GENESEE TRANSPORTATION COUNCIL

The Metropolitan Planning Organization for the Genesee-Finger Lakes Region

I-490 Integrated Corridor Management Plan

Final Report

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Bergmann Associates
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EXECUTIVE SUMMARY

I-490 is one of greater Rochester's key transportation corridors. It links the City of Rochester with its eastern and western suburbs and provides access to I-90 (New York State Thruway), the state's primary east-west corridor. During the past 20 years, the New York State Department of Transportation (NYSDOT) has deployed Intelligent Transportation Systems (ITS) instrumentation along the I-490 corridor in an effort to increase travel safety, efficiency, and reliability. ITS deployments currently in use include traffic cameras, Dynamic Message Signs (DMS), vehicle detection sensors, Road Weather Information Systems (RWIS) and their associated power and communications infrastructure. Monroe County Department of Transportation (MCDOT) has deployed computerized traffic signals and traffic cameras to better manage traffic operations at expressway intersections within the City of Rochester. These deployments are managed from the Regional Traffic Operations Center (RTOC) on Scottsville Road.

However, ITS deployments along this corridor have been traditionally planned on a piecemeal basis, as funding becomes available and in response to specific needs. There has not been a systematic ITS planning exercise conducted for the entire corridor to identify the optimal future locations of ITS deployments and their power and communications linkages or to ensure that existing ITS capabilities for traffic monitoring and management are maintained. In addition, there is a need to better link ITS capabilities with transportation system management strategies such as Traffic Incident Management (TIM).

The purpose of this overall project is to develop an Integrated Corridor Management (ICM) Plan for the entire (37-mile) I-490 corridor that will guide future investments in ITS and operations strategies aimed at improving safety, minimizing delay, and enhancing the overall efficiency of traffic operations in the corridor for all modes of transportation.

What is Integrated Corridor Management

ICM is a transportation planning approach that seeks to coordinate multi-modal operations along a corridor to maximize travel safety, efficiency, and reliability. The vision of ICM is that transportation networks will realize significant improvements in the efficient movement of people and goods through institutional collaboration and aggressive, proactive integration of existing infrastructure along major corridors. Through an ICM approach, corridors are managed as a multimodal system and make operational decisions for the benefit of the corridor as a whole.

Stakeholders

This multi-modal, multi-user imitative requires coordination of many stakeholders. In addition to the users (motoring public) of the corridor, there are other stakeholders along the corridor and in the metropolitan area that operate, manage, and maintain the network. Each has a role in successful ICM. The operational stakeholders include:

- NYSDOT — Owns and maintains I-490, many state arterials that parallel I-490 and Park-n-Ride facilities along I-490. They also operate the freeway Advanced Traffic Management System (NYSDOT ATMS) housed at the Regional Traffic Operations Center (RTOC), and the traffic signal network on the state arterials.
- New York State Thruway Authority (NYSTA) – Owns and maintains I-90, the New York State Thruway (Thruway). They also operate the Thruway ATMS.

- MCDOT — Owns and maintains traffic signals along county arterials and City streets that parallel I-490. They also operate many of the NYSDOT interchange signals and others along NYSDOT arterials. A complete list of the NYSDOT signals operated by MCDOT can be found in the Appendix. Their arterial traffic signal system is operated from the RTOC.
- Regional Transit Service (RTS) — Owns and operates regional local and express bus services
- New York State Police (NYSP) — Enforcement, security, and crash investigations on I-490.
- Monroe County Sheriff — Enforcement, security, and crash investigations on I-490 and Monroe County arterials.
- City of Rochester — Owns and maintains City arterials that parallel I-490.
- Fire Departments — Nine Fire Departments have territorial responsibility for responding to incidents and crashes on I-490 and the parallel arterials, including (from east to west):
    - Fishers Fire Department
    - Pittsford Fire Department
    - Rochester City Fire Department
    - Chili Fire Department
    - Bergen Fire Department
    - Bushnell's Basin Fire Department
    - Brighton Fire Department
    - Gates Fire Department
    - Riga Fire Department

Current Traffic Management Program

The traffic management program on I-490 is a coordinated effort of NYSDOT, MCDOT and RTS. Its mission is to improve mobility and safety for the users of the Rochester area's highways through the application of ITS technology and interagency teamwork. The program is not delivered by transportation agencies only, but in conjunction with the NYSP, the Monroe County Sheriff's Department and City and local fire departments.

Traffic management is accomplished by focusing on mitigation of non-recurring congestion that occurs due to events such as crashes, breakdowns, construction, weather, etc. According to the Federal Highway Administration (FHWA), non-recurring congestion is the cause of about 50 percent of highway congestion. Recurring congestion – generally caused by high volumes on highways with limited capacity – accounts for the other fifty percent.

At the heart of the area's traffic management program is the RTOC, which houses the central computing system that monitors the state highways in real-time, including I-490, and monitors and controls the ITS devices including detectors, closed circuit television cameras (CCTV), dynamic message signs (DMS), and road weather information systems (RWIS), and the state and county traffic signal systems. The RTOC's current functionality includes incident detection and management.

ITS Infrastructure

Current ITS infrastructure along the I-490 corridor include CCTV Cameras, DMS, System Sensors, limited RWIS devices and Portable VMS and Fiber Optic Cable. The primary locations of these devices are between NY-531 on the west side of the County and Penfield Rd on the east side of the County. Fiber optic cable and some wireless devices are installed to provide the backbone for communication along the corridor.

All of the installed devices transmit data back to the RTOC, where operators review and determine actions to be taken. Co-located at the RTOC are NYSDOT, MCDOT and the NYS Police. During incidents on I-490 the agencies work to manage traffic flow and determine the appropriate actions to be taken

Currently traffic signals along the diversion routes in the City of Rochester are maintained by MCDOT are coordinated and can be monitored and controlled by operators in the RTOC. Along with the traffic signals, MCDOT has several cameras to monitor traffic flow.

RTOC Operations

The RTOC's main operations floor is split evenly between NYSDOT and Monroe County traffic operations staff. New York State Police Troop "E" also maintains operations at the facility. However, NYSP is located in a secured set of rooms located apart from both the NYSDOT and MCDOT traffic operations staff.

The RTOC, and specifically NYSDOT's and MCDOT's operational capabilities, have a sound foundation for ICM, but several gaps and needs still exist to improve the program's core services – traffic and incident management – and ultimately provide an ICM program.

Both NYSDOT and MCDOT reported that they are currently lacking in processes to measure the performance of the transportation system and the efforts of the RTOC to manage it. The RTOC leadership has a strong vision and direction about the types of Key Performance Indicators that should be developed, and the specific performance areas to be measured. NYSDOT has identified expressway and arterial measures that would be desirable. These measures include:

• Monitoring and Managing Traffic	• Monitoring and Managing Incidents
• Monitoring and Managing Work Zones	• Monitoring and Managing Weather Data
• Monitoring and Managing.	

MCDOT's key areas of pursuit for measuring performance includes:

• Traffic signal timing overrides	• Performance of all traffic signal timing plans
• The number of highway light repairs, caller complaints, follow ups, etc. for each highway lighting location	• The number of signal repairs, timings adjustments, caller complaints, follow ups, etc. for each traffic signal.
• The number of stakeout tickets that are cleared, the number of tickets that crews mark out, and the number of emergency stake outs.	• Number of times each camera is called up on a display and/or moved and correlate that information to a crash and/or viewing the operations of traffic flow or response to a crash.
• The number of fire pre-emptions at each traffic signal	

RTOC TSMO Capability/Maturity Assessment

As part of the RTOC observation process related to ICM, an assessment of ICM capabilities was conducted. Through a series of interviews with NYSDOT and MCDOT staff and observations at the RTOC, a high-level assessment of the RTOC's current capabilities (maturity) to manage a future ICM project on the I-490 corridor was conducted. The capability maturity model assessment graded key attributes of integration to maturity levels including being siloed, centralized, partially integrated, multi-modal integrated, or multi-modal optimized. The key attributed examined include:

- Institutional Integration - interagency cooperation was assessed to be between being siloed and centralized, and funding to be partially integrated.
- Technical Integration - traveler information was assessed to be between centralized and partially integrated, and data fusion was assessed as siloed.
- Operational Integration - performance measures and decision support systems were both assessed as siloed.

Highway Infrastructure

While much of the ICM operational and ITS strategies available to the I-490 corridor are electronic and technological, highway infrastructure must be able to support some of the operational strategies.

One possible operational strategy, ramp metering, requires adequate storage along the on-ramps to store queuing traffic. There also must be adequate width on the ramp for emergency vehicles to bypass queued traffic when responding to a crash or other incident. In some cases, these two needs clash like when the full ramp width is necessary for queueing traffic (using multiple lanes rather than a single lane).

Comparative Metropolitan Areas

Planning for a possible I-490 ICM project can benefit from examining other existing ICM programs to capitalize on existing practices and lessons learned. By understanding the process other metropolitan areas took in developing their ICM program, the I-490 team can identify what is crucial to the development process early on and what ICM strategies should be considered. Comparable metropolitan areas were selected based on their similarities to Rochester, NY in the areas of population size, metropolitan area size, traffic characteristics of ICM corridor, current status of the ICM program. Buffalo, NY and Des Moines, IA were chosen due to the similarities in population and metropolitan areas.

Gaps and Needs

Based upon the Regional Traffic Operations Center (RTOC) observation, individual staff and management interviews, and the capability maturity model assessment in Task 3, a series of high-level gaps and needs were identified for future assessment of integrated corridor management.

Gaps

The gaps identified exist in the following areas:

- Coordinated inter-agency Traffic Incident Management (TIM) planning
- Automated travel time information
- Real-time weather and road surface/subsurface condition information

- Smart traffic signal system on the New York State Department of Transportation (NYSDOT) network
- Real-time traffic condition information from NYSDOT and Monroe County Department of Transportation (MCDOT) arterial network
- Real-time information on I-490 traffic conditions for diversion
- En-route traveler information
- Coordination and integration between Advanced Traffic Management System (ATMS) and arterial traffic signal systems
- Coordination and integration of personal vehicle motorists and bus transit

Needs

To achieve an integrated corridor, some or all of the following needs must be met:

- Formalized and regularly scheduled Traffic Incident Management (TIM) meetings
- TIM and on-scene State-of-the-Practice (SOTP) assessment and training
- Assessment of the implementation of a quick clearance policy
- Increased standardization/centralization of hardware/software systems to improve operational efficiency and reduce redundant effort
- Synchronization of signal plans between MCDOT and NYSDOT
- Event-based signal timing plans.
- Formalized process for Standard Operations Procedures (SOP) review and updates.
- Interconnection with, and real-time information from, NYSDOT and MCDOT signal systems
- Additional detector sensors and Closed-Circuit Television (CCTV) cameras for better situational awareness
- Additional Dynamic Message Signs (DMS) at strategic diversion locations along I-490 as well an intermittent location for travel time information display
- Additional Roadway Weather Information System (RWIS) stations for proactive weather response
- Communication to motorists on the availability of transit status

ICM Strategies

A number of operational strategies are available to support ICM. Some of these strategies are in place presently, but may need modification or expansion, while other strategies will need to be explored for viability along the I-490 Corridor. Operational strategies identified as feasible for deployment include:

- <u>Advanced Traveler Information Systems</u> (ATIS) – ATIS acquires, analyzes, and presents information to assist travelers in moving from a starting location (origin) to their desired destination. An ATIS operates by using data supplied by the traffic management centers. Relevant information may include locations of incidents, weather and road conditions, optimal routes, recommended speeds, and lane restrictions.
- <u>Closed-Circuit Television (CCTV) Monitoring</u> – CCTV systems have been used for many years to provide visual monitoring of I-490. The RTOC uses CCTV systems for detecting and verifying

incidents, monitoring traffic conditions, monitoring incident clearance, and monitoring environmental conditions (e.g., visibility distance, wet pavement).

- Intelligent Traffic Signal Control – Intelligent Traffic Signal Control are systems that collect and use data to provide real-time management and control of the traffic signals on arterials as well as isolated signals (like diamond interchange ramps). Intelligent traffic signal control will automatically detect and respond to ramp congestion impacts on the local arterial roads or increase volume throughput as a result of traffic being diverted from I-490 resulting from a crash or other incident
- Modal Integration – ICM is founded on balancing the traveler demand across expressway, arterial and transit. When both recurring and non-recurring congestion occurs, there is value in reducing the number of vehicles on the expressway or arterial by switching travelers to transit. This is done by providing real-time information on transit options and providing a hub for motorists to change to transit.
- Vehicle Detection – In a traffic management system, the data collected from the detection sensors or third-party providers, (e.g., HERE, etc.) supports the process in which data characterize traffic flow conditions on the expressway or arterial. The data are used to supply information about conditions on the roadway to other system components. Thus, detection provides the information needed to perform critical traffic management functions.
- Ramp Metering – Ramp Meters are traffic signals at expressway on-ramps that control the rate of vehicles entering the expressway. The meters can be set for different flow rates to optimize traffic flow and minimize congestion. When in operation, ramp meters will alternate between red and green lights, restricting the number of vehicles entering I-490, thereby reducing congestion, bottlenecks and managing the traffic flow on the mainline.
- Queue Warning – Queue Warning's purpose is to inform motorists of the presence of downstream stop and-go traffic (based on real-time traffic detection) using warning signs and in some cases, flashing lights. Drivers can anticipate an upcoming situation of emergency braking and slow down, avoid erratic behavior, and reduce queuing related crashes.
- Weather Monitoring – Road weather management strategies can be used to mitigate the impacts of rain, snow, ice, fog, high winds, flooding, tornadoes, hurricanes, and avalanches on the highway network:
- System Integration & Decision Support – When congested traffic conditions occur on one roadway, traffic on adjoining expressway interchanges in the corridor, are also impacted. Typically, as congestion occurs on one roadway, travelers respond in a variety of ways: finding an alternate route, selecting a different roadway (expressway versus arterial), adjusting their trip to another time of day, or remaining on their current route and enduring the significant delays.
- Field Communications – ICM relies on a significant amount of ITS field infrastructure resources such as CCTV cameras, detection sensors, DMS, etc. It is critical that there be enough connectivity to support the devices across the geographic area to be covered.

Other strategies that were studied, but found not to be feasible, include variable speeds limits, dynamic junction control, dynamic lane assignment, and dynamic shoulder lanes.

Recommendations

Specific recommendations that address the needs and meet the goals of ICM and the objectives of this project are categorized by priority based of need. They are fiscally-unconstrained and are a menu of recommendations that should be considered and assessed further for program- or project-level implementation. The priority categories are meant to rate a recommendation's importance to ICM, not imply the order of deployment. As traditional transportation planning dictates, these recommendations will be assessed in more detail to determine what recommendations are implemented. The priority categories are:

High Priority (H): These strategic recommendations are necessary, and the goal of having an ICM program to support operations cannot be achieved without them. These are must dos.

Medium Priority (M): These elements bring significant improvement to integrating the corridor to support operations and are strongly desired. The goal of having an integrated corridor management program to support operations and attain compliance with priority result areas can still reached without these elements; however, they bring significant improvement to the program.

Low Priority (L): These elements bring some benefit to integrated corridor management but are not highly desired because they either bring little benefit or are not financially feasible.

To display the ITS infrastructure required to implement ICM strategies, I-490 was divided into twelve sections, and a map was prepared for each section that shows the approximate location of current and anticipated future ITS elements. These maps are shown on Figures 15-26, inclusive of the main report. The arterial (parallel routes) recommendations are illustrated on Figures 27-29, Inclusive. These maps are intended to be a concept-level guide to the future siting of ITS infrastructure along I-490 and parallel routes.

Operations and Policy recommendations address:

- Coordinated Traffic and Incident Management Practices
- Improved Incident Management Response
- Data Quality and Management

Asset Management recommendations address:

- Asset Management Plan that includes:
    - A schedule of preventative maintenance and inspection of all ITS equipment
    - A timeline that prioritizes the replacement of aging / obsolete and legacy equipment so that new equipment can be incorporated into upcoming contracts
- Coordinated Maintenance Policy
- Asset Maintenance Best Practices

This assessment identified updates to the Genesee-Finger Lakes Regional ITS Architecture, which are needed to address:

- The strategies identified for deployment as part of the I-490 ICM project, and
- Changes to ARC-IT from the last update.

In addition to the prioritized recommendations, other strategies and deployments that could provide benefit to ICM, but not in the foreseeable future, are recommended for future study Those include:

- Transit Signal Priority (see section 4.1.8)
- Bus Rapid Transit (see section 4.1.9)
- Modal Integration (see section 4.1.10)
- Staffing: As recommendations are implemented and ICM evolves, it would be prudent to perform a task analysis to examine the need for additional NYSDOT or MCDOT professional staff as well as examining skill sets for current and future staff. For instance, a need for a data scientist may develop as more, and different types of, data are collected and used to measure performance and manage proactively.

Summary and Next Steps

Much discussion in this report centers around the disparate systems that are in operation from the RTOC. On their own, these systems, namely Foundation III (the expressway advanced traffic management system) and MCDOT's traffic signal system (TransSuite), are sound systems that provide the service that was intended. However, ICM and traffic and incident management dictate that these systems – and the NYSDOT traffic signal systems – be integrated together to achieve ICM, and any further engineering analysis moving forward on bettering the traffic management service on the corridor focus on this effort.

Moving forward toward deployment from this report, the next step is to develop a project or set of projects to implement the ICM plan. Specific steps in developing a project or set of projects are needed to further develop what the system will do and how it will perform. Project development includes the systems engineering process, including developing the concept of the system, identifying system requirements, and the design process. A critical first step, which this report provides sufficient detail to inform, is the development of the Concept of Operations (ConOps).

A ConOps is a document that describes how a system will be used and identifies the fundamental needs of all stakeholders involved throughout the lifecycle of a system. It also considers different use cases or scenarios for how the system will operate. A ConOps is essential to success, as it serves as the repository of needs and helps ensure that all aspects of the system lifecycle from design, implementation, maintenance, and upgrades, support those needs. The ConOps allows for stakeholders to understand how the system is to be developed, maintained, and operated; it also identifies users and system capabilities in an easy-to-understand format.

1 INTRODUCTION

1.1 Purpose of the Document

The purpose of this report is to summarize and document existing conditions, identify gaps and needs in the traffic management program and recommend future deployments and next steps to implement an Integrated Corridor Management (ICM) program along the entire length of the I-490 corridor.

1.2 Document Organization

For quick reference, Table 1 provides a brief description of each chapter.

Table 1: Overview of Tech Memo Chapters

Chapter	Key Elements and Notes
1 – Introduction	Includes background and purpose of the report
2 – Problem Statement	Describes the necessity of the project, defines Integrated Corridor Management, and identifies the stakeholders.
3 – Current Situation	A summary of existing ITS Infrastructure and operating strategies and conditions
4 - ICM Strategies	Description of possible operational strategies and policies that may be used to secure integrated corridor management and achieve the project goals
5 -- Recommendations	Details and prioritizes the operational and infrastructure recommendations.
6 – Summary and Next Steps	Summarizes the recommendations and describes the next steps in the project study.

