When path redundancy is not feasible, another option for providing improved resiliency is to establish a redundant network by using two pairs of fibers within the same cable. While this does not provide the same level of protection as a redundant ring, it will have improved resiliency for events such as device failures, lightning strikes, etc.
- *High Availability (failover)* – High availability (failover) capability is provided by the equipment and protocols that perform automatic failure recovery. These may include routing protocols, redundant network equipment, redundant power supplies, or uninterruptable power supply (UPS) devices.

COMMUNICATIONS MEDIUM
FIBER-OPTICS

Description

Fiber-optic communications consist of multiple strands of glass contained in a physical cable that provide a path for transceivers on each end to transmit and receive pulses of light, converting them into a digital signal. Fiber-optics provide reliable, high-bandwidth communications over long distances. This media is well-suited for providing backhaul systems for multiple devices and applications, especially for video transmission, which requires a relatively high amount of bandwidth. Service is generally provided using pairs of fibers (one for sending data, one for receiving data), however where fiber is limited, advanced technologies can be used to send multiple data streams across a single fiber by using additional light frequencies.

Benefits

- High bandwidth.
- High reliability.
- Long distances.
- Data transmitted across fiber is secure while in transit (i.e., it is not feasible to break into a fiber mid-stream and intercept data).
- Little maintenance is required.

Limitations

- Relatively high installation cost.
- Relatively high repair cost.
- Fiber can be susceptible to damage if placed in unprotected areas (e.g., anywhere but underground in interstate rights-of-way [ROW]).

Table 27. Fiber-Optics Communications Deployment Tactics.

Tactics	Description
Highest Priority Corridors	o Because of the importance of interstate corridors, use fiber-optics to connect devices to monitor and manage transportation along all Iowa interstates.
Statewide Backbone	o Use fiber-optics to establish a statewide backbone in a redundant path configuration around the state, where possible, to maximize reliability.
Urban Area Backbone	o When possible use fiber-optics as a backbone in a redundant path configuration for communications throughout each urban area for facility and device connections.
Inter-Facility Connections	o When available use fiber-optics to provide connectivity between staffed Iowa DOT facilities. o Use fiber-optics to provide connectivity between Iowa DOT and transportation partner networks.
Visual Monitoring	o Use fiber-optics along corridors identified for full visual monitoring coverage. o Use fiber-optics where feasible along corridors identified for representative coverage.

COMMUNICATIONS MEDIUM
WIRELESS

Description

Many types of wireless technologies are available to support a variety of applications. They can transmit either analog or digital information to support the specific need. They can be deployed in a point-to-point or point-to-multipoint configuration. Some frequencies require licensing with the FCC, while others may be used under specific restrictions without any FCC licensing.

Wireless technology is most applicable for communications distribution rather than for backhaul systems. The principal reason for this is wireless technology has an inverse relationship between possible bandwidth (throughput) and range, illustrated in Figure 16 below. Notwithstanding this relationship, technologies do exist to help overcome some of these limitations, such as specialized antennas that help extend range, reduce the impacts of occlusion, or reduce the effects of interference. Despite these advancements, wireless communications do not have the bandwidth, reliability, or range sufficient to provide backhaul communications services. With current technology, wireless should not be considered as a permanent solution to take the place of backbone or backhaul fiber.

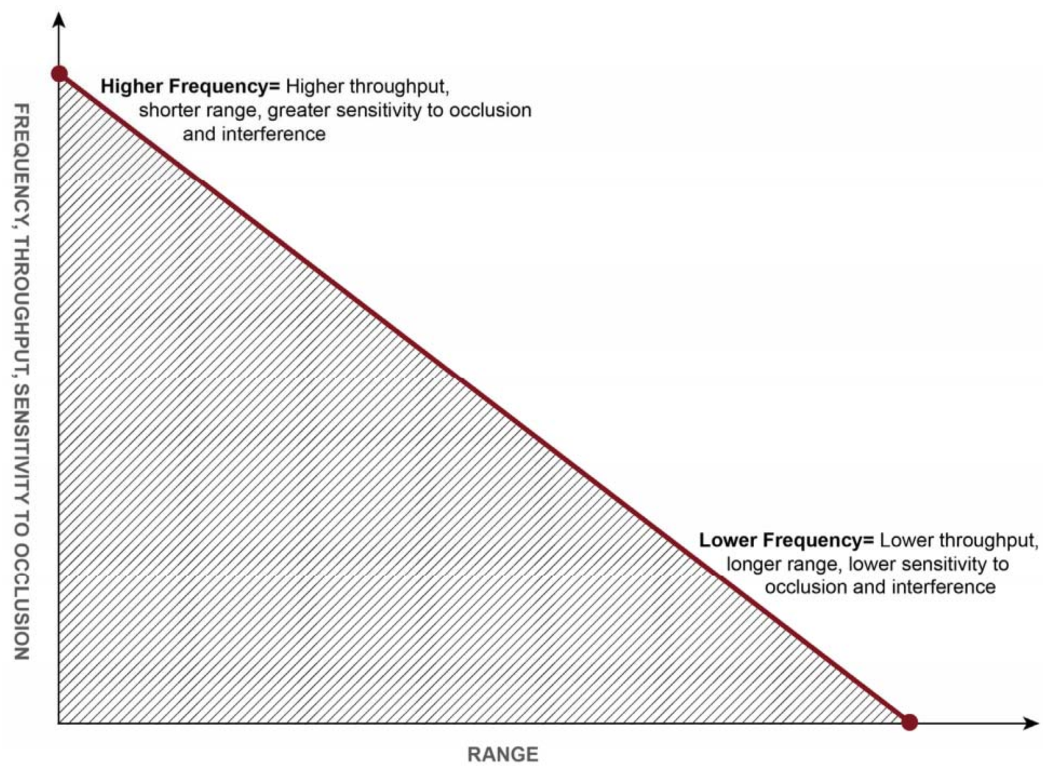


Figure 16. General Wireless Relationship of Range and Throughput.

The use of wireless technologies has been, and should continue to be strategic, based on the specific application. For example, wireless has been used in many "last mile" type applications for ITS devices in metro areas when no other reasons exist to extend fiber. Typically, this means that fiber may be installed only up through the last one or two devices. Wireless is then used to connect these last devices to the fiber backbone.

Benefits

- o Flexible.
- o Relatively inexpensive.
- o Can be operated on low power.

Limitations

- o Higher frequency radios require line-of-sight or near line-of-sight.
- o Lower throughput capability than fiber topics.
- o Regular maintenance is required.

Table 28. Wireless Communications Deployment Tactics.

Tactics	Description
"Last-mile" device connections	o Use wireless to connect the last one or two cameras or any number of low-bandwidth devices on a spur onto backbone fiber.
Minor or difficult-to-reach facility connections	o Connect facilities where fiber is infeasible and a high-bandwidth connection is not required.
Interim connection until fiber is available	o Use high-bandwidth wireless where feasible to establish connections to facilities and devices, with the intention to upgrade to fiber when possible.
Portable devices near fiber access points	o Install temporary wireless access to devices that are within or near locations with permanent backbone communications.
Low-bandwidth analog	o Use low-bandwidth analog wireless in specialized applications such as OHDS or ICWS.

Communications Medium
Cellular

Description

Cellular communications are often used to provide connectivity to devices where there is no access to fiber, most often consisting of devices in rural areas.

The exception to this are DMS, most of which presently have cellular modems. This was a component of the DOT's legacy plan for DMS communications. Presently, steps are being taken to convert to fiber-optic communications for DMS where available.

Cellular connectivity is provided using a modem with a cellular radio that connects to a private telecommunications carrier. The available bandwidth and reliability is contingent on multiple factors:

- The distance and terrain between the device and the tower.
- The technical capability of the tower equipment.
- The tower load (i.e., bandwidth and/or range can be reduced as the number of simultaneous cellular devices being served increases).
- The contracted level of service, which may include data or bandwidth restrictions.

Because of the variability and limitations, cellular technology is typically used for devices that have minimal bandwidth requirements. Where video or other high-bandwidth devices have used this technology, streaming video should be reduced to snapshots, on- demand video streaming, or other techniques that minimize required bandwidth to avoid exceeding the data limit.

Benefits

- Brings communications to areas with no other options.
- Can be operated on low power.
- Inexpensive to install.
- Cellular modems can include GPS capability to aid in locating portable devices.

Limitations

- Inconsistent/low bandwidth.
- Incurs monthly recurring costs.
- Subject to data limits.
- Data is transmitted over the public Internet.
- Large events or emergencies can overwhelm the capacity of a cellular tower, limiting or preventing connectivity.

Table 29. Cellular Communications Deployment Tactics.

Tactics	Description
Portable devices	o Install cellular communications with GPS capability in portable devices where access to high-bandwidth communications is not possible or feasible.
Rural units	o Install cellular communications in permanent devices that do not have access to high-bandwidth communications.
DMS	o Convert DMS communications to fiber-optics where existing fiber is near DMS.

Communications Infrastructure Ownership
Iowa DOT Owned

Description

Iowa DOT has installed its own communications infrastructure in many areas. Although these installations primarily support ITS deployments, they have also included connections to partner facilities for operations coordination. In some cases, they have established connections between Iowa DOT facilities.

Benefits

- Iowa DOT can determine the location, access, and management for all aspects of the communications.
- All bandwidth is available for Iowa DOT use.
- Iowa DOT can make any changes needed at times that are convenient.
- Network traffic only includes that allowed by Iowa DOT.
- Iowa DOT maintains full control of all aspects of the system, including physical and network security.

Limitations

- Iowa DOT-owned infrastructure can be expensive to install.
- Iowa DOT is responsible for all maintenance and management costs of the system.

Table 30. Iowa DOT Owned Communications Infrastructure Deployment Tactics.

Tactics	Description
Own as much of the infrastructure as possible	o Iowa DOT should own its own communications infrastructure wherever possible. o Iowa DOT should work to secure funding for its own infrastructure in areas where leased or public-public partnerships (with local jurisdictions) are currently in effect.

Communications Infrastructure Ownership

Leased

Description

Another option for the Iowa DOT is to contract for communications systems from private providers. Such systems are generally established for facilities, and only rarely for field devices. These systems are subject to the established contract terms for bandwidth, total data usage, contract length, and service level.

Benefits

- The system provider maintains and manages all leased communications infrastructure.
- The system provider generally performs maintenance and repairs very quickly.
- Installation costs (the cost of bringing communications from the provider's closest point of presence to the facility being served) maybe minimal, and often conduit and building entrances can be installed or contracted by Iowa DOT. If installed by the system provider, the costs can be either paid upfront or included in the monthly lease amount over the initial contract period.

Limitations

- Leased communications have recurring costs that can accumulate to significant amounts over time.
- System is subject to the conditions of the lease, which can limit or discourage modification or early termination of service.
- Bandwidth levels are based on cost.

Table 31. Leased Communications Infrastructure Deployment Tactics.

Tactics	Description
Remote facilities	o Iowa DOT should continue to lease communications to remote or inaccessible facilities, or to use as a backup where fiber redundancy does not exist.
Remote devices	o Where possible, remote devices can be connected to nearby facilities with existing leased communications. o Leased systems (not including cellular service) should not be installed to individual remote devices except where there is no other option.

COMMUNICATIONS INFRASTRUCTURE OWNERSHIP
PUBLIC-PUBLIC PARTNERSHIP

Description

It can be advantageous for Iowa DOT to partner with other agencies to share communications infrastructure in an area. This strategy allows all involved agencies to expand their investments by agreeing to exchange communications assets of approximately equal estimated monetary value – most often without requiring any financial transactions.

Benefits

- Providing a partner access to shared communications infrastructure provides access to additional conduit or fiber.
- The cost of installing additional conduit or fiber may be shared between agencies, making installation cost-effective for both agencies.
- Infrastructure sharing can help deepen the partnership between agencies and promote more tightly coordinated transportation operations.
- There is a positive perception of fiscal responsibility through public partnership.

Limitations

- Installation and maintenance costs of Iowa DOT-owned portions of a shared network are typically assumed by the DOT.
- Installation and maintenance of partner infrastructure is typically borne by the partner agency and may not meet the needs of Iowa DOT in terms of cost, quality, or maintenance windows.
- Maintenance and repairs must be coordinated among all sharing partner agencies.
- Each agency must have something of value to contribute.
- Use of existing partner agency-owned conduit frequently has additional challenges and costs, which compromises the ultimate savings to the Iowa DOT.

Table 32. Public-Public Partnership Communications Infrastructure Deployment Tactics.

Tactics	Description
Partner to reach difficult-to-reach areas	o In areas where the possibility of Iowa DOT-owned infrastructure is prohibitive, partnerships with local potential partner agencies should be explored. o Where possible, use the partner-owned connections as backups or redundant paths, with Iowa DOT-owned infrastructure as the primary path.
Partner to strengthen agency relationships	o In areas where it may be advantageous to use the possibility of sharing to strengthen partnering relationships with local agencies, such sharing opportunities should be explored.

Communications Infrastructure Ownership
Iowa Communications Network

Description

ICN is included here as a special case of a Public-Public partnership because Iowa DOT's partnership with ICN has been extensive. ICN is a state agency that provides broadband services to schools, libraries, medical facilities, and many other government agencies. Iowa DOT has partnered with ICN on many projects to extend each other's network by sharing infrastructure.

As a component of this partnership, Iowa DOT automatically reserves 25% of any fiber-optic cable for ICN's use. In return, ICN provides Iowa DOT with access to available fibers in many areas of the state. In addition, ICN provides locate services on shared fiber, general internet connections to some ITS network locations, and virtual Local Area Network connections.

Benefits

- Iowa DOT's partnership with ICN provides communications infrastructure and related services to facilities and devices across the state.

Limitations

- Much of the ICN fiber was installed 15-20 years ago or more. Many cables have a small fiber count with no spare fibers, and the aging fiber strands are limited in their overall bandwidth capacity.
- Some ICN regeneration facilities are located within other public facilities, such as libraries or schools.

Table 33. Iowa Communications Network Communications Infrastructure Deployment Tactics.

Tactics	Description
Continue the strong partnership with ICN	o Continue to dedicate fiber from Iowa DOT owned cables to ICN. o Continue to look for opportunities to use ICN infrastructure and services. o Include ICN in short and long-term fiber network planning.

COMMUNICATIONS INFRASTRUCTURE OWNERSHIP
PUBLIC-PRIVATE PARTNERSHIP

Description

Nationwide, many DOTs and other agencies are expanding their own services by partnering with private companies to extend their services into areas and facilities that are cost-prohibitive to do on their own. The public right-of-way is Iowa DOT's largest asset, and may have leverage this in exchange for conduit, fiber, or other services. Many agencies do this by establishing in-kind agreements, such as reduced prices for right-of-way access, or access to existing agency-owned conduit.

Some agencies install multiple empty conduits, then lease access to conduits to private companies, treating the conduit system as a public-owned utility. This strategy helps agencies manage and minimize the number of individual conduits that are installed in the public ROW and can serve as a revenue source.

Public-private partnerships of any type must be approached carefully to avoid the appearance of favoritism between providers or competition with them. Agencies such as Utah DOT have successfully implemented legislation, standards, and programs that allow these partnerships and give open and fair treatment to all providers. In this way, they have greatly multiplied their investment and can provide connectivity for transportation across the state.

Benefits

- Sharing communications infrastructure with private organizations can provide Iowa DOT access to additional conduit or fiber.
- The agency's value contribution to the partnership may not require any capital expenditure (e.g., as in the case of a reduction or elimination of permitting fees).
- The system provider generally performs maintenance and repairs on its portion of the infrastructure very quickly.

Limitations

- Public-private sharing of communications infrastructure is currently not addressed by existing state law.
- State-owned infrastructure installed on projects funded with federal aid may not allow such sharing agreements with partners operating on a for-profit basis.
- Maintenance system levels of Iowa DOT-owned infrastructure must meet the needs of all partners.
- Maintenance and repairs must be coordinated among all partners.
- Access to the communications infrastructure by private entities on fully controlled access highways facilities is restricted.

Table 34. Public-Private Partnership Communications Infrastructure Deployment Tactics.

Tactics	Description
Enable the increased use of PPP for communications	o Work through the appropriate channels to improve the possibility of using public-private partnerships for communications infrastructure.
Use PPP to expand the ITS network reach	o Seek out additional partnerships to extend the ITS network to additional devices and facilities

COMMUNICATIONS INFRASTRUCTURE CONSIDERATIONS

Communications Infrastructure is Integral to TSMO

Network communications are an integral part of TSMO, enabling the connection of people, systems, and devices for traffic operations. These systems are critical to all the TSMO strategic goals and objectives listed in Table 1. Because of its integral nature, it is recommended that Iowa DOT do the following:

Table 35. Communications Infrastructure Recommendations.

#	Recommendations
1	Continue to place priority and managing reliable communications services throughout the state to ITS devices and Iowa DOT facilities using a combination of all the means outlined previously in this section.
2	Strive toward a goal of owning and managing all backbone and distribution infrastructure to maintain a high of service and provide sufficient bandwidth for current and future communications needs at a minimum cost.
3	Establish a “dig once” standard that requires conduit and junction boxes to be installed on all construction projects where Iowa DOT disturbs the ground or builds a bridge – even if that conduit does not currently connect to anything. Over time this conduit can be connected into a complete statewide network.
4	The Iowa DOT’s Utility Accommodations Policy contains a provision requiring recurring fees for utilities longitudinally occupying interstate and specified freeway ROWs. The DOT needs to modify this provision along with enactment of other legislation to allow for a consistent and productive approach to future utilization of the public-private partnership communications strategy.

Communications Infrastructure Biases

Along with these recommendations, it is also important to understand some of the existing sensitivities and biases toward connectivity. One of these biases includes the opinion that DOT funding should be applied strictly to roads and bridges, arguing that communications infrastructure is not a part of the transportation infrastructure. The Iowa DOT strives to continue to be a good steward of pavement and bridge assets, while providing for the technology and connectivity that are an integral part of modern-day transportation operations. Therefore, DOT-provided communications infrastructure should also be considered part of the transportation system.

A similar bias that has hindered some agencies is the opinion that all communications systems should be provided by the public sector via leased communications, some even going as far as preventing agencies from owning any communications infrastructure through state statute. However, limiting such infrastructure to private providers makes delivering adequate bandwidth to all needed field locations and facilities prohibitively expensive, severely limiting the effectiveness and reach of TSMO.

Statewide Communications Backbone

A statewide, state-owned fiber-optic communications backbone is recommended for providing high-bandwidth communications at a high level of service to each metro area and the central Traffic Operations Center, as well as full visual monitoring coverage along all Iowa interstates. U.S. 20 across the state and U.S. 61 from Dubuque to Davenport are also included in this backbone network to complete three redundant rings.

Establishing redundant rings maximizes the network reliability for all of the services it supports. This is not only important for day-to-day operations, but especially for emergency operations. It also provides the foundation for future V2I communications for connected and autonomous vehicles. These benefits are in support of the Iowa In Motion 2045 State Transportation Plan, and are consistent with the ongoing I-80 Planning Study discussions.

Figure 17 illustrates the proposed statewide communications backbone and the resulting three redundant rings.

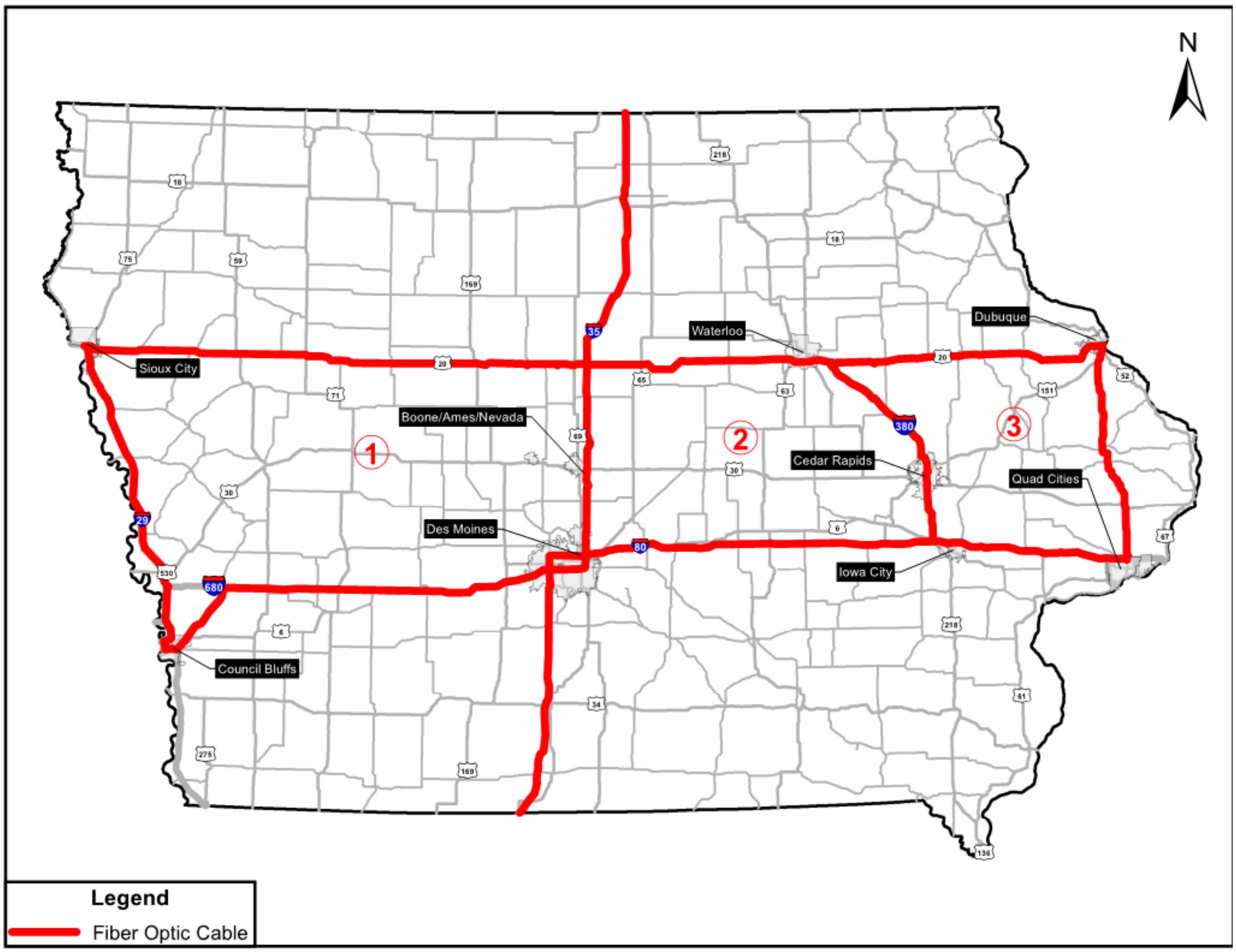


Figure 17. Statewide Redundant Fiber Backbone.

Priority should be placed on developing the redundant rings, after which the additional lengths of I-35 and I-29 should be completed. While this statewide backbone network is the goal, it is a significant undertaking and should be built in stages. Specifically, until the redundant rings are complete, segments of the redundant rings could be connected through leased communications over lower bandwidth connections to serve as a secondary route.

Communications Infrastructure Levels of Service

The type of communications to each type of device should be commensurate with the requirements of that device. For example, streaming video has sufficiently high bandwidth to justify fiber-optic connectivity in most cases. Wireless Ethernet connections could be used in some cases within one or two hops to a fiber access point. Connections to staffed facilities would also be served appropriately with a direct connection to fiber-optic communications, depending on the number and function of the staff members.

Other devices, such as vehicle sensors, RWIS sensors, or DMS, could be connected to fiber if they are in close proximity or are within a few wireless Ethernet hops of fiber access. However, they have sufficiently low bandwidth requirements such that when they are in remote areas, it is often more cost-effective and provides a sufficient level of service to use other means of communications, such as cellular service.

Backup Data Center

Currently the ITS and communications systems operate from a central location adjacent to the TMC. It is recommended that a Disaster Recovery (DR) site also be established and maintained that includes redundant central network equipment as well as backups of servers and database. The OTO has already begun planning for a DR site as part the fiber relocation portion of the I-80/I-380 interchange reconstruction project in Iowa City.

5.2 Communications Equipment and Services

The reliability and functionality requirements for ITS communications are provided in large part by the capability of the networking equipment. The equipment must provide a secure, high-availability environment that supports the TSMO program by providing connectivity among field locations, facilities, and partners across the state. This section provides a general framework based on best practices taken from the cybersecurity industry, includes recommended equipment capabilities, and describes the costs and other implications associated with its implementation. Generally, the network equipment must:

- Support high-availability, reliable, redundant, 24/7/365 operation that meets the needs of current and anticipated services
- Provide data security
- Be scalable to allow for expansion of the system and services, but without excessive capability that unnecessarily increases cost

The ITS network must support multiple types of traffic, based on the facilities and services that are anticipated. All network requirements in this section are written to be able to accommodate these various types of data. These include:

- Device-specific data to and from devices such as DMS, traffic sensors, RWIS sensors, and other ITS systems
- Video streams from cameras
- General business traffic, such as email, access to shared applications, and network storage
- Internet access to and from outside sources

- Voice over IP (VOIP) traffic for DOT offices
- Public Internet (currently serving rest areas)
- Connected vehicle data (future)

FRAMEWORK FOR NETWORK COMMUNICATIONS

To present the strategic plan in an organized manner, it is useful to first frame the network elements in terms of three distinct layers. This hierarchical framework is commonly referenced within the communications industry, and is defined as follows.

Access Layer – Connects all end devices such as servers, workstations, field devices, and "commodity" switching equipment such as field switches or wireless network links.
Distribution Layer – Is often referred to as the *smart* layer, and typically provides the routing, filtering, and quality of service policies. It can also be referred to as the *workgroup* layer, managing a region or groups of devices connected at the access level.
Core Layer – Provides high-speed, highly redundant connectivity between distribution layer services and network regions.

The current configuration of Iowa DOT's ITS network is a consolidated Core-Distribution layer (two-tier network). Many organizations are moving toward a two-tier network because the capability of the equipment has improved such that many of the routing and switching functions are being consolidated into a single piece of equipment. This both simplifies the configuration and reduces the total cost. For this reason, it is recommended that Iowa DOT continue to use a two-tier network.

This network framework is further divided into five modules, shown in Figure 18. This modularity provides the flexibility management, scalability, and resiliency to meet current and future network demands. Each module is defined by its specific functions within the overall network and has specific technical requirements described in the following paragraphs.

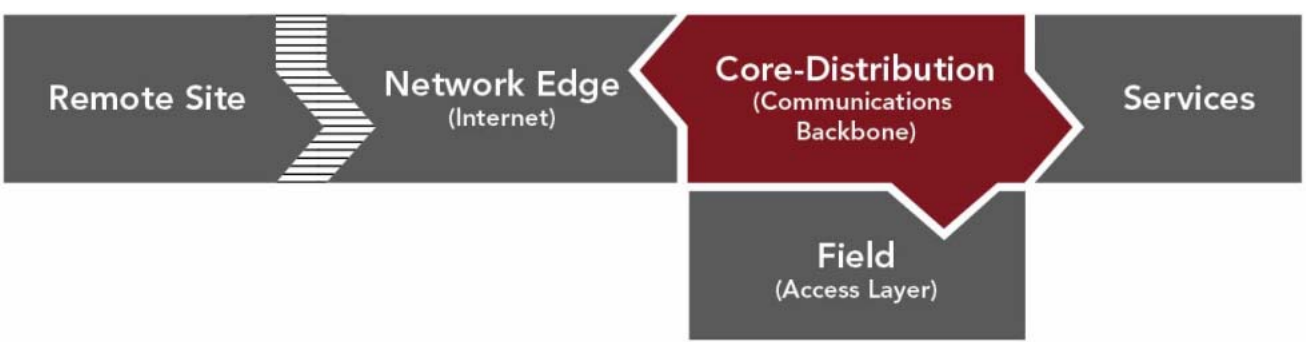


Figure 18. Modular Framework for the Communications Network.

Core-Distribution Module (Communications Backbone)
This module contains the most critical components in maintaining the high network speeds and availability that are critical to the communications backbone. For this reason, an appropriate level of redundancy must exist in this module to maintain the highest level of availability between all the other network regions.

The physical placement of this equipment should be carefully considered to maintain high-speed access to the overall network, such as aggregation points for network edge and field access switches and areas hosting server resources that are accessed across the network.

To meet the high-availability requirements, backbone equipment should be “enterprise grade,” meaning that it supports all needed protocols for backbone operations, physical redundancy for power and processing, and “hot-swappable” components for field maintenance and expansion without interruptions in service. The equipment should also include network traffic engineering functionality, such as multiprotocol label switching or virtual extensible local area network to allow network traffic to be prioritized appropriately. It should support scalability of 10 gigabits per second links in order to support needed network bandwidth, including consideration for links to backup locations where server and data replication will be required. Additional detail for recommended equipment functionality is included in Appendix E

Field Module (Access Layer)
This module serves as the entry point to the network. Devices in this layer connect directly to the field switches in a region (e.g., the central switch in a metro area).

Depending on the risk levels that are acceptable for an extended outage, these areas may also follow high-availability best practices for servicing critical endpoint devices. Considerations include uplinks to additional switches, voice, video, workstations, field sensors, or other ITS components. Strong access controls should be used at this level to maintain the security and integrity of the overall network.

General requirements for network equipment at this level include scalability, redundancy, and compliance with security policies. Additional detailed requirements are included in Appendix E.

Services Module
This component connects data center devices (servers, data storage, etc.) to the core-distribution layer. This layer provides the high-speed access required for data storage and applications. Design requirements in this area vary and are based on factors specific to the application demands, the volume of connections, or number of hosts that it serves. The communications backbone must be able to support and sustain the bandwidth and the availability requirements to access these resources.

Network management components that provide centralized administration and logging resources for the network infrastructure components also reside within this module.

Network Edge Module (Internet)
This component services and aggregates all the external mediums that provide connectivity back to the core network. This includes connectivity to Internet, demilitarized zone (DMZ) hosted services, as well as serving the termination point for virtual private network (VPN) tunnel connections and remote access users.

All network traffic within this module should be required to pass through security controls set and applied by firewall, and all traffic flows should be inspected by intrusion prevention systems. Detailed requirements for this equipment are provided in Appendix E.

Remote Site Module

Remote sites are geographically separated locations that are not directly connected to the access layer or core-distribution layer by means of a dedicated physical connection. Remote sites are reachable by a wide area network service or VPN tunnel through an untrusted connection. An untrusted connection is defined as a network not owned or under the control of Iowa DOT, and could include private or partner managed networks.

Remote locations may have similar high-availability requirements as other components of the communications infrastructure, depending on the risk level and criticality of the remote location. See Remote Site Device Requirements in Appendix E.

NETWORK MANAGEMENT TEAM

The ITS communications system is a complex network with diverse components and interfaces to many other communications systems. Because of this complexity, it is recommended that a Network Management Team (NMT) be formed to oversee and coordinate network operations, maintain network security, and to serve as a Change Control Board (CCB) to review and approve system designs and changes. The team should be comprised at a minimum of three representatives from the OTO (ITS network maintenance, office management, and ATMS contract management), Iowa DOT IT, the ITS network maintenance vendor, and the ATMS vendor.

5.3 Network Security

To meet the Iowa DOT's evolving operational needs, the ITS network will continue to grow in both its reach and in the types of services it provides. At the same time, the number and severity of threats to the security of the information it carries also continues to increase and evolve. Maintaining the confidentiality, integrity, and security of the information entrusted to Iowa DOT by the traveling public is of the highest importance.

Network security is a continuous cycle in which the organizational needs and requirements are evaluated against risk, the network is modified and improved to protect against that risk, and this cycle is repeated. This provides a framework and recommendations for the development of an Iowa DOT ITS network security program.

Network security starts with network design. Specifically, designs should be modular with respect to network roles. This modularity helps to define the security relationship between areas. Part of the design should also include the centralization and automation of the network management functions. Management of the network design should be a function of the NMT.

RESOURCES AND STANDARDS

The guidelines and recommendations are based primarily on industry best practices and standards, supplemented by practical experience and knowledge of the existing ITS network. A primary resource for best practices and benchmark data is available through the Center for Internet Security, which is a global community widely used as a reference by industry professionals (http://www.cisecurity.org) that provides a vendor-neutral guide for implementing the necessary controls in network environments.

Additional resources are available through the documentation and expertise within the following organizations:

- National Institute of Standards and Technology (NIST)
- International Organization for Standardization (ISO)
- Internet Engineering Task Force (IETF)
- Federal Information Processing Standards (FIPS)
- PCI Security Standards Council (PCI DSS)

If the network in the future is used to transport other types of data (e.g., health, financial, criminal justice, or personally identifiable information) for the state of Iowa or other entity, additional standards will apply and the network should be adapted to comply.

NETWORK SECURITY POLICY

Network security should be a component of any organization's larger security policy, and it should be a core component of Iowa DOT's TSMO program. Security is a distributed responsibility in which every individual has a responsibility. A network security policy should be developed for the ITS network with the following characteristics and sections:

- Is strategically aligned with the network's goal and design
- Leverages industry and security best practices
- Outlines high-level processes and procedures, guidelines, and standards
- Identifies roles and responsibilities for all groups and individuals managing and using the network
- Includes or refers to any acceptable-use agreements, nondisclosure agreements, or confidentiality agreements
- Includes an incident response plan to respond to incidents, vulnerabilities, and exploits (the NIST Special Publication 600-61 provides additional guidance on incident response)

A common methodology in the development or adherence to any network security policy should be centered around three primary security principles, commonly known as the CIA Triad (confidentiality, integrity, availability). These principles are described below and are illustrated in Figure 19.

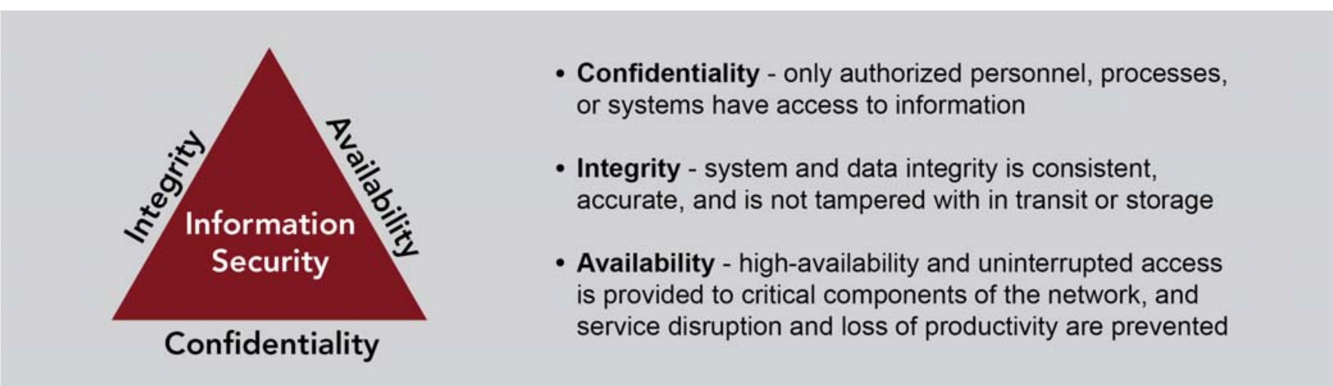


Figure 19. The CIA Triad for Information Security.

NETWORK SECURITY PLAN

A network security plan should also be developed to guide the implementation of the security policy. There are many examples of security plans and frameworks that can be used, such as those provided in Cisco's Security Architecture for Enterprise (SAFE) blueprints. As a first step in the plan development, several of these examples should be evaluated and an appropriate one selected for the Iowa DOT ITS network. At minimum, the network security plan should include the following components. A brief description is provided in the following sections, and additional detail is included in Appendix F.

- Asset Management
- Risk Management
- Operations and Maintenance

Asset Management

Network asset management is the process of documenting, deploying, operating, maintaining, and renewing all network devices and their configurations in a cost-effective manner. Network asset management is important for general management of the network, and it plays an important role in network security. At a minimum, the network asset management plan should address the following security-related items:

1. Network device inventory management and system documentation
2. Network performance baselines
3. Asset classification
4. Change management

Risk Management

Risk management consists of two parts: risk assessment and risk analysis. Both are a regulatory component of many compliance requirements, and a periodic security assessment typically includes both. Risk assessment helps identify specific vulnerabilities within the network. Risk analysis evaluates the threat level and exposure to the organization. Actions can then be taken to either eliminate the risk or provide further safeguards to protect against threats and ensure confidence in the network.

Many organizations form a risk management team that consists of key management staff, operations personnel, and subject matter experts to review risks on a regular basis. In addition, NIST has provided specific guidance on risk management in three special reports: (NIST Special Publication 800-30rev1, 2012), (NIST Special Publication 800-53rev5, 2017), and (NIST Special Publication 800-61rev2, 2012). It is recommended that the development, implementation, and oversight of a risk management plan be included as a function of the NMT.

Operations and Maintenance

The operations and maintenance aspect of the plan should identify all standard processes and procedures for day-to-day system operation and management, and it should include the following items:

1. Access controls
2. Software, firmware, and patch management
3. Log management
4. Configuration management
5. Backups
6. Network monitoring
7. Physical security
8. Reporting
9. Security awareness training
10. Testing and acceptance procedures
11. Hardware replacement plan

6.0 GAP ANALYSIS

This section applies the strategies and tactics defined in sections 4.0 ITS Strategies and Tactics and 5.0 Communications Systems Strategy to determine the difference (gap) between the ultimate desired condition and the existing system as described in section 3.0 Existing Conditions and Systems. The analysis is provided in two parts to capture both infrastructure and programmatic-related gaps.

6.1 Infrastructure Gaps

Gaps in the ITS infrastructure are presented in the following sections, following the same organization of Monitor, Manage, and Connect. The recommendations here provide high-level guidance on the ultimate build-out conditions without defining specific projects. However, the level of detail is dependent on the specific strategy being discussed. Summary maps are provided in this report as a visual representation of each system's existing and proposed locations. Detailed maps are provided in Appendix G. Related costs for each strategy or technology are included in section 9.0 Service Layer Cost Estimate.

It should be noted that the numbers of devices presented in this section are estimates only. If Iowa DOT determines that there is a specific need for an ITS device or system not included in this service layer plan, those determined needs take priority. In addition, Iowa DOT should continue to work with partner organizations to share infrastructure, systems, and information to help fill the identified gaps.

MONITOR

Visual Monitoring

The installation of additional cameras throughout the state will continue to provide a significant benefit to operations. For the purposes of cost estimation, each roadway category (Interstate, Primary Municipal Network, Primary Rural Network, and Border Bridge) was determined to either need full or key location coverage. Roadways with full coverage were assumed to need an average of one camera every 1.5 miles, and key location coverage was assumed to need an average of one camera per five miles of roadway. The ICE-OPS analysis generally indicated that full coverage was needed along the Interstate highways and primary municipal network and key location coverage was needed along the primary rural network. The recommended total number of devices in Table 36 are averages for estimation only, and the actual number to be installed should be a design decision based on actual field conditions. Visual monitoring gaps are illustrated in Figure 20. The full list of estimated densities by interstate or primary road segment is included in Appendix H. This does not include existing or desired cameras for specialty applications, such as security locations other than border bridges (e.g., rest areas or other trouble-spot locations).

Table 36. Visual Monitoring Gap Analysis.

Roadway Facility Priority	Camera Coverage	Existing # of Devices	Estimated Ultimate # of Devices	Difference
Interstate Highways	Full Coverage	239	549	310
Primary Municipal Network	ICE-OPS Priority Coverage	56	88	32
Primary Rural Network	ICE-OPS Priority Coverage	28	280	252
Border Bridges	Two Cameras / Bridge	10	54	44
Total		**333**	**971**	**638**

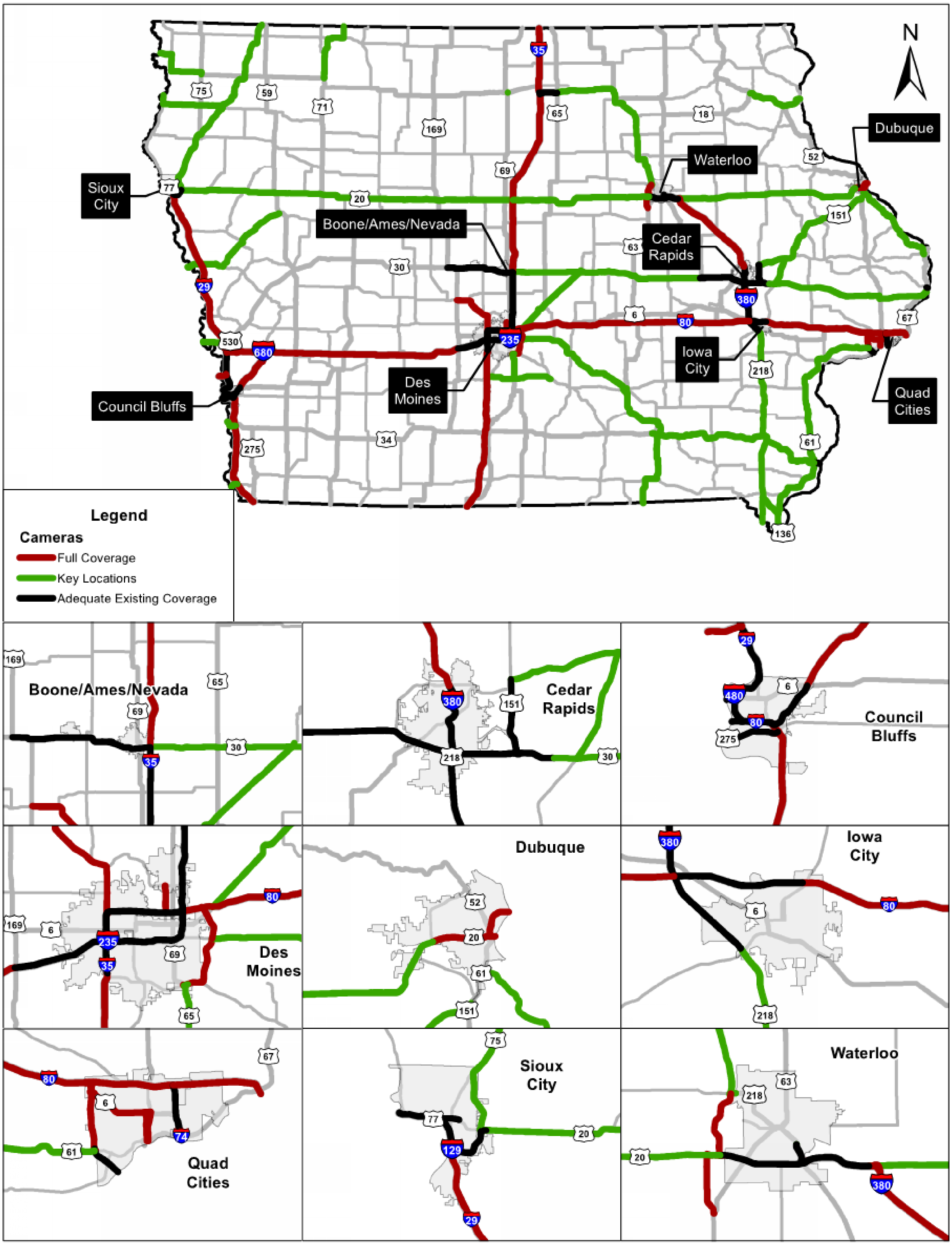


Figure 20. Visual Monitoring Gaps.

Traffic Data Monitoring

For general traffic monitoring, probe and crowd-sourced data coverage includes the full primary road network and is available wherever enough probe vehicles are on those segments. Iowa DOT should periodically review these connections to take full advantage of this data, especially as the quantity, type, and quality of data evolves from sources such as Google, Waze, and others.

Traffic data monitoring using roadside traffic sensors will continue to be useful for specific applications that require low latency, high accuracy, and detailed data, but it is not recommended for general traffic monitoring. Some of the applications that require this type of data will be included in the ATDM Service Layer Plan. Within this service layer plan, the OTO has worked closely with the OSP on the non-emergency lane closure system application, and has determined the locations of 45 additional needed roadside traffic sensors. The locations for these sensors are shown in Figure 21.

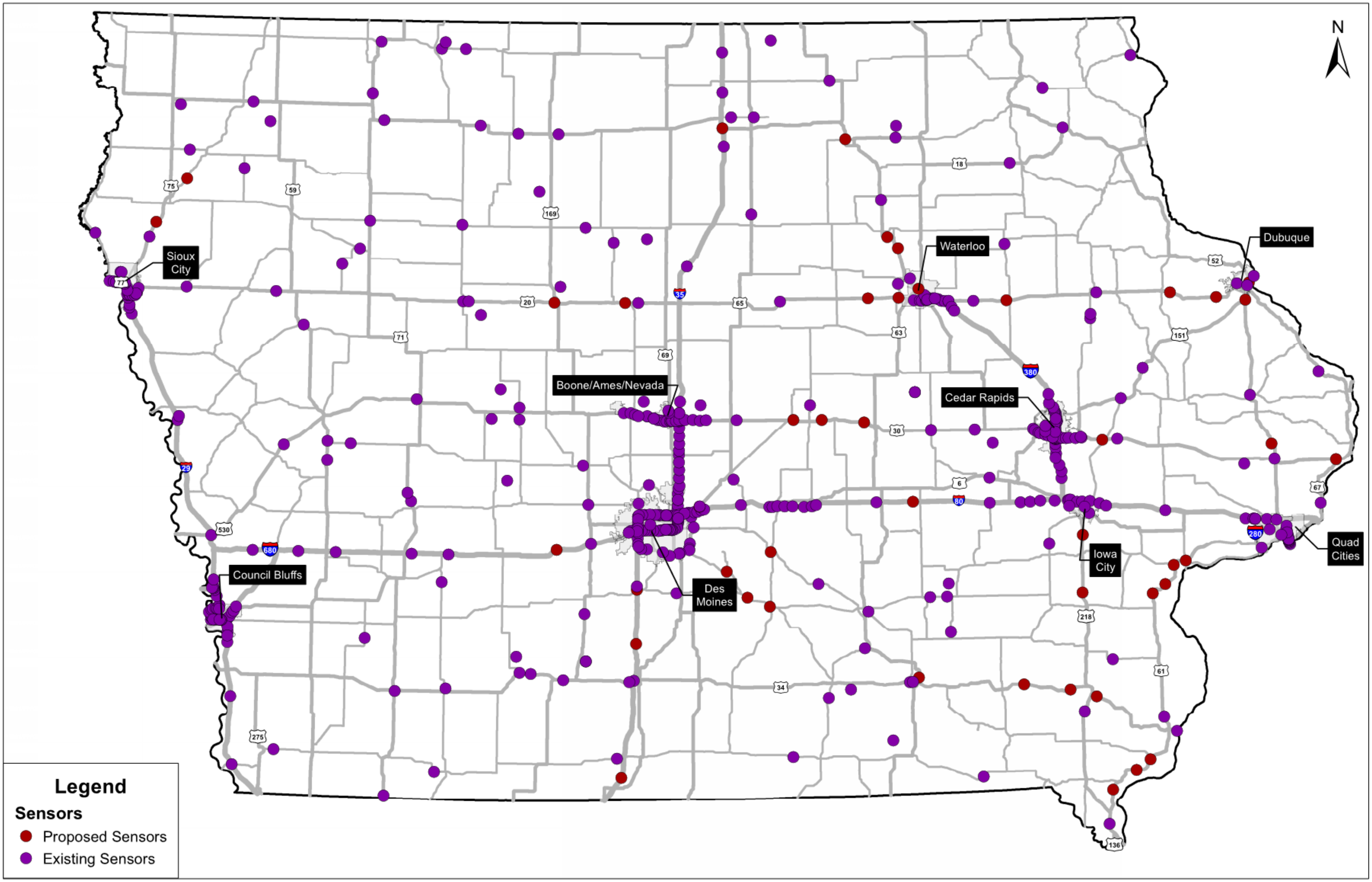


Figure 21. Traffic Data Monitoring Gaps.

Weather Monitoring

RWIS sensors are needed for two specific types of applications, including representative monitoring and trouble spots. Based on the criteria identified in the Weather Monitoring subsection of section 4.2 ITS Infrastructure, the following gaps and recommendations are identified:

Mobile RWIS Pilot

It is recommended that Iowa DOT continue to pilot and evaluate the possibility of gathering mobile RWIS data from fleet vehicles. If successful, these units will supplement – and may replace the need for – some permanent RWIS stations.

Trouble-Spot RWIS

RWIS devices targeted to monitor trouble spots were not identified in this plan; however, it is recommended that the OTO work with the Office of Maintenance to identify such locations and install RWIS to improve operations. It is estimated that this will consist of one additional site per year, shown in Table 37.

Representative RWIS

This plan recommends the installation of 10 additional RWIS to further complete the representative network. These sites are listed in Table 37, and their locations are shown in Figure 22. The priority for each of these should be determined in consultation with the Office of Maintenance. In addition, it is recommended that Iowa DOT work with neighboring states to integrate and share RWIS data to supplement data along Iowa's borders.

Table 37. Weather Monitoring Gap Analysis.

Number	Route	County	Location	Radius (miles)
1	IA 2	Page	Shenandoah	15
2	IA 3	Cherokee	Meriden	15
3	IA 4	Pocahontas	Havelock	15
4	IA 13	Clayton	Elkader	15
5	IA 14	Lucas	Chariton	15
6	IA 17	Wright	Renwick	15
7	IA 37	Monona	Soldier	15
8	US 34	Mills	Hastings	15
9	US 71	Audubon	Audubon	15
10	US 218	Mitchell	Osage	15
10 Trouble-spot RWIS Locations				5

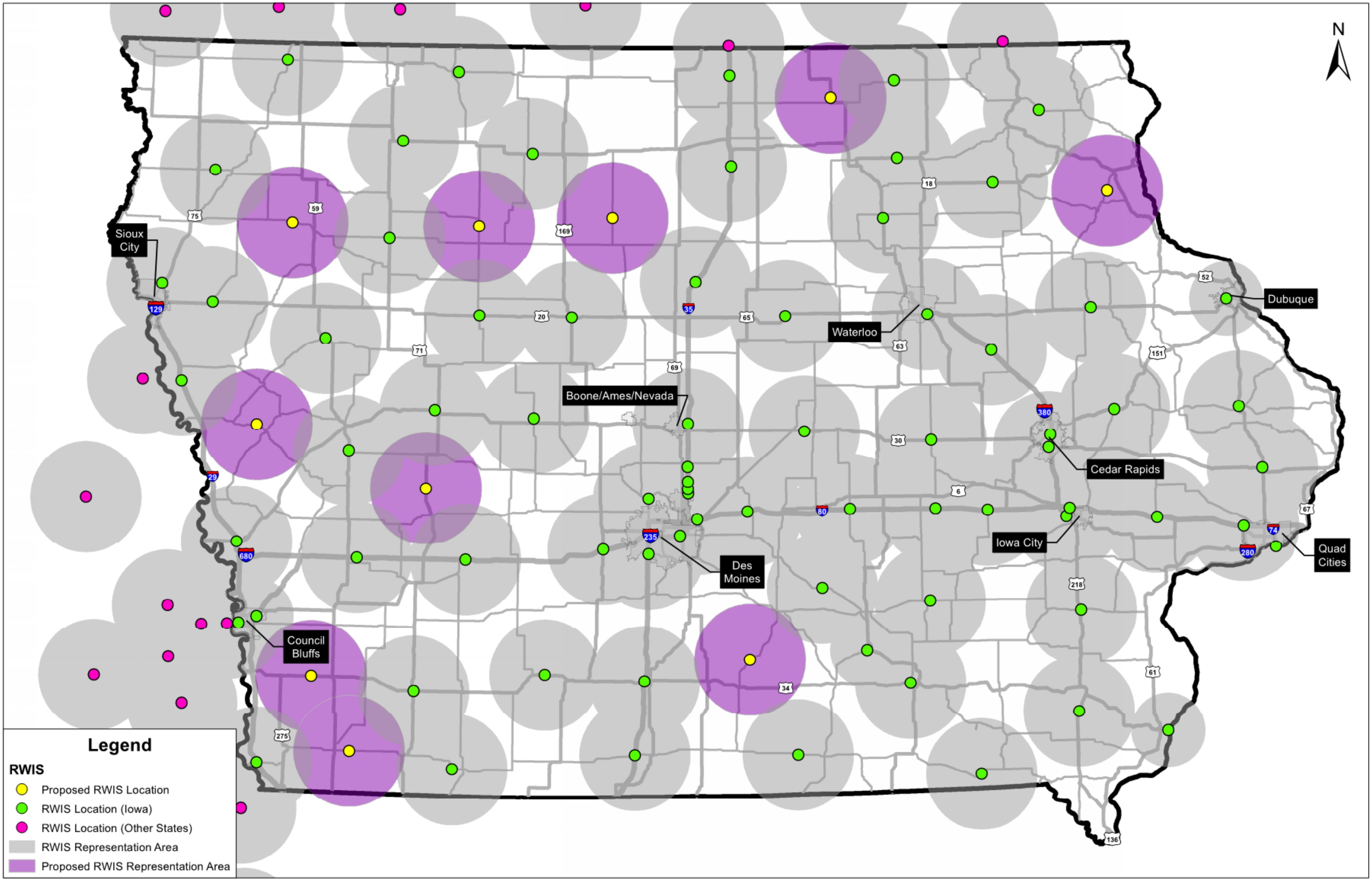


Figure 22. Weather Monitoring Gaps.

Security Monitoring

Security applications consist of two components, including border bridge security and other miscellaneous security applications. Because border bridge security consists primarily of visual monitoring with CCTV, it was included in the discussion of visual monitoring earlier in this section. For other miscellaneous security applications, it is recommended that Iowa DOT continue working with other divisions to identify the types and areas where the OTO may need to provide or supplement existing security efforts.

WIM

Currently, the MVE does not operate any WIM on open highways and freeways in Iowa (all existing open-road WIM are operated by the OSP). The following locations have been identified by MVE as needed locations. This includes upgrading four of the existing OSP sites to meet MVE needs and installing 12 additional sites throughout the state, listed in Table 38 and shown in Figure 23.

Table 38. WIM Gap Analysis.

Number	Route	County	New or Upgrade
1	I-29	Woodbury	New
2	I-29/I-680	Pottawattamie	New
3	I-35	Worth	New
4	I-80	Pottawattamie	New
5	I-80	Adair	New
6	US 20	Sac	New
7	US 20	Dubuque	Upgrade
8	US 20	Woodbury	Upgrade
9	US 30	Benton	New
10	US 30	Harrison	New
11	US 52	Clayton	Upgrade
12	US 61	Lee	New
13	US 61	Muscatine	New
14	IA 60	Osceola	Upgrade
15	IA 141	Dallas	New
16	IA 330	Marshall	New

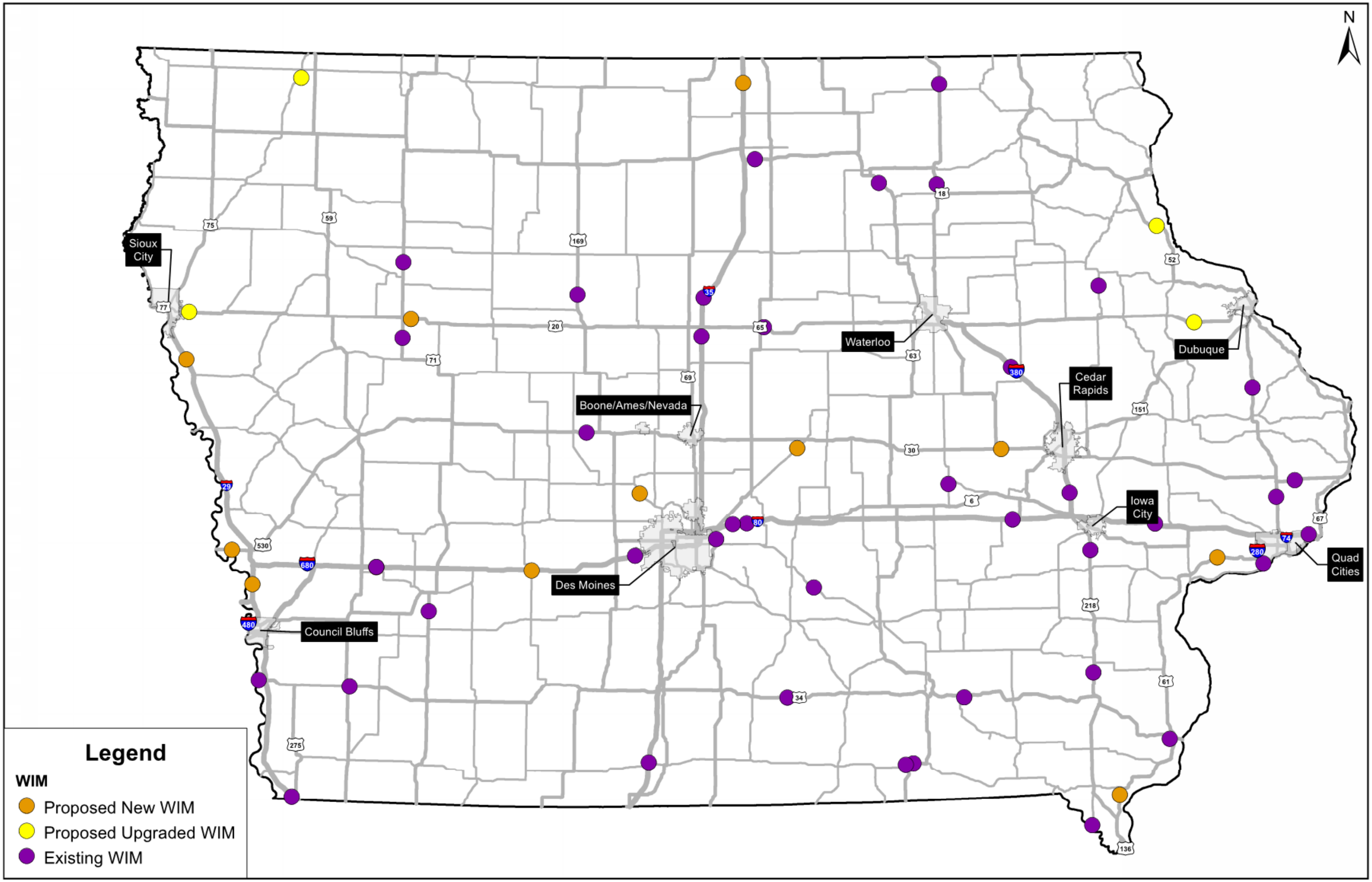


Figure 23. Weigh-In-Motion Gaps.

DMS

Based on the analysis in section 4.3 Dynamic Message Signs, the actions listed in Table 39 are considered high priority and are included here as system gaps. All new or replaced DMS should be color overhead unless stated otherwise. In addition, there are some DMS locations where construction has required DMS removal, and the sign is scheduled to be replaced. Some of these DMS are not being recommended for replacement, and the existing projects and plans should be modified accordingly. This list provides a guide, and the final decisions should be with the approval of OTO and district staff.

Table 39. DMS Gap Analysis.

Potential Project	DMS ID	Existing DMS Type[1]	Route	Direction[2]	Location	Area	Project Notes
1	Prop 19	-	I-35/80	EB	US 6	Des Moines	Install
2	Prop 18	-	I-35/80	EB	NW 2nd Ave	Des Moines	Remove DMS 217 and install Prop 18
	217	SM	I-35/80	EB	E 14th EB	Des Moines	
3	Prop 1	-	I-35	NB	245th St	Ames	Remove DMS 30 and do not reinstall DMS 124, install Prop 1
	30	OH	I-35	NB	Ames	Ames	
	124	OH	I-35	NB	Ames Merge	Ames	
4	Prop 64	-	I-380	SB	120th St	Cedar Rapids	Remove DMS 9 and reinstall in Prop 64 location
	9	OH	US 30	WB	Ramp	Cedar Rapids	
5	212	SM	I-35/80	SB	Douglas	Des Moines	Upgrade SM to OH
6	655	SM	I-35/80	WB	Beaver	Des Moines	Upgrade SM to OH
7	305	SM	US 75	NB	Leeds NB	Sioux City	Remove
8	408	SM	US 61	NB	Eldridge	Quad Cities	Remove
9	304	SM	US 75	SB	Leeds SB	Sioux City	Remove
10	659	SM	I-80	EB	Desoto	Statewide (Rural)	Remove
11	Prop 59	-	I-35/80	WB	86th St	Des Moines	Install
12	Prop 20	-	I-35/80	EB	172nd Street	Des Moines	Install
13	Prop 21	-	US 65	NB	8th Street	Des Moines	Install
14	Prop 9	-	I-29	NB	9th Ave	Council Bluffs	Install
-	112	OH	I-35	SB	Grand Avenue	Des Moines	Removed and may not be reinstalled
-	213	SM	I-35/80	EB	100th Street	Des Moines	Removed and may not be reinstalled
-	657	SM	I-80	WB	US 65	Des Moines	Removed and may not be reinstalled
Removals							**7**
Cancelled Re-installations							**4**
New Installations							**8**
Upgrades from Side-mount to Overhead							**2**
Net Difference in Total DMS							**-3**

*Note: DMS in red have already been removed and may or will not be reinstalled.

Legend: [1]OH = Overhead; SM = Side-mounted; [2]NB = Northbound; EB = Eastbound; SB = Southbound; WB = Westbound; Prop = Proposed

ICWS

It is recommended that OTO work with the Office of Traffic and Safety to identify specific problem intersections where ICWS could provide benefit. It is estimated that one site will be constructed every two years.

TPIMS

It is recommended that Iowa DOT continue to monitor the progress and effectiveness of the TPIMS currently being deployed. Once there is a better understanding of the operations and safety of this system, OTO will be able to decide on the addition of future sites.

WWDS

This study recommends following steps outlined in the discussion of WWDS in section 4.2 ITS Infrastructure to evaluate the effectiveness of both traditional and technology-based wrong-way driver treatments. Then technology-based solutions can be applied in locations where they are determined to be most appropriate.

Queue Detection

It is recommended that Iowa DOT use permanent queue detection technology in areas of recurring congestion and on temporary applications in support of IWZ installations.

Non-Emergency Lane Closure System

It is recommended that Iowa DOT take the steps needed to implement a non-emergency lane closure system. This involves software development, the implementation of additional vehicle detection sensors (reflected in the Traffic Data Monitoring portion of this Gap Analysis Section), and effort to modify the needed administrative rules.

Travel Time Display

It is recommended that Iowa DOT deploy travel times on DMS on the corridors recommended in the discussion of Travel Time Display in section 4.2 ITS Infrastructure where they are not already being displayed. Based on previous analysis by Iowa DOT, probe data provides sufficient accuracy to be used for the calculation of travel times. Therefore, no additional traffic sensors are anticipated. The gap analysis for these corridors is shown in Table 40.

Table 40. Travel Time Display Gaps.

Corridor	Currently Displaying Travel Times	DMS Presence
I-235 (Des Moines)	Yes	Yes
I-35/80 (Des Moines)	Yes	Yes
I-80 from Des Moines to Ames	No	Yes
I-380 from Cedar Rapids to Iowa City	No	Yes
I-80 through Council Bluffs and Omaha (only with participation with NDOT)	No	Yes, after I-29/I-80 reconstruction is complete

VWS

The MVE is currently constructing one VWS and has identified eight additional locations where VWS would provide significant benefits to MVE operations. These locations are listed in Table 41 and are shown in Figure 24.

Table 41. VWS Gap Analysis.

Number	Route	County
1*	I-35	Polk
2	I-80	Cedar
3	US 18	Clayton
4	US 20	Buchanan
5	US 30	Linn
6	US 61	Scott
7	US 63 / IA 163	Mahaska
8	US 75 / IA 60	Plymouth
9	US 151	Linn

*Currently in Progress

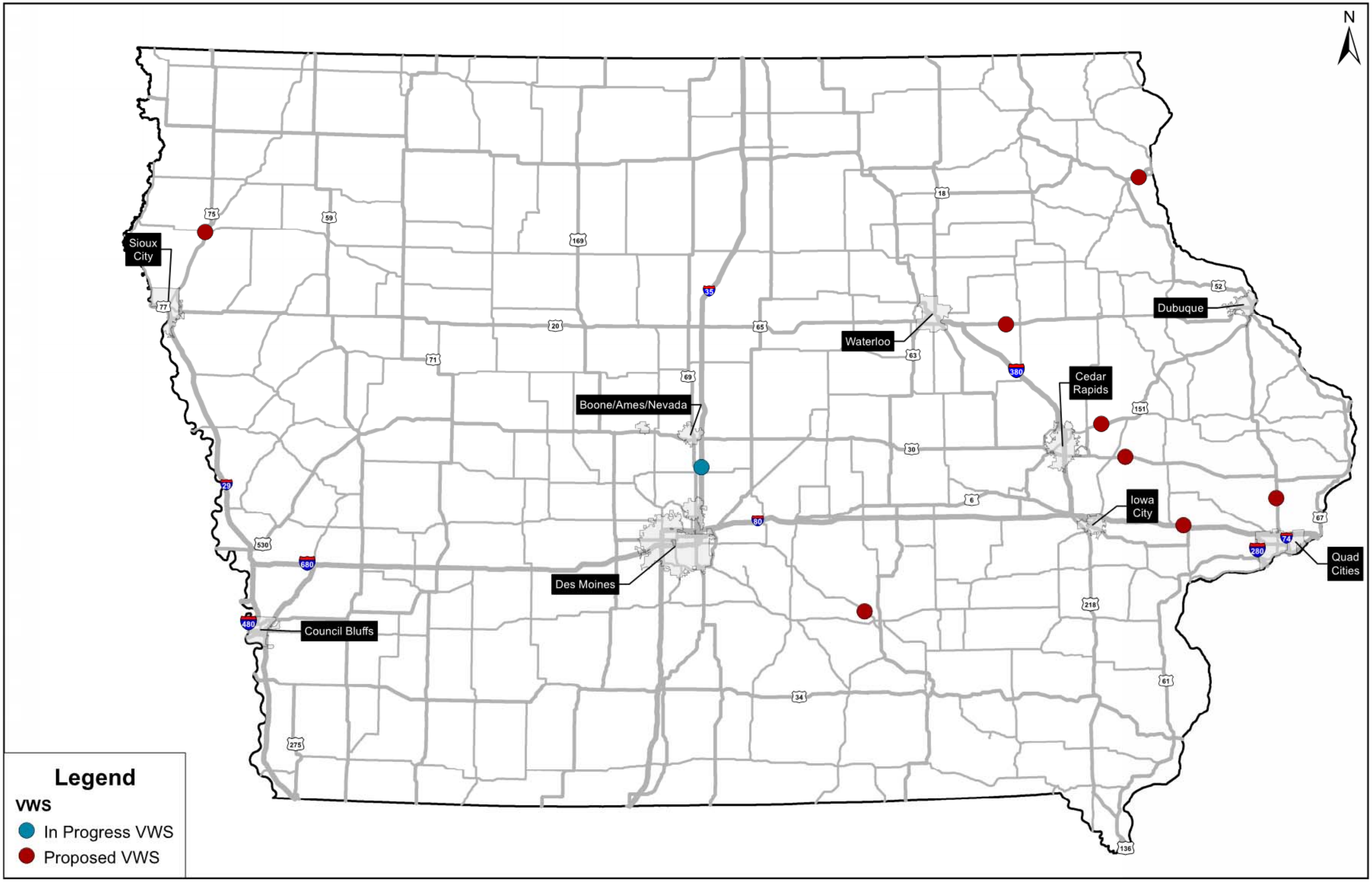


Figure 24. Virtual Weigh Station Gaps.

Network Equipment and Security

Iowa DOT is currently in the process of upgrading its existing network equipment to meet enterprise class standards for functionality, reliability, and security. Table 42 shows the status of the upgrade of the network and security infrastructure. Note that these updates have a life cycle of approximately seven years and should be included as part of continuous network management. For future updates, as the number of remote sites or nodes increases, the network and its maintenance and life cycle costs should also be adjusted.

Table 42. Network and Security Equipment Gaps.

Layer	Current Activity	Status / Schedule	Remaining Tasks
Core-Distribution	Replacing end-of life hardware for high-availability and enterprise functionality.	Procurement / Task complete January 2018	Replace Fiber-Optic Transceivers
Network Edge	Replacing firewall for graded scalability and security. Implement threat management tools.	Implementation / Task complete November 2017	None
Field (Access Layer)	Replacing end-of-life hardware for high-availability and enterprise functionality.	Design and Discovery / Estimated task complete March 2018	Procurement and Implementation
Services Layer (Data Center)	Holding until requirements for new ATMS and advanced traveler information systems are known	Hold / Estimated task complete by end of 2018	Discovery, Design, Procurement, and Implementation

In addition, two upgrade tasks should be considered in the relatively near future. The first is to introduce Internet Protocol Version 6 (IPv6) capability into the field network. While many devices have already moved to this addressing standard, some legacy devices still only support version 4.

Network Infrastructure

The recommended build-out of Iowa DOT's network is driven by the requirements for reliability, redundancy, and bandwidth. In addition, the bandwidth requirements are based on connectivity to Iowa DOT-staffed facilities, streaming video from cameras, and data center communications between primary server locations and a disaster recovery site (currently Ames and Ankeny, respectively).

From these requirements, a proposed ultimate build-out of the Iowa DOT ITS network was developed. This included establishing three redundant statewide rings and installing fiber along any corridor identified for installation of cameras (see Visual Monitoring within this section).

The resulting gaps are shown in Table 43 and in Figure 25. There are two important notes to consider in this analysis:

- Fiber along any of the proposed paths should consist of Iowa DOT-owned and installed infrastructure, and infrastructure should be shared with Iowa DOT from its partners through IRU agreements because the cost difference between these two options is significant ($100,000/mile and $5,000/mile, respectively). Figure 26 shows where existing partner fiber is located along with Iowa DOT fiber and the gaps that result from the proposed fiber installation.

- On non-interstate segments, it is not necessary for the actual fiber to follow the roadway, especially along the rural U.S. 20 corridor across the northern portion of the state and along the U.S. 52 / U.S. 67 corridor in eastern Iowa. That is if periodic access can be gained in a sufficient number of locations to be able to connect high-bandwidth devices within a few wireless hops.

Table 43. Network Infrastructure Gaps.

Fiber-Optic Priority	Proposed Fiber (miles)
Redundant Ring	728
Interstate Spur & Primary Road	250
Total	**978**

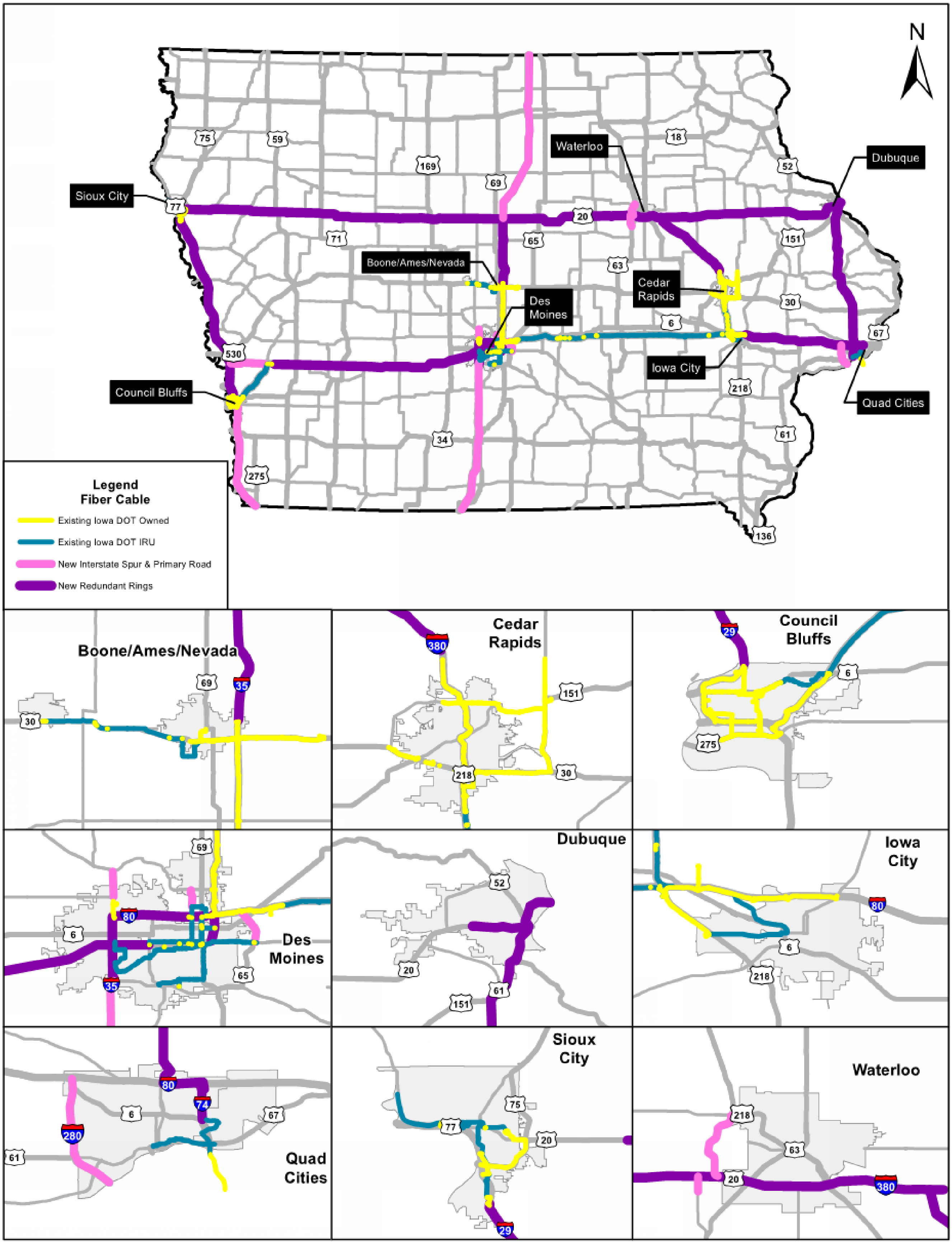


Figure 25. Network Infrastructure Gaps – Iowa DOT Fiber.

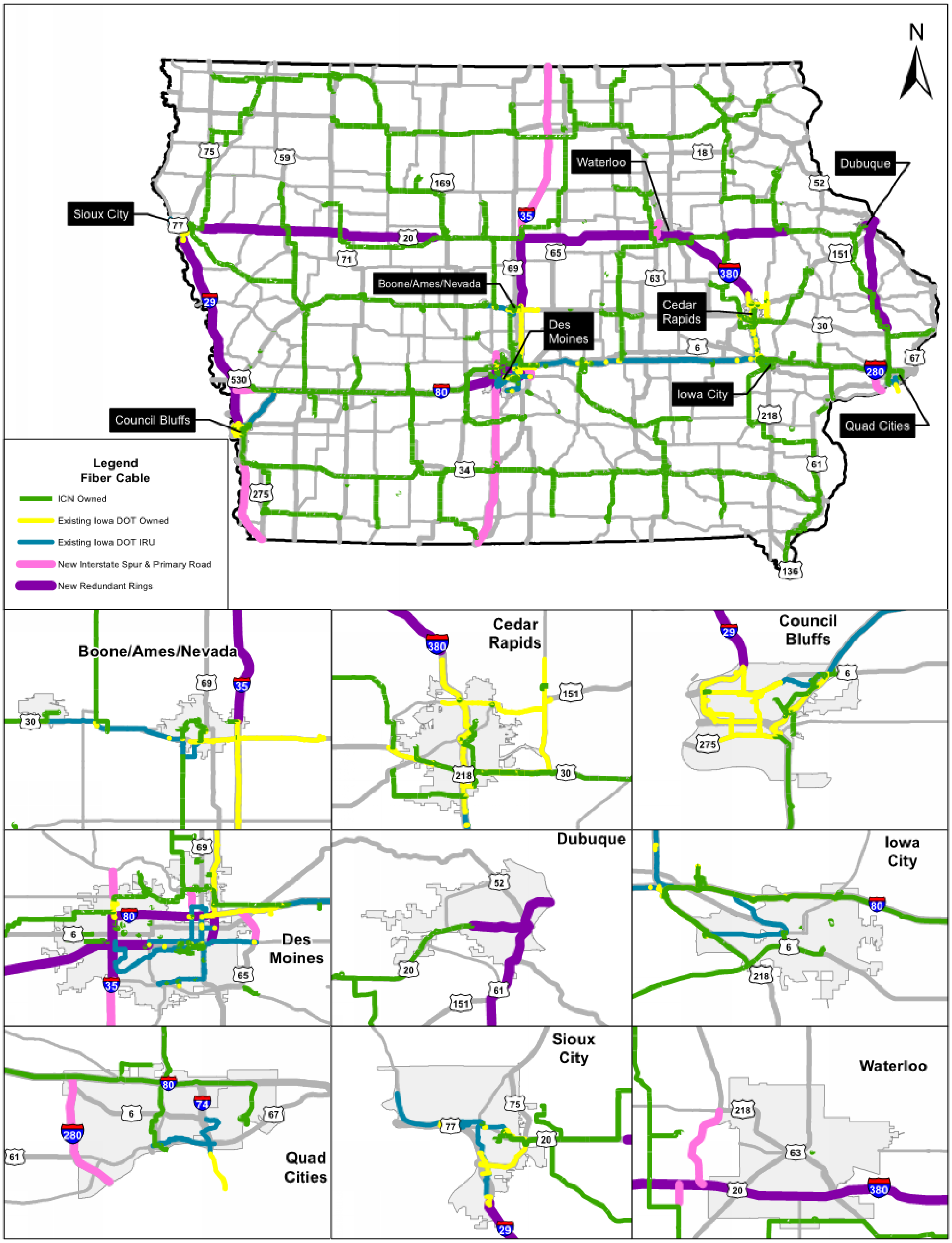


Figure 26. Network Infrastructure Gaps – Iowa DOT and ICN Fiber.

6.2 Programmatic Gaps

In addition to the gaps for systems and devices, several program-level gaps were also identified that are needed for Iowa DOT's ITS program to be fully effective. Because the ITS program has been in place for several years, most of the programmatic elements are in place. However, as the program continues to evolve and grow, the identified program gaps reflect this evolution.

NETWORK MANAGEMENT AND CYBER SECURITY

As the ITS network increases in size and complexity, and as it carries more information and connects to more systems, it will require a more formal and comprehensive management program to maintain its reliability, integrity, and security. Currently, these functions are carried out by a combination of the ITS maintenance vendor, one OTO staff member, and some occasional consultation with Iowa DOT's information technology staff. Moving forward, it will be important to formally establish an ITS NMT. Although this team may include many of the same team members, this formal organization will oversee all aspects of network management and security on a consistent basis, including development and adoption of needed policies, plans, and procedures.

PERFORMANCE MANAGEMENT

Iowa DOT and the OTO both recognize the need for and benefits of using data to help improve performance, a need that is reflected in the TSMO program plan. Even with these efforts, performance management is highlighted as a programmatic gap because the use of performance measures on a continual basis to make positive changes to the Iowa DOT's program is not yet part of the culture and day-to-day operations. Some concerted and continuous effort will be required to help make this cultural change and to take advantage of the available data.

INTEGRATION OF ITS INTO IOWA DOT PROCESSES

Just as the OTO and the TSMO steering committee is working to improve performance management, it is also already working on integrating ITS into Iowa DOT's existing processes for planning, design, and construction. This integration is emphasized again here because of the many benefits of this integration. Potential benefits including opportunities for cost savings by including ITS in other planning and design efforts and increasing consistency by incorporating ITS into Iowa DOT design standards. Along with these benefits, there also exists a challenge. Specifically, ITS technology and TSMO strategies are changed and improved on an accelerated timeline relative to traditional highway planning and design items. Iowa DOT should anticipate these more frequent changes and be prepared to update the standards accordingly.

RESEARCH AND DEVELOPMENT

ITS and TSMO continue to be developed at the rate of technology, many around the globe are continually developing new and better ways to improve traffic operations and safety through the application of TSMO and technology strategies, and Iowa DOT and Iowa motorists stand to benefit from many of these developments. Iowa DOT's ITS program already has a history of piloting new and innovative ways of improving transportation operations, and it is recommended that these efforts be continued. For Iowa DOT, this means a willingness to allocate funding and resources for emerging ITS application pilot projects. This can be done in conjunction with the existing partnership with the Center for Transportation Research and Education (CTRE), which currently focuses on decision support and data analytics for the OTO.

OPERATIONS MANAGEMENT

Currently several different offices within Iowa DOT own and operate ITS systems. While the OTO maintains and operates most of this infrastructure, they also work with and help others with their ITS systems, such as OSP, MVE, the Maintenance Division, and others. As Iowa DOT's ITS program continues to expand it is recommended to centralize the maintenance of these various systems. This will allow Iowa DOT to take advantage of the specialized knowledge, skills, and equipment housed within OTO, that are required to effectively maintain ITS.

7.0 SYSTEM MAINTENANCE

Regular maintenance is an essential part of ITS and communications systems. A well-functioning system provides the intended operational and safety benefits, whereas a partially functional or unreliable system has little or no benefit and can even hinder operations. Having a proactive maintenance program keeps the system functioning at a high level, maximizes Iowa DOT's investment in the ITS and communications systems, and helps meet the expectations of all use and benefit from them. Iowa DOT currently has a maintenance program that includes many of the tactics and recommendations outlined herein.

A proactive maintenance program is one that includes preventative maintenance as well as everything necessary to respond to failures quickly and effectively. Preventative maintenance not only extends the life of each system component, but also provides improves the system reliability. Preparation for response maintenance includes having the right people with the right skills and the right equipment in strategic locations. It also means having effective response procedures, communications protocols, and security systems.

BALANCING COST AND MAINTENANCE LEVEL

It is desirable to maintain a high degree of device functionality; however, it is also important to recognize the relationship between the level of maintenance, defined as the percent of devices working at any given time, and the cost of maintenance. Maintenance costs and maintenance levels follow the principle of diminishing returns. This means that at a certain point it takes a great amount of cost for a small increase in maintenance.

Cost increases occur when short response times are required for non-critical devices. Such responses can necessitate additional maintenance personnel to be on standby, and induce inefficiency by requiring crews to respond to individual non-critical device issues without the flexibility to schedule visits to multiple nearby devices on each trip.

The current ITS maintenance program is structured in an attempt to maximize operational benefit for the minimum cost. Specific tactics include: following a preventative maintenance schedule, basing response time requirements on failure criticality, and the use of maintenance and monitoring tools. These requirements are captured in the recommended structure of the ITS and communications system maintenance program, described in the following sections.

7.1 Maintenance Program Components

The primary recommended components for Iowa DOT's ITS and communications system maintenance program are shown in Figure 27. Many of these components are already included in the current maintenance program, outlined in the contract document for the current maintenance vendor. These components should continue to be foundational to Iowa DOT's maintenance program.

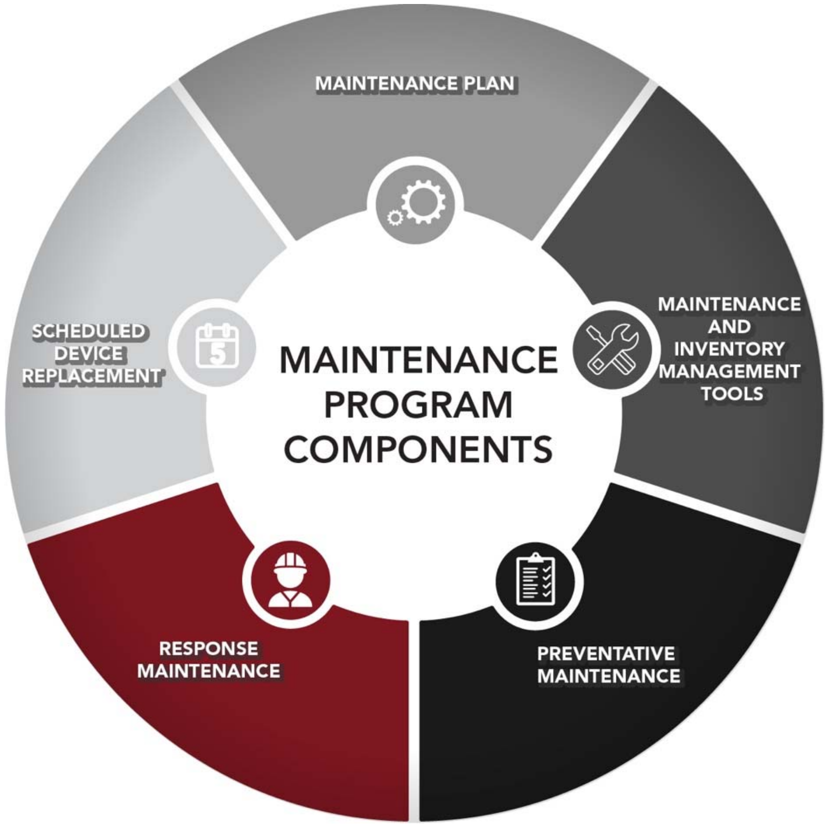


Figure 27. Maintenance Program Components.

MAINTENANCE PLAN

A documented maintenance plan defines the specific maintenance processes that should be followed. This should be developed and agreed upon jointly with all maintenance stakeholders, including the OTO staff, the TMC, other involved Iowa DOT offices and divisions, and contracted maintenance providers. The plan should define the maintenance program, including the following components:

- Roles and responsibilities
- Schedules for preventative maintenance and other recurring activities
- Communication lines and processes between all stakeholders
    - Emergency call-out authorization
    - Planned and completed activity reporting
    - Meeting schedules
- Performance measures and reporting periods
- Inventory management processes
- System monitoring processes
- Safety procedures and training schedules

MAINTENANCE AND INVENTORY MANAGEMENT TOOLS

The size and complexity of Iowa DOT's ITS and communications systems necessitate the use of a maintenance and inventory management system. Such a system serves as a tool to coordinate and document preventative and response maintenance activities, coordinate maintenance personnel schedules, and manage the inventory of deployed and spare equipment. The system should have the following characteristics and functions at a minimum:

- Be purpose-built for the maintenance of distributed electronic systems (using standard roadway or other asset management systems does not work well)
- Track routine and response maintenance activities
- Notification features for new maintenance activities appropriate for the issue criticality
- Reorder thresholds and alerts for spare inventory levels set individually for each device type
- Reporting capabilities, including standard and ad-hoc reporting
- Interfaces to allow integration with other Iowa DOT systems

In addition to the maintenance and inventory management tool, one or more network monitoring tools should also be used. These monitoring tools should provide real-time monitoring capabilities and provide alerts when problems or failures are detected. Monitoring and management should extend to physical connectivity as well as network management, server management, storage management, and security monitoring and protection.

PREVENTATIVE MAINTENANCE

The maintenance program should include a comprehensive schedule for performing preventative maintenance. Preventative maintenance maximizes the life and performance of the systems and maintains accurate calibration of field sensors. To maximize the benefit/cost of preventative maintenance, the schedule should reflect the differing needs of each device type. This frequency along with the specific preventative maintenance tasks should be refined over time based on experience with the failure rates and other maintenance considerations of each type of device. Table 44 shows the required frequencies defined in the current program.

Table 44. Required Maintenance Frequencies.

Device Type	Preventative Maintenance Frequency (months)
DMS	6
CCTV	3
Traffic Sensor	6
RWIS (between July 1 and October 1)	12
Network Device (switch, radio, etc.)	12
Intermittent Power Service	6
Portable Device	4
Device Cabinet	12

RESPONSE MAINTENANCE

A set of guidelines is required to provide a structured response process for failures in the ITS and communications systems. As discussed previously in this section, the required response times should correspond to the criticality of the failure in order to balance maintenance cost with device availability. The current maintenance contract includes this type of structure, which should be expanded as new device types are added, or refined as experience is gained. The current response times are shown in Table 45.

Table 45. Response Times.

Category	Resolution Time
Backbone Network / Major Portion of Urban Area	4 hours
Server / Software Failure	24 hours
Single Issue Causing Multiple Device Outage (>5 end devices)	Next business day
Portable Device in Use	Next business day
Overhead DMS	Next business day
Vehicle Sensor Used in Queue Detection or Travel Time Application	2 business days
Side-Mount DMS	5 business days
CCTV	5 business days
Traffic Sensor	5 business days
One or More Devices at an RWIS Site	5 business days
Portable Device in Storage	10 business days

SCHEDULED DEVICE REPLACEMENT

The maintenance program should include a plan to replace ITS devices and components at or near their end of life. Scheduling such replacements have advantages over replacement by attrition by minimizing device downtime and reducing overall cost through economies of scale.

As a general guideline for planning and budgeting purposes, the typical useful life for DMS components is 15-20 years, and 7-10 years for most other ITS and communications systems. This replacement is particularly important with network infrastructure due to the rate at which cyber security threats and corresponding protections are evolving.

7.2 Maintenance Service Center Locations

Experience to-date with the ITS and network maintenance has shown that operating multiple maintenance service center locations in or near the major metro areas provides better maintenance service than a single facility. While operating from a single location may reduce some costs by consolidating facilities, staff, and equipment, most or all reductions would be offset by the additional required travel, and the desired response times would be difficult or impossible to meet in remote areas. The current maintenance vendor has three service center locations located in Central Iowa (Ankeny), Eastern Iowa (Cedar Rapids), and Western Iowa (Council Bluffs).

7.3 Maintenance Staff Qualifications

Repairing and maintaining ITS and communications systems requires specialized knowledge and maintenance skills. Because of this, it is recommended to assign dedicated staff with this knowledge and skills to manage and perform the maintenance. The staff could consist of Iowa DOT employees, contracted staff, or a combination of both. The skills for all maintenance personnel should cover the various system specialties and be distributed geographically in order to have the personnel with the appropriate skills where they are needed. Skills required under the current contract are shown in Table 46. This list should be expanded as different device types are added, and as experience dictates.

Table 46. Maintenance Personnel Skills.

Certification / Role	One for Project	One per Maintenance Office	One per Maintenance Crew
Cisco CCNA Routing and Switching	X		
Cisco CCNP Security	X		
Fiber-Optic Technician			X
Manufacturer Certification for each Device Type		X	
ATSSA Traffic Control Supervisor		X	
ATSSA Traffic Control Technician			X
Aerial Lift Certification			X
Electrical Safety Trained			X

8.0 ACTION RECOMMENDATIONS

This section contains a summary of the recommendations made throughout this service layer plan.

MONITOR

Visual Monitoring

- Install cameras according to the densities recommended in 6.16.1 Infrastructure Gaps, in accordance with the ICE-OPS priorities.
- Use cameras in other key locations for monitoring trouble spots, security support, or to other ATDM or temporary applications.
- Plan the cameras deployment project in conjunction with available fiber-optic connections.

Traffic Data Monitoring

- Maintain the existing fleet of traffic sensors.
- Connect the existing traffic sensors installed on RWIS towers to the ATMS.
- Only deploy new traffic sensors in support of applications that require the type of data, low latency, or level of detail that these sensors provide.
- Use probe and crowd-sourced data to assess general travel conditions on the interstate and primary road network.

Weather Monitoring

- Install additional RWIS to fill in the major remaining gaps in representative coverage.
- Install additional RWIS in trouble-spot locations.
- Work with neighboring states to gain access and incorporate RWIS data from sites that provide some representative coverage within Iowa's borders.
- Initiate a pilot for mobile RWIS.

Security Monitoring

- Install cameras at border bridges and at other locations where the TMC has been asked to provide security support.

WIM

- Install new WIM to support MVE activities, including the upgrade to MVE standards of select existing sites currently operated by the OSP.

MANAGE

DMS

- Optimize the existing DMS fleet by relocating devices from low-impact areas to high-impact areas, or by upgrading DMS from side-mounted to overhead units.
- Limit the installation of any new side-mounted DMS to arterial or other specialty applications.
- Complete the inventory and maintenance plan study.

ICWS

- Deploy ICWS as needed, with locations and priorities determined in consultation with the Office of Traffic and Safety.

TPIMS

- Continue with the existing TPIMS deployment, and evaluate its effectiveness once it is operating.
- If the system is found to be effective, deploy the system at other Iowa DOT rest areas and truck parking locations.

WWDS

- Support efforts in the evaluation and treatment of wrong-way driving in Iowa.
- Research, pilot, and deploy wrong-way driving mitigation technologies where traditional methods of signing and lighting are not found to be effective.

Queue Detection

- Deploy queue detection and advisory systems as part of work zones and other corridors with recurring congestion.

Non-Emergency Lane Closure System

- Perform the programming required for the non-emergency lane closure system.
- Deploy additional vehicle detection sensors throughout the state in support of the system.
- Propose changes to the administrative rules to facilitate its use.

Travel Time Display

- Expand the use of travel time display to I-35 between Ames and Des Moines, I-380 between Cedar Rapids and Iowa City, and I-80 in the Council Bluffs/Omaha area if the Nebraska Department of Transportation (NDOT) is willing to partner on the effort.

VWS

- Deploy VWS at selected locations to support MVE operations.

Portable HAR

- Continue to maintain and use portable HAR for temporary or emergency situations.

CONNECT

Fiber-Optic Infrastructure

- Deploy a statewide fiber-optic backbone using a combination of Iowa DOT-owned and partner-owned infrastructure to connect systems throughout the state.
- Establish redundant rings to connect each metropolitan area, and connect CCTV on remaining interstates and priority primary road network segments that warrant CCTV coverage.
- Be opportunistic and utilize fiber in areas where fiber is already provided by Iowa DOT partners.
- Pursue additional public and private partnerships, including pursuit of administrative rule changes that will enable Iowa DOT to expand its network while minimizing costs.

Network and Cyber Security

- Continue to upgrade the existing network to enterprise class for a two-tier network.
- Implement specific security recommendations listed in sections 5.2 Communications Equipment and 5.3 Network Security. Priority should be given to the following steps:
    - Establish a statement of management commitment to identify the oversight and roles of each stakeholder.

- Organize an NMT that will oversee the following:
    - Develop network management and cyber security plans
    - Implement asset management controls
    - Develop and maintain operational controls (e.g., patch management, log audits, device configurations, physical safeguards, etc.)
    - Develop and conduct regular security awareness training
    - Develop an incident response plan

GENERAL

ITS Infrastructure

- All portable devices should be equipped with a GPS enabled cellular modem.
- Seek opportunities to share ITS infrastructure and data with Iowa DOT partners.
- Centralize maintenance of ITS and communications infrastructure to OTO.

ICE-OPS Prioritization Tool

- Re-apply the ICE-OPS prioritization tool to ITS and Communications service layer plan as the tool is expanded to cover the full primary road network.

Performance Management

- Work to integrate performance management into day-to-day operations.

Integrate ITS and Communications Systems into Iowa DOT Processes

- Take steps to integrate ITS into Iowa DOT planning, design, and construction processes.
- Incorporate ITS design and construction standards into Iowa DOT standard plans and specifications.

Research and Development

- Allocate funding annually to stay abreast of current development in technology and traffic operations and to pilot applications with potential benefit to Iowa DOT.

Contingency

- Allocate contingency funding annually to respond to emergencies and other unforeseen needs.

System Maintenance

- Balance maintenance level with maintenance cost.
- Address the five components of a maintenance program: maintenance plan, maintenance and inventory tools, preventative maintenance, response maintenance, and scheduled device replacement.
- Include multiple maintenance service centers throughout the state to minimize response times.
- Provide a maintenance staff with the required skills and abilities describe in Section 7.3.

Plan Maintenance

- Review and update this plan every three years.

9.0 SERVICE LAYER COST ESTIMATE

ITS and communications have become an integral part of an effective transportation system. Because of this, it is recommended that consistent funding be allocated for the continued expansion, maintenance, and advancement of these systems. The National Operations Academy's annual senior management training program recommends that the appropriate funding level is approximately 2-3 percent of an agency's annual program budget. For the elements in this service layer plan, this budget is $10-12 million annually with an approximate 3-5 percent annual increase for additional maintenance as the system continues to expand and evolve.

This funding level covers basic maintenance and recapitalization, and allows for some annual expansion of the systems as described in section 6.0 Gap Analysis. The Iowa DOT will update this service layer plan periodically to reflect system expansion and the changing landscape of ITS, technology in general, and traffic operations.

To allocate this funding annually, it is recommended that the OTO generally use a balanced approach, applying some funding to each of the areas identified below:

- **ITS Infrastructure** – The cost to add ITS systems depends on the specific system or device. Device costs range from $15,000 for cameras and sensors to $1,000,000 for VWS. Power and communications to specific field devices should also be included in installation costs, each costing on average $15,000. Section 6.1 Infrastructure Gaps provides an estimated total for each of the ITS infrastructure systems and devices that need to be installed along the Iowa DOT transportation system.
- **Fiber-Optic Infrastructure** – The cost to deploy fiber-optic infrastructure ranges between $75,000 to $100,000 per mile. This cost includes all installation, splicing, vaults, and terminations. If Iowa DOT can use partner-owned infrastructure, the cost ranges from between $2,000 to $5,000 per mile. This cost includes testing, splicing, and repair of existing fiber. Depending on the length of the segment, the use of partner-owned fiber may also require new equipment or some other work within a regeneration hut, which receives and retransmits the fiber-optic signal to compensate for attenuation of the signal over long distances. In some cases, it may require the construction of a new regeneration hut (e.g., if the partner is regenerating its signal at an off-site private facility to which Iowa DOT does not have access).
- **Network Equipment** – Given the current rate of technology improvement and development, this equipment should be updated on a seven-year cycle. In addition, as the network size increases, the total amount of equipment will also increase.
- **Maintenance** – The cost to perform system maintenance on the ITS and Communications Networks is extrapolated from the current maintenance contract expenditures. This value should be increased as the size of the systems increase, and can be estimated by the total number of devices being maintained. In addition to the maintenance of the current system, additional costs should be planned for locate services on both fiber and copper assets.

- **Unfunded Strategies** – Several of the strategies discussed in this report will be able to be deployed through additional configuration accomplished through Iowa DOT-provided labor or existing service contracts. These consist of implementation of system-related strategies from section 6.1 Infrastructure Gaps, including the deployment of additional travel time display and queue detection segments, and the proposed non-emergency lane closure system. It also includes several programmatic gaps identified in section 6.2 Programmatic Gaps, such as the formation of an NMT, implementation of a performance management program, and integration of ITS into Iowa DOT planning, design, and construction processes.
- **Research and Development** – Commensurate with the recommendation of a research and development task in section 6.2 Programmatic Gaps, it is recommended that $250,000 per year be dedicated to investigating new technologies and pilot programs.
- **Contingency** – In addition to the programmed elements of this plan, it is recommended that the OTO reserve $500,000 for the deployment and enhancement of the ITS system, for emergency response, and to respond to unanticipated requests for additional permanent or temporary ITS throughout the state. Some examples may include such items as an expansion of the TPIMS, WWDS, ICWS, and/or implementation of the non-emergency lane closure system.

  As part of the contingency item, it is also recommended that the OTO work ahead in the design process to have "shovel-ready" designs ready to build to use the available budget to maximum effectiveness if any initiatives or projects do not use as much budget as projected.

There are also several recommendations that the OTO should consider when developing an annual budget allocation:

- **Cyber Security** – Priority should be given to addressing cyber security needs as soon as possible. Many organizations have experienced a dramatic increase in the number, sophistication, and impact of attacks. Taking steps to minimize vulnerabilities in the ITS network will help protect the potential impact to Iowa DOT and its customers.
- **Statewide Communications Network** – Establishing a robust statewide ITS communications network will greatly increase the effectiveness of existing systems, and will provide a basis for many future opportunities. Such opportunities include a platform on which to build CAV applications, improved emergency management communications, and others that have yet to be conceived.
- **ITS Maintenance and Recapitalization** – The benefit of an ITS system is only as great as the maintenance program that supports it. Adequate annual funding should be allocated to properly maintain the ITS and communications system.
- **Unanticipated Needs and Emergencies** – The OTO should allocate funding each year to be able to respond to unanticipated operational needs, safety needs, and emergencies. As experienced over the past decade, these needs may come from any number of sources, including Iowa DOT central office, Districts, or emergencies such as major storms or flooding.

10.0 PERFORMANCE MANAGEMENT

Iowa DOT continues to invest in the ITS and communications systems because of the significant positive impact they can have on the overall TSMO program and to transportation operations. To maximize these benefits, both systems need to operate effectively and reliably. To this end, it is recommended that Iowa DOT use a performance management process specifically for the elements of this ITS and communications service layer.

PERFORMANCE MANAGEMENT PROCESS

The goal of performance management is to continuously improve performance of a program or process in pursuit of specific objectives. For this service layer plan, performance management consists of deploying and operating the ITS and communications systems that provide the foundation for transportation operations. This performance management process is described in the following four steps, which are repeated in a continuous cycle. Note that this process is a variation on Plan-Do-Study-Act (Deming, 1986), which is the basis for many business and quality improvement programs.

1. **Operate** the system
2. **Measure** system performance
3. **Study** and understand the meaning and implication of the measurements
4. **Implement** improvements based on what is learned from the measures

For the ITS and communications service layer plan, these steps should be overseen by OTO personnel and incorporated into day-to-day operations. OTO staff should be assigned to oversee the performance management program. The performance management process should include a minimum of semiannual review meetings with appropriate stakeholders to review each performance measure for continued appropriateness and to add additional measures.

CONNECTION TO OTHER PLANS

For the ITS and communications system program to be truly successful, it must be aligned with the plans and programs of which it is a part. This means that the performance elements that are measured and evaluated should support the TSMO program plan, Iowa DOT's overall mission and goals, and federal programs such as MAP-21 (Moving Ahead for Progress in the 21st Century Act) and the FAST (Fixing America's Surface Transportation) Act. For the purposes of this plan, Table 1 identified the connections of this plan's objectives to the ITS and communications system, and showed how the plan's objectives support the TSMO program plan.

PROPOSED PERFORMANCE MEASURES

The performance measures for the ITS and Communications service layer plan are grouped into three general categories: Coverage, which measures the build-out of the system; Reliability, which measures system availability and performance; and Programmatic, which measures completion of program enhancement tasks that will improve the ITS and communications systems. These are described as follows:

ITS Applications (devices and systems)

- *Coverage*
  - Install ITS applications according to the recommended coverage and priorities presented in this plan.
- *Reliability*
  - Maintain the ITS devices such that they are available and accurate.
- *Programmatic*
  - Develop construction and integration standards for incorporation into Iowa DOT's design and construction standards.
  - Integrate planning-level guidance for the installation of ITS applications into Iowa DOT's planning and design processes.

ITS Network

- *Coverage*
  - Install target level of communications to devices, facilities, and partners for whom they have been identified.
- *Reliability*
  - Provide physical and device redundancy.
  - Maintain network operations for high availability.
  - Maintain a high level of network security.
- *Programmatic*
  - Develop and implement network operations and network security plans, policies, processes, and procedures.

The proposed performance measures for this plan are shown in Table 47. For each of these measures, a description, the source of data, whether the measure can be obtained automatically, and the recommended review and reporting frequency are included. It is important to note that these are high-level (strategic) measures and that additional performance measures can be assessed and used by OTO staff to help manage system operations.

Table 47. Proposed ITS and Communications Performance Measures.

Category	Measure	Data Source	Automatic	Review Frequency
ITS Applications / Coverage	Percentage of system coverage for each device type	Assigned OTO staff		Semiannual
ITS Applications / Reliability	Uptime for each device type	ITS maintenance program	Yes	Monthly
ITS Applications / Programmatic	Percentage complete for integration of construction standards	Assigned OTO staff		Semiannual
ITS Applications / Programmatic	Percentage complete for integration of planning processes	Assigned OTO staff		Semiannual
ITS Network / Coverage	Percentage of devices with target level of connectivity	Network maintenance program		Semiannual
ITS Network / Reliability	Percentage of sites with target redundancy	Network maintenance program		Semiannual
ITS Network / Reliability	Network uptime	Network maintenance program	Yes	Monthly
ITS Network / Reliability	Number of thwarted security attempts (maybe)	Network maintenance program	Yes	Monthly
ITS Network / Programmatic	Percentage complete for network security plans, policies, processes, procedures	Assigned OTO staff		Semiannual
ITS Network / Programmatic	Successful execution of developed network and security plans	Assigned OTO staff		Semiannual

During the periodic review of each measure (the “study” step identified previously), the responsible OTO staff member should investigate in detail any performance issues and anomalies to help identify potential actions that would improve performance for that specific item.

Cambridge Systematics. (2005). *Traffic Congestion and Reliability, Trends and Advanced Strategies for Congestion Mitigation.* Washington, DC: Federal Highway Administration.

Convery, S., & Trudel, B. (2000). *Cisco SAFE: A Security Blueprint for Enterprise Networks*. Retrieved from https://www.cisco.com/c/dam/en/us/products/collateral/wireless/mobile-office-net-software/product_implementation_design_guide09186a00800a3016.pdf

Deming, E. (1986). *Out of the Crisis.* MIT Center of Advanced Engineering Study.

Federal Aid Policy Guide, 23 C.F.R. § 940.1 (2002). (n.d.).

Iowa Department of Transportation. (2014). *Iowa DOT Strategic Plan*. Retrieved from https://iowadot.gov/strategicplan/home

Iowa Department of Transportation. (2017). *I-80 Planning Study*. Retrieved from https://iowadot.gov/interstatestudy

Iowa Department of Transportation. (2017). *Iowa In Motion 2045 State Transportation Plan*. Retrieved from https://iowadot.gov/iowainmotion/files/IIM-2045-Full-Plan.pdf

Lakeside Engineers, LLC & Pat Noyes & Associates. (2016). *Iowa Transportation Systems Management and Operations (TSMO) Program Plan, Version 1.0*. Retrieved from https://iowadot.gov/TSMO/TSMO-Program-Plan.pdf?ver=2016-05-02-113238-843

Lakeside Engineers, LLC & Pat Noyes & Associates. (2016). *Iowa Transportation Systems Management and Operations (TSMO) Strategic Plan, Version 1.0*. Retrieved from https://iowadot.gov/TSMO/TSMO-Strategic-Plan.pdf?ver=2016-05-02-113238-673

NIST Special Publication 800-30rev1. (2012). *Information Security*. Retrieved from http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpubications800-30r1.pdf

NIST Special Publication 800-53rev5. (2017). *Security and Privacy Controls for Information Systems and Organizations.* Retrieved from https://csrc.nist.gov/csrc/media/publications/sp/800-53/rev-5/draft/documents/sp800-53r5-draft.pdf

NIST Special Publication 800-61rev2. (2012). *Computer Security Incident Handling Guide*. Retrieved from http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-61r2.pdf

Simpson, S., & Bruggeman, D. (2015). Detection and Warning Systems for Wrong-Way Driving. *FHWA-AZ-15-741*, 9.

U.S. DOT Federal Highway Administration. (2002). *Federal-Aid Policy Guide*. Retrieved from https://www.fhwa.dot.gov/legsregs/directives/fapg/cfr0940.htm

APPENDIX A. STAKEHOLDER INFORMATION

INTENTION OF STAKEHOLDER MEETINGS

Meeting Purpose:
Iowa DOT held stakeholder meetings during the week of October 31st – November 4th to gather information to help in the development of a 10-year statewide plan for the deployment and use of Intelligent Transportation Systems (ITS) and its supporting Network Communications infrastructure. Attendees of the meeting helped Iowa DOT:

- Understand ways in which ITS could help meeting your current transportation operations needs
- Explore ways that we can work together more effectively
- Define the framework for providing and prioritizing ITS and network communications services

The ultimate goal is for Iowa's ITS services to provide improved mobility, travel time reliability, and safety along the transportation system.

This ITS service layer plan is one of 8 service layer plans that will be completed as a part of the Transportation Systems Management and Operations (TSMO) Program Plan. The ITS service layer plan encompasses and supports all of the other service layer plans. To help complete the ITS service layer plan, four overarching categories were created for Iowa DOT's ITS services to provide an easy to understand grouping of services. The four categories and examples of services provided in those categories are shown below:

Monitor: Resources and tools that observe and assess the performance of the transportation system. Examples are:

- Road Weather Information System
- Cameras
- Truck Parking Sensors
- Security Monitoring Sensors
- Over-Height Warning Systems
- Probe Vehicle Data Sensors
- Weigh-In-Motion
- Vehicle Detection Sensors

Communicate: Services that allow Iowa DOT to provide information to travelers and agency partners. Examples are:

- Social Media
- Web
- Mobile Apps
- Telephone
- Email
- Data Feed
- Direct Digital Connection
- Historical Data Porta

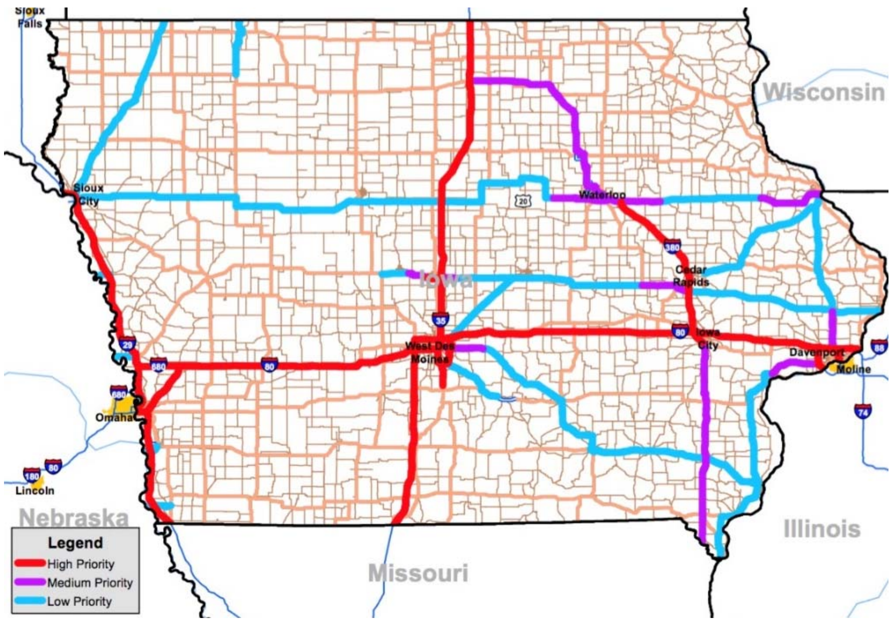
Manage: Services that actively maintain and enhance traffic along the transportation system. Examples are:

- Dynamic Message Signs
- Traffic Signal Control
- Wrong-Way Detection Systems
- Active Merge Systems
- Freeway/Highway Gates
- Bridge Anti-Icing Systems
- Integrated Corridor Management
- Rural Intersection Conflict Warning Systems
- Connected Vehicle Roadside Devices

Connect: The digital communications backbone enabling all ITS services. Examples are:

- Fiber Optic Cable
- Fixed Wireless
- DOT Owned Fiber Optic
- Mobile Wireless
- Shared Communications
- Leased Communications

Future needs of the transportation system were also discussed to account for the rapidly changing transportation technology. The input received from the meetings will be used to help prioritize corridors throughout Iowa and its metro areas. These corridors will be determined to be either high, medium, or low priority corridors and the needs of the corridor will be determined based on the corridor priority. The map below is an example of what the corridor prioritization can look like.



During the meetings questions were asked to initiate discussion. Not all of the questions were discussed at each of the meetings. Discussion questions included:

1) What are your biggest challenges?
2) What are some additional ways we can work together?
3) What additional services could you benefit from?
4) What services have you tried that have not worked well?
5) Where do you see these types of services in 5 years?
6) In your most congested areas, what services are deployed? Are they helpful?
7) What can you contribute?

STAKEHOLDER MEETINGS COMMENT SUMMARY

This document summarizes the common themes and highlights from the series of stakeholder meetings held in October/November of 2016 and January 2017 to obtain input on the ITS and Communications Service Layer Plan. Some of the comments and themes relate to services and activities already being provided as well as comments that will be addressed in other Service Layer Plans. The comments received can be characterized by the following quote from Jim Armstrong from Iowa DOT in District 5:

> "Whatever we do, I would like to be plugged in and have information at my fingertips so that I can deploy any resource to be as proactive as I can be to manage the mobility, safety, and operations of our roadways."

Data

- There is too much data and too little time for people to make sense of it – Systems should be improved to help people know when to make decisions (performance measures, predictive, alarms, Decision Support Systems (DSS), prioritization tools, etc.)
- Data is currently stored in many locations – there needs to be a better way to organize and share
- GIS based tools and analysis are useful in this area – DOT needs more GIS expertise and resources
- Analyze how asset management and performance management can work together

Inter-agency and Intra-Agency Communication

- Several organizations expressed a desire to improve operations-related inter-agency and inter-office communications – both for advanced planning and for real-time event management
- To operate as a true system, partner agencies in a region should continue to work toward common goals
- Partner agencies can take advantage of shared purchasing agreements to have consistent technology and share in bulk pricing
- Multi-agency training in the use and operation of ITS and TSMO would be beneficial to all
- Rural districts would like information on TSMO strategies which will help with specific challenges
- Establish consistent diversion routes agreed upon by all jurisdictions, and provide consistent signage and monitoring for the diversion routes

General Services

- Future developments will change the way data and information are gathered and disseminated. However, investments need to be made for operations today while at the same time anticipating future changes
- An entire spectrum of drivers needs to be served, from drivers who rely heavily on technology to drivers that do not
- Services that support emergency operations need to be provided
- Continue to work ITS and TSMO services into mainstream Iowa DOT processes

Network Security

- Security concerns are growing and changing, requiring constant adaptation
- Cyber-security of end devices needs to be addressed

Traveler information

- Some existing traveler information services are not widely known
- There are some concerns with the usability of existing services
- DOT needs to determine how to provide information to drivers without causing more driver distraction
- DOT should maximize the partnerships and potential with 3rd party providers (e.g. Waze, etc.)
- DOT should provide information to travelers in the way drivers want it (get regular feedback and input)
- DOT should make sure there is consistency across jurisdictional boundaries (DMS and other signage)

Technologies

- DMS
    - Develop a consistent strategy for deployment/relocation of DMS
        - During winter weather DMS messages should display roadway closure information
    - Future technology may eliminate the need for DMS, but currently there is a need for DMS
    - Color DMS have additional potential uses
- CCTV
    - CCTV was determined to be very useful and commenters expressed a want for more in general
    - Some inter-agency sharing does exist, and several commented that this sharing should increase
    - If the technology is improved in the future, DOT should consider providing cameras that automatically zooms to queue and congestion
- Traffic Data
    - Probe data has reduced the need for some roadside sensors, but not eliminated it (probe data provides speeds and speed-based metrics only)
    - Roadside sensors are needed where accurate Volume/Occupancy/Classification information is desired
    - Connected vehicles may further reduce the need for both roadside sensors and probe data
- RWIS
    - Continues to be very important and helpful
- Communications Infrastructure
    - Balance the use of fiber/wireless based on needs and costs

Specific Technologies and Strategies to Pursue, Expand or Consider

- Integrated Corridor Management
- Ramp Metering
- Signal control, (provide expertise to local agencies, expand adaptive)
- Over-dimension warnings
- Predictive data analysis
- Variable Speed Limits
- Rail crossings (warning/accommodation for other traffic)
- Highway helper along critical corridors
- Border bridge monitoring
- Falling rock warning (McGregor)
- Rural intersection conflict warning
- Wrong-way detection/warning
- Drones for emergency management

Traffic Demand Management

- Provide information to grain elevators so the grain elevators know when to dispatch trucks – preventing trucker bottlenecks on freight corridors

DETAILED SUMMARIES OF EACH STAKEHOLDER MEETING

CENTRAL IOWA STAKEHOLDER MEETING – 10.31.16

Attendees:

Name	Organization
Brent Long	Polk County Sheriff
John Taylor	Polk County Sheriff
John Wilson	Iowa DOT
Brian Willham	City of Des Moines
Tim Simodynes	Iowa DOT
Rob Dehnert	City of West Des Moines
Marcus Coenen	DMAMPO
Neil Hawkins	CTRE
Skylar Knickerbocker	CTRE
Jeremy Vortherms	Iowa DOT
Sinclair Stolle	Iowa DOT
Tony Taylor	Iowa DOT
Michael Jackson	Iowa DOT
Erin Flanigan	Cambridge Systematics
Jessica Das	Olsson Associates
Blake Hansen	Olsson Associates

Meeting Highlights:

1) Data Sharing
    a) Currently the City of Des Moines has a few cameras for traffic monitoring, but other data sharing services are sparse.
    b) Would like to start reviewing predictive data
        i) Once we start analyzing the live data it would be great to be able to form predictions on traffic flow and where traffic may be heading.
    c) Impacts of weather (heavy rain, snow, ice, etc.) on traffic in an area
        i) First Watch has been used to aggregate call data and determine where crashes are happening in an area based on weather events. This can be looked into.
        ii) Partnering with the National Weather Service is an option.
    d) Would be helpful if Iowa DOT were like a clearing house where they gather data from all the communities, combine it with data from other sources, then process it and send communities more actionable information based on that data.

2) Cross-Agency Communication
    a) Passing along data whether it be weather, traffic flow, etc. to other area jurisdictions could make a difference for travelers on the roadways.
    b) Consider having the DOT take over ramp signals if there is a backup and the City is not available to make changes.

c) Need to have a common goal between agency and jurisdictions.
    i) In five years we should be able to solve a problem along a roadway or ramp without worrying about whose jurisdiction it falls under.
    ii) Traffic Management Advisory Committee (TMAC) may be a good forum.
    iii) Should provide consistent technology and signage along roadways when going through different jurisdictions.

3) Existing and Future Needs
    a) Corridors need to be prioritized to determine what should be provided whether that be fiber, connectivity, software, cameras, etc.
    b) Operational awareness services / Performance Metrics
        i) Provides information to understand what to expect when an event or flooding is going on in an area and relay that information to other jurisdictions as well as law enforcement.
        ii) Consider determining the economic impact of good flow versus bad flow along major corridors and how that can be monetized. Let that help decide where we are going and why we want operational awareness.
    c) Determine how to handle railroad crossings in the area.
        i) Could install a device that sends information to DOT or other agencies letting them know that a signal was triggered to provide awareness of when intersections are blocked.
        ii) Engage emergency responders as they are most impacted by the crossings/blockages.
    d) Consider having something like a highway helper along critical corridors during peak periods, integrated corridor management. Also, may want to look at growth areas.
        i) 22nd & Hickman
        ii) 235 from 63rd to the interchange
    e) Redundant communications

4) Iowa DOT's 511
    a) There is a two-way data exchange where Waze events are shown on 511 site and app.
    b) The services that the 511 service provides should be advertised to a greater level.
        i) e.g. DMS, infomercial, email, commercial, social media.
    c) Increase awareness of the Waze interface and data sharing DOT provides

Action Items:

1) Look into if Iowa DOT can work with Waze to pre-emptively redirect travelers during major events, such as the NCAA tournament, without closing down roadways.
    a. Sinclair will look into if this.
2) Blake will see if there is an application for train locations (understanding due to the proprietary nature of the rail industry).
3) Consider putting together a commercial or infomercial about what Iowa's 511 has to offer.
    a. PD was looking for additional information on Iowa's 511 service, Sinclair was going to provide this information through handout and email.

COUNCIL BLUFFS STAKEHOLDER MEETING – 11.06.16

Attendees:

Name	Organization
Don Stevens	Iowa DOT
Dick Moraine	Iowa DOT
Jim Bane	Iowa DOT
Scott Manz	Pottawattamie County EMA
Greg Reeder	City of Council Bluffs
Scott Schram	Iowa DOT
Mark Franz	City of Council Bluffs
Bob Andersen	Pottawattamie County EMA
Greg Youell	MAPA
Matt Balier	NDOR
Austin Yates	NDOR
Tara Kramer	CBIS
Tony Taylor	Iowa DOT
Tim Simodynes	Iowa DOT
Michael Jackson	Iowa DOT
Erin Flanigan	Cambridge Systematics
Jessica Das	Olsson Associates
Blake Hansen	Olsson Associates

Meeting Highlights:

1) Data Sharing
    a. Data has been gathered and developed, but we are not getting it out to the public as much as we need to, where it can help.
    b. It is important to determine how best to provide data to agencies.
        i. Currently, the best way to reach most agencies is a phone call.
    c. Filtering data so that jurisdictions and travelers only see what is useful. Often times there is too much data being provided (data overload).
        i. Still need to be able to communicate with the people that will not quickly adapt to the new vehicle technology.

2) Cross-Agency Communication
    a. Primary challenge is communication coordination; it should follow more of a procedure instead of ad-hoc.
    b. Agencies and jurisdictions should work closely with media outlets; providing them with information about the transportation system so that they can relay it to travelers.
    c. Different jurisdictions need to work together to make the transportation system easy to navigate and understand.
        i. Street names and signs should be consistent from jurisdiction to jurisdiction.
        ii. Mile markers should be clearly defined.

d. NDOR, Iowa DOT, and City TMC's should communicate with each other more so they can do more to help the transportation systems as well as provide travelers with information.
    i. Consider having a lower level communication between the TMCs that provides a heads-up when traffic is beginning to build (optimized predictive mechanism).
e. Communication with the railroad agency could help us understand when trains may arrive and we could update signals near to the railroad prior to a train's arrival.

3) Existing and Future Needs
    a. Provide automated messaging when there is congestion (especially true for elevated sections and work zones).
    b. Determine a way to measure performance during rush hour.
        i. Speed is a good way to measure performance.
        ii. This information could also help during winter storms
            1. Inrix is a resource; however, only average speed is provided, not the number of vehicles on the roadway.
    c. Integrated corridor management should be considered along some roadways.
    d. Providing moisture probes on RWIS devises could be very helpful.
    e. If Iowa DOT began managing traffic signals, having a central traffic system would benefit each area.
    f. Providing live data when incidents occur could help travelers along a transportation system.
        i. Provide the magnitude of the incident, minor or major.
        ii. Provide the distance to the incident which update as they get closer.
        iii. Might be a good use for drones in the future.
    g. Iowa DOT could help with adaptive signal projects, and provide statewide expertise.
    h. Determining how to automate lane closures during an incident could ultimately improve traffic and help clear the incident more quickly.
        i. Law enforcement are currently the ones closing ramps and lanes during incidents.
    i. Provide travel times along alternative freeway routes.

Action Items:

None at this time

Attendees:

Name	Organization
Dan Holderness	City of Coralville
Doris Moreno	Moline EMA
Scott Ryckeghem	Moline EMA
Emily Bothell	
Matthew Getz	University of Iowa
David Ness	City of Dubuque
Ron Perkins	City of Davenport
Gary Statz	City of Davenport
Chandra Ravada	DMATS
Johnny Shandler	Iowa DOT
Cathy Cutler	Iowa DOT
Roger Walton	Iowa DOT
Sam Shea	Iowa DOT
Jim Schnoebelen	Iowa DOT
Ron Griffith	City of Cedar Rapids
Kenneth Yanna	Iowa DOT
Tony Taylor	Iowa DOT
Tim Simodynes	Iowa DOT
Michael Jackson	Iowa DOT
Erin Flanigan	Cambridge Systematics
Jessica Das	Olsson Associates
Blake Hansen	Olsson Associates

Meeting Highlights:

1) Data Sharing
    a. Iowa DOT and other jurisdictions need to determine how to share data with border states, especially concerning border bridges.
        i. At some bridges there are already sharing agreements in place, and Iowa could easily share system data.
    b. During the most recent Cedar Rapids flood, there was a several mile backup and the traffic signals were not coordinated. When the Iowa DOT contacted the City about this they sent someone out to check on it, even though Iowa DOT was able to monitor it by camera and there was a huge backup. Sharing information would be a good way to improve coordination during emergency response.
    c. Providing roadways other than state owned routes on the 511 would be helpful to travelers and other jurisdictions.
    d. Iowa DOT has a number of contracts for buying different ITS equipment, other agencies within the state can buy off of those contracts. They can also take advantage of the license for our ATMS software that controls these devices.

e. Iowa DOT owns a lot of fiber around the state, but partners with the ICN to do locates and help manage some of the fiber.
f. We can share our Inrix data with local agencies and jurisdictions. Iowa DOT will actively pursue additional partnerships with agencies around the state.

2) Cross-Agency Communication
   a. DOT should share what hardware they are purchasing so all of the jurisdictions can have commonality.
   b. Agencies need to coordinate efforts and make sure that we have a consistent message across all of our systems.
   c. When an incident occurs in the area, the City sometimes finds out about it through the media.
   d. It would be beneficial for the Iowa DOT to get involved in the City's command center during flooding or other major events.
      i. Having someone at the communications center to get information back and forth between municipalities sooner is key.

3) Concerns
   a. Moline shares the I-74 bridge with Bettendorf, which is currently under construction. Volumes on the bridge is a big concern, providing more notifications to help get traffic diverted sooner would be helpful.
   b. When an incident occurs, traffic can sometimes be diverted to a construction zone.
      i. Might be able to set up a separate diversion route for this or divert them sooner.
   c. Interstate work zone crashes are a major problem in the Cedar Rapids area.
      i. May need to provide enforcement or some kind of technology to help with this.
   d. Need to have an updated plan and list of contacts and resources when a major event, such as flooding occurs.
      i. The flood plan that was updated last year does not provide the proper information.
   e. The City of Clinton wants more DMS boards for the two river bridges that are narrow.
   f. The DOTs current camera system is slow, partly because of infrastructure and our computers struggle with all of the data that we are analyzing.
   g. An issue that the current 511 system has is you can only enter certain descriptions into the system which can make it difficult to push out alerts. None of the I-36 routes are available.
      i. Is it possible to add local roads to the 511?

4) Existing and Future Needs
   a. Iowa DOT should set up a standard for storage, such as a common cloud, so that there is a common storage of traffic operations data throughout the state.
      i. Iowa DOT could consider RITIS for data storage in addition to the other tools that are available.
   b. Providing integrated corridor management could be helpful in determining queue lengths at critical points.
   c. The more ITS services that we can deploy and data that we can gather will help the system operate better.

d. More monitoring should be provided along the bridges in Clinton and Dubuque.
e. Training is essential, especially since it can be difficult to hire already trained staff. Having an information share training on how to use some of these technologies and how we can get the most out of them would be a great benefit.
f. Adaptive signals should be considered for some corridors in the area.
g. Develop specific diversion routes in the area.
h. Need to keep up and understand where transportation is headed once connected and autonomous vehicles are here and prepare accordingly.
i. City of Dubuque is working on installing fiber along all major corridors.
j. Predictive modeling could help determine if a backup is likely to occur.
k. Deploy more cameras to make monitoring the system easier.

Action Items:

1) Complete an after-action review of the flood response. See if someone from the DOT could get involved in the City's command center.
2) Mike needs to email Ron Perkins about contracts for buying ITS equipment and licensing ATMS software.

Attendees:

Name	Organization
Jim Webb	Iowa DOT
Jeff Owen	Iowa DOT
Jared Klein	Iowa DOT
Jim Armstrong	Iowa DOT
Mark Van Dyke	Iowa DOT
Tony Taylor	Iowa DOT
Tim Simodynes	Iowa DOT
Michael Jackson	Iowa DOT
Jessica Das	Olsson Associates
Blake Hansen	Olsson Associates

Meeting Highlights:

1) Data Sharing
    a. Should incorporate what work the counties are doing into Waze and other services to help mitigate traffic once an incident occurs.

2) Cross-Agency Communication
    a. Building a relationship with the local jurisdictions is one of the biggest challenges.
        i. We could work together on determining impacts construction will have on the roadway and if timings need to be modified.
        ii. DOT should support signal installation and timing
        iii. Work with locals on TIM plans.
    b. There is a Multidisciplinary Safety Team (MDST) here that should be helping the Iowa DOT communicate with local agencies and jurisdictions.
    c. Work with counties and cities to provide easy-to-understand diversion routes or Transportation Incident Management (TIM) routes.
        i. Diversion route signs may need to be color coded or the route should be signed electronically.
        ii. Eventually these routes will be automatically sent to the car.
    d. Determine if local jurisdictions will allow Iowa DOT to connect to their cameras.
        i. Determine what should be done with this access.

3) Concerns
    a. We do not have the expertise here to be able to take over the surrounding local Cities' signal systems and other traffic control devices on a day-to-day basis.
        i. How do we work on getting our staff trained to design and time signals?
    b. Need to include Iowa Highway 28 on service priority map.
    c. We need to gain direct access to available monitoring systems. Often passwords change before staff has a chance to become proficient.

4) Existing and Future Needs
    a. Consider reviewing signal systems in the area to determine if updated signal timings would reduce the number of crashes.
    b. Providing cameras at more intersections will enable us to monitor the system without going out into the field.
    c. Probe data could help alert agencies of potential issues.
    d. Could plow cameras or something of the sort be used on dry pavement?
        i. Plow cams and RWIS were very helpful during the winter months.
    e. "Whatever we do, I would like to be plugged in, have information at my fingertips, so that I can deploy any resource I have to be as proactive as I can be to manage the mobility, safety, and operations of our roadways."
    f. Determine if adaptive signals would work at any of our corridors.

Action Items:

1) Need to help connect and set up the operations center.

Attendees:

Name	Organization
Krista Rostad	Iowa DOT
Craig Wood	Iowa DOT
Nick Hampac	Iowa DOT
Jon Ranney	Iowa DOT
Dave Little	Iowa DOT
Tony Taylor	Iowa DOT
Michael Jackson	Iowa DOT
Jessica Das	Olsson Associates
Blake Hansen	Olsson Associates

Meeting Highlights:

1) Cross-Agency Communication
    a. Ethanol plants sometimes have trucks backed up and either parked on the shoulder of the road or in the roadway because the plant does not provide truck parking. If we could provide information to the elevators that says when to dispatch the trucks so that we would have a continuous flow of trucks that would help alleviate this problem.
    b. Need to work on learning from the office of traffic operations about what applications are helpful for our specific problems.

2) Concerns
    a. There was a double fatality accident recently at an intersection. Some changes need to be made to the intersection. Possibly:
        i. Flashing beacons
        ii. J-turn
    b. McGregor and I-76 rocks are falling off a bluff. A sign is provided, but should consider if any ITS services can be provided to warn vehicles of safety hazards.
        i. A device that can detect if debris is on the roadway and warns vehicles ahead of time.
    c. One of the detour routes for the upcoming Lancing bridge project has a length of 70 miles. We need a solution to help monitor its operation.
        i. Inrix can help and determine alternative travel times so the traveler can determine the best detour option.
    d. Advanced notifications can obscure real-time events in 511, if the user doesn't know to turn off that layer.
    e. During the shopping season a DMS advanced warning is required because the left-turn from 58 South to Viking Rd always backs up around the curve.

3) Existing and Future Needs
    a. A rural intersection conflict system should be considered in certain areas.
        i. Avenue of the Saints

ii. Floyd

b. Integrated corridor management should be considered at Floyd
c. District 2 would like to be considered if you need to test any tools out, we want to optimize whatever tools we have to manage our projects and corridors.
d. Provide advanced warning to travelers if there is going to be a delay or construction.
    i. Educate the public on the what is a realistic view of congestion.
e. Develop strategies to meet future local pressure along corridors.
f. Determine a more strategic view for our bridge programming. Instead of looking at bridge resurfacing or replacements on a per bridge basis, we should look to see if any other bridges in the area are going to need to have work done in the next couple of years and do the work at the same time.
g. Improve time it takes to complete bridge deck overlay.
h. Determine if there should be any policy guidelines for when to use DMS.
    i. Currently we provide them when law enforcement asks
i. Need to determine when DMS signs should be permanent instead of portable.
j. Drones should be considered for the transportation system emergency management.
k. Consider real-time satellite imagery in the future.
l. Consider expanding camera coverage.
m. Trains are a concern and can back up traffic for a long time.

Action Items:

None at this time

Attendees:

Name	Organization
Craig Markley	Iowa DOT – Systems Planning
Deanna Maifield	Iowa DOT – Design
Donna Buchwald	Iowa DOT – Local Systems
Michael Kennerly	Iowa DOT – Design
Marty Sankey	Iowa DOT – Right of Way
Bill George	Iowa DOT – Information Technology
Garrett Pedersen	Iowa DOT – Systems Planning
Phil Mescher	Iowa DOT – Systems Planning
Todd Szymkowski	Gannett Fleming
Tim Simodynes	Iowa DOT – Traffic Operations
Tony Taylor	Iowa DOT – Traffic Operations
Scott Marler	Iowa DOT – Traffic Operations
Jessica Das	Olsson Associates
Blake Hansen	Olsson Associates

Meeting Highlights:

1) ITS Services
   - d) Providing information to travelers is key (commuters, truckers, recreational travelers, etc.)
     - i) This can help reroute travelers if there is congestion
     - ii) Systems Planning has data on commuter routes
   - e) Operational information, such as analyzing traffic volumes and characteristics, for incident types and locations can be utilized by Systems Planning to help the Office of Design make forecasts based on different scenarios and assumptions to help design/choose the correct type of interchange. Specifically:
     - i) This becomes an additional tool that Systems Planning can use to accurately evaluate needs
     - ii) It helps Design plan traffic control that addresses maintenance and operations needs
     - iii) Anticipates the impact on system operators and maintenance personnel so that there is fully integrated design, construction, and operations
   - f) The prioritization model needs to be somewhat consistent with Systems Planning's existing processes to maximize its benefit
   - g) Consider providing wireless communications in the future instead of underground
   - h) Consider sharing congestion information with third parties (Google, Here, Waze)
   - i) Utilize data that has been collected to provide a lane closure planning tool

2) General Concerns
   - a. The DOT advocates for travelers not to look at their phones while driving, but we send travelers updates through mobile devices and other means which can distract them while driving

            i. Should determine how to provide information to travelers through audio and not visuals

   b. The former Iowa DOT director issued a directive to not installing additional DMS, but this technology continues to be relevant. While connected and autonomous vehicles appear to be imminent, they are not expected to be the majority in 10 years; therefore, DMS will continue to be an important way to provide travelers with real-time information
      i. Need to work with the community of drivers that are not adapting to technology provided on their phones or computers
      ii. Need to keep an understanding of where transportation is headed once connected and autonomous vehicles are here and prepare accordingly
   c. For the DOT IT department, hacking into DOT ITS devices is a major concern
      i. Someone turning a camera is not a big deal
      ii. Someone changing a DMS can do some damage
      iii. Someone hacking into the system is a major problem
   d. The Office of Traffic Operations (OTO) and the Office of Design need to establish consistent guidance for the inclusion of conduit in bridge and roadway designs
      i. May need to start considering providing conduit along roadways, inserting it when a roadway project is in construction
   e. Right-of-Way does not need specific information from the ITS system, but sometimes the ITS network will need Right-of-Way services for its deployments

3) Existing and Future Needs
   a. Work on finding strategies to help maximize existing capacity
   b. Look at strengthening partnerships with Cities when it comes to sharing video and data
   c. Need to determine how best to gather and utilize roadway operational data
      i. INRIX is a great resource, but does not meet all of our needs
         1. Determine how to fill the gap that INRIX leaves with truck data and vehicles getting off the interstate onto other roadways
         2. INRIX provides speeds, but we are still working on ways to harvest, store, and analyze the data
      ii. Acquire or use Bluetooth or Wi-Fi sensors to get accurate arterial travel times and build origin-destination matrices
         1. INRIX provides this, but it is expensive
      iii. Work with the TOC to maximize the use of Wavetronix devices
      iv. When buying external data, we should make sure it can integrate well with what we have
      v. Develop guidance for the appropriate use of roadside sensors
   d. Guidance for the strategic placement of DMS signs needs to be revisited. This can include relocation of existing DMS
      i. DMS should be provided where traffic is located; primarily along commuter and freight corridors
      ii. In anticipation of in-vehicle information, DMS may eventually not be needed
      iii. Provide more color DMS along interstates
      iv. Consider providing inter-city travel times on DMS
         1. Keeping the distance between 30-60 miles

2. May be helpful to use across state lines

e. Need to determine if firewalls are provided at appropriate locations throughout the system, review their policies, and establish a regular testing process
    i. Security at each device location is a topic that needs to be explored
    ii. Levels of security need to be considered for different services

f. Work on improving the bandwidth and communications at maintenance garages
    i. Good communications to DOT facilities is very important – it doesn't matter how many devices are in the field if you can't get that information to the people who need to use it

g. Considering a trip planning app that would account for congestion, weather forecast, history of travel during this day in the past, and a risk based planning tool
    i. This may be something that a third party should build and we provide data
    ii. Google maps and other apps already reroute travelers
    iii. Inform Iowa travelers how applications such as Google, Waze, and Here can help them with their travels
        1. The partnership Iowa DOT has with Waze allows the DOT to inform Waze of any crashes along the roadways

h. Need to determine how we can leverage our existing ITS infrastructure along corridors or if any new infrastructure is needed

i. We need a mechanism to help understand the value of the system to guide and substantiate investment decisions

j. Begin providing safety and mobility analysis and determine if ITS should be part of the design
    i. Providing temporary ITS in work zones can be done without much hassle
    ii. Providing permanent ITS for a project should be determined with an overall plan for ITS. Determining what ITS services should be provided on a project by project basis will raise project costs and can cause incorrect placement of ITS services along a corridor; therefore, an overall plan would be helpful.
        1. This is something that can be determined with the project scoping tool

Action Items:

1) Set up a meeting to meet directly with Systems Planning about how to prioritize and break down the services that the different travelers need

IOWA DOT DEPARTMENT STAKEHOLDER MEETING #2 - 1.18.17

Attendees:

Name	**Organization**
Amy Worzella	Lakeside Engineers
Rebecca Herring	TMC – Lakeside Engineers
Keith Ellis	Iowa DOT – TMC
Bonnie Castillo	Iowa DOT – TMC
Mark Bortle	Iowa DOT – Construction & Materials
Ken Morrow	Iowa DOT – Maintenance
Tony Taylor	Iowa DOT – Traffic Operations
Willy Sorenson	Iowa DOT – Traffic & Safety
Jason Dale	Iowa DOT – Traffic Operations
Randall Friend	Iowa DOT – Traffic Operations
Matthew Rensch	Iowa DOT – Highway Support
David Anderson	Iowa DOT – Network & Radio Support
Peggi Knight	Iowa DOT – Research & Analytics
Dave Lorenzen	Iowa DOT – Motor Vehicle Enforcement
Annette Dunn	Iowa DOT – Information Technology
Alex Jansen	Iowa DOT – Vehicle & Motor Carrier Services
Jeff Sundholm	Iowa DOT – Information Technology
Matt Haubrich	Iowa DOT – Organizational Improvement
John Selmer	Iowa DOT – Performance & Technology
Zhaia Wineinger	Iowa DOT – Strategic Communications
Andrea Henry	Iowa DOT – Strategic Communications
Scott Marler	Iowa DOT – Traffic Operations
Tina Greenfield	Iowa DOT – Maintenance
Jessica Das	Olsson Associates
Blake Hansen	Olsson Associates

Meeting Highlights:

1) Data Sharing
    a. Providing information to the public is key
        i. Data has been gathered and developed, but we are not getting it out to the public as much as we need to. It is necessary to make the data into useful information
            1. We need to use this information to help measure and manage performance
        ii. Provide information about the system in real-time to travelers which helps notify and reroute them during congestion
    b. Determine what data we should collect and analyze, and what data should be left to 3rd parties such as Waze, Google, and Here
    c. Departments need to communicate what data is being collected and share the data when necessary to help prevent data duplication.
        i. Consider a coordinated data storage and sharing system or tool

d. The motor vehicle department should be included in the system
    i. This will allow for better real-time communication
e. Utilize data that has been collected to provide a lane closure planning tool

2) Internal Agency Communication
    a. Communication between IT and other departments needs to be improved so known needs and changes can be planned and carried out more effectively and efficiently
    b. The Organizational Improvement department should work with the departments that utilize applications for the DOT highway system and make the application process consistent throughout the DOT
    c. There needs to be better real-time communication about what is happening along the roadways so everyone can make better decisions (enforcement officers and maintenance crews specifically)
    d. Real-time incident information should be communicated in both directions between who is out in the field and the TMC.
    e. The Strategic Communications department needs to be able to verify roadway conditions and incidents without having to speak directly with the TMC
    f. When developing RWIS plans communication with maintenance is important
    g. DOT should work with Cities to get data from their traffic signals

3) Existing and Future Needs
    a. The plan needs to balance the costs and benefits of deploying and maintaining devices vs. what we can purchase through 3rd party services or share with partners
    b. Technology and other aspects of the existing weigh stations need attention and improvement
    c. Design similar technology to weigh stations but bring in driver's license security data from driver's license stations
    d. We need to work with CTRE and DOT research to help find innovative ways to use the volumes of data that are being collected
    e. Utilize collected data to develop a lane closure planning tool
    f. Determine a way to have a secure but accessible DOT data system
        i. Employees should be able to access the tools and information from anywhere on any device
    g. We need a mechanism to help understand the value of the system to guide and substantiate investment decisions
    h. Need to determine what data is available to us in terms of vehicle classification
    i. Plans should be developed for critical parallel routes as well as commuter (feeder) routes
        i. Sensors are not provided along US 69 which doesn't allow the DOT to know what is going on when travelers are diverted
    j. DOT should start using predictive data
        i. This can help the DOT know what to expect in a work zone when volumes are high and patterns in the system can be determined
    k. Provide more electronic truck height sensors along interstates. We do a good job helping those who need permits, but need some way to help those who operate without permits
    l. DMS should be provided in key areas

        i. Eventually DMS will not be needed; however, current roadway technology calls for DMS to be provided
    m. Consider adding variable speed limits along some areas of the interstate
    n. Provide ramp metering in areas where incidents along the ramps occur often
    o. Install more cameras in rural areas of the state
    p. Consider buying more thermal cameras which can help determine roadway temperatures
    q. More sensors should be provided throughout the state
    r. Consider wrong-way detection solutions
    s. Collect more rural traffic speed information
        i. Traffic speeds are a good indication of how well maintenance crews are taking care of the roads
    t. We need to do a better job at assessing what people really want and need in terms of traveler information and delivery methods. This could be coordinated through existing DOT survey efforts and focus groups. This information should guide us in how we serve our customers
    u. When prioritizing TSMO solutions, consider both the benefits of supporting DOT frontline staff as well as the traveling public
    v. Need to keep up and understand where transportation is headed once connected and autonomous vehicles are here and prepare accordingly
        i. Don't expect connected and autonomous vehicles to be in the majority in the next 10 years
    w. Train at least one employee in each office to be a GIS expert

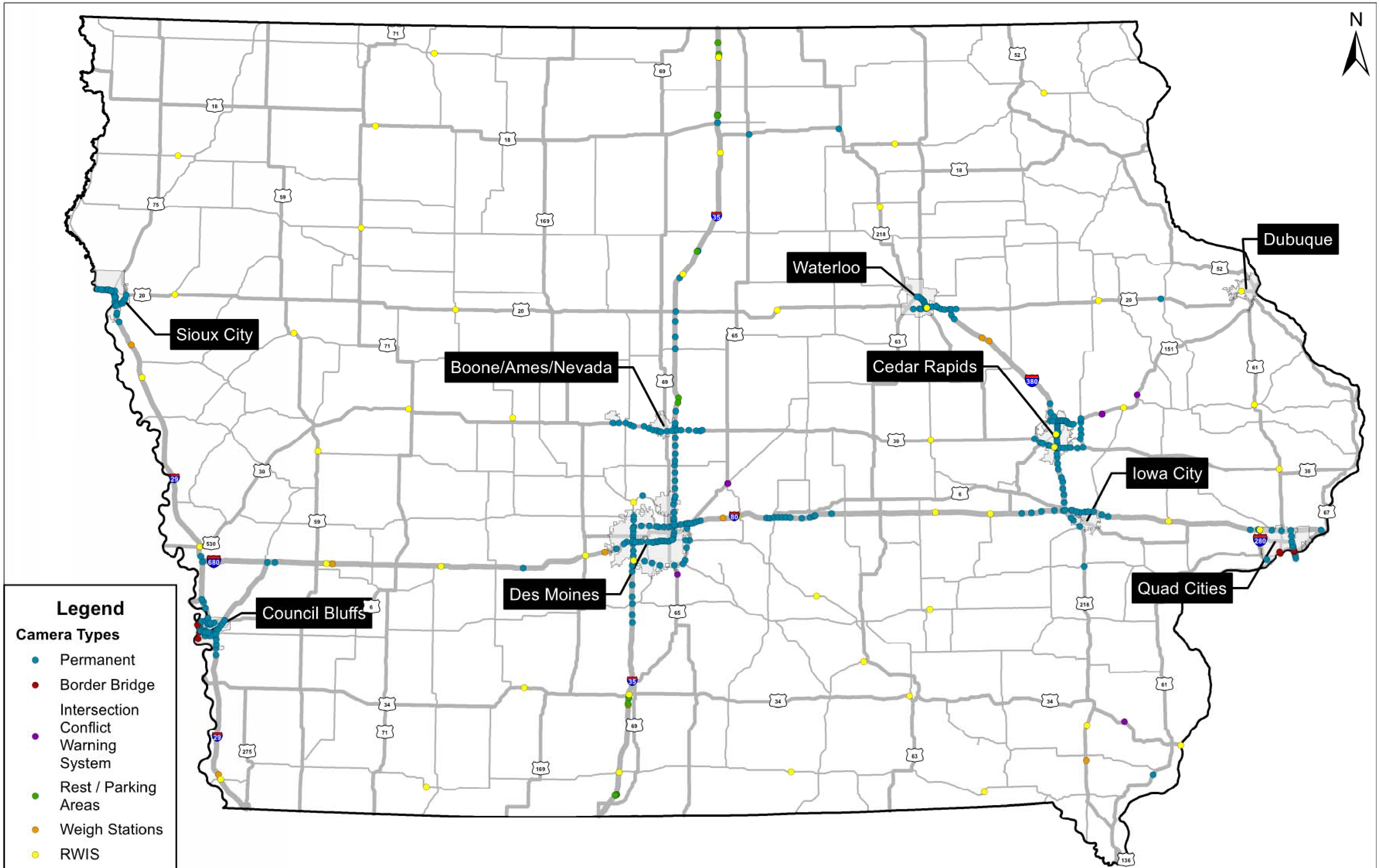
4) Iowa DOT's 511
    a. The phone application should be revamped so travelers do not have to zoom in to see the roadways
        i. Consider moving away from a specific DOT application and instead partnering with third party applications and provide data to them (Google, Here, Waze)
        ii. People utilize their phone GIS applications and rarely check the computer when traveling

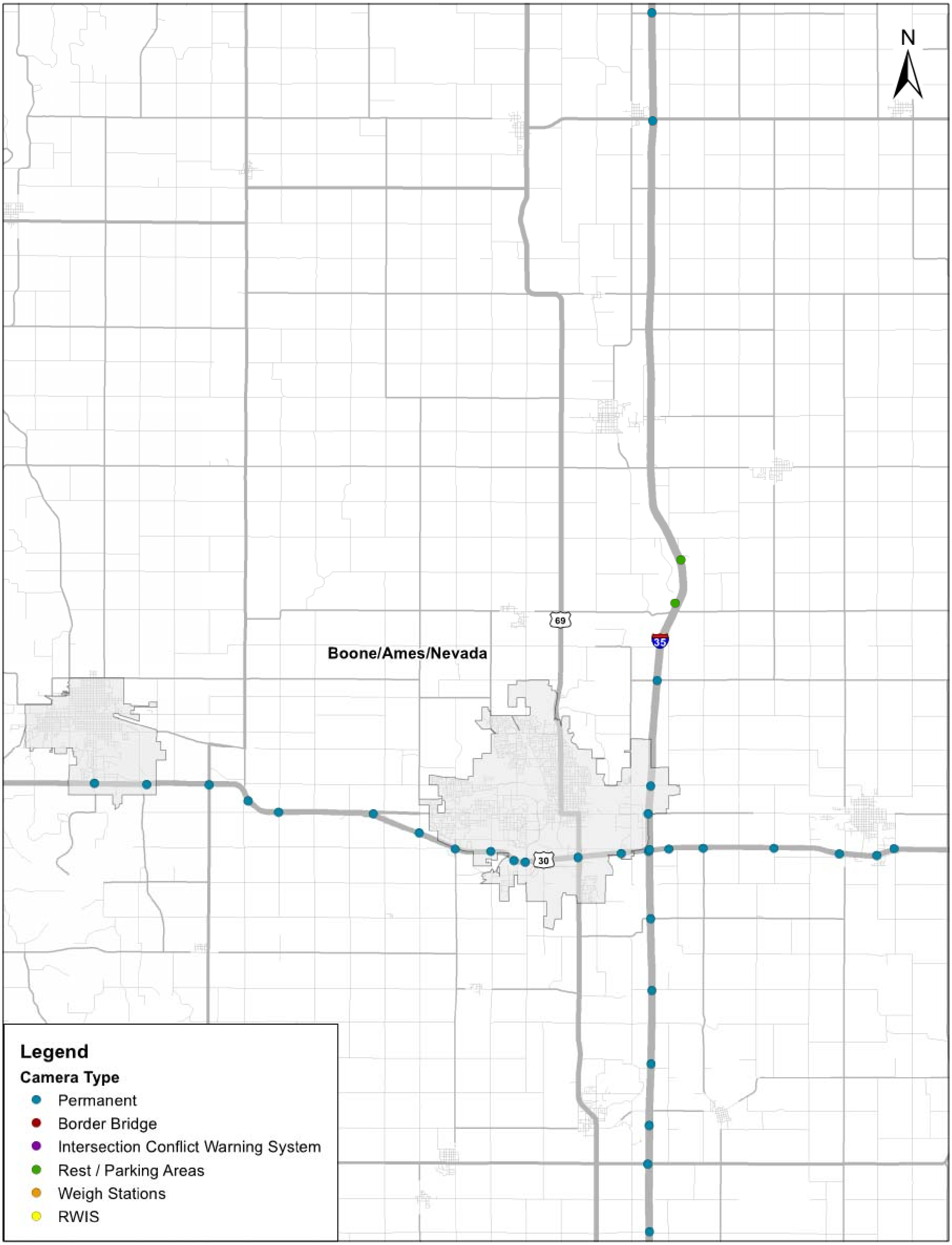
5) Technologies that have been less successful
    a. Nighttime camera views
    b. HAR
    c. Ramp gates
    d. Email alerts (sometimes too much)
    e. Over-sensitive speed detection

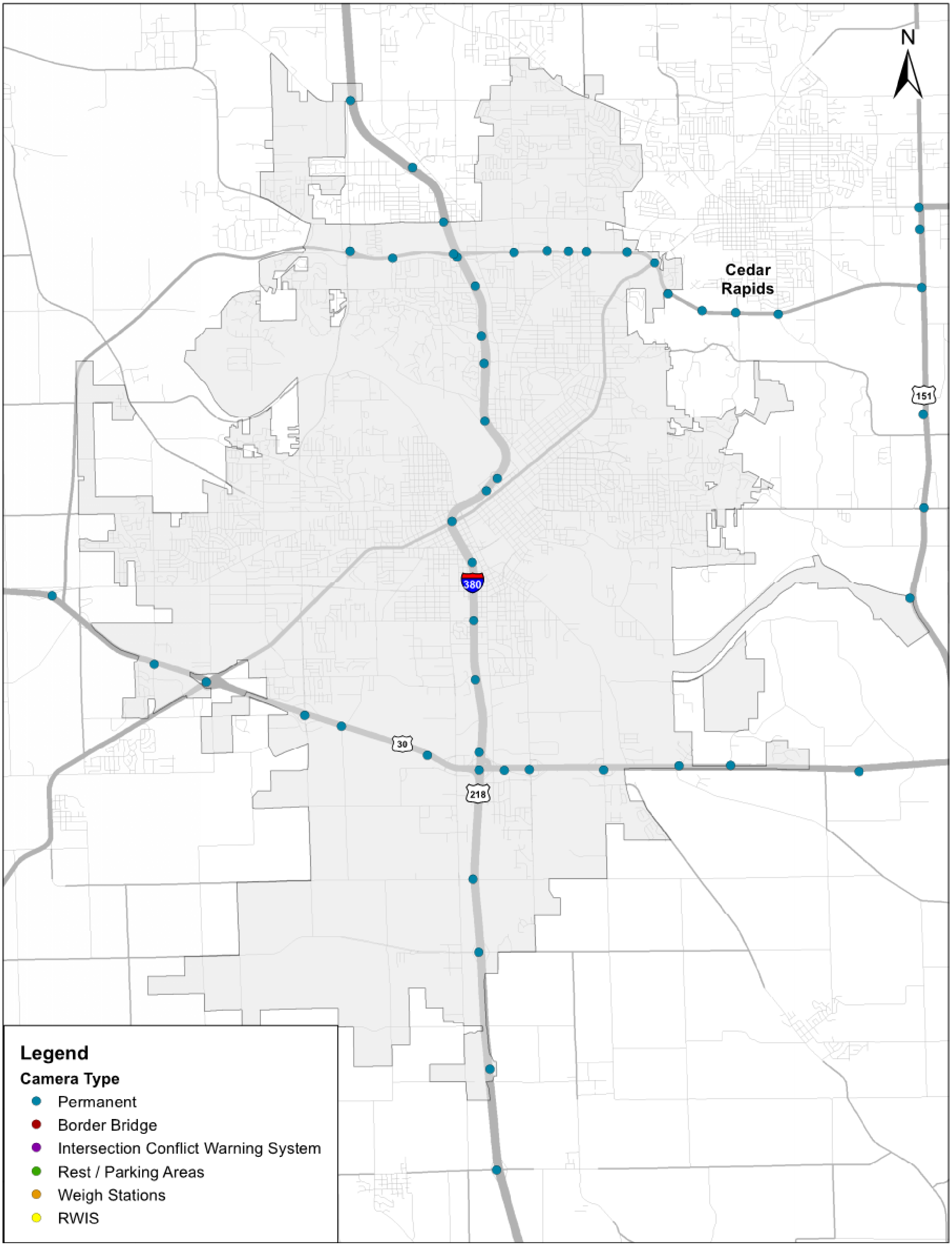
Action Items:

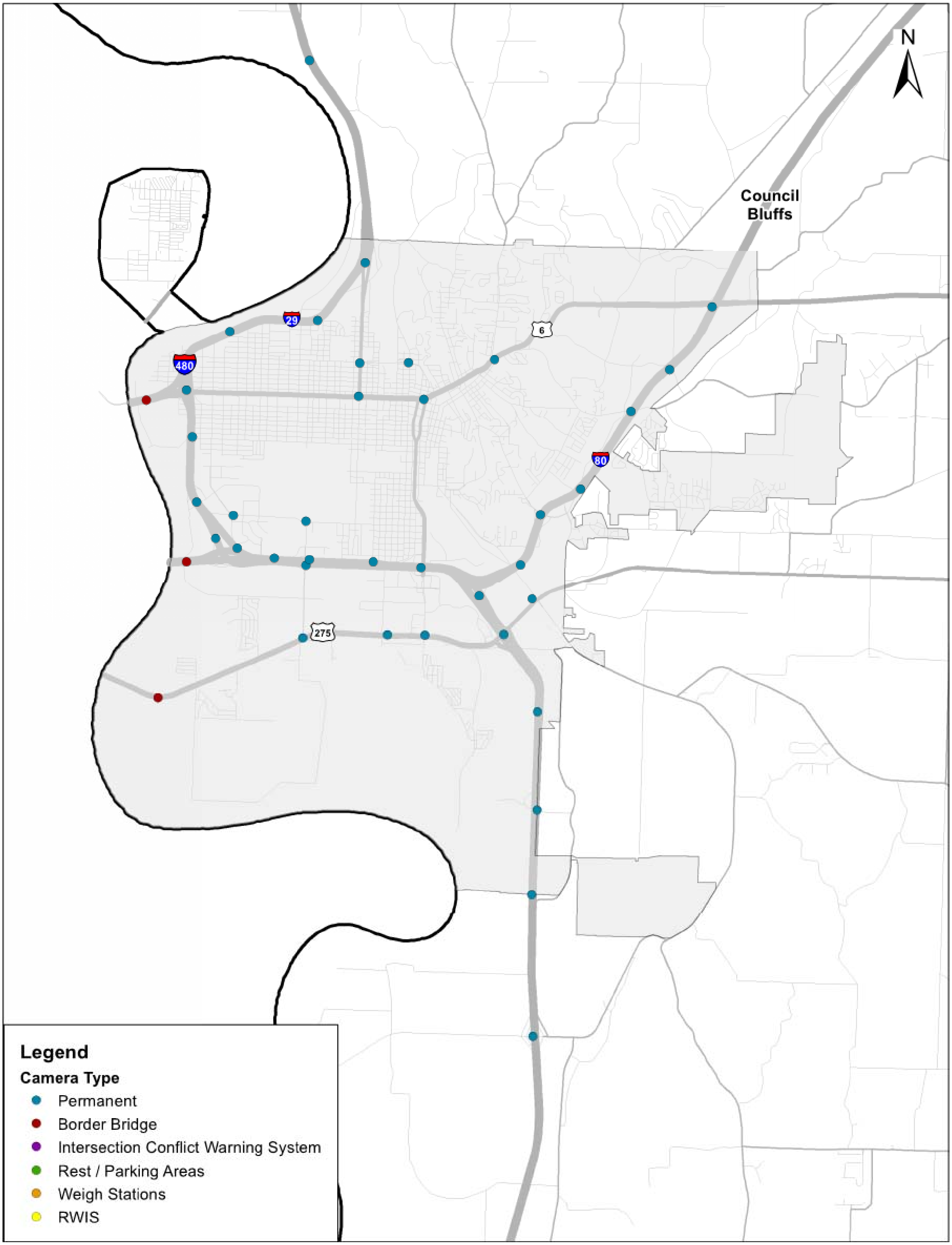
1) Time should be scheduled where different department should get together to brainstorm and innovate how to use the data that is being collected.