1.3 List of Abbreviations and Acronyms

Abbreviations and acronyms found within this report are listed below.

ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
BRT	Bus Rapid Transit
CCTV	Closed circuit Television
ConOps	Concept of Operations
CTCS	Computerized Traffic Control System

DJC	Dynamic Junction Control
DLA	Dynamic Lane Assignment
DMS	Dynamic Message Sign
DSL	Dynamic Shoulder Lane
DSS	Decision Support System
FHWA	Federal Highway Administration
GTC	Genesee Transportation Council
HAR	Highway Advisory Radio
H.E.L.P.	Highway Emergency Local Patrol
ICM	Integrated Corridor Management
ITS	Intelligent Transportation Systems
MCDOT	Monroe County Department of Transportation
MOU	Memoranda of Understanding
NYSDOT	New York State Department of Transportation
NYSP	New York State Police
NYSTA	New York State Thruway Authority
PVMS	Portable Variable Message Sign
QW	Queue Warning
RGRTA	Rochester-Genesee Regional Transportation Authority
RM	Ramp Metering
RTOC	Regional Traffic Operations Center
RTS	Regional Transit Service
RWIS	Road Weather Information System
SOP	Standard Operating Procedures
TIM	Traffic Incident Management
TSMO	Transportation Systems Management and Operations

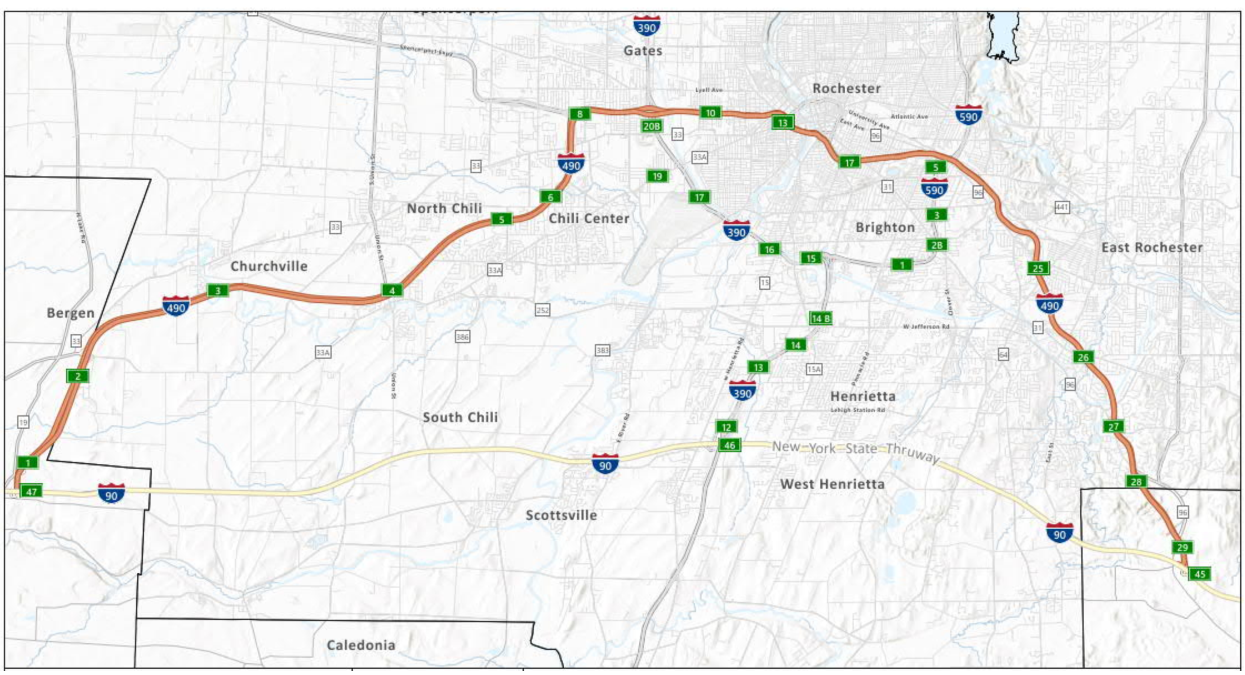
TSOC	Thruway Statewide Operations Center
TSP	Transit Signal Priority
VMS	Variable Message Sign
VSL	Variable Speed Limits

2 PROBLEM STATEMENT

I-490 is one of greater Rochester's key transportation corridors. It links the City of Rochester with its eastern and western suburbs and provides access to I-90 (New York State Thruway), the state's primary east-west corridor. During the past 20 years, the New York State Department of Transportation (NYSDOT) has deployed Intelligent Transportation Systems (ITS) instrumentation along the I-490 corridor in an effort to increase travel safety, efficiency, and reliability. ITS deployments currently in use include traffic cameras, Dynamic Message Signs (DMS), vehicle detection sensors, Road Weather Information Systems (RWIS) and their associated power and communications infrastructure. Monroe County Department of Transportation (MCDOT) has deployed computerized traffic signals and traffic cameras to better manage traffic operations at expressway intersections within the City of Rochester. These deployments are managed from the Regional Traffic Operations Center (RTOC) on Scottsville Road.

However, ITS deployments along this corridor have been traditionally planned on a piecemeal basis, as funding becomes available. There has not been a systematic ITS planning exercise conducted for the entire corridor to identify the optimal future locations of ITS deployments and their power and communications linkages or to ensure that existing ITS capabilities for traffic monitoring and management are maintained. In addition, there is a need to better link ITS capabilities with transportation system management strategies such as Traffic Incident Management (TIM).

Figure 1: I-490 Corridor



2.1 I-490 ICM Project

The purpose of this overall project is to develop an ICM Plan for the entire (37-mile) I-490 corridor that will guide future investments in Intelligent Transportation Systems (ITS) and operations strategies aimed at improving safety, minimizing delay, and enhancing the overall efficiency of traffic operations in the corridor for all modes of transportation.

2.1.1 What is ICM

ICM is a transportation planning approach that seeks to coordinate multi-modal operations along a corridor to maximize travel safety, efficiency, and reliability. The vision of ICM is that transportation networks will realize significant improvements in the efficient movement of people and goods through institutional collaboration and aggressive, proactive integration of existing infrastructure along major corridors. Through an ICM approach, corridors are managed as a multimodal system and make operational decisions for the benefit of the corridor as a whole.

2.1.2 I-490 ICM Vision

In 2018, Genesee Transportation Council (GTC) published a study that examined TSMO conditions and needs in the Rochester area. That project's steering committee defined a regional TSMO vison as follows:

> "Transportation System Management and Operations (TSMO) in the Rochester-Genesee region improves the efficiency, safety, and convenience of the multi-modal transportation system through the use of advanced transportation technologies, free flow of information and data, and partnerships among public agencies and other transportation service providers."

The vision of ICM on the corridor is consistent with the TSMO vison.

2.1.3 I-490 ICM Goals and Objectives

The operational goals of the I-490 ICM Project are:

- Mobility – Provide improvements that maximize vehicle throughput, minimize vehicle travel times, and create a more predictable commuter trip along I-490.
- Safety – Provide for a safer I-490 corridor by detecting, diagnosing, and responding to incidents faster, providing real-time information to motorists on congestion and queues, ultimately reducing (secondary) crashes.
- Traveler Experience - Improve travel time reliability for both people and freight on both freeways and arterials.

These goals will be achieved through the following objectives:

- Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools
- Achieve a cleaner environment by reducing emissions through the reduction of congestion
- Enhance planning and policy development through improved data quality and data analysis
- Enhance the quality of communications with the corridor's traveling public
- Enhance the ability of the organizations to deliver and manage services given limited organizational resources and improved coordination

2.2 Project Stakeholders

In addition to the users (motoring public) of the corridor, there are other stakeholders along the corridor and in the metropolitan area that operate, manage, and maintain the network. Each has a role in successful ICM. Each of these operators, managers and maintainers is addressed in this section.

- NYSDOT — Owns and maintains I-490, many state arterials that parallel I-490 and Park-n-Ride facilities along I-490. They also operate the freeway Advanced Traffic Management System (NYSDOT ATMS) housed at the Regional Traffic Operations Center (RTOC), and the traffic signal network on the state arterials.
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- Fire Departments– Nine Fire Departments have territorial responsibility of responding to incidents and crashes on I-490 and the parallel arterials, including:
    - Fishers Fire Department
    - Pittsford Fire Department
    - Rochester City Fire Department
    - Chili Fire Department
    - Bergen Fire Department
    - Bushnell's Basin Fire Department
    - Brighton Fire Department
    - Gates Fire Department
    - Riga Fire Department

3 CURRENT SITUATION

3.1 Existing Physical Conditions

I-490 and the arterial diversion corridors have unique physical and operational characteristics.

3.1.1 I-490

I-490 is a connecting Interstate Highway that serves the City of Rochester, New York. It acts as a northerly alternate route to the New York State Thruway (I-90), leaving it at exit 47 in the Town of Le Roy and rejoining the highway at exit 45 in the Town of Victor 37.40 miles (60.19 km) to the east. I-490 connects with I-390, New York State Route 390 (NY 390), and NY-531 on the western side of Rochester and I-590 and NY 590 on the east side of the city. The highway comprises the southernmost portion of the Inner Loop, around the interior of the City of Rochester. Outside of the city, I-490 serves several suburban villages and towns, such as Bergen, Churchville, Gates Brighton, Pittsford, Penfield, Perinton and Victor. Constructed in stages in the 1960's and 1970's, traffic volumes steadily increased as suburban growth continued. I-490 has varying physical and operational characteristics throughout its length. Similarly, the variances occur in both directions. It can, however, be broken into logical operating segments; segments that are similar in physical and operational characteristics.

Today, Average Annual Daily Traffic volumes are as shown in Table 2.

The geometry (number of lanes) varies from 2 to 4 along its length. Table 3 shows the number of lanes in various sections.

Table 2: 2019 Calculated AADT Along I-490 (Note: AADT shown is combined total of both directions and rounded to the nearest 100.)

I-490 Segment		2019 AADT
From	To	
Western Terminus (I-90 Exit 47)	Exit 1 (NY 19)	14,500
Exit 1 (NY 19)	Exit 2 (NY 33 / NY 33A)	14,500
Exit 2 (NY 33 / NY 33A)	Exit 3 (NY 36)	21,700
Exit 3 (NY 36)	Exit 4 (NY 259)	25,800
Exit 4 (NY 259)	Exit 5 (NY 386)	29,600
Exit 5 (NY 386)	Exit 6 (NY 204)	38,800
Exit 6 (NY 204)	Exit 7 (NY 33)	44,800
Exit 7 (NY 33)	Exit 8 (NY 531)	52,900
Exit 8 (NY 531)	Exit 9 (I-390 / NY 390)	106,400
Exit 9 (I-390 / NY 390)	Exit 10 (Mount Read Blvd)	102,800
Exit 10 (Mount Read Blvd)	Exit 11 (Ames St / Child St)	108,400
Exit 11 (Ames St / Child St)	Exit 12 (Broad St)	113,500
Exit 12 (Broad St)	Exit 13 (Inner Loop)	105,200
Exit 13 (Inner Loop)	Exit 14 (Broad St / Plymouth Ave)	80,600
Exit 14 (Broad St / Plymouth Ave)	Exit 16 (Clinton Ave)	92,200
Exit 16 (Clinton Ave)	Exit 17 (Goodman St / Broadway)	98,200
Exit 17 (Goodman St / Broadway)	Exit 18 (NY 31)	108,900
Exit 18 (NY 31)	Exit 19 (Culver Rd)	109,600
Exit 19 (Culver Rd)	Exit 21 (I-590 / NY 590)	117,100
Exit 21 (I-590 / NY 590)	Exit 22 (Penfield Rd)	128,800
Exit 22 (Penfield Rd)	Exit 23 (NY 441)	117,900
Exit 23 (NY 441)	Exit 24 (East Rochester)	94,600
Exit 24 (East Rochester)	Exit 25 (NY 31F)	70,100
Exit 25 (NY 31F)	Exit 26 (NY 31)	73,600
Exit 26 (NY 31)	Exit 27 (NY 96 - Bushnell's Basin)	60,900
Exit 27 (NY 96 - Bushnell's Basin)	Exit 28 (NY 96)	50,500
Exit 28 (NY 96)	Exit 29 (NY 96 - Victor)	43,500
Exit 29 (NY 96 - Victor)	Eastern Terminus (I-90 Exit 45)	37,900

Table 3: Number of Lanes by Segment on I-490

I-490 Segment		Number of Travel Lanes	
From	To	Eastbound	Westbound
Western Terminus (I-90 Exit 47)	Exit 6 (NY 204)	2	2
Exit 6 (NY 204)	Exit 7 (NY 33)	3	3
Exit 7 (NY 33)	Exit 8 (NY 531)	2	3
Exit 8 (NY 531)	Exit 9 (I-390 / NY 390)	3	3
Exit 9 (I-390 / NY 390)	Exit 10 (Mount Read Blvd)	4	4
Exit 10 (Mount Read Blvd)	Exit 11 (Ames St / Child St)	3	3
Exit 11 (Ames St / Child St)	Exit 12 (Broad St)	3	4
Exit 12 (Broad St)	Exit 19 (Culver Rd)	3	3
Exit 19 (Culver Rd)	Exit 20 (Winton Rd)	3	4
Exit 20 (Winton Rd)	Exit 21 (I-590 / NY 590)	3	4
Exit 21 (I-590 / NY 590)	Exit 22 (Penfield Rd)	4	3
Exit 22 (Penfield Rd)	Exit 25 (NY 31F)	3	3
Exit 25 (NY 31F)	Exit 27 (NY 96 - Bushnell's Basin)	2	2
Exit 27 (NY 96 - Bushnell's Basin)	Exit 29 (NY 96 - Victor)	3	3
Exit 29 (NY 96 - Victor)	Eastern Terminus (I-90 Exit 45)	2	2

3.1.1.1 Crash Data

Crash data obtained from the NYS ALIS system for the years 2015-2019 shows many crashes along the length of I-490. Table 4 lists the volumes by year along with the report crash severity, and road condition if wet or snow and ice.

Table 4: Crash Data Along I-490 (2015-2019)

Year	Total Crash Events	Crash Events with Roadway Surface Condition as WET	Crash Events with Roadway Surface Condition as SNOW/ICE or SLUSH	Crash Events at NIGHT (DARK ROADS)	Crash Events at DAWN/DUSK	Crash Event Severity FATAL	Crash Event Severity INJURY	Crash Event Severity PROPERTY DAMAGE ONLY
2015	1524	286	348	423	79	2	253	1269
2016	1434	240	189	354	73	4	255	1175
2017	1516	345	173	390	73	0	287	1229
2018	1580	381	240	394	84	1	270	1309
2019	1488	301	248	343	59	0	227	1261

The spatial plot of the crashes by year can be found in this report's Appendix.

3.1.2 Diversion Routes

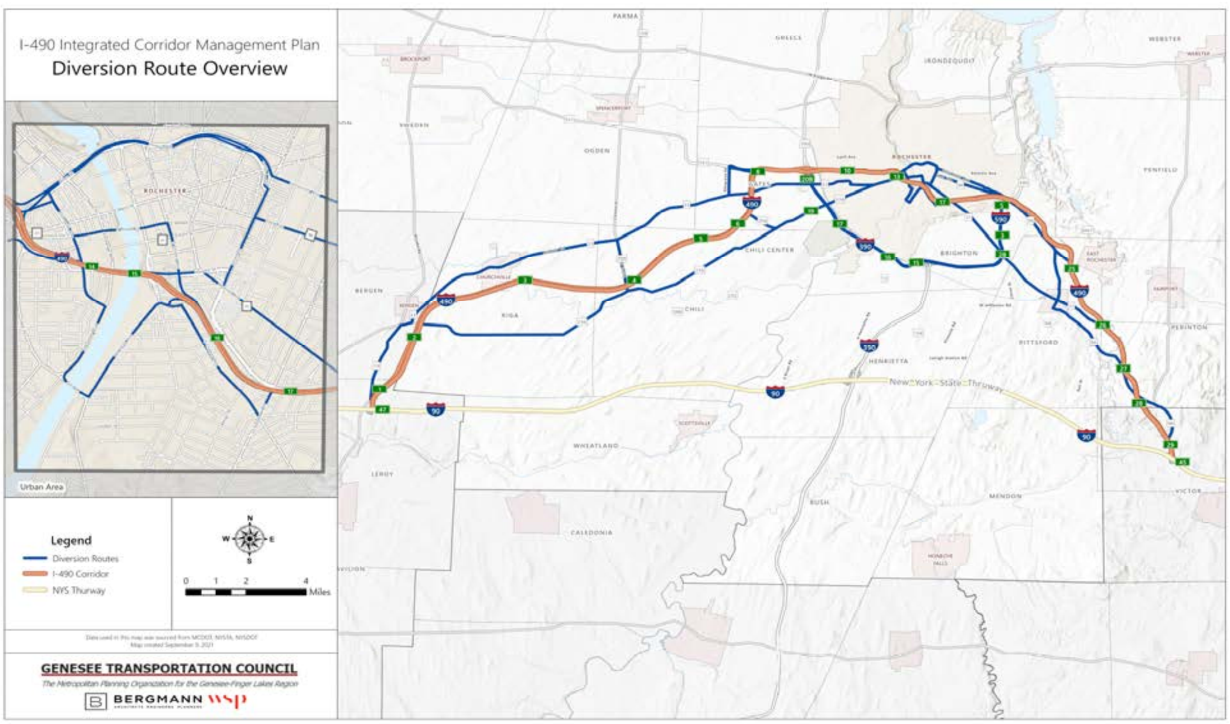
Diversion routes are a traffic management technique used to mitigate the impacts of road closures on traffic operations. A diversion route provides a designated path for traffic to follow in the event of a road closure. They begin at a specific point, typically at an interchange or intersection, on a certain road and end at another specific point on the same road. They allow traffic to bypass the road closure with minimum disruption to travel times. Diversion routes may be implemented in response to traffic incidents, nontraffic incidents, emergencies, planned special events, and road work activities. Diversion routes are one means of providing temporary relief to the traveling public, including freight carriers, from travel delays resulting from one or more of the aforementioned events. They help maintain reliable travel times and safeguard lives and property.[1]

As shown in Figure 2, several diversion routes are available along the I-490 corridor including:

- NY-33,
- NY-33A,
- NY-96,
- NY-31,
- University Ave., and
- I-390

In addition to these primary routes, other routes are identified that connect I-490 to the diversion routes.

Figure 2: I-490 Diversion Routes



[1] Genesee Transportation Council, Genesee-Finger Lakes Regional Diversion Route Plan. Genesee Transportation Council, 2015

3.1.3 Transit

Modal split on I-490 is primarily automobile and truck traffic. However, Park and Ride lots are located along the route and some provide express bus travel to the RTS Transit Center in downtown Rochester. The location of the Park and Ride lots along I-490 are listed below.