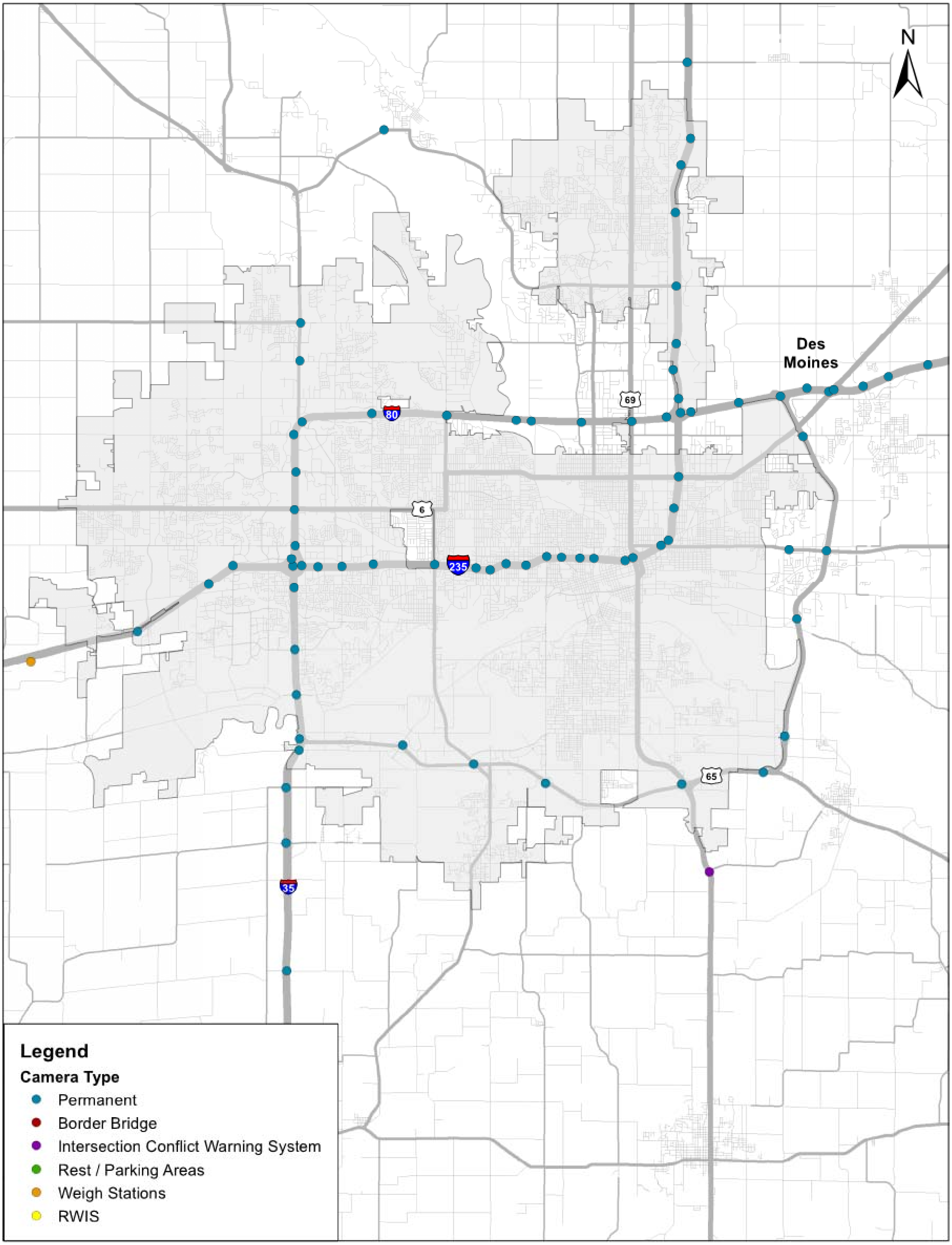
APPENDIX B. EXISTING CONDITIONS DETAILED MAPS

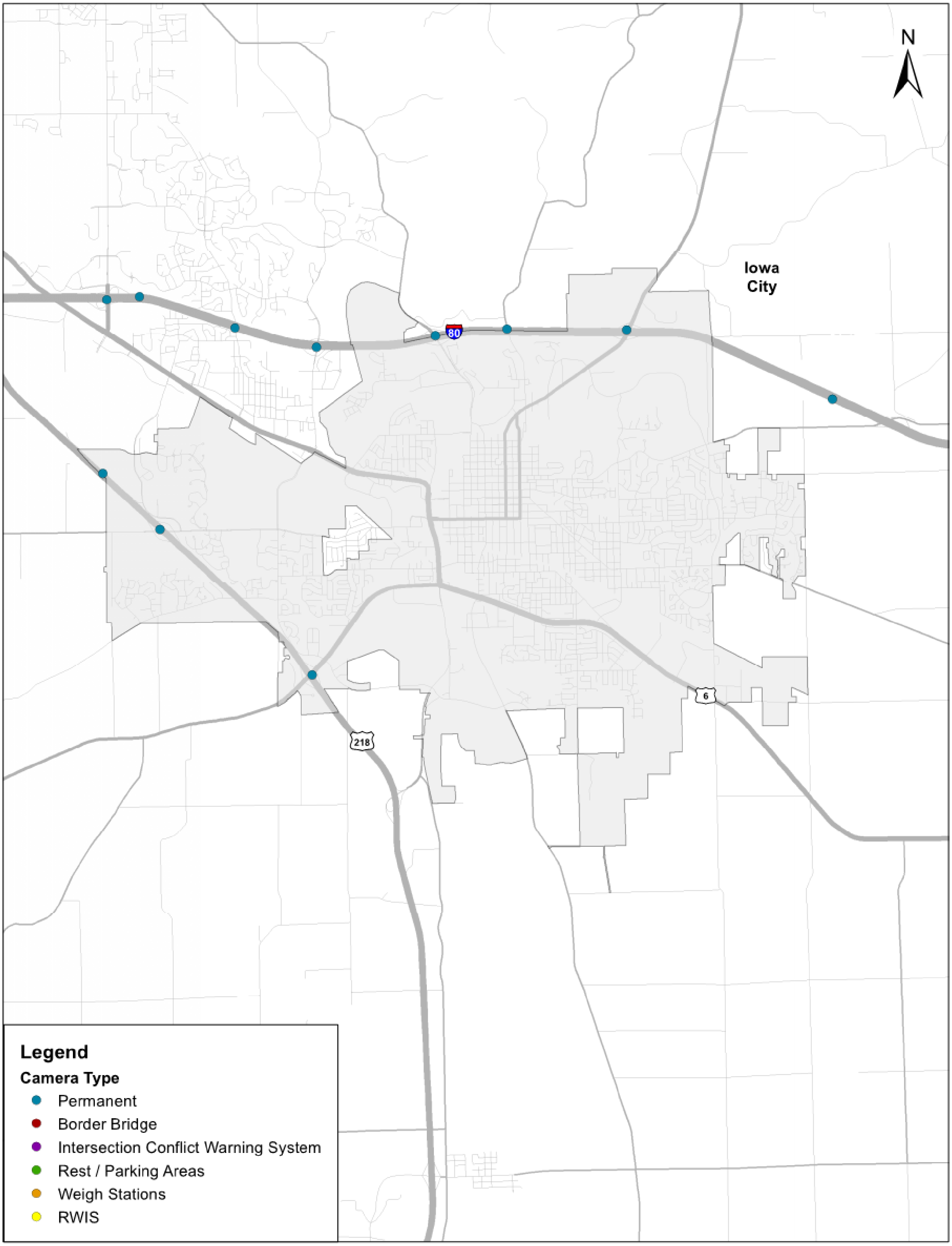

N
Dubuque
Waterloo
Sioux City
Boone/Ames/Nevada
Cedar Rapids
Iowa City
Des Moines
Council Bluffs
Quad Cities
Legend
Camera Types
Permanent
Border Bridge
Intersection Conflict Warning System
Rest / Parking Areas
Weigh Stations
RWIS

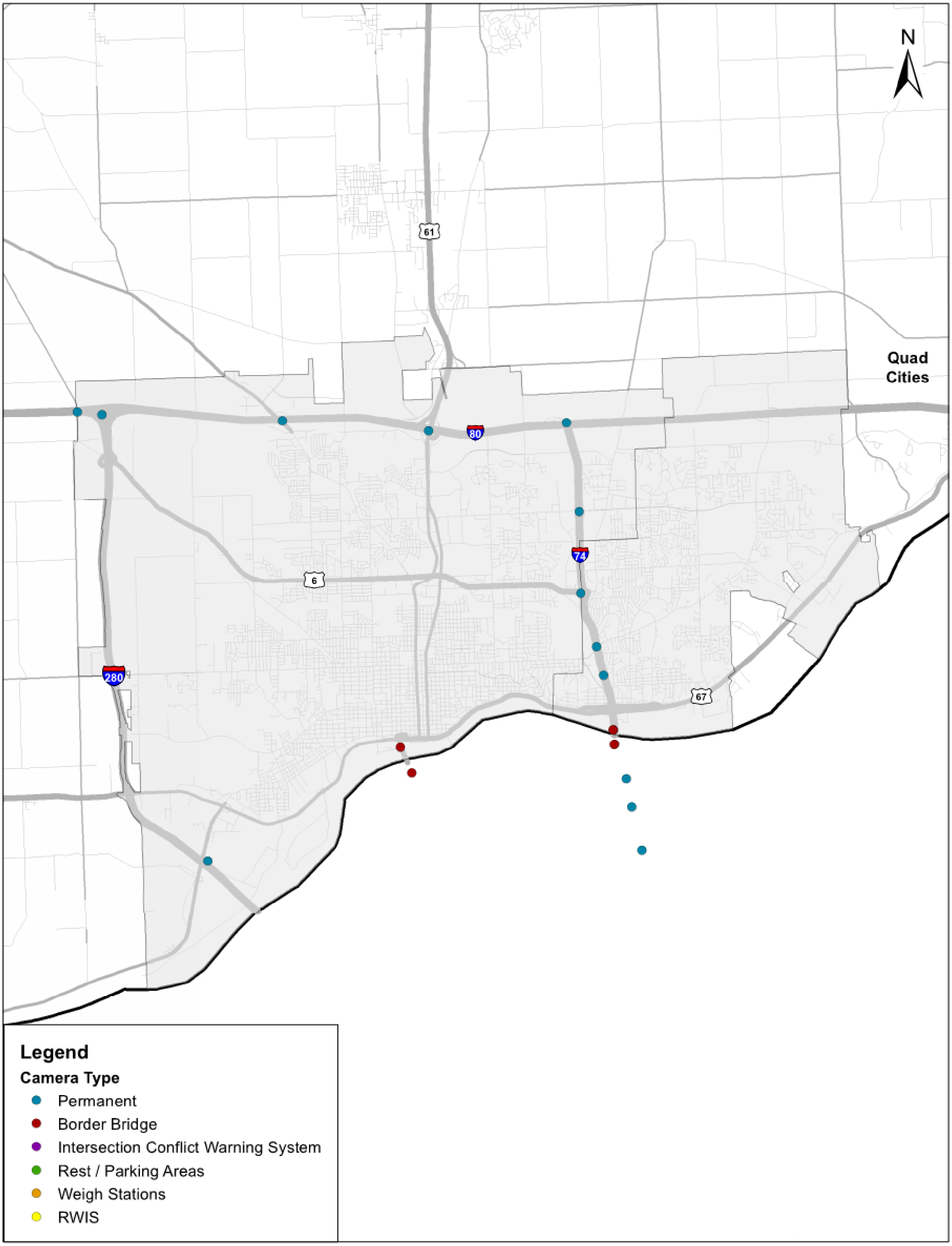

N
69
35
Boone/Ames/Nevada
30
Legend
Camera Type
Permanent
Border Bridge
Intersection Conflict Warning System
Rest / Parking Areas
Weigh Stations
RWIS

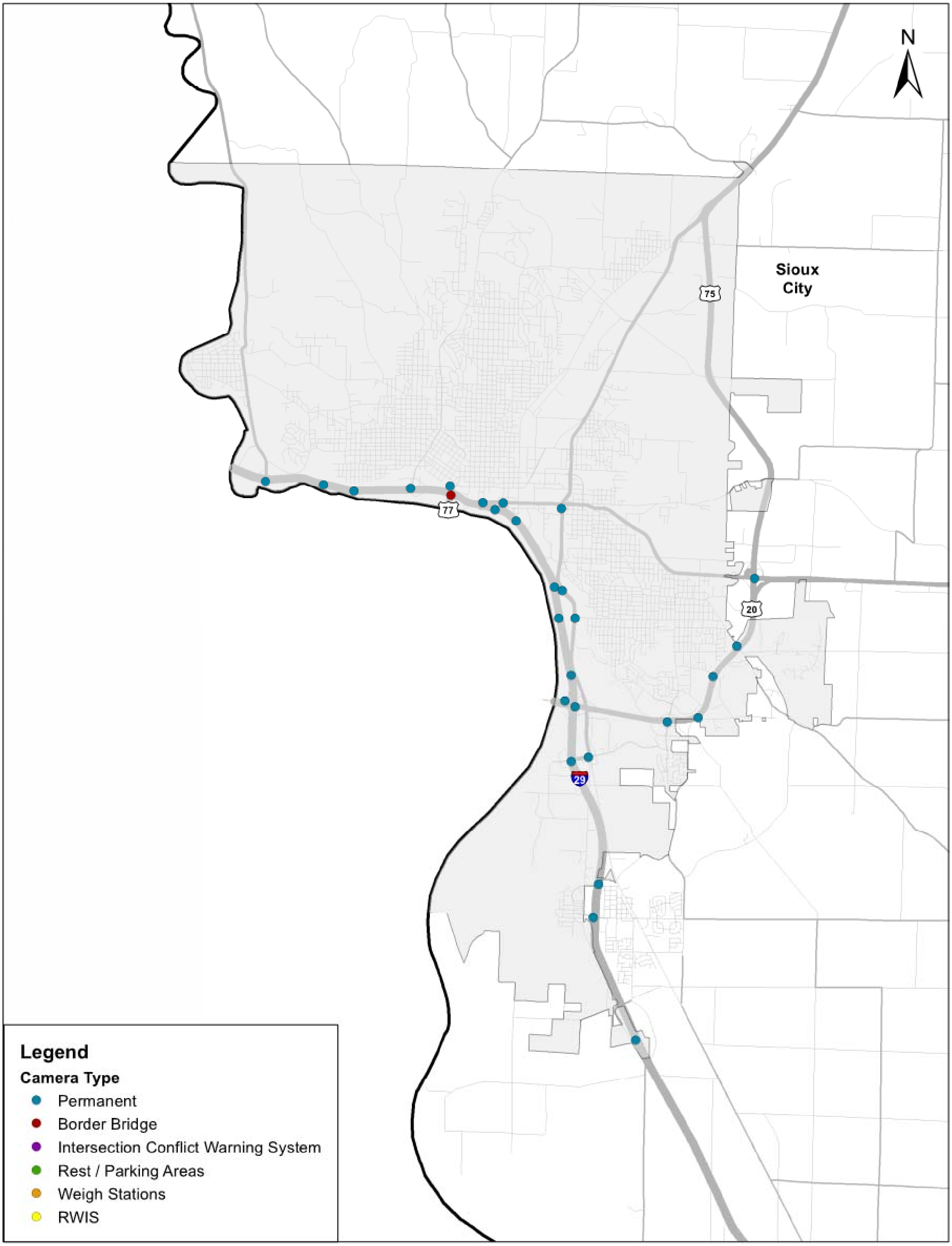

N
Cedar
Rapids
151
380
30
218
Legend
Camera Type
Permanent
Border Bridge
Intersection Conflict Warning System
Rest / Parking Areas
Weigh Stations
RWIS

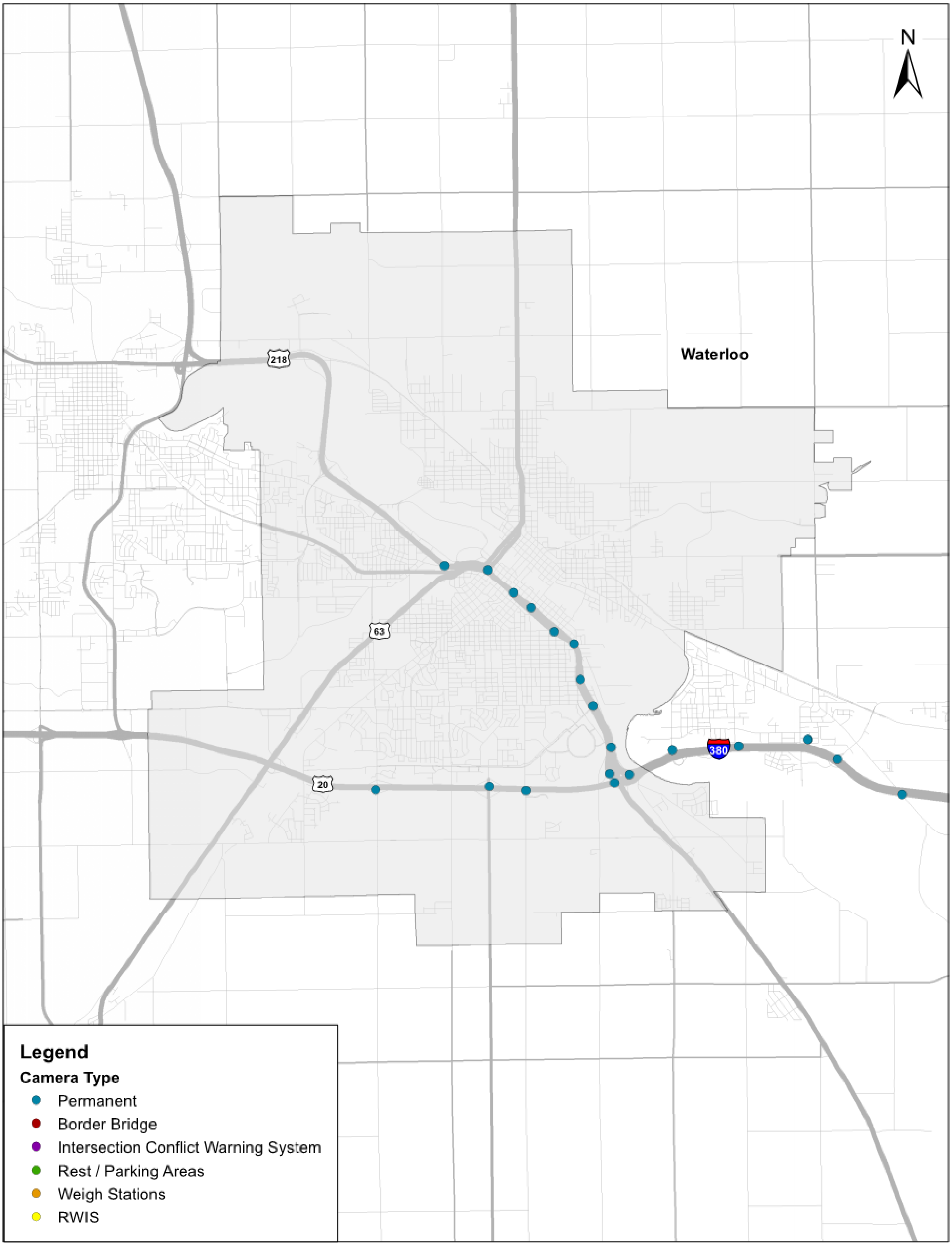

N
Council Bluffs
29
480
6
80
275
Legend
Camera Type
Permanent
Border Bridge
Intersection Conflict Warning System
Rest / Parking Areas
Weigh Stations
RWIS

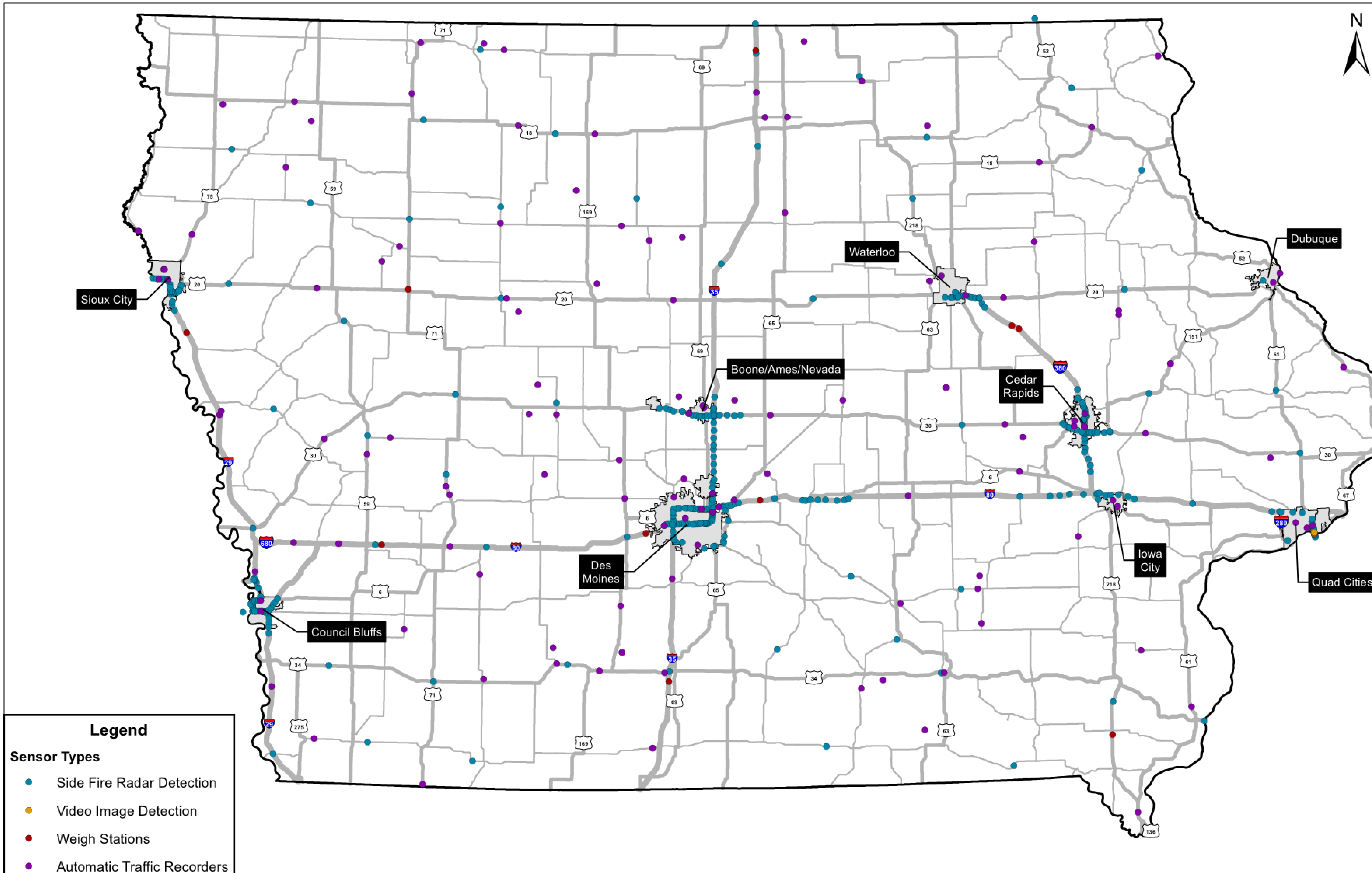

N
Des Moines
80
69
6
235
65
35
Legend
Camera Type
Permanent
Border Bridge
Intersection Conflict Warning System
Rest / Parking Areas
Weigh Stations
RWIS

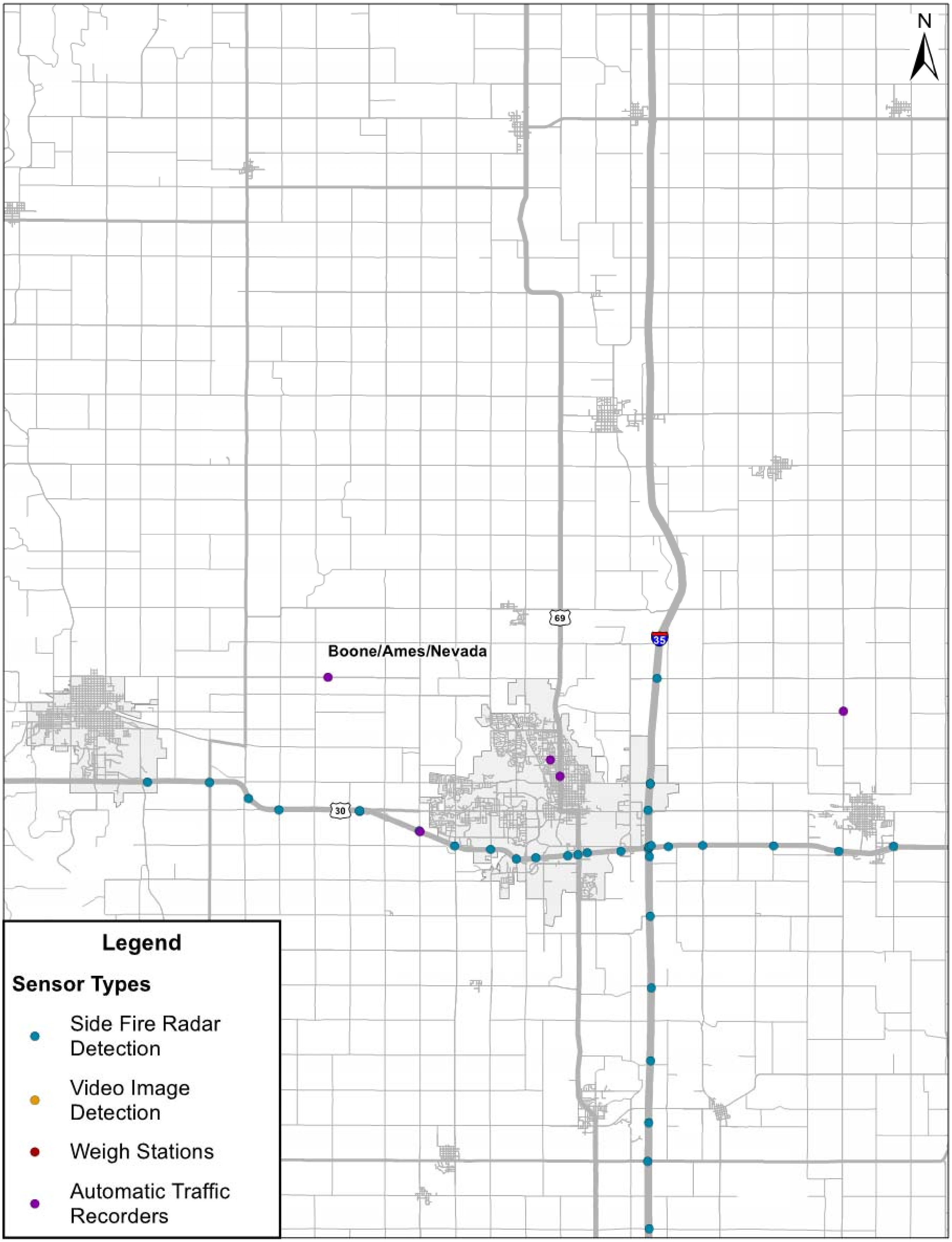

N
Iowa
City
80
218
6
Legend
Camera Type
Permanent
Border Bridge
Intersection Conflict Warning System
Rest / Parking Areas
Weigh Stations
RWIS

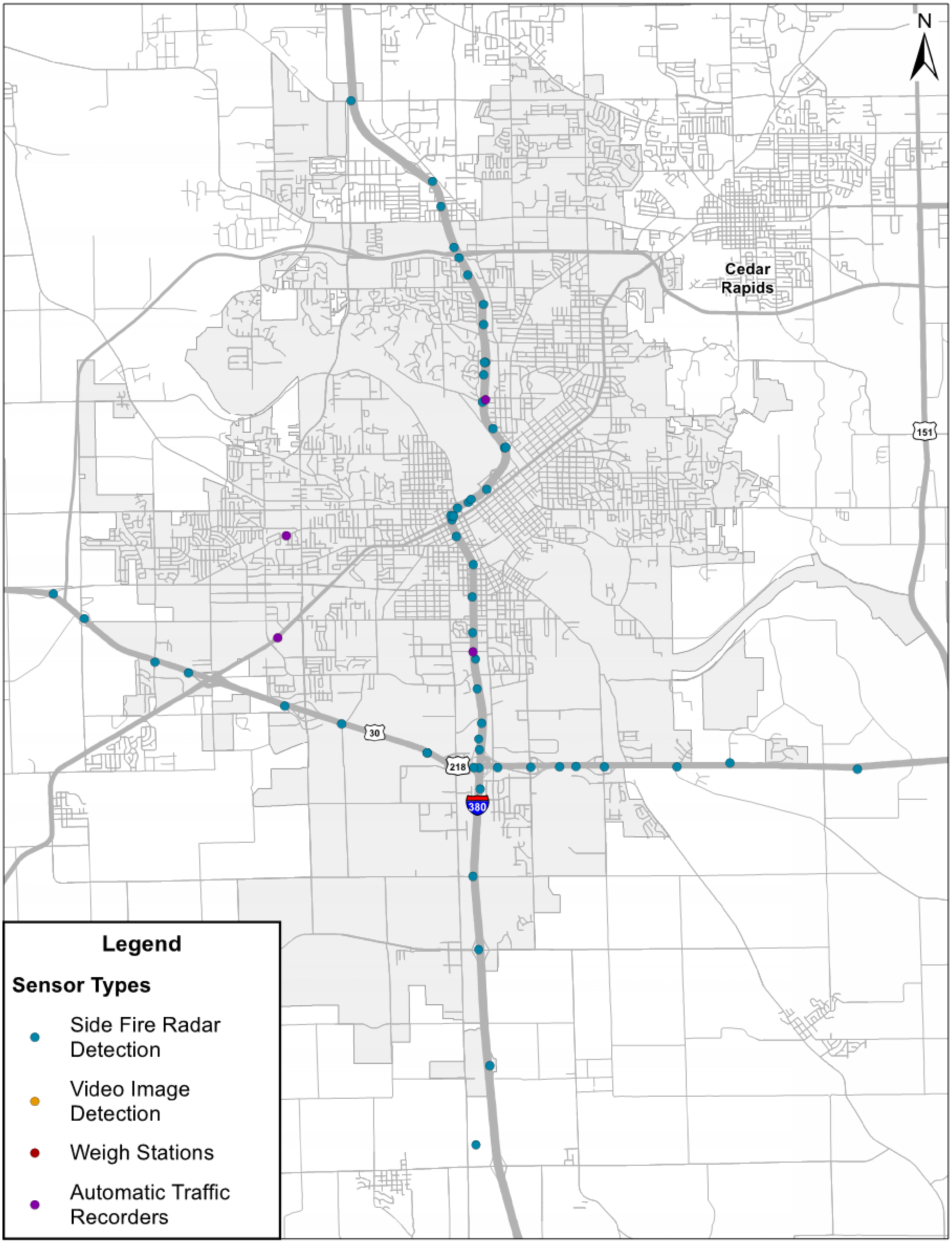

N
Quad
Cities
61
80
74
6
280
67
Legend
Camera Type
Permanent
Border Bridge
Intersection Conflict Warning System
Rest / Parking Areas
Weigh Stations
RWIS

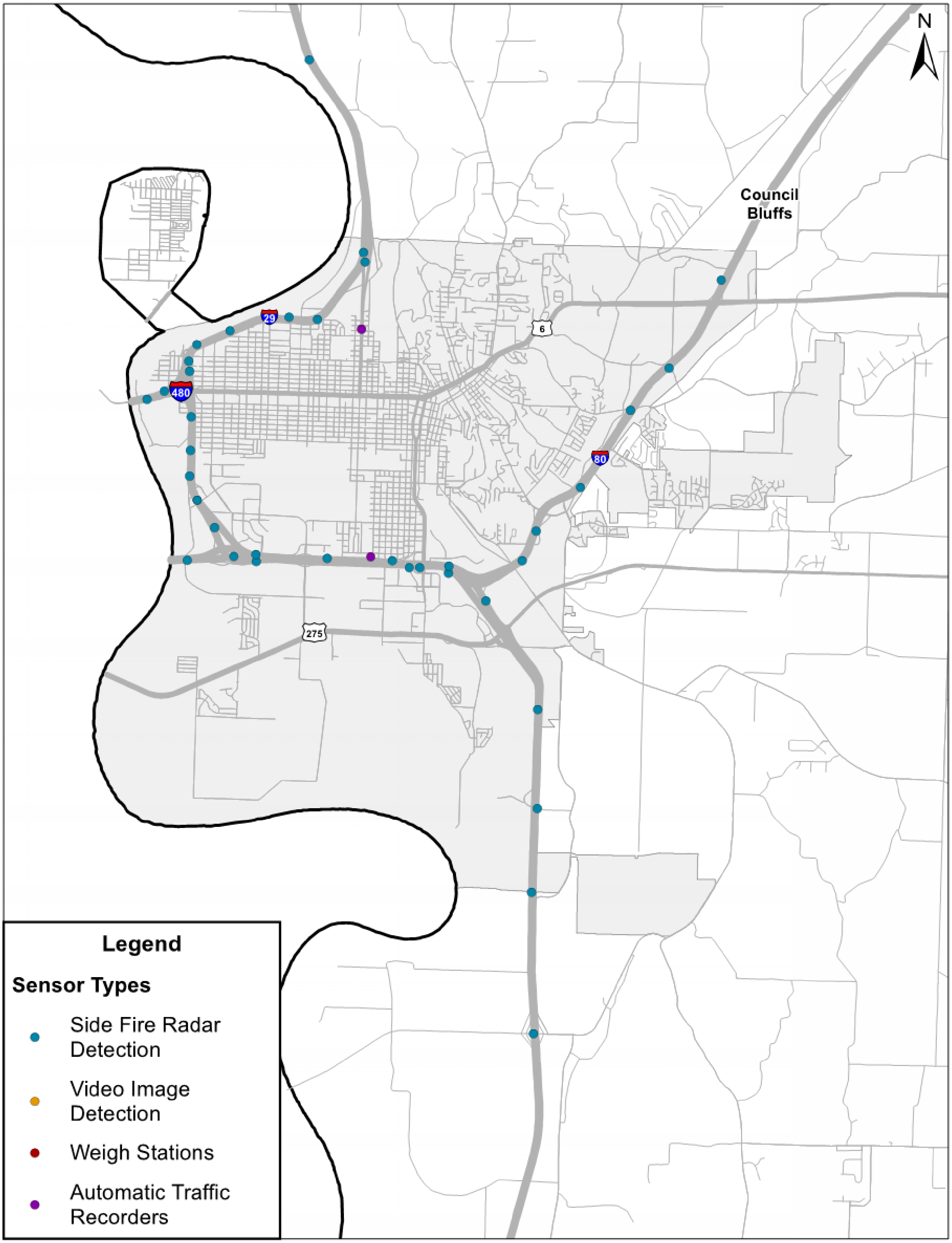

N
Sioux City
75
77
20
29
Legend
Camera Type
Permanent
Border Bridge
Intersection Conflict Warning System
Rest / Parking Areas
Weigh Stations
RWIS

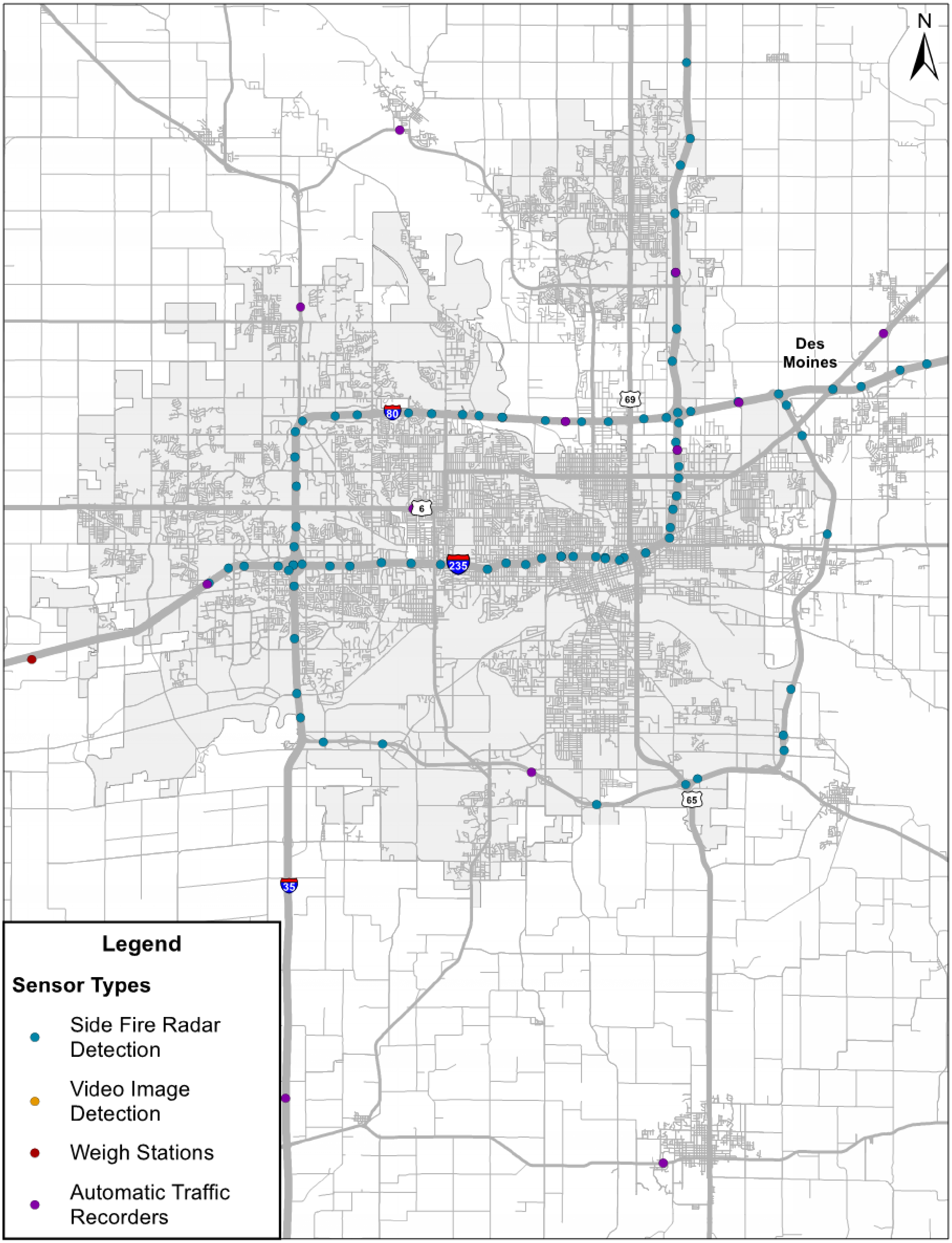

N
Waterloo
218
63
20
380
Legend
Camera Type
Permanent
Border Bridge
Intersection Conflict Warning System
Rest / Parking Areas
Weigh Stations
RWIS

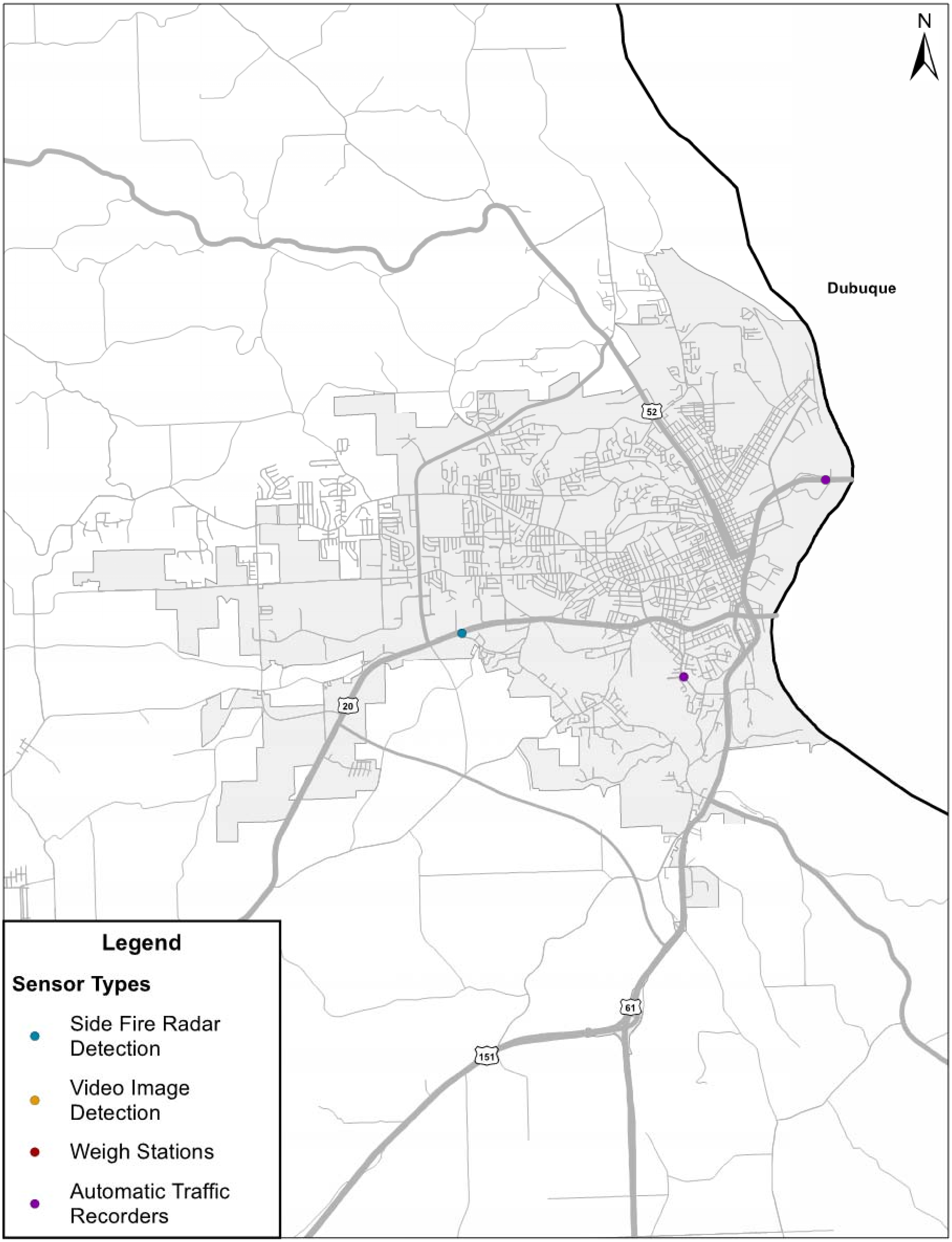

N
Sioux City
Waterloo
Dubuque
Boone/Ames/Nevada
Cedar Rapids
Des Moines
Iowa City
Quad Cities
Council Bluffs
Legend
Sensor Types
Side Fire Radar Detection
Video Image Detection
Weigh Stations
Automatic Traffic Recorders

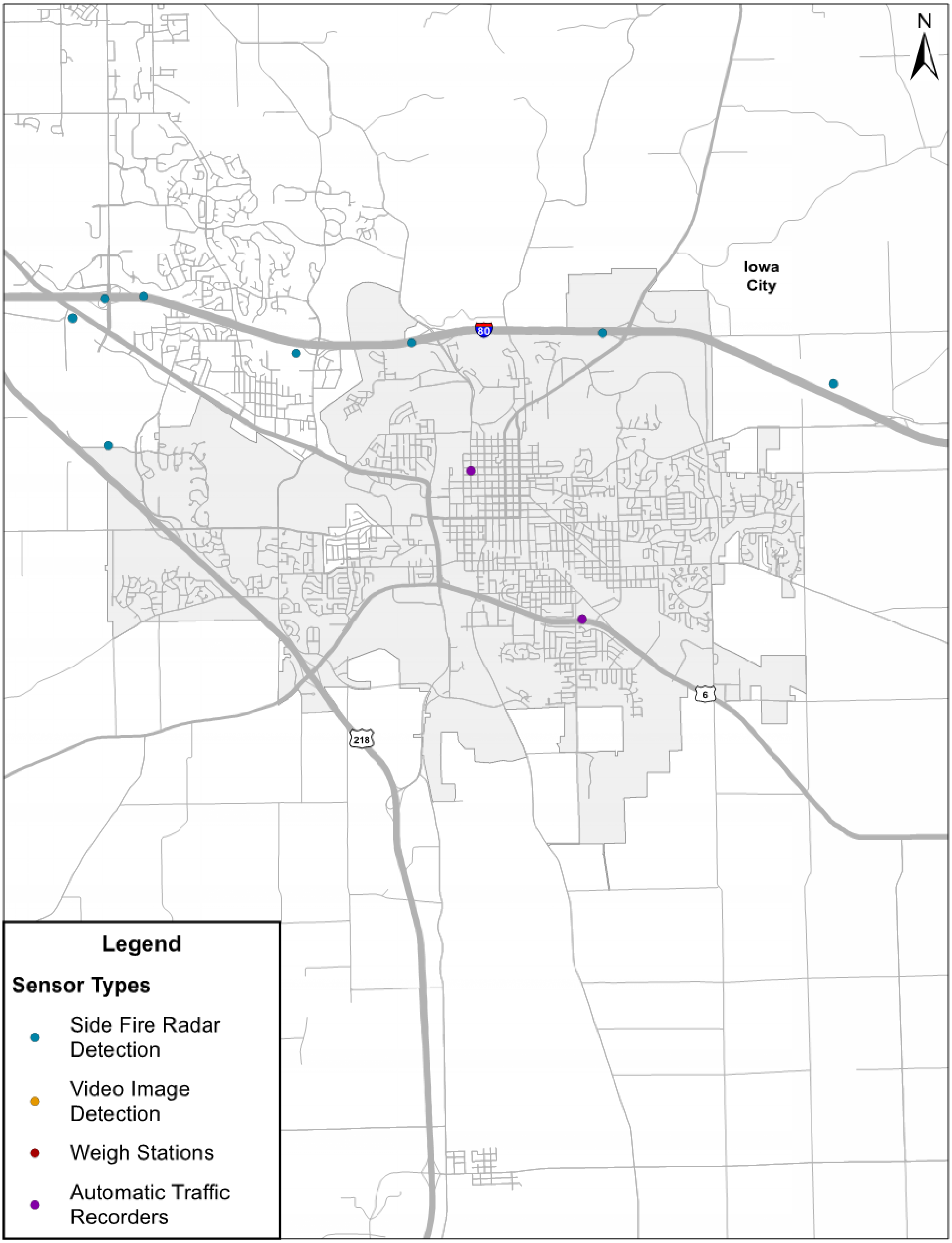

N
69
35
30
Boone/Ames/Nevada
Legend
Sensor Types
Side Fire Radar Detection
Video Image Detection
Weigh Stations
Automatic Traffic Recorders

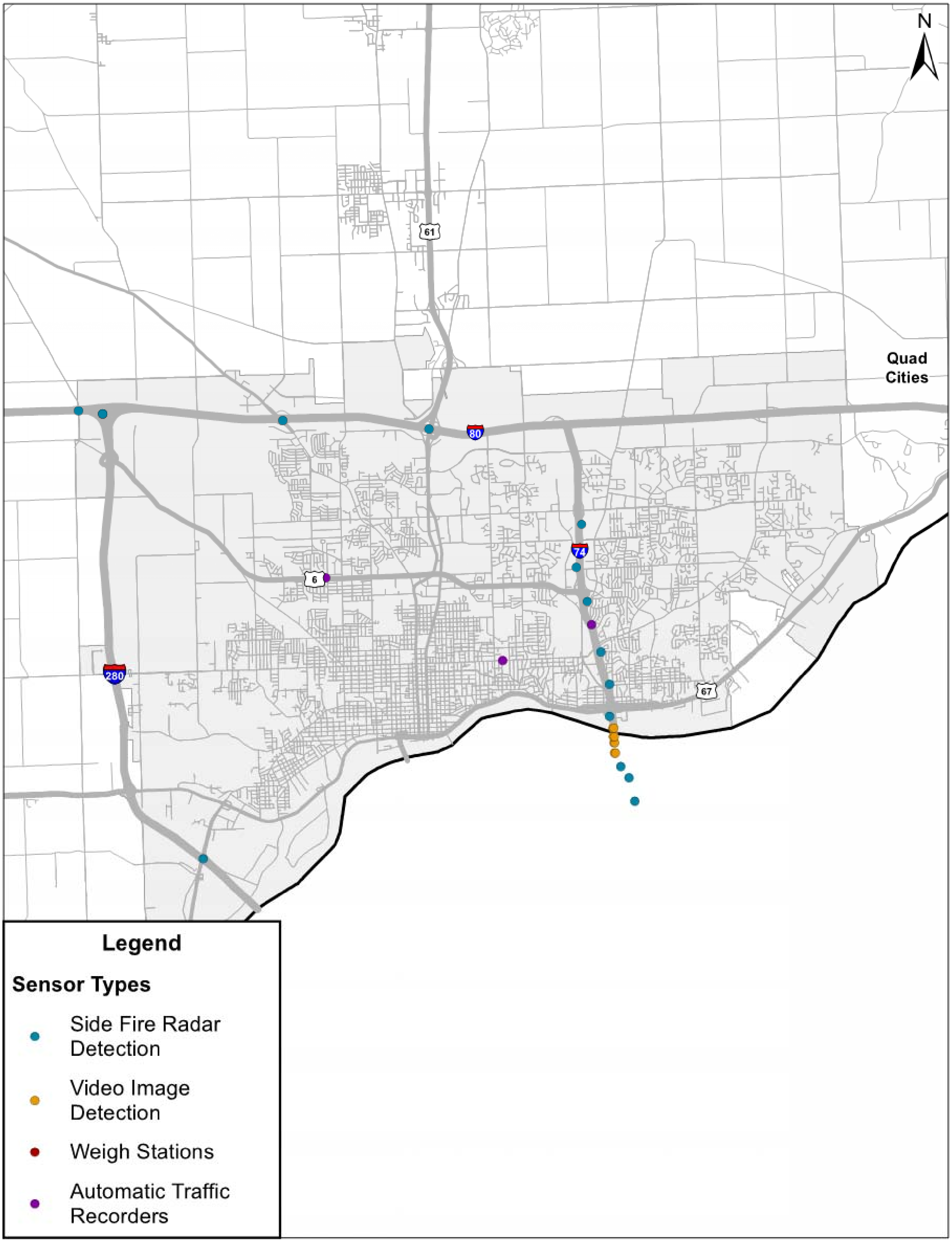

N
Cedar
Rapids
151
30
218
380
Legend
Sensor Types
Side Fire Radar
Detection
Video Image
Detection
Weigh Stations
Automatic Traffic
Recorders

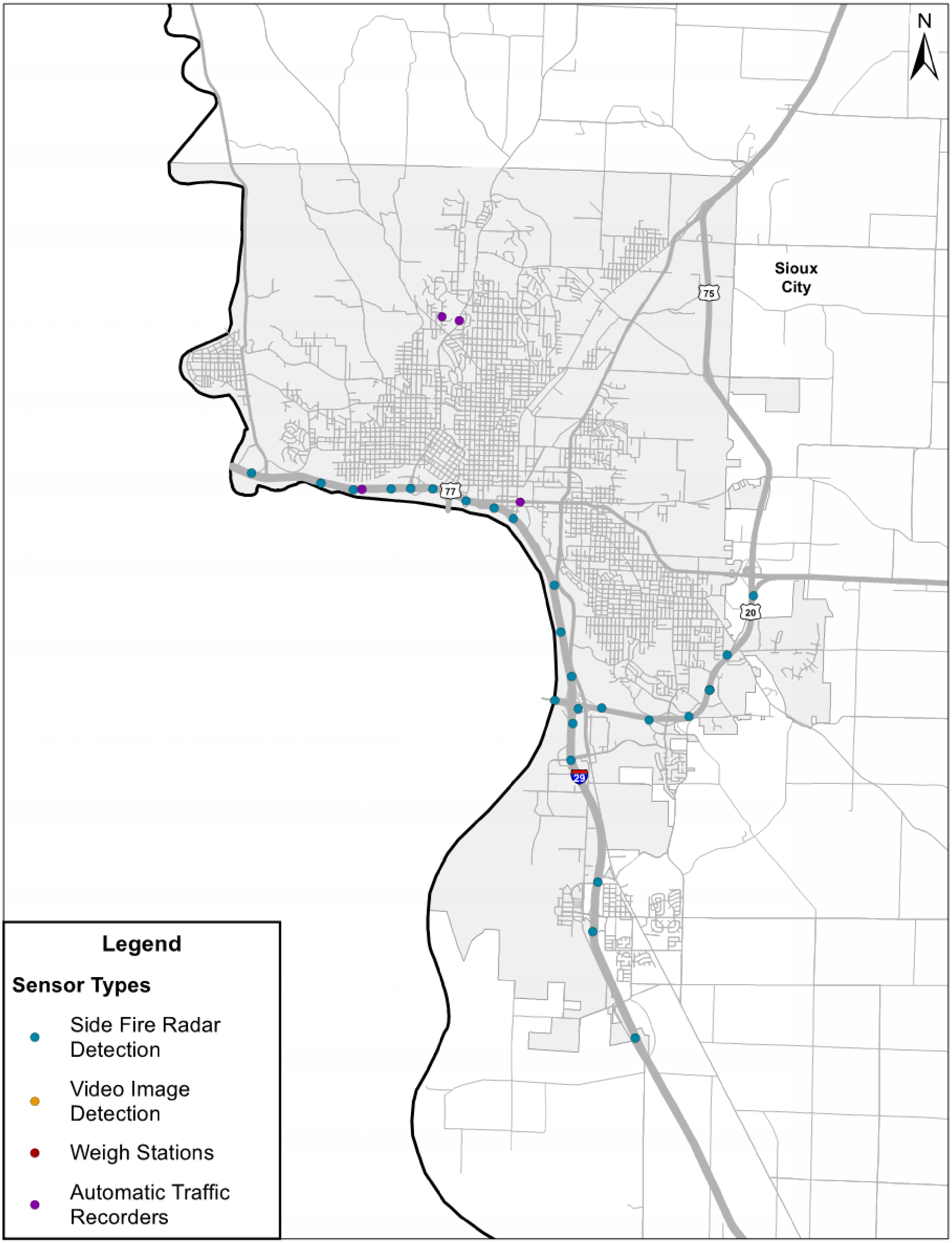

N
Council
Bluffs
29
480
80
6
275
Legend
Sensor Types
Side Fire Radar Detection
Video Image Detection
Weigh Stations
Automatic Traffic Recorders

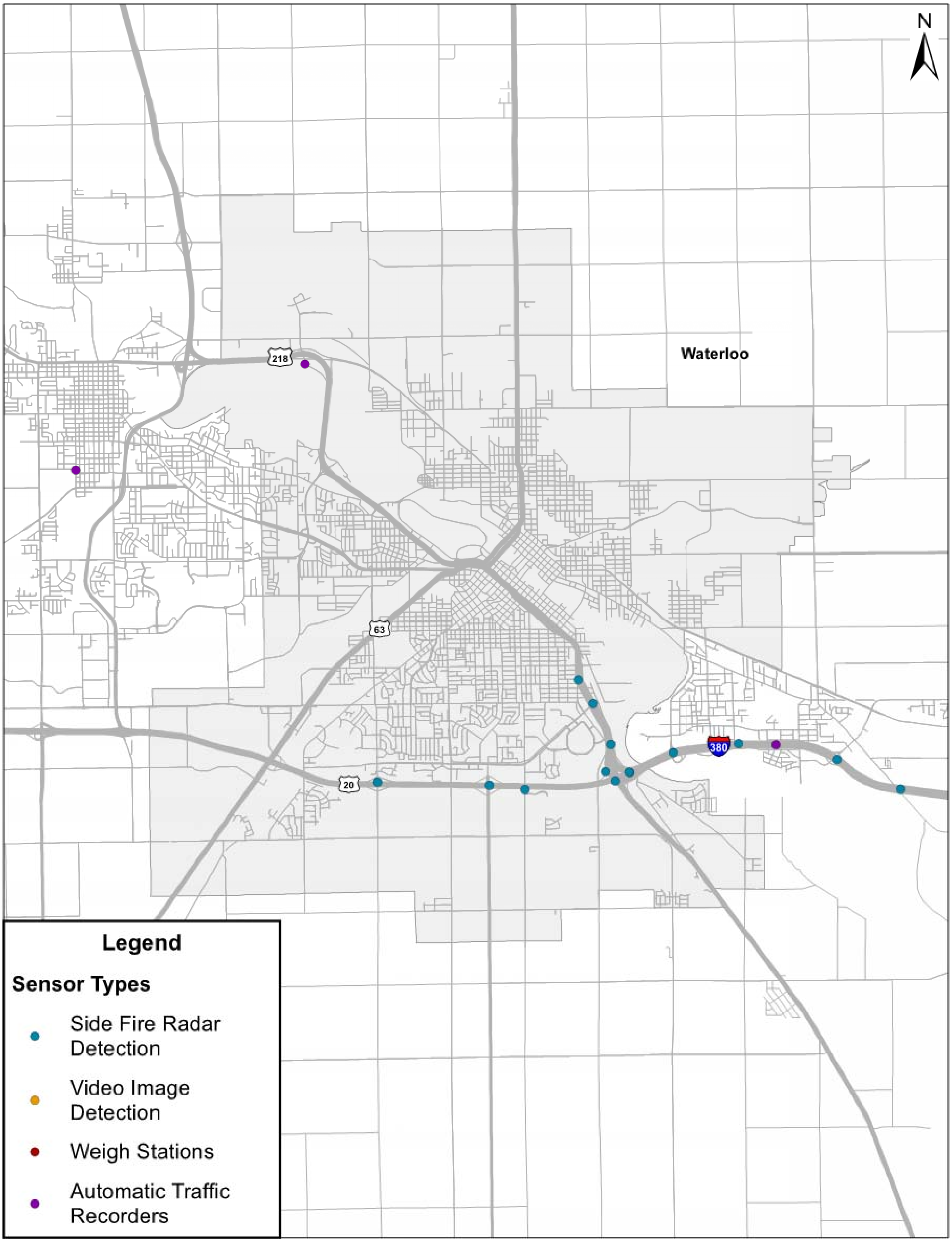

N
Des
Moines
80
69
6
235
35
65
Legend
Sensor Types
Side Fire Radar
Detection
Video Image
Detection
Weigh Stations
Automatic Traffic
Recorders

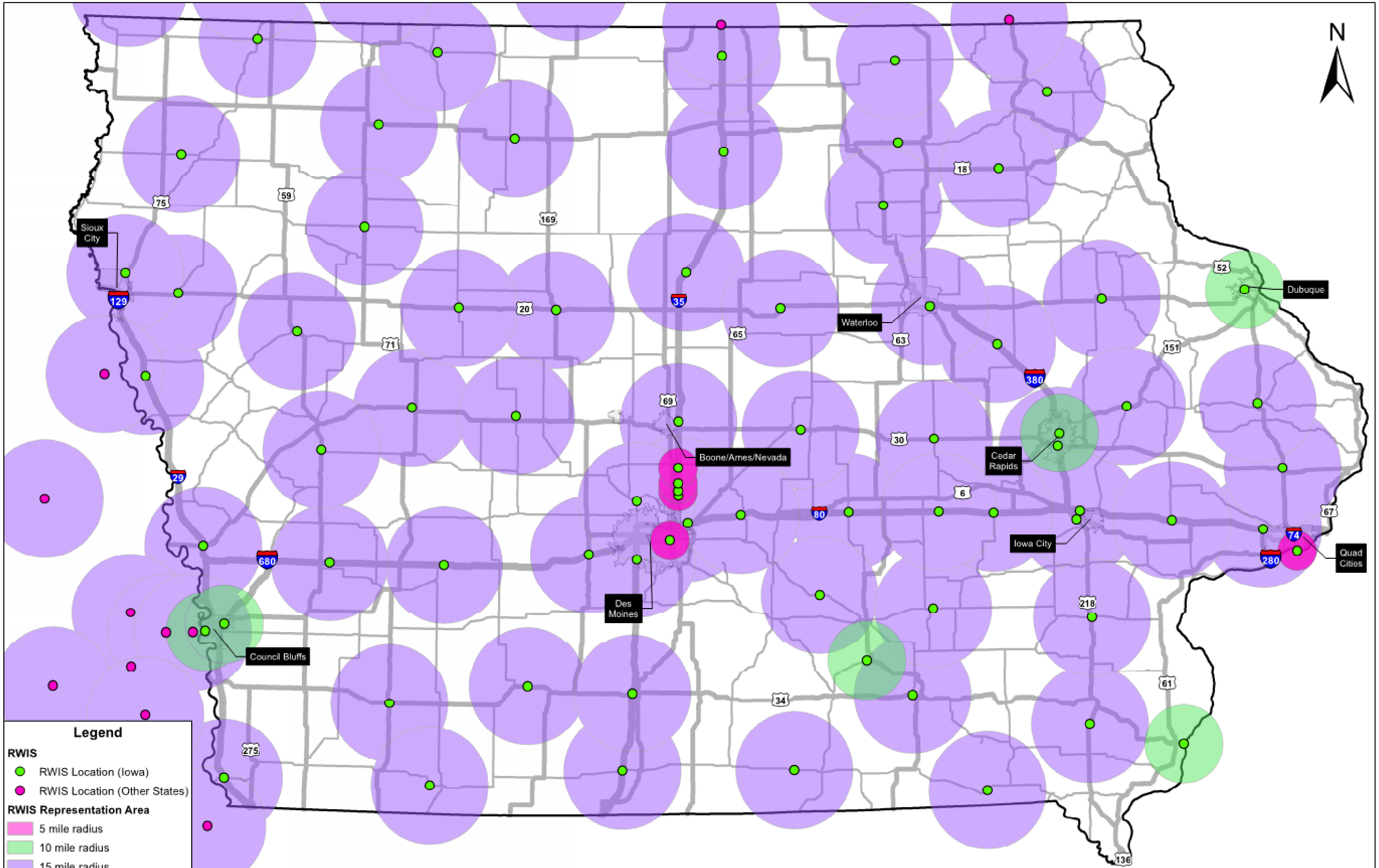

N
Dubuque
52
20
61
151
Legend
Sensor Types
Side Fire Radar Detection
Video Image Detection
Weigh Stations
Automatic Traffic Recorders

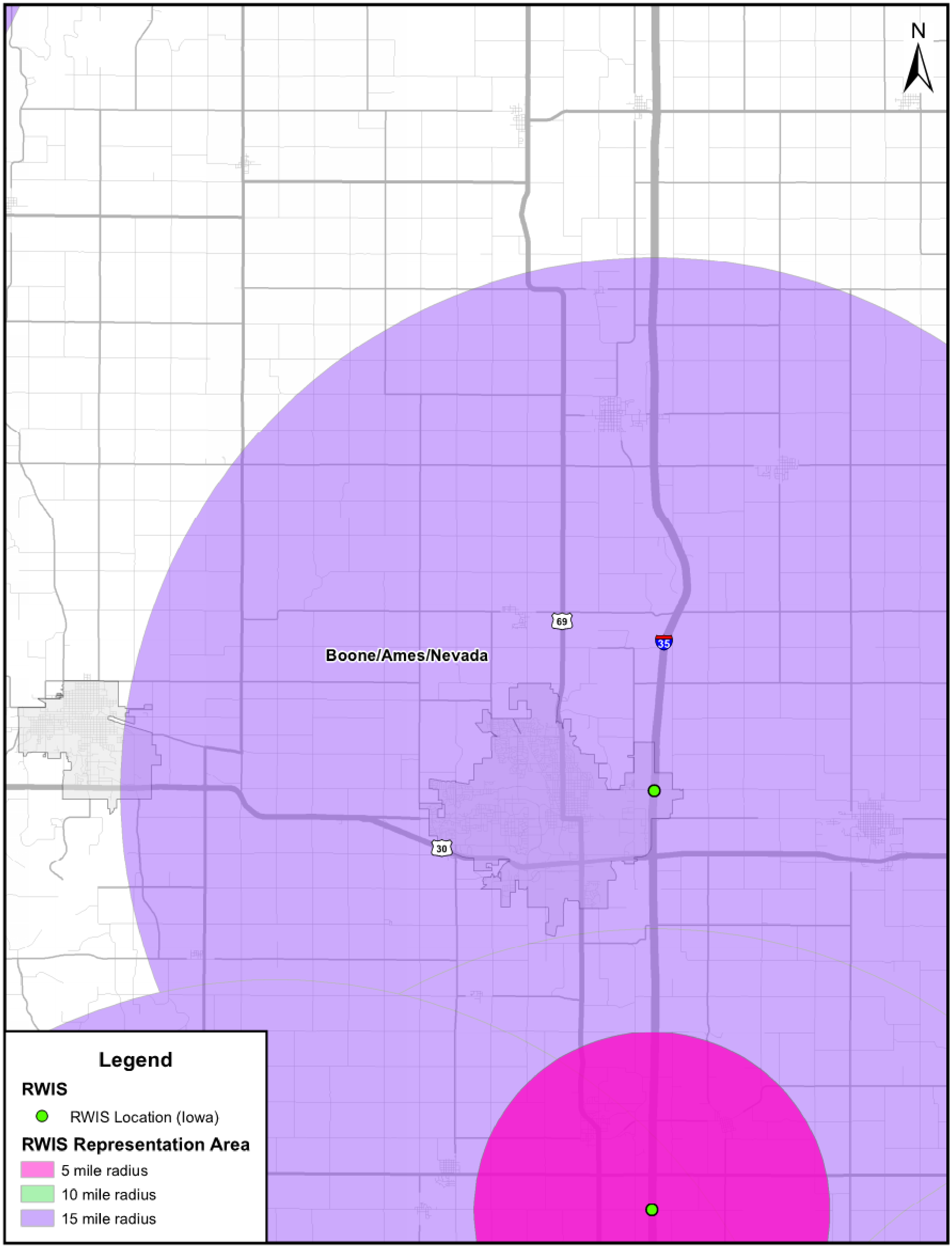

N
Iowa City
80
218
6
Legend
Sensor Types
Side Fire Radar Detection
Video Image Detection
Weigh Stations
Automatic Traffic Recorders

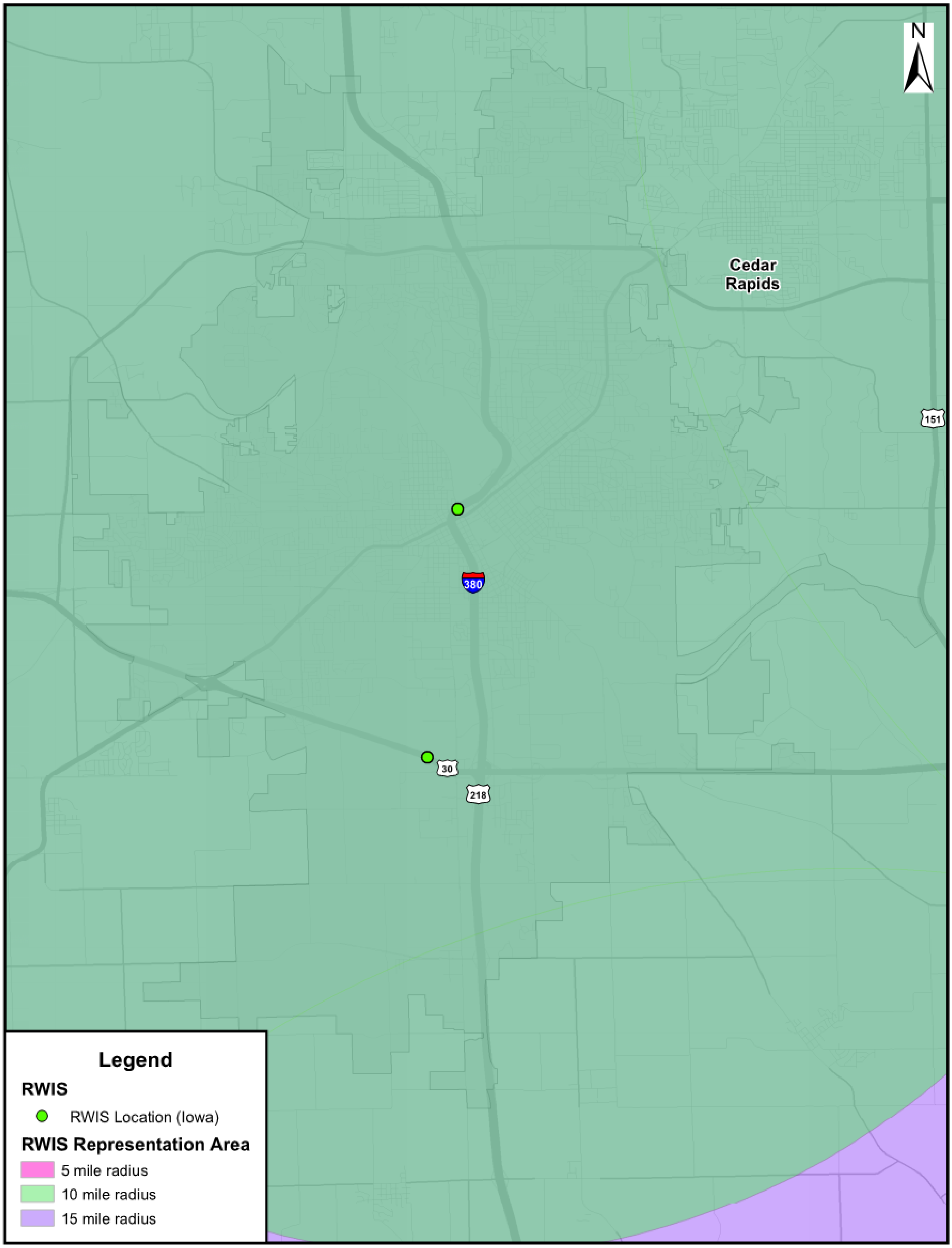

N
Quad Cities
61
80
74
6
280
67
Legend
Sensor Types
Side Fire Radar Detection
Video Image Detection
Weigh Stations
Automatic Traffic Recorders

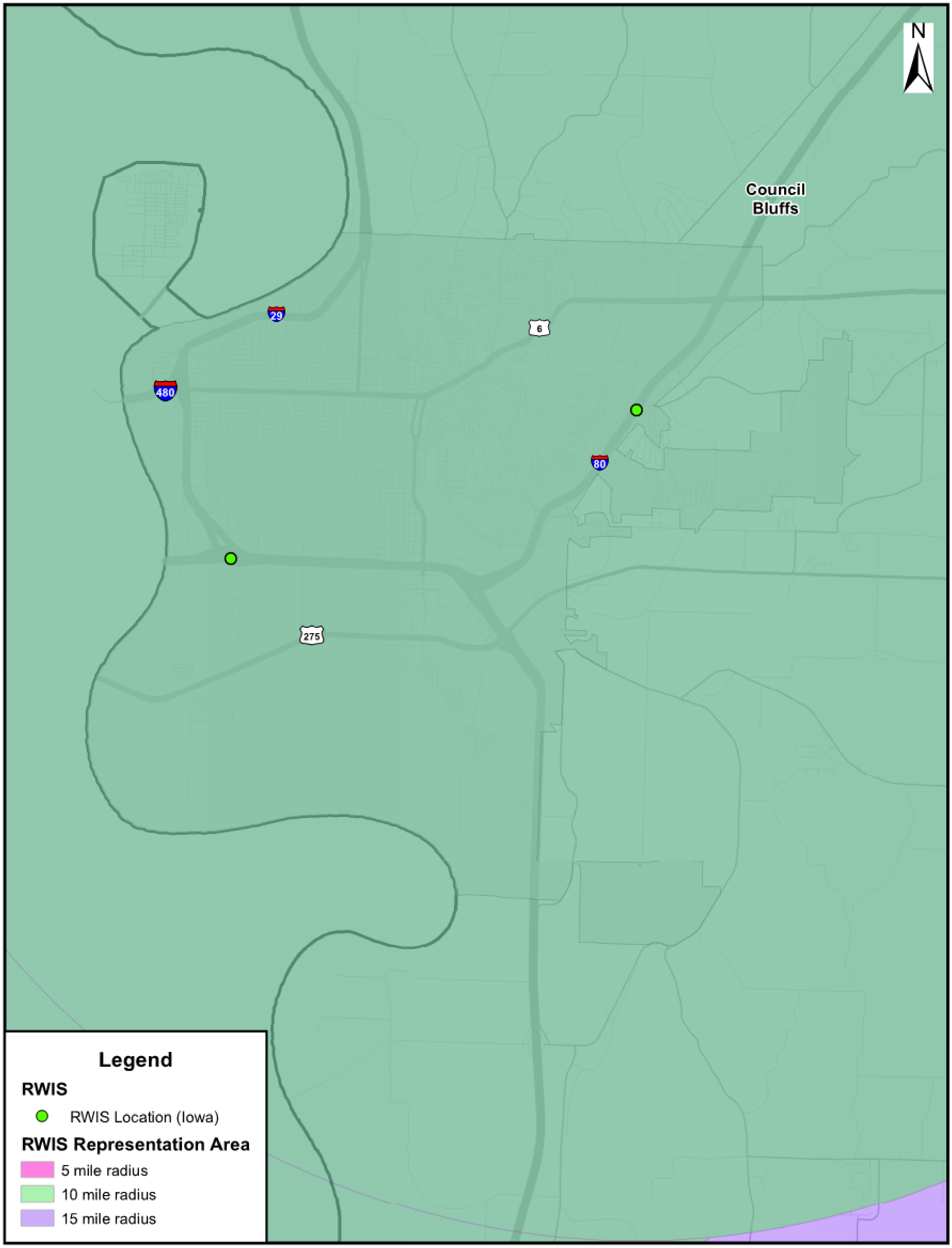

N
Sioux City
75
77
20
29
Legend
Sensor Types
Side Fire Radar Detection
Video Image Detection
Weigh Stations
Automatic Traffic Recorders

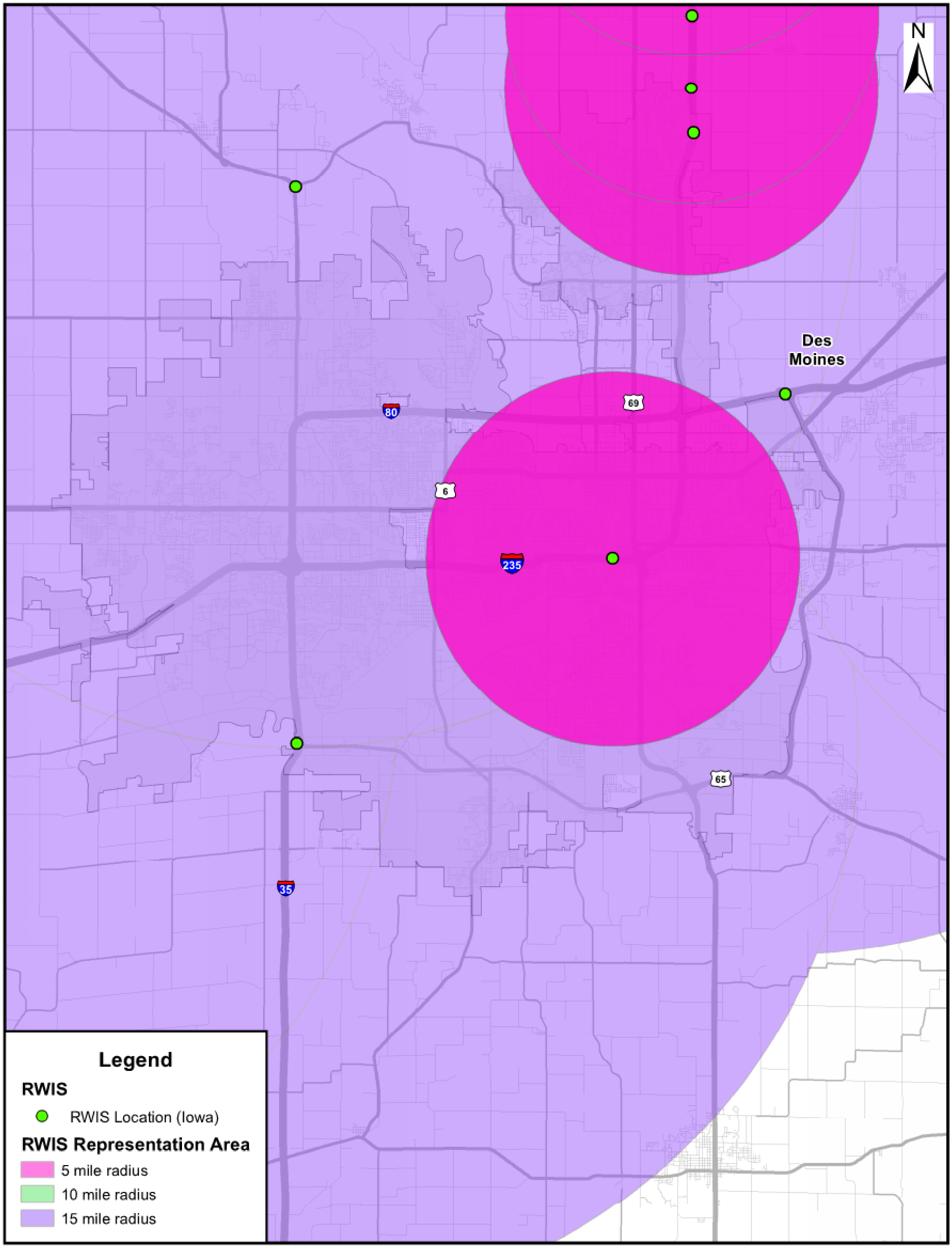

N
Waterloo
218
63
20
380
Legend
Sensor Types
Side Fire Radar Detection
Video Image Detection
Weigh Stations
Automatic Traffic Recorders

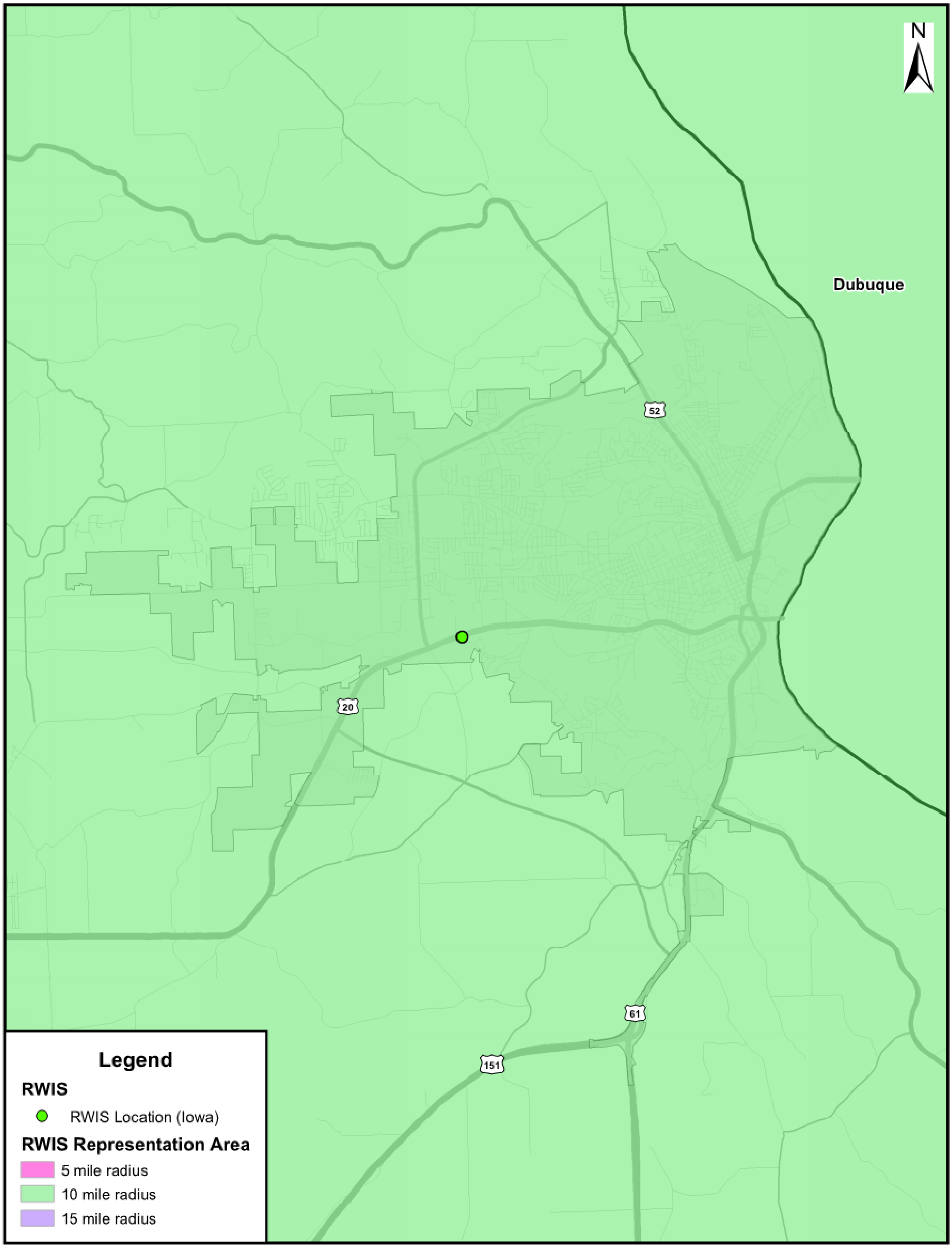

N
Sioux City
Dubuque
Waterloo
Boone/Ames/Nevada
Cedar Rapids
Iowa City
Quad Cities
Des Moines
Council Bluffs
Legend
RWIS
RWIS Location (Iowa)
RWIS Location (Other States)
RWIS Representation Area
5 mile radius
10 mile radius
15 mile radius

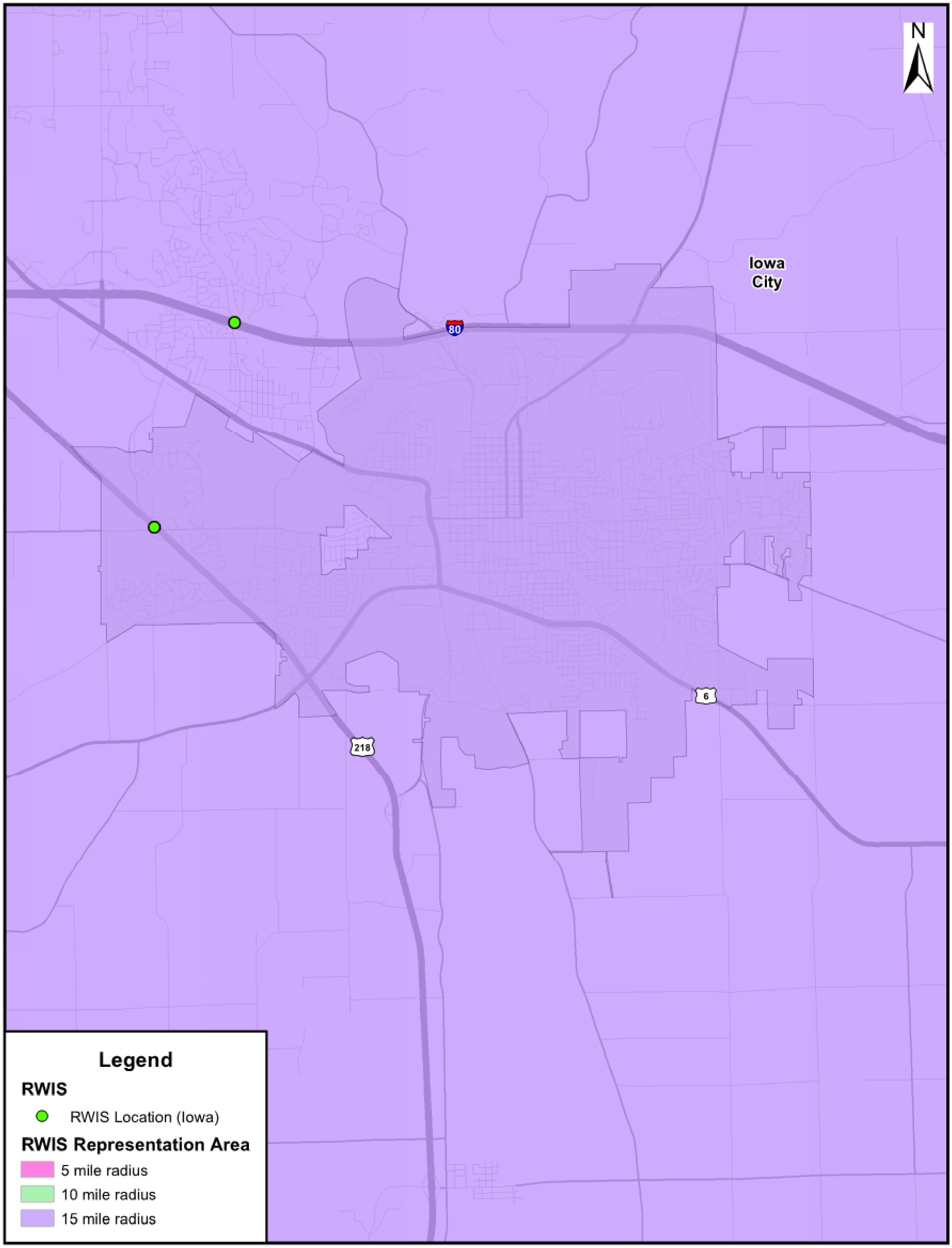

N
69
35
Boone/Ames/Nevada
30
Legend
RWIS
RWIS Location (Iowa)
RWIS Representation Area
5 mile radius
10 mile radius
15 mile radius

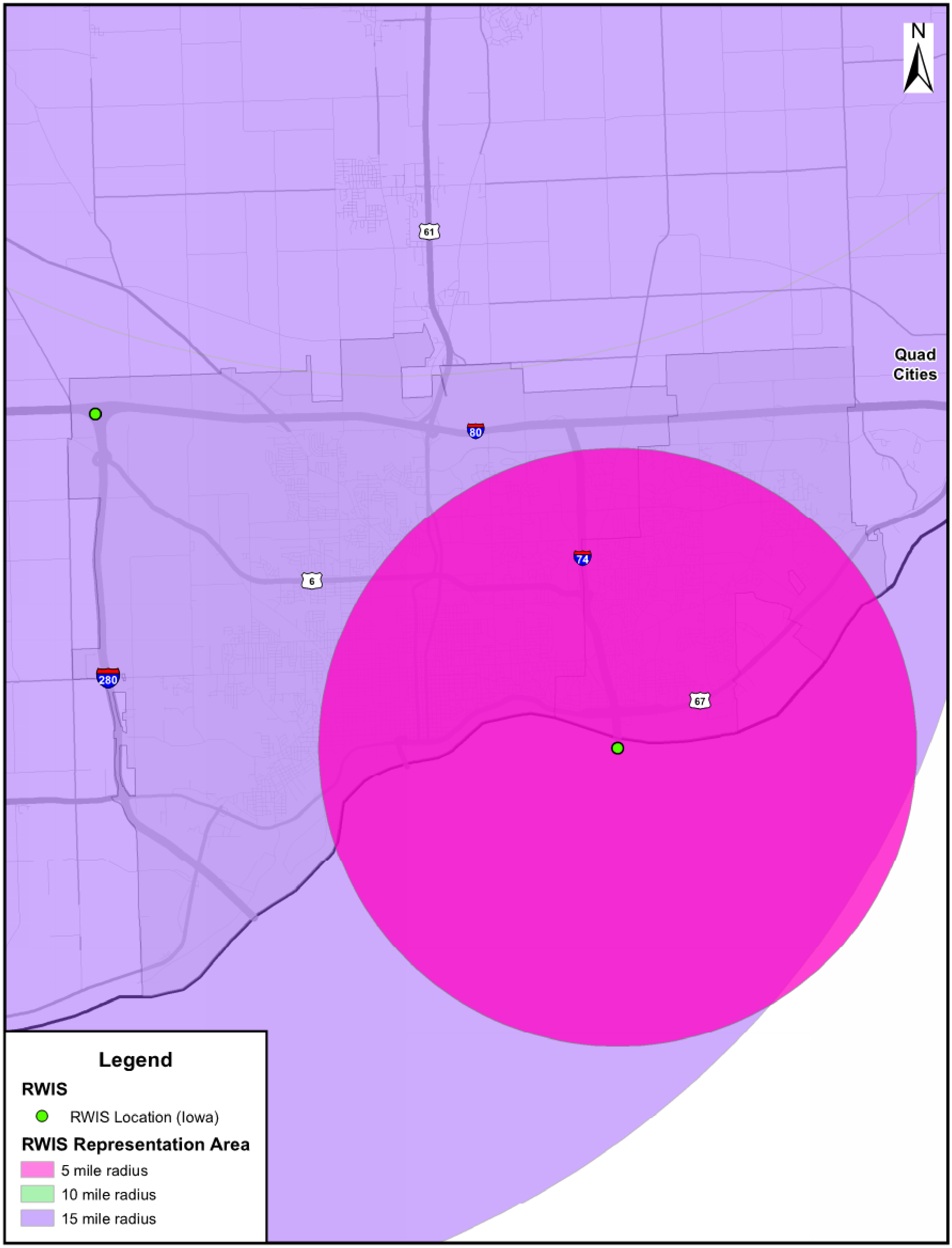

N
Cedar
Rapids
151
380
30
218
Legend
RWIS
RWIS Location (Iowa)
RWIS Representation Area
5 mile radius
10 mile radius
15 mile radius

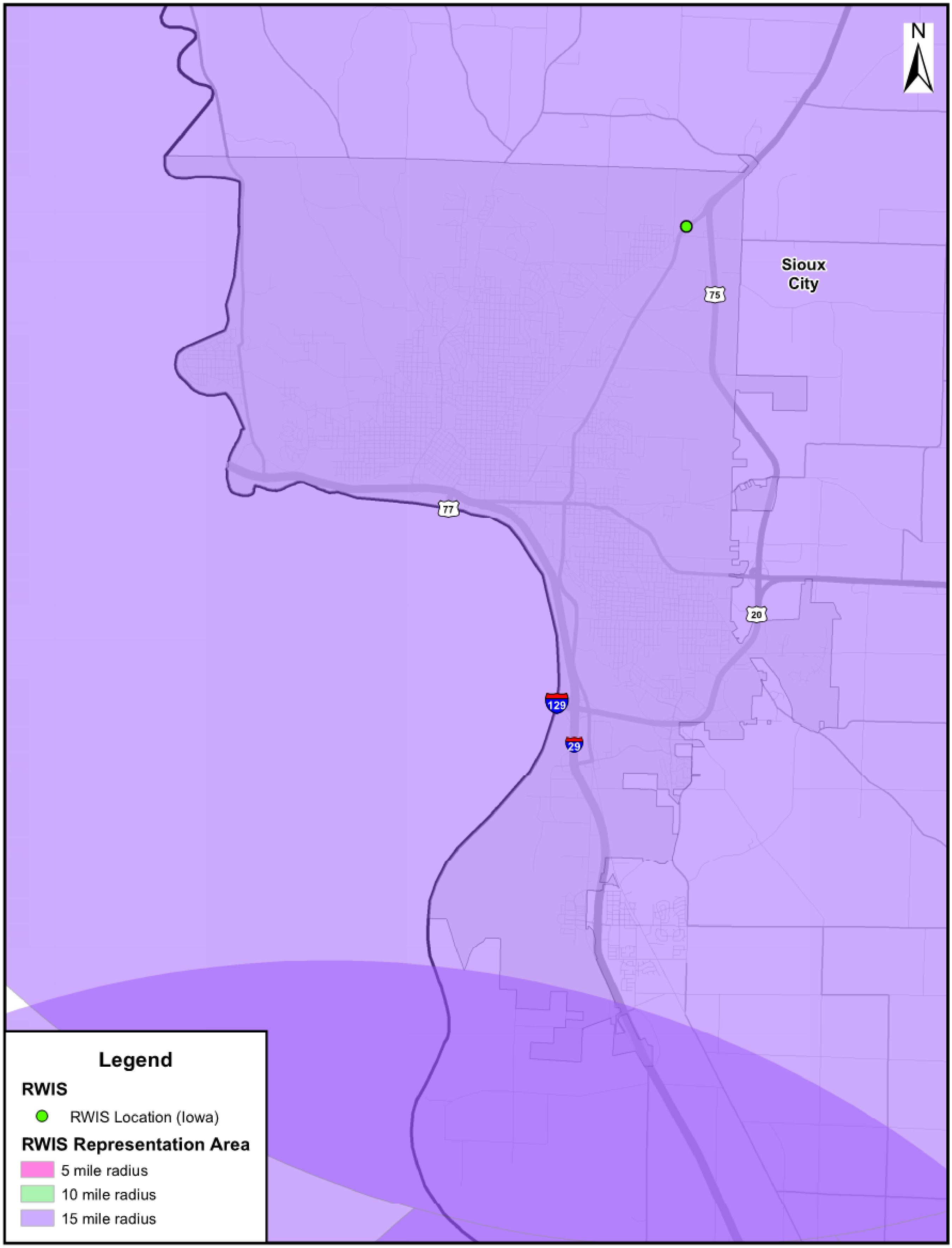

N
Council Bluffs
29
480
6
80
275
Legend
RWIS
RWIS Location (Iowa)
RWIS Representation Area
5 mile radius
10 mile radius
15 mile radius

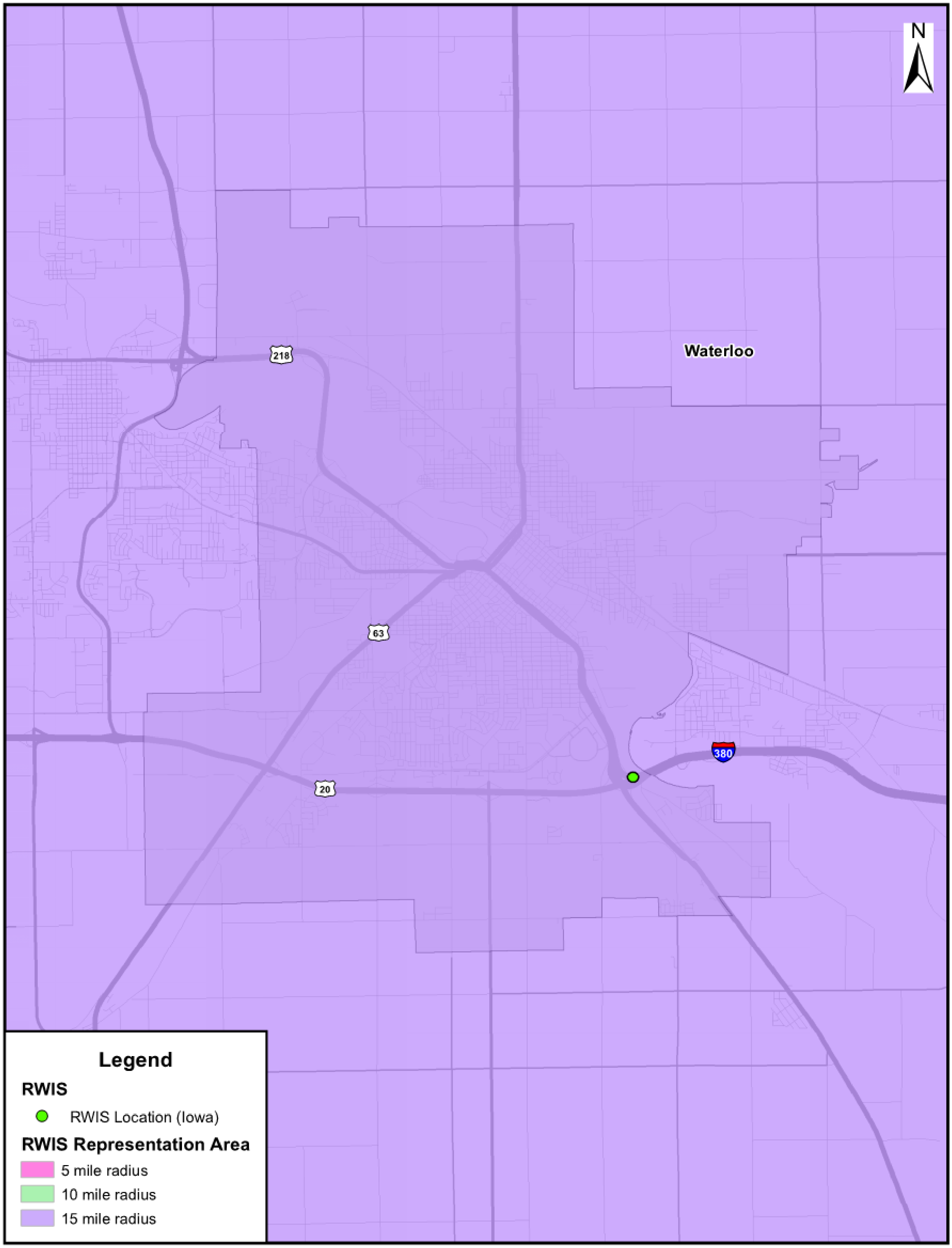

N
Des Moines
69
80
6
235
65
35
Legend
RWIS
RWIS Location (Iowa)
RWIS Representation Area
5 mile radius
10 mile radius
15 mile radius

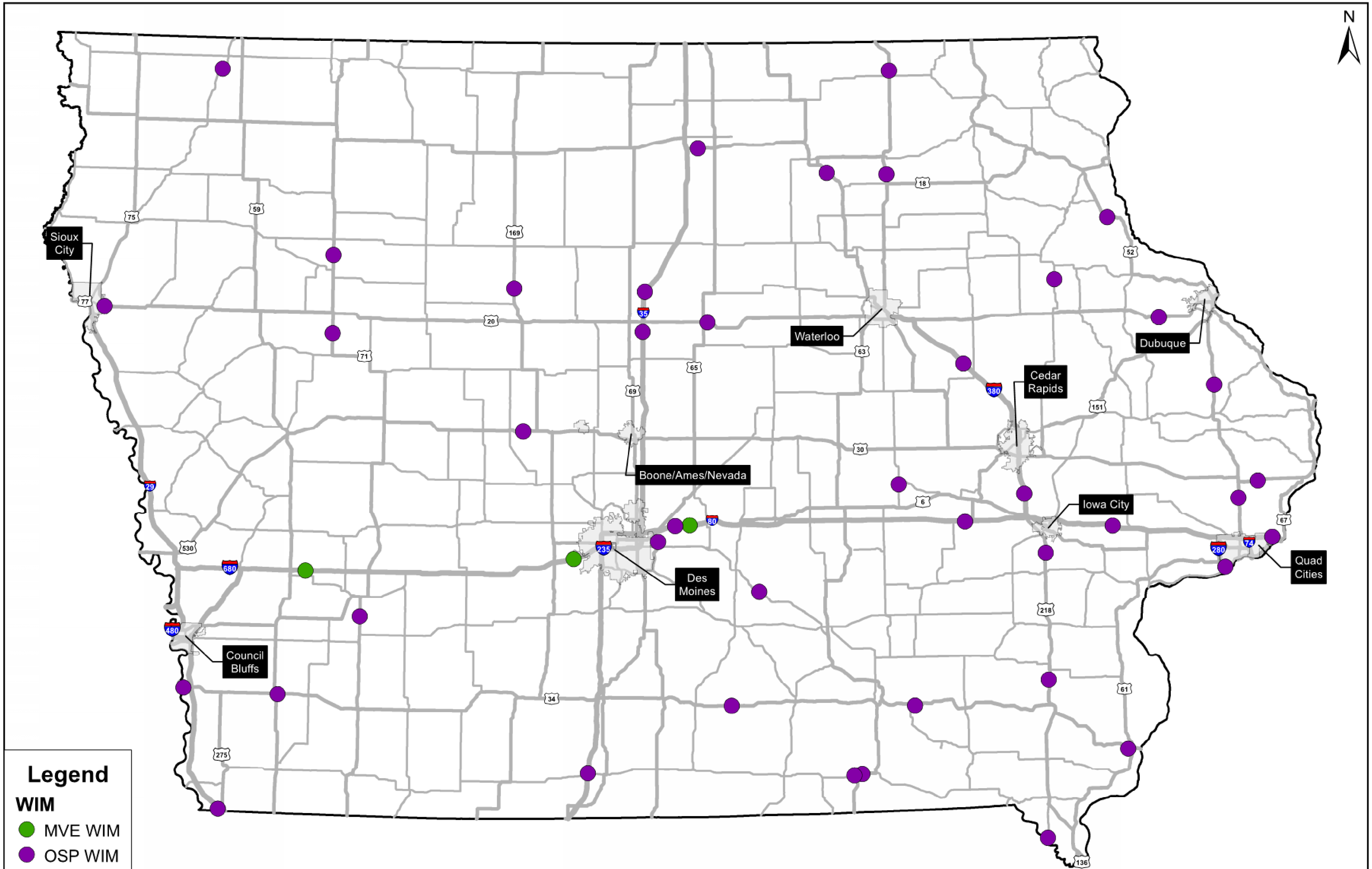

N
Dubuque
52
20
61
151
Legend
RWIS
RWIS Location (Iowa)
RWIS Representation Area
5 mile radius
10 mile radius
15 mile radius

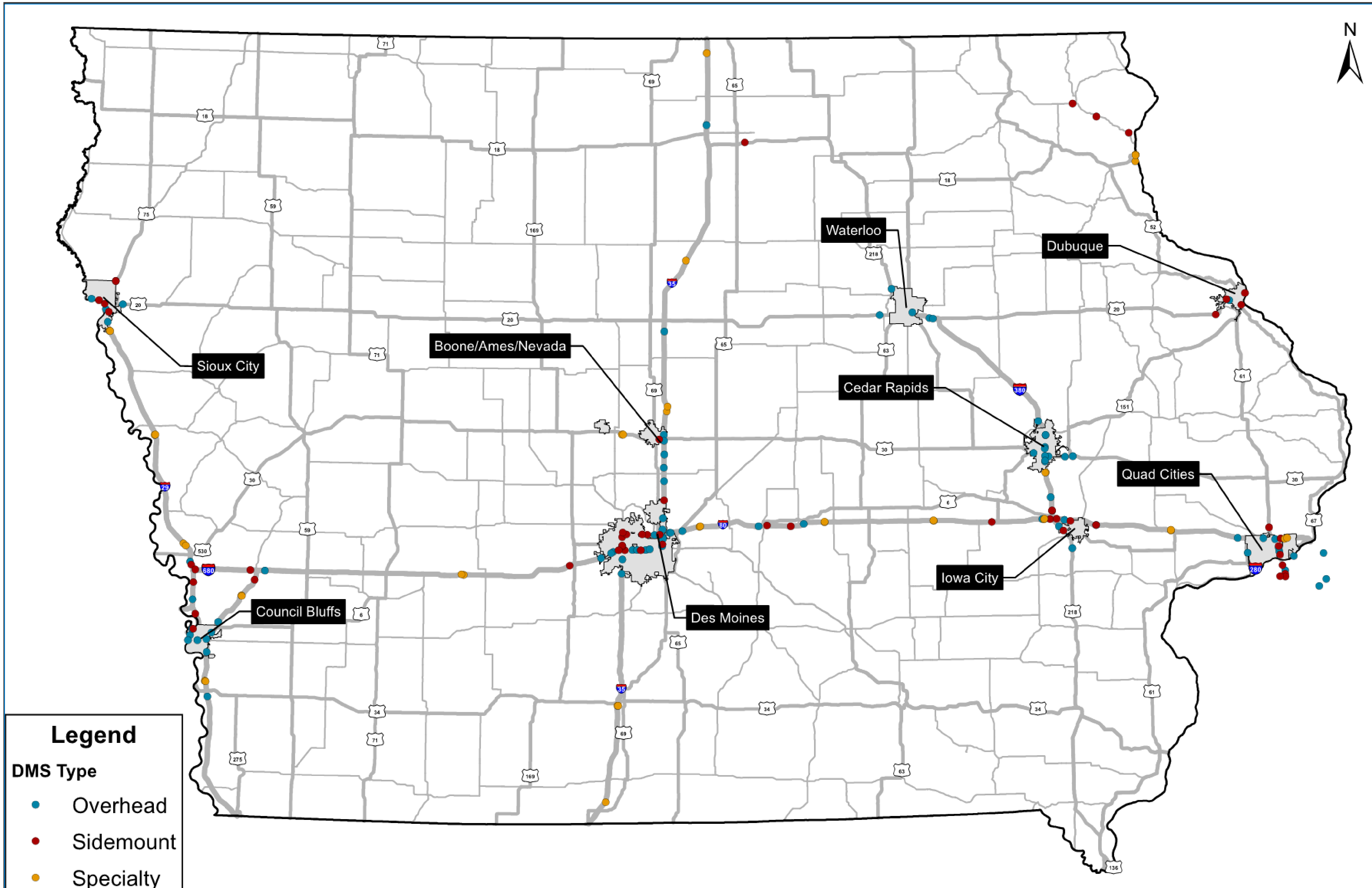

N
Iowa
City
80
6
218
Legend
RWIS
RWIS Location (Iowa)
RWIS Representation Area
5 mile radius
10 mile radius
15 mile radius

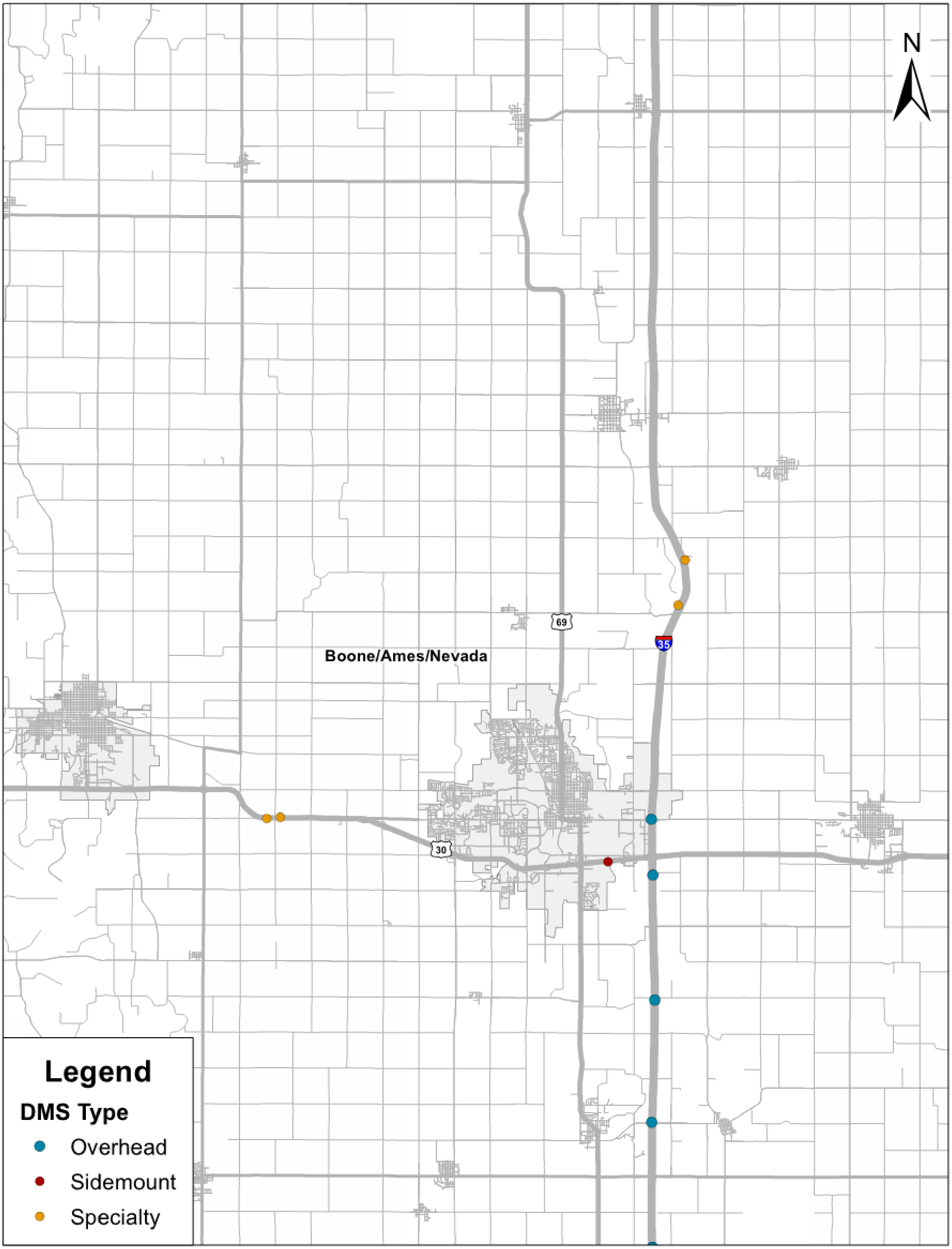

N
Quad
Cities
61
80
74
6
280
67
Legend
RWIS
RWIS Location (Iowa)
RWIS Representation Area
5 mile radius
10 mile radius
15 mile radius

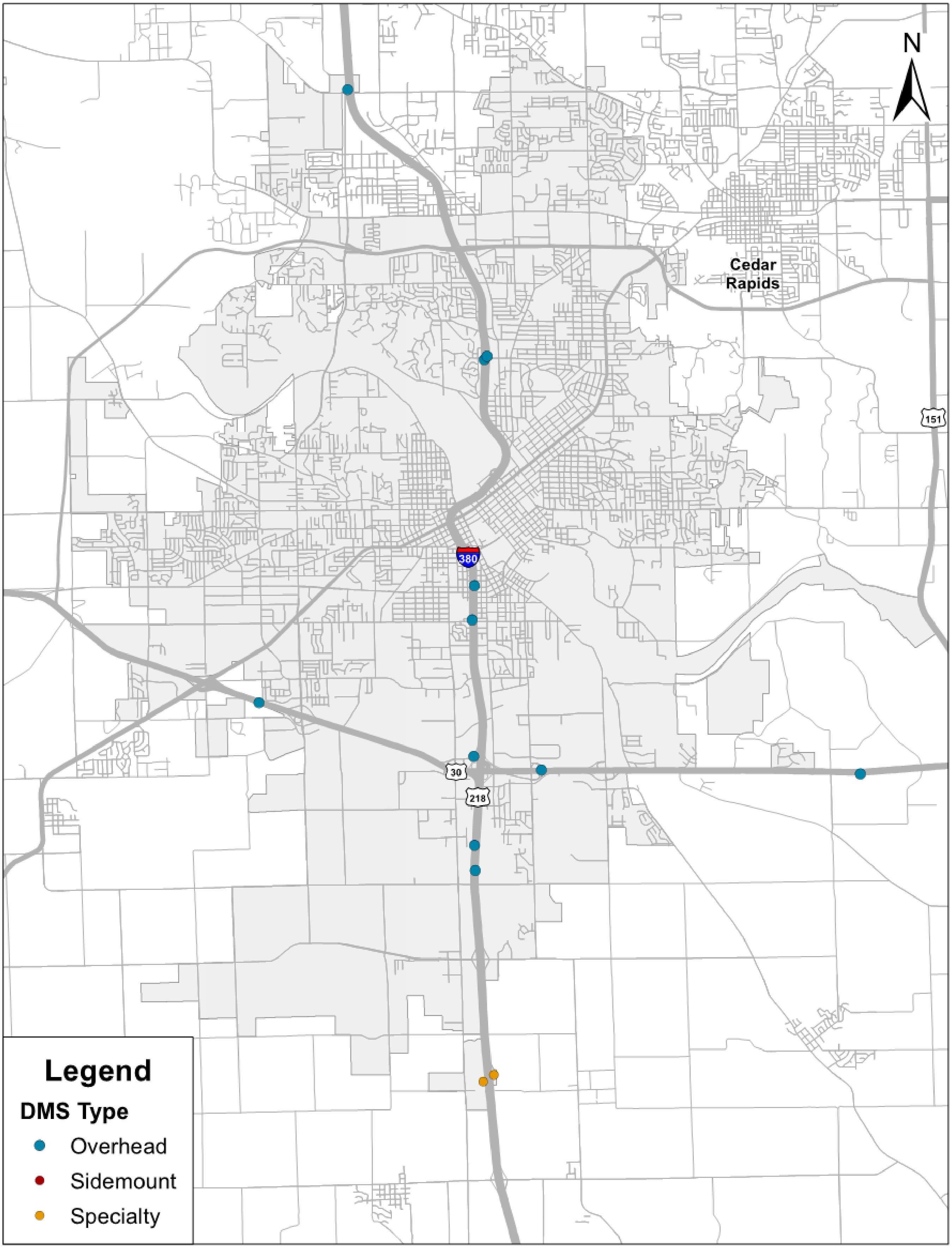

N
Sioux
City
75
77
20
129
29
Legend
RWIS
RWIS Location (Iowa)
RWIS Representation Area
5 mile radius
10 mile radius
15 mile radius

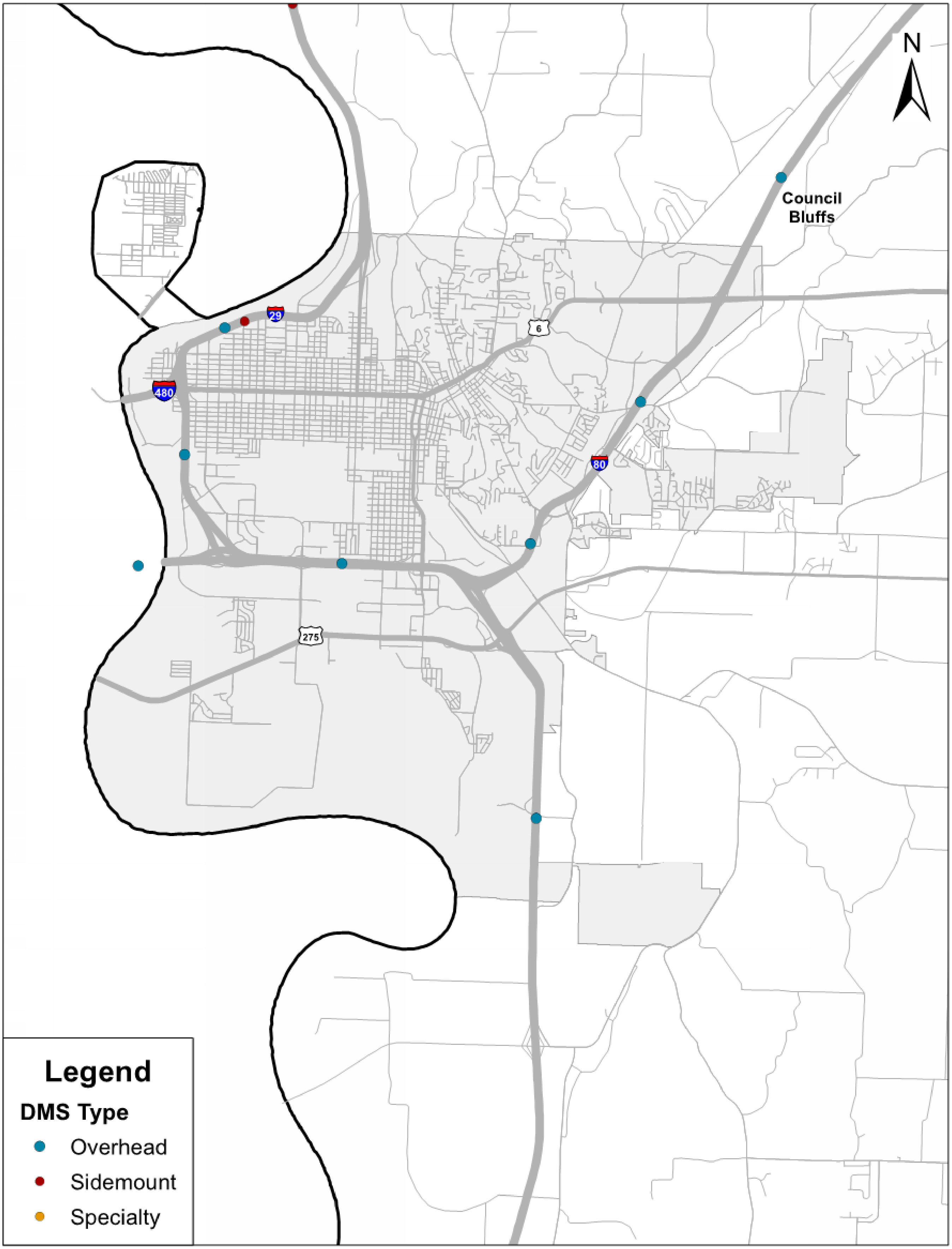

N
Waterloo
218
63
20
380
Legend
RWIS
RWIS Location (Iowa)
RWIS Representation Area
5 mile radius
10 mile radius
15 mile radius

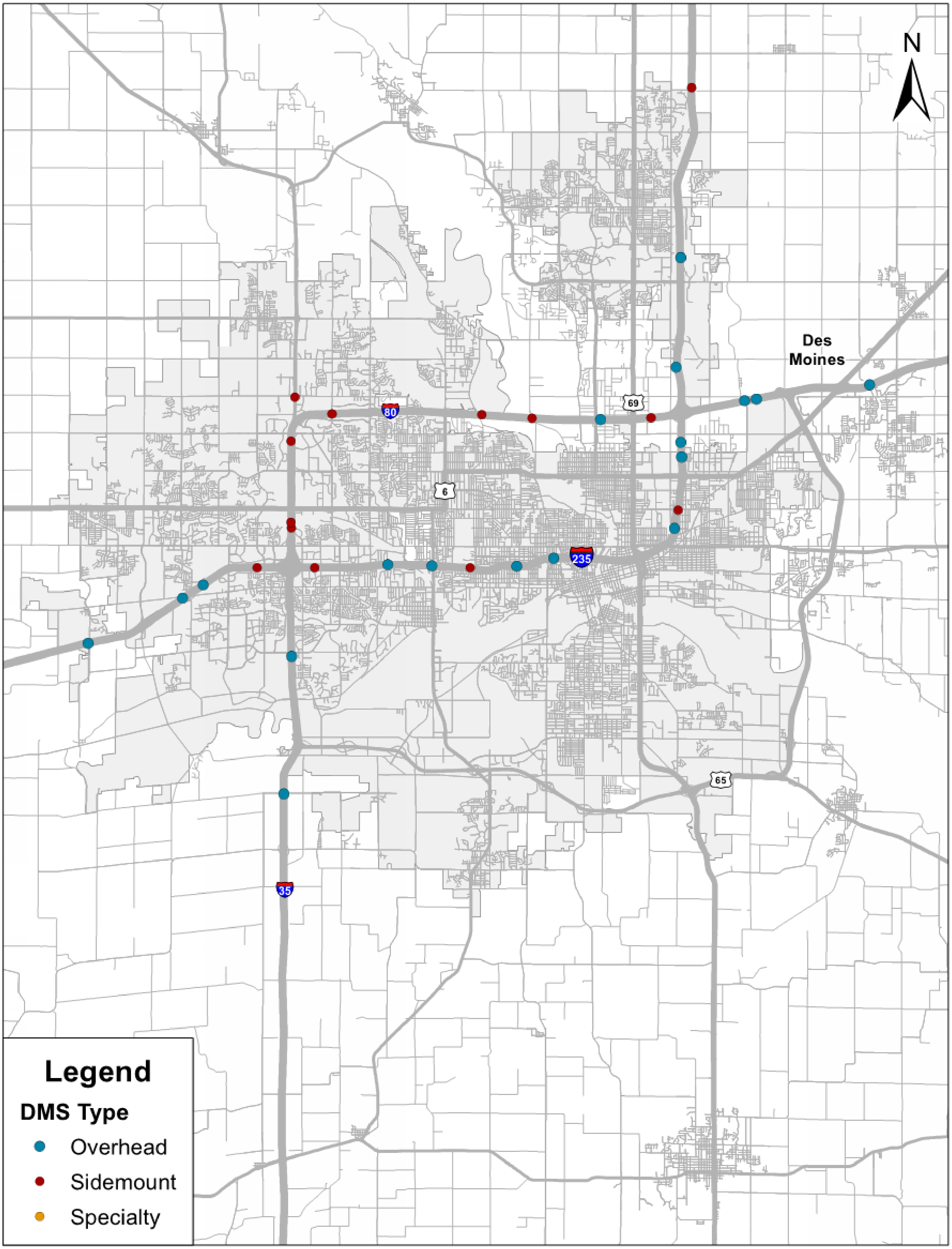

N
Sioux City
Waterloo
Dubuque
Cedar Rapids
Boone/Ames/Nevada
Iowa City
Des Moines
Quad Cities
Council Bluffs
75
59
169
77
20
35
71
65
63
380
151
69
30
29
6
80
530
680
235
280
74
67
480
218
34
61
275
136
18
52
Legend
WIM
MVE WIM
OSP WIM

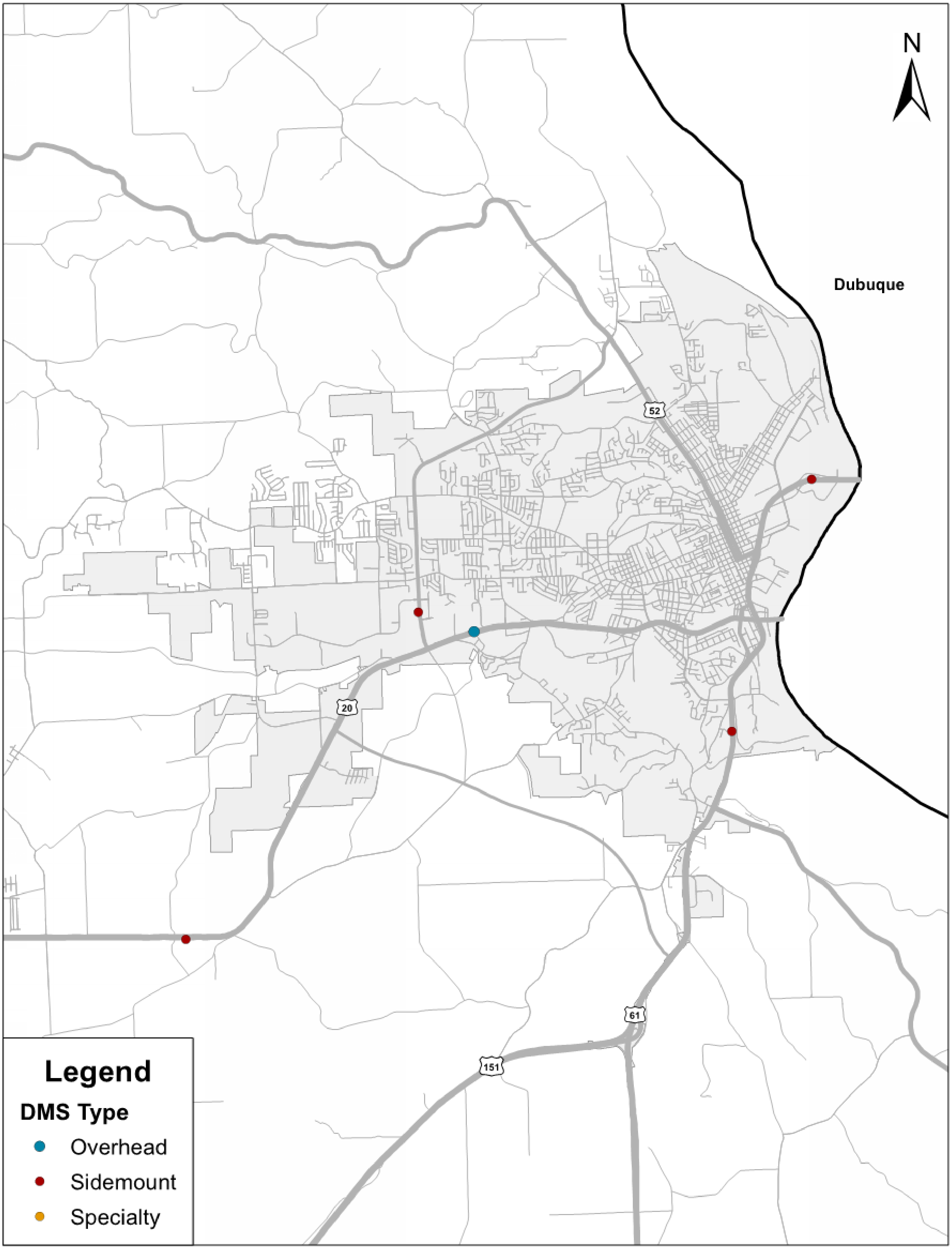

N
Waterloo
Dubuque
Sioux City
Boone/Ames/Nevada
Cedar Rapids
Quad Cities
Iowa City
Des Moines
Council Bluffs
Legend
DMS Type
Overhead
Sidemount
Specialty


N
69
35
Boone/Ames/Nevada
30
Legend
DMS Type
Overhead
Sidemount
Specialty

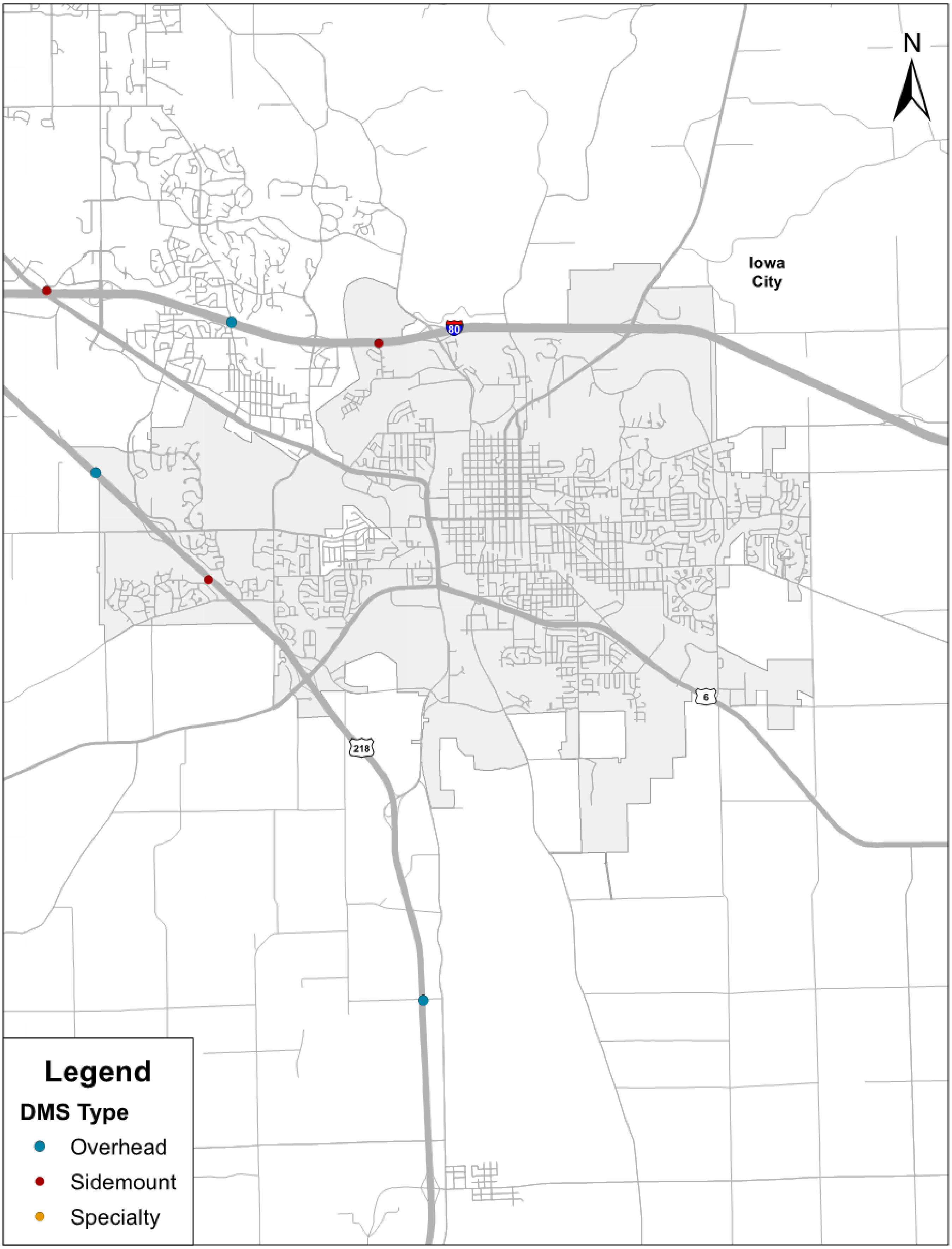

N
Cedar
Rapids
380
151
30
218
Legend
DMS Type
Overhead
Sidemount
Specialty

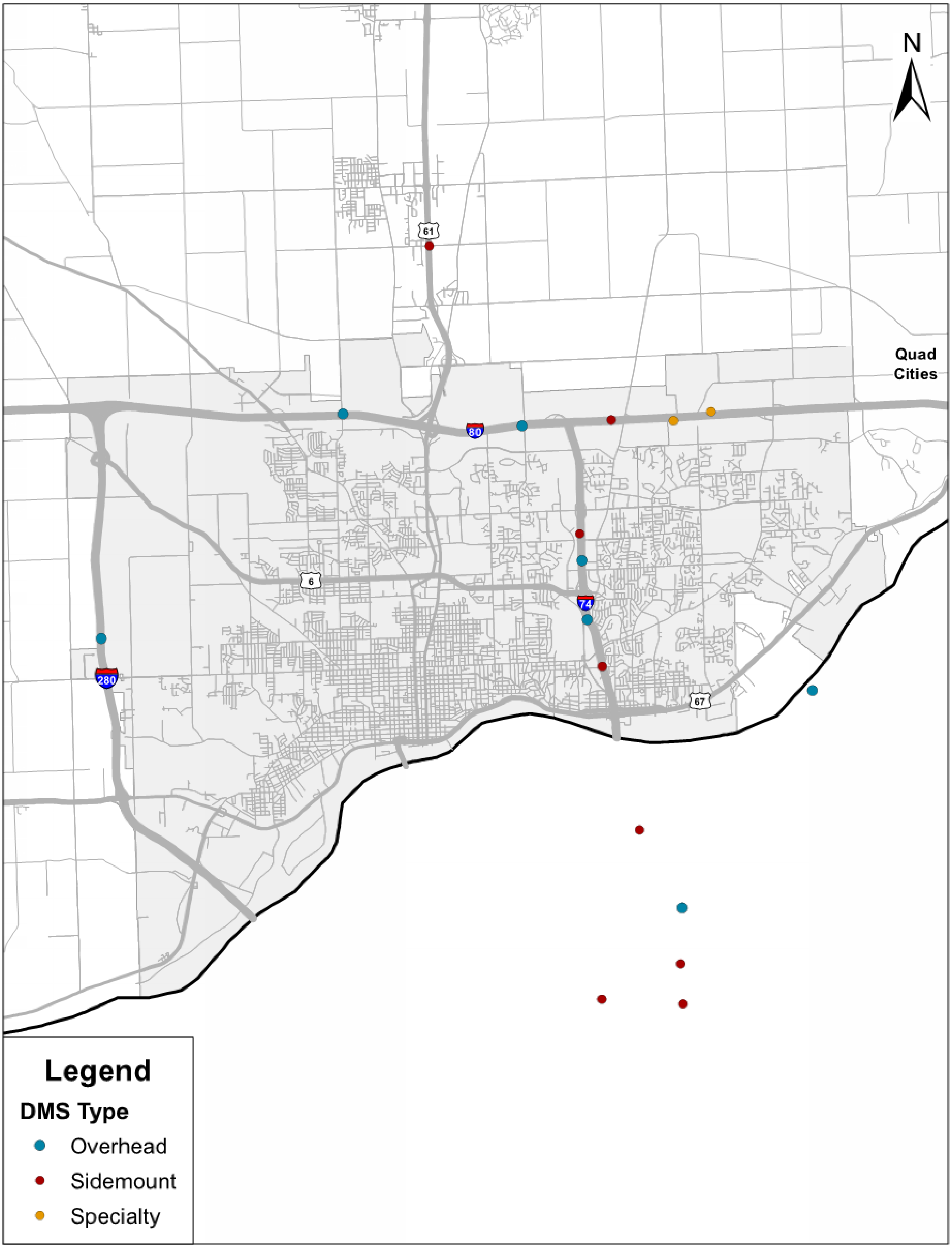

N
Council Bluffs
29
480
6
80
275
Legend
DMS Type
Overhead
Sidemount
Specialty

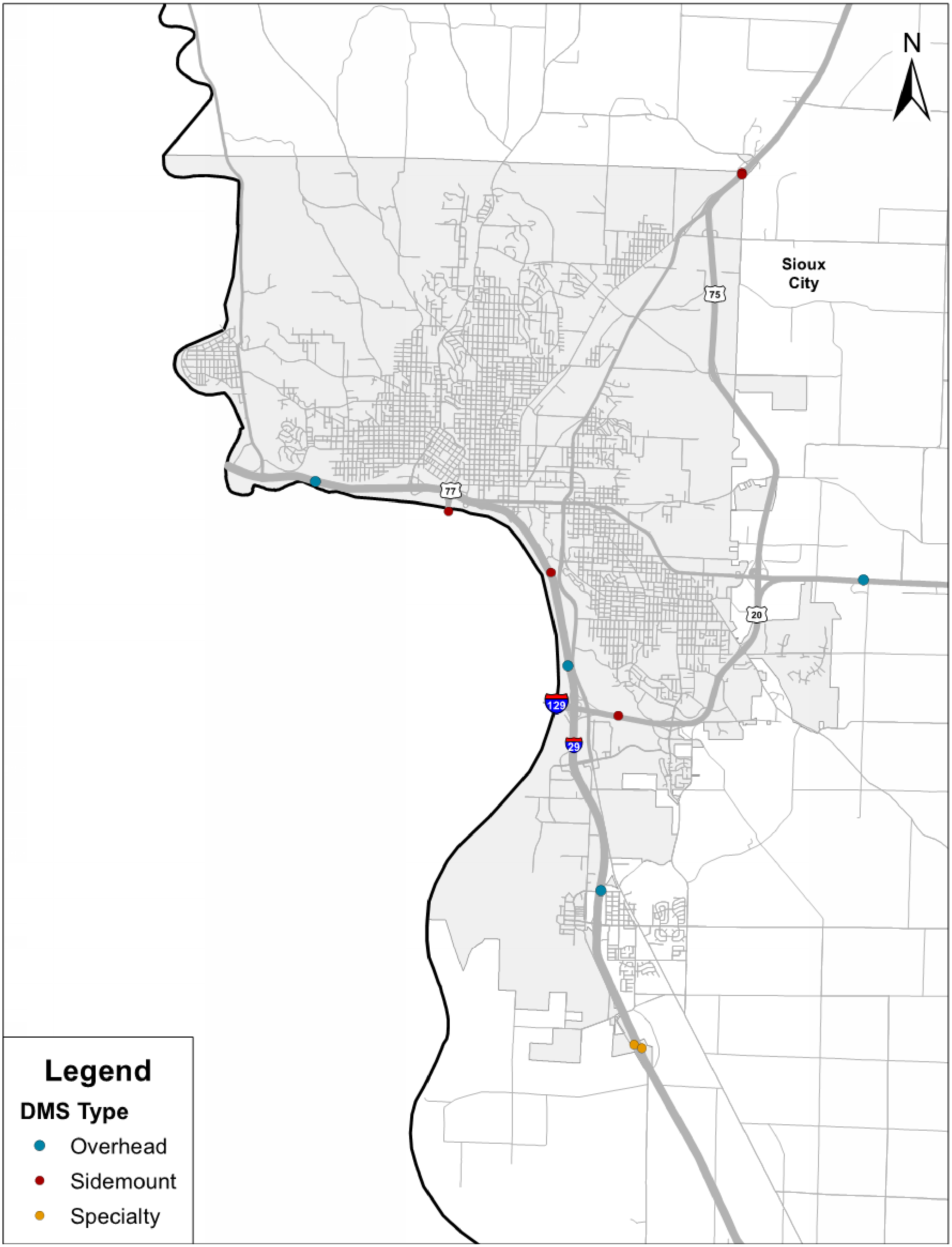

N
Des Moines
80
69
6
235
65
35
Legend
DMS Type
Overhead
Sidemount
Specialty

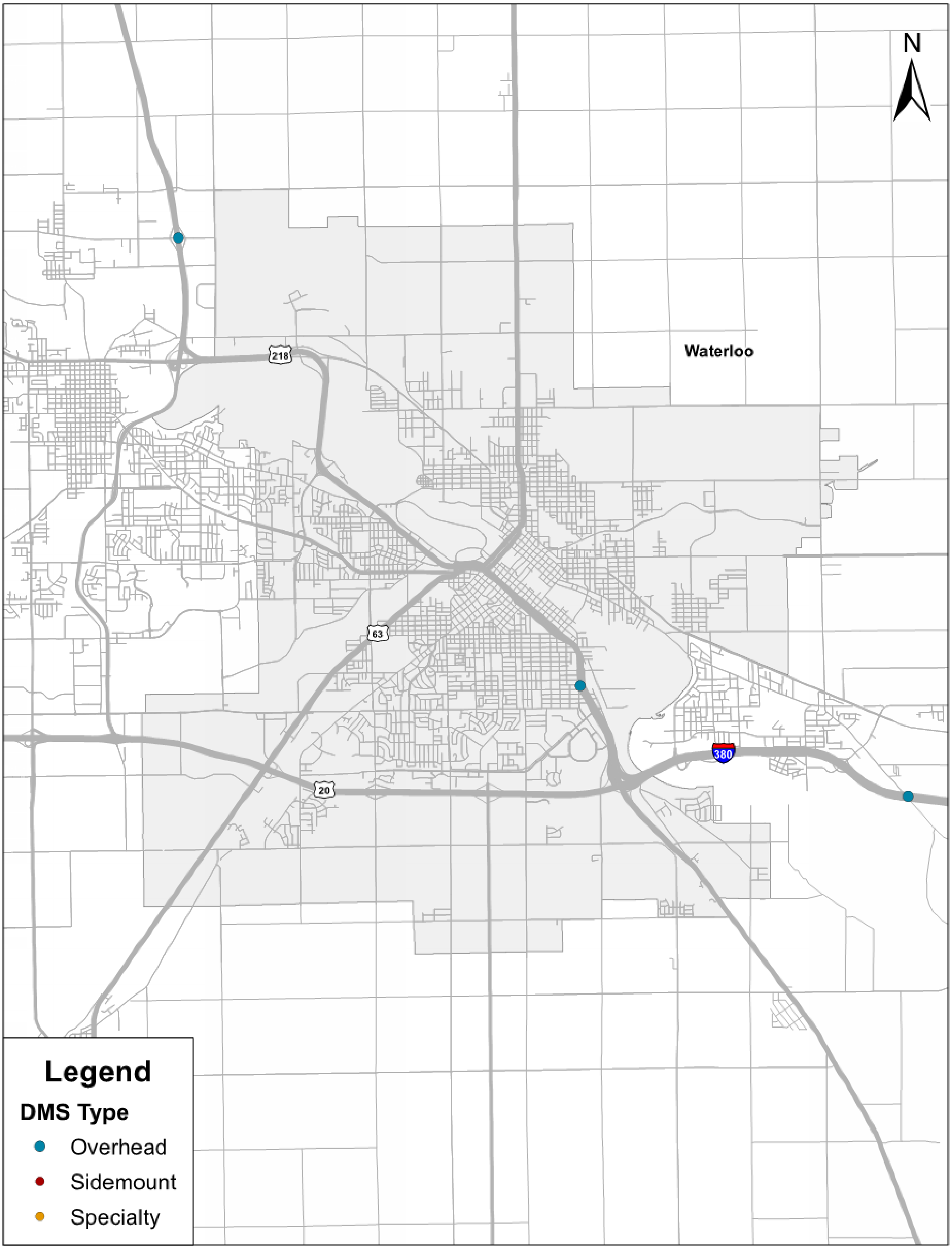


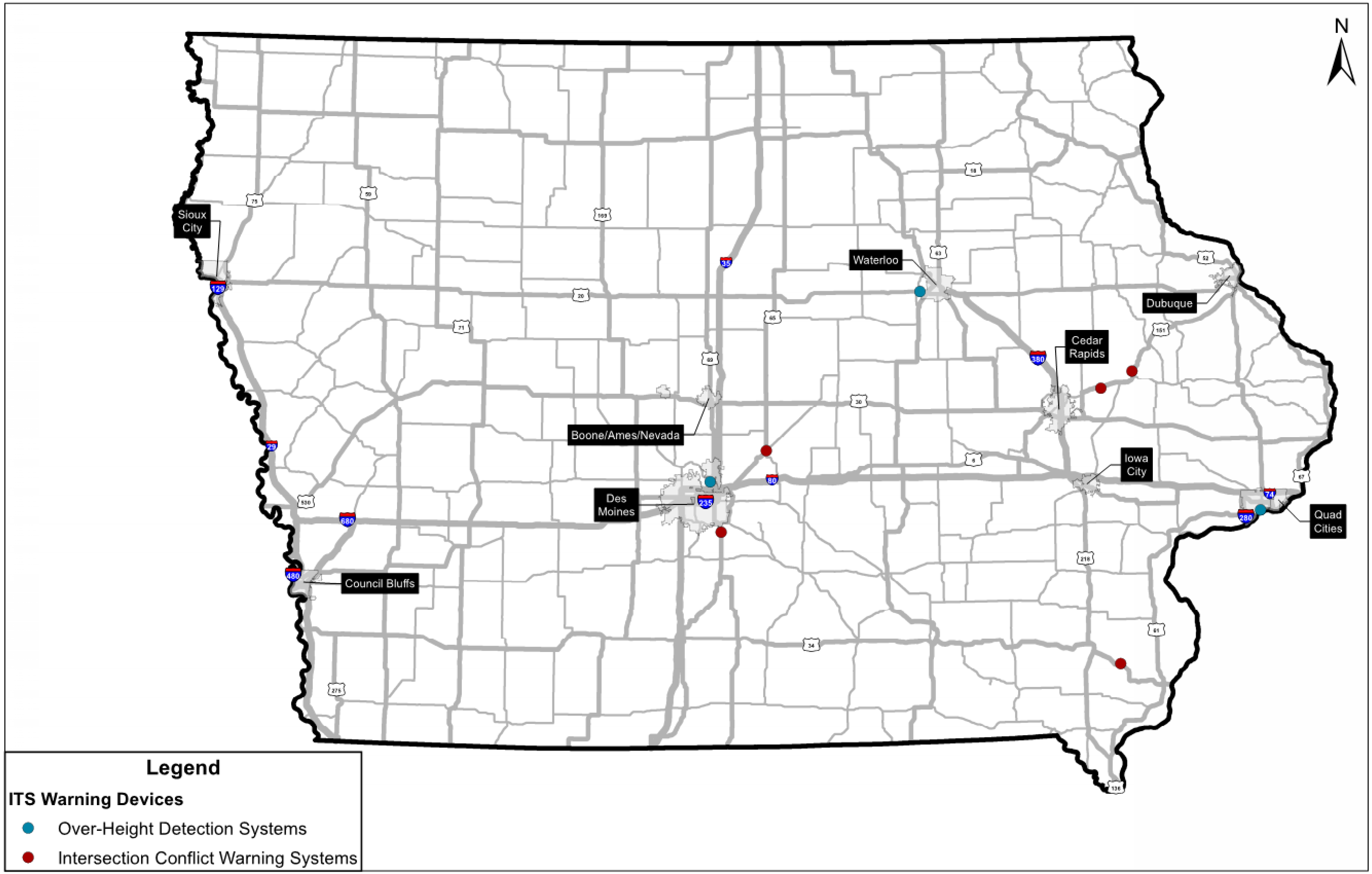
N
Dubuque
52
20
61
151
Legend
DMS Type
Overhead
Sidemount
Specialty

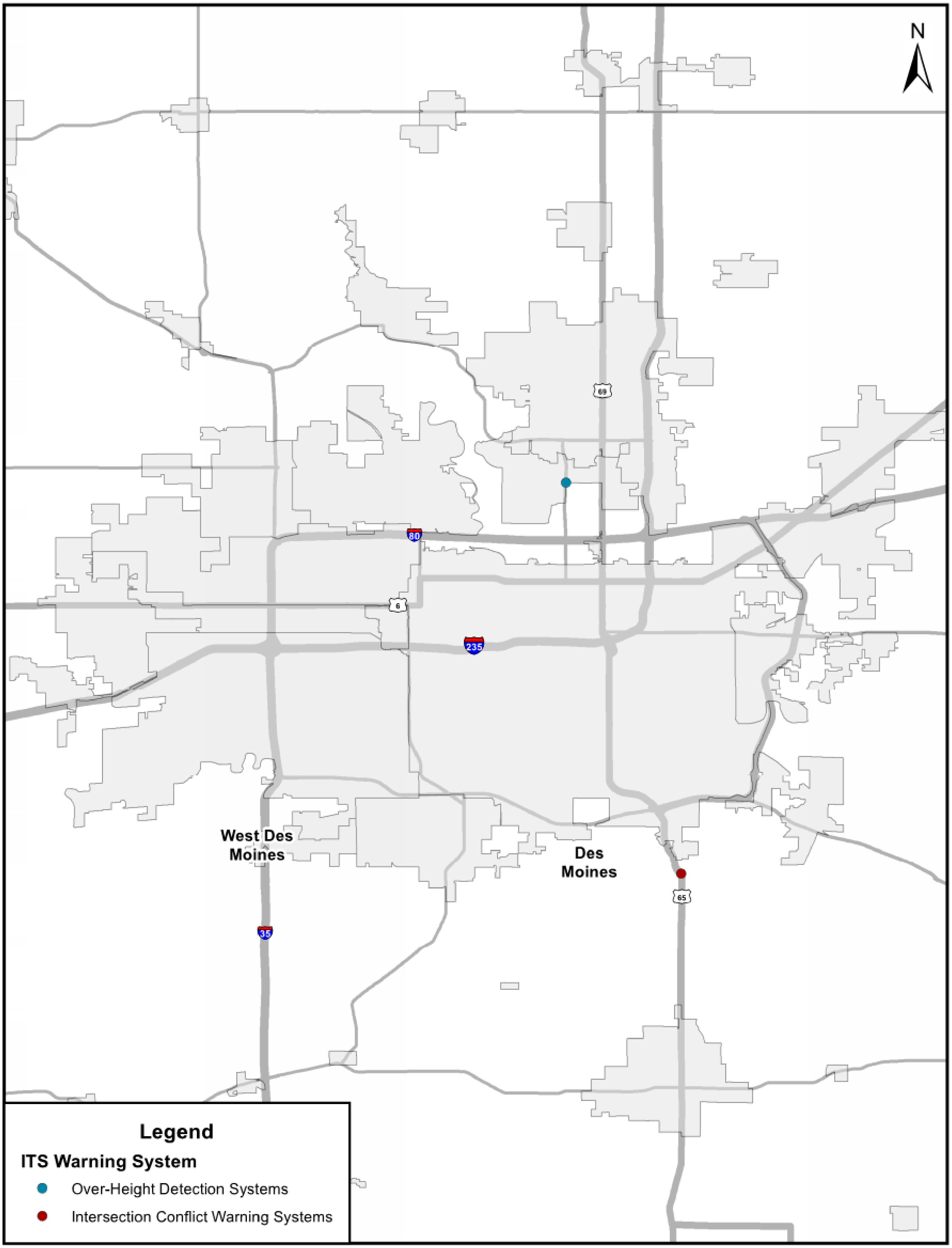

N
Iowa
City
80
218
6
Legend
DMS Type
Overhead
Sidemount
Specialty

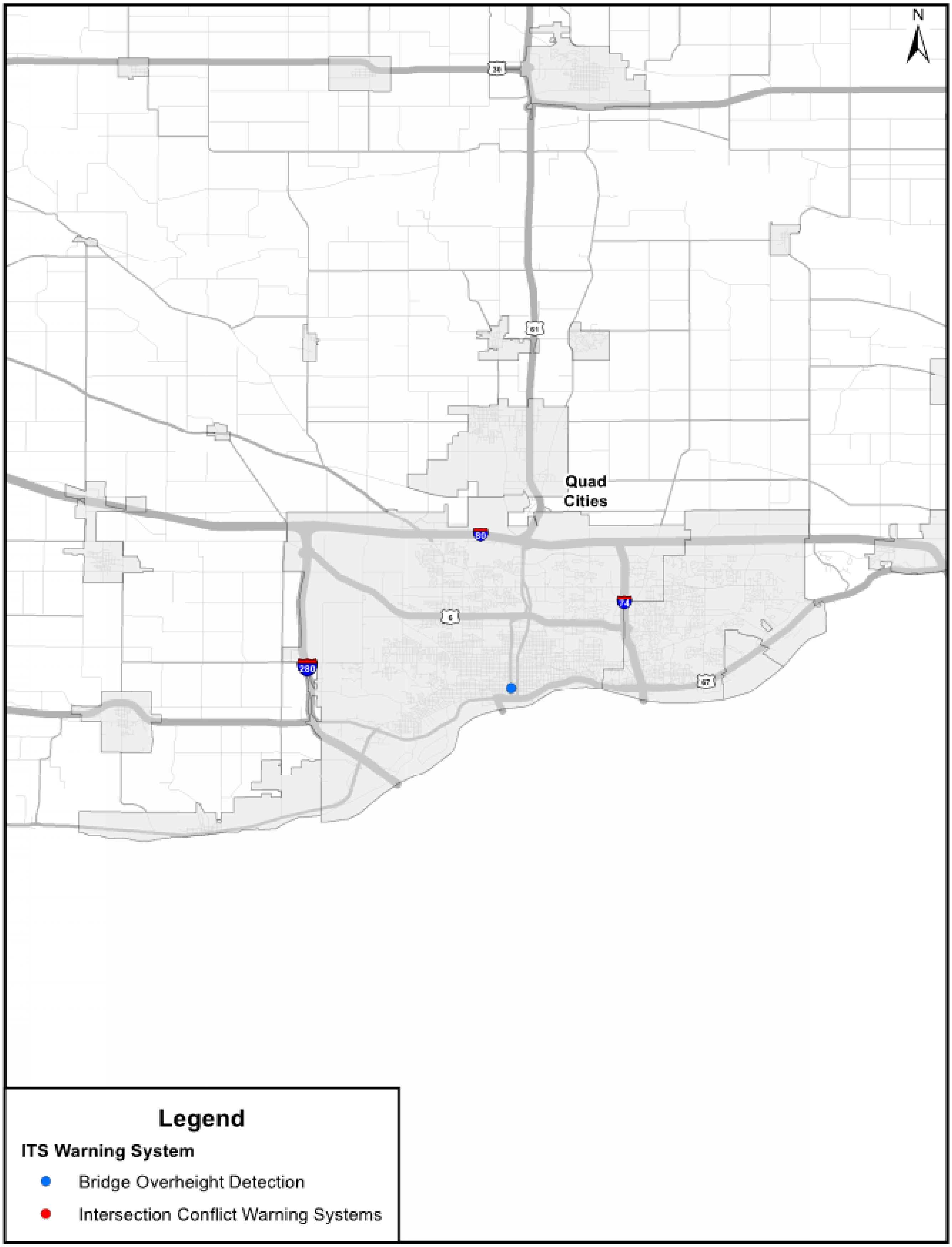

N
Quad Cities
61
80
6
74
280
67
Legend
DMS Type
Overhead
Sidemount
Specialty

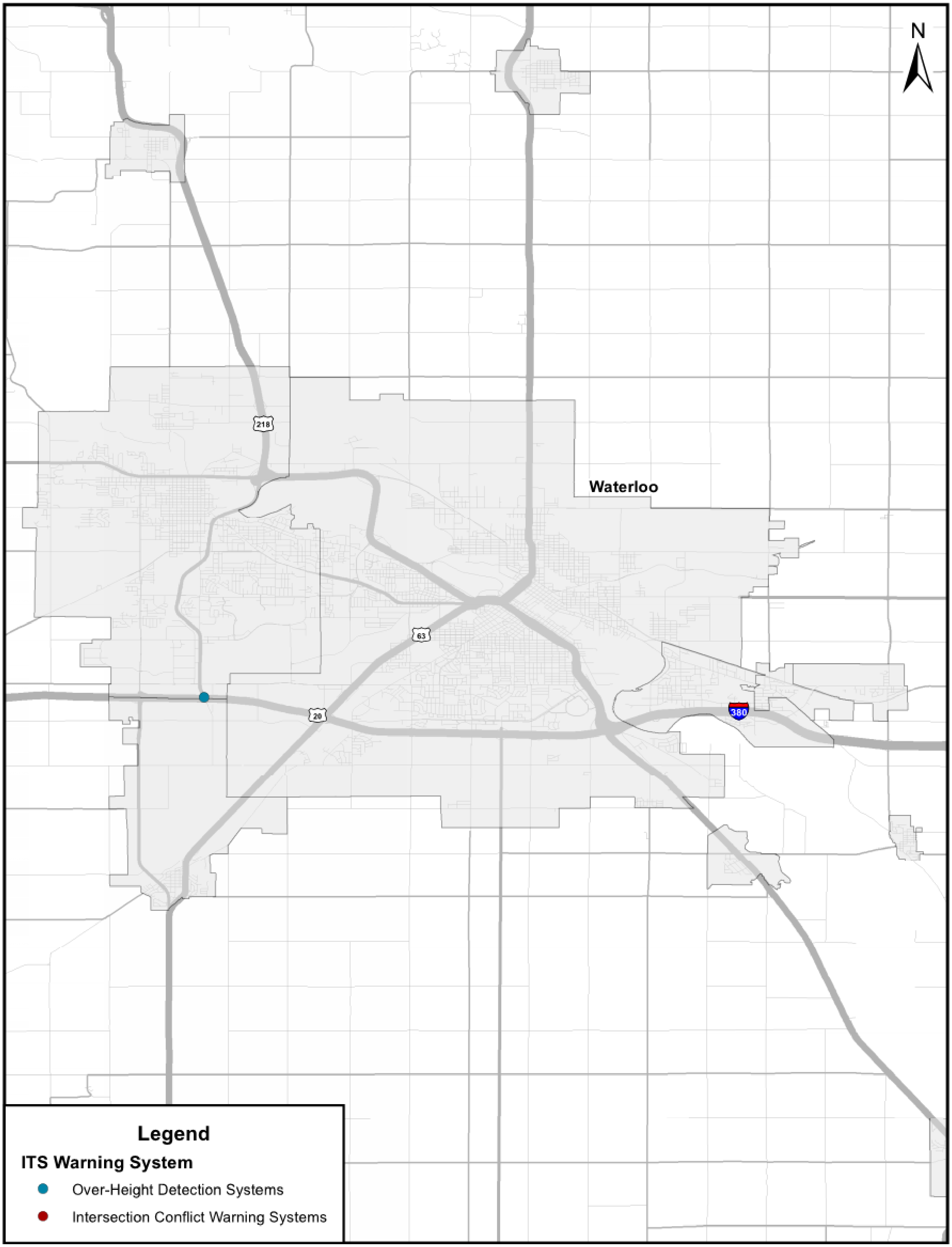

N
Sioux
City
75
77
20
129
29
Legend
DMS Type
Overhead
Sidemount
Specialty

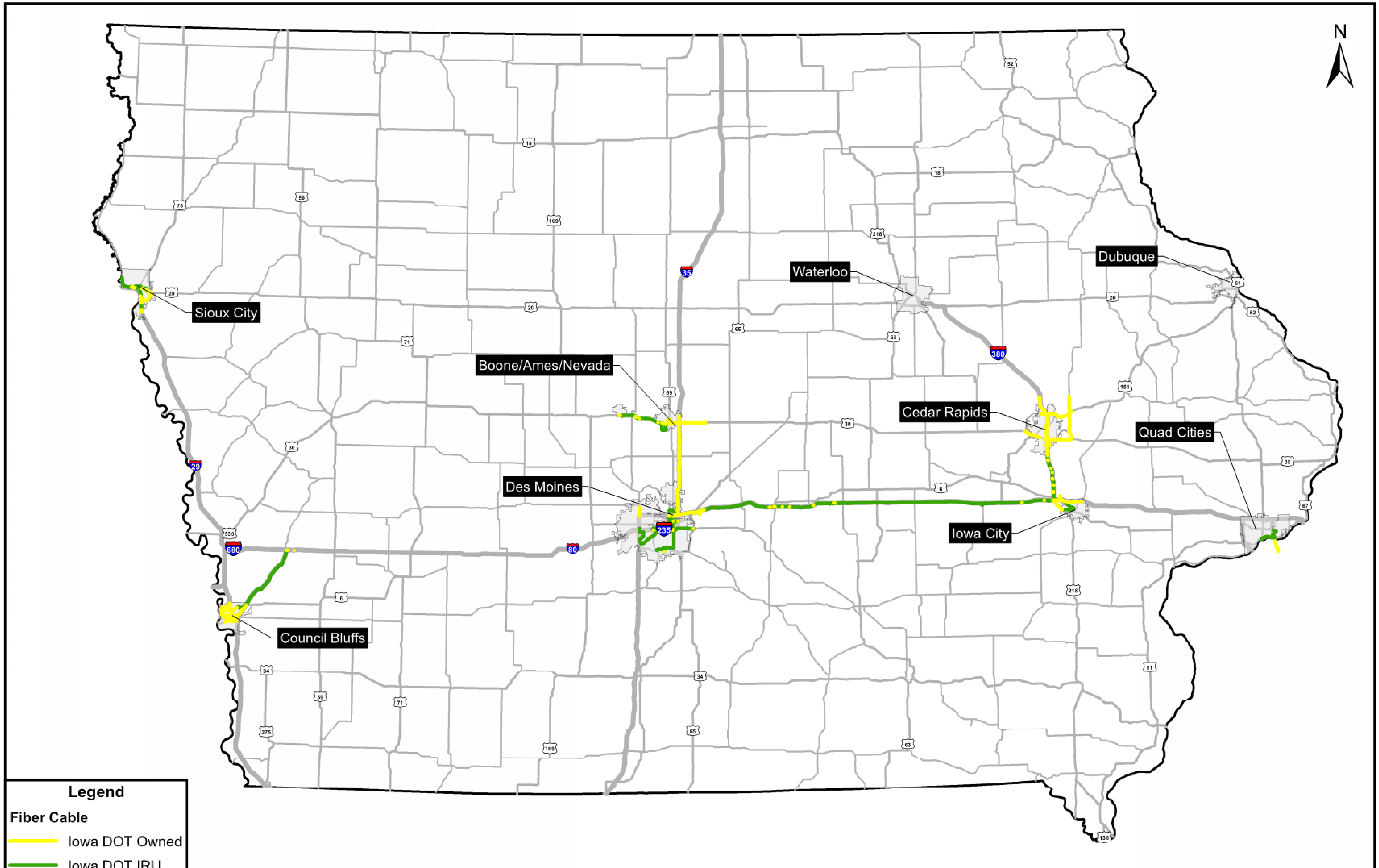

N
Waterloo
218
63
20
380
Legend
DMS Type
Overhead
Sidemount
Specialty

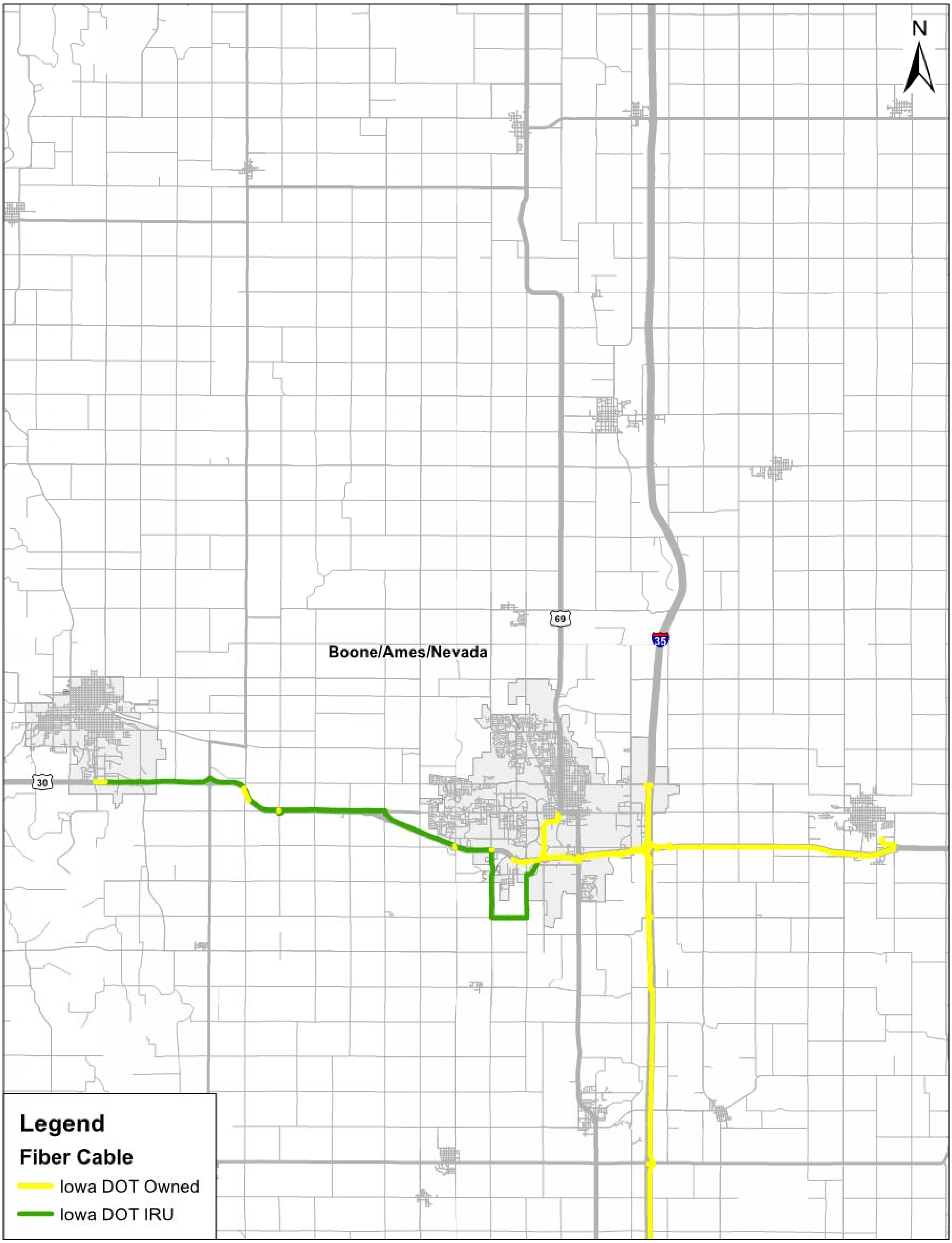

N
Sioux City
Waterloo
Dubuque
Cedar Rapids
Boone/Ames/Nevada
Iowa City
Des Moines
Quad Cities
Council Bluffs
Legend
ITS Warning Devices
Over-Height Detection Systems
Intersection Conflict Warning Systems