3.1.3.1 Fairport Park & Ride Lot

This lot is located on Route 31F (Fairport Road) at Interstate 490 in the Town of Pittsford, Monroe County. It has a total of 310 spaces. The lot is shared with St. John Fisher College. The lot has a bus stop, two shelters, security lighting, advanced traveler information, emergency blue light phone and a bicycle rack.

RTS connections available for this P&R lot are:

- Route 11 Monroe
- Route 91 Newark/Lyons Commuter
- Route 95 Eastview Commuter
- Route 96 St. John Fisher Express
- RTS On Demand service within Pittsford/Eastview Zone

3.1.3.2 Bushnell's Basin Park & Ride Lot

This lot is located on State Route 96 (Pittsford-Victor Road) in the hamlet of Bushnell's Basin, Monroe County. It has a total of 146 spaces. This lot is owned and maintained by NYSDOT and RTS currently operates a bus stop as a permissible use. The lot has a shelter, a public telephone and bicycle racks.

Along I-490, current service is provided to the RTS Transit center via RTS Route 84. Future service (Spring 2021) will utilize RTS On Demand within the Pittsford/Eastview Zone.

3.1.4 Non-Transit-Serviced Park and Ride Lots

The LeRoy Park & Ride Lot is located on NY-19 at I-490 in the Town of LeRoy, Genesee County. It has a total of 108 unrestricted and handicap spaces.

3.2 Traffic Management Program

The traffic management program is coordinated effort of NYSDOT, MCDOT and RTS. Its mission is to improve mobility and safety for the users of the Rochester area's highways through the application of ITS technology and interagency teamwork. The program is not delivered by transportation agencies only, but in conjunction with the New York State Police (NYSP), the Monroe County Sheriff's Department and City and local fire departments.

Traffic management is accomplished by focusing on mitigation of non-recurring congestion that occurs due to events such as crashes, breakdowns, construction, weather, etc. According to the FHWA, non-recurring congestion is the cause of about 50 percent of highway congestion. Recurring congestion – generally caused by high volumes on highways with limited capacity – accounts for the other fifty percent.

At the heart of the area's traffic management program is the RTOC, which houses the central computing system that monitors the state highways in real-time, including I-490, and monitors and controls the ITS devices including detectors, closed circuit television cameras (CCTV), dynamic message signs (DMS), and road weather information systems (RWIS), and the state and county traffic signal systems. The RTOC's current functionality includes incident detection and management.

3.2.1 ITS Infrastructure

The existing I-490 corridor ITS infrastructure currently is instrumented with Cameras, DMS, System Sensors, limited RWIS devices and Portable VMS and Fiber Optic Cable. The primary locations of these devices are between NY-531 on the west side of the County and Penfield Rd on the east side of the County. Fiber optic cable and some wireless devices are installed to provide the backbone for communication along the corridor.

All of the installed devices transmit data back to the RTOC located on Scottsville Rd. where operators review and determine actions to be taken. Co-located at the RTOC are NYSDOT, MCDOT and the NYS Police. During incidents on I-490 the agencies work to manage traffic flow and determine the appropriate actions to be taken

Currently traffic signals along the diversion routes in the City of Rochester are maintained by MCDOT are coordinated and can be monitored and controlled by operators in the RTOC. Along with the traffic signals MCDOT has a number of cameras to monitor traffic flow.

Specific location of all the currently installed ITS devices for the I-490 corridor can be found in the Appendix.

3.2.2 RTOC Operations

Figure 3: RTOC Video Wall

The RTOC is located at 1155 Scottsville Road in Rochester on the grounds of the Greater Rochester International Airport. The building is owned by Monroe County, and the county rents a portion of the space to the New York State Department of Transportation. The lease was executed in January 2002 and is scheduled to expire on December 31, 2036.

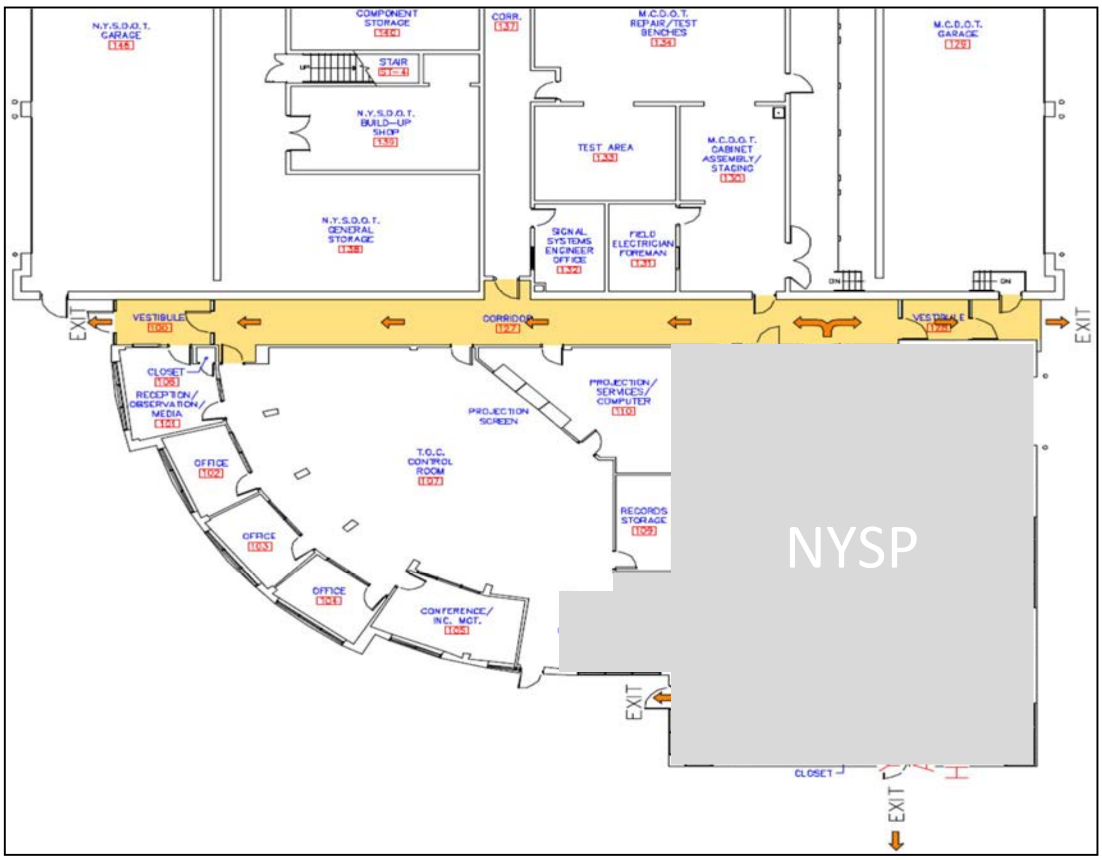
The main operations floor is split evenly between NYSDOT and Monroe County traffic operations staff. The video wall shown in Figure 3 is indicative of this "split", with rear-projection imagery of a NYSDOT map on the left showing the location of various ITS devices, while the map on the right shows real-time system information for the status of traffic signals in the region which are managed by MCDOT staff. Individual monitors are installed surrounding the main video wall and along adjacent walls for the purposes of monitoring live CCTV on area roadways.

New York State Police Troop "E" also maintains operations at the facility. However, NYSP is located in a secured set of rooms located apart from both the NYSDOT and MCDOT traffic operations staff. While there are accommodations for NYSP to view CCTV images from the main operations floor, any information exchange is handled by low-tech communications methods whereby a NYSP Trooper may either place a phone call to operations staff or walk to the main operations floor to obtain additional information about ongoing incidents.

A common theme that was noted during staff discussions is that the RTOC has "outgrown" the room, and many noted a desire for more space. A floor plan of the RTOC is illustrated in Figure 4.

The RTOC is staffed 24 hours per day, 365 days per year. The schedule is fashioned in a manner which promotes overlap and transfer of information from outgoing staff to incoming staff during shift transitions. This information includes events which occurred during the previous shift, ongoing incidents and activities including roadway maintenance, construction projects, and ITS equipment operational status.

Figure 4: NYSDOT MCDOT RTOC Floor Plan



3.2.1 NYSDOT RTOC Staff

Minimum NYSDOT RTOC floor operations staffing levels are shown in Table 5.

Operational staffing may be modified in response to major incidents and on an as-needed basis at the discretion of the TMC Operations Manager in conjunction with the NYSDOT TMC Manager.

Each shift is required to have a minimum of two employees capable of fully operating all TMC systems. If necessary, supervisory and management level staff will fill vacancies. However, every effort will be made to cover vacancies utilizing Operator I or Operator II level staff.

Systems Operators are supervised by a consultant operations manager, who is in direct communications with the NYSDOT TMC Manager. The NYSDOT TMC Manager is also supported by the NYSDOT ITS Systems Engineer, who also serves as the ITS Design Lead and is responsible for all elements of ITS including design and system testing (Field Acceptance and Stand-Alone).

Table 5: Minimum NYSDOT RTOC Floor Operations Staffing Levels

NYSDOT RTOC OPERATIONS STAFFING LEVELS			
Monday thru Friday			
Shift	Horus	Staff	
		Supervisors	Operators
A	6:00am to 2 :30pm	1	2
B	2:00pm to 10:30pm	1	2
C	10:00pm to 6:30am	0	2
Saturday and Sunday			
Shift	Hours	Staff	
		Supervisors	Operators
A	10:00pm to 10:30am	1 *	2
B	10:00am to 10:30pm	1 *	2

- During the weekend, a single Supervisor works from 6:00 Am to 6:00 PM

NYSDOT RTOC floor operations staff is primarily comprised of consultant operators with the following titles and job responsibilities[2]:

- Systems Operator Trainee/Systems Operator I:
  - ATMS Operations
  - Support TIM program
  - Coordinate NYSDOT responses on roadway concerns
  - Dispatch Maintenance crews for snow and ice operations
  - Maintain logs and records of roadway incidents, concerns, and incoming/outgoing communications
- Systems Operator II
  Systems Operator II personnel carry all responsibilities of System Operator I plus;
  - Possess strong familiarity with regional roadways and the location/purpose of all ITS assets

[2] Source: “TMC Titles and Tasks” document provided by Monroe County DOT

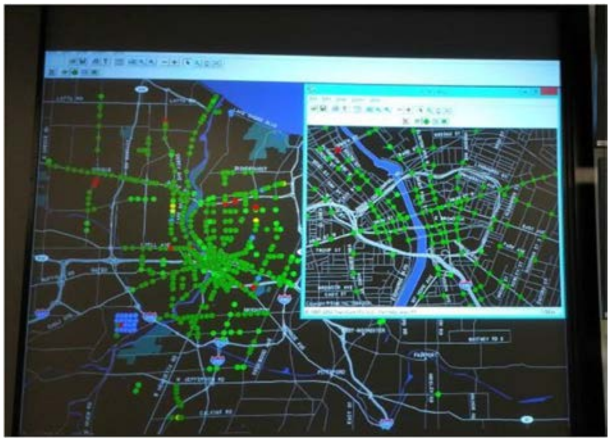
  - Possess a working knowledge of TMC policy and guidance
  - Participate in training of new System Operators
- Systems Operator III
  The Systems Operator III is a key position and serves as the acting manager on duty in the absence of the Operations Manager. A Systems Operator III is expected to have all of the skills and capabilities of an Operator II, and is also responsible for the following additional duties:
  - Assist Operations Manager with developing protocols and Standard Operating Guidelines
  - Ensure compliance with accepted guidelines and practices
  - Oversee the operations floor, and assume a leadership role over staff and activities
  - Provide QA/QC for all operational steps and ensure staff actions comply with expectations.

3.2.2 MCDOT RTOC Staff

Only a portion of MCDOT RTOC staff work on the main operations floor for the purpose of real-time transportation management. MCDOT has one Senior Traffic Control Operator, two Traffic Control Operators, and one Traffic Engineer which is a direct report to the Chief of Traffic Signal Engineering & Operations. The Traffic Engineer also helps with signal timing overrides and implementing other timing plans.

Additional county personnel work in other areas within the building adjacent to the RTOC operations floor and will come to the operations floor to discuss specific issues with the signal operators on duty.

Figure 5: Monroe County Signals Map (photo courtesy of Monroe County Operator User Manual)



Operators maintain constant situational awareness of signal operations at their individual workstations, and the system status map is also prominently displayed on the main video wall as shown in Figure 5.

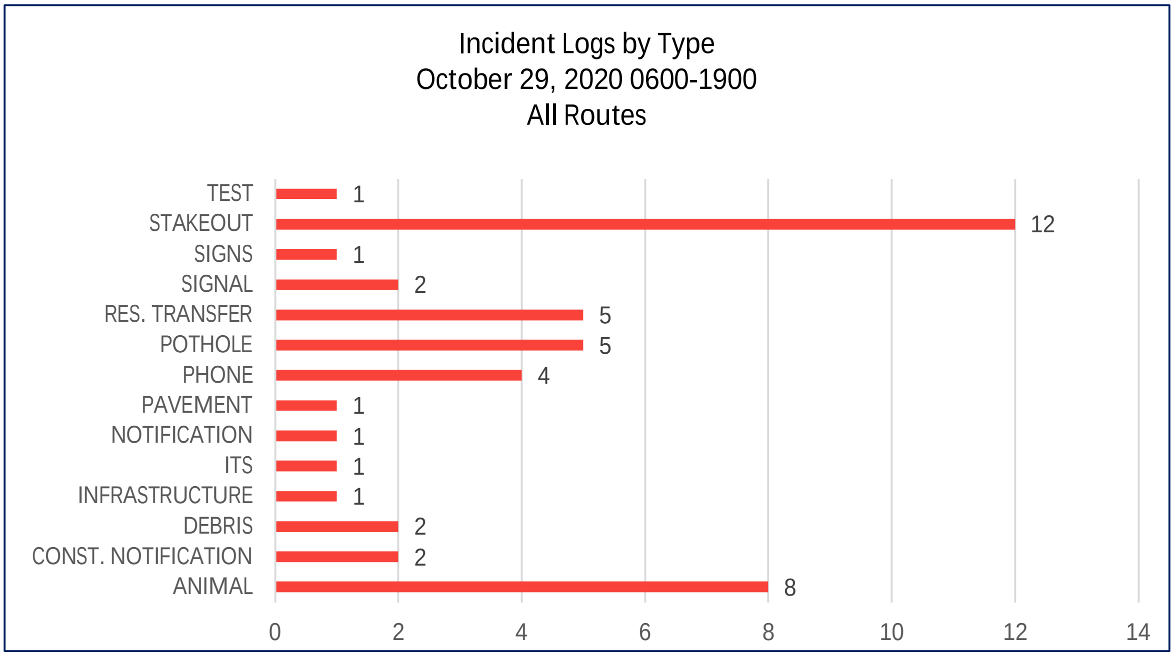
MCDOT dispatchers are at the RTOC Monday through Friday from 6 AM through 6 PM. Outside of these hours the phones are then rolled over to the NYSDOT. Overnight operators have no control over signal timing changes and serve primarily as an intermediary to route off-hours issues to the correct personnel at MCDOT. As shown previously in Table 2, NYSDOT Shift "A" operators begin work at 6:00am, at the start of morning peak traffic.

NYSDOT and MCDOT networks are hardwired and independent of one another. Most operator-to-operator or supervisor-to-operator communication on the main operations floor is conducted verbally in-person.

3.2.3 Daily Activity Levels

Activity level within the room during the observation period was generally minimal and sound levels were reasonable. It is important to note that this observation was conducted during the COVID-19 Pandemic when vehicular transportation was substantially less than normal. Figure 6 shows the total incidents logged by NYSDOT operators between 6:00am and 7:00pm on October 29th 2020.

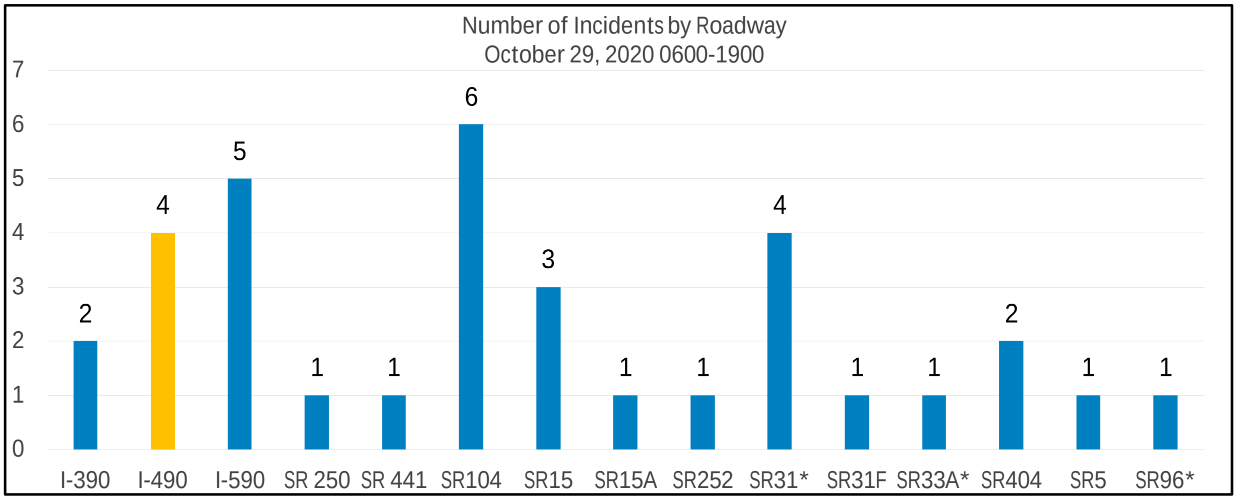
Figure 6: Observation Period Incident Chart



While most incident captions are self-explanatory, the term “Stakeout” may require additional definition since it represented most of the activity during the observation period. “Stakeout” is an incident type which correlates to an excavation request where digging could potentially impact NYSDOT or Monroe County infrastructure.

Figure 7 illustrates the distribution of incidents by roadway. Note that while a total of 46 incidents were reported in Figure 6, there were only 34 incidents that specified a roadway. The remaining 12 were either labeled as “Test” or simply omitted roadway information, likely due to the nature of the incident.

Figure 7: Observation Period Incidents by Roadway (*indicates roadway is a detour route for I-490)



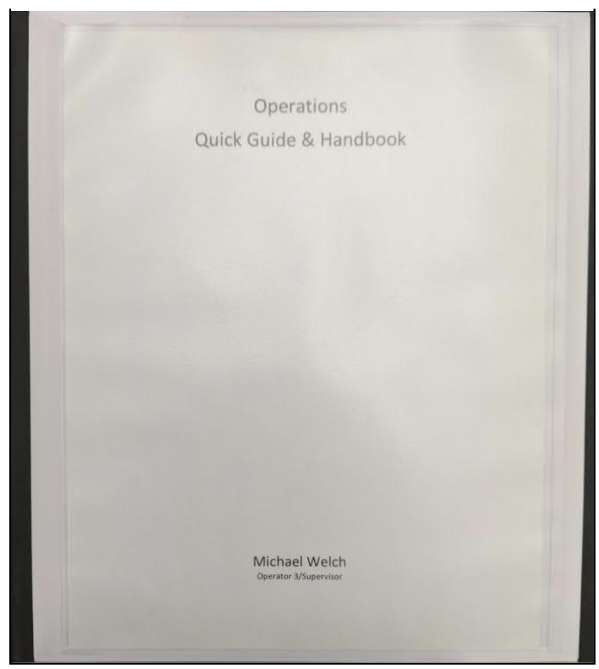
It should be noted that while there was a "Date" field on this data, there were no specific time stamps for the beginning or end of incidents that would allow an assessment of incident durations.

3.2.4 NYSDOT SOP and IM Plans

NYSDOT maintains Standard Operating Procedures (SOP) documents in three-ring binder hard copy format only. However, during the observation period it was noted that a conversion to an all-electronic format is in progress. While there are electronic versions of individual SOP documents, there was no complete document available for download. NYSDOT maintains two versions of their SOP; one is a "full version" and the other is a "quick reference" version (shown in Figure 8) which allows quick access to the most referenced procedures. The last update of the NYSDOT Quick Reference Handbook was indicated as June 2020. The Quick Reference Handbook contains the following sections:

- Phone Contacts
- Traffic Incidents
- Signals
- Stakeouts
- Signs
- VMS
- Weather-related issues
- Truck Bans
- Bridges
- O'Rorke Bridge
- Animals
- Bus Incidents
- CCTV Feeds
- Debris
- NYSDOT Routes
- Protests/Civil Unrest

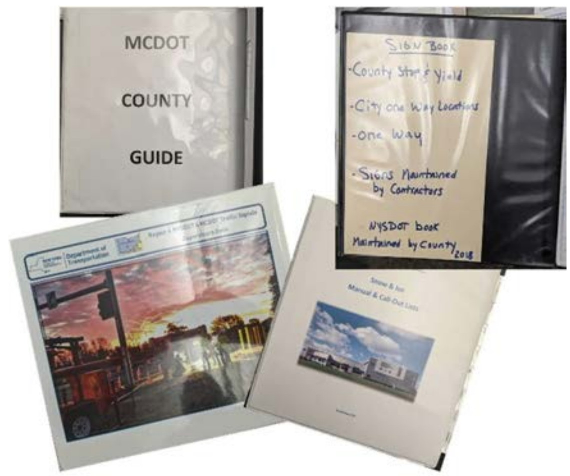
Figure 8: NYSDOT Quick Guide & Handbook



Other manuals specific to NYSDOT include the Snow & Ice Manual/Call-Out Lists (Figure 8). Again, this resource is maintained in a three-ring binder in a central area of the main operations floor and was last updated in September 2020.

Personnel working in the capacity of a NYSDOT Supervisor also have access to the NYSDOT/MCDOT Traffic Signals (Figure 8) book. This resource was last updated in 2020, although a specific month could not be ascertained.

Figure 9: Various NYSDOT/MCDOT Guide Notebooks



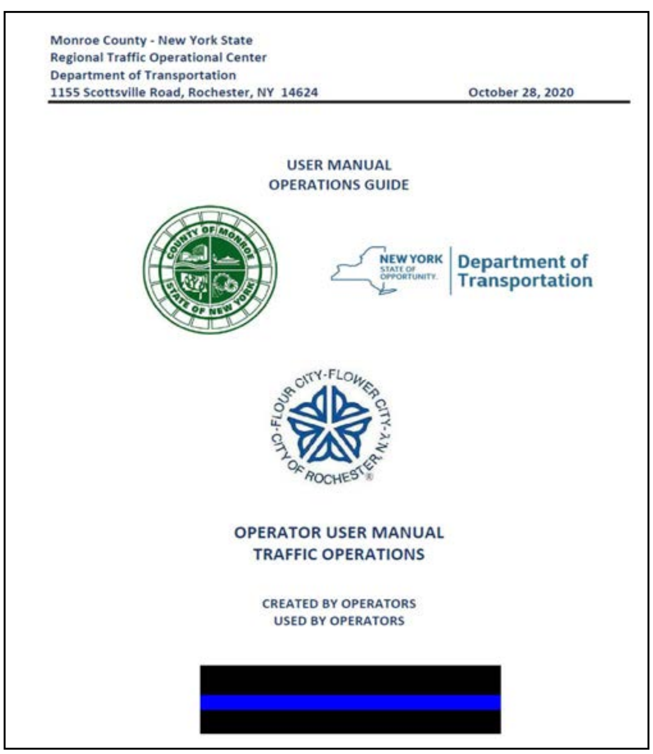
3.2.5 Monroe County SOP and IM Plans

Monroe County maintains several procedural guidebooks for their own internal use, as well as for use by NYSDOT during off-hours operations. One important resource is the MCDOT County Guide (Figure 9) which is contained within a three-ring binder and offers the following sections:

- Main
- Town Roads
- Signals
- Bridge
- Contacts

This resource book contains various version updates ranging from 2010 to 2020.

Figure 10: MCDOT-NYSDOT RTOC Operator User Manual



Monroe County - New York State
Regional Traffic Operational Center
Department of Transportation
1155 Scottsville Road, Rochester, NY 14624 October 28, 2020

USER MANUAL
OPERATIONS GUIDE

NEW YORK STATE OF OPPORTUNITY. Department of Transportation

OPERATOR USER MANUAL
TRAFFIC OPERATIONS

CREATED BY OPERATORS
USED BY OPERATORS

The primary resource for the facility is the Monroe County-New York State RTOC Operator User Manual (Figure 10). This 249-page PDF document provides policy and procedure guidance as well as step-by-step instructions for the use of all systems in the RTOC. While billed as a "combination" resource for both NYSDOT and MCDOT, much of the content within is weighted more heavily to MCDOT operations and systems use than that of NYSDOT.

With regard to Incident Response Plans, both NYSDOT and Monroe County operations personnel deferred to the NYSDOT Statewide Incident Level system as their official guidance resource.

3.2.6 Highway Emergency Local Patrol (H.E.L.P.) Service

H.E.L.P. has been in service in the Rochester area since 2004. The program currently has four H.E.L.P. beats that patrol almost 100 directional miles of the Region's principal highway network.

The H.E.L.P. program is dispatched at the Regional Traffic Operations Center (RTOC). In 2018, these four trucks logged over 4100 "assists." Hours of operation are from 6:00am to 10:00am and 3:00pm to 7:00pm Monday through Friday. Hours are expanded as needed for special events and holidays.[3]

NYSDOT consultant operators dispatch H.E.L.P. trucks via portable hand-held two-way radios. No communication problems were noted during the observation period, but direct phone communication is available as a backup in the event of poor or failed radio communications.

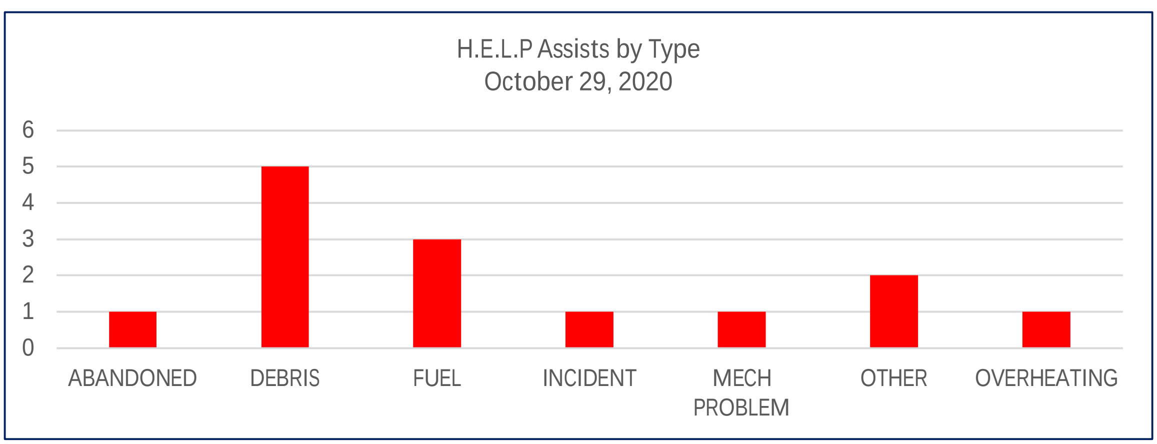
H.E.L.P Truck beats are shown in Table 6.

Table 6: H.E.L.P. Truck Beats

Truck #	Beat
Truck 102	• Rte. 390 Lehigh Station Rd to the Lake Ontario State Pkwy. A portion of Rte. 590 between the Rte. 390 Interchange and S. Winton Rd.
Truck 103	• Rte. 104 from Lake Ave (City) to Rte. 250 Webster
Truck 104	• Rte. 590 at S. Winton Rd. to East Ridge Rd.
Truck 105	• Rte. 490 at Buffalo Rd. to Rte. 441. Also Rte. 531 from Rte. 490 to Manitou Rd.
Truck 101	• Spare

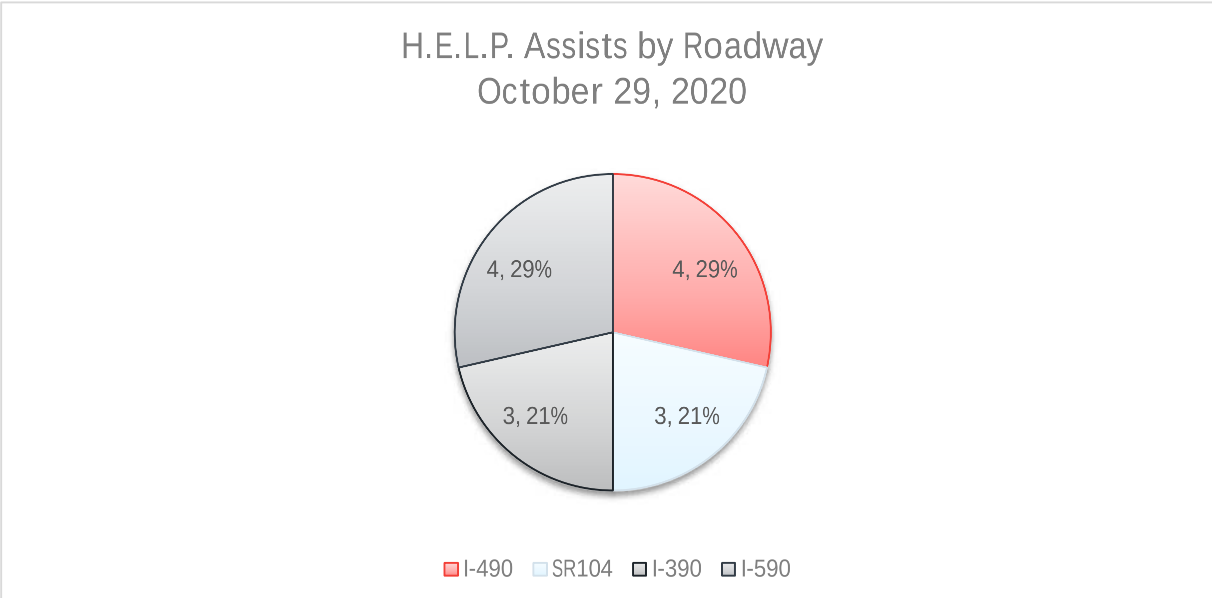
Figure 11 provides a breakdown of H.E.L.P. assists by type during the observation period, while Figure 12 indicates the roadway location where H.E.L.P. assistance was rendered.

Figure 11: H.E.L.P. Assists by Type



[3] Source: New York State DOT website: https://www.dot.ny.gov/divisions/operating/oom/transportation-systems/systems-optimization-section/ny-moves/H.E.L.P.-program/patrols/rochester

Figure 12: H.E.L.P. Assists by Roadway



Like the incident data provided in Figure 6 and Figure 7, there were no time stamps provided with the H.E.L.P. truck data to determine overall duration of each incident.

3.2.7 Institutional

Both NYSDOT and Monroe County reported that there are very few formalized agreements or Memoranda of Understanding (MOU) between the agencies. There is no MOU between the County and the State of New York for the RTOC, but there is a lease agreement for the use of the physical space (more information is available on Page 1 of this report). There is a lease agreement with New York State Police for use of the physical space. The only formalized operational agreement in existence and agreed upon by both MCDOT and NYSDOT is a one for the sharing of fiberoptic communication resources. NYSDOT also reported that there is a video sharing agreement in place through Skyline for the use of CCTV images on local television traffic reports.

3.3 Systems and Communications

The RTOC uses multiple software systems for daily operations. During interviews conducted both before and during the RTOC observation, there was general agreement that there are too many separate software packages with no integration amongst them which results in redundant effort when it comes to reporting and managing incidents. Augmenting this issue is a lack of standardization between MCDOT and NYSDOT as it relates to both hardware and software within the RTOC and in the field.

The following management software and hardware systems were identified during the observational period:

Foundation III ATMS: This is the Advanced Transportation Management System that has been identified as the statewide solution for NYSDOT. However, the ATMS in its current form is limited largely to command and control of NTCIP-compliant ITS devices, and does not handle any other functions (e.g., call logging, incident tracking, signal control, etc.)

R4 Database: The R4 database is a Microsoft Access database which was created in-house by a previous TMC manager. The R4 is the primary method of tracking incidents handled by the RTOC operators. This application is in the process of being sunsetted and will ultimately be replaced by a commercial software package at some point in the future although a specific time frame is not known.

FLIR: Often referred to internally as "DVTel", FLIR manages the command/control of CCTV feeds into the RTOC. DVTel was acquired by FLIR in 2015.[4] Both NYSDOT and Monroe County can exert Pan/Tilt/Zoom control over each other's CCTV assets. The system offers a "lock" function that can temporarily disable PTZ function when it is necessary to keep a camera focused on a particular incident.

Utilisphere: Utilisphere is used for tracking calls for Stakeouts, which are requests to dig on NYSDOT/Monroe County right-of-way. Requests are made by calling 8-1-1.

TransSuite: TransCore's TransSuite system is the software which provides signal control for Monroe County. Signals communicate by either fiber or wireless methods.

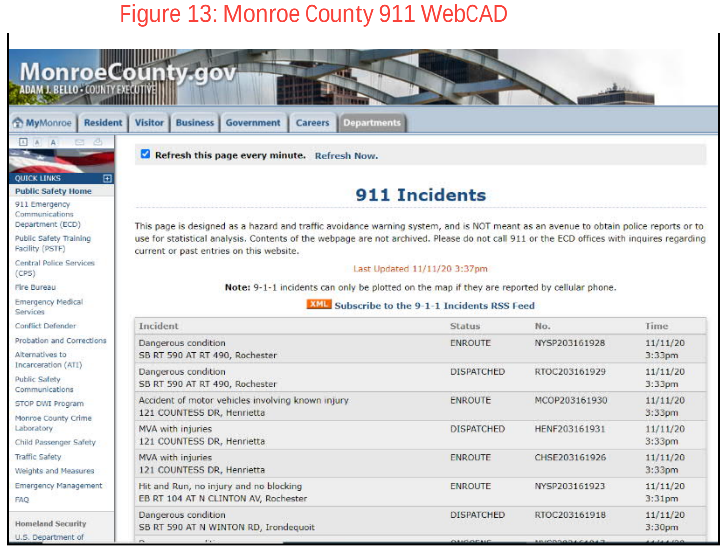
Safety Track: This is a fleet management software system which manages CCTV images coming from H.E.L.P. trucks. H.E.L.P. trucks utilize both forward and rear facing CCTV for situational awareness.

AVL/GIS: H.E.L.P. trucks are outfitted with Automated Vehicle Location, but that information is not widely shared. The AVL data can be used in conjunction with GIS software to track H.E.L.P. truck locations in real time. This information is primarily used by the contracted H.E.L.P. truck provider.

Monroe County 911 website/Mobile Data Terminals (MDT): The RTOC has a direct connection to the Mobile Data Terminal (MDT) page of the Monroe County Public Safety website. This connection allows RTOC operations staff at both NYSDOT and MCDOT to see real-time dispatch information for incidents which may impact regional roadways.

Monroe County also maintains a public-facing WebCAD for displaying current 911 incidents (Figure 13). https://www.monroecounty.gov/safety-incidents

Figure 13: Monroe County 911 WebCAD



Radio System: The RTOC utilizes a two-way radio system with hand-held portable radios for dispatching H.E.L.P. trucks.

3.4 Performance Measures

Both NYSDOT and MCDOT reported that they are currently lacking in processes to measure the performance of the transportation system and the efforts of the RTOC to manage it. However, RTOC personnel are working with the Genesee Transportation Council (GTC) to develop a performance

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[4] Source: https://www.flir.com/news-center/press-releases/flir-systems-acquires-dvtel-inc.-for-$92-million/

measurement database. A full technical report was completed by GDG IoT and submitted to GTC in late 2019 outlining best practices in performance measures. However, efforts to implement these practices remains a work in progress. It is worth noting that the organization chart for NYSDOT does specify a "Transportation Analyst" role to presumably manage a performance management program, however that position remains unfilled as of this report.

The RTOC leadership has a strong vision and direction about the types of Key Performance Indicators that should be developed, and the specific performance areas to be measured. At present, NYSDOT's database is unable to generate performance reports, and as such, do not have a list of reports they use. However, as part of another study, a number of expressway and arterial measures that would be desirable have been identified in Table 7.

Table 7: Desired Performance Measures

	PERFORMANCE MEASURE	DESCRIPTION	SUPPORTED BY DATA?	APPLICABLE SYSTEM
Monitoring and Managing Traffic	Real-time Congestion	Calculated via Volume, Speed and Occupancy Should provide current condition in real-time	YES	CoVal Foundation TransCore TransSuite
	Congestion by Roadway	Occurrence of congestion by location List of Top-10 most congested roadways (per Volume, Speed and Occupancy) per month List of Top-10 areas with most signal overrides per month List of Top-10 areas with most signal downloads per month	YES	CoVal Foundation TransCore TransSuite
Monitoring and Managing Incidents	Incident Type	Type and quantity of Incident per Month	YES	Dispatch Database
	Incident Severity	Rated severity of Incidents per NYSDOT scale per month	YES	Dispatch Database
	Incident Location	Count of each location where incident occurred per month	YES	Dispatch Database
	Incident Date & Time	Count of date and hour interval when incident detection occurred per month	YES	Dispatch Database
	Incident Clearance Time	Timestamp to indicate incident clearance time averaged per month per incident	YES	Dispatch Database
	Incident Impact	Quantity of Lanes Closed per incident per month	YES	Dispatch Database
	Quantity of H.E.L.P. Truck Service Calls	Quantity of H.E.L.P. Truck Service Calls, by type by Truck # per month (e.g., flat tire, fuel debris clearing, animal, etc.	YES	Dispatch Database
	Signal Overrides due to an Incident	Count per month	YES	Dispatch Database TransCore TransSuite
	Signal Downloads due to an Incident	Count per month	YES	Dispatch Database TransCore TransSuite

	PERFORMANCE MEASURE	DESCRIPTION	SUPPORTED BY DATA?	APPLICABLE SYSTEM
Monitoring and Managing Work Zones	Work Zone Impact	Average congestion during presence of work zone or other planned event e.g., lane closures, detours with time stamp for beginning planned event and end of planned event and location tied to monitored section of roadway (RTMS or System Sensor)	YES	CoVal Foundation TransCore TranSuite
	Work Zone Count	Count of all Work Zones per month and who owns Work Zone (NYSDOT MCDOT, Sub-Contractor, Utility)	YES	Dispatch Database
Monitoring and Managing Weather Data Monitoring and Managing Systems	Weather Closures	Quantity of road closures, by roadway segment, hours closed per day, count summarized per month	TBD	TBD
	System Uptime	Indication of percentage of uptime per month	YES	TBD
	Message Type	Type of message per month for VMS and PVMS	YES	CoVal Foundation
	Device Uptime	Uptime percent per month for VMS, PVMS, RTMS	YES	CoVal Foundation
	Device Uptime	Uptime percent per month for CCTVs	YES	DVTel
	Device Uptime	Uptime percent per month for Traffic Signals	YES	TransCore TranSuite
	Device Uptime	Uptime percent per month for System Sensors	YES	TransCore TranSuite
	Signal Interventions	Quantity of required signal interventions per month (“downloads” and “overrides”)	YES	TransCore TranSuite

The following list, provided by MCDOT, summarizes key areas of pursuit related to the MCDOT’s performance measures.