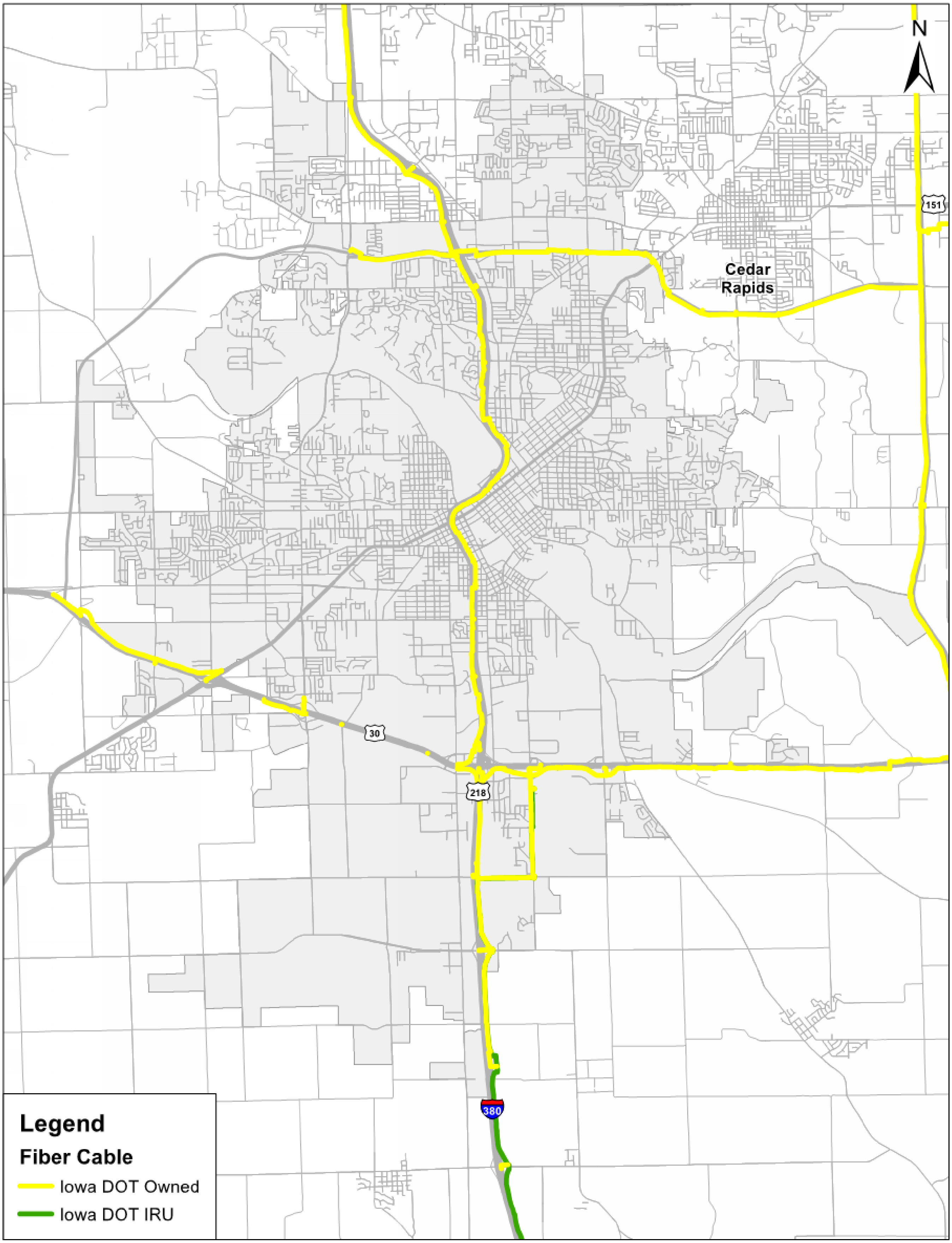

N
West Des Moines
Des Moines
80
235
35
69
6
65
Legend
ITS Warning System
Over-Height Detection Systems
Intersection Conflict Warning Systems

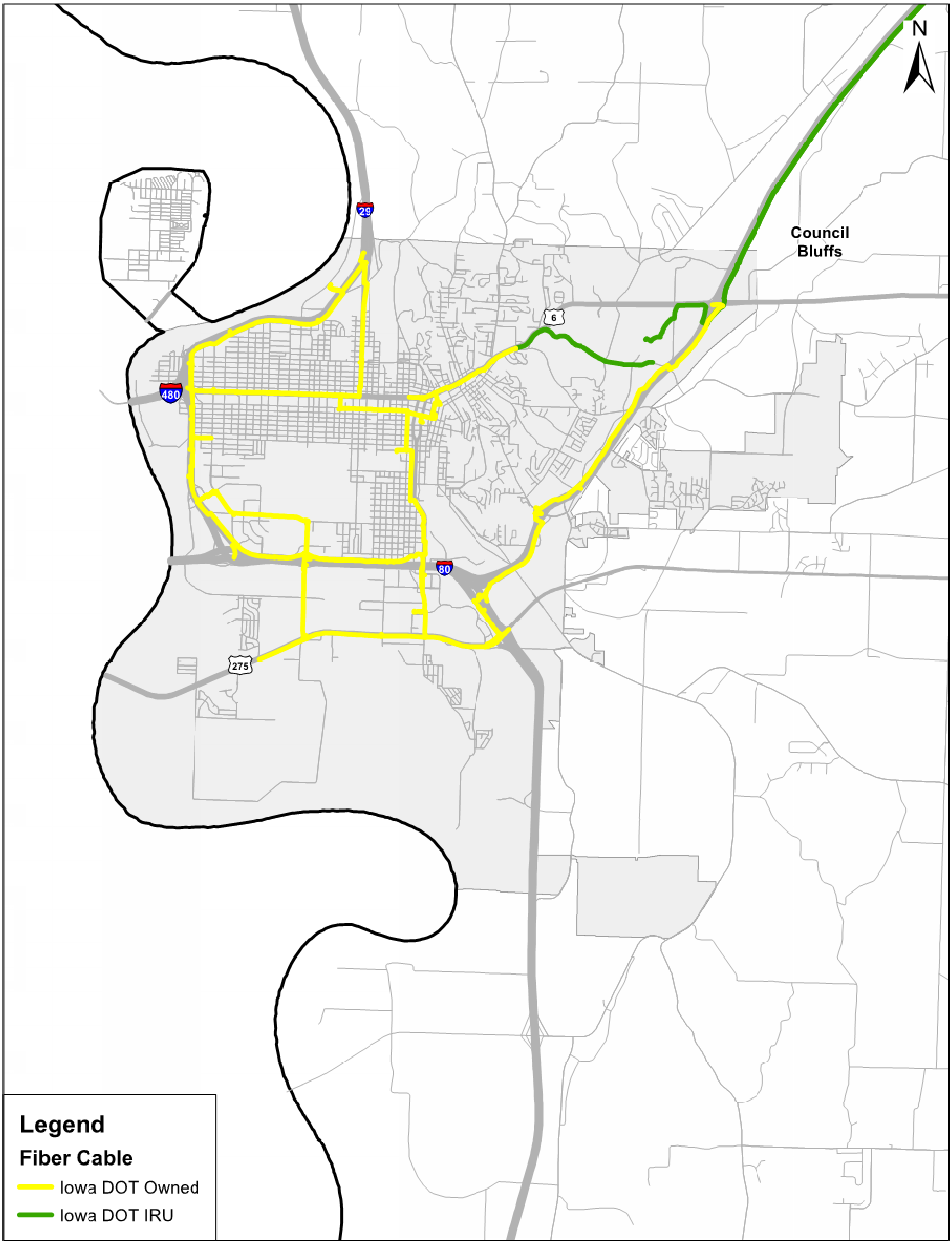

N
Quad Cities
30
61
80
74
6
280
67
Legend
ITS Warning System
Bridge Overheight Detection
Intersection Conflict Warning Systems

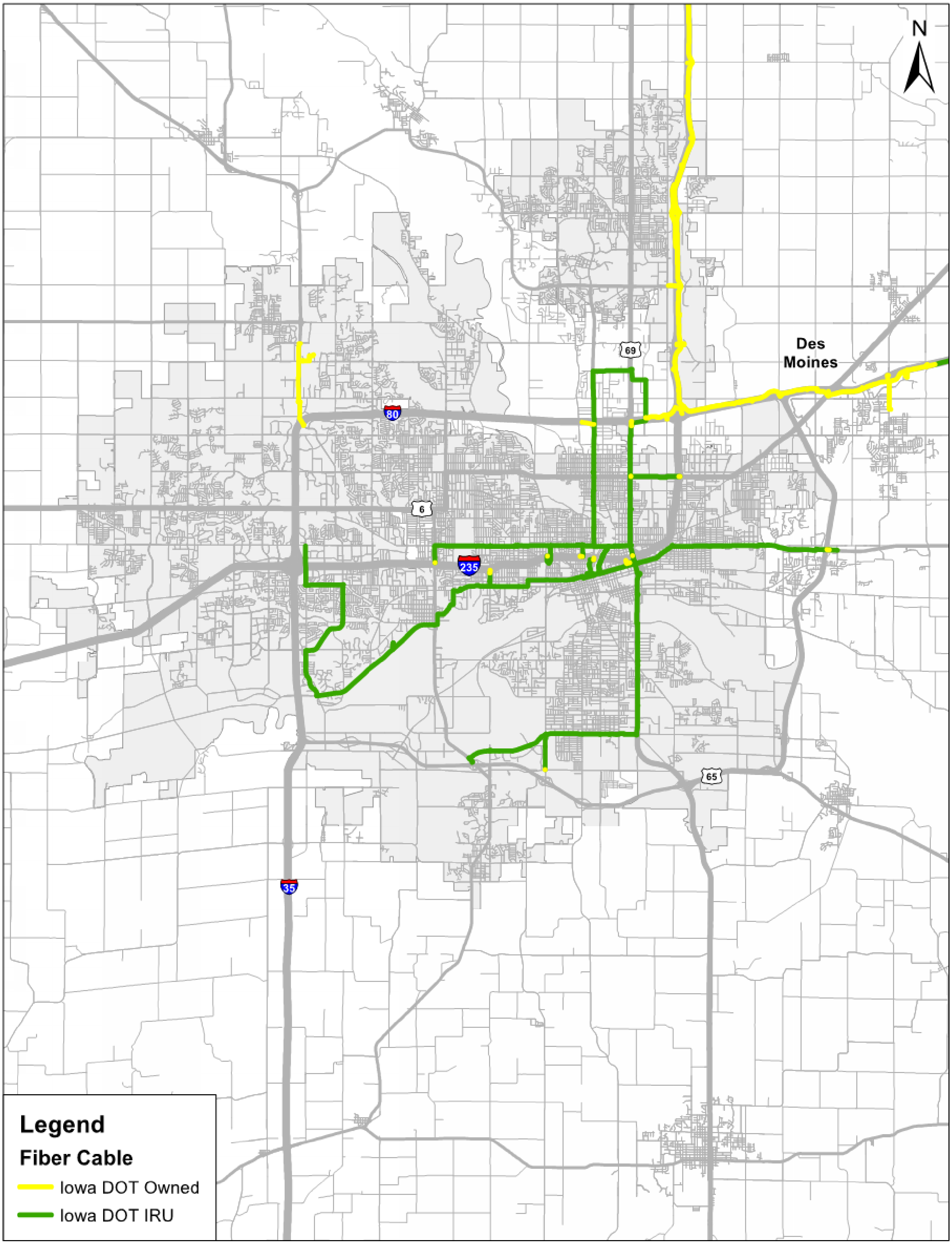

N
Waterloo
218
63
20
380
Legend
ITS Warning System
Over-Height Detection Systems
Intersection Conflict Warning Systems

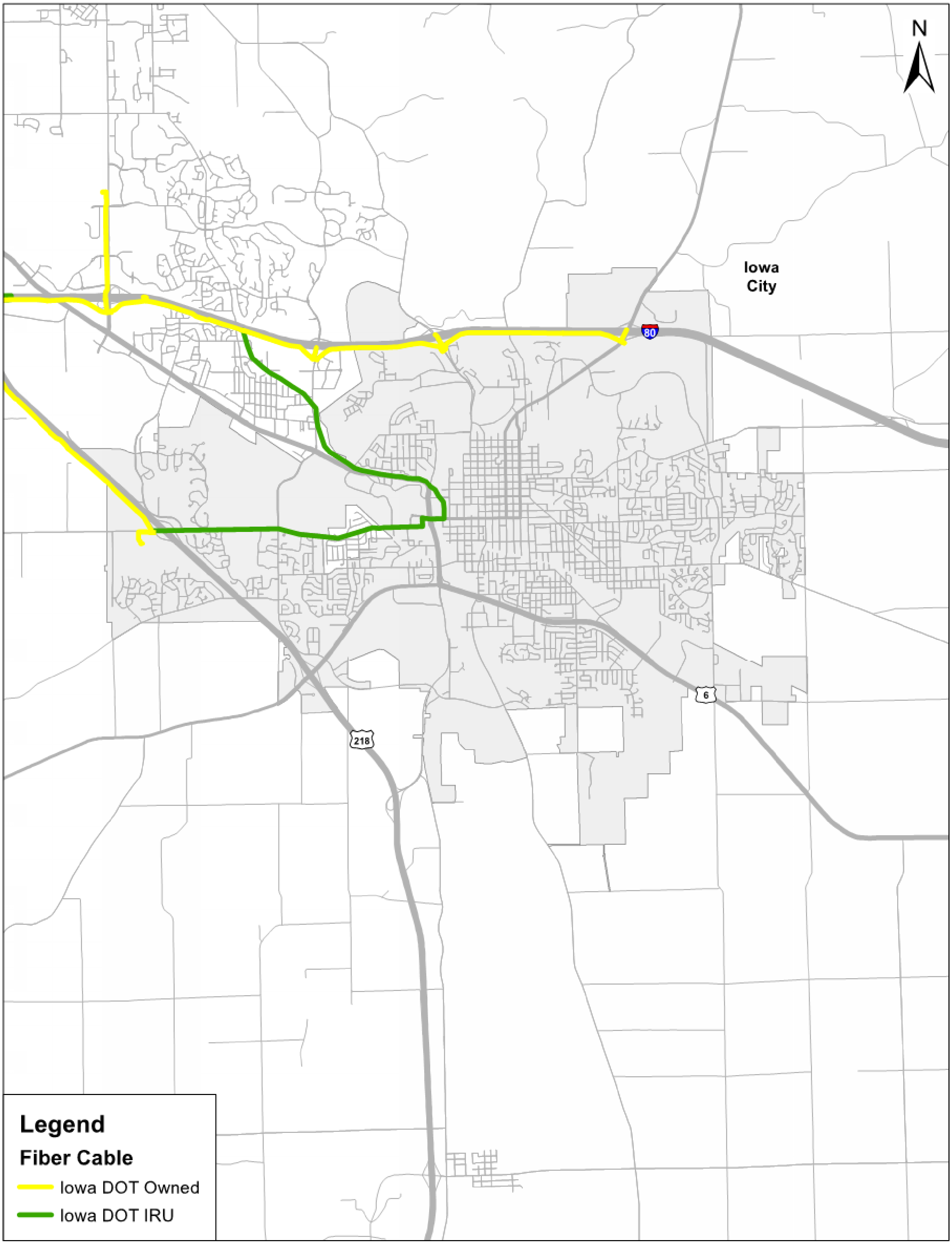

N
Sioux City
Waterloo
Dubuque
Boone/Ames/Nevada
Cedar Rapids
Quad Cities
Des Moines
Iowa City
Council Bluffs
Legend
Fiber Cable
Iowa DOT Owned
Iowa DOT IRU

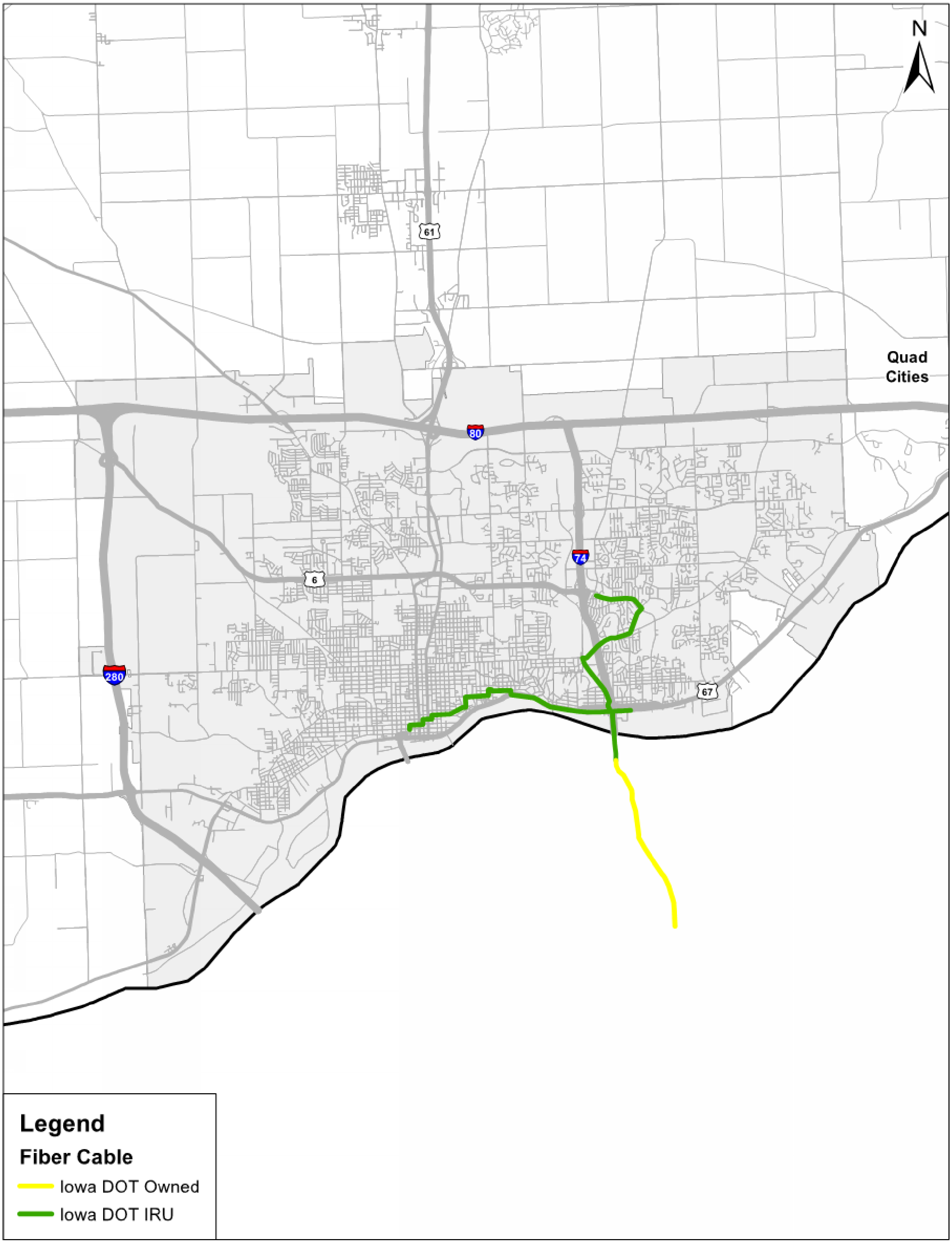

N
Boone/Ames/Nevada
69
35
30
Legend
Fiber Cable
Iowa DOT Owned
Iowa DOT IRU

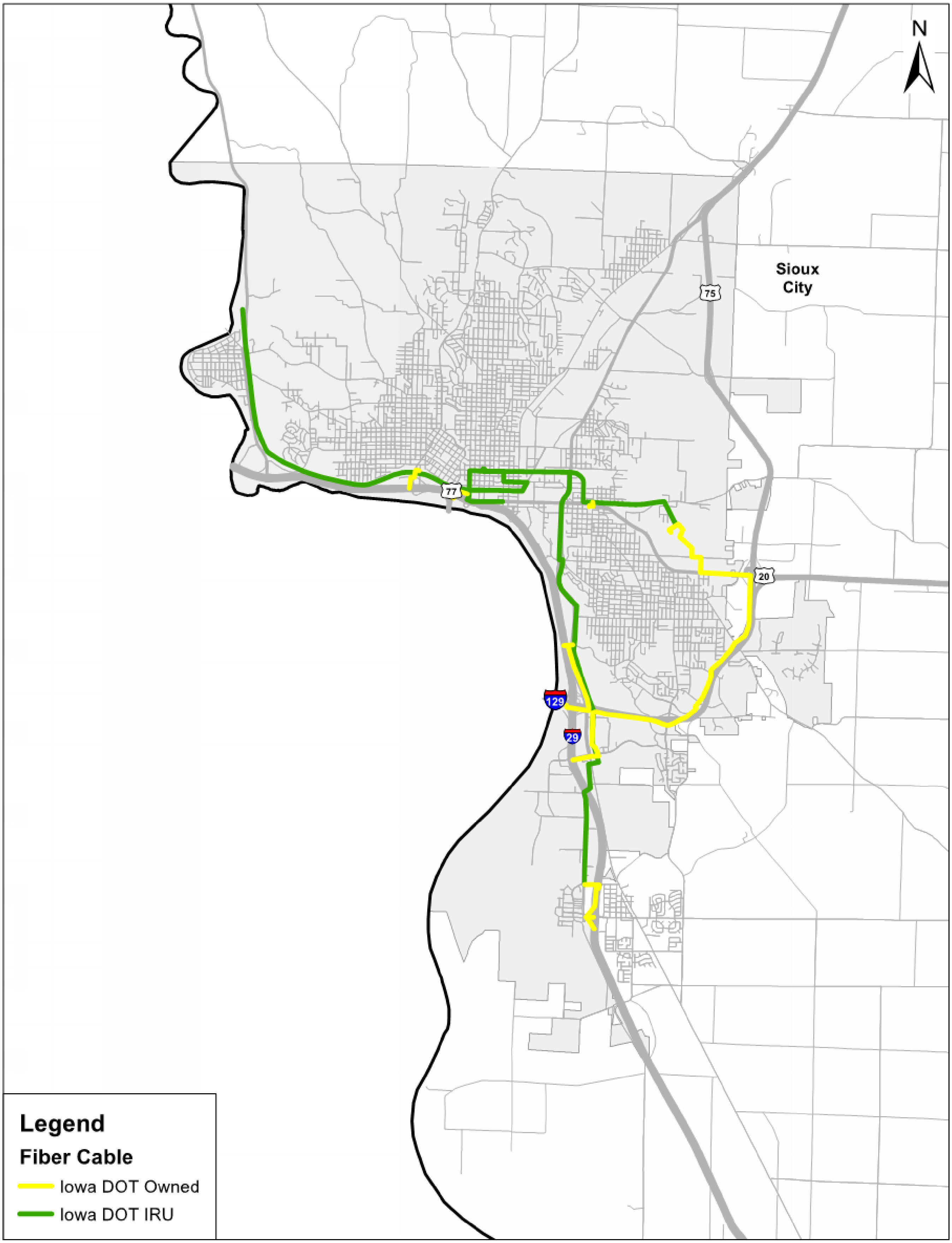

N
Cedar Rapids
151
30
218
380
Legend
Fiber Cable
Iowa DOT Owned
Iowa DOT IRU


29
480
80
6
275
Council Bluffs
N
Legend
Fiber Cable
Iowa DOT Owned
Iowa DOT IRU


N
Des Moines
69
80
6
235
65
35
Legend
Fiber Cable
Iowa DOT Owned
Iowa DOT IRU


N
Iowa City
80
6
218
Legend
Fiber Cable
Iowa DOT Owned
Iowa DOT IRU

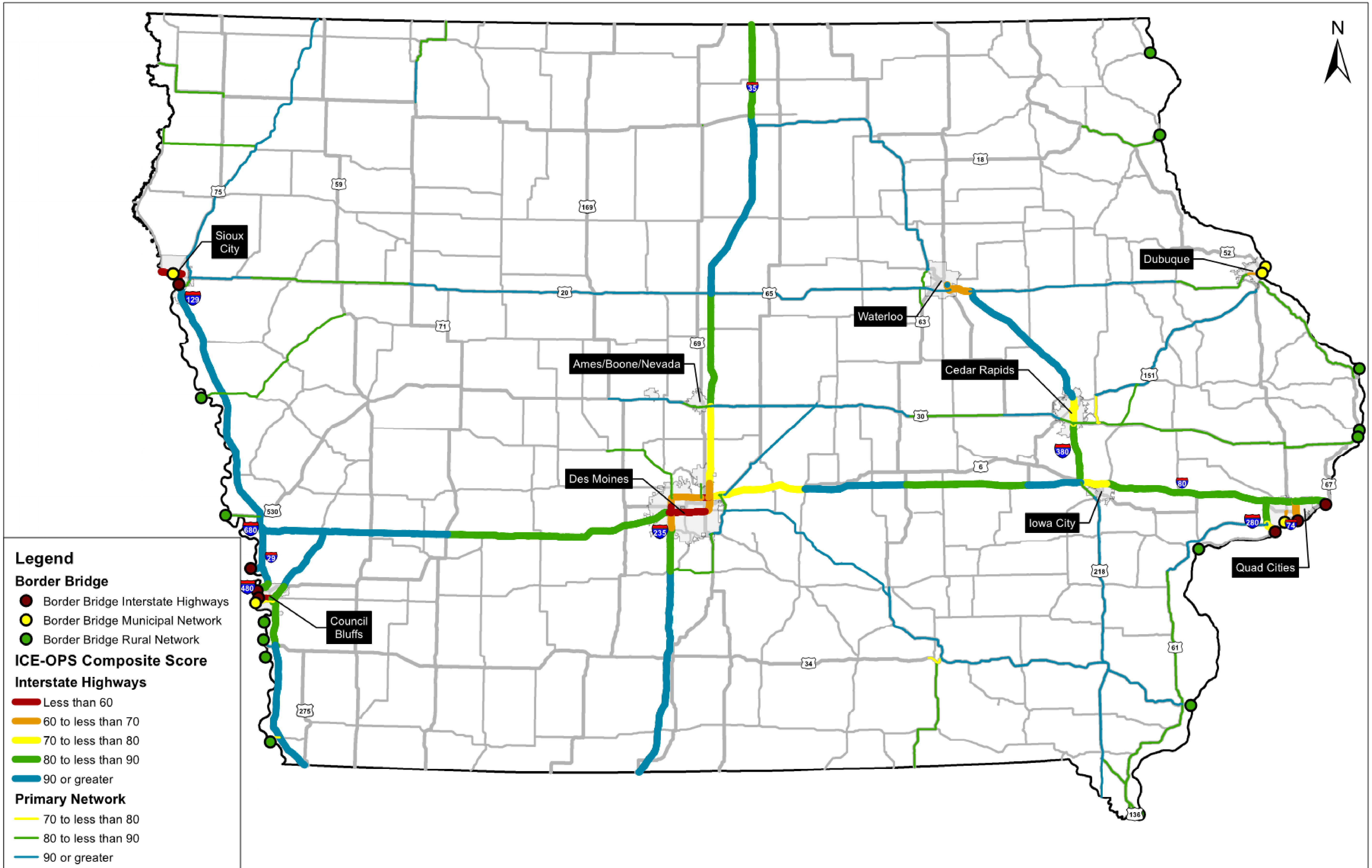

N
Quad Cities
61
80
74
6
280
67
Legend
Fiber Cable
Iowa DOT Owned
Iowa DOT IRU

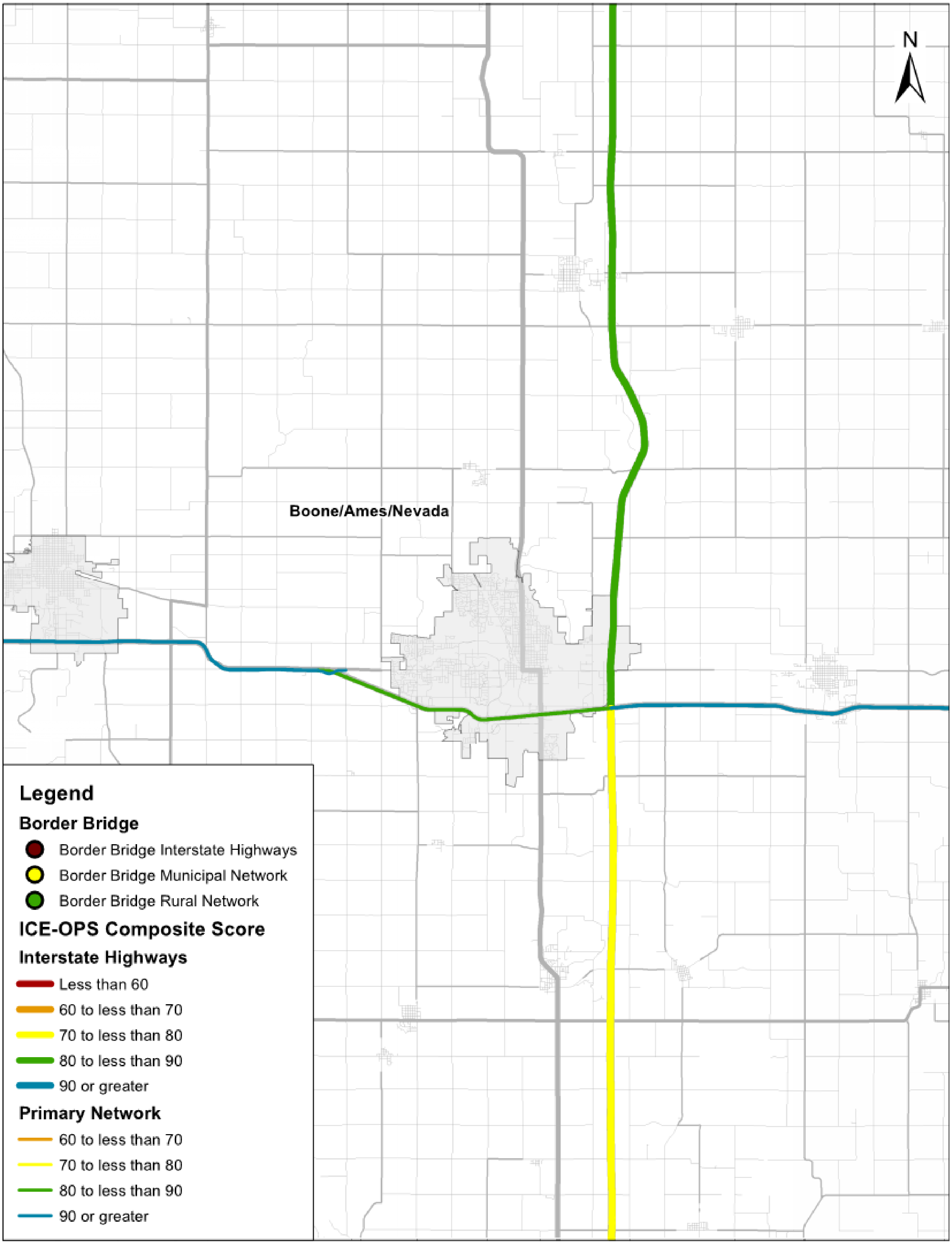

N
Sioux
City
75
77
20
129
29
Legend
Fiber Cable
Iowa DOT Owned
Iowa DOT IRU

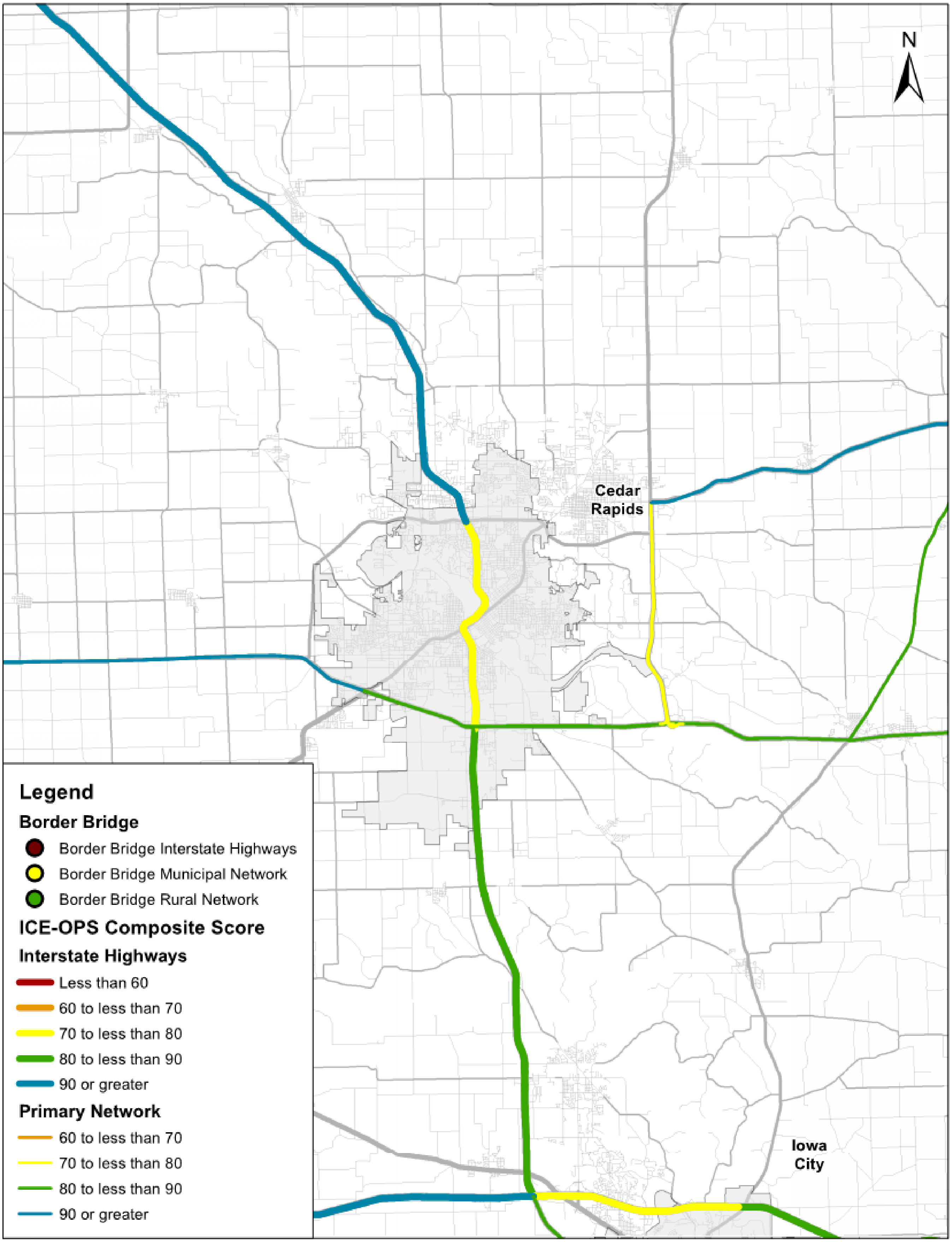
APPENDIX C. ICE-OPS SEGMENT RANKINGS

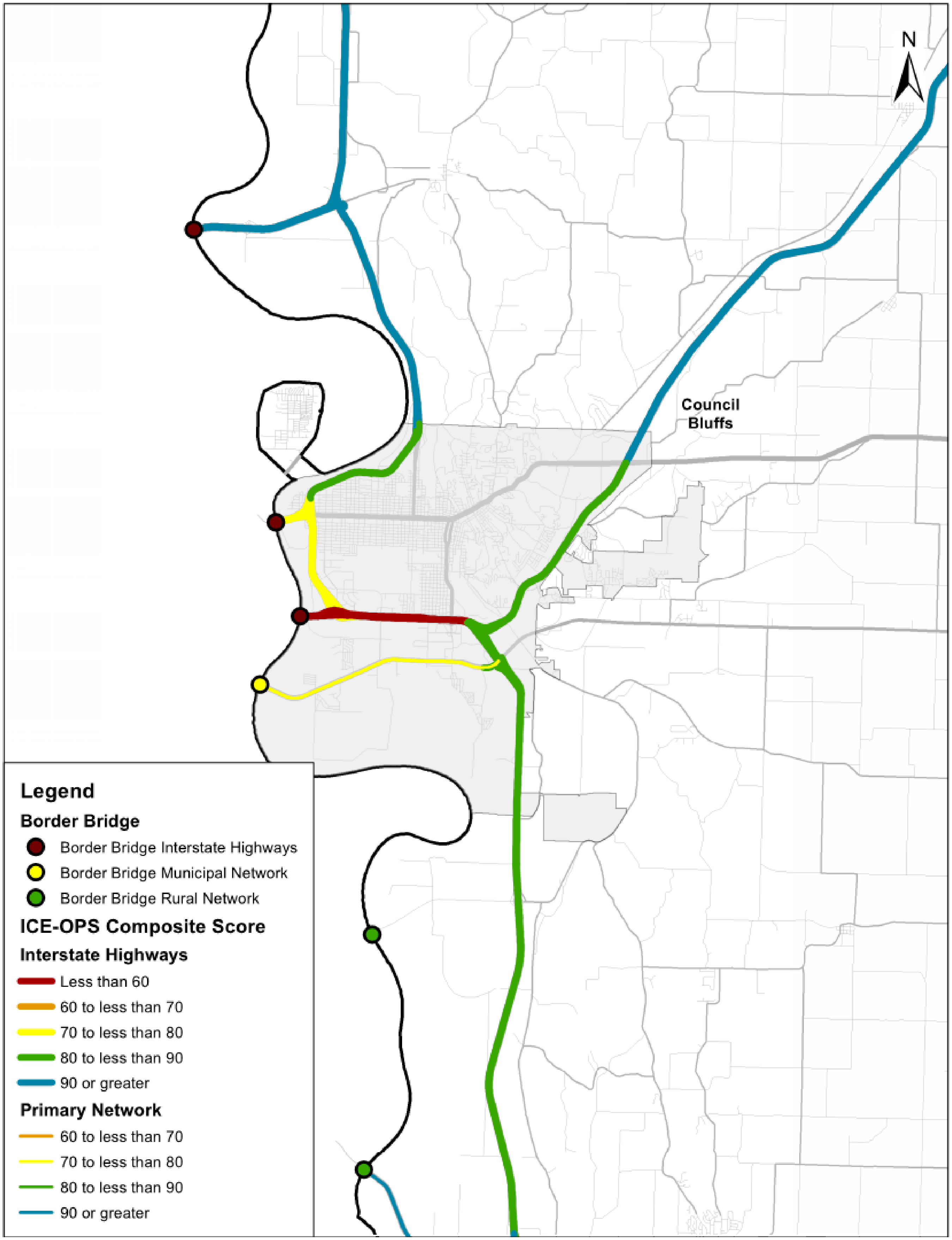
Corridor ID	Route	Corridor	Counties	Route Type	Length (mi)	All Bottlenecks per mile (10%)	Freight Bottlenecks per mile (10%)	Incident Frequency per mile (15%)	Crash Rate (15%)	Buffer Time Index (BTI) (10%)	Event Center buffer mileage (5%)	Weather Sensitive Corridor mileage (10%)	AADT (20%)	ICE rating (5%)	Composite Rating	Rank	BTI Notes
395	I-235	IA 28 to US 69	Polk	I	5.7	1	10	4	1	5	1	10	1	5	38.5	1	
463	I-35/80	W mixmaster to US 6	Polk	I	2.1	4	1	3	3	8	7	10	2	4	41.5	2	
394	I-235	W mixmaster to IA 28	Polk	I	5.1	1	10	1	5	6	1	10	3	6	45.5	3	
368	I-80	NE border to I-29	Pottawattamie	I	3.5	6	1	5	4	8	9	10	5	1	53.5	4	
263	I-29	US 20/I-129 to SD border	Woodbury	I	8.4	1	10	3	5	1	9	10	9	5	59	5	
344	US 20	IA 32 to US 52/US 61	Dubuque	D	4.0	1	10	10	1	1	10	10	8	1	60	6	
406	I-35/80	IA 415 to E mixmaster	Polk	I	2.0	8	5	8	3	8	7	10	4	2	60	6	
261	I-129	NE border to I-29	Woodbury	I	0.3	1	10	6	1	4	10	10	9	5	61	8	
407	I-35/80	IA 141 to IA 28	Polk	I	3.9	7	4	8	8	9	3	10	3	3	63	9	
408	I-35	I-80/I-235 to IA 160	Polk	I	3.1	8	4	7	7	8	5	10	4	4	63.5	10	
281	I-235	US 69 to E mixmaster	Polk	I	4.4	5	10	7	6	6	2	10	5	5	64	11	
275	I-74	IL border to I-80	Scott	I	5.2	1	10	7	5	1	10	10	8	7	64.5	12	
462	I-35/80	IA 28 to IA 415	Polk	I	4.0	9	6	8	8	9	3	10	2	2	64.5	12	
459	IA 461	US 67 to US 6	Scott	D	2.9	1	10	10	1	3	10	10	10	1	66	14	
277	I-35/80	US 6 to IA 141	Polk	I	2.5	10	9	7	8	8	7	10	2	2	68	15	
440	I-380	US 20 to end of route	Black Hawk	I	7.3	7	2	9	7	2	10	10	8	8	70	16	
430	I-35	IA 5 to I-80/I-235	Polk	I	4.7	8	5	10	6	7	3	10	6	6	70.5	17	
272	I-80	E mixmaster to IA 14	Polk, Jasper	I	28.5	10	8	9	8	8	1	4	7	5	72.5	18	
280	I-35	IA 160 to US 30	Polk, Story	I	20.9	10	9	10	6	10	1	4	7	5	74	19	
366	I-29	I-80 to I-480/US 6	Pottawattamie	I	2.9	5	10	10	4	5	9	10	8	5	74	19	
270	I-480	NE border to I-29	Pottawattamie	I	0.9	10	10	9	4	4	10	10	8	2	75.5	21	
473	IA 2	NE border to I-29	Fremont	D	2.9	1	10	10	7	2	10	10	10	5	76	22	
354	US 34	Ottumwa W CL to US 63	Wapello	D	5.0	2	10	10	5	5	10	10	10	5	77	23	
334	US 61	US 20 to WI border	Dubuque	D	2.6	1	10	10	7	6	10	10	9	3	77	23	
268	I-380	US 30 to IA 100	Linn	I	7.6	9	7	9	9	8	8	10	5	4	77	23	
343	US 151	US 30 to IA 13	Linn	D	8.2	1	10	10	8	6	10	10	9	1	77.5	26	
414	I-280	IL border to US 61/IA 146	Scott	I	3.2	3	10	10	7	3	10	10	9	7	78	27	
432	I-80	I-380 to IA 1	Johnson	I	7.1	10	9	10	6	10	2	10	6	4	78	27	
374	US 275	I-29 to NE border	Pottawattamie	D	5.1	1	10	10	6	5	10	10	10	7	78.5	29	
379	IA 27	US 20 to US 218	Black Hawk	D	5.8	4	10	10	6	6	9	10	10	4	80.5	30	
475	US 77	NE border to I-29	Woodbury	D	0.3	10	10	10	1	10	10	10	9	3	81	31	NA
267	I-380	I-80 to US 30	Johnson, Linn	I	16.2	10	9	9	8	9	6	10	6	5	81	31	
244	IA 92	I-35 to US 65	Warren	ND	12.0	8	10	10	2	8	10	10	10	5	81.5	33	
339	IA 92	US 65 to IA 5	Warren, Marion	ND	16.0	10	10	10	1	8	10	10	10	4	81.5	33	
474	IA 136	IL border to US 67	Clinton	ND	0.5	10	10	10	1	10	10	10	10	1	82	35	
388	IA 415	IA 160 to I-35/80	Polk	D	3.6	8	10	10	5	7	9	10	9	4	82	35	
425	I-80	I-29 to US 6	Pottawattamie	I	5.0	10	8	9	7	7	10	10	8	4	82	35	
271	I-80	I-280 to I-74	Scott	I	7.8	8	5	10	8	9	10	10	8	5	82.5	38	
411	I-80	US 6 to I-280	Cedar, Scott	I	18.7	10	10	10	9	10	10	1	8	4	82.5	38	
259	IA 141	US 169 to I-35/80	Dallas, Polk	D	22.4	1	10	10	8	8	8	10	10	6	83	40	
165	US 71	IA 86 to MN border	Dickinson	ND	18.3	8	10	10	3	8	10	10	10	5	83	40	
182	US 218	US 61 to IA 27	Lee	ND	13.0	10	10	10	2	8	10	10	10	4	83	40	
278	I-35	US 30 to US 20	Story, Hamilton	I	30.7	10	10	10	9	9	5	2	9	7	83.5	43	
434	US 136	US 61 to US 218	Lee	ND	2.4	9	10	10	5	6	10	10	10	3	84	44	
262	I-280	US 61/IA 146 to I-80	Scott	I	6.9	4	10	10	9	5	10	10	9	7	84	44	
409	I-80	IA 1 to US 6	Johnson, Cedar	I	24.6	10	10	10	7	10	7	7	8	4	84	44	
454	US 30	NE border to I-29	Harrison	ND	9.6	9	10	10	5	7	10	10	10	2	84.5	47	
461	US 65	IA 92 to IA 5	Warren	D	10.5	7	10	10	8	6	7	10	9	6	84.5	47	
448	I-29	I-480/US 6 to IA 192	Pottawattamie	I	2.9	7	10	10	5	7	10	10	10	6	84.5	47	
224	US 18	SD state line to US 75	Lyon, Sioux	ND	26.0	10	10	10	5	5	10	10	10	5	85	50	
352	US 34	US 61 to IL border	Des Moines	D	2.2	1	10	10	8	9	10	10	10	7	85.5	51	
31	US 52	IA 64 to US 20	Jackson, Dubuque	ND	40.5	10	10	10	4	7	10	10	10	5	85.5	51	
373	I-80	US 63 to US 151	Poweshiek, Iowa	I	32.8	10	10	10	9	10	10	1	9	6	85.5	51	
437	IA 141	IA 144 to US 169	Dallas	D	4.4	4	10	10	8	7	10	10	10	6	86	54	
18	IA 175	NE border to US 59	Monona, Woodbury, Ida	ND	49.8	8	10	10	6	6	10	10	10	7	86.5	55	
216	US 30	I-380 to 2.4 mi W of IA 1	Linn	D	10.9	8	10	10	8	8	10	10	9	1	86.5	55	
273	I-80	US 6/US 71 to US 169	Cass, Adair, Madison, Dallas	I	48.9	10	10	10	9	9	10	3	9	6	86.5	55	
371	I-80	US 169 to W mixmaster	Dallas, Polk	I	12.3	10	10	10	9	9	6	10	7	4	86.5	55	
226	US 18	US 52 to WI state	Allamakee, Clayton	ND	24.7	9	10	10	5	8	10	10	10	5	87	59	
361	US 61	US 218 to IA 2	Lee	D	9.0	7	10	10	5	8	10	10	10	9	87	59	
198	US 63	MO border to US 34	Davis, Wapello	ND	33.9	8	10	10	5	9	10	10	10	5	87	59	
410	I-80	I-74 to IL border	Scott	I	8.9	9	6	10	9	10	10	10	8	5	87	59	
457	US 20	I-29 to US 75	Woodbury	D	4.3	7	10	10	9	8	10	10	9	2	87.5	63	
455	US 30	IA 930 to I-35	Boone, Story	D	8.7	8	10	10	8	8	7	10	9	6	87.5	63	
202	US 61	IA 2 to Burlington N CL	Lee, Des Moines	D	24.4	10	10	10	6	6	10	9	10	7	87.5	63	NA
364	US 218	IA 1 to I-80	Johnson	D	5.4	10	10	10	9	8	8	10	8	2	87.5	63	
365	I-35	US 18 to MN border	Cerro Gordo, Worth	I	24.6	10	10	10	9	10	10	2	9	8	87.5	63	
429	I-35	IA 92 to IA 5	Warren, Polk	I	12.0	10	9	10	8	7	5	10	9	8	87.5	63	
201	US 61	Burlington N CL to Muscatine Co line	Des Moines, Louisa	ND	35.0	10	10	10	5	9	10	10	10	3	88	69	
220	US 20	3.5 mi E of IA 140 to US 59	Woodbury, Ida	ND	23.4	9	10	10	6	9	10	10	10	3	88.5	70	

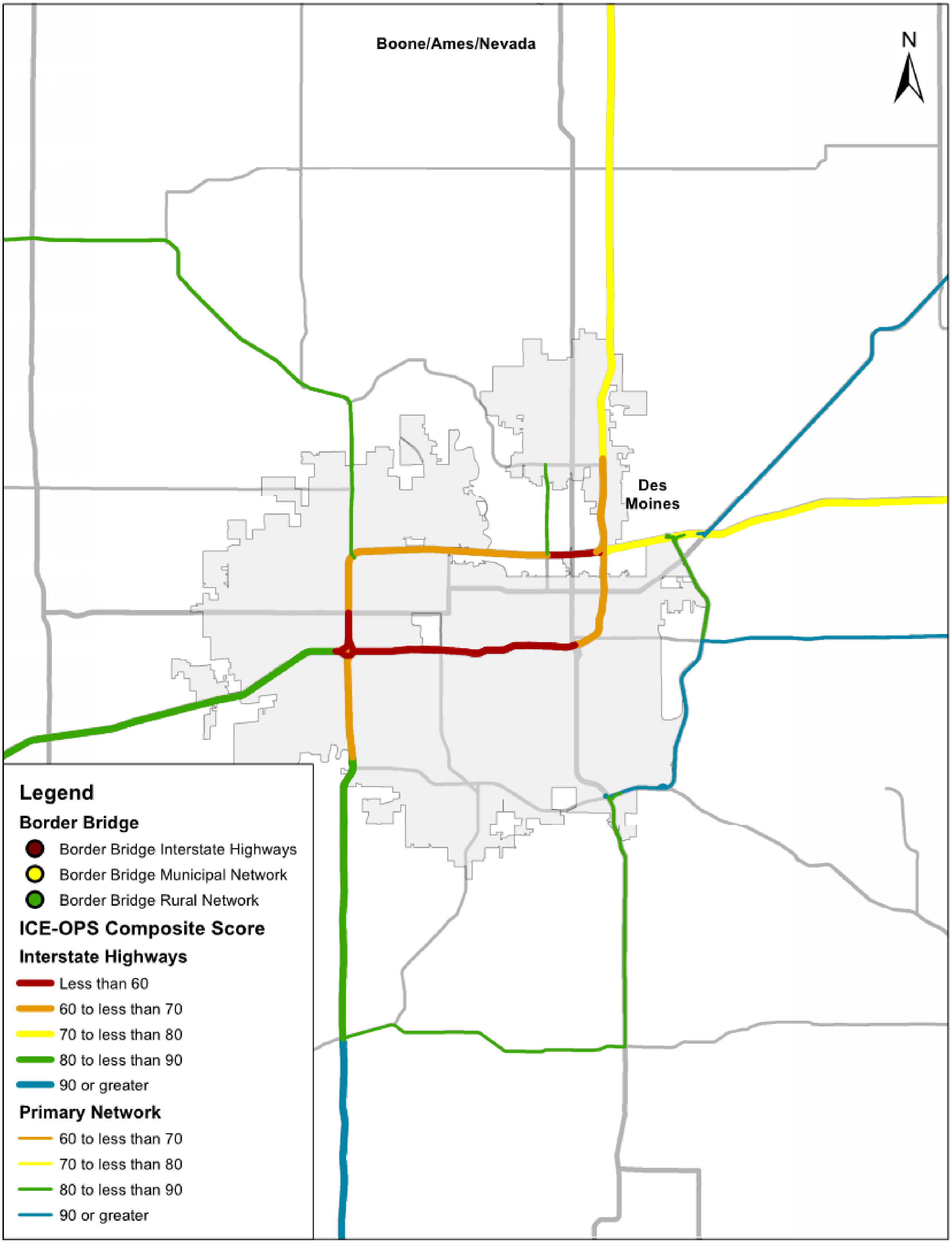
Corridor ID	Route	Corridor	Counties	Route Type	Length (mi)	All Bottlenecks per mile (10%)	Freight Bottlenecks per mile (10%)	Incident Frequency per mile (15%)	Crash Rate (15%)	Buffer Time Index (BTI) (10%)	Event Center buffer mileage (5%)	Weather Sensitive Corridor mileage (10%)	AADT (20%)	ICE rating (5%)	Composite Rating	Rank	BTI Notes
345	US 20	IA 136 to IA 32	Dubuque	D	21.1	5	10	10	8	9	10	10	10	5	88.5	70	
99	IA 10	NE border to IA 60	Sioux	ND	29.4	10	10	10	5	10	9	10	10	3	88.5	70	
217	US 30	2.4 mi W of IA 1 to US 61	Linn, Cedar, Clinton	ND	47.0	9	10	10	6	9	10	10	10	4	89	73	
417	US 65	IA 163 to I-80	Polk	D	5.0	9	10	10	9	8	8	10	9	3	89	73	
399	IA 58	US 63 to US 20	Black Hawk	ND	5.4	10	10	10	4	10	10	10	10	6	89	73	
360	US 20	US 59 to US 71	Ida, Sac	ND	19.1	10	10	10	5	9	10	10	10	6	89.5	76	Partial
351	IA 1	US 30 to US 151	Linn, Jones	ND	11.7	9	10	10	6	8	10	10	10	7	89.5	76	
215	US 30	3.3 mi E of US 63 to US 218	Tama, Benton	ND	26.1	10	10	10	6	9	10	10	10	4	90	78	
447	US 30	IA 922 to I-380	Linn	D	4.1	8	10	10	10	7	10	10	9	4	90	78	
218	US 30	US 61 to IL state line	Clinton	D	23.0	9	10	10	7	8	10	10	10	5	90	78	
362	US 61	MO border to US 218	Lee	D	9.6	8	10	10	7	8	10	10	10	7	90	78	
266	I-29	US 34 to I-80	Mills, Pottawattamie	I	14.0	9	8	10	8	9	10	10	9	8	90	78	
330	I-680	NE border to I-29	Pottawattamie	I	3.3	6	10	10	9	7	10	10	10	7	90	78	
309	IA 163	US 65 to IA 14	Polk, Jasper	D	24.5	7	10	10	9	9	6	10	10	6	90.5	84	
436	US 61	IA 38 to I-280	Muscatine, Scott	D	20.5	7	10	10	9	8	10	10	10	5	91	85	
191	US 65	IA 5 to IA 163	Warren, Polk	D	8.7	9	10	10	10	8	7	10	9	5	91	85	
274	I-680	I-29 to I-80	Pottawattamie	I	17.0	9	10	10	7	8	10	10	10	7	91	85	
358	I-35	US 20 to IA 3	Hamilton, Wright, Franklin	I	23.5	10	10	10	9	10	10	3	10	9	91	85	
372	I-80	IA 14 to US 63	Jasper, Poweshiek	I	27.6	10	10	10	8	10	6	10	9	6	91	85	
190	US 65	I-80 to IA 330	Polk, Jasper	D	15.5	9	10	10	8	8	7	10	10	8	91.5	90	
451	I-80	US 151 to I-380	Iowa, Johnson	I	19.7	10	10	10	9	10	8	10	8	6	91.5	90	
219	US 20	US 75 to 3.5 mi E of IA 140	Woodbury	D	16.8	8	10	10	9	8	10	10	10	5	92	92	
214	US 30	IA 14 to 3.3 mi E of US 63	Marshall, Tama	D	21.3	10	10	10	7	8	10	10	10	7	92	92	
200	US 61	Louisa Co line to IA 38	Muscatine	D	14.9	9	10	10	8	8	10	10	10	6	92	92	
283	US 151	IA 13 to US 61	Linn, Jones, Dubuque	D	56.9	9	10	10	8	8	10	10	10	6	92	92	
357	US 218	IA 57 to IA 3	Black Hawk, Bremer	D	16.9	9	10	10	8	9	10	10	10	4	92	92	
264	I-29	IA 175 to US 20/I-129	Monona, Woodbury	I	36.5	6	10	10	9	10	10	8	10	9	92	92	
439	I-380	IA 100 to IA 150	Linn, Benton	I	19.6	10	10	10	9	9	10	10	8	7	92	92	
400	US 20	IA 27 to US 218	Black Hawk	D	7.2	10	10	10	10	9	10	10	9	1	92.5	99	NA
212	US 30	US 169 to IA 930	Boone	D	20.1	10	10	10	7	9	9	10	10	7	92.5	99	
337	US 63	US 34 to IA 149	Wapello	D	7.1	9	10	10	8	8	10	10	10	7	92.5	99	
171	US 75	US 20 to IA 60	Woodbury, Plymouth	D	27.9	9	10	10	9	9	9	10	10	4	93	102	
370	I-80	US 6 to US 59	Pottawattamie	I	31.5	10	10	10	8	10	10	10	9	6	93	102	
405	I-35	US 34 to IA 92	Clarke, Warren	I	23.6	10	10	10	8	9	10	10	9	8	93	102	
346	US 20	IA 13 to IA 136	Delaware, Dubuque	D	18.9	10	10	10	8	8	10	10	10	7	93.5	105	Partial
197	US 63	IA 149 to IA 92	Wapello, Mahaska	D	22.6	9	10	10	9	8	10	10	10	6	93.5	105	
225	US 18	US 65 to US 218	Cerro Gordo, Floyd	D	32.4	9	10	10	9	9	10	10	10	5	94	107	
458	US 20	I-35 to US 65	Hamilton, Hardin	D	15.7	10	10	10	9	8	10	10	10	5	94	107	
403	US 20	IA 14 to IA 27	Grundy, Black Hawk	D	16.7	10	10	10	9	9	10	10	10	3	94	107	
168	US 20	I-380 to IA 150	Black Hawk, Buchanan	D	16.0	10	10	10	9	8	10	10	10	5	94	107	
213	US 30	I-35 to IA 14	Story, Marshall	D	33.9	10	10	10	8	9	9	10	10	7	94	107	
359	US 30	US 218 to IA 922	Benton, Linn	D	15.4	10	10	10	9	8	10	10	10	6	94.5	112	
210	US 34	IA 1 to US 218	Jefferson, Henry	D	26.3	10	10	10	8	9	10	10	10	7	94.5	112	
181	US 218	IA 27 to US 34	Lee, Henry	D	24.9	10	10	10	9	8	10	10	10	6	94.5	112	
363	US 218	IA 92 to IA 1	Washington, Johnson	D	24.4	10	10	10	10	9	7	10	10	4	94.5	112	NA
369	I-80	US 59 to US 6/US 71	Pottawattamie, Cass	I	20.9	10	10	10	9	10	10	10	9	6	94.5	112	
256	IA 60	US 75 to US 18	Plymouth, Sioux, O'Brien	D	35.0	10	10	10	8	9	10	10	10	8	95	117	NA
222	US 20	US 169 to I-35	Webster, Hamilton	D	33.1	10	10	10	9	9	10	10	10	5	95	117	
347	US 20	IA 150 to IA 13	Buchanan, Delaware	D	20.8	10	10	10	9	8	10	10	10	7	95	117	NA
353	US 34	US 218 to US 61	Henry, Des Moines	D	25.5	10	10	10	8	9	10	10	10	8	95	117	
449	US 71	US 18 to IA 86	Clay, Dickinson	D	10.8	9	10	10	9	8	10	10	10	9	95	117	
180	US 218	US 34 to IA 92	Henry, Washington	D	21.9	10	10	10	9	9	10	10	10	5	95	117	
178	US 218	IA 3 to US 18	Bremer, Chickasaw, Floyd	D	26.0	10	10	10	9	9	10	10	10	5	95	117	
477	IA 163	IA 14 to US 63	Marion, Mahaska	D	31.7	10	10	10	9	9	10	10	10	6	95.5	124	
242	IA 330	US 65 to US 30	Jasper, Story, Marshall	D	21.0	10	10	10	8	10	10	10	10	7	95.5	124	
257	IA 27	MO border to US 218	Lee	D	10.7	10	10	10	8	10	10	10	10	7	95.5	124	
276	I-35	MO border to US 34	Decatur, Clarke	I	32.9	10	10	10	9	8	10	10	10	8	95.5	124	
355	US 34	US 63 to IA 1	Wapello, Jefferson	D	24.4	10	10	10	9	9	10	10	10	7	96	128	
265	I-29	IA 192 to I-680	Pottawattamie	I	14.4	10	10	10	9	10	10	10	9	9	96	128	
269	I-380	IA 150 to US 20	Benton, Buchanan, Black Hawk	I	22.1	10	10	10	9	9	10	10	10	7	96	128	
321	IA 60	US 18 to MN border	O'Brien, Osceola	D	24.1	10	10	10	9	9	10	10	10	8	96.5	131	
316	US 18	I-35 to US 65	Cerro Gordo	D	7.4	10	10	10	10	9	10	10	10	5	96.5	131	
223	US 20	US 65 to IA 14	Hardin, Grundy	D	27.0	10	10	10	10	9	10	10	10	5	96.5	131	NA
419	I-29	MO border to IA 2	Fremont	I	10.0	10	10	10	10	10	10	8	10	8	97	134	
438	I-29	US 30 to IA 175	Harrison, Monona	I	40.9	10	10	10	9	10	10	10	10	8	97.5	135	
221	US 20	US 71 to US 169	Sac, Calhoun, Webster	D	51.6	10	10	10	9	10	10	10	10	9	98	136	
279	I-35	IA 3 to US 18	Franklin, Cerro Gordo	I	28.3	10	10	10	9	10	10	10	10	9	98	136	
420	I-29	IA 2 to US 34	Fremont, Mills	I	25.8	10	10	10	10	9	10	10	10	9	98.5	138	
464	US 34	NE border to I-29	Mills	D	4.3	10	10	10	10	10	10	10	10	10	100	139	

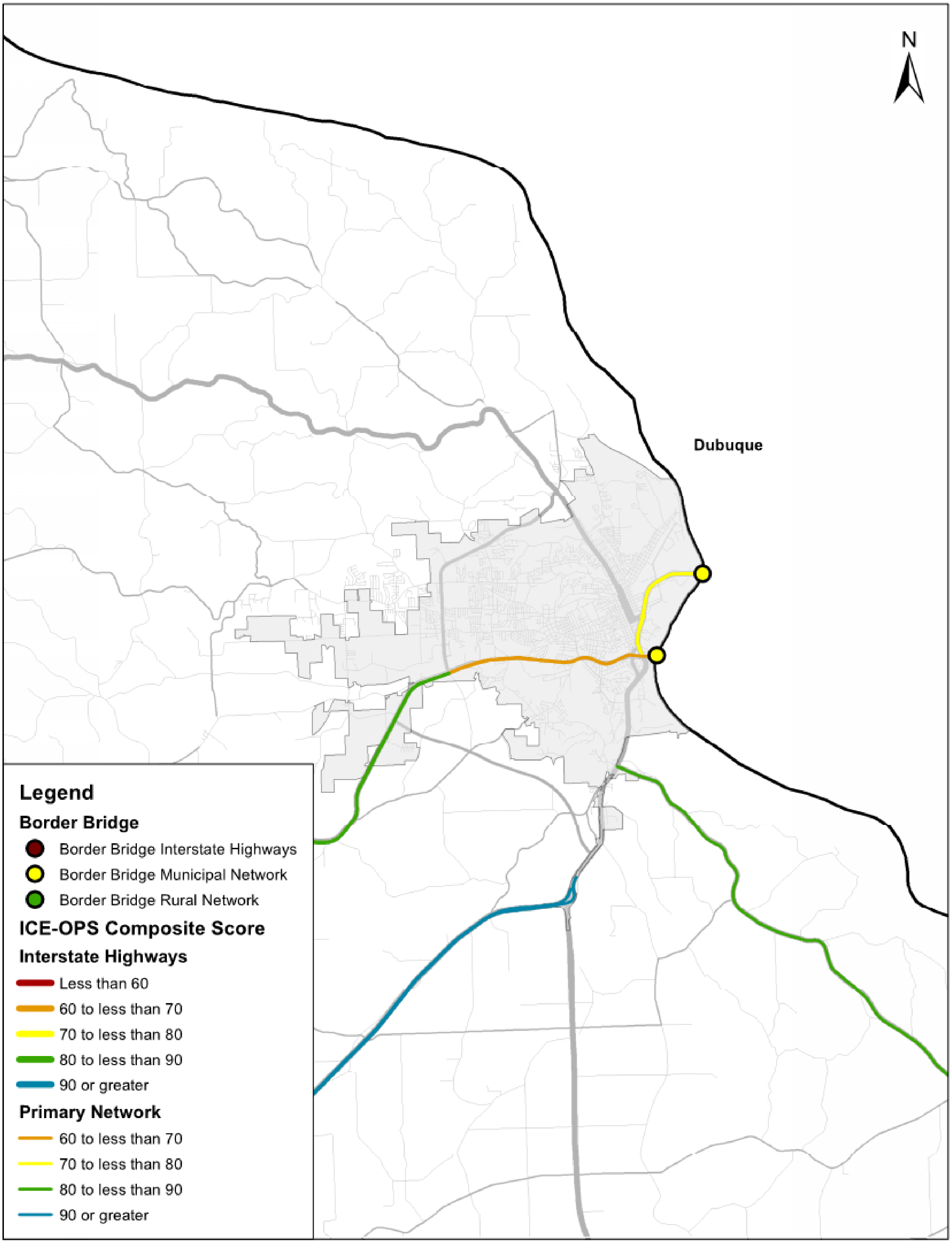

N
Sioux City
Waterloo
Dubuque
Cedar Rapids
Ames/Boone/Nevada
Des Moines
Iowa City
Quad Cities
Council Bluffs
Legend
Border Bridge
Border Bridge Interstate Highways
Border Bridge Municipal Network
Border Bridge Rural Network
ICE-OPS Composite Score
Interstate Highways
Less than 60
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater
Primary Network
70 to less than 80
80 to less than 90
90 or greater

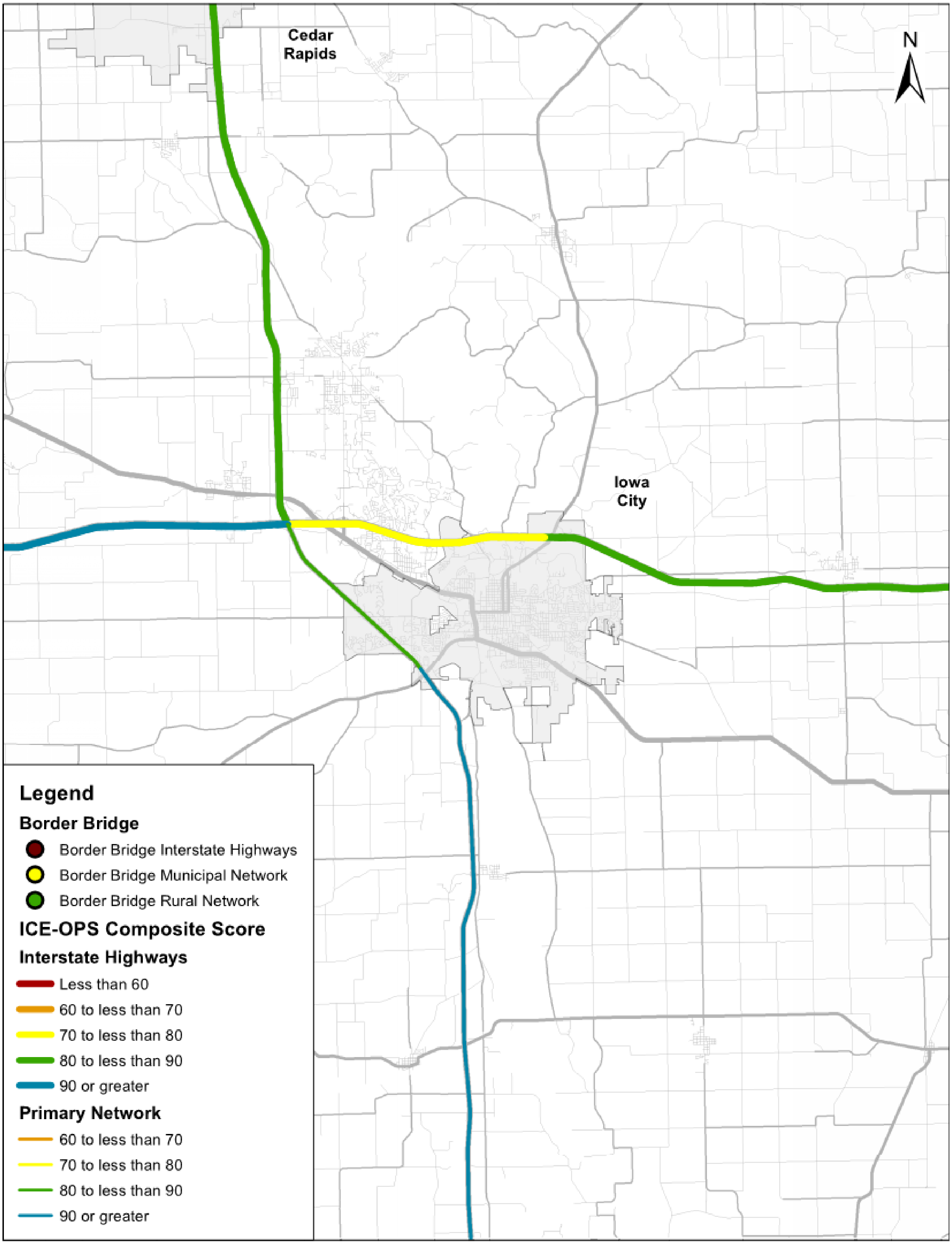

N
Boone/Ames/Nevada
Legend
Border Bridge
Border Bridge Interstate Highways
Border Bridge Municipal Network
Border Bridge Rural Network
ICE-OPS Composite Score
Interstate Highways
Less than 60
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater
Primary Network
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater

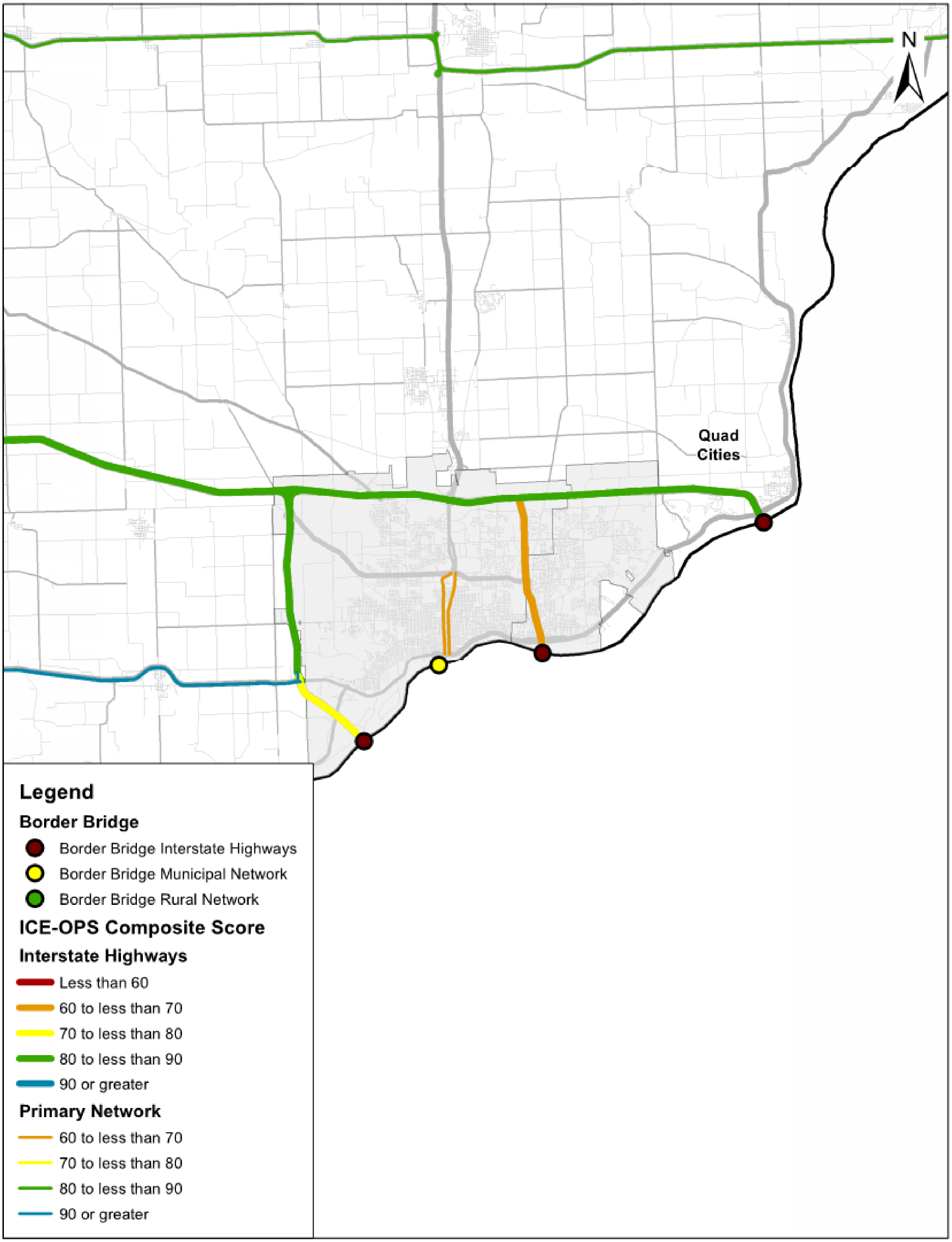

N
Cedar Rapids
Iowa City
Legend
Border Bridge
Border Bridge Interstate Highways
Border Bridge Municipal Network
Border Bridge Rural Network
ICE-OPS Composite Score
Interstate Highways
Less than 60
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater
Primary Network
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater


N
Council Bluffs
Legend
Border Bridge
Border Bridge Interstate Highways
Border Bridge Municipal Network
Border Bridge Rural Network
ICE-OPS Composite Score
Interstate Highways
Less than 60
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater
Primary Network
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater

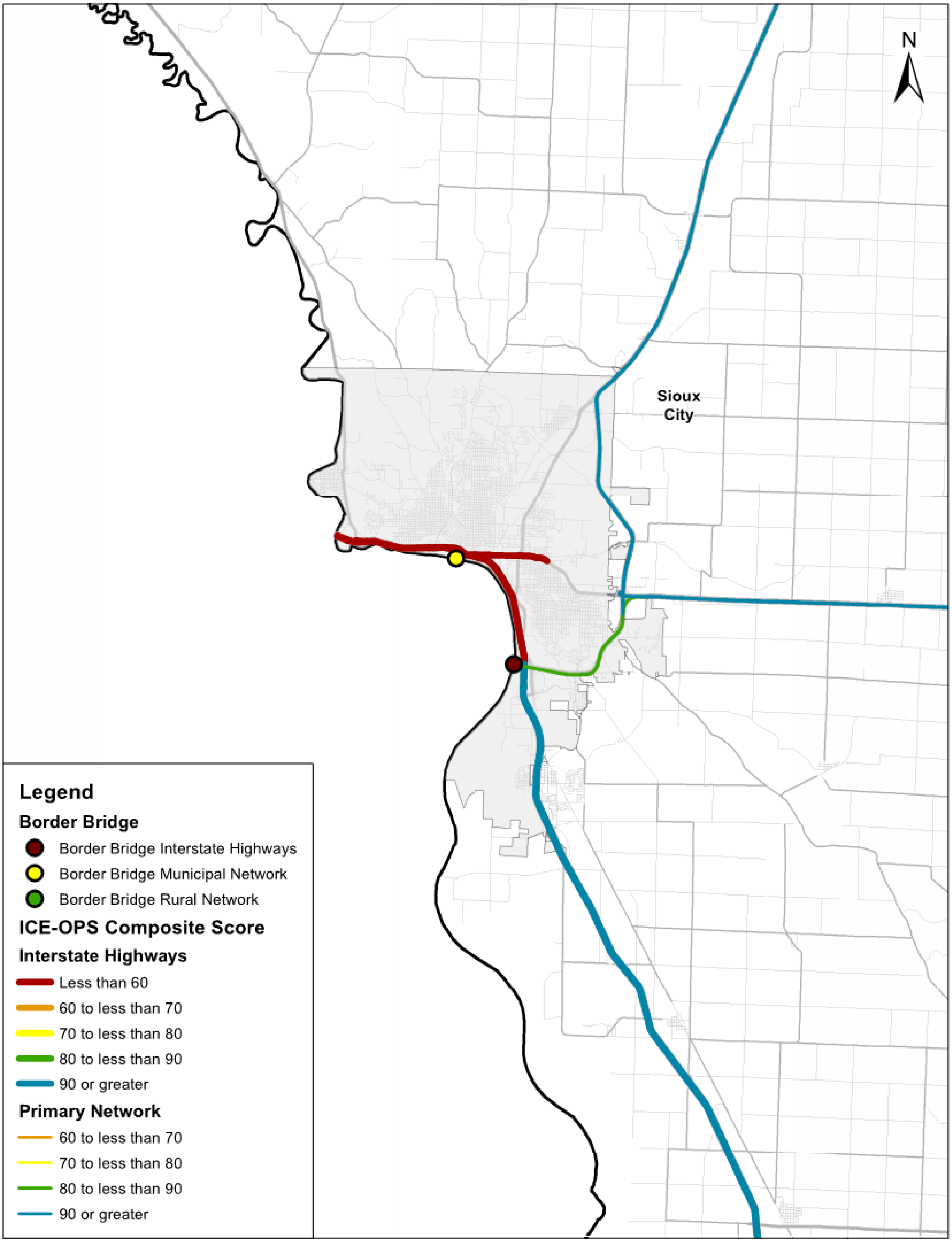

Boone/Ames/Nevada
N
Des Moines
Legend
Border Bridge
Border Bridge Interstate Highways
Border Bridge Municipal Network
Border Bridge Rural Network
ICE-OPS Composite Score
Interstate Highways
Less than 60
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater
Primary Network
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater

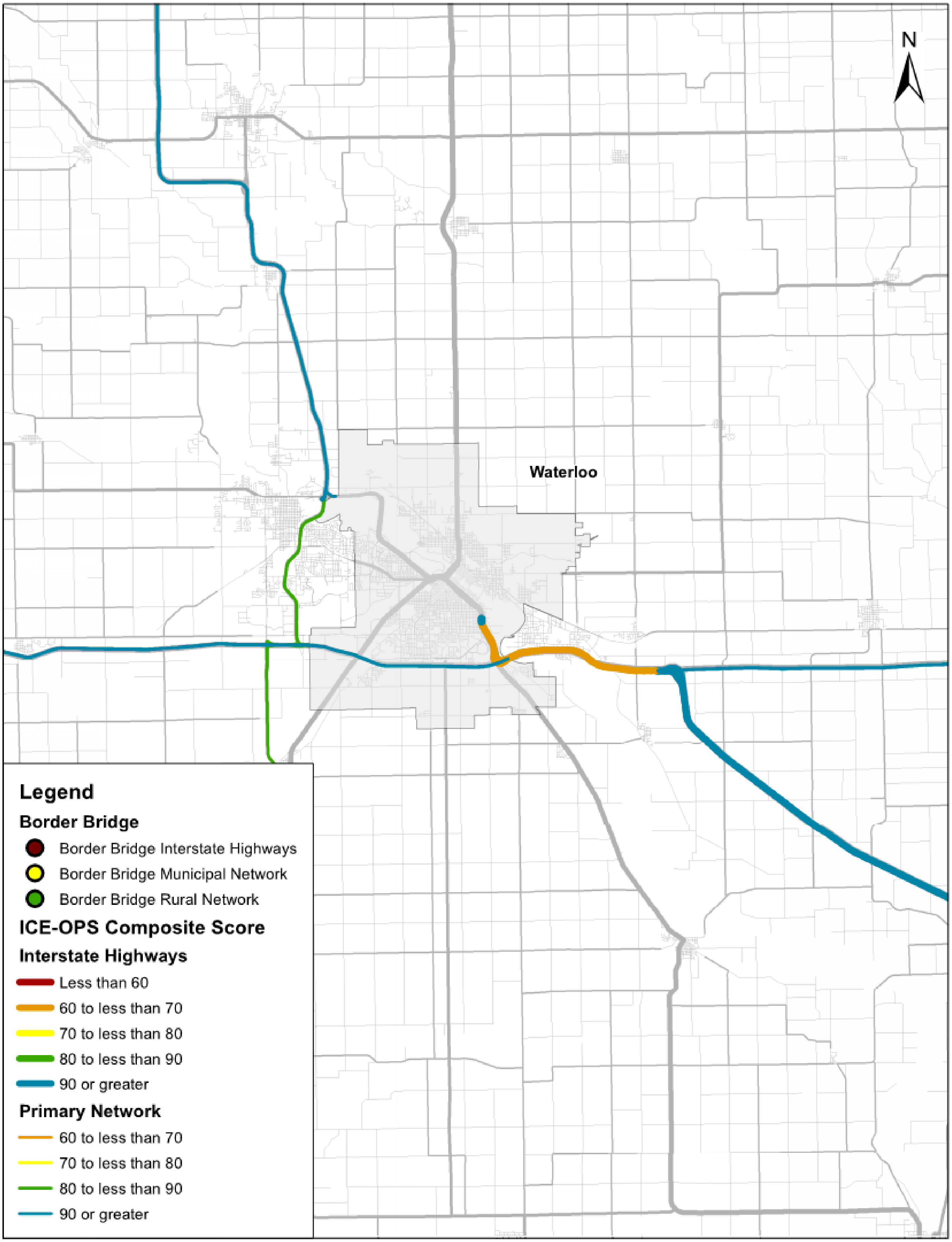

N
Dubuque
Legend
Border Bridge
Border Bridge Interstate Highways
Border Bridge Municipal Network
Border Bridge Rural Network
ICE-OPS Composite Score
Interstate Highways
Less than 60
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater
Primary Network
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater


Cedar Rapids
N
Iowa City
Legend
Border Bridge
Border Bridge Interstate Highways
Border Bridge Municipal Network
Border Bridge Rural Network
ICE-OPS Composite Score
Interstate Highways
Less than 60
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater
Primary Network
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater



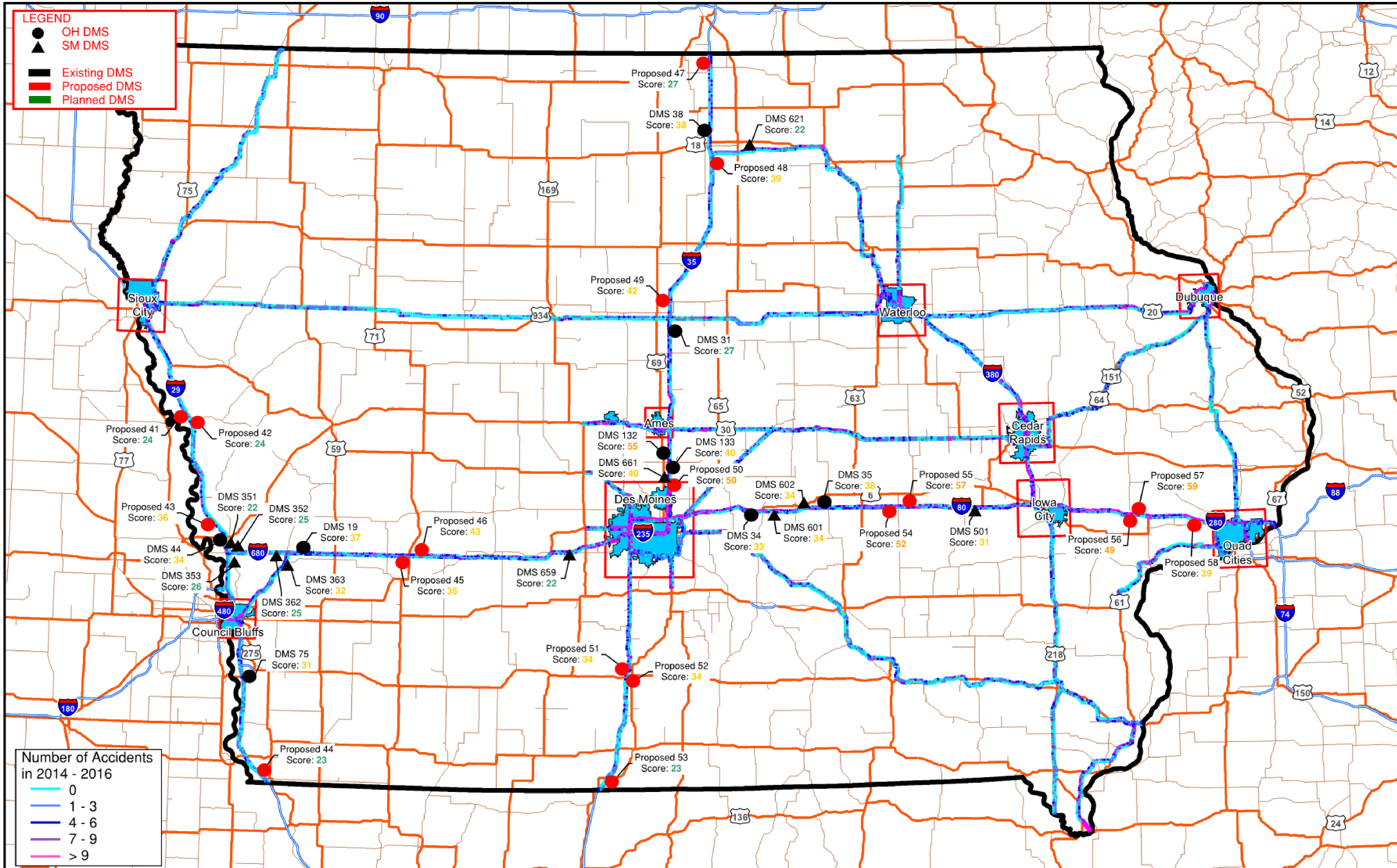
N
Quad Cities
Legend
Border Bridge
Border Bridge Interstate Highways
Border Bridge Municipal Network
Border Bridge Rural Network
ICE-OPS Composite Score
Interstate Highways
Less than 60
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater
Primary Network
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater


N
Sioux
City
Legend
Border Bridge
Border Bridge Interstate Highways
Border Bridge Municipal Network
Border Bridge Rural Network
ICE-OPS Composite Score
Interstate Highways
Less than 60
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater
Primary Network
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater



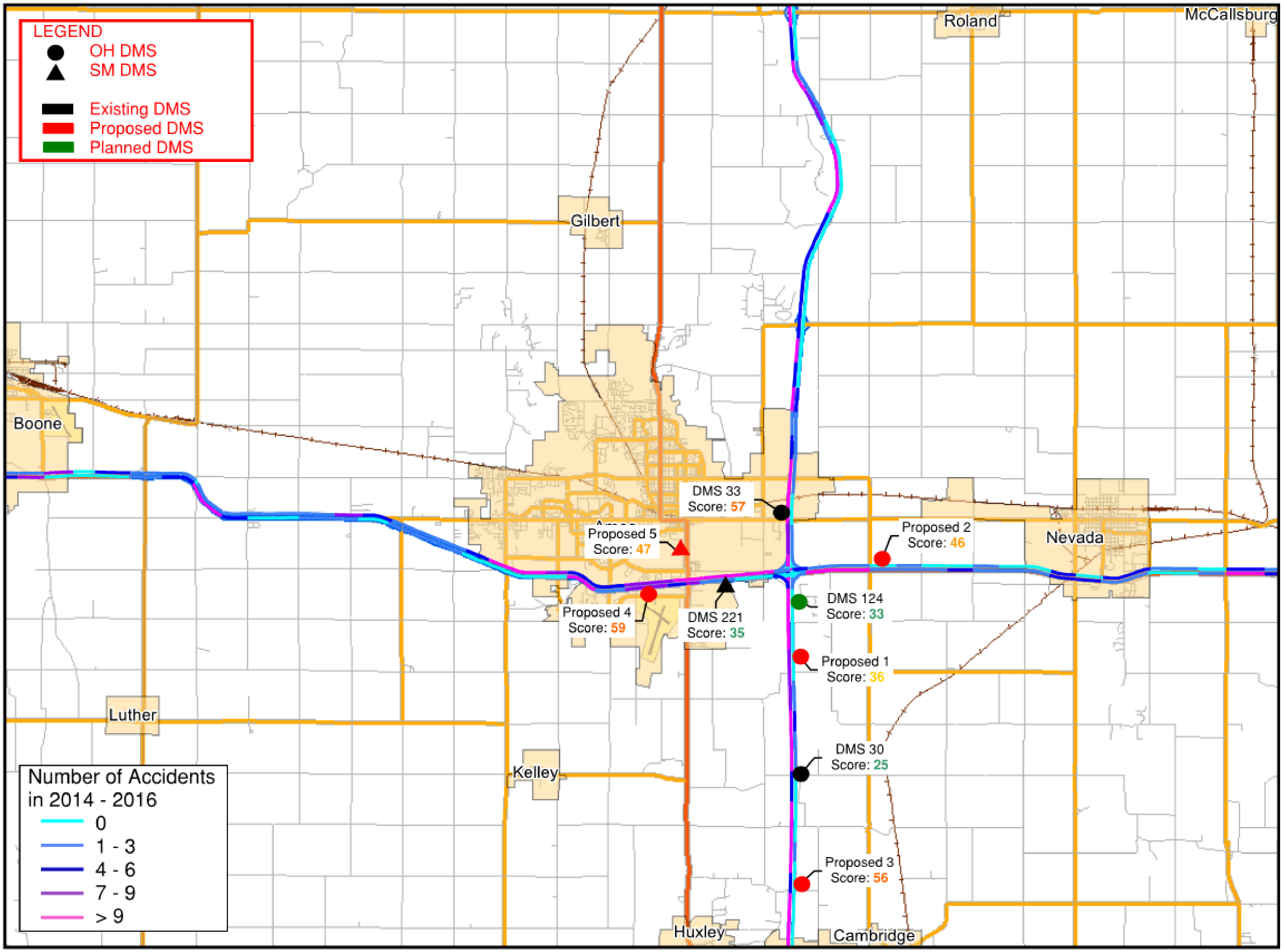
N
Waterloo
Legend
Border Bridge
Border Bridge Interstate Highways
Border Bridge Municipal Network
Border Bridge Rural Network
ICE-OPS Composite Score
Interstate Highways
Less than 60
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater
Primary Network
60 to less than 70
70 to less than 80
80 to less than 90
90 or greater

APPENDIX D. DMS INFORMATION

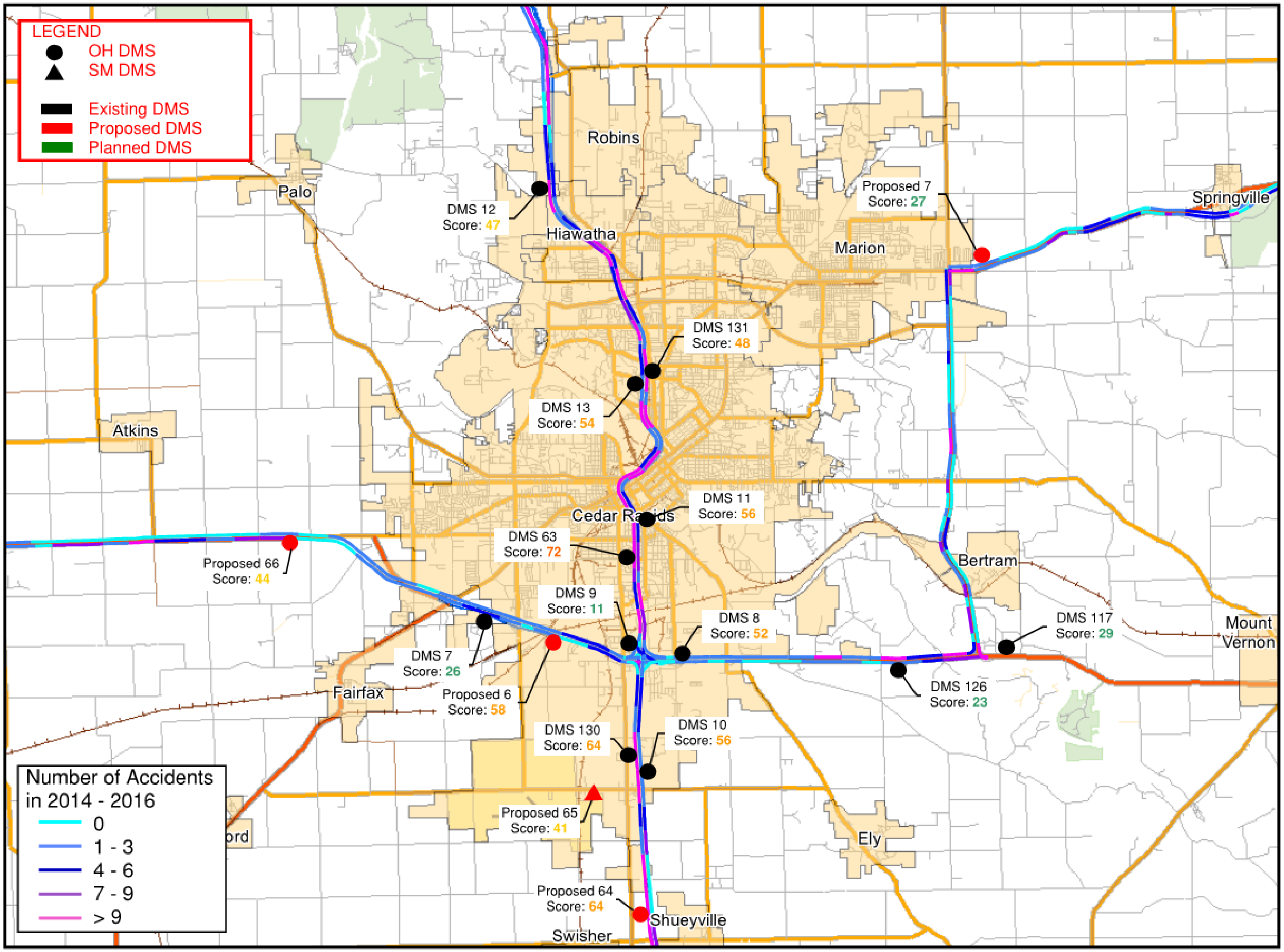


LEGEND
OH DMS
SM DMS
Existing DMS
Proposed DMS
Planned DMS
Number of Accidents in 2014 - 2016
0
1 - 3
4 - 6
7 - 9
> 9
Sioux City
Waterloo
Dubuque
Ames
Cedar Rapids
Des Moines
Iowa City
Quad Cities
Council Bluffs
Proposed 47 Score: 27
DMS 38 Score: 38
DMS 621 Score: 22
Proposed 48 Score: 39
Proposed 49 Score: 42
DMS 31 Score: 27
Proposed 41 Score: 24
Proposed 42 Score: 24
DMS 132 Score: 55
DMS 133 Score: 40
DMS 661 Score: 40
Proposed 50 Score: 50
DMS 602 Score: 34
DMS 35 Score: 38
Proposed 55 Score: 57
Proposed 57 Score: 59
Proposed 43 Score: 36
DMS 351 Score: 22
DMS 352 Score: 25
DMS 19 Score: 37
Proposed 46 Score: 43
DMS 34 Score: 33
DMS 601 Score: 34
Proposed 54 Score: 52
DMS 501 Score: 31
Proposed 56 Score: 49
Proposed 58 Score: 39
DMS 44 Score: 34
DMS 353 Score: 26
DMS 363 Score: 32
DMS 362 Score: 25
Proposed 45 Score: 35
DMS 659 Score: 22
DMS 75 Score: 31
Proposed 51 Score: 34
Proposed 52 Score: 34
Proposed 44 Score: 23
Proposed 53 Score: 23
90
12
14
18
75
169
35
934
20
71
69
29
380
151
52
64
65
63
30
59
77
6
67
88
80
280
235
680
480
61
74
275
218
150
180
136
24

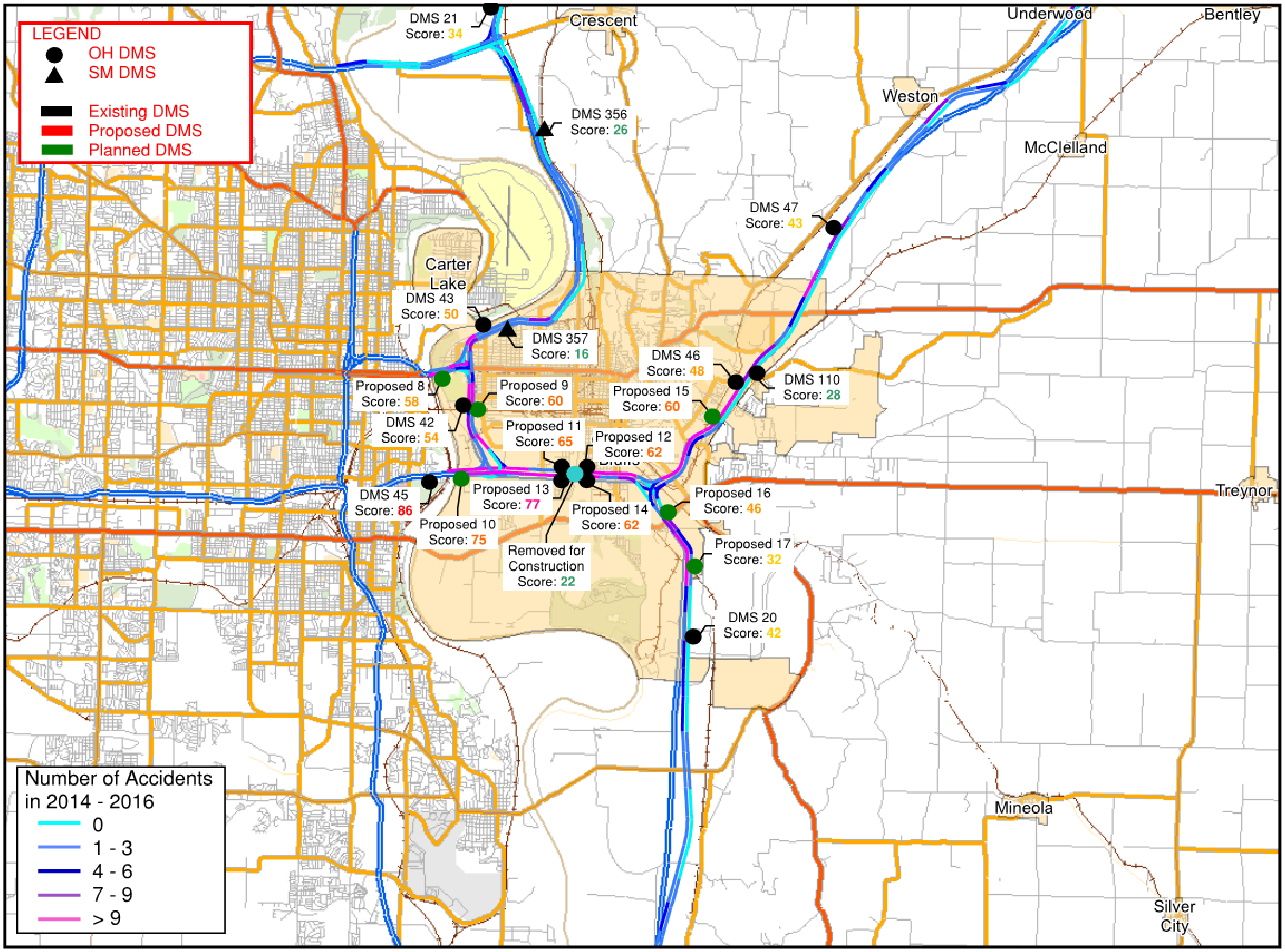
D2


LEGEND
OH DMS
SM DMS
Existing DMS
Proposed DMS
Planned DMS
Roland
McCallsburg
Gilbert
Boone
Ames
Nevada
Luther
Kelley
Huxley
Cambridge
DMS 33
Score: 57
Proposed 5
Score: 47
Proposed 2
Score: 46
Proposed 4
Score: 59
DMS 221
Score: 35
DMS 124
Score: 33
Proposed 1
Score: 36
DMS 30
Score: 25
Proposed 3
Score: 56
Number of Accidents in 2014 - 2016
0
1 - 3
4 - 6
7 - 9
> 9

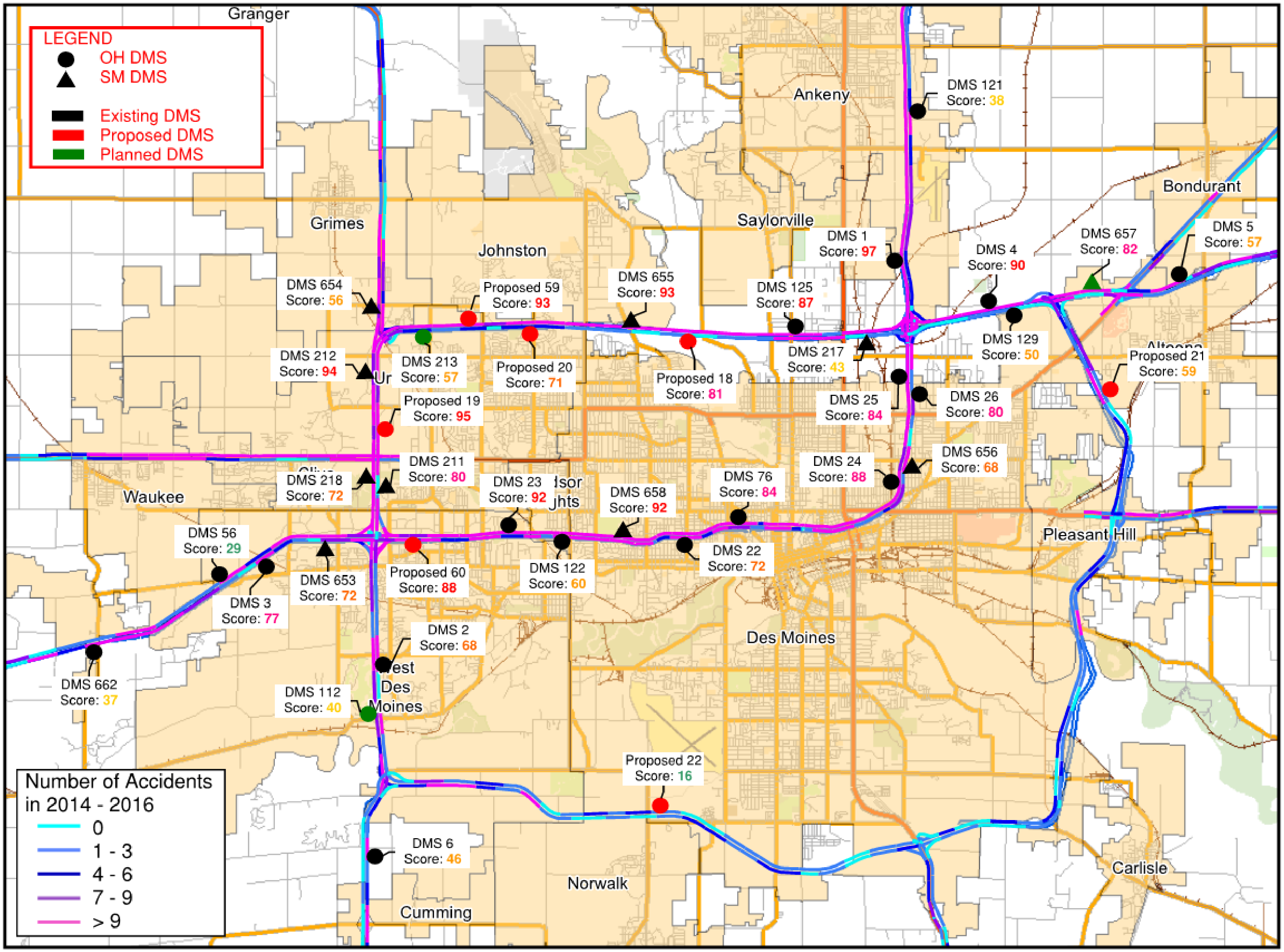
D3


LEGEND
OH DMS
SM DMS
Existing DMS
Proposed DMS
Planned DMS
Robins
Palo
Hiawatha
Marion
Springville
Proposed 7
Score: 27
DMS 12
Score: 47
DMS 131
Score: 48
DMS 13
Score: 54
Atkins
DMS 11
Score: 56
Cedar Rapids
DMS 63
Score: 72
Proposed 66
Score: 44
Bertram
DMS 9
Score: 11
DMS 8
Score: 52
DMS 117
Score: 29
Mount
Vernon
DMS 7
Score: 26
Fairfax
Proposed 6
Score: 58
DMS 126
Score: 23
DMS 130
Score: 64
DMS 10
Score: 56
Number of Accidents
in 2014 - 2016
0
1 - 3
4 - 6
7 - 9
> 9
Proposed 65
Score: 41
Ely
Proposed 64
Score: 64
Shueyville
Swisher

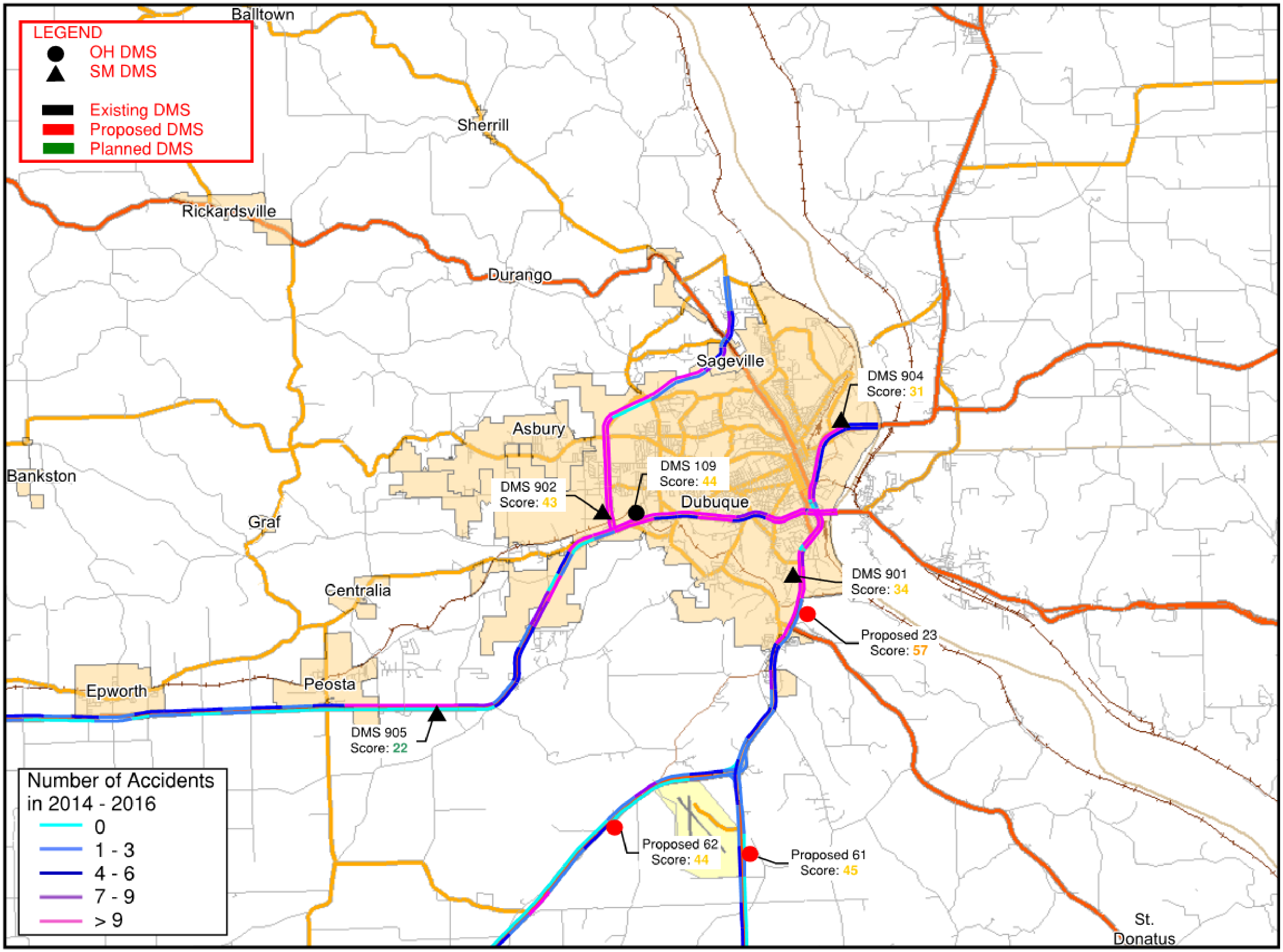
D4

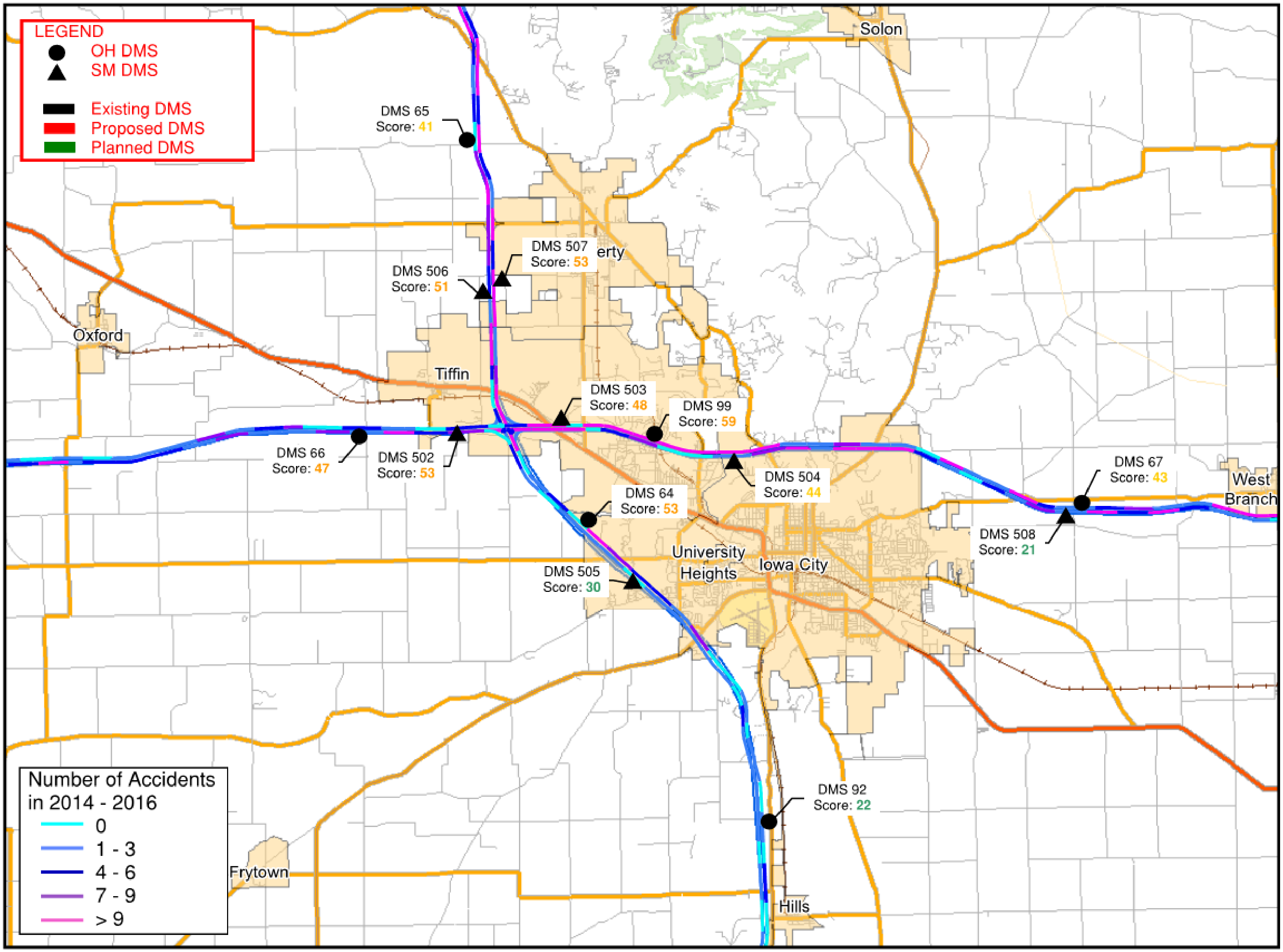


LEGEND
OH DMS
SM DMS
Existing DMS
Proposed DMS
Planned DMS
Crescent
Underwood
Bentley
Weston
McClelland
Carter Lake
Treynor
Mineola
Silver City
DMS 21 Score: 34
DMS 356 Score: 26
DMS 47 Score: 43
DMS 43 Score: 50
DMS 357 Score: 16
DMS 46 Score: 48
DMS 110 Score: 28
Proposed 8 Score: 58
Proposed 9 Score: 60
Proposed 15 Score: 60
DMS 42 Score: 54
Proposed 11 Score: 65
Proposed 12 Score: 62
DMS 45 Score: 86
Proposed 13 Score: 77
Proposed 14 Score: 62
Proposed 16 Score: 46
Proposed 10 Score: 75
Removed for Construction Score: 22
Proposed 17 Score: 32
DMS 20 Score: 42
Number of Accidents in 2014 - 2016
0
1 - 3
4 - 6
7 - 9
> 9

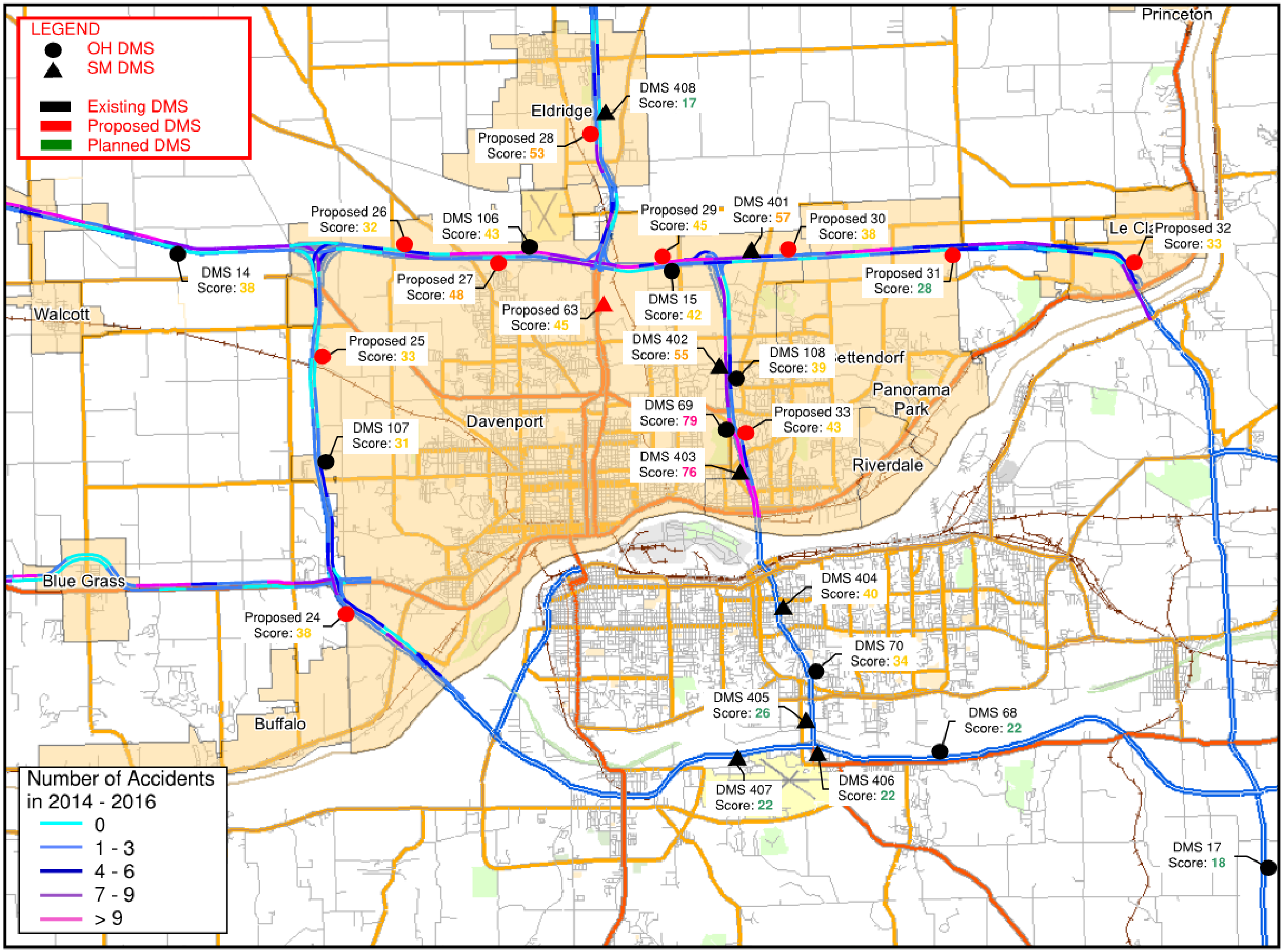

LEGEND
OH DMS
SM DMS
Existing DMS
Proposed DMS
Planned DMS
Number of Accidents in 2014 - 2016
0
1 - 3
4 - 6
7 - 9
> 9
Granger
Grimes
Johnston
Ankeny
Saylorville
Bondurant
Waukee
Pleasant Hill
Des Moines
West Des Moines
Norwalk
Cumming
Carlisle
DMS 121 Score: 38
DMS 1 Score: 97
DMS 4 Score: 90
DMS 657 Score: 82
DMS 5 Score: 57
DMS 654 Score: 56
Proposed 59 Score: 93
DMS 655 Score: 93
DMS 125 Score: 87
DMS 129 Score: 50
DMS 212 Score: 94
DMS 213 Score: 57
Proposed 20 Score: 71
Proposed 18 Score: 81
DMS 217 Score: 43
Proposed 21 Score: 59
Proposed 19 Score: 95
DMS 25 Score: 84
DMS 26 Score: 80
DMS 211 Score: 80
DMS 218 Score: 72
DMS 23 Score: 92
DMS 658 Score: 92
DMS 76 Score: 84
DMS 24 Score: 88
DMS 656 Score: 68
DMS 56 Score: 29
DMS 3 Score: 77
DMS 653 Score: 72
Proposed 60 Score: 88
DMS 122 Score: 60
DMS 22 Score: 72
DMS 2 Score: 68
DMS 662 Score: 37
DMS 112 Score: 40
Proposed 22 Score: 16
DMS 6 Score: 46

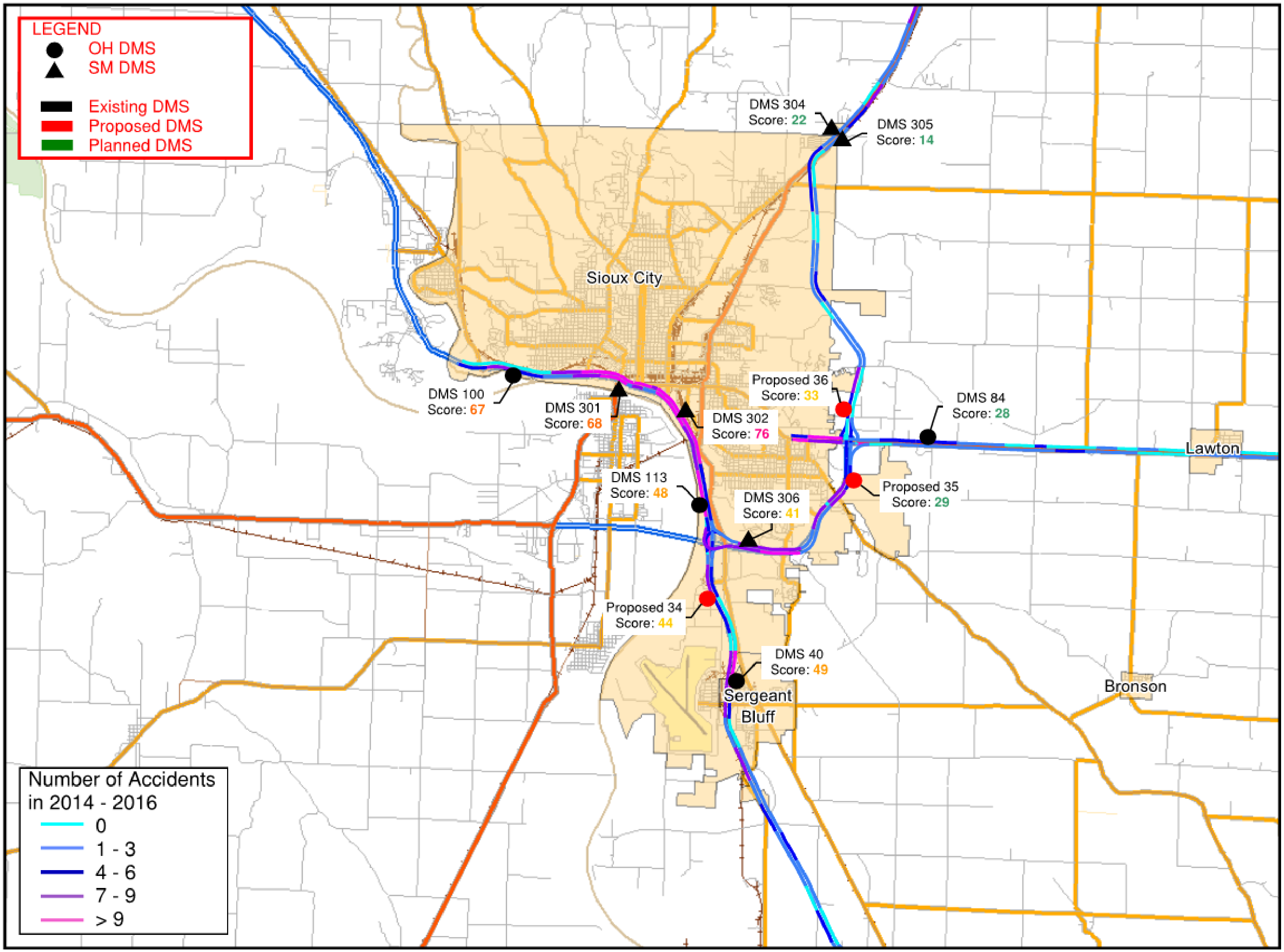
D6

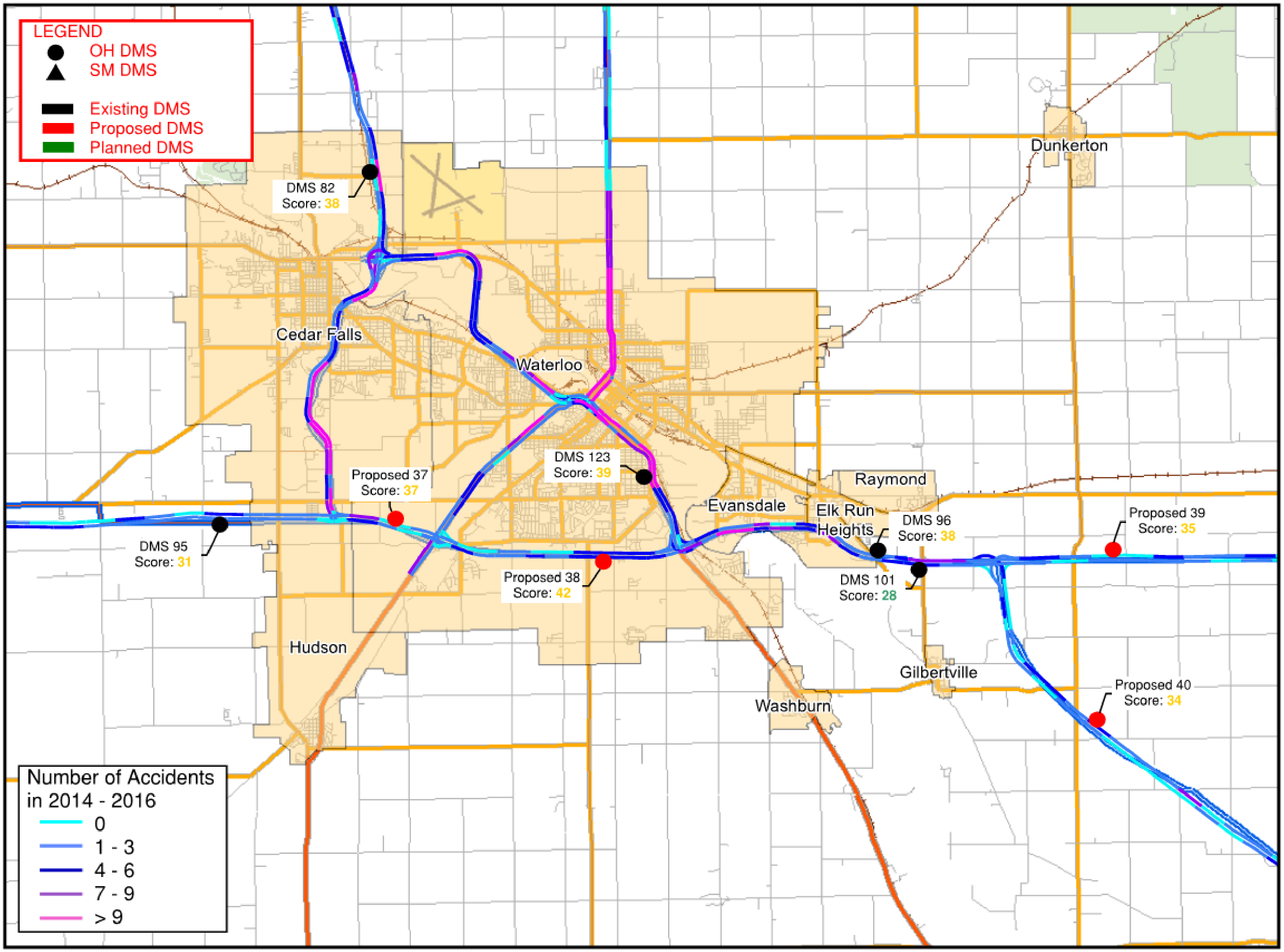

LEGEND
OH DMS
SM DMS
Existing DMS
Proposed DMS
Planned DMS
Balltown
Sherrill
Rickardsville
Durango
Sageville
Asbury
Bankston
Graf
Dubuque
Centralia
Epworth
Peosta
St. Donatus
DMS 904
Score: 31
DMS 109
Score: 44
DMS 902
Score: 43
DMS 901
Score: 34
Proposed 23
Score: 57
DMS 905
Score: 22
Proposed 62
Score: 44
Proposed 61
Score: 45
Number of Accidents in 2014 - 2016
0
1 - 3
4 - 6
7 - 9
> 9


LEGEND
OH DMS
SM DMS
Existing DMS
Proposed DMS
Planned DMS
Solon
DMS 65
Score: 41
DMS 507
Score: 53
erty
DMS 506
Score: 51
Oxford
Tiffin
DMS 503
Score: 48
DMS 99
Score: 59
DMS 66
Score: 47
DMS 502
Score: 53
DMS 504
Score: 44
DMS 67
Score: 43
West
Branch
DMS 64
Score: 53
DMS 508
Score: 21
University
Heights
Iowa City
DMS 505
Score: 30
DMS 92
Score: 22
Number of Accidents
in 2014 - 2016
0
1 - 3
4 - 6
7 - 9
> 9
Frytown
Hills

D8


LEGEND
OH DMS
SM DMS
Existing DMS
Proposed DMS
Planned DMS
Number of Accidents in 2014 - 2016
0
1 - 3
4 - 6
7 - 9
> 9
Princeton
Eldridge
Walcott
Davenport
Blue Grass
Buffalo
Panorama Park
Riverdale
DMS 408 Score: 17
Proposed 28 Score: 53
Proposed 26 Score: 32
DMS 106 Score: 43
Proposed 29 Score: 45
DMS 401 Score: 57
Proposed 30 Score: 38
Proposed 32 Score: 33
DMS 14 Score: 38
Proposed 27 Score: 48
Proposed 63 Score: 45
DMS 15 Score: 42
Proposed 31 Score: 28
DMS 402 Score: 55
DMS 108 Score: 39
Proposed 25 Score: 33
DMS 69 Score: 79
Proposed 33 Score: 43
DMS 107 Score: 31
DMS 403 Score: 76
DMS 404 Score: 40
Proposed 24 Score: 38
DMS 70 Score: 34
DMS 405 Score: 26
DMS 68 Score: 22
DMS 407 Score: 22
DMS 406 Score: 22
DMS 17 Score: 18


LEGEND
OH DMS
SM DMS
Existing DMS
Proposed DMS
Planned DMS
Sioux City
Sergeant Bluff
Lawton
Bronson
DMS 304 Score: 22
DMS 305 Score: 14
DMS 100 Score: 67
DMS 301 Score: 68
DMS 302 Score: 76
Proposed 36 Score: 33
DMS 84 Score: 28
Proposed 35 Score: 29
DMS 113 Score: 48
DMS 306 Score: 41
Proposed 34 Score: 44
DMS 40 Score: 49
Number of Accidents in 2014 - 2016
0
1 - 3
4 - 6
7 - 9
> 9



LEGEND
OH DMS
SM DMS
Existing DMS
Proposed DMS
Planned DMS
DMS 82 Score: 38
Cedar Falls
Waterloo
Dunkerton
DMS 123 Score: 39
Proposed 37 Score: 37
Raymond
Evansdale
Elk Run Heights
DMS 96 Score: 38
Proposed 39 Score: 35
DMS 95 Score: 31
Proposed 38 Score: 42
DMS 101 Score: 28
Hudson
Gilbertville
Washburn
Proposed 40 Score: 34
Number of Accidents in 2014 - 2016
0
1 - 3
4 - 6
7 - 9
> 9

					DMS						Justification Categories						Volumes	Crashes	DMS Usage			
											2	3	4	5	Sum	Category Score	AADT Score	Crash Score	Usage Score	TMC Input	Overall Score	
ID	TS ID	Route	Direction	MM	Location	Latitude	Longitude	Area	Condition	Type	8	6	2	5		20%	20%	20%	20%	20%	100%	Notes
1	2	I-35	SB	88.4	Corp Woods	41.67002	-93.57829	Des Moines	Existing	OH	1	1	1	1	21	10	9	10	10	10	97	
Prop 19		I-35/80	NB	125.43	US 6	41.619819	-93.776608	Des Moines	Proposed New	OH	1	1	1	1	21	10	10	8		10	95	Propose replace 211 with Proposed 19
212	26	I-35/80	SB	126.9	Douglas	41.64107	-93.777155	Des Moines	Existing	SM	1	1	1	1	21	10	10	9	9	9	94	Move and make OH N of bridge douglass
Prop 59		I-35/I-80	WB	129.1	86th Street	41.592049	-93.771437	Des Moines	Proposed New	OH	1	1	1	1	21	10	9	8		10	93	
655	298	I-35/I-80	WB	132.4	Beaver	41.65137	-93.67886	Des Moines	Existing	SM	1	1	1	1	21	10	8	9	10	10	93	Replace with overhead
23	37	I-235	WB	2.65	17th St	41.5934	-93.72697	Des Moines	Existing	OH	1	1	1	1	21	10	6	10	10	10	92	
658	349	I-235	WB	4.89	Bogey	41.592217	-93.684517	Des Moines	Existing	SM	1	1	1	1	21	10	6	10	10	10	92	
4	4	I-80	WB	139.56	4-Mile	41.6571	-93.54309	Des Moines	Existing	OH	1	1	1	1	21	10	8	7	10	10	90	
24	31	I-235	WB	10.8	Washington	41.60758	-93.57917	Des Moines	Existing	OH	1	1	1	1	21	10	7	9	9	9	88	
Prop 60		I-235	EB	0.72	50th St	41.592049	-93.771437	Des Moines	Proposed New	OH	1	1	1	1	21	10	9	8		8	88	
125	375	I-35/80	WB	135.65	2nd Ave	41.64971	-93.61736	Des Moines	Existing	OH		1	1	1	13	6	8	10	10	10	87	
45	355	I-80	EB	454.5	Spring Street	41.23098056	-95.91694444	Council Bluffs (NE)	Planned	OH	1	1	1	1	21	10	6	9	9	9	86	Existing sidemount being replaced with color
25	99	I-235	WB	13.15	DM Broadway	41.640904	-93.575847	Des Moines	Existing	OH		1	1	1	13	6	7	9	10	10	84	
76	347	I-235	WB	7.5	19th St	41.595967	-93.64137	Des Moines	Existing	OH		1	1	1	13	6	6	10	10	10	84	
657	300	I-80	WB	141	Between 65N and 65S	41.66208	-93.49967	Des Moines	Planned	SM	1	1	1	1	21	10	6	10	8	7	82	Planned SM, this was taken out, not going back in
Prop 18	38	I-35/80	EB	133.8	NW 2nd Ave	41.649233	-93.629498	Des Moines	Proposed New	SM		1	1	1	13	6	8	9		10	81	maybe move slightly east - closer to DMS 217
26	100	I-235	EB	12.75	Euclid	41.635172	-93.575491	Des Moines	Existing	OH	1	1	1	1	21	10	7	7	8	8	80	
211	36	I-35/80	EB	124.57	Hickman NB	41.607468	-93.77673	Des Moines	Existing	SM		1	1	1	13	6	10	4	10	10	80	Propose replace with Proposed 19 (keep per District comments)
69	96	I-74	EB	2.5	Duck Creek	41.54832	-90.52116	Quad Cities (IA)	Existing	OH	1	1	1	1	21	10	5	10	7	7	79	
3	3	I-80	EB	120.63	Jordan Creek	41.585241	-93.822117	Des Moines	Existing	OH	1	1	1	1	21	10	5	4	10	10	77	
Prop 13		I-80	EB	2.06	Expressway Street	41.231964	-95.871397	Council Bluffs	Planned	OH	1	1	1	1	21	10	7	9		5	77	
403	225	I-74	EB	1.56	Lincoln Road	41.536855	-90.51694	Quad Cities (IA)	Existing	SM	1	1	1	1	21	10	6	10	10	2	76	Consider removing
302	265	I-29	NB	146.6	SC Barb	42.475006	-96.383365	Sioux City	Existing	SM	1	1		1	19	9	3	8	9	9	76	
Prop 10		I-80	EB	0.2	I-29	41.231828	-95.90711	Council Bluffs	Planned	OH	1	1	1	1	21	10	6	9		5	75	
653	296	I-80	EB	122.2	I-80 @ 60th	41.59205	-93.79434	Des Moines	Existing	SM	1	1	1	1	21	10	7	7	4	8	72	Keep
63	248	I-380	NB	18.37	Wilson Ave	41.956349	-91.671132	Cedar Rapids	Existing	OH	1	1	1	1	21	10	5	8	5	8	72	
218	19	I-35/80	SB	124.72	Hickman SB	41.60964	-93.777018	Des Moines	Existing	SM	1	1	1	1	21	10	10	8	4	4	72	Keep
22	32	I-235	EB	6.15	31st St	41.59295	-93.66047	Des Moines	Existing	OH		1	1	1	13	6	6	8	8	8	72	Very important 5
Prop 20		I-35/80	EB	130.34	I72nd Street	41.652544	-93.719351	Des Moines	Proposed New	OH	1	1	1	1	21	10	8	1		10	71	
656	299	I-235	EB	11.7	Guthrie	41.614641	-93.577357	Des Moines	Existing	SM		1	1	1	13	6	7	5	8	8	68	
2	1	I-35	NB	70.5	Mills Civic	41.55778	-93.77623	Des Moines	Existing	OH	1	1	1	1	21	10	4	6	7	7	68	
301	264	US 77	NB	188.5	Vets Bridge	42.48728	-96.41338	Sioux City (NE)	Existing	SM	1	1		1	19	9	3	8	7	7	68	
100	354	I-29	EB	150.55	Hamilton	42.492626	-96.451988	Sioux City	Existing	OH		1		1	11	5	3	7	9	9	67	
Prop 11		I-80	WB	2.06	Expressway Street	41.232847	-95.871351	Council Bluffs	Planned	OH	1	1	1	1	21	10	7	4		5	65	
130	418	I-380	SB	15.34	66th Ave	41.912762	-91.671795	Cedar Rapids	Existing	OH	1	1	1	1	21	10	5	7	3	7	64	
Prop 64		I-380	SB	11.37	120th St	41.85526667	-91.66861111	Cedar Rapids	Proposed New	OH		1	1	1	13	6	5	7		7	64	
Prop 12		I-80	WB	2.3	Expressway Street	41.232847	-95.866931	Council Bluffs	Planned	OH	1	1	1	1	21	10	7	3		5	62	
Prop 14		I-80	EB	2.3	Expressway Street	41.231953	-95.867088	Council Bluffs	Planned	OH	1	1	1	1	21	10	7	3		5	62	
Prop 09		I-29	NB	52.78	9th Ave	41.248824	-95.906599	Council Bluffs	Proposed New	OH	1	1		1	19	9	4	4		7	60	
Prop 15		I-80	SB	5.56	Madison Ave	41.245647	-95.817272	Council Bluffs	Planned	OH	1	1	1	1	21	10	3	6		5	60	
122	377	I-235	EB	3.87	63rd St	41.59292	-93.704112	Des Moines	Existing	OH	1	1	1	1	21	10	6	8	3	3	60	
Prop 04		US 30	EB	114.64	Duff Street	42.00383056	-93.62361111	Ames	Proposed New	OH	1	1	1	1	21	10	3	4		7	59	Contingent on Prop 05 being added
Prop 21		US 65	NB	82.4	8th Street	41.638558	-93.506456	Des Moines	Proposed New	OH	1	1		1	19	9	3	2		10	59	
99	81	I-80	WB	242.1	12th Ave	41.689137	-91.58167	Iowa City	Existing	OH	1	1	1	1	21	10	6	8	3	3	59	
Prop 57		I-80	WB	267.35	IA 38	41.645037	-91.104943	Statewide (Rural)	Proposed New	OH	1	1			14	7	4	5		8	59	Section may be reconstructed in 5 years (Possibly Postpone)
Prop 06		US 30	EB	251.24	21st Street	41.933534	-91.697799	Cedar Rapids	Proposed New	OH	1	1	1	1	21	10	3	2		8	58	
Prop 08		I-480	EB	0	I-29	41.26001944	-95.91888889	Council Bluffs	Planned	OH	1	1		1	19	9	2	7		5	58	Very important 5
5	7	I-80	WB	142.96	Altoona	41.663131	-93.478549	Des Moines	Existing	OH	1	1	1	1	21	10	5	8	3	3	57	Move to where DMS 657 is
33	305	I-35	SB	112.9	Abe	42.022979	-93.571585	Ames	Existing	OH	1	1	1		16	8	4	8	3	6	57	
Prop 23		US 61	NB	44.1	US 52	42.461663	-90.671207	Dubuque	Proposed New	OH	1	1		1	19	9	2	7		5	57	
Prop 55		I-80	WB	202.59	V 18 Rd	41.69569444	-92.34222222	Statewide (Rural)	Proposed New	OH	1	1		1	19	9	3	3		8	57	
213	39	I-35/80	EB	128.45	100th St	41.651525	-93.75611111	Des Moines	Planned	SM	1	1	1	1	21	10	8	1	5	5	57	Planned SM, this was taken out, not going back in
401	223	I-80	WB	2.1	Utica Ridge Road	41.596464	-90.51123	Quad Cities (IA)	Existing	SM	1	1	1	1	21	10	3	8	2	5	57	Consider moving east and making OH (Prop 30)
Prop 03		I-35	NB	105.65	260th Street	41.91930833	-93.57	Ames	Proposed New	OH	1	1	1		16	8	5	0		10	56	Move DMS 30 to Prop 01 if DMS 124 is not reinstalled
10	14	I-380	NB	15.02	76th St	41.90788	-91.67176	Cedar Rapids	Existing	OH	1	1	1	1	21	10	5	4	4	5	56	
11	71	I-380	NB	18.83	15th St	41.96295	-91.67039	Cedar Rapids	Existing	OH		1		1	11	5	5	8	3	7	56	Very important 5
654	297	IA 141	EB	154.4	Hwy 141	41.65802	-93.77515	Des Moines	Existing	SM	1	1	1	1	21	10	4	6	2	6	56	May be better to move north to IA 44 Consider converting to OH - see what future projects look like
402	224	I-74	EB	4.1	53rd St	41.565903	-90.52257	Quad Cities (IA)	Existing	SM	1	1	1	1	21	10	4	5	7	2	55	Consider removing
132	415	I-35	SB	103.69	SB IA 210	41.899907	-93.571326	Statewide (Rural)	Existing	OH	1	1	1	1	21	10	5	7	3	3	55	
42	77	I-29	SB	52.85	Railroad Bridge	41.25055	-95.90695	Council Bluffs	Planned	OH	1	1	1	1	21	10	4	7	3	3	54	Existing sidemount being replaced with color
13	74	I-380	SB	22.33	29th St SB	42.00669	-91.66656	Cedar Rapids	Existing	OH		1		1	11	5	4	7	3	8	54	
Prop 28		US 61	SB	125.7	I-80	41.63378056	-90.56833333	Quad Cities (IA)	Proposed New	OH	1	1	1	1	21	10	3	1		7	53	
502	232	I-80	EB	238.37	Ireland Ave	41.693902	-91.652498	Iowa City	Existing	SM	1	1	1	1	21	10	4	9	3	1	53	Consider removing
64	42	US 218	NB	94.57	Melrose	41.66636	-91.61042	Iowa City	Existing	OH	1	1	1	1	21	10	4	5	4	4	53	
507	236	I-380	NB	2.196	Forevergreen NB	41.725618	-91.641846	Iowa City	Existing	SM	1	1	1	1	21	10	5	5	3	3	53	Scheduled for removal for construction
Prop 54		I-80	EB	201.12	V 18 Rd	41.69549167	-92.37055556	Statewide (Rural)	Proposed New	OH	1	1		1	19	9	3	1		8	52	
8	76	US 30	WB	253.59	Kirkwood	41.92701	-91.65404	Cedar Rapids	Existing	OH	1	1	1	1	21	10	3	1	7	5	52	
506	236	I-380	SB	2.05	Forevergreen SB	41.72349	-91.642438	Iowa City	Existing	SM	1	1	1	1	21	10	5	4	3	3	51	Scheduled for removal for construction
Prop 50		I-35	NB	95.9	36th Street	41.77773	-93.570668	Statewide (Rural)	Proposed New	OH	1	1	1	1	21	10	5	0		5	50	
129	420	I-80	EB	139.95	Berwick	41.657643	-93.536872	Des Moines	Existing	OH	1	1		1	19	9	8	2	3	3	50	

					DMS						Justification Categories						Volumes	Crashes	DMS Usage			
											2	3	4	5	Sum	Category Score	AADT Score	Crash Score	Usage Score	TMC Input	Overall Score	
ID	TS ID	Route	Direction	MM	Location	Latitude	Longitude	Area	Condition	Type	8	6	2	5		20%	20%	20%	20%	20%	100%	Notes
43	62	I-29	SB	54.76	Ave G	41.27279	-95.8985	Council Bluffs	Existing	OH	1	1	1	1	21	10	2	7	3	3	50	
40	44	I-29	NB	141.74	Sgt. Bluff	42.4077	-96.36594	Sioux City	Existing	OH		1		1	11	5	3	3	7	7	49	
Prop 56		I-80	EB	266.64	IA 38	41.645054	-91.119041	Statewide (Rural)	Proposed New	OH	1	1			14	7	4	1		8	49	Section may be reconstructed in 5 years (Possibly Postpone)
Prop 27		I-80	EB	293.68	IA 130	41.599697	-90.605728	Quad Cities (IA)	Proposed New	OH	1	1	1	1	21	10	4	0		5	48	Remove
113	372	I-29	SB	145.47	Ravine Park	42.455318	-96.377556	Sioux City	Existing	OH	1	1		1	19	9	3	6	3	3	48	
503	233	I-80	WB	240.12	US 6	41.694688	-91.619647	Iowa City	Existing	SM	1	1	1	1	21	10	6	2	3	3	48	
46	79	I-80	WB	6.87	McPherson WB	41.260583	-95.80365	Council Bluffs	Existing	OH		1	1	1	13	6	3	7	4	4	48	On the Madison entrance ramp? (Consider removing if Proposed 15 is being installed)
131	419	I-380	NB	22.38	29th St NB	42.007383	-91.665769	Cedar Rapids	Existing	OH	1	1		1	19	9	4	5	2	4	48	
12	73	I-380	SB	26.58	Tower	42.05956	-91.70046	Cedar Rapids	Existing	OH		1		1	11	5	3	4	3	8	47	
66	46	I-80	EB	236.39	Tiffin	41.69443	-91.69096	Iowa City	Existing	OH	1	1	1	1	21	10	3	4	3	3	47	
Prop 05		US 69	SB	147.71	16th Street	42.014225	-93.61055556	Ames	Proposed New	SM	1	1		1	19	9	2	0		8	47	
Prop 02		US 30	WB	153.13	580th Avenue	42.00907778	-93.53722222	Ames	Proposed New	OH	1			1	13	6	2	6		5	46	
Prop 16		I-29	NB	48.16	Veterans' Memorial Hwy	41.223534	-95.834962	Council Bluffs	Planned	OH	1	1	1	1	21	10	2	1		5	46	
6	6	I-35	NB	66.58	Cumming	41.50461	-93.78013	Des Moines	Existing	OH	1	1	1	1	21	10	3	4	3	3	46	
Prop 61		US 61	NB	181.7	Airport Rd	42.39431944	-90.69361111	Dubuque	Proposed New	OH	1	1		1	19	9	1	1		7	45	
Prop 63		IA 461	NB	122	Veterans Memorial Pkwy	41.58195	-90.57111111	Quad Cities (IA)	Proposed New	SM	1	1		1	19	9	3	1		5	45	
Prop 29		I-80	WB	297	Jersey Ridge Road	41.595791	-90.543788	Quad Cities (IA)	Proposed New	OH	1	1		1	19	9	5	2		2	45	Remove
109	309	US 20	WB	316.45	Catfish	42.491342	-90.727869	Dubuque	Existing	OH	1	1		1	19	9	3	6	2	2	44	
504	234	I-80	EB	243.71	Iowa River	41.685315	-91.551336	Iowa City	Existing	SM	1	1	1	1	21	10	6	4	1	1	44	
Prop 34		I-29	SB	143.19	Industrial Rd	42.427635	-96.370743	Sioux City	Proposed New	OH	1	1		1	19	9	3	2		4	44	Good for winter closure
Prop 62		US 151	NB	91.99	St Joes Prairie Rd	42.40624444	-90.74416667	Dubuque	Proposed New	OH	1	1		1	19	9	1	1		7	44	
Prop 66		I-80	EB	245.31	16th Ave	41.96402222	-91.80333333	Cedar Rapids	Proposed New	OH	1	1		1	19	9	1	0		7	44	
Prop 33		I-74	NB	3.47	US 6	41.546621	-90.519459	Quad Cities (IA)	Proposed New	OH	1	1	1	1	21	10	5	0		2	43	Remove
67	47	I-80	WB	250.57	Wapsi	41.66783	-91.42448	Iowa City	Existing	OH	1	1		1	19	9	4	3	3	3	43	
217	12	I-35/80	EB	137	E 14th EB	41.650262	-93.591319	Des Moines	Existing	SM	1	1	1	1	21	10	8	0	4	0	43	Remove this, replace with Prop 18
Prop 46		I-80	WB	61.34	US 6	41.497265	-94.930971	Statewide (Rural)	Proposed New	OH	1	1			14	7	2	3		5	43	
902	308	IA 32	SB	0.5	Chavenelle	42.495028	-90.740947	Dubuque	Existing	SM	1	1		1	19	9	2	8	1	1	43	
106	217	I-80	WB	235	Division St	41.600078	-90.597614	Quad Cities (IA)	Existing	OH	1	1		1	19	9	4	4	2	2	43	
47	61	I-80	WB	9.97	Hwy 6	41.30163	-95.77094	Council Bluffs	Existing	OH	1	1	1	1	21	10	2	3	3	3	43	
20	65	I-29	NB	45.6	South	41.18898	-95.82346	Council Bluffs	Existing	OH	1	1		1	19	9	3	1	4	4	42	
Prop 49		I-35	SB	143.48	US 20	42.462181	-93.569038	Statewide (Rural)	Proposed New	OH	1	1			14	7	2	3		5	42	
15	88	I-80	EB	297.11	Jersey Ridge	41.59578	-90.53996	Quad Cities (IA)	Existing	OH	1	1	1	1	21	10	5	0	3	3	42	
Prop 38		US 20	EB	230.9	IA 21	42.452793	-92.338164	Waterloo	Proposed New	OH	1	1		1	19	9	3	3		2	42	
65	41	I-380	SB	5.67	Swan Lake	41.77546	-91.64681	Iowa City	Existing	OH		1	1	1	13	6	6	3	3	3	41	
306	380	US 20	WB	0.95	Lakeport	42.445005	-96.362569	Sioux City	Existing	SM	1	1		1	19	9	3	4	2	2	41	
Prop 65		Wright Bro	EB		Atlantic Dr	41.89090556	-91.68694444	Cedar Rapids	Proposed New	SM		1		1	11	5	1	5		5	41	
661	348	I-35	SB	95.4	Elkhart	41.778029	-93.570949	Statewide (Rural)	Existing	SM		1			6	3	5	8	2	2	40	
133	416	I-35	NB	100.83	NB IA 210	41.849282	-93.570794	Statewide (Rural)	Existing	OH	1	1	1	1	21	10	5	1	2	2	40	
404	226	I-74	WB	4.2	13th Ave	41.497098	-90.506826	Quad Cities (IL)	Existing	SM	1	1	1	1	21	10	0	0	10	0	40	
112	421	I-35	SB	0	Grand Ave	41.54183611	-93.77583333	Des Moines	Planned	OH	1	1		1	19	9	5	3	3	0	40	Low value - eliminate from planning
123	376	I-380	SB	179.33	San Marnan	42.473673	-92.322305	Waterloo	Existing	OH	1	1		1	19	9	3	4	2	2	39	
108	218	I-74	WB	298.6	Spruce Hills	41.562656	-90.522183	Quad Cities (IA)	Existing	OH	1	1	1	1	21	10	4	2	2	2	39	
Prop 48		I-35	NB	189.8	US 18	43.084743	-93.342572	Statewide (Rural)	Proposed New	OH	1	1			14	7	2	2		5	39	
Prop 58		I-80	EB	283.63	60th Ave	41.619126	-90.796586	Statewide (Rural)	Proposed New	OH	1	1		1	19	9	4	0		3	39	EB I-80 W of Walcott I/C (& truck stops) (consider removing)
96	345	I-380	NB	236.39	Evansdale	42.451367	-92.237067	Waterloo	Existing	OH	1	1		1	19	9	3	3	2	2	38	
Prop 30		I-80	WB	299.16	Utica Ridge Road	41.596561	-90.500696	Quad Cities (IA)	Proposed New	OH	1	1	1	1	21	10	3	0		2	38	Propose replace DMS 401 (Remove)
38	56	I-35	SB	196.31	Clear Lake	43.17744	-93.35656	Statewide (Rural)	Existing	OH	1	1			14	7	2	0	2	8	38	Important for winter closures
82	346	US 218	SB	189.14	Lone Tree	42.56135	-92.4259	Waterloo	Existing	OH	1			1	13	6	2	7	2	2	38	
Prop 24		I-280	SB	7.21	US 61	41.502167	-90.668561	Quad Cities (IA)	Proposed New	OH	1	1	1	1	21	10	2	1		2	38	
35	70	I-80	WB	175.1	Kellogg	41.68916	-92.87671	Statewide (Rural)	Existing	OH	1	1		1	19	9	3	3	2	2	38	Newton Speedway
121	373	I-35	NB	91.29	1st St	41.7123	-93.57606	Des Moines	Existing	OH		1	1		8	4	7	2	3	3	38	Very important 3
14	13	I-80	EB	287.49	Walcott	41.60426	-90.72482	Quad Cities (IA)	Existing	OH	1	1	1	1	21	10	4	1	3	1	38	
662	378	I-80	EB	117.13	Booneville	41.562434	-93.881322	Des Moines	Existing	OH		1			6	3	4	6	3	3	37	
19	84	I-80	WB	29.4	Minden	41.49828	-95.54574	Statewide (Rural)	Existing	OH	1	1		1	19	9	2	1	3	3	37	
Prop 37		US 20	WB	226.5	US 63	42.462576	-92.422771	Waterloo	Proposed New	OH	1	1		1	19	9	3	1		2	37	
Prop 01		I-35	SB	110.14	245th Street	41.984286	-93.570563	Ames	Proposed New	OH		1	1		8	4	5	1		5	36	Ok to not install if DMS 33 and something EB & WB on 30 exists
Prop 43		I-29	SB	83.78	IA 300	41.638263	-96.011314	Statewide (Rural)	Proposed New	OH	1	1			14	7	2	1		5	36	Remove
Prop 45		I-80	EB	59.8	US 6	41.497087	-94.960568	Statewide (Rural)	Proposed New	OH	1	1			14	7	2	0		5	35	
Prop 39		US 20	WB	241.02	Canfield Rd	42.450274	-92.146598	Waterloo	Proposed New	OH	1	1		1	19	9	1	2		2	35	
221	221	US 30	EB	150.15	Dayton/Skunk River	42.00581	-93.595256	Ames	Existing	SM	1	1	1		16	8	3	2	2	2	35	removal contingent on Prop 04 and 05
21	64	I-29	SB	63.95	Crescent	41.38363	-95.89982	Council Bluffs	Existing	OH	1	1	1	1	21	10	2	1	2	2	34	
44	80	I-29	SB	73.9	Loveland	41.52423	-95.91789	Statewide (Rural)	Existing	OH	1	1		1	19	9	2	2	2	2	34	
Prop 51		I-35	SB	33.43	US 34	41.030665	-93.794923	Statewide (Rural)	Proposed New	OH	1	1			14	7	2	0		5	34	
Prop 40		I-380	NB	61.25	Poyner Rd	42.403855	-92.157404	Waterloo	Proposed New	OH	1	1		1	19	9	2	1		2	34	
601	267	I-80	EB	165.3	Newton SM EB	41.68351	-93.058983	Statewide (Rural)	Existing	SM	1	1		1	19	9	3	1	2	2	34	Newton Speedway
602	266	I-80	WB	171.4	Newton SM WB	41.680204	-92.941383	Statewide (Rural)	Existing	SM	1	1		1	19	9	3	3	1	1	34	Newton Speedway
70	177	I-74	WB	3.5	Moline	41.477871	-90.493967	Quad Cities (IL)	Existing	OH	1	1	1	1	21	10	0	0	7	0	34	
Prop 52		I-35	NB	32.73	US 34	41.020615	-93.793981	Statewide (Rural)	Proposed New	OH	1	1			14	7	2	0		5	34	
901	384	US 61	SB	186.98	Grandview	42.472493	-90.668122	Dubuque	Existing	SM	1	1		1	19	9	2	4	1	1	34	
Prop 32		I-80	WB	305.85	US 67	41.59211667	-90.37194444	Quad Cities (IA)	Proposed New	OH		1		1	11	5	3	0		5	33	

	DMS										Justification Categories						Volumes	Crashes	DMS Usage			
											2	3	4	5	Sum	Category Score	AADT Score	Crash Score	Usage Score	TMC Input	Overall Score	
ID	TS ID	Route	Direction	MM	Location	Latitude	Longitude	Area	Condition	Type	8	6	2	5		20%	20%	20%	20%	20%	100%	Notes
124	374	I-35	NB	111.25	Ames Merge	42.00037	-93.57069	Ames	Construction	OH	1	1			14	7	5	1	3	1	33	Removed for construction, may be relocated
Prop 25		I-280	NB	2.28	US 6	41.572437	-90.677927	Quad Cities (IA)	Proposed New	OH	1	1	1	1	21	10	2	1		0	33	Consider removing
34	69	I-80	EB	161.9	Newton	41.68074	-93.10068	Statewide (Rural)	Existing	OH	1	1		1	19	9	3	0	2	2	33	Newton Speedway
Prop 36		US 75	SB	94.53	US 20	42.485085	-96.323367	Sioux City	Proposed New	OH	1			1	13	6	2	3		2	33	
Prop 17		I-29	SB	46.86	IA 370	41.161315	-95.823668	Council Bluffs	Proposed New	OH	1	1			14	7	3	1		2	32	
Prop 26		I-80	WB	291.7	I-280	41.601606	-90.643497	Quad Cities (IA)	Proposed New	OH	1	1		1	19	9	4	0		0	32	Remove
363	316	I-80	EB	25.01	Old 83	41.46325	-95.596	Statewide (Rural)	Existing	SM	1	1		1	19	9	2	1	2	2	32	
904	388	US 61	SB	191	Greyhound	42.515842	-90.647316	Dubuque	Existing	SM		1		1	11	5	2	7	1	1	31	
75	423	I-29	NB	34.02	Pacific Junction	41.02445	-95.8137	Statewide (Rural)	Existing	OH	1	1		1	19	9	1	1	2	2	31	
95	344	US 20	EB	223.22	Union	42.465167	-92.48747	Waterloo	Existing	OH	1	1		1	19	9	1	1	2	2	31	
501	231	I-80	EB	238	Little Amana	41.68747778	-91.9425	Statewide (Rural)	Existing	SM	1	1		1	19	9	3	1	1	1	31	EB I-80 W of US 151 I/C - Iowa City diversion route
107	216	I-280	WB	3.96	Locust	41.547817	-90.677883	Quad Cities (IA)	Existing	OH	1	1		1	19	9	2	0	2	2	31	
505	235	US 218	SB	92.9	Rohert Rd	41.649347	-91.587639	Iowa City	Existing	SM	1	1		1	19	9	3	1	1	1	30	Consider making this portable - limited to special events
Prop 35		US 20	NB	3.81	US 75	42.465084	-96.323558	Sioux City	Proposed New	OH	1			1	13	6	3	1		2	29	
117	422	US 30	WB	260.1	Knapp Rd	41.926364	-91.53162	Cedar Rapids	Existing	OH				1	5	2	1	4	2	5	29	Very important 5 (investigate usage statistics) - may be better as portable
56	379	I-80	WB	119.98	Alice's Rd	41.580156	-93.832746	Des Moines	Existing	OH		1			6	3	5	2	2	2	29	Very Important 3
84	243	US 20	WB	6.8	Buchanan	42.475661	-96.293411	Sioux City	Existing	OH	1			1	13	6	1	3	2	2	28	
Prop 31		I-80	EB	302.48	Middle Road	41.597384	-90.436821	Quad Cities (IA)	Proposed New	OH		1	1	1	13	6	3	0		2	28	Might be good to move further east
110	306	I-80	EB	6.9	McPherson	41.261943	-95.802053	Council Bluffs	Existing	OH	1	1			14	7	3	0	2	2	28	
101	68	I-380	SB	67.47	Waterloo	42.44932	-92.2198	Waterloo	Existing	OH	1	1			14	7	3	0	2	2	28	
Prop 47		I-35	SB	218.43	IA 130	43.496592	-93.353044	Statewide (Rural)	Proposed New	OH		1			6	3	2	1		5	27	SB I-35 Entering Iowa
31	67	I-35	NB	139.8	Williams	42.40833	-93.56971	Statewide (Rural)	Existing	OH	1	1			14	7	2	0	2	2	27	
Prop 07		US 151	WB	38.48	IA 13	42.0363	-91.5375	Cedar Rapids	Proposed New	OH	1				8	4	2	2		3	27	
353	313	I-29	NB	68.45	Honey Creek	41.4483	-95.899	Statewide (Rural)	Existing	SM	1	1		1	19	9	2	0	1	1	26	
405	227	I-74	WB	0	John Deere Rd	41.46431	-90.495119	Quad Cities (IL)	Existing	SM	1	1	1	1	21	10	0	0	3	0	26	
7	75	US 30	EB	249.64	Edgewood	41.9412	-91.72686	Cedar Rapids	Existing	OH				1	5	2	2	1	3	5	26	Review with Prop 6 in more detail (move further west past 100)
356	314	I-29	NB	60.01	Pigeon Creek	41.329417	-95.8849	Council Bluffs	Existing	SM	1	1		1	19	9	2	0	1	1	26	
352	312	I-680	WB	13.55	Old Lincoln	41.495217	-95.891333	Statewide (Rural)	Existing	SM	1	1		1	19	9	1	1	1	1	25	
362	317	I-680	EB	27.75	Daisy	41.498783	-95.61835	Statewide (Rural)	Existing	SM	1	1		1	19	9	1	1	1	1	25	
30	43	I-35	NB	107.75	Ames	41.94958	-93.56948	Ames	Existing	OH		1	1		8	4	5	1	2	1	25	Propose to move north to Prop 01
Prop 41		I-29	SB	112.92	IA 175	42.033823	-96.138275	Statewide (Rural)	Proposed New	OH		1			6	3	2	0		5	24	
Prop 42		I-29	NB	111.73	IA 175	42.01991	-96.126597	Statewide (Rural)	Proposed New	OH		1			6	3	1	0		5	24	
Prop 44		I-29	NB	124.48	IA 333	40.587147	-95.656892	Statewide (Rural)	Proposed New	OH		1			6	3	1	0		5	23	NB I-29 Entering Iowa
Prop 53		I-35	NB	0.5	US 69	40.580768	-93.931161	Statewide (Rural)	Proposed New	OH		1			6	3	1	0		5	23	NB I-35 Entering Iowa
126	417	US 30	EB	257.86	Jappa Rd	41.92492	-91.57143	Cedar Rapids	Existing	OH				1	5	2	3	1	2	4	23	Very important 5 (investigate usage statistics) - may be better as portable
92	82	US 218	NB	87.63	Riverside	41.58355	-91.545229	Iowa City	Existing	OH		1		1	11	5	2	0	2	2	22	Very important 5 - Consider making this portable via district 6
621	293	US 18	WB	188	Mason City	43.112062	-93.160793	Statewide (Rural)	Existing	SM	1	1			14	7	1	1	1	1	22	
351	385	I-29	NB	73.011	Missouri Valley	41.512719	-95.911286	Statewide (Rural)	Existing	SM	1	1			14	7	2	0	1	1	22	
905	387	US 20	EB	310.87	Cottingham	42.439964	-90.811268	Dubuque	Existing	SM		1		1	11	5	2	2	1	1	22	Consider upgrading via District 6
659	383	I-80	EB	108.74	DeSoto	41.533731	-94.037674	Statewide (Rural)	Existing	SM		1			6	3	3	3	1	1	22	
68	178	I-280	WB	20	Coal Valley	41.453152	-90.449528	Quad Cities (IL)	Existing	OH	1	1	1	1	21	10	0	0	1	0	22	
406	228	I-74	WB	16	Airport	41.454575	-90.494864	Quad Cities (IL)	Existing	SM	1	1	1	1	21	10	0	0	1	0	22	
407	229	I-280	EB	16	Milan	41.456435	-90.520813	Quad Cities (IL)	Existing	SM	1	1	1	1	21	10	0	0	1	0	22	
48	60	I-80	WB	2.16	24th St	41.2324	-95.86999	Council Bluffs	Construction	OH					0	0	7	0	2	2	22	Removed for construction, will be replaced by color, may be able to relocate
304	382	US 75	SB	100.33	Leeds SB	42.561492	-96.33232	Sioux City	Existing	SM	1			1	13	6	2	1	1	1	22	Determine if needed (may have been requested by District)
508	238	I-80	EB	250.54	Wapsi side	41.667433	-91.424999	Iowa City	Existing	SM		1			6	3	4	2	1	1	21	Getting removed in 2021. Replace w/ OH
801	10000	US 30	EB	139.33	United Comm EB	42.02308	-93.781233	Ames	Existing	SM (School Zone)					0	0	2	0	1	5	15	Specialty sign (school zone speed limit)
802	10000	US 30	WB	139.7	United Comm WB	42.02355	-93.773895	Ames	Existing	SM (School Zone)					0	0	2	0	1	5	15	Specialty sign (school zone speed limit)
16	89	I-80	WB	12.1	Geneseo	41.440304	-90.293169	Quad Cities (IL)	Existing	OH	1	1	1		16	8	0	0	2	0	20	
18	90	I-88	WB	2.1	Silvis	41.536242	-90.302206	Quad Cities (IL)	Existing	OH	1	1	1		16	8	0	0	2	0	20	
17	91	I-74	WB	15.67	Lynn Center	41.414821	-90.328722	Quad Cities (IL)	Existing	OH	1	1	1		16	8	0	0	1	0	18	
408	230	US 61	NB	126.2	Eldridge	41.640019	-90.567881	Quad Cities (IA)	Existing	SM				1	5	2	3	1	1	1	17	Consider moving to Prop 31 (ok for removal via District 6)
357	315	I-29	NB	50.01	Magnum	41.274	-95.894	Council Bluffs	Existing	SM		1			6	3	2	0	1	2	16	Remove if Prop 15 goes in, leave if not.
Prop 22		IA 5	WB	98.55	IA 28	41.51440556	-93.66972222	Des Moines	Proposed New	OH				1	5	2	2	1		1	16	Very low importance
305	381	US 75	NB	100.31	Leeds NB	42.561025	-96.332259	Sioux City	Existing	SM				1	5	2	2	1	1	1	14	Determine if needed (may have been requested by District)
9	72	US 30	WB	16.52	Ramp	41.92995	-91.67154	Cedar Rapids	Existing	OH				1	5	2	0	1	2	0	11	Possible removal - no ADM fog anymore
805	272	IA 76	NB	2.89	McGregor	43.019649	-91.181043	Statewide (Rural)	Existing	SM (Rock)					0	0	0	0	2	2	9	Specialty sign (falling rock)
806	275	IA 76	NB	4.59	Pink Elephant	43.041916	-91.178017	Statewide (Rural)	Existing	SM (Rock)					0	0	0	0	1	1	5	Specialty sign (falling rock)
633	386	IA 9	EB	275.61	Waukon	43.240298	-91.491192	Statewide (Rural)	Existing	SM (Rock)					0	0	0	0	1	1	5	Specialty sign (falling rock)
803	276	IA 76	SB	4.73	Under Bridge	43.043884	-91.178348	Statewide (Rural)	Existing	SM (Rock)					0	0	0	0	1	1	4	Specialty sign (falling rock)
632	295	IA 76	SB	11.49	Area 52/Missle Silo	43.126144	-91.210378	Statewide (Rural)	Existing	SM (Rock)					0	0	0	0	1	1	4	Specialty sign (falling rock)
631	294	IA 76	SB	21.4	Roswell	43.189376	-91.3719	Statewide (Rural)	Existing	SM (Rock)					0	0	0	0	1	1	4	Specialty sign (falling rock)
804	277	US 18	NB/SB	304.81	Ramp to 76	43.043074	-91.179233	Statewide (Rural)	Existing	SM (Rock)					0	0	0	0	1	0	3	Specialty sign (falling rock)

APPENDIX E. NETWORK EQUIPMENT

NETWORK EQUIPMENT

The high-level design requirements for **backbone devices** must meet the following:

- Hardware serving the core-distribution module must be NEBS Level 3 Compliant[1].
- Components at this level must support high-availability (HA) technologies at both the hardware and the software level.
    - Hardware technologies
        - Redundant memory and processing (processors).
        - Redundant power supplies.
        - Redundant physical links.
        - Support hot-swappable, field-replaceable components.
    - Software technologies
        - Support in-service software upgrades.
        - Virtual Switching Software (VSS) capabilities (in multi-chassis implementations).
- Support bandwidth scalability of 10Gbps links.
- Support OSPF, BGP routing protocols that are NSF aware to ensure fast convergence.
- Support IPv4, IPv6 protocol stack, as well as IP Multicast technologies.
- Support Layer 3 aggregation technologies[2].
- Support Layer 2 aggregation technologies[3].
- Support underlying security technologies as required by the network security policy to protect the control-plane.
- Support underlying network management technologies as identified in the network security policy that includes QoS, SNMPv3, NetFlow, IPFIX (IETF standard) and syslog functions.