- Use TransSuite data to report when traffic signal timing overrides were sent from the RTOC to traffic signals in the field and done and/or managed within TransCore.

- Use TransSuite data to count the performance measures of all traffic signal timing plans and how often they occur in the day.

- Use TransSuite data to report the number of fire pre-emptions that each traffic signal responded to.

- Use SAP Work Order system data pertaining to traffic signal repairs, timings, caller complaints, follow ups, etc. for each traffic signal location.

- Use SAP Work Order system data pertaining to highway light repairs, caller complaints, follow ups, etc. for each highway lighting location.

- Use Monroe County's FLIR system to count the number of times each Monroe County camera is called up on a display and/or moved and correlate that information to a crash and or viewing the operations of traffic flow or response to a crash.

- Use Utilisphere data to report the number of stakeout tickets that are cleared and the number of tickets that our crews mark out, and emergency stake outs. This is something that would have to be done through Monroe County DES.

- Include a custom module for Monroe County since MCDOT maintains many NYSDOT traffic signals.

3.5 RTOC TSMO Capability/Maturity Assessment

As part of the RTOC observation process related to ICM, a series of interviews were conducted to get a high-level assessment of the RTOC's current capabilities to manage a future ICM project on the I-490 corridor. Table 8[5] shows the results of a gap and CMM analysis conducted at the time of site visit. The following individuals were interviewed for this effort:

- Matt Oravec, NYSDOT TMC Manager
- Bill Robinson, NYSDOT ITS Engineer/Design Lead
- Jim Pond, MCDOT Acting Director[6]
- Adam Cook, RTOC Operations Manager (Consultant)
- Brandt Smith, MCDOT Traffic Engineer

[5] Source: NCHRP Project 20-68A Scan Team Report, "Advances in Strategies for Implementing Integrated Corridor Management"
[6] Title at time of discussion. Jim Pond has since been named permanent MCDOT Director of Transportation

Table 8: RTOC TSMO/ICM Capability Maturity Model Assessment

Key Attributes	Level 1 Silo	Level 2 Centralized	Level 3 Partially Integrated	Level 4 Multimodal Integrated	Level 5 Multimodal Optimized	Current Assessed Level
Institutional Integration						
Inter-agency Cooperation	Agencies do not coordinate their operations	Some agencies share data, but operate their networks independently	Agencies share data, and some cooperative responses are done	Agencies share data, and implement multi-modal incident response plans	Operations are centralized for the corridor with personnel operating the corridor cooperatively	2.4
Funding	Single Agency	MPO tracks funding	Coordinated funding through MPO	Cooperatively fund deployment projects	Cooperatively fund deployment, operations, and maintenance of projects.	3
Technical Integration						
Traveler Information	Static information on corridor travel modes	Static trip planning with limited real-time alerts	Multimodal trip planning and account-based alerts	Location-based, on-journey multimodal information	Location-based, multimodal proactive routing	2.75
Data Fusion	Limited or manual	Near real-time data for multiple modes	Integrated multi-modal data (one way)	Integrated multi-modal data (two-way)	Multi-source multi-modal data integrated and fused for operations	1.3
Operational Integration						
Performance Measures	Some ad-hoc performance measures based on historic data	Periodic performance measures based on historic data	High-level performance measures using real-time data	Detailed performance measures in real-time for one or more modes	Multi-modal performance measures in real-time	1.4
Decision Support System	Manual coordination of responses	Pre-agreed incident responses plans	Tool section of pre-agreed plans	Model based selection of pre-agreed plans	Model based creation of incident response plans.	1.1

3.6 Highway Infrastructure

While much of the ICM operational and ITS strategies available to the I-490 corridor are electronic and technological, highway infrastructure must be able to support some of the operational strategies.

One possible operational strategy, ramp metering (refer to section 4.1.1), requires adequate storage along the on-ramps to store queuing traffic. There also must be adequate width on the ramp for emergency vehicles to bypass queued traffic when responding to a crash or other incident. In some cases, these two needs clash like when the full ramp width is necessary for queueing traffic (using multiple lanes rather than a single lane). Table 9 lists a Google Earth-measured summary of inadequate ramp widths for safe emergency vehicle passage along both directions of I-490.

Table 9: I-490 On-ramps with Inadequate Emergency Vehicle Passage Width

EB I-490	WB I-490
	Exit 16 (From Howell St) – 12’
Exit 17 (From S Goodman St) - 18’	Exit 17 (From S Goodman St) – 16’
Exit 18 (From Monroe Ave) – 15’	Exit 18 (From Monroe Ave.) – 18’
Exit 19 (From Culver Rd) – 18’	Exit 19 (From Culver Rd) – 12’

Ramp storage lengths are generally lengthy along I-490 and appear to be capable of sufficient storage for ramp metering, a modeling exercise was not part of this effort to determine if the ramps could be used for storage in a ramp metering deployment. All the ramp widths and storage lengths can be found in the complete table in the Appendix.

Another strategy, dynamic shoulder lanes (refer to section 4.1.14), requires adequate width (minimum of 11’) to run trucks with sufficient clear zone (and no pooling of water). The same Google Earth review shows that none of the median shoulders are wide enough for this application, and while the right-side shoulders are wide enough in some instances, further study will have to done to examine the use of the shoulder because of the frequency and spacing of the interchange ramps in the most congested sections of I-490.

3.7 Comparable Metropolitan Areas

Planning for a possible I-490 ICM project can benefit from examining other existing ICM programs to capitalize on existing practices and lessons learned. By understanding the process other metropolitan areas took in developing their ICM program, the I-490 team can identify what is crucial to the development process early on and what ICM strategies should be considered. The metropolitan areas selected are in different phases of ICM program development with strategies deployed in some areas while others remain in the planning process. Nonetheless, each area is beneficial to the Rochester region in the development of its own program.

3.7.1 Methodology

Comparable metropolitan areas were selected based on their similarities to Rochester, NY in the following areas:

- population size
- metropolitan area size,
- traffic characteristics of ICM corridor,
- current status of the ICM program.

Buffalo, NY and Des Moines, IA were chosen due to the similarities in population and metropolitan areas. The tables below show demographic and transportation data for peer cities (Table 10) as well as ICM strategies and lessons learned (Table 11).

Table 10: Demographic and Transportation Data for Peer Cities

Metropolitan Area	Population (2019)[i]	Population Growth (April 1, 2010 to July 1, 2019)[i]	Area Size in Square Miles (2010)[ii]	Transit Authority	Transit Description	Year	Annual Ridership	Regional Travel Time Index (2017)[iii]
Rochester, NY	1,079,704	-0.90%	2,982.1	Rochester Genesee Regional Transportation Authority[iv]	The authority is comprised of separate business unit. The Regional Transit Service (RTS) serves the Rochester Area. It includes 41 fixed routes and 216 buses.	2019	14,873,569	1.16
Buffalo, NY	1,127,983	-0.70%	1,565.1	Niagara Frontier Transportation Authority[v]	NFTA - Metro serves both Erie and Niagara Counties. It includes 6.4 mile of light rail and 59 bus routes.	2019-2020 (March 31, 2020)	23,841,188	1.16
Des Moines, IA	699,292	15.30%	2,883.7	Des Moines Area Regional Transit Authority (DART)[vi]	DART serves the Greater Des Moines region and has 19 local routes, 7 express routes, and 2 shuttle routes. (28 Fixed Routes)	FY 2019	4,394,939	1.08

Table 11: ICM Strategies and Lessons Learned from Deployments in Similar Cities as Rochester

Metropolitan Area	Status	ICM Strategies	Lessons Learned
Rochester, NY	N/A	N/A	N/A
Buffalo, NY	Planning	Dynamic Traveler Information Freeway Incident Detection and Service Patrol Ramp Metering VSL and Queue Warning Variable Toll Pricing Signal Coordination[vii]	The proposed strategies were sorted into two different packages. Package A included dynamic traveler information, freeway incident detection and service patrol, ramp metering, VSL and queue warning, and variable toll pricing. Package B added the signal coordination strategy. The packages were then simulated in the ICM model and the impacts of the strategies were assessed. The simulations show benefit/cost ratio of 2.25 or package A and 2.49 for package B.
Des Moines, IA	Planning	Phase 1 Strategies: Regional Traffic Signal Optimization Ramp Queue Spillback Mitigation Over Dimension Freight Vehicle Permitting Median Barrier Gates Ramp Naming Conventions Additional Strategies: Dynamic Shoulder Lanes/Part Time Shoulder Use, Variable Speed Advisories, Extend Acceleration/Deceleration Lanes, Add Exit Option Lanes, Ramp Metering [viii]	Des Moines is further along in their planning process than Buffalo. A Program-Level ConOps has been developed to serve as the overarching strategy document for the ICM. From the program level ConOps, Phase 1 strategies were identified. Implementation Plans and ConOps have been developed for the Signal Optimization and Median Barrier Gates strategies. Implementation plans have been developed for freight permitting, queue spillback, and ramp naming strategies.

3.8 Gaps and Needs

Based upon the Regional Traffic Operations Center (RTOC) observation, individual staff and management interviews, and the capability maturity model assessment, a series of high-level gaps and needs were identified for future assessment of integrated corridor management.

3.8.1 Gaps

The gaps identified exist in the following areas:

- Coordinated inter-agency Traffic Incident Management (TIM) planning
- Automated travel time information
- Real-time weather and road surface/subsurface condition information
- Smart traffic signal system on the New York State Department of Transportation (NYSDOT) network
- Real-time traffic condition information from NYSDOT and Monroe County Department of Transportation (MCDOT) arterial network
- Real-time information on I-490 traffic conditions for diversion
- En route traveler information
- Coordination and integration between Advanced Traffic Management System (ATMS) and arterial traffic signal systems
- Coordination and integration of personal vehicle motorists and bus transit

3.8.2 Needs

To achieve an integrated corridor, some or all of the following needs must be met:

- Formalized and regularly scheduled Traffic Incident Management (TIM) meetings
- TIM and on-scene State-of-the-Practice (SOTP) assessment and training
- Assessment of the implementation of a quick clearance policy
- Increased standardization/centralization of hardware/software systems to improve operational efficiency and reduce redundant effort
- Synchronization of signal plans between MCDOT and NYSDOT
- Event-based signal timing plans.
- Formalized process for Standard Operations Procedures (SOP) review and updates.
- Interconnection with, and real-time information from, NYSDOT and MCDOT signal systems
- Additional detector sensors and Closed-Circuit Television (CCTV) cameras for better situational awareness
- Additional Dynamic Message Signs (DMS) at strategic diversion locations along I-490 as well an intermittent location for travel time information display
- Additional Roadway Weather Information System (RWIS) stations for proactive weather response
- Communication to motorists on the availability of transit status

4 ICM STRATEGIES

Resources for new infrastructure construction have become scarcer in the recent economic climate. As highways have become more congested, attention has been focused on strategies to optimize existing infrastructure to move traffic. Applying a range of such operations strategies can decrease the congestion and delay, increase travel time reliability, and improve safety. ICM is designed to actively monitor for recurring and nonrecurring events that impact traffic on the most visibly congested highways or expressways that define a corridor. Because of near constant congestion, even minor events on an anchor facility can have a huge impact.

ICM along the I-490 Corridor will be neither nominal (i.e., day-to-day) traffic management, nor traditional incident response (i.e., a detour), as those approaches are reactive. The future I-490 ICM system will utilize proactive engagement of the City of Rochester, MCDOT and NYSDOT assets on parallel routes or alternate travel modes (RTS). This engagement is characterized by actively changing signal timings, promoting (and if need be, temporarily increasing) transit alternatives, providing bus bridges, and generally flexing the entire corridor to absorb the congestion event rather than merely responding only in the vicinity of the event on I-490.

A number of operational strategies are available to support integrated corridor management. Some of these strategies are in place presently, but may need modification or expansion, while other strategies will need to be explored for viability along the I-490 Corridor. The remainder of this chapter will describe the menu of strategies available to implement and follow through to recommending which of these strategies is viable and how it should be implemented. Chapter 5 will identify specific recommendations from these strategies.

4.1 Strategy Assessment

Operational strategies that support ICM are described and assessed in Table 12 through Table 25. For this effort, these strategies are examined for planning-level feasibility, that is, evaluating if the strategy can be eliminated from further consideration. Later in Chapter 5, these feasible strategies are more finely described in the form of planning-level recommendations.

The tables that follow present each of the operational strategies as described below:

- What is It? This is a recap of the information described in Task 3. It describes what is necessary to implement the strategy and how it works to advance ICM.
- How Much Does It Cost? This describes, in comparative terms to the other strategies, how expensive the strategy is to implement, operate and maintain. Actual costs are not calculated, but the costs in the table range from “$” (less expensive) to “$$$$” (expensive).
- Is it Feasible? In this column of the table, the narrative describes the pros and /or cons of the strategy, and ultimately define the strategy as either feasible (for further study/implementation) or not.

4.1.1 Ramp Metering

Table 12: Planning-level Feasibility Assessment of Ramp Metering Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Ramp Metering (RM)	RM are traffic signals at expressway on-ramps that control the rate of vehicles entering the expressway. The meters can be set for different flow rates to optimize traffic flow and minimize congestion. When in operation, ramp meters will alternate between red and green lights, restricting the number of vehicles entering I-490, thereby reducing congestion, bottlenecks and managing the traffic flow on the mainline. Effective ramp metering programs using suitable strategies often realize significant, long-term benefits. While the magnitude of the benefits may vary depending on the level of congestion and configuration, common benefits persist. The widespread benefits of ramp metering, even relative to its high costs, make it one of the most cost-effective expressway management strategies. Travel times, even when considering time in queue on the ramp, are generally reduced when ramp metering is implemented. Travel time reliability has become an important measure of ramp metering effectiveness. Many regions have experienced increased travel time reliability (reduced variations in day-to-day travel times) due to ramp metering. Ramp meters help break up platoons of vehicles that are entering I-490 and competing for the same limited gaps in traffic. By allowing for smooth merging maneuvers, crashes on I-490 can be minimized or avoided. Many regions have reported significant reductions in crash rates after starting ramp metering.	$$$$	Ramp metering requires adequate storage along the on-ramps to store queuing traffic. There also must be adequate width on the ramp for emergency vehicles to access the expressway. Candidate locations are where accident frequency is higher in the immediate vicinity of the on-ramp to the congested expressway. In the City sections where these criteria are most common, interchanges are closely spaced, and many on-ramps are auxiliary lanes to the downstream interchange off-ramp creating weaving sections. This configuration can be detrimental to effective ramp metering that requires free access onto the expressway from the on-ramp. Further, on-ramps along EB I-490 (Exits 17, 18 and 19) and WB I-490 (Exits 16, 17, 18, 19) are not wide enough to allow emergency vehicle passage and would need to be widened which in the closed urban section is not feasible. There are a few locations that, based on volume, crash frequency and ramp geometry, may be feasible to meter. This strategy is recommended for further study.

4.1.2 Queue Warning

Table 13: Planning-level Feasibility Assessment of Queue Warning Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Queue Warning (QW)	QW's purpose is to inform motorists of the presence of downstream stop and-go traffic (based on real-time traffic detection) using warning signs and in some cases, flashing lights. Drivers can anticipate an upcoming situation of emergency braking and slow down, avoid erratic behavior, and reduce queuing related crashes. Like variable speed limits, QW displays use overhead lane control signals that provide indications of closed lanes ahead using symbols like arrows and "X"'s to indicate open and closed lanes, respectively. Alternatively, QW messages can be displayed on DMSs. The system can be automated or controlled by a traffic management center operator. Work zones also benefit from queue warning with portable dynamic message signs units placed upstream of expected queue points. QW systems reduce the potential for primary and secondary crashes by alerting drivers to congested conditions; delay the onset of congestion, improving smooth and efficient traffic flow and trip reliability.	$$-$$$	Unlike variable speed limits and ramp metering, QW is not mutually exclusive to other strategies. It is comprised of infrastructure including detection and CCTV to determine the existing queuing and DMS to post warning messages. In addition to these field devices, the ATMS must be able to assess the detection data and determine that a queue has formed, where it has formed (the end of the queue) and predict its extent in the future. From this determination, messages are placed on the DMS to warn of the queue and/or recommend diversion around the congestion, and/or provide information on transit availability. This strategy is valuable as a safety tool and feasible along I-490 if used with DMS and not overhead individual-lane DMS on gantries. This strategy is recommended for further study.

4.1.3 Travel Time System

Table 14: Planning-level Feasibility Assessment of Travel Time System Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Travel Time System	This system uses real-time traffic data to calculate travel times between points on the network. Signs along the expressway display the amount of time it will take to get to specific destinations. Some of the signs provide times for alternate routes to the same destination, allowing the driver to choose which route to take. Travel times can be displayed on DMS or on purpose-built signs. Travel times are calculated based on information collected from various sources either directly or indirectly measuring vehicle flow. Traditional infrastructure-based detection can detect and measure traffic parameters at a given point and derive speed and travel time information. Other more advanced probe-based technologies using Wi-Fi, Bluetooth, or GPS-based applications provide a direct measure of travel time between two points, but only for a sampling of the traffic. Wi-Fi and Bluetooth readers are installed along roadways to detect vehicles (actually mobile phones or other devices) using Bluetooth or Wi-Fi. As devices are detected by successive readers, the system compiles aggregate data on average speeds, travel times, and the number of non-arriving vehicles (vehicles expected but not yet detected by the next reader downstream). Commercial GPS probe-based solutions, such as INRIX and HERE, rely on smart phone applications to constantly and anonymously report back device position information which is then used as a surrogate to calculate travel time of the occupant in the vehicle. A large sample set will accurately represent the actual travel time conditions on the roadway. Travel time signs provide motorists knowledge of their future trip duration which aids in providing trip predictability.	$$-$$$$	By displaying travel times on the I-490's DMSs, motorists can make informed decisions about their commute patterns. Through this "real time" travel information, motorists using I-490 can avoid, or at least limit exposure to expressway congestion by adjusting their travel route (detour) or departure times. This strategy is valuable and has proven itself across New York State as well as across the country. It requires enough detection, central processing to compute the travel time algorithm, and DMS for display. This strategy relies on the detection and traveler information strategies, and as such the implementation of these other strategies lessens the cost of the travel time system, giving the region a return on their investment. Further, the travel time display devices, if DMSs, can be the same DMSs used for queue warning and detour recommendations. The DMSs will display travel time as their default message when not displaying higher priority messages. Where queue warning or detour DMSs are not needed a hybrid static/dynamic sign may be used for permanent travel time information display. A central processing system would need to be implemented at the RTOC, but these systems are commonplace and neither an expensive nor complex system. This strategy is valuable as a mobility tool and recommended for further study.

4.1.4 Advanced Traveler Information System

Table 15: Planning-level Feasibility Assessment of Advanced Traveler Information System Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Advanced Traveler Information System (ATIS)	An Advanced Traveler Information System (ATIS) acquires, analyzes, and presents information to assist travelers in moving from a starting location (origin) to their desired destination. An ATIS operates by using data supplied by the traffic management centers. Relevant information may include locations of incidents, weather and road conditions, optimal routes, recommended speeds, and lane restrictions. Traveler information can be categorized as either pre-trip which provides travelers with current roadway and/or transit information prior to deciding upon the time, mode, and route of travel, or en-route traveler information which provides the traveler with current roadway and transit information while traveling en-route.	$$	Providing motorists and pre-trip travelers with real-time traveler information (crashes, congestion, queues, travel time) has significant return of the investment. Linking the arterial with the expressway for balancing demand is the foundation to ICM and getting the information to travelers so they can make informed decisions is paramount. The RTOC has experience with DMS management and 511NY, so an expansion of this system to provide more information is valuable to travelers and cost-effective to NYSDOT. This strategy is valuable as a mobility tool and feasible if used with DMS for other strategies. It is recommended for further study.

4.1.5 Intelligent Traffic Signal Control

Table 16: Planning-level Feasibility Assessment of Smart Signals and Traffic Signal Synchronization Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Intelligent Traffic Signal Control	ICM relies on balancing traffic demand on the expressway and signalized arterials. It is critical to have a responsive traffic signal system on the arterials to provide better throughput so that diverted traffic from the expressway can move most efficiently. Intelligent traffic signal control along arterials provides benefits of using real-time data, collected by (detection) sensors to regularly update signal timing based on actual real-time conditions, rather than a set of time-of-day plans with little adaptability. This real-time adaptability is superior to conventional signal systems in that it can automatically adapt to unexpected changes in traffic conditions, improve travel time reliability, reduce congestion and fuel consumption, reduce the complaints that agencies receive in response to outdated signal timing, make traffic signal operations proactive by monitoring and responding to gaps in performance. Along with the detection, intelligent traffic signal control is augmented with a communication network that allows the control center (RTOC) and its operators to know, in real-time, what the current conditions are on the arterials. This is important for operators so that they can make smart and informed decisions on diverting traffic from the expressway during congested conditions. In additional to arterials improvements, intelligent traffic signal control will improve operations of signalized interchange operations. It can automatically detect and respond to ramp congestion impacts on the local arterial roads or increase volumes as a result of traffic being diverted from I-490 resulting from a crash or other incident.	$$$	ICM is based on the integration between the I-490 and the arterials serving the corridor (diversion routes) to balance the demand. This integration is necessary during recurring and non-recurring congestion. With efficient traffic signal coordination, motorists can divert onto the detour routes and the routes are able to better manage the increased demand. Similarly, efficiency along the arterials will likely reduce the demand on I-490 as some motorists will choose to stay on the arterial if they are efficiently moving (rather than using I-490 for a short length). Smart signal technology is also imperative to gathering real-time information and providing situational awareness to the RTOC (central system) so a decision support system (DSS) can assess alternative response plans. This strategy is recommended for further study.

4.1.6 Vehicle Detection

Table 17: Planning-level Feasibility Assessment of Vehicle Detection Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Vehicle Detection	In a traffic management system, the detection and video monitoring components support the process in which data are collected to describe or characterize traffic flow conditions on the expressway or arterial. The data are used to supply information about conditions on the roadway to other system components. Thus, detection and video monitoring provide the information needed to perform the following traffic management functions including: Measuring traffic flow and environmental conditions, formulating control decisions, disseminating traveler information, monitoring and evaluating system performance, supporting other expressway management and operations functions such as incident detection and verification, planned special event and emergency management, ramp management, and transportation planning. Vehicle detection on I-490 will provide faster detection of incidents and detect vehicular queues, while improving safety.	$	Currently the RTOC uses microwave, inductive loop and video detection technology to get real-time information of traffic conditions. The amount and density of this detection, however, is lacking and further detection in critical areas would improve traffic management along the corridor. Since detection along the corridor, specifically on I-490 already exists, expansion of the system will be cost-effective and would provide significant return on investment given that it will prove faster detection of anomalies on I-490. This strategy is important and recommended for further study.

4.1.7 Closed-Circuit Television Monitoring

Table 18: Planning-level Feasibility Assessment of Closed-Circuit Television Monitoring Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Closed-Circuit Television (CCTV) Monitoring	CCTV systems have been used by NYSDOT since the 1990's and MCDOT since the early 2000's to provide visual monitoring of I-490 and the arterial network. Control centers typically use CCTV systems for detecting and verifying incidents, monitoring traffic conditions, monitoring incident clearance, verifying message displays on changeable message signs, and monitoring environmental conditions (e.g., visibility distance, wet pavement). On a critical expressway like I-490, full video coverage is a necessity in critical high-volume, high crash sections to allow RTOC to detect and diagnose and respond quickly and efficiently.	$	Like detection, CCTV brings great benefit to the RTOC's traffic management capabilities. It is a proven tool at the RTOC. There are gaps along I-490 that need to be addressed as well as critical intersections on the detour routes. This strategy recommended for further study.

4.1.8 Transit Signal Priority

Table 19: Planning-level Feasibility Assessment of Transit Signal Priority Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Transit Signal Priority (TSP)	TSP is simply the idea of giving special treatment to transit vehicles at signalized intersections. Since transit vehicles can hold many people, giving priority to transit can potentially increase the person throughput of an intersection. It employs the use of sensors and/or traffic signal timing to detect approaching transit vehicles and grant them priority passage at an intersection. TSP is a tool that can be used to help make transit service more reliable, improve on-time performance and schedule reliability, decrease bus headways, increase ridership, reduce travel time providing travel time savings to transit users, and cut transit agencies' operating costs. The most common uses of TSP are for fixed-route buses and light-rail systems.	$$$	RGRTA has explored the TSP in the past (Lake Avenue and Dewey Avenue), but found its cost outweighed the benefits realized at the time. TSP is a proven strategy and an important element of ICM. It will require outfitting of buses and traffic signal modifications. TransSuite along MCDOT's routes can currently provide TSP, but NYSDOT's traffic signal system(s) would require an upgrade (this would complement the intelligent traffic signal control strategy). TSP should be considered along the diversion corridors. TSP has shown to provide benefit and while not recommended for immediate further study, it should be re-examined as transit demand changes in the future.

4.1.9 Bus Rapid Transit

Table 20: Planning-level Feasibility Assessment of Bus Rapid Transit Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Bus Rapid Transit (BRT)	BRT is a high-quality bus-based transit system that delivers fast and efficient service that may include specially branded service, dedicated lanes, busways, traffic signal priority, off-board fare collection, elevated platforms and enhanced stations. BRT has advanced throughout the U.S. in the last decade as congestion has increased and community leaders have sought affordable transit alternatives. BRT is a common cost-effective transit enhancement being realized in mid-sized metropolitan areas like Rochester, although no BRT systems exist in the Rochester area at present.	$$$	Where BRT has been thoroughly studied and wisely implemented, it has proven to provide congestion relief on both expressways and arterials. The strategy, however, can be very expensive to implement if it is constructed on separate right-of-way, and without enough demand (ridership), it decreases available throughput capacity (by reducing the number of general-purpose lanes). A less expensive alternative would be enhanced service – shortening of headways. BRT has shown to provide benefit and while not recommended for further study, it should be re-examined as transit demand changes in the future.

4.1.10 Transit Availability Information

Table 21: Planning-level Feasibility Assessment of Transit Availability Information Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Modal Integration	During excessive congestion periods, motorists can be encouraged to transfer their mode of travel from a single-occupancy vehicle to a ride-share or express bus mode. For this to operate effectively, motorists must know at a point when a mode-decision must be made whether there is available parking at a park & ride lot. This requires a real-time information system that informs motorists on transit (bus) availability, and a counting system at the park & ride lots to provide real-time parking space availability.	$$$	An important aspect to balancing the demand is mode-shift. This is most important in the event of severe congestion from an incident, crash, or major construction. The park & ride lots, especially those with bus connections, are attractive targets for commuters wishing to get on a bus or carpool rather than drive in the stop-and-go traffic. For this to be effective, motorists must know if there is available parking at the park & ride lots in real time. Modal integration has shown to provide benefit and while not recommended for immediate further study, it should be re-examined as transit demand changes in the future.

4.1.11 Variable Speed Limits

Table 22: Planning-level Feasibility Assessment of Variable Speed Limit Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Variable Speed Limits (VSL)	VSL is a method to reduce congestion and improve traffic performance. The strategy involves gradually lowering speeds before a heavily congested area in order to reduce the stop-and-go traffic that contributes to driver frustration and crashes. A key component in this speed harmonizing strategy is the ability of the system to warn drivers of downstream queues (see queue warning). The system can be automated or controlled by a traffic management center operator. It is accomplished by installing lane control signals over each travel lane and posting (advisory or regulatory) speed limits on the signs over lanes that are slower than the posted speed. As drivers progress along I-490, the speeds reduce as travelers get nearer to the congestion. VSL has the potential to smooth traffic, increase the number of vehicles that an expressway can handle, and improve safety by making it easier for drivers to change lanes when necessary. It also has the potential to reduce the number of rear-end crashes caused by drivers who do not brake early enough when they encounter slow-moving or stopped vehicles.	$$$$	Requires a Decision Support System (DSS) (as do other strategies) and significant infrastructure - gantries across all lanes and spaced frequently enough that a driver can see two at any given times. Congestion along I-490 in the urban area may occur during peak hours and at times may be unacceptable. This strategy could yield some benefit; however, it is a very expensive strategy to deploy because it requires gantries over the entire cross-section of I-490 in order to provide lane-specific speed indications. Further, in the most congested section of I-490 where this strategy would yield the most benefit, interchanges are closely spaced; sign bridges (structures) are located between each interchange; and most of the intersecting roadways bridge over I-490. This condition restricts sight distance which is necessary for deployment. This strategy is not recommended for further study.

4.1.12 Dynamic Junction Control

Table 23: Planning-level Feasibility Assessment of Dynamic Junction Control Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Dynamic Junction Control (DJC)	DJC is a method to dynamically change lane allocation at an interchange. It can be used at expressway on-ramps or off-ramps. For example, when ramp volumes are relatively light or mainline volumes are very heavy, it might be most effective to have an entrance ramp merge into the right lane. However, there may be times that the volume on the ramp is extremely high while the mainline volumes are low. In this case, traffic merging from the on-ramp will have to find gaps in the mainline traffic. Even though the mainline traffic is relatively light, the hesitation needed at times to find a gap may be disruptive to ramp flows and may create a situation with higher rear-end crash potential on the ramp. DJC could be used to “close” the right lane of the expressway upstream of the ramp, using lane control signs in order to give ramp traffic a free-flowing merge transition onto the mainline. This use of junction control provides priority to the facility with the higher volume and reduces priority to the lesser volume roadway. DJC can also be used at off-ramps, especially when hard shoulder running is used, to dynamically create a two-lane off-ramp with an expressway drop lane and an option lane.	$$$$	DJC can improve service at ramp junctions where congestion is excessive because of a lack of capacity on the expressway off-ramp and/or an excessive off-ramp volume from the expressway. This strategy is best applied dynamically rather than on a scheduled basis (with static signs and a fixed schedule, e.g., M-F 7A-9A, etc.). The dynamic approach uses either overhead lane signals (DMS) to indicates lane usage on expressway and ramp or an overhead DMS at the junction. Both alternatives are very expensive without a large return given that typical backups on the ramps do not impede I-490. Improvements along the arterial can alleviate ramp back-ups by disseminating the ramp queue. This strategy is not recommended for further study.

4.1.13 Dynamic Lane Assignments

Table 24: Planning-level Feasibility Assessment of Dynamic Lane Assignments Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Dynamic Lane Assignment (DLA)	DLA is used to indicate lane closures that may be due to downstream congestion, crashes, work zones, or debris. In accordance with the MUTCD the signs can display green arrows indicating the lane is open, a red "X" indicating the lane is closed, or a yellow "X" indicating pending lane closure notifying motorist the need to merge out of the lane.	$$$$	Like VSL, this strategy requires overhead lane signals (DMS). It reduces congestion in response to an incident or crash by notifying motorists that lanes are closed ahead and provides advice to change lanes using arrows and "X" s over each lane. Where the expressway is over-capacity, there is an improvement from this implementation, however, like VSL, the gantries are very expensive, and the sight distance is not adequate to deploy the gantries, because of the existing static sign bridges and the roadway bridges over I-490. This strategy is not recommended for further study.

4.1.14 Dynamic Shoulder Lanes

Table 25: Planning-level Feasibility Assessment of Dynamic Shoulder Lanes Strategy

Operational Strategy	What is it?	How Much Does It Cost?	Is it feasible?
Dynamic Shoulder Lanes (DSL)	DSL also known as hard shoulder running or temporary shoulder use, is a dynamic measure designed to adapt limited-access roadway capacity to high traffic volumes on a temporary basis. By allowing vehicles on the shoulder, it is possible to serve a higher number of vehicles and avoid congestion, either totally or partially, during peak periods. The decision to implement shoulder use on a segment is taken by the operator in the traffic management center based on operating policies and volume considerations after a check for obstacles. Temporary shoulder use can help postpone the onset of congestion. By increasing capacity and encouraging more uniform speeds, traffic flows more smoothly and efficiently, which can improve trip travel time reliability. Increased vehicle volume can be another benefit of temporary shoulder use by temporarily increasing capacity.	$$$$	Dynamic shoulder lanes require adequate width (minimum of 11') to run trucks with sufficient clear zone (and no ponding of water). A review shows that the median shoulders are not wide enough for this application, and while the right-side shoulders are wide enough in some instances, however where congestion is most severe, the interchanges are closely-spaced and many of the sections between on- and off-ramps are auxiliary lanes creating weaving sections. This configuration is detrimental to effective shoulder use because the motorist would have to repeatedly change lanes to avoid the ramps. This strategy is not recommended for further study.

The strategies identified in Section 4.1 for possible implementation were selected based on a planning-level feasibility assessment. The strategies were deemed feasible based on constructability cost magnitude and an expected return - the expense to implement. Those that were not selected for future assessment were eliminated because they were found not to be feasible at this time (e.g., hard shoulder running was excessive as it required expressway reconstruction and operationally, in the most needed area – the urban sections through the City - the ramps are too-closely spaced.)

To further define and assess the strategies, each is broken into recommended implementation strategies, and are traced to the ICM objectives and gaps previously identified. These are presented in Table 26 through Table 35 that follow.

4.2 Strategy Implementation Recommendations

4.2.1 Advanced Traveler Information Systems

Table 26: Traceability Matrix of Advanced Traveler Information System Implementation Strategy Against ICM Project Objectives and Project Needs

ADVANCED TRAVELER INFORMATION SYSTEMS (ATIS) An Advanced Traveler Information System (ATIS) acquires, analyzes, and presents information to assist travelers in moving from a starting location (origin) to their desired destination. An ATIS operates by using data supplied by the traffic management centers. Relevant information may include locations of incidents, weather and road conditions, optimal routes, recommended speeds, and lane restrictions.		
Implementation Strategy	Associated Objectives	Associated Needs
DMS should be deployed at key diversion points (based on volume and crash history)	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools Enhance the quality of communications with the corridor's traveling public	Additional DMS (signs) at strategic diversion locations along I-490 as well an intermittent location for travel time information display
DMS should be deployed at recurring queuing locations to warn of stopped/slowed traffic (this could also be addressed below)	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools	Additional DMS (signs) at strategic diversion locations along I-490 as well an intermittent location for travel time information display
DMS should be deployed strategically to provide travel times	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools	Additional DMS (signs) at strategic diversion locations along I-490 as well an intermittent location for travel time information display

4.2.2 Closed-Circuit Television Monitoring

Table 27: Traceability Matrix of Closed-Circuit Television Monitoring Implementation Strategy Against ICM Project Objectives and Project Needs

CLOSED-CIRCUIT TELEVISION (CCTV) MONITORING Closed-circuit television (CCTV) systems have been used for many years to provide visual monitoring of I-490. The RTOC uses CCTV systems for detecting and verifying incidents, monitoring traffic conditions, monitoring incident clearance, and monitoring environmental conditions (e.g., visibility distance, wet pavement).		
Implementation Strategy	Associated Objectives	Associated Needs
Full video coverage should be deployed where high crash rates and volumes exist	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools	Additional detector sensors and CCTV cameras for better situational awareness
Video coverage should be deployed at key strategic interchanges	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools	Additional detector sensors and CCTV cameras for better situational awareness
Video coverage should be deployed at key strategic intersections along the diversion routes	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools	Additional detector sensors and CCTV cameras for better situational awareness

4.2.3 Intelligent Traffic Signal Control

Table 28: Traceability Matrix of Intelligent Traffic Signal Control Implementation Strategy Against ICM Project Objectives and Project Needs

INTELLIGENT TRAFFIC SIGNAL CONTROL

Intelligent Traffic Signal Control are systems that collect and use data to provide real-time management and control of the traffic signals on arterials as well as isolated signals (like diamond interchange ramps). These systems can change how the traffic signals operate based on real-time conditions. They enable the maximum number of vehicles to pass through intersections, thereby reducing stops and delays experienced by motorists. The main benefits of intelligent traffic control over conventional signal systems are that they can automatically adjust to unexpected changes in traffic conditions, improve travel time reliability, reduce congestion and fuel consumption, prolong the effectiveness of traffic signal timing, reduce the complaints that agencies receive in response to outdated signal timing, and make traffic signal operations proactive by monitoring and responding to gaps in performance. These systems are outfitted with (detection) sensors that provide real-time data to the system so that to adjust and the real-time conditions as well as measure performance and report that performance in real-time to the RTOC. Along the I-490 corridor, better management of arterials will aid in balancing the corridor's demand by improving throughput on the arterials both during recurring and non-recurring congestions periods. Lastly, intelligent traffic signal control will automatically detect and respond to ramp congestion impacts on the local arterial roads or increase volume throughput as a result of traffic being diverted from I-490 resulting from a crash or other incident.