The high-level design requirements for **backbone devices** must meet the following:

- Redundant uplinks to one or more core-distribution sites.
- Stacking technologies or virtual software switching (VSS) should be used when possible for redundant control planes.
- Redundant power supplies.
- Layer 3 – capable, supporting layer 3 aggregation technologies.
- Layer 2 aggregation technologies.
- Support underlying security technologies as required by the network security policy to protect the control-plane.
- Support underlying network management technologies as identified in the network security policy that includes QoS, SNMPv3, NetFlow, IPFIX (IETF standard) and syslog functions.
- Support security, network management, and network access controls (SSHv2, Netflow, SNMPv3, RMON, 802.1x, Cisco TrustSec).

---

[1] NEBS is an industry certification that classifies equipment based on environmental demands and placement in infrastructure utilized in service-provider-type environments. Equipment must meet the requirements of GR-63-CORE and GR-1089-CORE.

[2] Layer 3 aggregation technologies include Layer 3 routing technologies, CEF, GLBP, HSRP, VRRP, NHRP, VRF, NAT, EVN, etc.

[3] Layer 2 aggregation technologies include: 802.3ad/Etherchannel, Fast UDLD, 802.1x, Jumbo frames, NSF Awareness, VTP ver3, support for 256+ VLANs, 802.1q Trunks, Rapid PVST, MST, etc.

The high-level design requirements for **Network Edge devices** should meet the following guidelines and recommendations.:

- Implement high-availability redundancies or clustering.
- Provide advanced network protection between network separations of trust.
  - Performed by Next-Generation Firewall devices, explicit permissions between zones (networks) utilizing URL, Web and content filtering that include “blacklisting” and “whitelisting” capabilities at the Network Edge.
  - Packet inspection, including SSL inspection.
- Deploy intrusion detection and intrusion prevention sensors between zones.
  - Performed by Next-Generation IPS devices that include advanced AV/Malware and Application inspection technologies.
- Support automated update mechanisms to maintain code on protection mechanisms.
- Recommend utilizing sandbox technologies where applicable to perform real-time analysis of file inspections.
- Support strong cryptographic mechanisms as defined by FIPS.

The high-level design requirements for **remote sites** should meet the following:

- Have redundant WAN connection to serve for redundancy to the network edge module accessing the resources.
- Leverage high-availability technologies at the network gateway.
- Maintain Next-Generation Firewall (NGFW) and Next-Generation IPS (NGIPS) services at the boundary between networks.
- Support strong cryptographic mechanisms that includes encryption and hashing algorithms over all traffic connections between the Network Edge Module and the Remote Site.
  - Methods should be accordance with FIPS[4] standards published by the NIST.
  - Site-to-Site connections must leverage secure protocols like IPSec.
    - Use 256-bit keys
    - Use Perfect Forward Secrecy (PFS)
    - Replay detection
- Utilize switch redundancies that service critical infrastructure components
- Support Layer 2 & 3 aggregation technologies.

[4] Federal Information Processing Standards (FIPS) - http://csrc.nist.gov/publications/PubsFIPS.html

APPENDIX F. NETWORK SECURITY

ASSET MANAGEMENT

1. *Network device inventory* – Identifying potential vulnerabilities requires an accurate inventory of all network devices that exist on the network. The inventory should be constantly maintained and frequently reviewed for accuracy. It should also:
    a. **be stored and supported by a centralized management tool**
    b. **include procedures for the addition or removal of network devices, including updates to all documentation such as network diagrams**
    c. **include standardization of supported network devices (e.g. consistent management protocols such as SNMPv3, SSH, and 802.1x, consistent naming conventions, and standard configuration templates)**
2. *Network Performance Baselines* – Establishment and documentation of network performance baselines can help with the identification of security risks and intrusion events.
3. *Change Management* – Establish a process to make all responsible parties aware any network changes. This is often accomplished through a Change Control Board (CCB), consisting of key stakeholders throughout the organization.
4. *Classification* – Categorization of network assets according to risk level aids in the risk management and operational maintenance of monitored services. Examples include:
    a. **Core Switch – Infrastructure – Critical (outage)**
    b. **Access Switch – Infrastructure – Major (service degraded)**
    c. **Security – Major (failed logon attempt)**

RISK MANAGEMENT

1. *Risk Assessment* (primarily performed in conjunction with a security assessment)
    a. **review of the organizations security policies, procedures, and documentation**
    b. **review any changes in compliance standards**
    c. **provide a vulnerability scan of network devices (this step requires expert knowledge and is typically performed by an outside professional)**
    d. **test the validity of the network's security (penetration testing)**
2. *Risk Analysis*
    a. **evaluates identified risks**
    b. **assigns a risk level and prioritizes identified risks**
    c. **coordinates resources, including budget planning, to address known issues**

MAINTENANCE AND OPERATIONS

1. Access controls
    a. Use authentication, authorization, and accounting according to the principle of *Least Privilege*
    b. On supported devices, implement credentials management (e.g. Terminal Access Controller Access Control System (TACACS+), Remote Dial-in User Service (RADIUS)), Network Access Control (NAC), and two-form factor authentication
2. Patch Management

   a. Maintain updated software and firmware. Vulnerability updates maintain a level or CVSS[5] score that identified the level of importance. While feature or product updates can maintain a scheduled deployment interval (quarterly for example), vulnerabilities identified with a high CVSS rating to your environment should be tested and deployed immediately.
3. Log Management
   a. Centralize and maintain comprehensive logging.
4. Configuration Management
   a. Restrict/limit access to control-plane components.
   b. Implementing change controls.
5. Backups
   a. Scheduled backups of network management components, logs, device configurations.
6. Network Monitoring
   a. Event notification
   b. Reporting
   c. Application Monitoring
   d. QoS
   e. Traffic visibility with NetFlow
7. *Physical security*
   a. Controlled access
8. *Reporting*
   a. An Executive summary to provide status of network health that is seen by key leaders or management.
9. *Security awareness training*
   a. Training should be organization-wide
10. testing and acceptance procedures
11. Hardware replacement plan
    a. Adoption of a hardware lifecycle plan helps to alleviate and distribute the budgeting requirements over time. As it can be a controlled cost.
    b. Hardware Replacement should occur:
       i. When it has reached EOL (End-of-Life) and is no longer supported by the manufacturer and risks are unacceptable.
       ii. New technical requirements exist.
       iii. Existing equipment is over utilized.

GUIDELINES ON INGRESS AND EGRESS FIREWALL RULES

Guidelines for proper firewall rule-sets include the following:

- Avoid using “ANY” statements in classification of any egress traffic.
- Egress rules should not be overly permissive, restrict the rule for the source subnet or host for which it is destined for. This avoids IP spoofing.
- Block all RFC 1918[6] and 6761 subnets from egressing Internet access circuits.

---

[5] Common Vulnerability Scoring System Q & A - http://www.cisco.com/c/en/us/about/security-center/cvss-q-a.html)

[6] RFC 1918 - https://tools.ietf.org/html/rfc1918

- Block egress traffic from internal servers that have no need for external communication, or restrict to specific services.
- Ingress rules for Internet-Accessible services should only allow the specific service ports needed.
- When possible, ingress (as well as egress), should be restrictive to geographical locations.
- External logging of dropped traffic. In critical environments or Internet-Accessible hosts, it may be necessary to log all traffic.
- All rule-sets should be reviewed periodically as part of a security assessment.
- Following filtering guidelines outlined in RFC 1918 and RFC 2827[7].

AUTHENTICATION AND ENCRYPTION GUIDELINES

Authentication is best administered centrally with respect to network devices. TACACS+ is the preferred security application in enhancing network security. Additional protocols can include RADIUS, as well as LDAP to authenticate remote access users.

Two-form factor authentication should be adopted for users accessing secure networks remotely.

All data that transits unsecure or untrusted networks must be encrypted to protect the integrity and confidentiality of the data. Encryption is widely mandated in Federal, state, and local government agencies, critical infrastructure providers like public utilities, and private sector organizations that do business over the public network with these agencies must use encryption that meets the Federal Information Processing Standards (FIPS) 140-2 standard.

IPSec is the most widely adopted framework. The NIST Special Publication 800-77[8] provides the basic recommendation in deployment. It is also recommended to minimize and avoid use of cipher suites that are older than 10 years.

GUIDELINES FOR IDS AND IPS USAGE

Traditional IPS/IDS device have since been replaced with “Next-Generation” devices that provide a mix of security and threat defenses that are essential and a critical component any network landscape.

Next-generation IPS (NGIPS) devices require less “tuning” than that of traditional appliances. Provide advanced protection against fragmentation, low-bandwidth attacks, address spoofing/proxying, pattern-change, and encryption techniques that traditional IDS and IPS devices have failed to protect against.

NGIPS devices include DNS intelligence, URL reputation, anti-virus/malware, protocol analysis (including SSL, TLS), as well as anomaly detection measures at the network edge between all boundaries of trust.

NGIPS devices should be properly sized based on bandwidth throughput. Most common location exists between the Internet and extranet locations. With many hardware manufacturers, this can be an integrated component of an existing firewall.

---

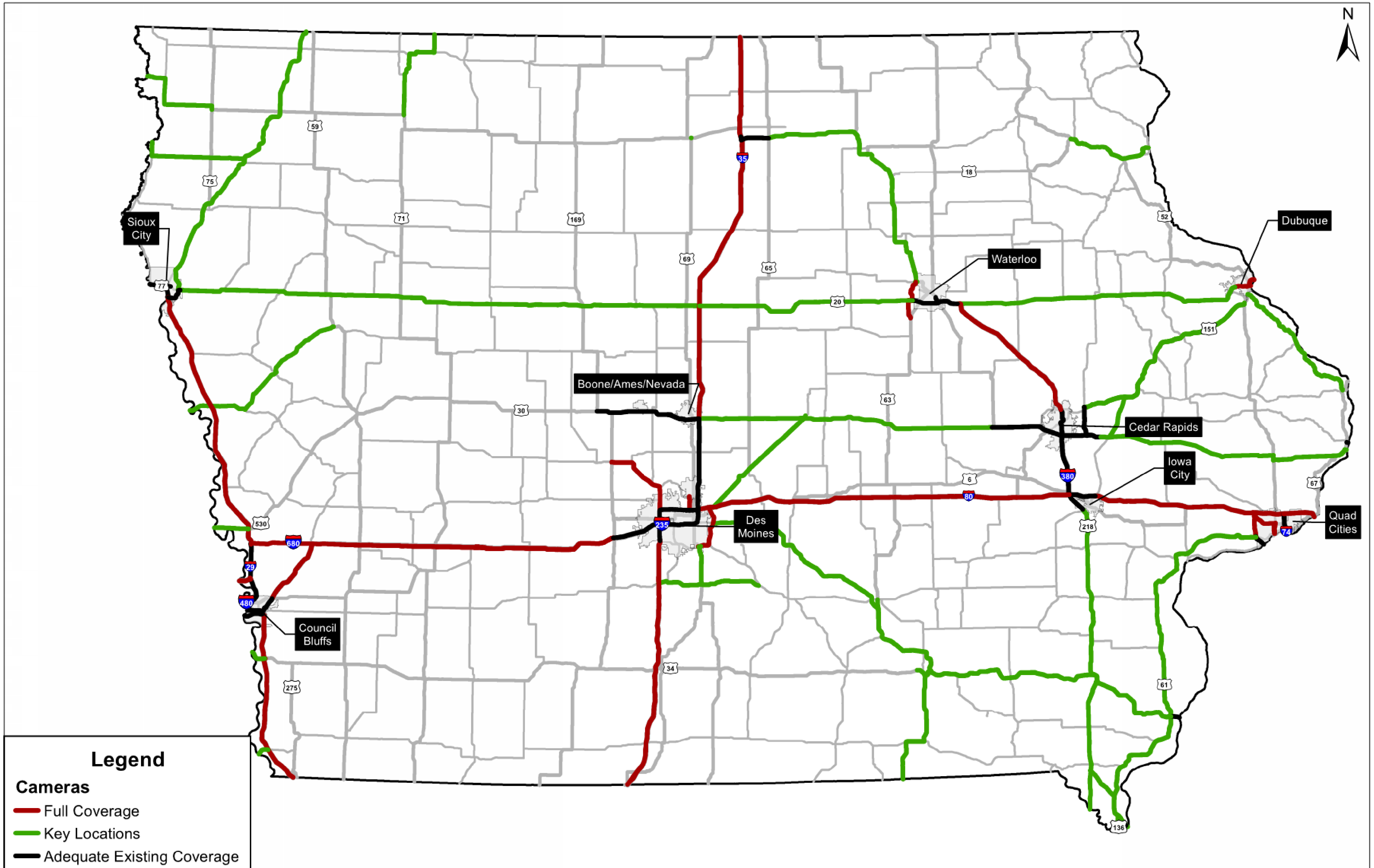
[7] RFC 2827 - https://tools.ietf.org/html/rfc2827
[8] NIST Publication 800-77 - http://csrc.nist.gov/publications/nistpubs/800-77/sp800-77.pdf

The attack signature database should be regularly updated. Subscription services are available to automate the update process and minimize management.

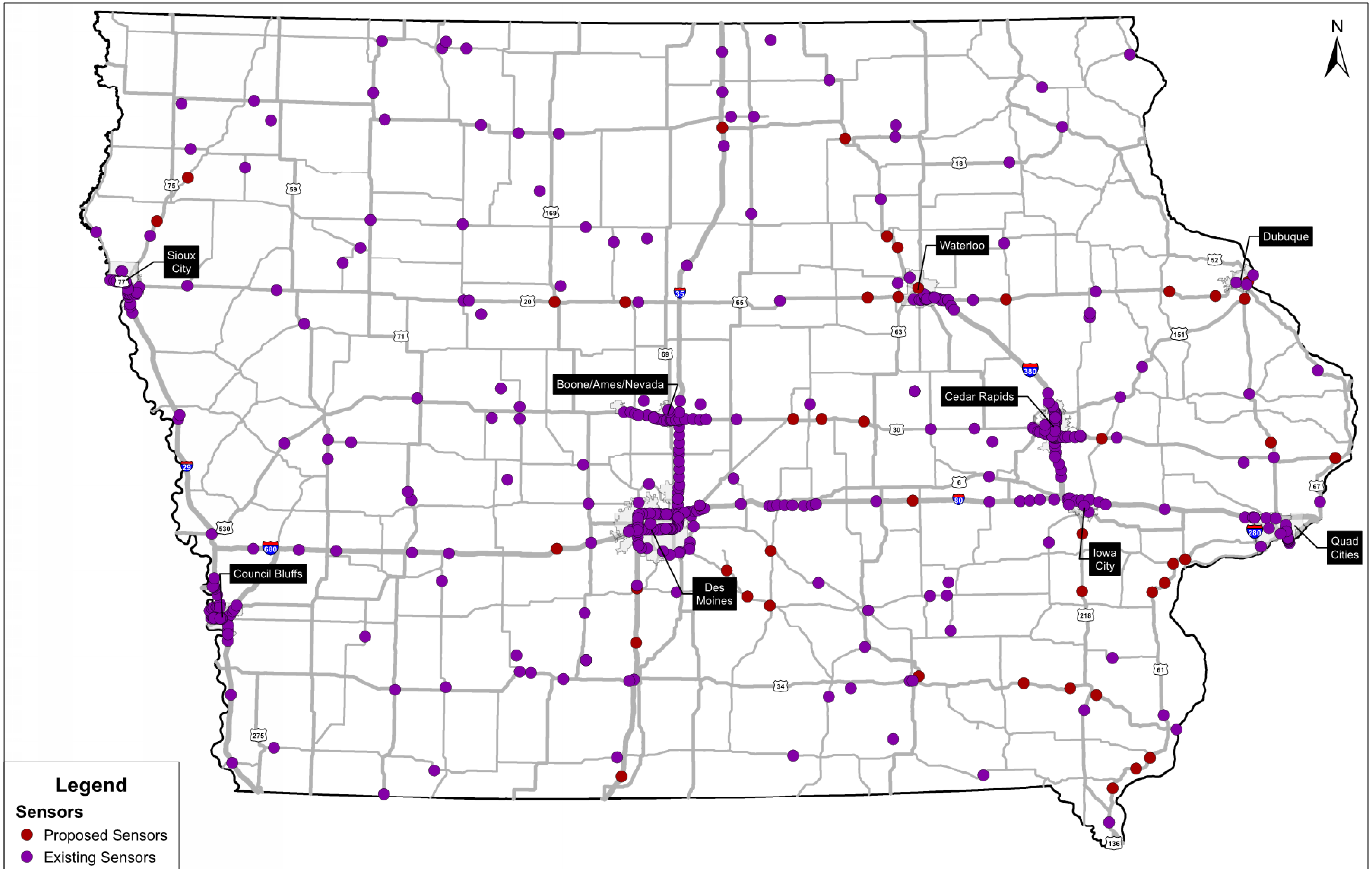
Configuration of alerting profiles is essential to alert network management personnel. Logging should be down externally to a syslog device or centralized management device.

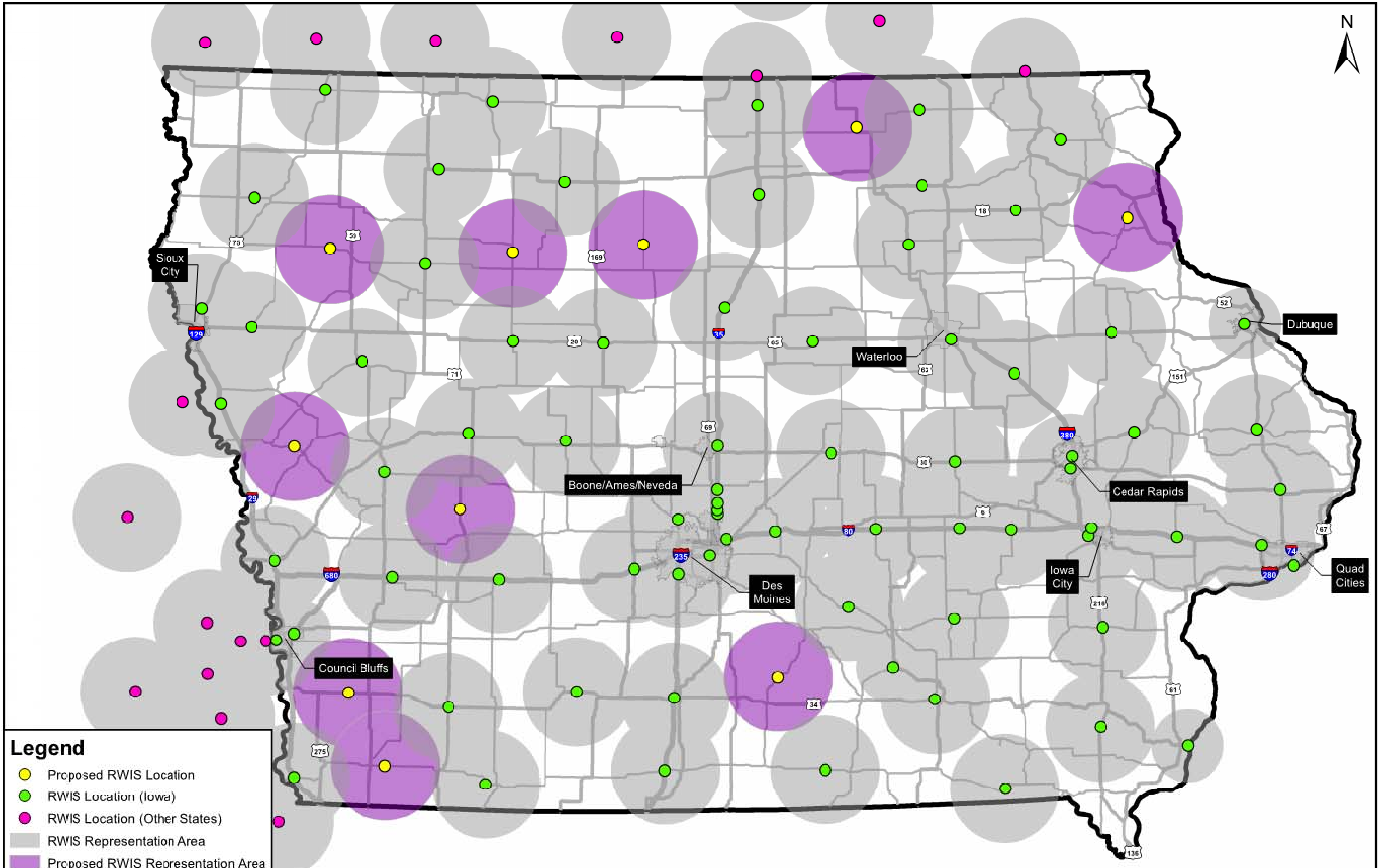
Should be regularly tested as part of a security assessment.

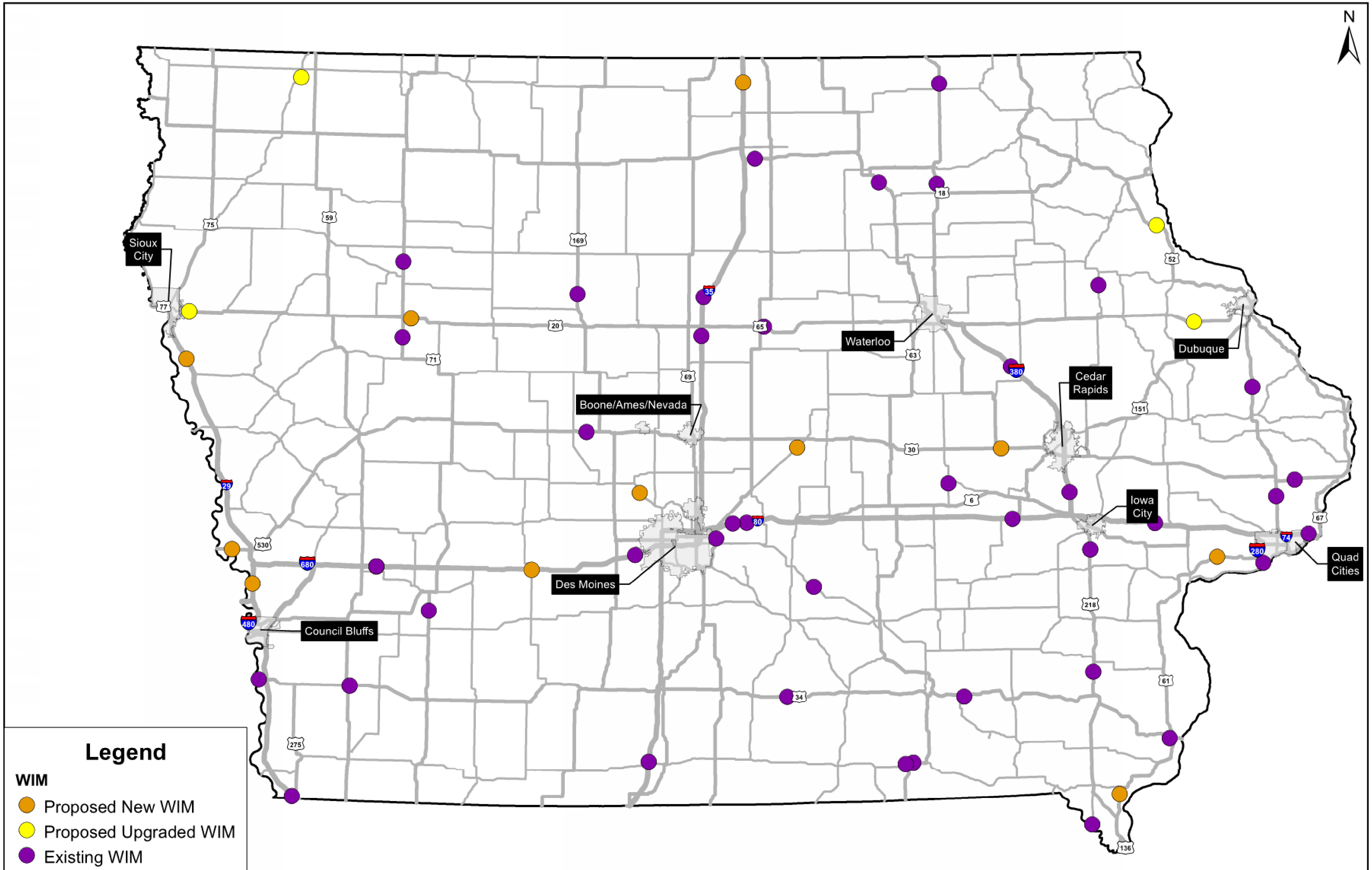
APPENDIX G. INFRASTRUCTURE GAP DETAILED MAPS

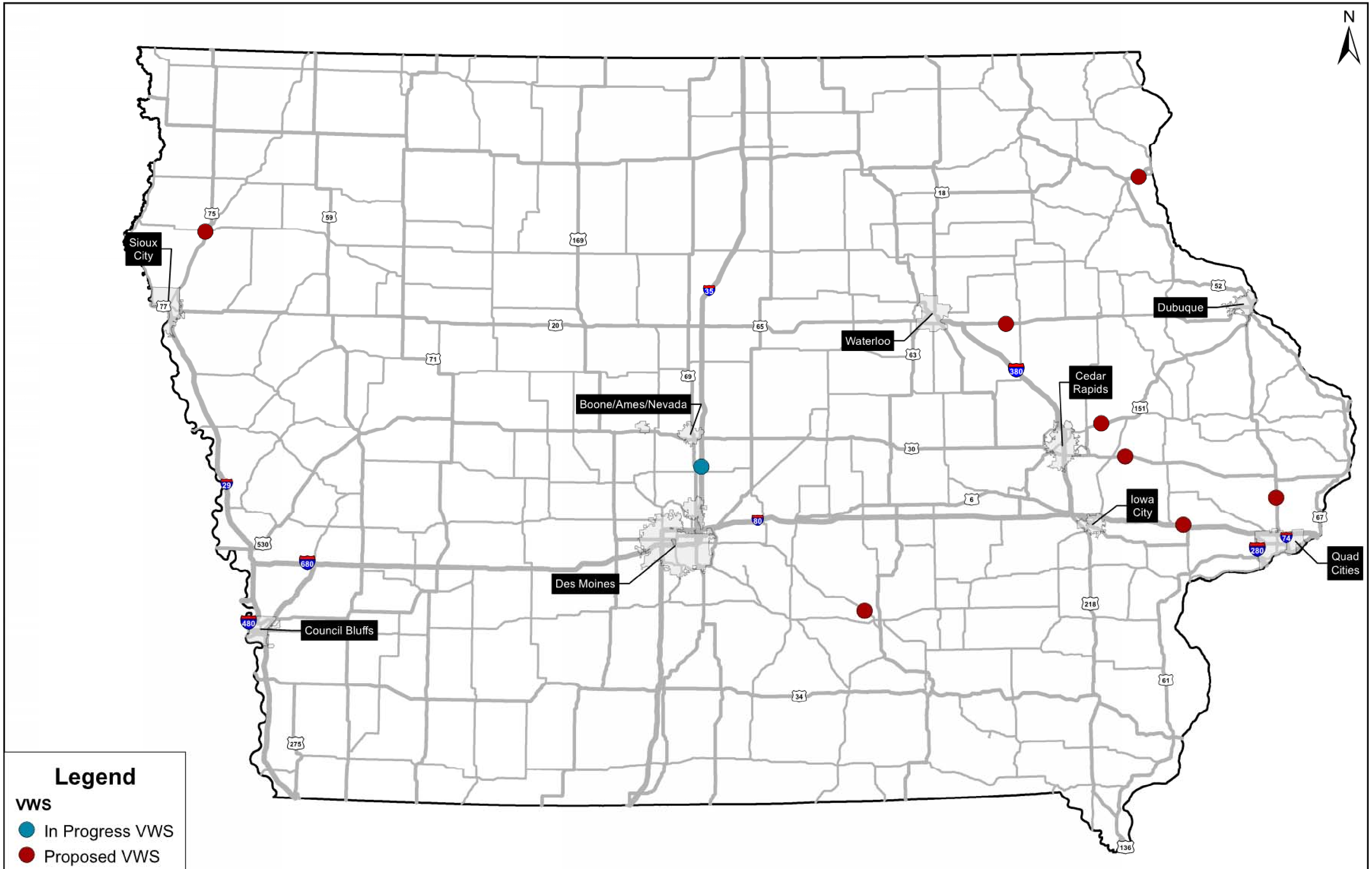

N
Sioux City
Dubuque
Waterloo
Boone/Ames/Nevada
Cedar Rapids
Iowa City
Quad Cities
Des Moines
Council Bluffs
Legend
Cameras
Full Coverage
Key Locations
Adequate Existing Coverage

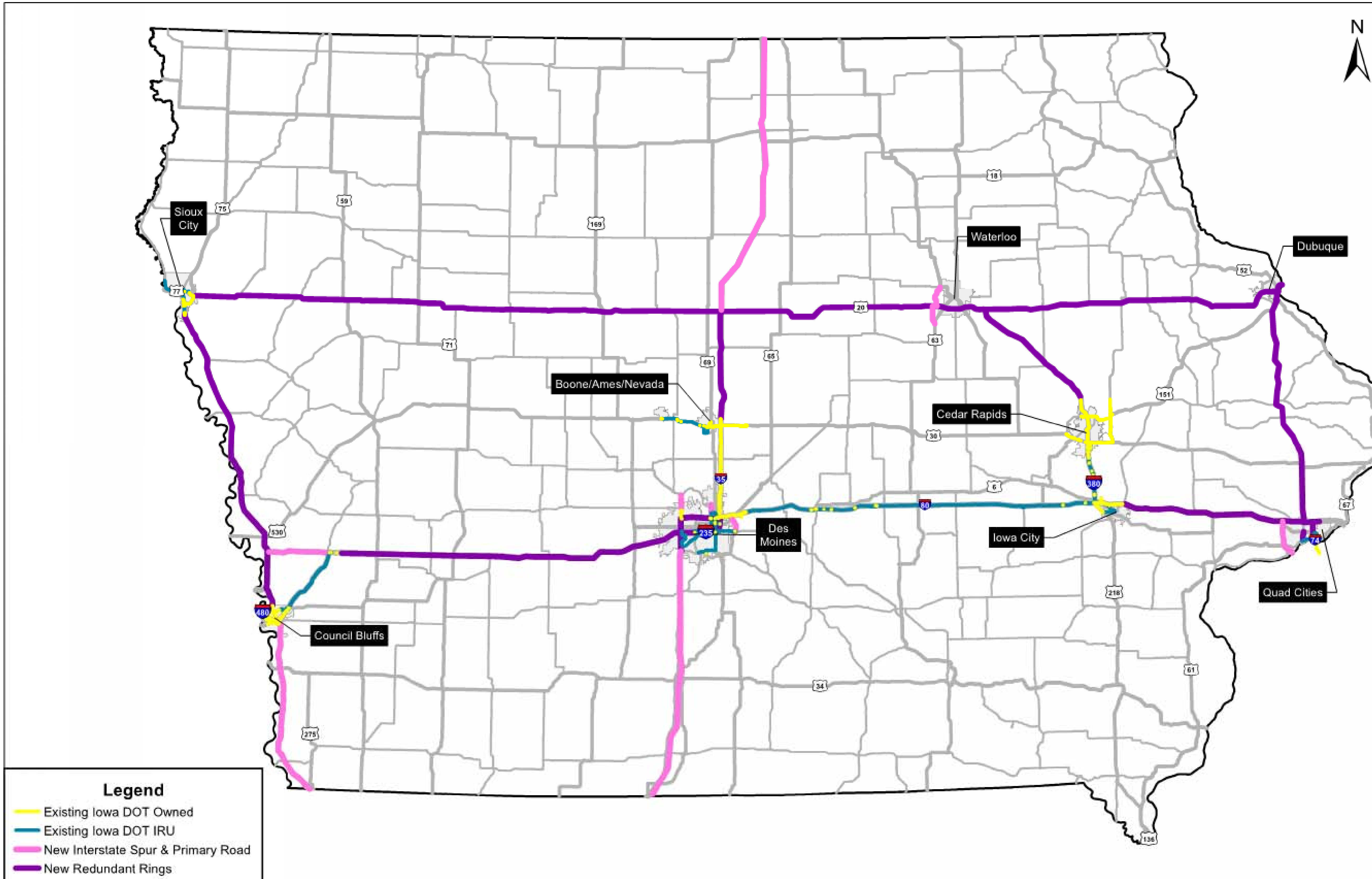
TRAFFIC SENSOR GAPS

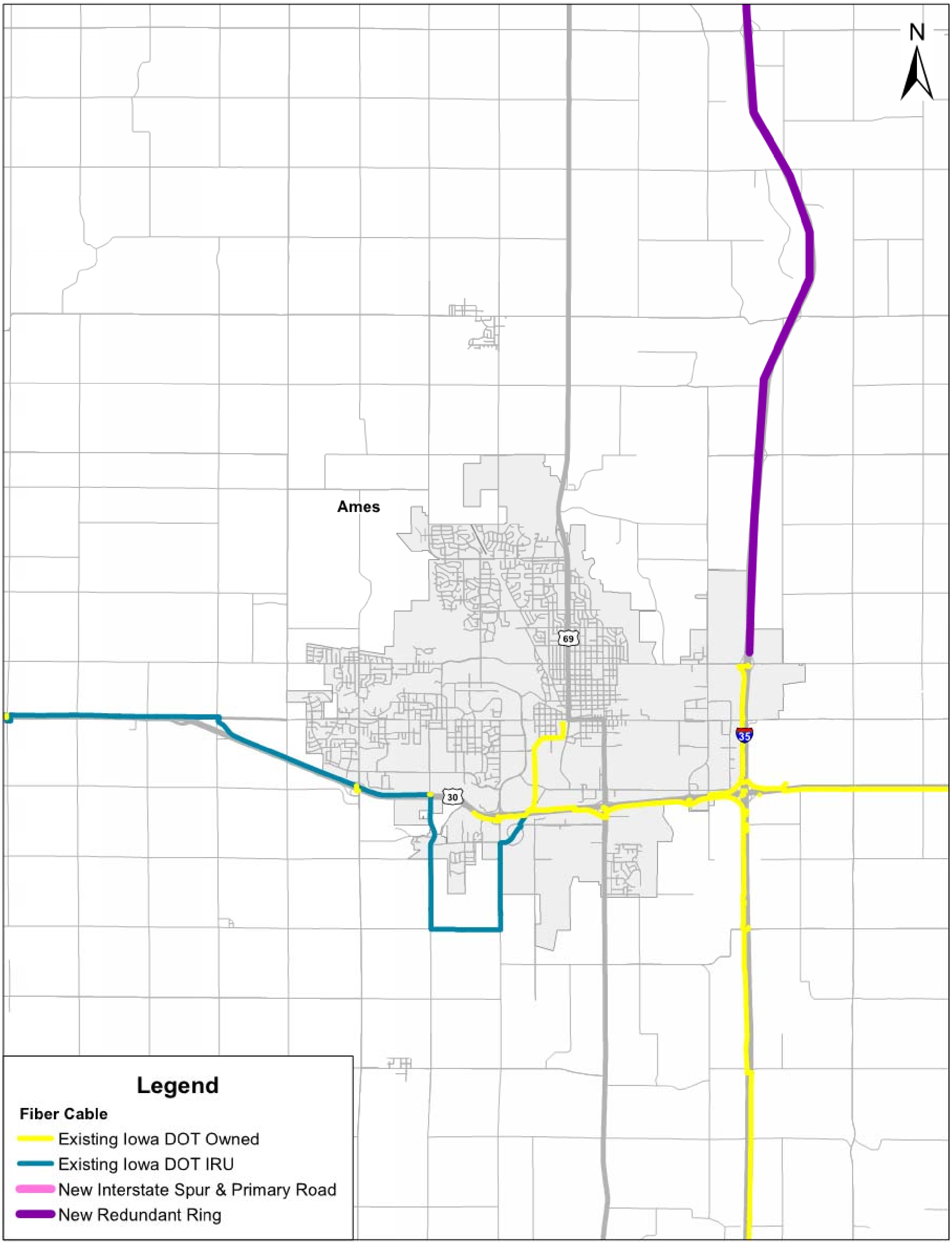


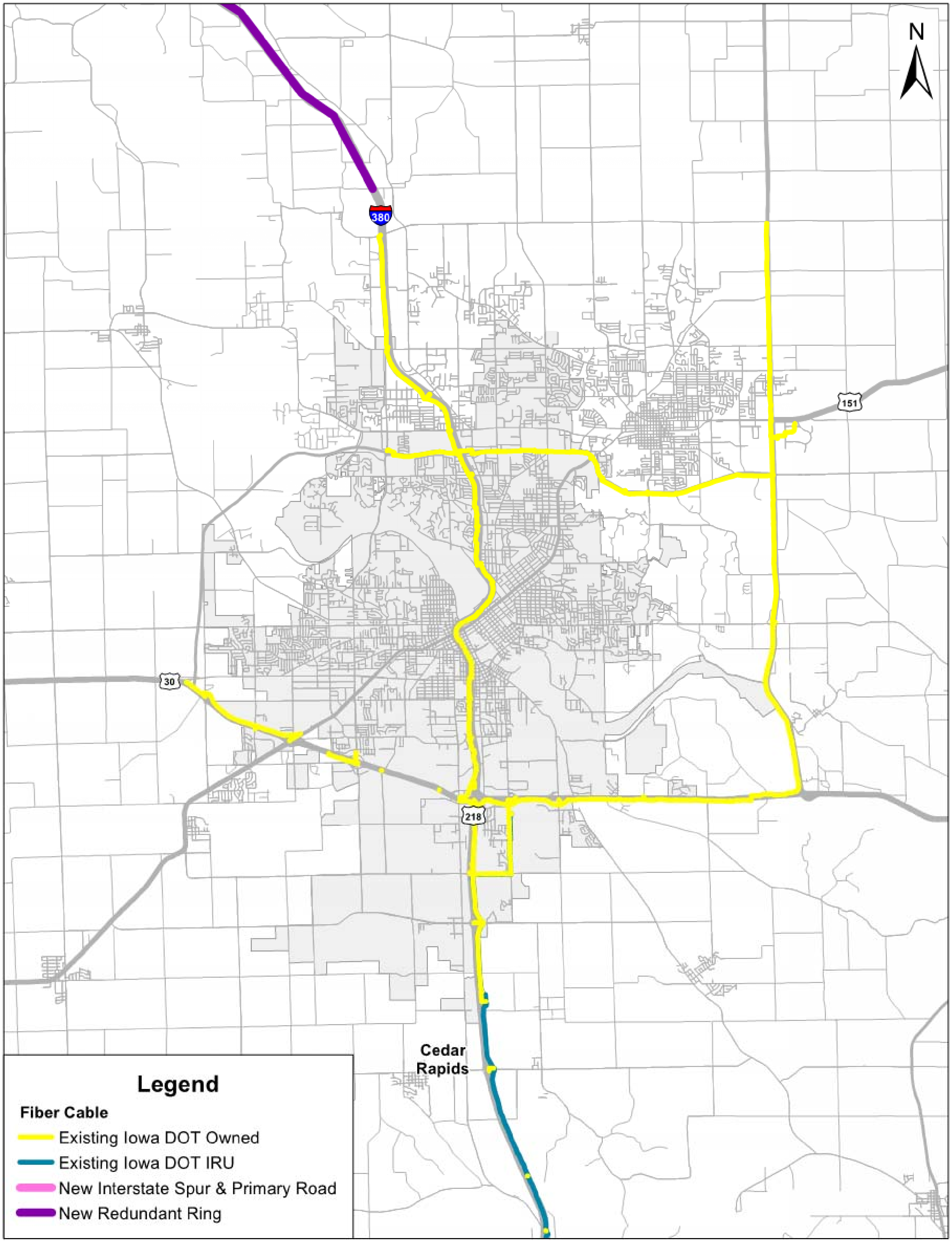

N
Sioux City
Dubuque
Waterloo
Boone/Ames/Neveda
Cedar Rapids
Iowa City
Quad Cities
Des Moines
Council Bluffs
Legend
Proposed RWIS Location
RWIS Location (Iowa)
RWIS Location (Other States)
RWIS Representation Area
Proposed RWIS Representation Area


N
Sioux City
Waterloo
Dubuque
Cedar Rapids
Boone/Ames/Nevada
Iowa City
Des Moines
Quad Cities
Council Bluffs
Legend
WIM
Proposed New WIM
Proposed Upgraded WIM
Existing WIM

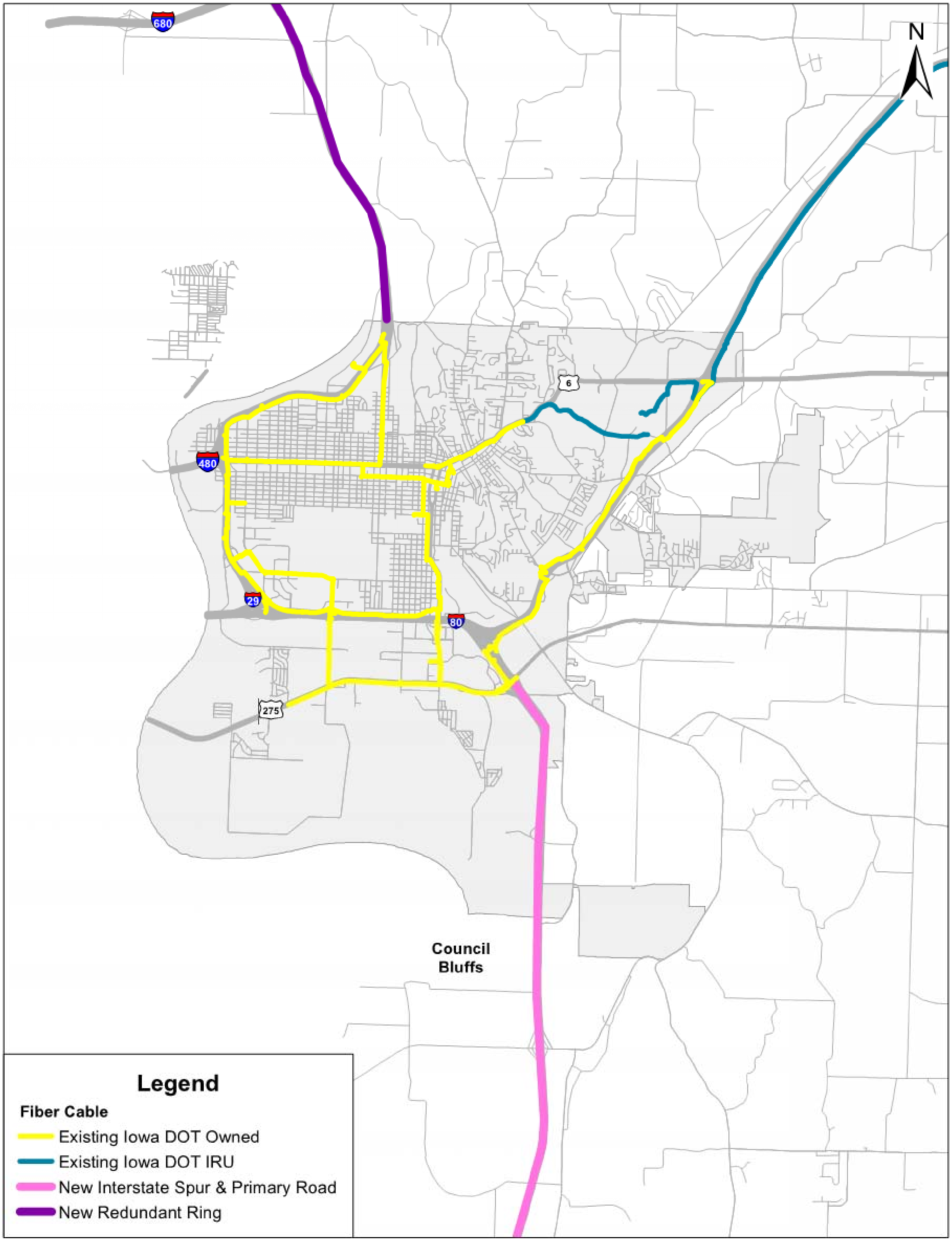

N
Sioux City
Waterloo
Dubuque
Cedar Rapids
Boone/Ames/Nevada
Iowa City
Quad Cities
Des Moines
Council Bluffs
Legend
VWS
In Progress VWS
Proposed VWS

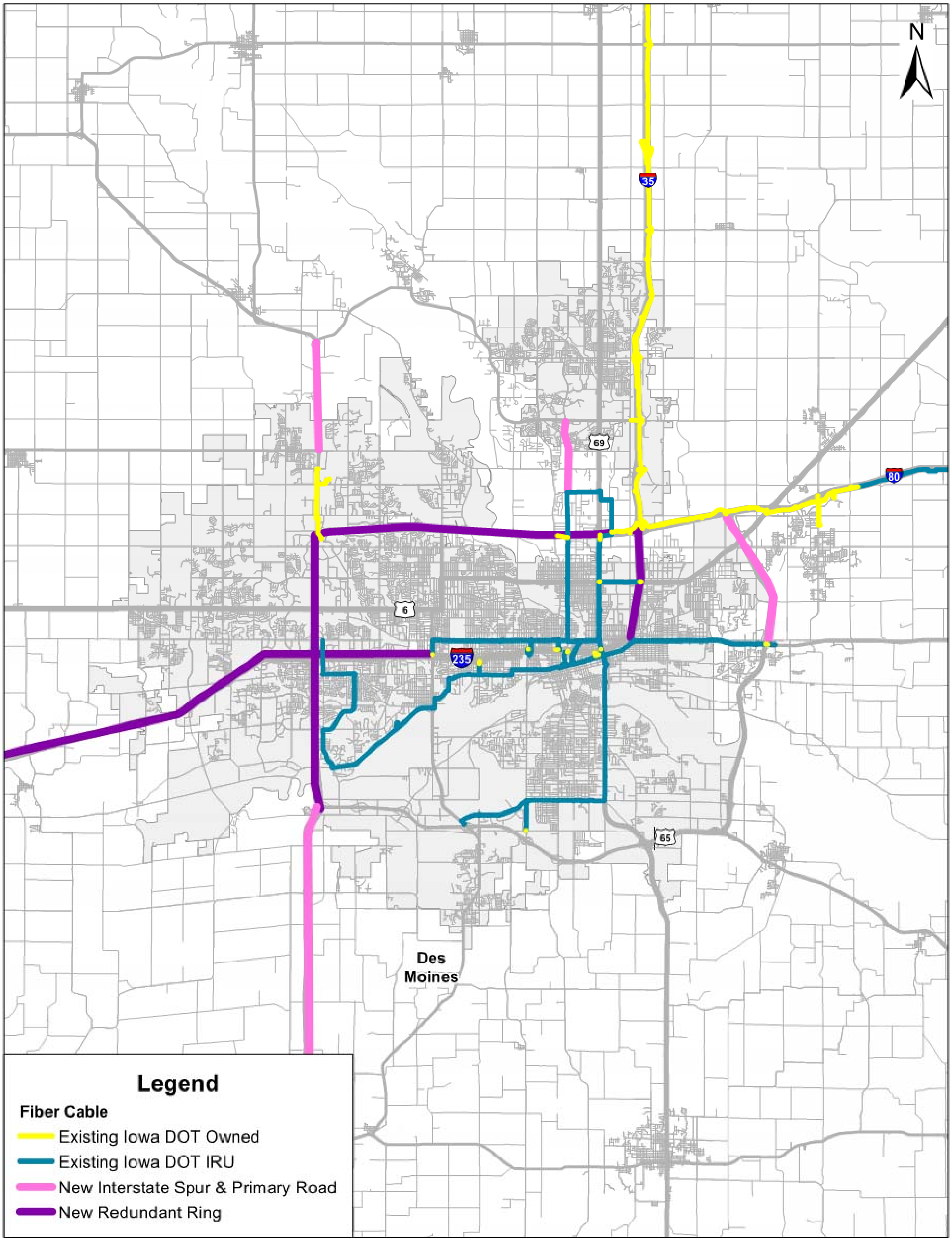

N
Sioux City
Waterloo
Dubuque
Boone/Ames/Nevada
Cedar Rapids
Des Moines
Iowa City
Quad Cities
Council Bluffs
Legend
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Rings

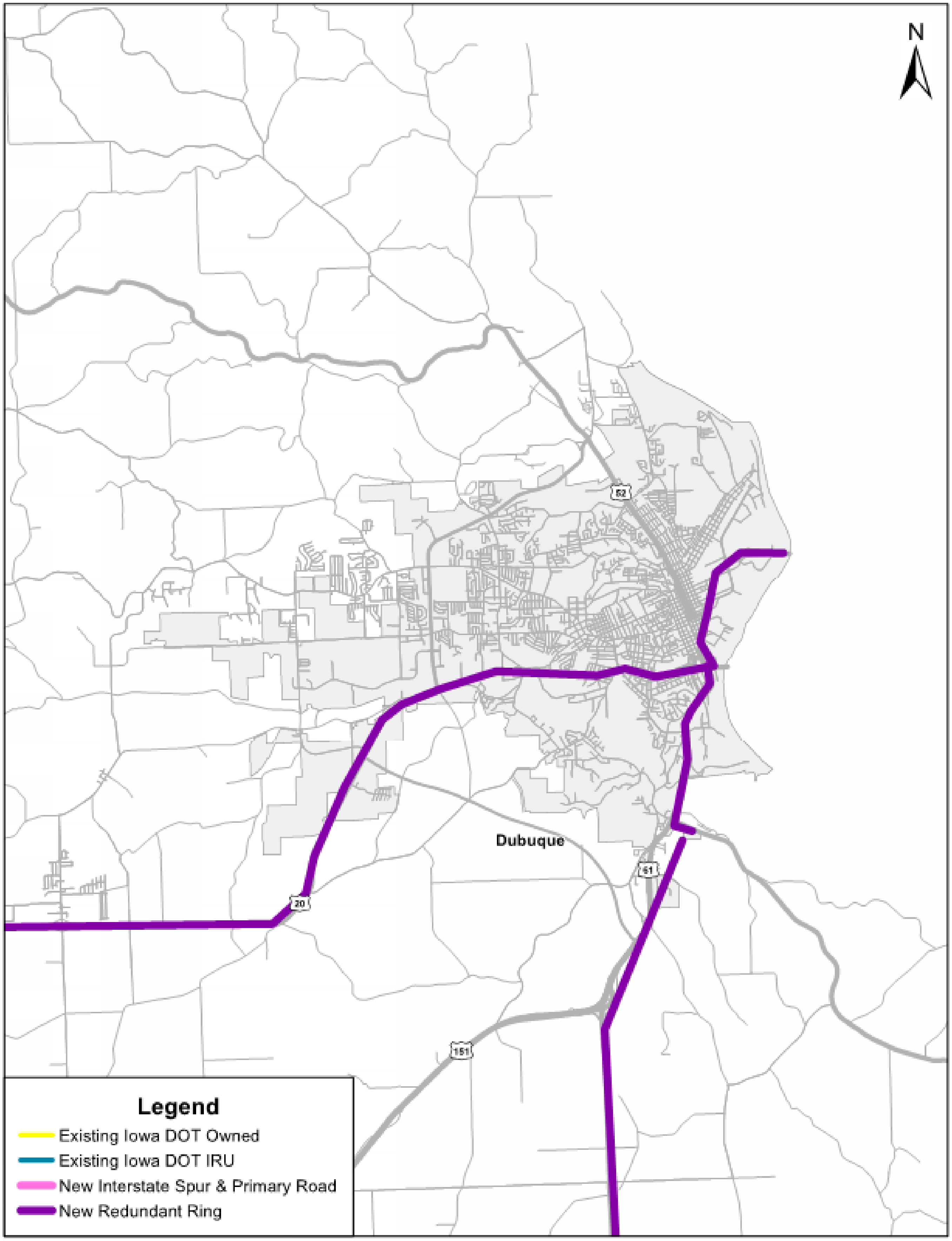

N
Ames
69
30
35
Legend
Fiber Cable
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Ring

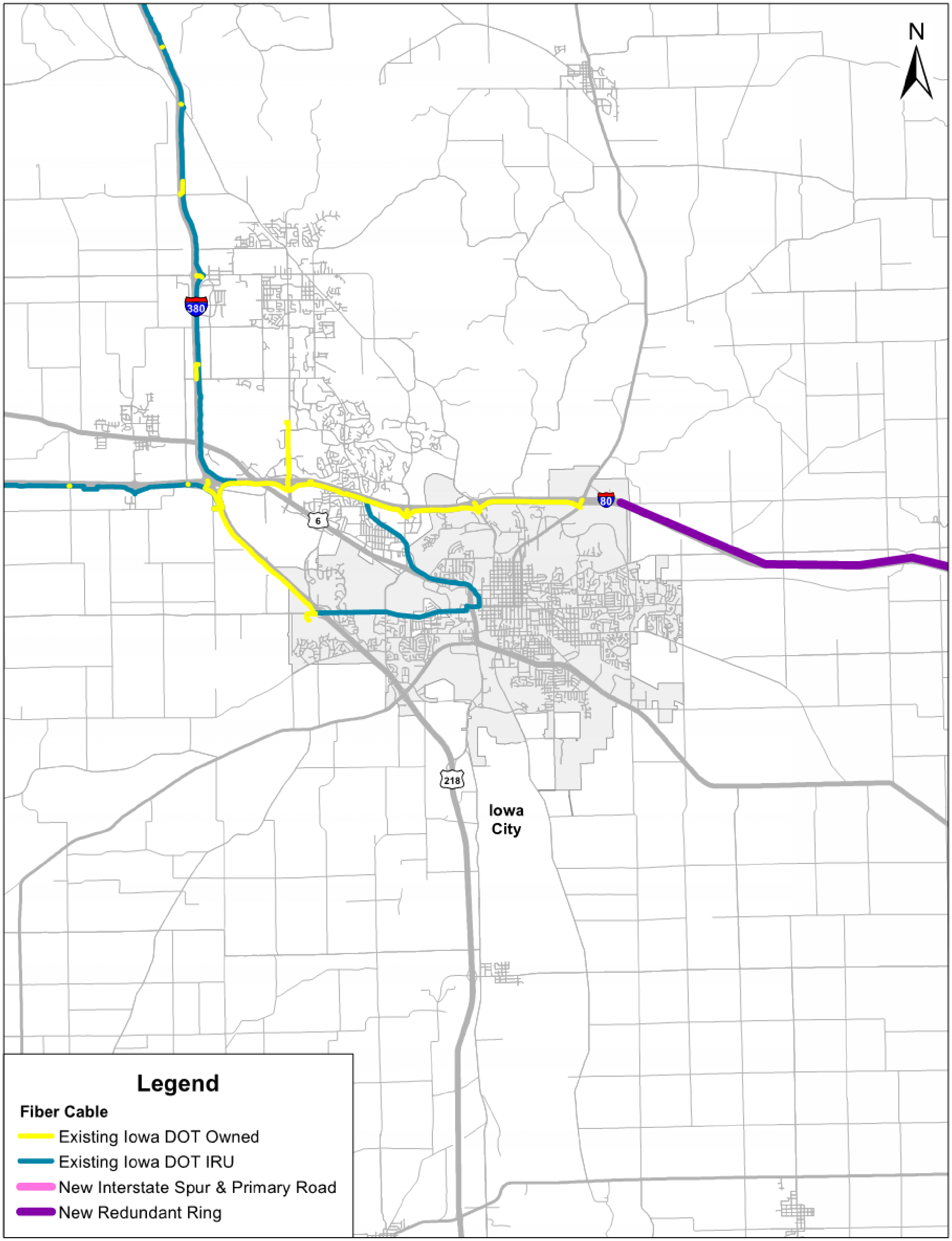


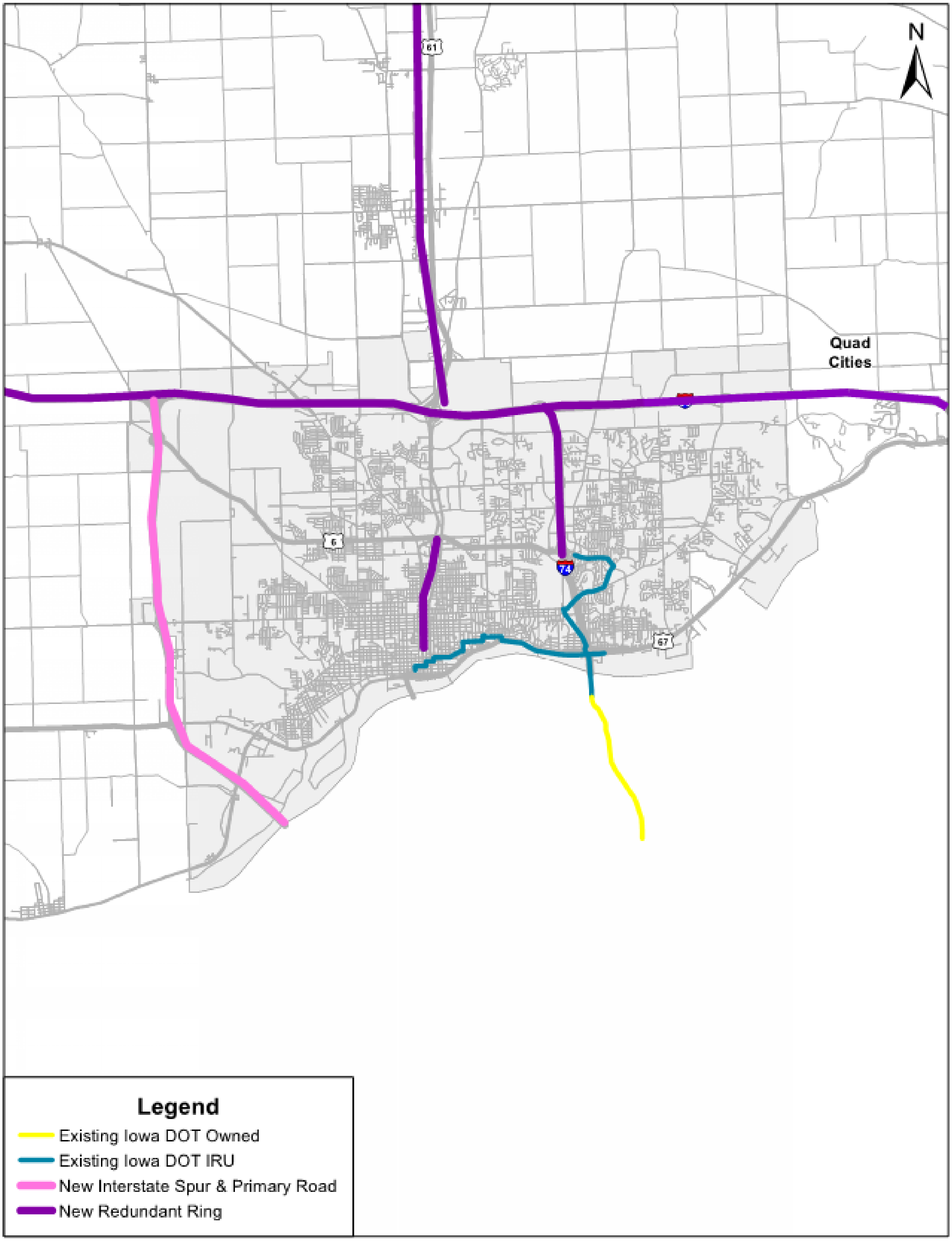
N
380
151
30
218
Cedar
Rapids
Legend
Fiber Cable
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Ring

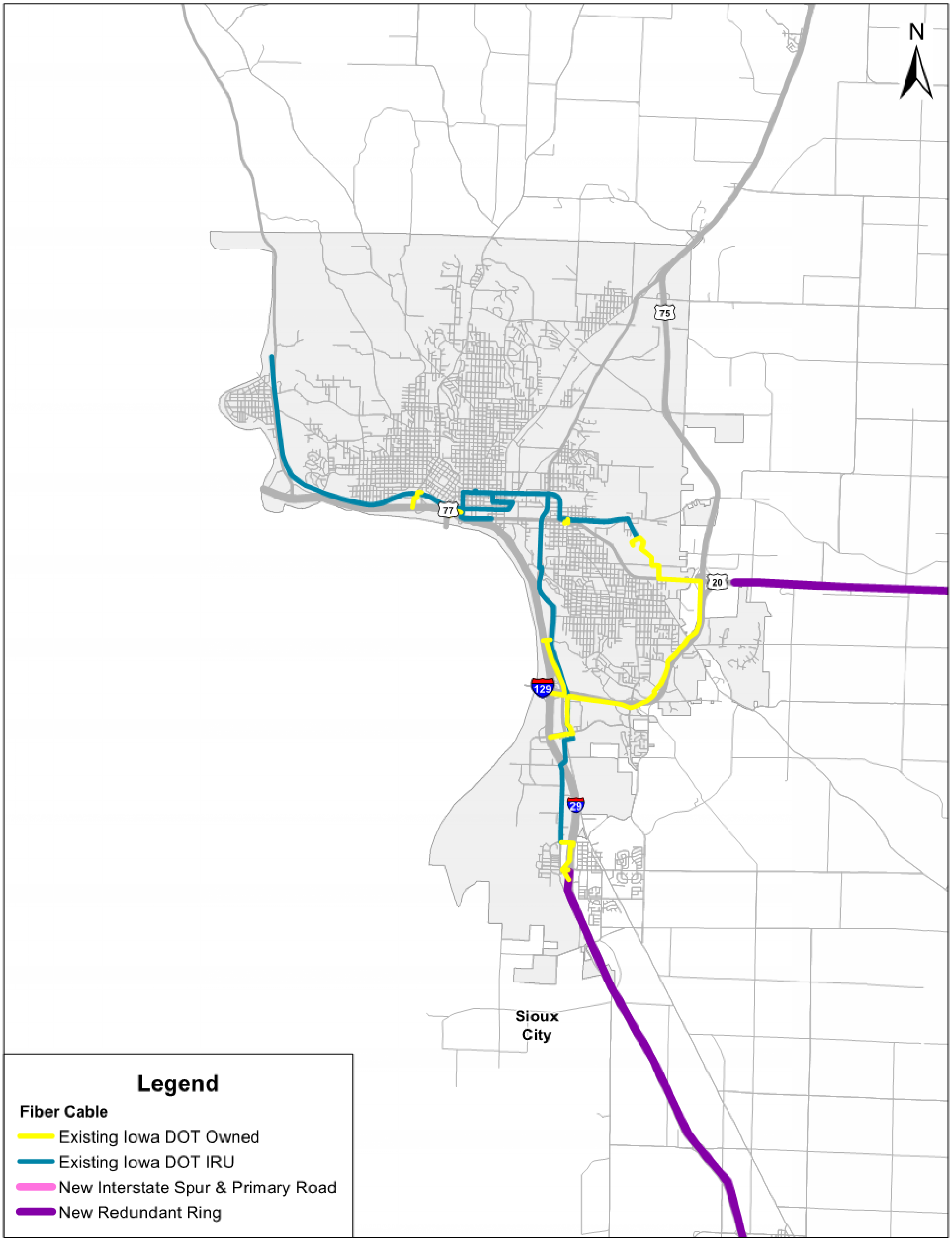

680
480
29
80
6
275
N
Council
Bluffs
Legend
Fiber Cable
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Ring

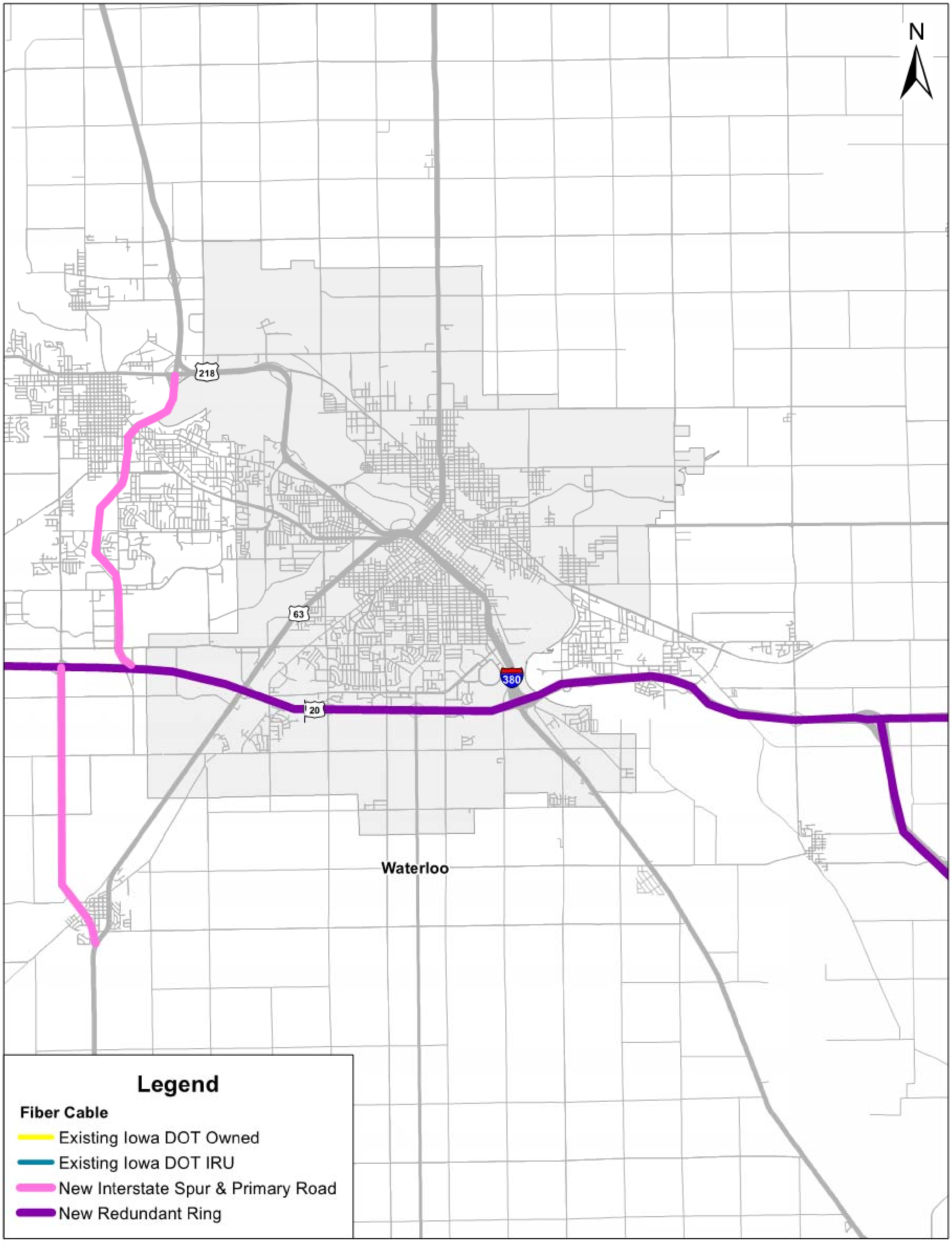

N
35
69
80
6
235
65
Des
Moines
Legend
Fiber Cable
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Ring

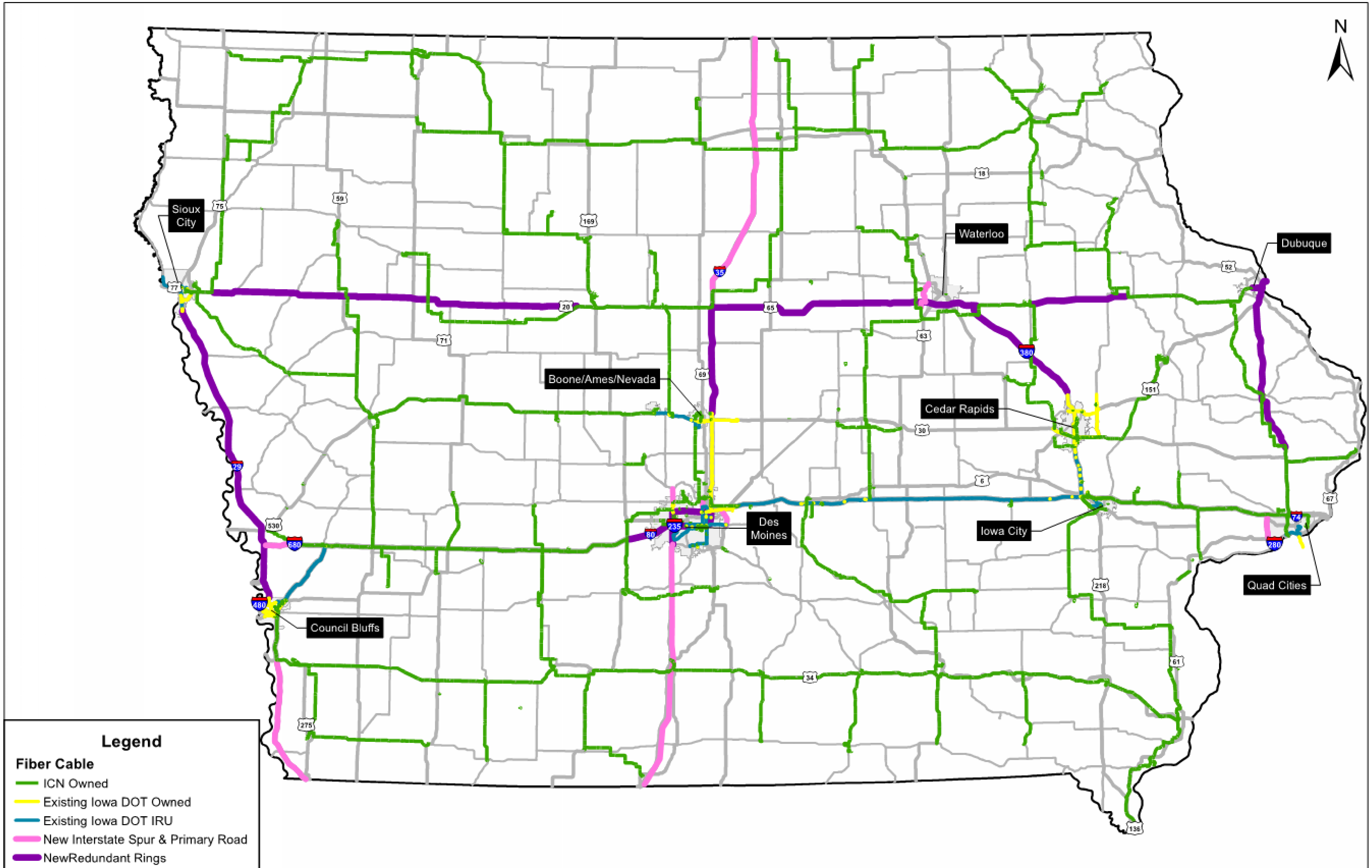

N
52
Dubuque
61
20
151
Legend
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Ring