Implementation Strategy	Associated Objectives	Associated Needs
All arterial diversion routes should be outfitted with smart traffic signal systems to improve coordination, reduce congestion and increase vehicular throughput	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools Achieve a cleaner environment by reducing emissions through the reduction of congestion (stops & delay)	Synchronization of signal plans between MCDOT and NYSDOT Event-based signal timing plans Interconnection with, and real-time information from, NYSDOT and MCDOT signal systems
All arterial diversion routes should be outfitted with smart traffic signal systems to improve situational awareness	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools Enhance planning and policy development through improved data quality and data analysis	Synchronization of signal plans between MCDOT and NYSDOT Event-based signal timing plans Interconnection with, and real-time information from, NYSDOT and MCDOT signal systems Additional detector sensors and CCTV cameras for better situational awareness

4.2.4 Vehicle Detection

Table 29: Traceability Matrix of Vehicle Detection Implementation Strategy Against ICM Project Objectives and Project Needs

VEHICLE DETECTION		
In a traffic management system, the data collected from the detection sensors or third-party providers, (e.g., HERE, etc.) supports the process in which data characterize traffic flow conditions on the expressway or arterial. The data are used to supply information about conditions on the roadway to other system components. Thus, detection provides the information needed to perform the following traffic management functions including measuring traffic flow and environmental conditions, formulating control decisions, disseminating traveler information, monitoring and evaluating system performance, supporting other expressway management and operations functions such as incident detection and verification, planned special event and emergency management, ramp management, and transportation planning.		
Implementation Strategy	Associated Objectives	Associated Needs
Detection (sensors or probes) should be provided along the entire length of the urban section of I-490	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools Enhance planning and policy development Achieve a cleaner environment by reducing emissions through the reduction of congestion	Additional detector sensors and CCTV cameras for better situational awareness
Detection (sensors or probes) should be provided between each interchange outside the urban section of I-490	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools Enhance planning and policy development Achieve a cleaner environment by reducing emissions through the reduction of congestion	Additional detector sensors and CCTV cameras for better situational awareness
Detection (sensors or probes) should be provided along the diversion routes to provide situational awareness of real-time traffic conditions	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools Enhance planning and policy development through improved data quality and data analysis	Synchronization of signal plans between MCDOT and NYSDOT Event-based signal timing plans Interconnection with, and real-time information from, NYSDOT and MCDOT signal systems Additional detector sensors and CCTV cameras for better situational awareness

4.2.5 Ramp Metering

Table 30: Traceability Matrix of Ramp Metering Implementation Strategy Against ICM Project Objectives and Project Needs

RAMP METERING		
Ramp Meters are traffic signals at expressway on-ramps that control the rate of vehicles entering the expressway. The meters can be set for different flow rates to optimize traffic flow and minimize congestion. When in operation, ramp meters will alternate between red and green lights, restricting the number of vehicles entering I-490, thereby reducing congestion, bottlenecks and managing the traffic flow on the mainline.		
Implementation Strategy	Associated Objectives	Associated Needs
Provide metering at on-ramps where I-490 congestion is significant, and the crash rates are high and dense in the ramp vicinity.	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools	Interconnection with, and real-time information from, NYSDOT and MCDOT signal systems Additional detector sensors and CCTV cameras for better situational awareness

4.2.6 Queue Warning

Table 31: Traceability Matrix of Queue Warning Implementation Strategy Against ICM Project Objectives and Project Needs

QUEUE WARNING (QW)		
QW's purpose is to inform motorists of the presence of downstream stop and-go traffic (based on real-time traffic detection) using warning signs and in some cases, flashing lights. Drivers can anticipate an upcoming situation of emergency braking and slow down, avoid erratic behavior, and reduce queuing related crashes.		
Implementation Strategy	Associated Objectives	Associated Needs
Provide a system to warn motorists approaching slowed or stopped traffic to prevent crashes	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools Enhance the quality of communications with the corridor's traveling public	Additional detector sensors and CCTV cameras for better situational awareness Additional DMS (signs) at strategic diversion locations along I-490 as well an intermittent location for travel time information display

4.2.7 Weather Monitoring

Table 32: Traceability Matrix of Weather Monitoring Implementation Strategy Against ICM Project Objectives and Project Needs

WEATHER MONITORING

There are three types of road weather management strategies that can be used to mitigate the impacts of rain, snow, ice, fog, high winds, flooding, tornadoes, hurricanes, and avalanches on the highway network:

- Advisory strategies provide information on prevailing and predicted conditions to both transportation managers and motorists. Posting fog warnings on DMS and listing flooded routes on web sites are examples of advisory strategies.
- Control strategies alter the state of roadway devices to permit or restrict traffic flow and regulate roadway capacity. Modifying traffic signal timing based on pavement conditions are examples of control strategies.
- Treatment strategies supply resources to roads to minimize or eliminate weather impacts. The most common treatment strategies are application of sand, salt, and anti-icing chemicals to pavements to improve traction and prevent ice bonding.

Implementation Strategy	Associated Objectives	Associated Needs
Provide roadway weather systems along targeted sections of I-490 (both surface and atmospheric sensors) to enhance maintenance operations during snow and ice events by being able to predict and detect snow and ice conditions	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools Enhance the ability of the organizations to deliver and manage services given limited organizational resources	Additional Road Weather Information Systems (RWIS) stations for proactive weather response

4.2.8 System Integration & Decision Support

Table 33: Traceability Matrix of System Integration & Decision Support Implementation Strategy Against ICM Project Objectives and Project Needs

SYSTEM INTEGRATION & DECISION SUPPORT		
When congested traffic conditions occur on one roadway, traffic on adjoining expressway interchanges in the corridor, are also impacted. Typically, as congestion occurs on one roadway, travelers respond in a variety of ways: finding an alternate route, selecting a different roadway (expressway versus arterial), adjusting their trip to another time of day, or remaining on their current route and enduring the significant delays.		
Implementation Strategy	Associated Objectives	Associated Needs
The NYSDOT expressway management system and the NYSDOT and MCDOT arterial traffic signal systems should be integrated with each other to provide a combined traffic response through a future Decision Support System	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools Achieve a cleaner environment by reducing emissions through the reduction of congestion Enhance planning and policy development through improved data quality and data analysis Enhance the ability of the organizations to deliver and manage services given limited organizational resources	Increased standardization/centralization of hardware/software systems to improve operational efficiency and reduce redundant effort Synchronization of signal plans between MCDOT and NYSDOT Interconnection with, and real-time information from, NYSDOT and MCDOT signal systems
Decision Support System that interfaces with both the expressway management system and the arterial management systems should be provided that enhances integrated corridor management	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools Achieve a cleaner environment by reducing emissions through the reduction of congestion Enhance planning and policy development through improved data quality and data analysis Enhance the ability of the organizations to deliver and manage services given limited organizational resources	Increased standardization/centralization of hardware/software systems to improve operational efficiency and reduce redundant effort Synchronization of signal plans between MCDOT and NYSDOT Interconnection with, and real-time information from, NYSDOT and MCDOT signal systems

4.2.9 Field Communications

Table 34: Traceability Matrix of Field Communications Implementation Strategy Against ICM Project Objectives and Project Needs

FIELD COMMUNICATIONS ICM relies on a significant amount of ITS field infrastructure resources such as CCTV cameras, detection sensors, DMS, etc. It is critical that there be enough connectivity to support the devices across the geographic area to be covered.		
Implementation Strategy	Associated Objectives	Associated Needs
The ITS communication network should be expanded along I-490 to provide continuous deployment of ITS devices beyond the current deployment. It would also serve to support future connected and automated vehicle deployment.	Achieve greater safety and mobility in traffic operations with better monitoring, control, and feedback tools Traceability Matrix of Field Communications Implementation Strategy Against ICM Project Objectives and Project Needs Achieve a cleaner environment by reducing emissions through the reduction of congestion Enhance the ability of the organizations to deliver and manage services given limited organizational resources	Interconnection with, and real-time information from, NYSDOT and MCDOT signal systems Additional detector sensors and CCTV cameras for better situational awareness Additional DMS (signs) at strategic diversion locations along I-490 as well an intermittent location for travel time information display Additional RWIS stations for proactive weather response

4.2.10 Modal Integration

Table 35: Traceability Matrix of Modal Integration Implementation Strategy Against ICM Project Objectives and Project Needs

MODAL INTEGRATION		
ICM is founded on balancing the traveler demand across expressway, arterial and transit. When both recurring and non-recurring congestion occurs, there is value in reducing the number of vehicles on the expressway or arterial by switching travelers to transit. This is done by providing real-time information on transit options and providing a hub for motorists to change to transit. This is a two-fold exercise comprised of providing information to motorists on real-time transit (next-bus, etc.) using in-vehicle (display device) and DMS notifications, as well as parking availability at transit-equipped Park & Ride Lots		
Implementation Strategy	Associated Objectives	Associated Needs
Alternate transit mode information should be provided to en route and pre-trip travelers including available parking spaces at transit Park & Ride lots and next bus information	Achieve a cleaner environment by reducing emissions through the reduction of congestion Enhance planning and policy development through improved data quality and data analysis Enhance the ability of the organizations to deliver and manage services given limited organizational resources	Communication to motorists on the availability of transit status

5 RECOMMENDATIONS

This chapter will present the specific recommendations that address the needs and meet the goals of ICM and the objectives of this project. The recommendations will be categorized and presented by infrastructure, operational/policy, and Regional ITS Architecture recommendations. The recommendations will be prioritized and presented in maps where infrastructure is involved. In addition to the prioritized recommendations, this chapter identifies other strategies and deployments that could provide benefit to ICM, but not in the foreseeable future. These recommendations are identified for further study in the future.

5.1 Prioritization

The recommendations herein, are categorized by priority based of need. They are fiscally unconstrained and are a menu of recommendations that should be considered and assessed further for program-or project-level implementation. The priority categories that follow are meant to rate a recommendation's importance to ICM, not imply the order of deployment. As traditional transportation planning dictates, these recommendations will be assessed in more detail to determine what recommendations are implemented.

The priority categories are:

High Priority (H):	These strategic recommendations are necessary, and the goal of having an ICM program to support operations cannot be achieved without them. These are <u>must dos.</u>
Medium Priority (M)	These elements bring significant improvement to integrating the corridor to support operations and are strongly desired. The goal of having an integrated corridor management program to support operations and attain compliance with priority result areas can still reached without these elements; however, they bring significant improvement to the program.
Low Priority (L)	These elements bring some benefit to integrated corridor management but are not highly desired because they either bring little benefit or are not financially feasible.

5.2 ITS Infrastructure

This section will identify the preferred strategy, location, priority and justification for future ITS infrastructure deployments required to realize the capabilities identified in Task 3 and the recommended strategies in this Tech Memo. These will address expressway, arterial and transit infrastructure. Recommended devices were identified based upon the volume of traffic and crashes in the identified sections. Crash and volume data and their associated heat maps were developed to show these areas. The data and heat maps can be found in the Appendix.

The maps and associated tables in this section display the recommended locations of future ITS field instrumentation. However, these locations are intended to be conceptual and provide a guide to where ITS devices should be placed along the I-490 corridor. For example, a proposed CCTV camera icon may be placed on a section map, and a textual recommendation associated with that icon in the recommendations table, however this icon depicts the need for CCTV camera coverage in that vicinity; not the actual location, nor does it mean that a single camera will be needed. The site-specific locations of new ITS field instrumentation will be determined by engineering assessments that consider factors such as device coverage needs, site access, power and communications connections, and foundation needs.

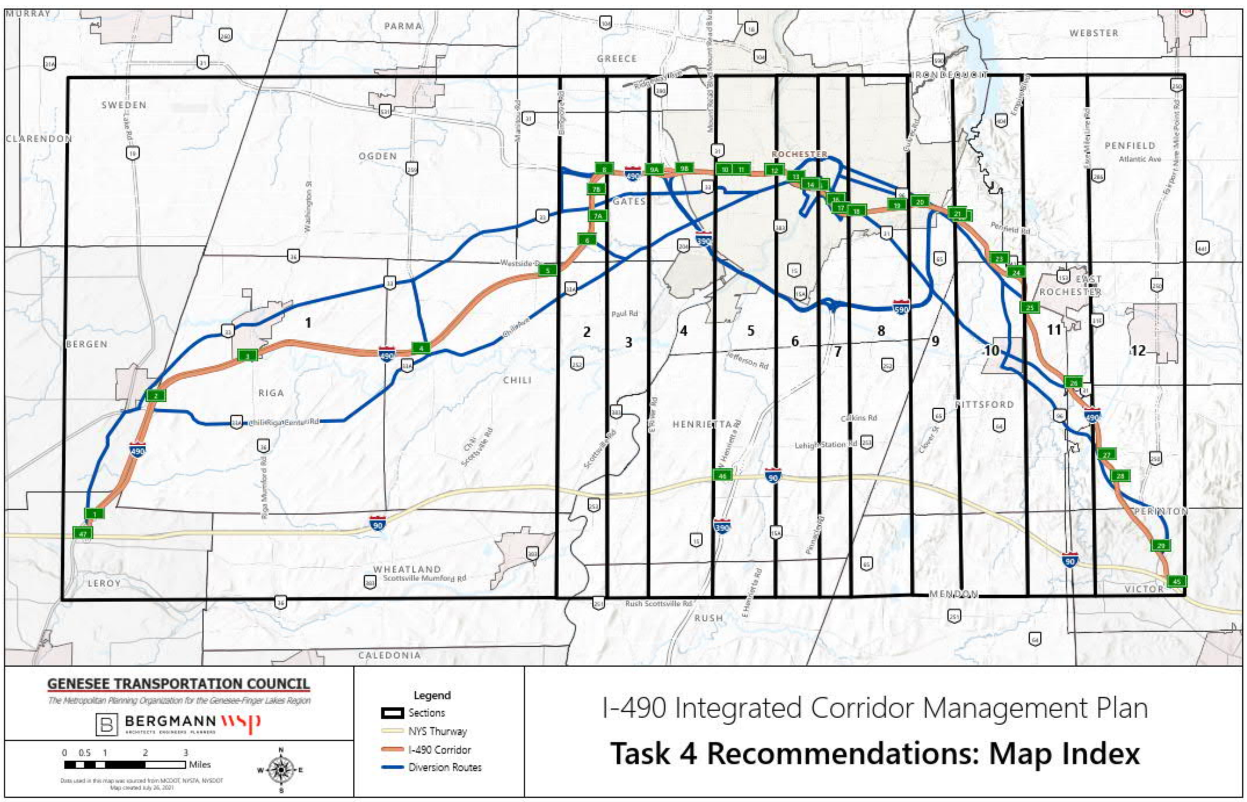
5.2.1 ITS Device Infrastructure - Expressways

The recommendations that follow are specifically proposed for application for I-490. These recommendations include infrastructure placed along I-490 as well as on I-390, I-590, NY-590, NY-531, and other arterials on their approach to I-490. Specific recommendations related to arterial improvements are found in section 5.2.2.

Due to the geographic extent of the corridor, the I-490 corridor was divided into twelve sections to facilitate better presentation of the recommended deployments. These sections, illustrated in Figure 14, were determined based the ability to clearly display current and proposed ITS field instrumentation on the maps.

The arterial infrastructure recommendations are presented separately in Section 5.2.2.

Figure 14: I-490 Segment Index for ITS and Communication Infrastructure Recommendations



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5.2.1.1 Section 1: Thruway Interchange 46 to I-490 Exit 6 (NY-204) – refer to Figure 15

Table 36: ITS Device Recommendations for Section 1 (Thruway Interchange 46 to I-490 Exit 6 (NY-204))

Map Section	Strategy	Deployment Location	Number	Agency	Priority	Reason
1	Install DMS at key diversion areas	EB I-490 in advance of Exit 6 (NY 204)	1-1	NYSDOT	H	This area experiences a higher frequency of crashes
	Install detection sensors at key corridor locations	I-490 from I-90 Interchange 47 to Exit 9 (I-390)	1-2	NYSDOT	H	I-490 crashes in this section to warrant surveillance along with traffic flow and speeds
	Install CCTV cameras at key corridor locations and interchanges	I-490 at Exit 1 (NY 19)	1-3	NYSDOT	M	To monitor traffic operations at the interchange
		I-490 at Exit 2 (NY 33 / NY 33A)	1-4	NYSDOT	M	To monitor traffic operations at the interchange
		EB I-490 in advance (west) of Exit 3 (NY 36)	1-5	NYSDOT	M	There is a higher frequency of crashes between Exit 2 and Exit 3 to warrant surveillance along this section of I-490
		I-490 at Exit 3 (NY 36)	1-6	NYSDOT	M	To monitor traffic operations at the interchange
		I-490 at Exit 4 (NY 259)	1-7	NYSDOT	M	To monitor traffic operations at the interchange
		I-490 at Exit 5 (NY 386)	1-8	NYSDOT	M	To monitor traffic operations at the interchange

Figure 15: ITS Device Recommendations for Section 1 (Thruway Interchange 46 to I-490 Exit 6 (NY-204)