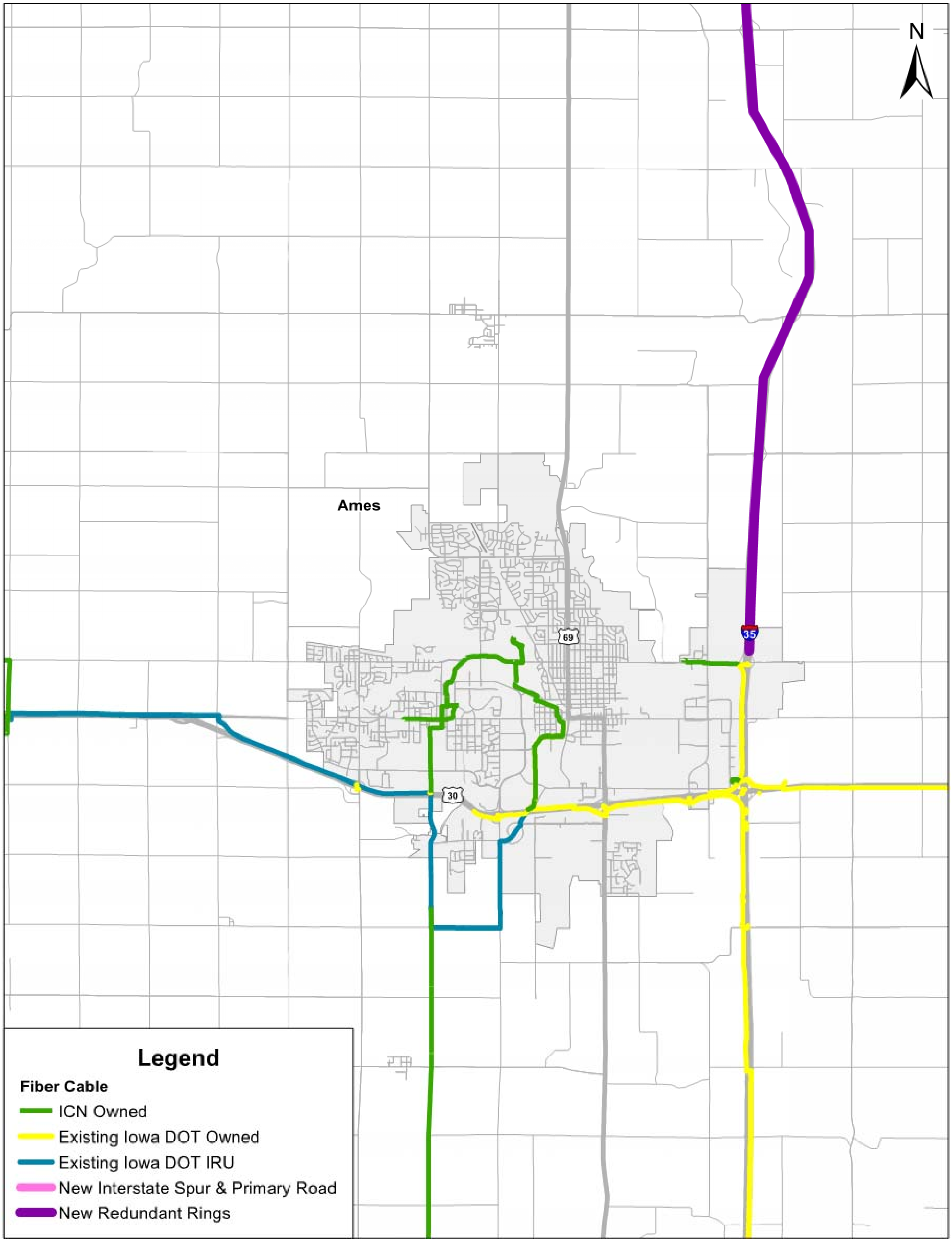

N
380
80
6
218
Iowa City
Legend
Fiber Cable
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Ring

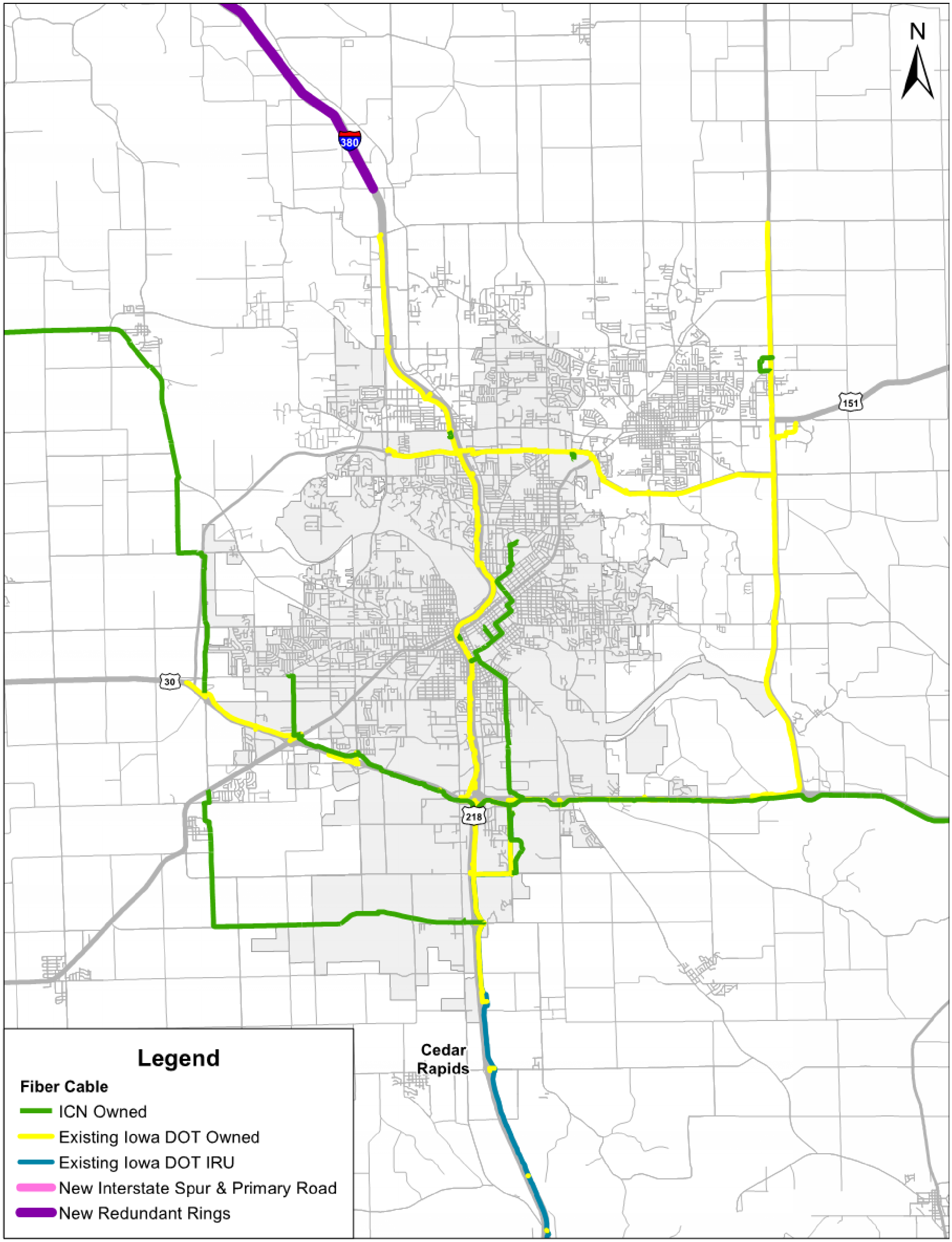

N
Quad
Cities
61
6
74
67
Legend
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Ring


N
75
77
20
129
29
Sioux
City
Legend
Fiber Cable
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Ring

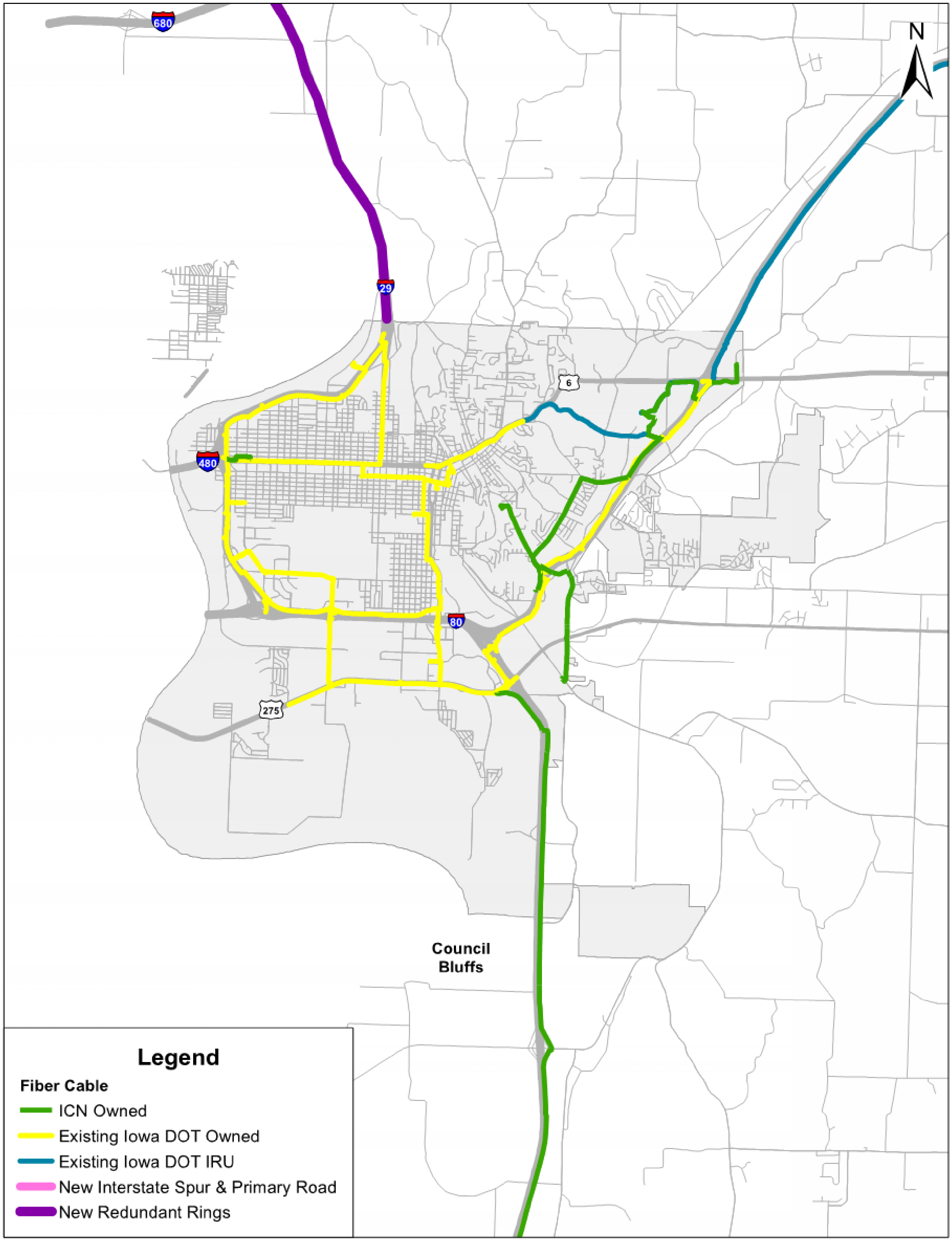

N
218
63
380
20
Waterloo
Legend
Fiber Cable
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Ring


N
Sioux City
Waterloo
Dubuque
Boone/Ames/Nevada
Cedar Rapids
Des Moines
Iowa City
Quad Cities
Council Bluffs
Legend
Fiber Cable
ICN Owned
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
NewRedundant Rings

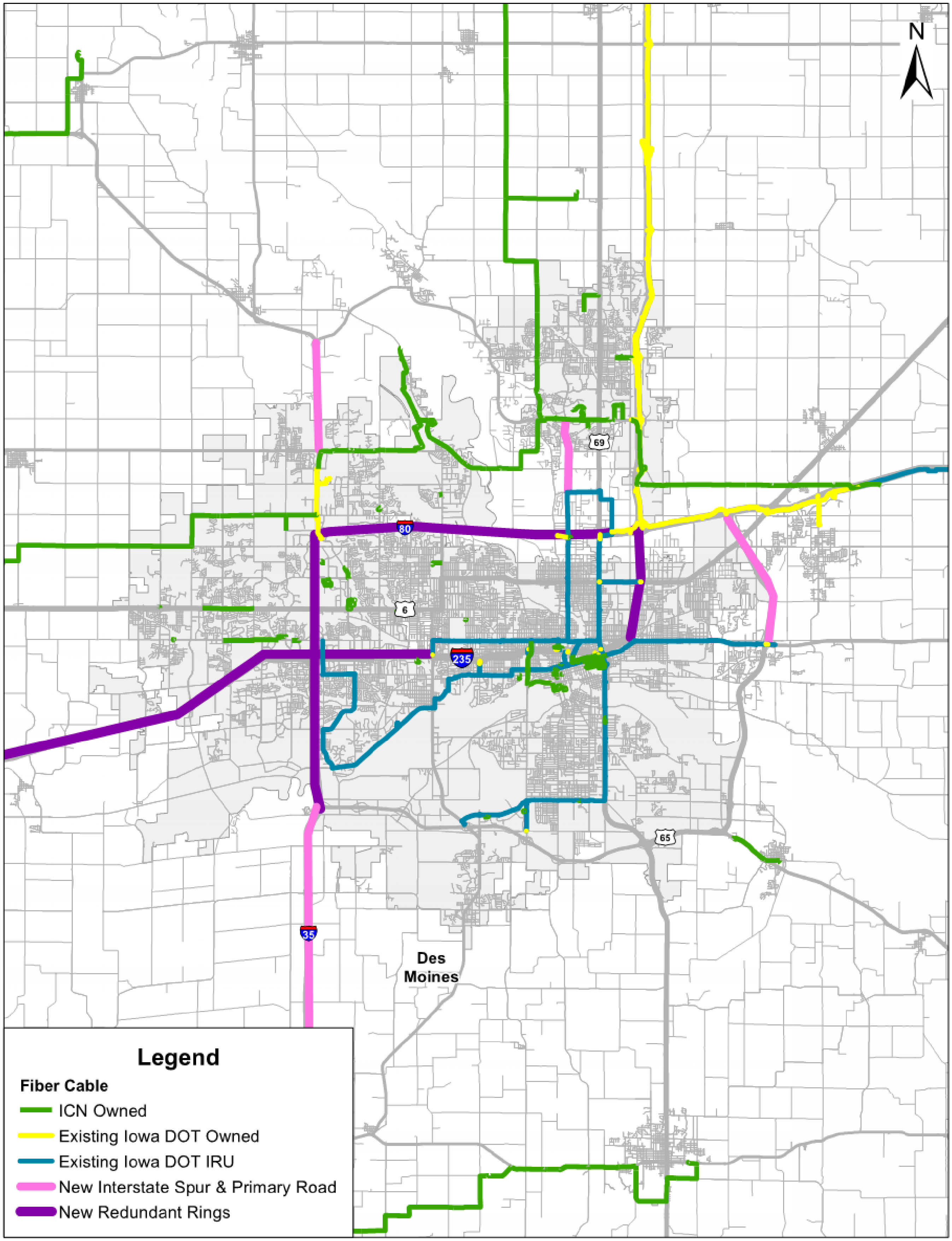

N
Ames
69
35
30
Legend
Fiber Cable
ICN Owned
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Rings

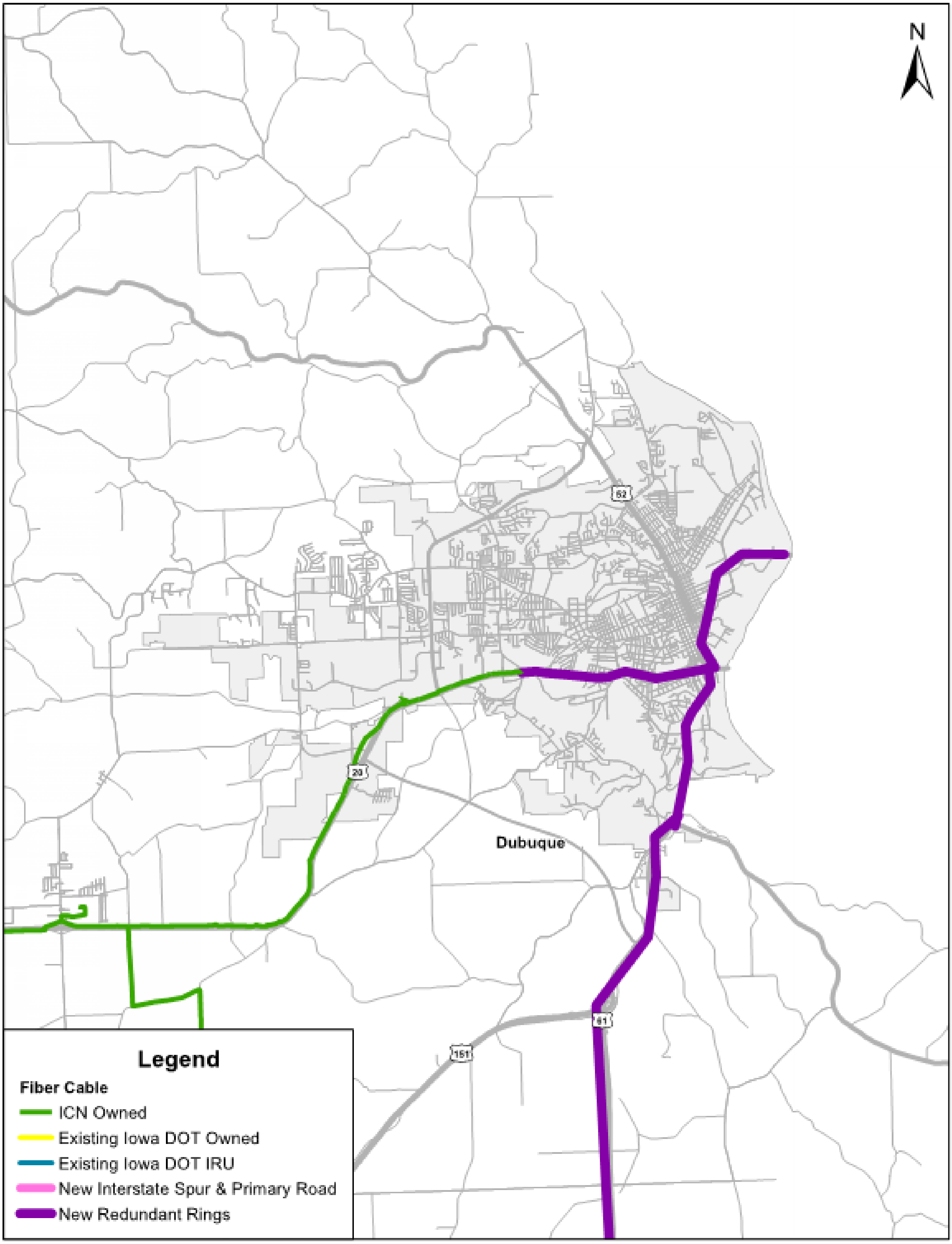


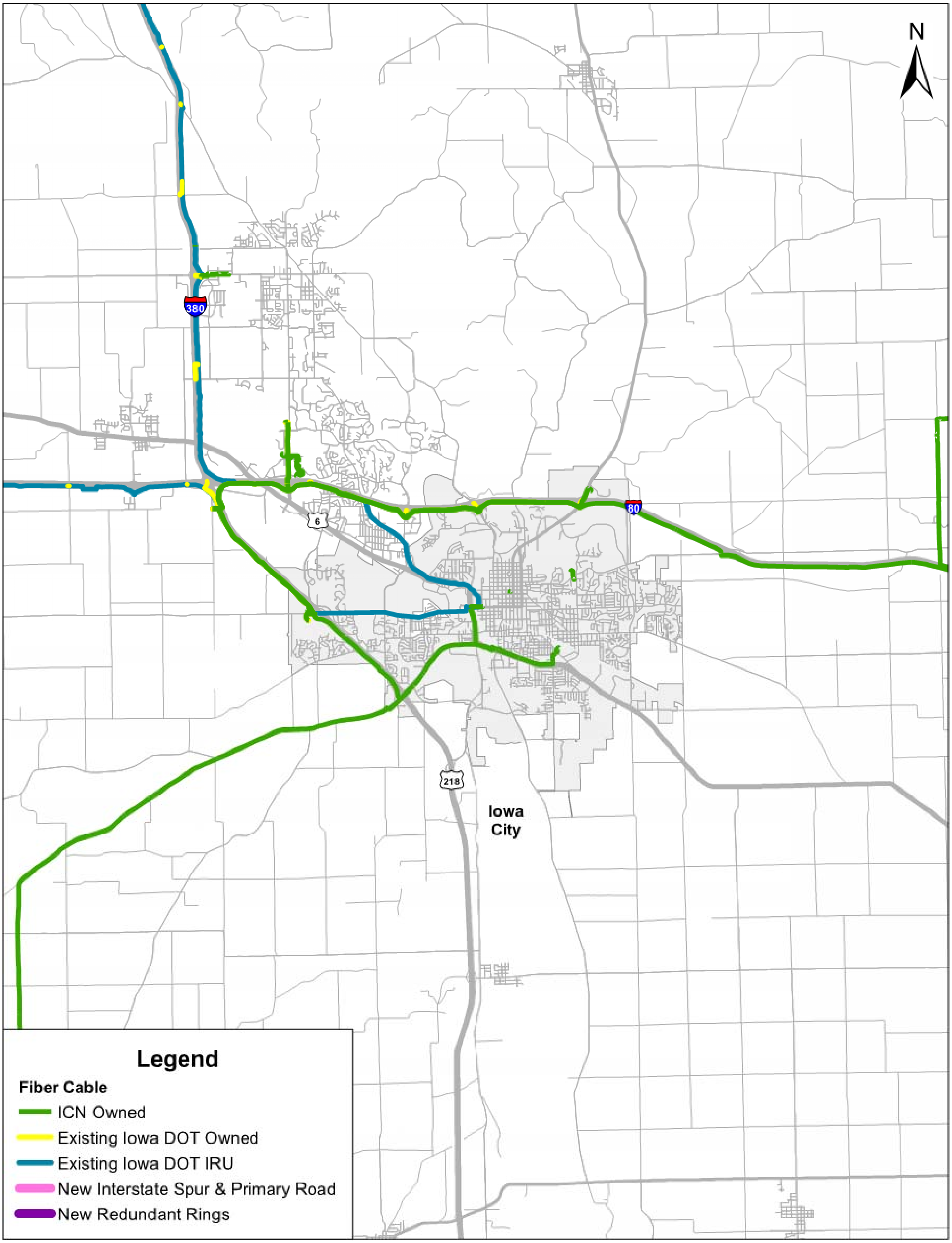
N
380
151
30
218
Cedar
Rapids
Legend
Fiber Cable
ICN Owned
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Rings

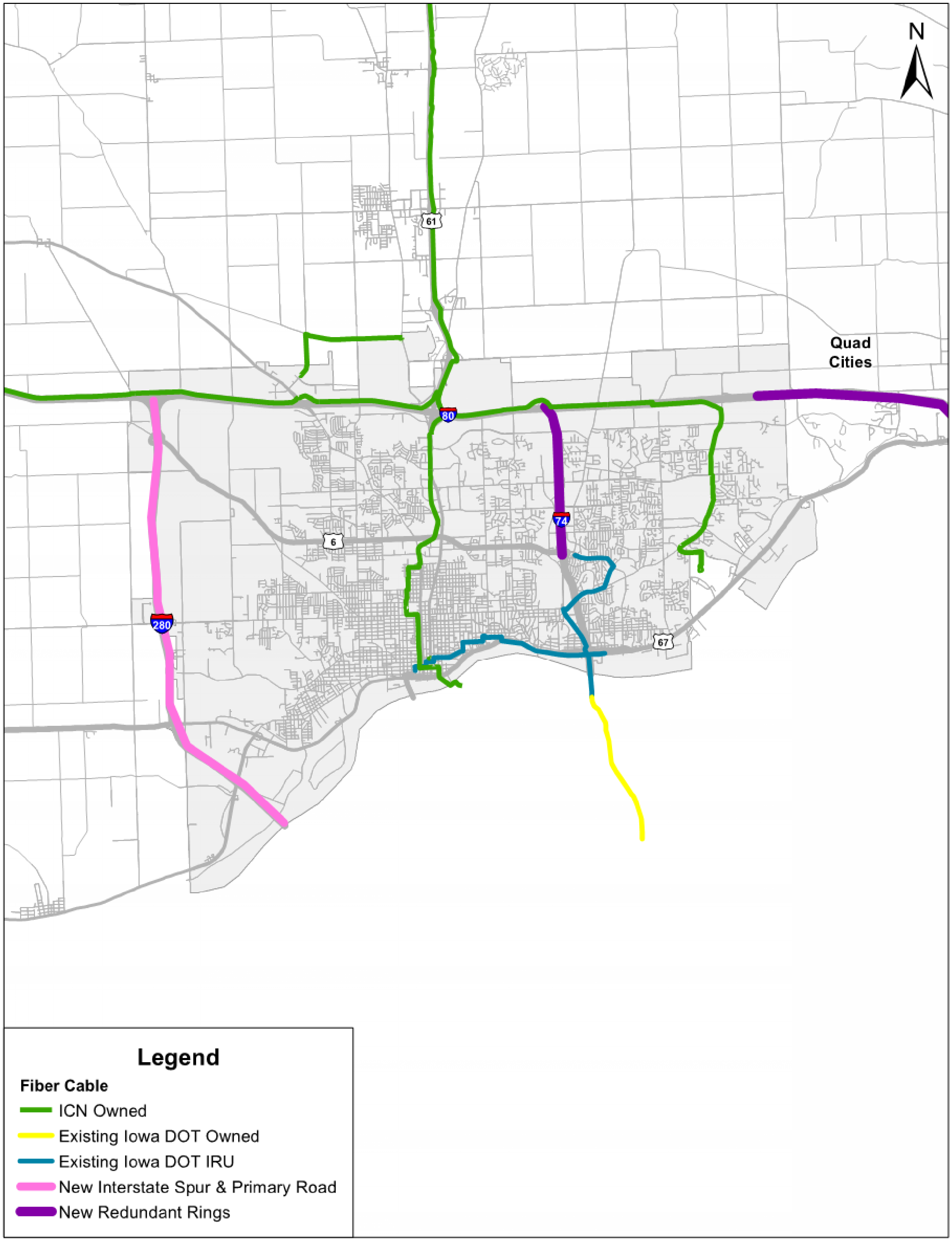


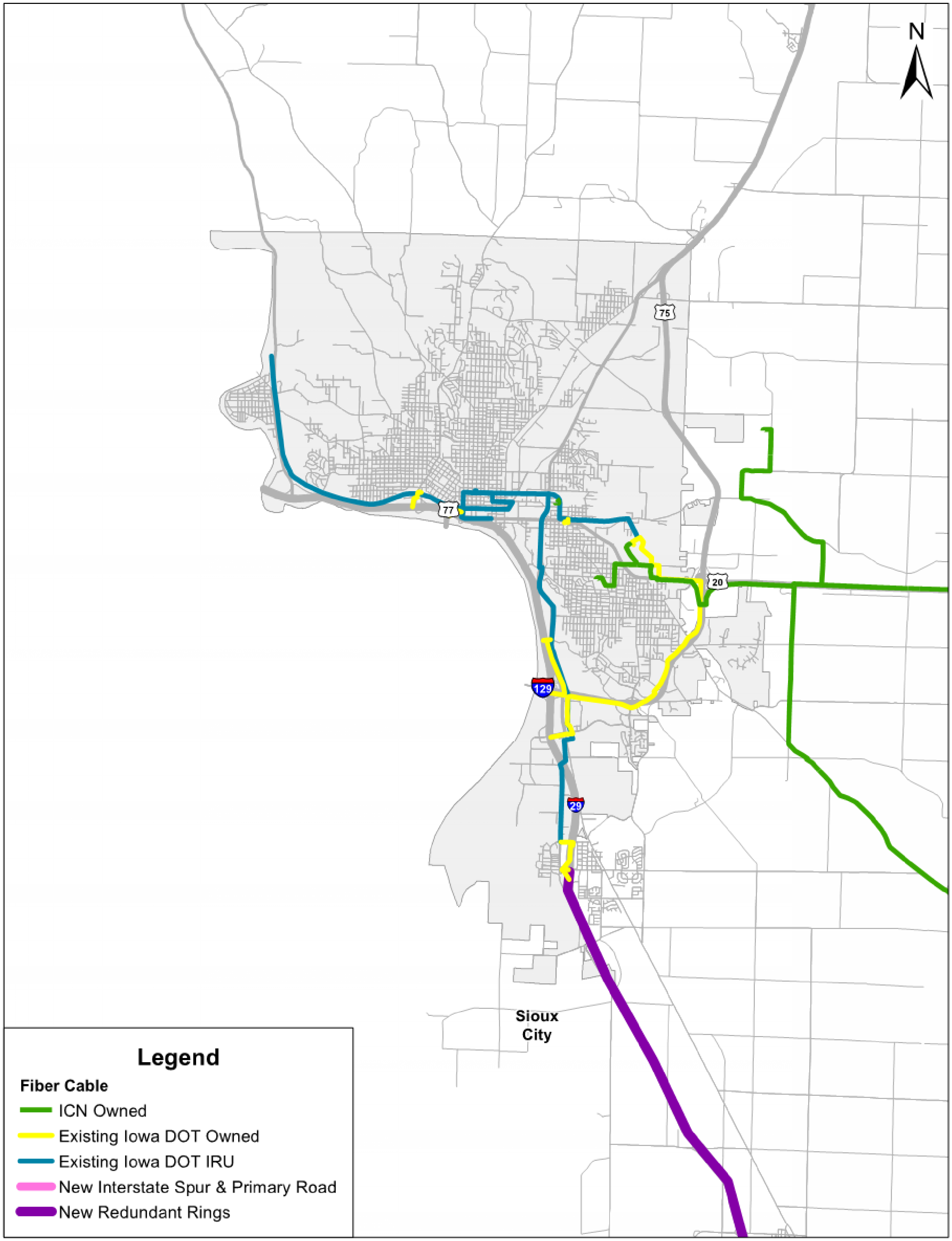
680
29
480
6
80
275
N
Council
Bluffs
Legend
Fiber Cable
ICN Owned
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Rings

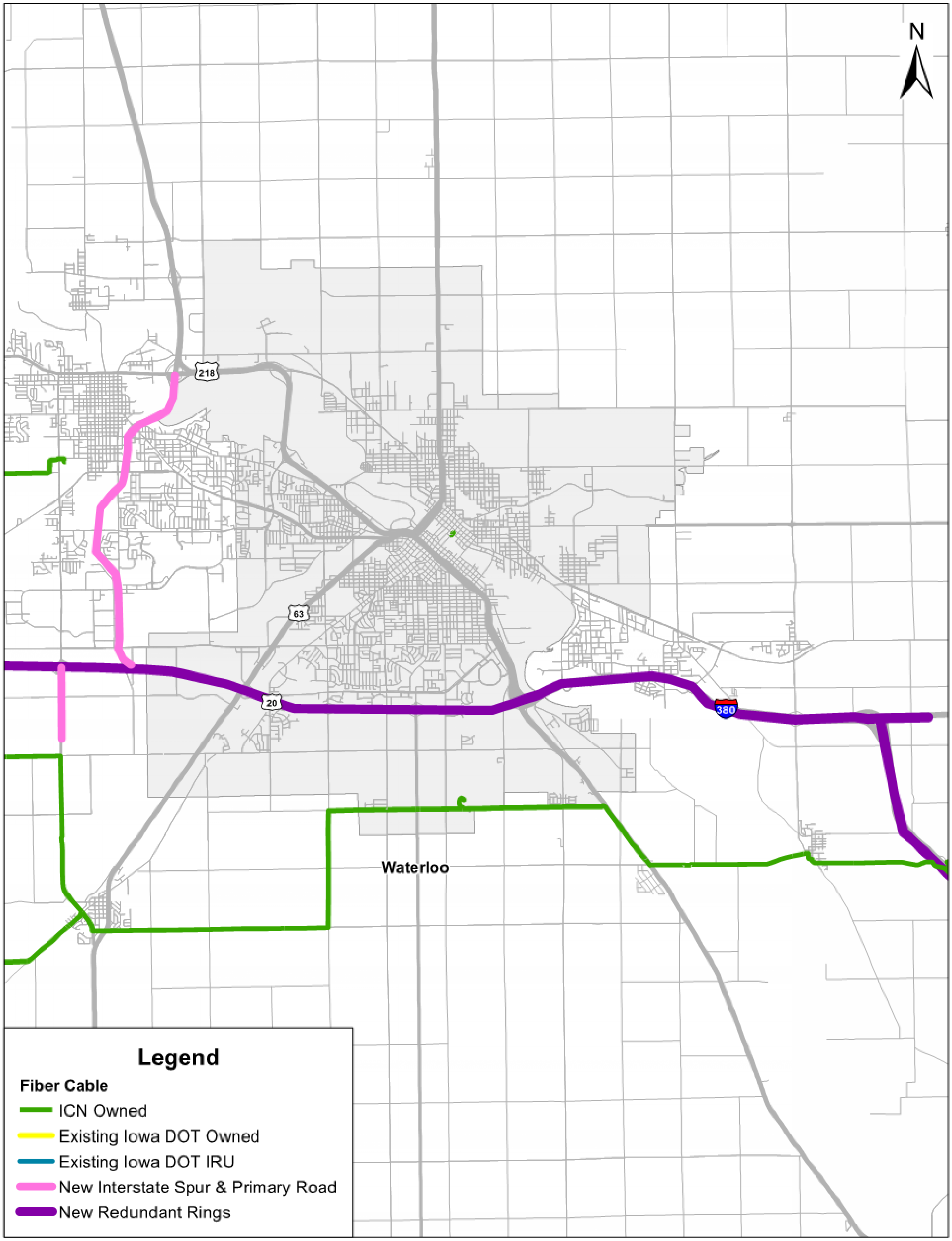

N
Des
Moines
80
235
35
6
69
65
Legend
Fiber Cable
ICN Owned
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Rings


N
52
20
Dubuque
61
151
Legend
Fiber Cable
ICN Owned
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Rings


N
380
80
6
218
Iowa
City
Legend
Fiber Cable
ICN Owned
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Rings


N
Quad Cities
61
80
74
6
280
67
Legend
Fiber Cable
ICN Owned
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Rings


N
75
77
20
129
29
Sioux
City
Legend
Fiber Cable
ICN Owned
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Rings


N
218
63
20
380
Waterloo
Legend
Fiber Cable
ICN Owned
Existing Iowa DOT Owned
Existing Iowa DOT IRU
New Interstate Spur & Primary Road
New Redundant Rings

APPENDIX H. INFRASTRUCTURE GAP DETAILED TABLES

ITS AND COMMUNICATIONS COSTS / UNIT

Device	Cost	Unit
Cameras	$ 15,000	EA
Power	$ 15,000	EA
Communications	$ 15,000	EA
Sensors	$ 20,000	EA
RWIS	$ 75,000	EA
Mobile RWIS	$ 250,000	EA
DMS New OH (Color - 4-lane)	$ 190,000	EA
DMS New OH (Color - 3-lane)	$ 120,000	EA
DMS New OH (Amber)	$ 55,000	EA
DMS New SM (Amber)	$ 45,000	EA
DMS Install OH	$ 195,000	EA
DMS Install SM	$ 80,000	EA
DMS Remove OH	$ 50,000	EA
DMS Remove SM	$ 20,000	EA
Fiber (Iowa DOT)	$ 100,000	MI
Fiber (Partner)	$ 5,000	MI
Fiber (Hybrid)	$ 35,000	MI
WIM	$ 250,000	EA
Upgraded WIM	$ 100,000	EA
VWS	$ 1,000,000	EA

CAMERAS

Corridor ID	Route	Corridor	Urban/Rural	Counties	Length (mi)	Mile/Device	Recommended # of Devices	Existing # of Devices	Difference	Camera Cost / Segment	
265	I-29	IA 192 to I-680	Rural	Pottawattamie	14.4	1.5	6	5	1	$ -	*
266	I-29	US 34 to I-80	Rural	Mills, Pottawattamie	14	1.5	8	6	2	$ 90,000.00	
419	I-29	MO border to IA 2	Rural	Fremont	10	1.5	7	0	7	$ 315,000.00	
420	I-29	IA 2 to US 34	Rural	Fremont, Mills	25.8	1.5	17	0	17	$ 765,000.00	
438	I-29	US 30 to IA 175	Rural	Harrison, Monona	36.5	1.5	24	1	23	$ 1,035,000.00	
276	I-35	MO border to US 34	Rural	Decatur, Clarke	32.9	1.5	22	0	22	$ 990,000.00	
279	I-35	IA 3 to US 18	Rural	Franklin, Cerro Gordo	28.3	1.5	19	0	19	$ 855,000.00	
358	I-35	US 20 to IA 3	Rural	Hamilton, Wright, Franklin	23.5	1.5	16	3	13	$ 585,000.00	
365	I-35	US 18 to MN border	Rural	Cerro Gordo, Worth	24.6	1.5	16	2	14	$ 630,000.00	
405	I-35	US 34 to IA 92	Rural	Clarke, Warren	23.6	1.5	16	3	13	$ 585,000.00	
429	I-35	IA 92 to IA 5	Rural	Warren, Polk	12	1.5	8	6	2	$ 90,000.00	
269	I-380	IA 150 to US 20	Rural	Benton, Buchanan, Black Hawk	22.1	1.5	15	3	12	$ 540,000.00	
439	I-380	IA 100 to IA 150	Rural	Linn, Benton	19.6	1.5	8	5	3	$ 135,000.00	
274	I-680	I-29 to I-80	Rural	Pottawattamie	17	1.5	11	2	9	$ 405,000.00	
330	I-680	NE border to I-29	Rural	Pottawattamie	3.3	1.5	2	1	1	$ 45,000.00	
273	I-80	US 6/US 71 to US 169	Rural	Cass, Adair, Madison, Dallas	48.9	1.5	33	1	32	$ 1,440,000.00	
369	I-80	US 59 to US 6/US 71	Rural	Pottawattamie, Cass	20.9	1.5	14	0	14	$ 630,000.00	
370	I-80	US 6 to US 59	Rural	Pottawattamie	31.5	1.5	21	3	18	$ 810,000.00	
372	I-80	IA 14 to US 63	Rural	Jasper, Poweshiek	27.6	1.5	11	9	2	$ 90,000.00	
373	I-80	US 63 to US 151	Rural	Poweshiek, Iowa	32.8	1.5	22	0	22	$ 990,000.00	
409	I-80	IA 1 to US 6	Rural	Johnson, Cedar	24.6	1.5	16	2	14	$ 630,000.00	
451	I-80	US 151 to I-380	Rural	Iowa, Johnson	19.7	1.5	13	5	8	$ 360,000.00	
414	I-280	IL border to US 61/IA 146	Urban	Scott	3.2	1.5	2	1	1	$ -	*
366	I-29	I-80 to I-480/US 6	Urban	Pottawattamie	2.9	1.5	4	4	0	$ -	
430	I-35	IA 5 to I-80/I-235	Urban	Polk	4.7	1.5	5	5	0	$ -	
268	I-380	US 30 to IA 100	Urban	Linn	7.6	1.5	12	12	0	$ -	
440	I-380	US 20 to end of route	Urban	Black Hawk	7.3	1.5	11	11	0	$ -	
270	I-480	NE border to I-29	Urban	Pottawattamie	0.9	1.5	2	2	0	$ -	
271	I-80	I-280 to I-74	Urban	Scott	7.8	1.5	5	4	1	$ 45,000.00	
425	I-80	I-29 to US 6	Urban	Pottawattamie	5	1.5	5	5	0	$ -	
432	I-80	I-380 to IA 1	Urban	Johnson	7.1	1.5	8	8	0	$ -	
278	I-35	US 30 to US 20	Rural	Story, Hamilton	30.7	1.5	20	8	12	$ 540,000.00	
280	I-35	IA 160 to US 30	Rural	Polk, Story	20.9	1.5	14	13	1	$ -	*
267	I-380	I-80 to US 30	Rural	Johnson, Linn	16.2	1.5	11	11	0	$ -	
272	I-80	E mixmaster to IA 14	Rural	Polk, Jasper	28.5	1.5	19	12	7	$ 315,000.00	
411	I-80	US 6 to I-280	Rural	Cedar, Scott	18.7	1.5	12	3	9	$ 405,000.00	
399	IA 58	US 63 to US 20	Urban	Black Hawk	5.4	1.5	4	0	4	$ 180,000.00	
457	US 20	I-29 to US 75	Urban	Woodbury	4.3	1.5	4	4	0	$ -	
364	US 218	IA 1 to I-80	Urban	Johnson	5.4	1.5	4	4	0	$ -	*
216	US 30	I-380 to 2.4 mi W of IA 1	Urban	Linn	10.9	1.5	8	8	0	$ -	
447	US 30	IA 922 to I-380	Urban	Linn	4.1	1.5	5	5	0	$ -	
455	US 30	IA 930 to I-35	Urban	Boone, Story	8.7	1.5	8	8	0	$ -	*
417	US 65	IA 163 to I-80	Urban	Polk	5	1.5	3	3	0	$ -	
400	US 20	IA 27 to US 218	Urban	Black Hawk	7.2	1.5	5	4	1	$ -	*
191	US 65	IA 5 to IA 163	Urban	Warren, Polk	8.7	1.5	6	5	1	$ 45,000.00	
259	IA 141	US 169 to I-35/80	Urban	Dallas, Polk	22.4	1.5	15	2	13	$ 585,000.00	
379	IA 27	US 20 to US 218	Urban	Black Hawk	5.8	1.5	4	0	4	$ 180,000.00	
388	IA 415	IA 160 to I-35/80	Urban	Polk	3.6	1.5	2	0	2	$ 90,000.00	
459	IA 461	US 67 to US 6	Urban	Scott	2.9	1.5	2	0	2	$ 90,000.00	
343	US 151	US 30 to IA 13	Urban	Linn	8.2	1.5	7	7	0	$ -	*
344	US 20	IA 32 to US 52/US 61	Urban	Dubuque	4	1.5	3	0	3	$ 135,000.00	

Corridor ID	Route	Corridor	Urban/Rural	Counties	Length (mi)	Mile/Device	Recommended # of Devices	Existing # of Devices	Difference	Camera Cost / Segment
374	US 275	I-29 to NE border	Urban	Pottawattamie	5.1	1.5	5	5	0	$ - *
334	US 61	US 20 to WI border	Urban	Dubuque	2.6	1.5	2	0	2	$ 90,000.00
475	US 77	NE border to I-29	Urban	Woodbury	0.3	1.5	1	1	0	$ -
351	IA 1	US 30 to US 151	Rural	Linn, Jones	11.7	5	2	0	2	$ 90,000.00
99	IA 10	NE border to IA 60	Rural	Sioux	29.4	5	6	0	6	$ 270,000.00
474	IA 136	IL border to US 67	Rural	Clinton	0.5	5	0	0	0	$ -
474	IA 136	IL border to US 67	Rural	Clinton	0.5	5	0	0	0	$ -
309	IA 163	US 65 to IA 14	Rural	Polk, Jasper	24.5	5	5	0	5	$ 225,000.00
477	IA 163	IA 14 to US 63	Rural	Marion, Mahaska	31.7	5	6	0	6	$ 270,000.00
18	IA 175	NE border to US 59	Rural	Monona, Woodbury, Ida	49.8	5	10	0	10	$ 450,000.00
473	IA 2	NE border to I-29	Rural	Fremont	2.9	5	1	0	1	$ 45,000.00
257	IA 27	MO border to US 218	Rural	Lee	10.7	5	2	0	2	$ 90,000.00
242	IA 330	US 65 to US 30	Rural	Jasper, Story, Marshall	21	5	4	0	4	$ 180,000.00
256	IA 60	US 75 to US 18	Rural	Plymouth, Sioux, O'Brien	35	5	7	0	7	$ 315,000.00
321	IA 60	US 18 to MN border	Rural	O'Brien, Osceola	24.1	5	5	0	5	$ 225,000.00
244	IA 92	I-35 to US 65	Rural	Warren	12	5	2	0	2	$ 90,000.00
339	IA 92	US 65 to IA 5	Rural	Warren, Marion	16	5	3	0	3	$ 135,000.00
434	US 136	US 61 to US 218	Rural	Lee	2.4	5	0	0	0	$ -
283	US 151	IA 13 to US 61	Rural	Linn, Jones, Dubuque	56.9	5	11	3	8	$ 360,000.00
224	US 18	SD state line to US 75	Rural	Lyon, Sioux	26	5	5	0	5	$ 225,000.00
225	US 18	US 65 to US 218	Rural	Cerro Gordo, Floyd	32.4	5	6	1	5	$ 225,000.00
226	US 18	US 52 to IA 76	Rural	Allamakee, Clayton	24.7	5	5	0	5	$ 225,000.00
316	US 18	I-35 to US 65	Rural	Cerro Gordo	7.4	5	1	1	0	$ -
168	US 20	I-380 to IA 150	Rural	Black Hawk, Buchanan	16	5	3	2	1	$ 45,000.00
219	US 20	US 75 to 3.5 mi E of IA 140	Rural	Woodbury	16.8	5	3	0	3	$ 135,000.00
220	US 20	3.5 mi E of IA 140 to US 59	Rural	Woodbury, Ida	23.4	5	5	0	5	$ 225,000.00
221	US 20	US 71 to US 169	Rural	Sac, Calhoun, Webster	51.6	5	10	0	10	$ 450,000.00
222	US 20	US 169 to I-35	Rural	Webster, Hamilton	33.1	5	7	1	6	$ 270,000.00
223	US 20	US 65 to IA 14	Rural	Hardin, Grundy	27	5	5	0	5	$ 225,000.00
345	US 20	IA 136 to IA 32	Rural	Dubuque	21.1	5	4	0	4	$ 180,000.00
346	US 20	IA 13 to IA 136	Rural	Delaware, Dubuque	18.9	5	4	1	3	$ 135,000.00
347	US 20	IA 150 to IA 13	Rural	Buchanan, Delaware	20.8	5	4	0	4	$ 180,000.00
360	US 20	US 59 to US 71	Rural	Ida, Sac	19.1	5	4	0	4	$ 180,000.00
403	US 20	IA 14 to IA 27	Rural	Grundy, Black Hawk	16.7	5	3	0	3	$ 135,000.00
458	US 20	I-35 to US 65	Rural	Hamilton, Hardin	15.7	5	3	1	2	$ 90,000.00
178	US 218	IA 3 to US 18	Rural	Bremer, Chickasaw, Floyd	26	5	5	0	5	$ 225,000.00
180	US 218	US 34 to IA 92	Rural	Henry, Washington	21.9	5	4	0	4	$ 180,000.00
181	US 218	IA 27 to US 34	Rural	Lee, Henry	24.9	5	5	0	5	$ 225,000.00
182	US 218	US 61 to IA 27	Rural	Lee	13	5	3	0	3	$ 135,000.00
357	US 218	IA 57 to IA 3	Rural	Black Hawk, Bremer	16.9	5	3	0	3	$ 135,000.00
363	US 218	IA 92 to IA 1	Rural	Washington, Johnson	24.4	5	5	1	4	$ 180,000.00
212	US 30	US 169 to IA 930	Rural	Boone	20.1	5	6	6	0	$ -
213	US 30	I-35 to IA 14	Rural	Story, Marshall	33.9	5	7	6	1	$ 45,000.00
214	US 30	IA 14 to 3.3 mi E of US 63	Rural	Marshall, Tama	21.3	5	4	0	4	$ 180,000.00
215	US 30	3.3 mi E of US 63 to US 218	Rural	Tama, Benton	26.1	5	5	0	5	$ 225,000.00
217	US 30	2.4 mi W of IA 1 to US 61	Rural	Linn, Cedar, Clinton	47	5	9	0	9	$ 405,000.00
218	US 30	US 61 to IL state line	Rural	Clinton	23	5	5	0	5	$ 225,000.00
359	US 30	US 218 to IA 922	Rural	Benton, Linn	15.4	5	3	3	0	$ -
454	US 30	NE border to I-29	Rural	Harrison	9.6	5	2	0	2	$ 90,000.00
210	US 34	IA 1 to US 218	Rural	Jefferson, Henry	26.3	5	5	0	5	$ 225,000.00
352	US 34	US 61 to IL border	Rural	Des Moines	2.2	5	0	0	0	$ -

Corridor ID	Route	Corridor	Urban/Rural	Counties	Length (mi)	Mile/Device	Recommended # of Devices	Existing # of Devices	Difference	Camera Cost / Segment
353	US 34	US 218 to US 61	Rural	Henry, Des Moines	25.5	5	5	1	4	$ 180,000.00
354	US 34	Ottumwa W CL to US 63	Rural	Wapello	5	5	1	0	1	$ 45,000.00
355	US 34	US 63 to IA 1	Rural	Wapello, Jefferson	24.4	5	5	0	5	$ 225,000.00
464	US 34	NE border to I-29	Rural	Mills	4.3	5	1	0	1	$ 45,000.00
31	US 52	IA 64 to US 20	Rural	Jackson, Dubuque	40.5	5	8	0	8	$ 360,000.00
200	US 61	Louisa Co line to IA 38	Rural	Muscatine	14.9	5	3	0	3	$ 135,000.00
201	US 61	Burlington N CL to Muscatine Co line	Rural	Des Moines, Louisa	35	5	7	0	7	$ 315,000.00
202	US 61	IA 2 to Burlington N CL	Rural	Lee, Des Moines	24.4	5	5	0	5	$ 225,000.00
361	US 61	US 218 to IA 2	Rural	Lee	9	5	2	0	2	$ 90,000.00
362	US 61	MO border to US 218	Rural	Lee	9.6	5	2	0	2	$ 90,000.00
436	US 61	IA 38 to I-280	Rural	Muscatine, Scott	20.5	5	4	0	4	$ 180,000.00
197	US 63	IA 149 to IA 92	Rural	Wapello, Mahaska	22.6	5	5	0	5	$ 225,000.00
198	US 63	MO border to US 34	Rural	Davis, Wapello	33.9	5	7	0	7	$ 315,000.00
337	US 63	US 34 to IA 149	Rural	Wapello	7.1	5	1	0	1	$ 45,000.00
190	US 65	I-80 to IA 330	Rural	Polk, Jasper	15.5	5	3	0	3	$ 135,000.00
461	US 65	IA 92 to IA 5	Rural	Warren	10.5	5	2	1	1	$ 45,000.00
165	US 71	IA 86 to MN border	Rural	Dickinson	18.3	5	4	0	4	$ 180,000.00
449	US 71	US 18 to IA 86	Rural	Clay, Dickinson	10.8	5	2	0	2	$ 90,000.00
171	US 75	US 20 to IA 60	Rural	Woodbury, Plymouth	27.9	5	6	0	6	$ 270,000.00
									Total	$ 26,505,000.00
	*	Note: These corridor costs were not counted due to the segment containing almost full coverage and the difference needed being small								

BORDER BRIDGE CAMERAS

Corridor ID	Route	Corridor	Urban/Rural	Nearest City	Counties	Bordering State	Volume	Bridge Priority	# of Lanes	Recommended # of Devices	Existing # of Devices	Difference	Cost
91	WI 82	IA 9 to MN border	Rural	Lansing	Allamakee	Wisconsin	-	Low	2	2	0	2	$ 90,000.00
226	US 18	US 52 to IA 76	Rural	Marquette	Clayton	Wisconsin	8600	Low	2	2	0	2	$ 90,000.00
334	US 61	US 20 to WI border	Urban	Dubuque	Dubuque	Wisconsin	21600	Medium	4	2	0	2	$ 90,000.00
344	US 20	IA 32 to US 52/US 61	Urban	Dubuque	Dubuque	Illinois	-	Medium	2	2	0	2	$ 90,000.00
61	US 52	US 61 to IL border	Rural	Sabula	Jackson	Illinois	-	Low	2	2	0	2	$ 90,000.00
474	IA 136	IL border to US 67	Rural	Clinton	Clinton	Illinois	10500	Low	2	2	0	2	$ 90,000.00
218	US 30	US 61 to IL state line	Rural	Clinton	Clinton	Illinois	11400	Low	2	2	0	2	$ 90,000.00
410	I-80	I-74 to IL border	Rural	Le Claire	Scott	Illinois	35800	High	4	2	0	2	$ 90,000.00
275	I-74	IL border to I-80	Urban	Quad Cities	Scott	Illinois	70000	High	4	4	4	0	$ -
187	US 67	US 61 to I-74	Urban	Quad Cities	Scott	Illinois	32300	Medium	4	2	2	0	$ -
414	I-280	IL border to US 61/IA 146	Urban	Quad Cities	Scott	Illinois	24400	High	4	2	0	2	$ 90,000.00
433	IA 38	IL border to US 61	Rural	Muscatine	Muscatine	Illinois	3710	Low	4	2	0	2	$ 90,000.00
352	US 34	US 61 to IL border	Rural	Burlington	Des Moines	Illinois	11000	Low	4	2	0	2	$ 90,000.00
182	US 136	US 61 to IA 27	Rural	Keokuk	Lee	Illinois	11000	Low	4	2	0	2	$ 90,000.00
473	IA 2	NE border to I-29	Rural	Nebraska City	Freemont	Nebraska	9600	Low	4	2	0	2	$ 90,000.00
-	Livingston Road	-	Rural	Plattsmouth	Mills	Nebraska	-	Low	2	2	0	2	$ 90,000.00
464	US 34	NE border to I-29	Rural	La Platte	Mills	Nebraska	1430	Low	4	2	0	2	$ 90,000.00
-	NE 370	-	Rural	Bellevue	Mills	Nebraska	-	Low	2	2	0	2	$ 90,000.00
374	US 275	I-29 to NE border	Urban	Council Bluffs	Pottawattamie	Nebraska	9100	Medium	4	2	1	1	$ 45,000.00
368	I-80	NE border to I-29	Urban	Council Bluffs	Pottawattamie	Nebraska	67600	High	6	2	1	1	$ 45,000.00
270	I-480	NE border to I-29	Urban	Council Bluffs	Pottawattamie	Nebraska	20300	High	8	2	1	1	$ 45,000.00
330	I-680	NE border to I-29	Rural	Omaha	Pottawattamie	Nebraska	16400	High	4	2	0	2	$ 90,000.00
454	US 30	NE border to I-29	Rural	Blair	Harrison	Nebraska	5200	Low	2	2	0	2	$ 90,000.00
18	IA 175	NE border to US 59	Rural	Decatur	Monona	Nebraska	1470	Low	2	2	0	2	$ 90,000.00
261	I-129	NE border to I-29	Urban	Sioux City	Woodbury	Nebraska	23600	High	4	2	0	2	$ 90,000.00
475	US 77	NE border to I-29	Urban	Sioux City	Woodbury	Nebraska	30700	Medium	4	2	1	1	$ 45,000.00
												Total	**$1,980,000.00**

SENSORS

Sensors Cost

Corridor ID	Route	Corridor	Urban/Rural	Counties	Latitude	Longitude	# of Devices	Cost
171	US 75	US 20 to IA 60	Rural	Plymouth	42.722656	-96.244308	1	$ 50,000
256	IA 60	US 75 to US 18	Rural	Plymouth	42.889114	-96.093864	1	$ 50,000
221	US 20	US 71 to US 169	Rural	Webster	42.447992	-94.205156	1	$ 50,000
222	US 20	US 169 to I-35	Rural	Hamilton	42.449117	-93.845681	1	$ 50,000
273	I-80	US 6/US 71 to US 169	Rural	Dallas	41.517853	-94.184428	1	$ 50,000
279	I-35	IA 3 to US 18	Rural	Cerro Gordo	43.10715	-93.348958	1	$ 50,000
276	I-35	MO border to US 34	Rural	Decatur	40.661417	-93.854897	1	$ 50,000
405	I-35	US 34 to IA 92	Rural	Warren	41.166164	-93.784158	1	$ 50,000
429	I-35	IA 92 to IA 5	Rural	Warren	41.369764	-93.780564	1	$ 50,000
190	US 65	I-80 to IA 330	Rural	Polk	41.682717	-93.46835	1	$ 50,000
340	IA 5	W jct of IA 92 to US 65/US 69	Rural	Warren	41.43765	-93.331769	1	$ 50,000
235	IA 5	E jct of IA 92 to W jct of IA 92	Rural	Marion	41.340133	-93.227358	1	$ 50,000
235	IA 5	E jct of IA 92 to W jct of IA 92	Rural	Marion	41.305736	-93.116703	1	$ 50,000
309	IA 163	US 65 to IA 14	Rural	Jasper	41.511289	-93.111247	1	$ 50,000
213	US 30	I-35 to IA 14	Rural	Marshall	42.0075	-92.993442	1	$ 50,000
214	US 30	IA 14 to 3.3 mi E of US 63	Rural	Marshall	42.007011	-92.849831	1	$ 50,000
214	US 30	IA 14 to 3.3 mi E of US 63	Rural	Tama	41.996561	-92.635778	1	$ 50,000
225	US 18	US 65 to US 218	Rural	Floyd	43.063589	-92.717433	1	$ 50,000
357	US 218	IA 57 to IA 3	Rural	Bremer	42.693733	92.508117	1	$ 50,000
357	US 218	IA 57 to IA 3	Rural	Bremer	42.650881	-92.453306	1	$ 50,000
470	US 218	I-380 terminus to IA 27	Urban	Black Hawk	42.4971	-92.351611	1	$ 50,000
403	US 20	IA 14 to IA 27	Rural	Grundy	42.463278	-92.610167	1	$ 50,000
403	US 20	IA 14 to IA 27	Rural	Black Hawk	42.464633	-92.454869	1	$ 50,000
373	I-80	US 63 to US 151	Rural	Poweshiek	41.696158	-92.394514	1	$ 50,000
168	US 20	I-380 to IA 150	Rural	Buchanan	42.448408	-91.905808	1	$ 50,000
345	US 20	IA 136 to IA 32	Rural	Dubuque	42.464292	-91.071808	1	$ 50,000
345	US 20	IA 136 to IA 32	Rural	Dubuque	42.44065	-90.838686	1	$ 50,000
468	US 61	US 151 to US 20	Rural	Dubuque	42.427781	-90.690481	1	$ 50,000
344	US 20	IA 32 to US 52/US 61	Rural	Dubuque	42.491508	-90.669106	1	$ 50,000
217	US 30	2.4 mi W of IA 1 to US 61	Rural	Linn	41.916558	-91.435458	1	$ 50,000
336	US 61	US 30 to IA 64	Rural	Clinton	41.883136	-90.581869	1	$ 50,000
218	US 30	US 61 to IL state line	Rural	Clinton	41.815317	-90.261039	1	$ 50,000
363	US 218	IA 92 to IA 1	Rural	Johnson	41.559728	-91.544797	1	$ 50,000
363	US 218	IA 92 to IA 1	Rural	Washington	41.343211	-91.552422	1	$ 50,000
337	US 63	US 34 to IA 149	Rural	Wapello	41.034022	-92.375789	1	$ 50,000
210	US 34	IA 1 to US 218	Rural	Jefferson	41.002272	-91.853647	1	$ 50,000
210	US 34	IA 1 to US 218	Rural	Henry	40.978056	-91.622531	1	$ 50,000
353	US 34	US 218 to US 61	Rural	Henry	40.950278	-91.493236	1	$ 50,000
200	US 61	Louisa Co line to IA 38	Rural	Muscatine	41.4531	-91.032206	1	$ 50,000
200	US 61	Louisa Co line to IA 38	Rural	Muscatine	41.438272	-91.091914	1	$ 50,000
200	US 61	Louisa Co line to IA 38	Rural	Muscatine	41.366539	-91.137717	1	$ 50,000
201	US 61	Burlington N CL to Muscatine Co line	Rural	Louisa	41.332603	-91.200842	1	$ 50,000
202	US 61	IA 2 to Burlington N CL	Rural	Lee	40.709175	-91.235275	1	$ 50,000
202	US 61	IA 2 to Burlington N CL	Rural	Lee	40.670594	-91.304531	1	$ 50,000
361	US 61	US 218 to IA 2	Rural	Lee	40.598719	-91.423508	1	$ 50,000
						Total	45	$ 2,250,000

RWIS

RWIS Cost

Corridor ID	Route	Corridor	Urban/Rural	Counties	Latitute	Longitude	Radius (mi)	# of Devices	Cost
297	IA 3	US 75 to US 59	Rural	Cherokee	42.799797	-95.667303	15	1	$ 75,000.00
41	IA 17	IA 3 to US 18	Rural	Wright	42.835869	-93.971167	15	1	$ 75,000.00
69	IA 14	US 34 to IA 5	Rural	Lucas	41.111664	-93.249419	15	1	$ 75,000.00
313	US 34	0.8 mi W of US 275 to US 59	Rural	Mills	41.03215	-95.513747	15	1	$ 75,000.00
9	IA 4	IA 3 to US 18	Rural	Pocahontas	42.79895	-94.678264	15	1	$ 75,000.00
117	IA 37	US 30 to IA 175	Rural	Monona	42.009133	-95.828869	15	1	$ 75,000.00
231	IA 2	US 59 to US 71	Rural	Page	40.741961	-95.310172	15	1	$ 75,000.00
166	US 71	I-80 to US 30	Rural	Audubon	41.77205	-94.937381	15	1	$ 75,000.00
32	US 218	US 18 to MN border	Rural	Mitchell	43.302719	-92.810078	15	1	$ 75,000.00
35	IA 13	IA 3 to US 52	Rural	Clayton	42.924469	-91.344761	15	1	$ 75,000.00
Trouble Spot Locations							5	10	$ 750,000.00
								Total	$ 1,500,000.00

WIM

WIM Cost

Corridor ID	Route	Corridor	Urban/Rural	Counties	Latitude	Longitude	Upgrade	# of Devices	Cost
359	US 30	US 218 to IA 922	Rural	Benton	41.963125	-92.000981	N	1	$ 250,000
242	IA 330	US 65 to US 30	Rural	Marshall	41.975308	-93.068972	N	1	$ 250,000
369	I-80	US 59 to US 6/US 71	Rural	Pottawattamie	41.496633	-95.261047	N	1	$ 250,000
273	I-80	US 6/US 71 to US 169	Rural	Adair	41.493872	-94.453486	N	1	$ 250,000
365	I-35	US 18 to MN border	Rural	Worth	43.403189	-93.348356	N	1	$ 250,000
264	I-29	IA 175 to US 20/I-129	Rural	Woodbury	42.288775	-96.283672	N	1	$ 250,000
265	I-29/I-680	IA 192 to I-680	Rural	Pottawattamie	41.419472	-95.902583	N	1	$ 250,000
221	US 20	US 71 to US 169	Rural	Sac	42.469461	-95.105686	N	1	$ 250,000
436	US 61	IA 38 to I-280	Rural	Muscatine	41.518694	-90.885958	N	1	$ 250,000
454	US 30	NE border to I-29	Rural	Harrison	41.551211	-96.013622	N	1	$ 250,000
361	US 61	US 218 to IA 2	Rural	Lee	40.602733	-91.423583	N	1	$ 250,000
259	IA 141	US 169 to I-35/80	Rural	Dallas	41.798267	-93.892564	N	1	$ 250,000
206	US 52	IA 3/IA 136 to US 18	Rural	Clayton	42.821461	-91.153089	Y	1	$ 100,000
345	US 20	IA 136 to IA 32	Rural	Dubuque	42.440528	-90.970364	Y	1	$ 100,000
321	IA 60	US 18 to MN border	Rural	Osceola	43.402244	-95.718014	Y	1	$ 100,000
219	US 20	US 75 to 3.5 mi E of IA 140	Rural	Woodbury	42.475236	-96.278414	Y	1	$ 100,000
								Total	**$ 3,400,000**

DMS

DMS ID	Route	Type	Area	Condition	Remove / Add / Upgrade	DMS New OH (Color - 4-lane) $190,000	DMS New OH (Color - 3-lane) $120,000	DMS New OH (Amber) $55,000	DMS New SM (Amber) $45,000	DMS Install OH $195,000	DMS Install SM $80,000	DMS Remove OH $50,000	DMS Remove SM $20,000	Score	Direction	# of Lanes	Latitude	Longitude	Cost
9	US 30	OH	Cedar Rapids	Existing	Remove							1		11	WB	-	41.92995	-91.67154	$ 50,000.00
30	I-35	OH	Ames	Existing	Remove							1		25	NB	-	41.94958	-93.56948	$ 50,000.00
212	I-35/80	SM	Des Moines	Existing	Upgrade		1			1			1	94	SB	3	41.64107	-93.777155	$ 335,000.00
217	I-35/80	SM	Des Moines	Existing	Remove								1	43	EB	-	41.650262	-93.591319	$ 20,000.00
304	US 75	SM	Sioux City	Existing	Remove								1	22	SB	-	42.561492	-96.33232	$ 20,000.00
305	US 75	SM	Sioux City	Existing	Remove								1	14	NB	-	42.561025	-96.332259	$ 20,000.00
408	US 61	SM	Quad Cities (IA)	Existing	Remove								1	17	NB	-	41.640019	-90.567881	$ 20,000.00
655	I-35/80	SM	Des Moines	Existing	Upgrade	1				1			1	93	WB	3	41.65137	-93.67886	$ 405,000.00
659	I-80	SM	Statewide (Rural)	Existing	Remove								1	22	EB	-	41.533731	-94.037674	$ 20,000.00
Prop 1	I-35	OH	Ames	Proposed	Add		1			1				36	SB	2	41.984286	-93.570563	$ 315,000.00
Prop 9	I-29	OH	Council Bluffs	Proposed	Add		1			1				60	NB	3	41.248824	-95.906599	$ 315,000.00
Prop 18	I-35/80	OH	Des Moines	Proposed	Add		1			1				81	EB	3	41.649233	-93.629498	$ 315,000.00
Prop 19	I-35/80	OH	Des Moines	Proposed	Add	1				1				95	NB	4	41.619819	-93.776608	$ 385,000.00
Prop 20	I-35/80	OH	Des Moines	Proposed	Add		1			1				71	EB	3	41.652544	-93.719351	$ 315,000.00
Prop 21	US 65	OH	Des Moines	Proposed	Add		1			1				59	NB	2	41.638558	-93.506456	$ 315,000.00
Prop 59	I-35/80	OH	Des Moines	Proposed	Add		1			1				93	WB	3	41.592049	-93.771437	$ 315,000.00
Prop 64	I-380	OH	Cedar Rapids	Proposed	Add		1			1				64	SB	3	41.8552667	-91.668611	$ 315,000.00
					Total	2	8			10		2	7						$ 3,530,000.00

VWS

VWS Cost

Corridor ID	Route	Corridor	Urban/Rural	Counties	Latitude	Longitude	Being Constructed	# of Devices	Cost
280	I-35	IA 160 to US 30	Rural	Polk	41.830717	-93.571219	Y	1	$ -
409	I-80	IA 1 to US 6	Rural	Cedar	41.640558	-91.054458	N	1	$ 1,000,000
168	US 20	I-380 to IA 150	Rural	Buchanan	42.450197	-91.994794	N	1	$ 1,000,000
171	US 75/IA 60	US 20 to IA 60	Rural	Plymouth	42.787294	-96.206525	N	1	$ 1,000,000
217	US 30	2.4 mi W of IA 1 to US 61	Rural	Linn	41.918206	-91.371956	N	1	$ 1,000,000
226	US 18	US 52 to IA 76	Rural	Clayton	43.012025	-91.2424	N	1	$ 1,000,000
199	US 61	I-80 to US 30	Rural	Scott	41.739919	-90.568936	N	1	$ 1,000,000
283	US 151	IA 13 to US 61	Rural	Linn	42.050911	-91.472142	N	1	$ 1,000,000
477	US 63/IA 163	IA 14 to US 63	Rural	Mahaska	41.332878	-92.723206	N	1	$ 1,000,000
								Total	**$ 8,000,000**

FIBER

Fiber Cost / Segment

Corridor ID	Route	Corridor	Urban/Rural	Counties	Section Priority	Length (mi)	Fiber Needed (mi)	Cost (Only Iowa DOT Fiber)	Cost (Utilizing Partner Fiber)	Cost (Hybrid)
459	IA 461	US 67 to US 6	Urban	Scott	High	2.9	2.9	$ 290,000.00	$ 14,500.00	$ 101,500.00
334	US 61	US 20 to WI border	Urban	Dubuque	High	2.6	2.6	$ 260,000.00	$ 13,000.00	$ 91,000.00
219	US 20	US 75 to 3.5 mi E of IA 140	Rural	Woodbury	High	16.8	16.8	$ 1,680,000.00	$ 84,000.00	$ 588,000.00
220	US 20	3.5 mi E of IA 140 to US 59	Rural	Woodbury, Ida	High	23.4	23.4	$ 2,340,000.00	$ 117,000.00	$ 819,000.00
360	US 20	US 59 to US 71	Rural	Ida, Sac	High	19.1	19.1	$ 1,910,000.00	$ 95,500.00	$ 668,500.00
221	US 20	US 71 to US 169	Rural	Sac, Calhoun, Webster	High	51.6	51.6	$ 5,160,000.00	$ 258,000.00	$ 1,806,000.00
222	US 20	US 169 to I-35	Rural	Webster, Hamilton	High	33.1	33.1	$ 3,310,000.00	$ 165,500.00	$ 1,158,500.00
458	US 20	I-35 to US 65	Rural	Hamilton, Hardin	High	15.7	15.7	$ 1,570,000.00	$ 78,500.00	$ 549,500.00
223	US 20	US 65 to IA 14	Rural	Hardin, Grundy	High	27	27	$ 2,700,000.00	$ 135,000.00	$ 945,000.00
403	US 20	IA 14 to IA 27	Rural	Grundy, Black Hawk	High	16.7	16.7	$ 1,670,000.00	$ 83,500.00	$ 584,500.00
400	US 20	IA 27 to US 218	Urban	Black Hawk	High	7.2	7.2	$ 720,000.00	$ 36,000.00	$ 252,000.00
168	US 20	I-380 to IA 150	Rural	Black Hawk, Buchanan	High	16	16	$ 1,600,000.00	$ 80,000.00	$ 560,000.00
347	US 20	IA 150 to IA 13	Rural	Buchanan, Delaware	High	20.8	20.8	$ 2,080,000.00	$ 104,000.00	$ 728,000.00
346	US 20	IA 13 to IA 136	Rural	Delaware, Dubuque	High	18.9	18.9	$ 1,890,000.00	$ 94,500.00	$ 661,500.00
345	US 20	IA 136 to IA 32	Rural	Dubuque	High	21.1	21.1	$ 2,110,000.00	$ 105,500.00	$ 738,500.00
344	US 20	IA 32 to US 52/US 61	Urban	Dubuque	High	4	4	$ 400,000.00	$ 20,000.00	$ 140,000.00
185	US 67	I-80 to US 30	Rural	Scott, Clinton	High	21	21	$ 2,100,000.00	$ 105,000.00	$ 735,000.00
435	US 67	US 30 to Clinton N CL	Rural	Clinton	High	5.4	5.4	$ 540,000.00	$ 27,000.00	$ 189,000.00
62	US 67	Clinton N CL to US 52	Rural	Clinton, Jackson	High	12.1	12.1	$ 1,210,000.00	$ 60,500.00	$ 423,500.00
31	US 52	IA 64 to US 20	Rural	Jackson, Dubuque	High	40.5	40.5	$ 4,050,000.00	$ 202,500.00	$ 1,417,500.00
468	US 52	US 151 to US 20	Urban	Dubuque	High	5.2	5.2	$ 520,000.00	$ 26,000.00	$ 182,000.00
265	I-29	IA 192 to I-680	Rural	Pottawattamie	High	14.4	14.4	$ 1,440,000.00	$ 72,000.00	$ 504,000.00
438	I-29	US 30 to IA 175	Rural	Harrison, Monona	High	36.5	36.5	$ 3,650,000.00	$ 182,500.00	$ 1,277,500.00
264	I-29	IA 175 to US 20/I-129	Rural	Monona, Woodbury	High	36.5	33.25	$ 3,325,000.00	$ 166,250.00	$ 1,163,750.00
430	I-35	IA 5 to I-80/I-235	Urban	Polk	High	4.7	4.7	$ 470,000.00	$ 23,500.00	$ 164,500.00
278	I-35	US 30 to US 20	Rural	Story, Hamilton	High	30.7	30.7	$ 3,070,000.00	$ 153,500.00	$ 1,074,500.00
463	I-35/80	W mixmaster to US 6	Urban	Polk	High	2.1	2.1	$ 210,000.00	$ 10,500.00	$ 73,500.00
277	I-35/80	US 6 to IA 141	Urban	Polk	High	2.5	2.5	$ 250,000.00	$ 12,500.00	$ 87,500.00
407	I-35/80	IA 141 to IA 28	Urban	Polk	High	3.9	3.9	$ 390,000.00	$ 19,500.00	$ 136,500.00
462	I-35/80	IA 28 to IA 415	Urban	Polk	High	4	4	$ 400,000.00	$ 20,000.00	$ 140,000.00
406	I-35/80	IA 415 to E mixmaster	Urban	Polk	High	2	2	$ 200,000.00	$ 10,000.00	$ 70,000.00
275	I-74	IL border to I-80	Urban	Scott	High	5.2	2.8	$ 280,000.00	$ 14,000.00	$ 98,000.00
370	I-80	US 6 to US 59	Rural	Pottawattamie	High	31.5	12.27	$ 1,227,000.00	$ 61,350.00	$ 429,450.00
369	I-80	US 59 to US 6/US 71	Rural	Pottawattamie, Cass	High	20.9	20.9	$ 2,090,000.00	$ 104,500.00	$ 731,500.00
273	I-80	US 6/US 71 to US 169	Rural	Cass, Adair, Madison, Dallas	High	48.9	48.9	$ 4,890,000.00	$ 244,500.00	$ 1,711,500.00
371	I-80	US 169 to W mixmaster	Urban	Dallas, Polk	High	12.3	12.3	$ 1,230,000.00	$ 61,500.00	$ 430,500.00
409	I-80	IA 1 to US 6	Rural	Johnson, Cedar	High	24.6	24.6	$ 2,460,000.00	$ 123,000.00	$ 861,000.00
411	I-80	US 6 to I-280	Rural	Cedar, Scott	High	18.7	18.7	$ 1,870,000.00	$ 93,500.00	$ 654,500.00
271	I-80	I-280 to I-74	Urban	Scott	High	7.8	7.8	$ 780,000.00	$ 39,000.00	$ 273,000.00
410	I-80	I-74 to IL border	Urban	Scott	High	8.9	8.9	$ 890,000.00	$ 44,500.00	$ 311,500.00
394	I-235	W mixmaster to IA 28	Urban	Polk	High	5.1	5.1	$ 510,000.00	$ 25,500.00	$ 178,500.00
281	I-235	US 69 to E mixmaster	Urban	Polk	High	4.4	4.4	$ 440,000.00	$ 22,000.00	$ 154,000.00
439	I-380	IA 100 to IA 150	Rural	Linn, Benton	High	19.6	14.64	$ 1,464,000.00	$ 73,200.00	$ 512,400.00
269	I-380	IA 150 to US 20	Rural	Benton, Buchanan, Black Hawk	High	22.1	22.1	$ 2,210,000.00	$ 110,500.00	$ 773,500.00
440	I-380	US 20 to end of route	Urban	Black Hawk	High	7.3	5.66	$ 566,000.00	$ 28,300.00	$ 198,100.00
330	I-680	NE border to I-29	Rural	Pottawattamie	High	3.3	3.3	$ 330,000.00	$ 16,500.00	$ 115,500.00
379	IA 27	US 20 to US 218	Urban	Black Hawk	Low	5.8	5.8	$ 580,000.00	$ 29,000.00	$ 203,000.00
399	IA 58	US 63 to US 20	Urban	Black Hawk	Low	5.4	5.4	$ 540,000.00	$ 27,000.00	$ 189,000.00
417	US 65	IA 163 to I-80	Urban	Polk	Low	5	5	$ 500,000.00	$ 25,000.00	$ 175,000.00
388	IA 415	IA 160 to I-35/80	Urban	Polk	Low	3.6	3.6	$ 360,000.00	$ 18,000.00	$ 126,000.00
259	IA 141	US 169 to I-35/80	Rural	Dallas, Polk	Low	22.4	4.62	$ 462,000.00	$ 23,100.00	$ 161,700.00
447	US 30	IA 922 to I-380	Urban	Linn	Low	4.1	4.1	$ 410,000.00	$ 20,500.00	$ 143,500.00
419	I-29	MO border to IA 2	Rural	Fremont	Low	10	10	$ 1,000,000.00	$ 50,000.00	$ 350,000.00
420	I-29	IA 2 to US 34	Rural	Fremont, Mills	Low	25.8	25.8	$ 2,580,000.00	$ 129,000.00	$ 903,000.00
266	I-29	US 34 to I-80	Rural	Mills, Pottawattamie	Low	14	14	$ 1,400,000.00	$ 70,000.00	$ 490,000.00
276	I-35	MO border to US 34	Rural	Decatur, Clarke	Low	32.9	32.9	$ 3,290,000.00	$ 164,500.00	$ 1,151,500.00
405	I-35	US 34 to IA 92	Rural	Clarke, Warren	Low	23.6	23.6	$ 2,360,000.00	$ 118,000.00	$ 826,000.00
429	I-35	IA 92 to IA 5	Rural	Warren, Polk	Low	12	12	$ 1,200,000.00	$ 60,000.00	$ 420,000.00
358	I-35	US 20 to IA 3	Rural	Hamilton, Wright, Franklin	Low	23.5	23.5	$ 2,350,000.00	$ 117,500.00	$ 822,500.00
279	I-35	IA 3 to US 18	Rural	Franklin, Cerro Gordo	Low	28.3	28.3	$ 2,830,000.00	$ 141,500.00	$ 990,500.00
365	I-35	US 18 to MN border	Rural	Cerro Gordo, Worth	Low	24.6	24.6	$ 2,460,000.00	$ 123,000.00	$ 861,000.00
414	I-280	IL border to US 61/IA 146	Urban	Scott	Low	3.2	3.2	$ 320,000.00	$ 16,000.00	$ 112,000.00
262	I-280	US 61/IA 146 to I-80	Urban	Scott	Low	6.9	6.9	$ 690,000.00	$ 34,500.00	$ 241,500.00
274	I-680	I-29 to I-80	Rural	Pottawattamie	Low	17	17	$ 1,700,000.00	$ 85,000.00	$ 595,000.00
					Total	1027	978	$ 97,784,000.00	$ 4,889,200.00	$ 34,224,400