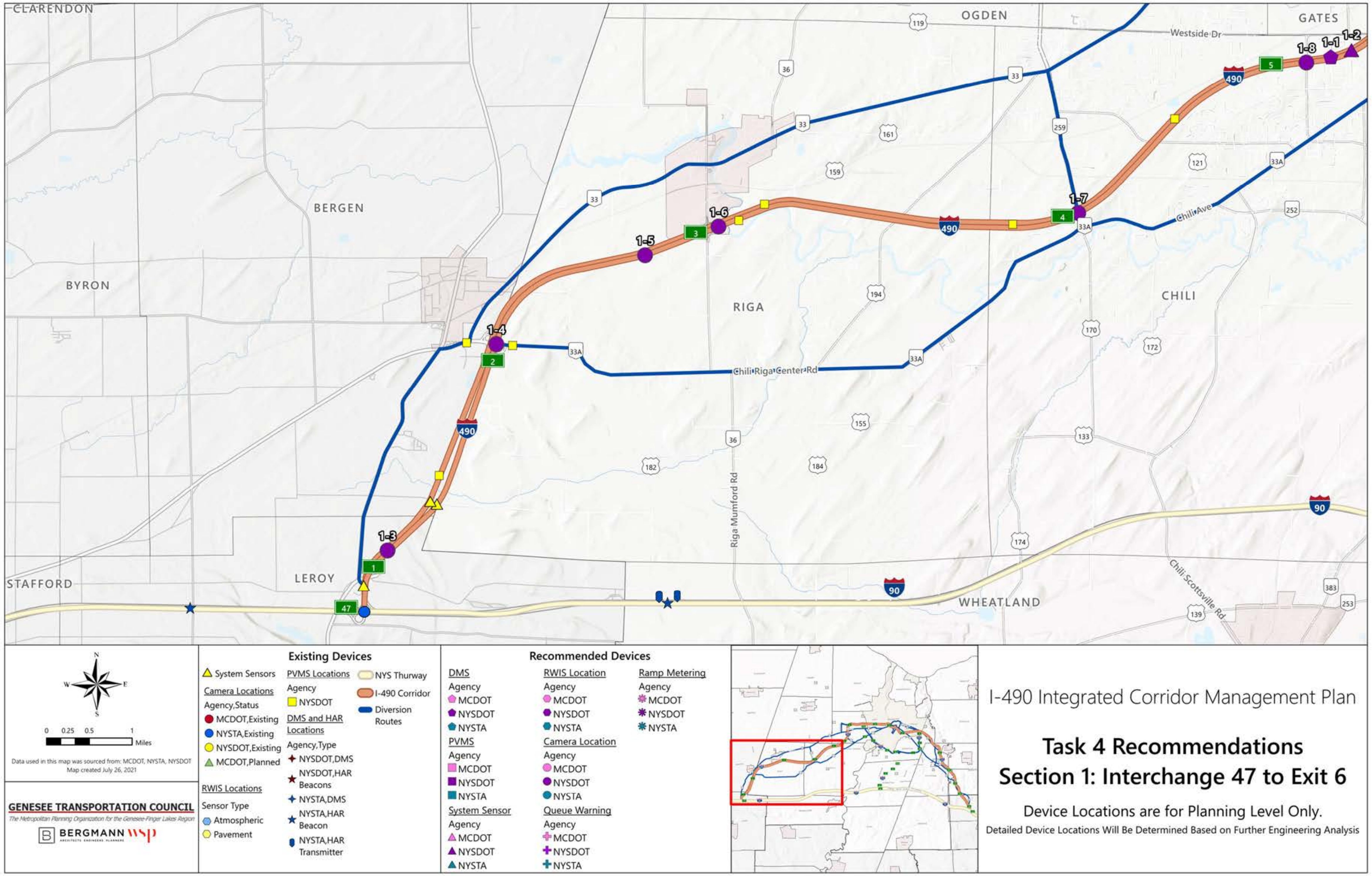
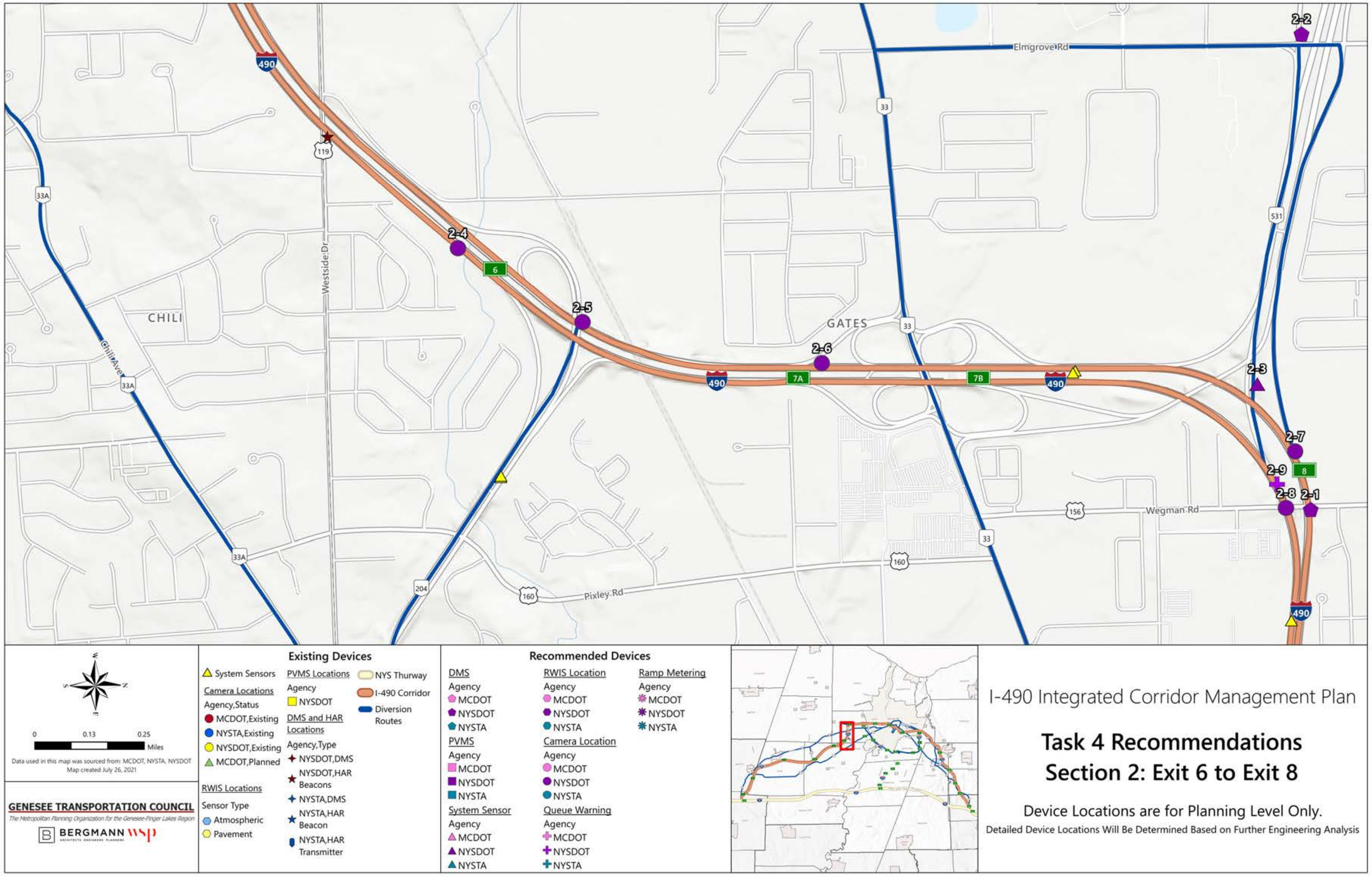


Figure 16: ITS Device Recommendations for Section 2 (Exit 6 (NY-204) to Exit 8 (NY-531))



5.2.1.2 Section 2: Exit 6 (NY-204) to Exit 8 (NY-531) – refer to Figure 16

Table 37: ITS Device Recommendations for Section 2 (Exit 6 (NY-204) to Exit 8 (NY-531))

Map Section	Strategy	Deployment Location	Number	Agency	Priority	Reason
2	Install DMS at key diversion areas	WB I-490 in advance of Exit 8 (NY 531)	2-1	NYSDOT	H	NY 531 is a good diversion route to Elmgrove Rd. (CR 158) if the there is an incident WB on I-490 west of NY 531
		NY 531 EB in advance of Elmgrove Rd. (CR 158)	2-2	NYSDOT	M	Traffic volumes on I-490 increase east of NY 531. Elmgrove Rd. (CR 158) can be a good diversion route to NY 33
	Install detection sensors at key corridor locations	NY 531 from I-490 Exit 8 to Elmgrove Rd. (CR 158)	2-3	NYSDOT	H	This is an important diversion route and should be monitored for traffic flow
	Install CCTV cameras at key corridor locations and interchanges	EB I-490 in advance of NY 204 (west of Exit 6)	2-4	NYSDOT	M	There is a higher frequency of crashes in this area, where an incident may cause congestion impacts
		I-490 at Exit 6 (NY 204)	2-5	NYSDOT	M	To monitor traffic operations at the interchange
		I-490 at Exit 7 (NY 33)	2-6	NYSDOT	M	To monitor traffic operations at the interchange
		I-490 at Exit 8 (NY 531)	2-7	NYSDOT	H	To monitor traffic operations at the interchange
		WB I-490 in advance of NY 531 (east of Exit 8)	2-8	NYSDOT	H	There is a higher frequency of crashes in this area, where an incident may cause congestion impacts
	Implement queue warning at key corridor areas	EB I-490 in advance of Exit 8 (NY 531)	2-9	NYSDOT	H	There is a higher frequency of crashes in this area, where an incident may cause congestion impacts

5.2.1.3 Section 3: Exit 8 (NY-531) to Exit 9 (I-390)

Table 38: ITS Device Recommendations for Section 3 (Exit 8 (NY-531) to Exit 9 (I-390))

Map Section	Strategy	Deployment Location	Number	Agency	Priority	Reason
3	No expressway recommendations in this section. Refer to arterial traffic signals recommendations in section 5.2.2					

5.2.1.4 Section 4: Exit 9 (I-390) to Exit 10 (Mt. Read Blvd.) – refer to Figure 17

Table 39: ITS Device Recommendations for Section 4 (Exit 9 (I-390) to Exit 10 (Mt. Read Blvd.))

Map Section	Strategy	Deployment Location	Number	Agency	Priority	Reason
4	Deploy RWIS at key corridor areas	Install RWIS Station on I-490 between Exit 9 (I-390) and Exit 13 (Inner Loop)	4-1	NYSDOT	H	There were approximately 200 snow and ice related crashes along I-490 in this section (in 5-year analysis period)
	Implement queue warning at key corridor areas	WB I-490 in advance of Exit 9 (I-390)	4-2	NYSDOT	H	This area has high traffic volumes and a higher frequency of crashes, where an incident may cause significant congestion impacts
	Install CCTV cameras at key corridor locations and interchanges	I-490 west of Exit 10 (Mt. Read Blvd.)	4-3	NYSDOT	H	To monitor traffic operations at the interchange

Figure 17: ITS Device Recommendations for Section 4 (Exit 9 (I-390) to Exit 10 (Mt. Read Blvd.))

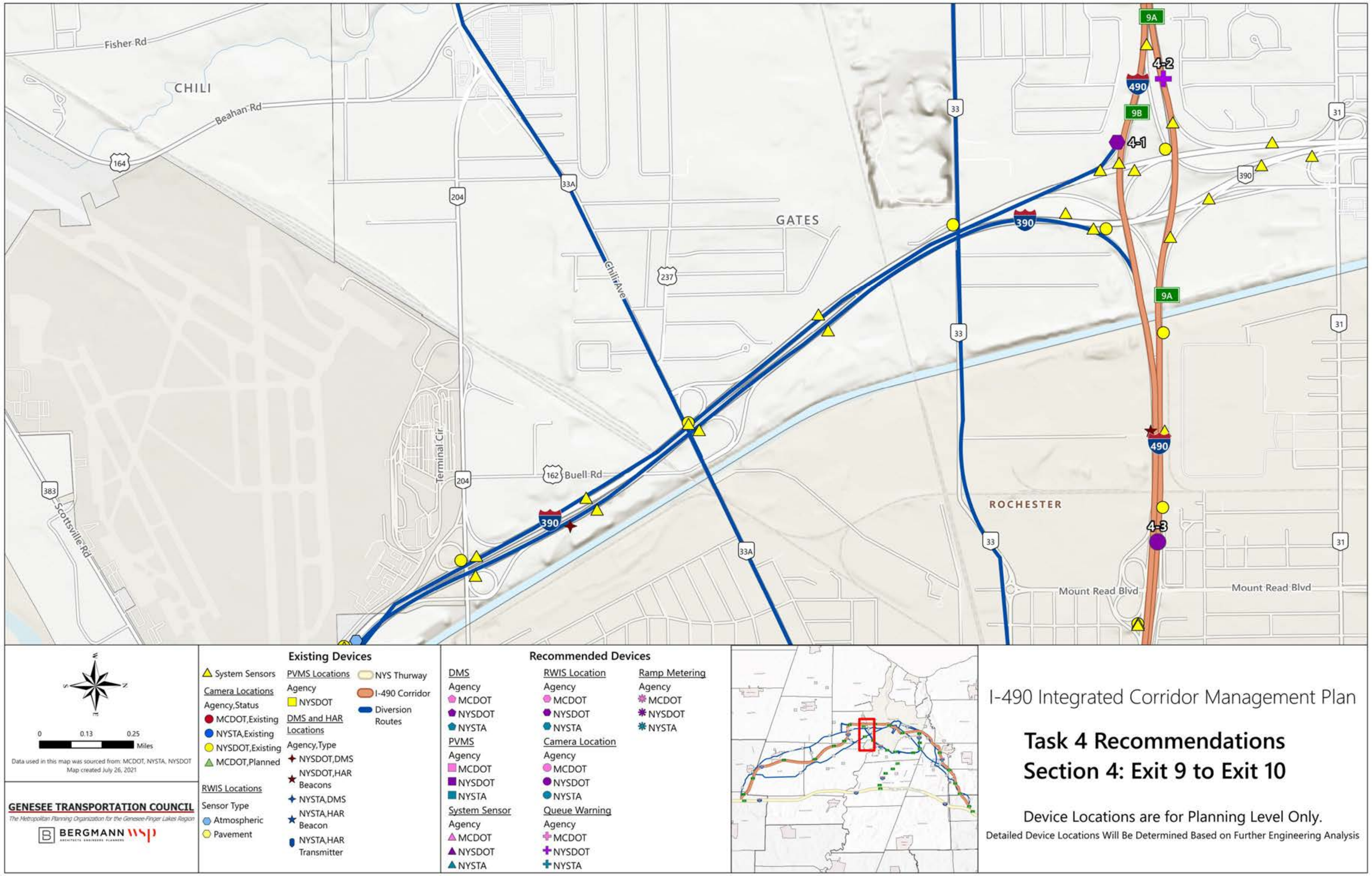
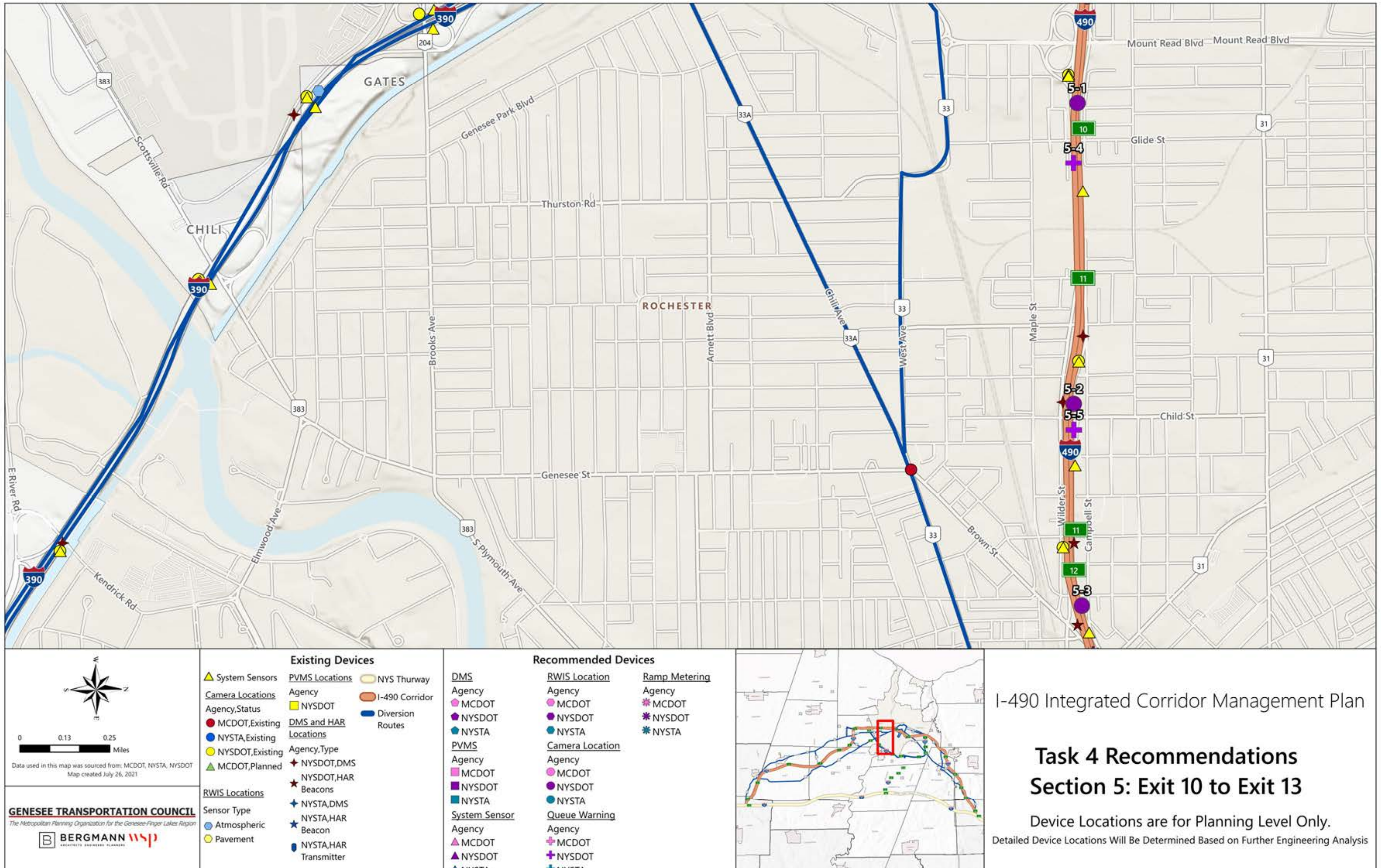


Figure 18: ITS Device Recommendations for Section 5 (Exit 10 (Mt. Read Blvd.) to Exit 13 (Inner Loop))



5.2.1.5 Section 5: Exit 10 (Mt. Read Blvd.) to Exit 13 (Inner Loop) – refer to Figure 18

Table 40: ITS Device Recommendations for Section 5 (Exit 10 (Mt. Read Blvd.) to Exit 13 (Inner Loop))

Map Section	Strategy	Deployment Location	Number	Agency	Priority	Reason
5	Install CCTV cameras at key corridor locations and interchanges	I-490 east of Exit 10 (Mt. Read Blvd.)	5-1	NYSDOT	H	To monitor traffic operations at the interchange
		I-490 at Exit 11 (Ames St. / Child St.)	5-2	NYSDOT	H	To monitor traffic operations at the interchange
		I-490 at Exit 12 (Broad St. / Brown St.)	5-3	NYSDOT	H	To monitor traffic operations at the interchange
	Implement queue warning at key corridor areas	WB I-490 in advance of Exit 10 (Mt. Read Blvd.)	5-4	NYSDOT	H	This area has high traffic volumes and a higher frequency of crashes, where an incident may cause significant congestion impacts
		EB I-490 in advance of Exit 11 (Child St.)	5-5	NYSDOT	H	This area has high traffic volumes and a higher frequency of crashes, where an incident may cause significant congestion impacts

5.2.1.6 Section 6: Exit 13 (Inner Loop) to Exit 15 (NY-15, NY-31, South Ave.) – refer to Figure 19

Table 41: ITS Device Recommendations for Section 6 (Exit 13 (Inner Loop) to Exit 15 (NY-15, NY-31, South Ave.))

Map Section	Strategy	Deployment Location	Number	Agency	Priority	Reason
6	Install CCTV cameras at key corridor locations and interchanges	I-490 at Exit 13 (Inner Loop)	6-1	NYSDOT	H	To monitor traffic operations at the interchange
		I-490 at Exit 14 (Broad St. / Plymouth Ave.)	6-2	NYSDOT	H	To monitor traffic operations at the interchange
		I-490 at Exit 15 (NY 31 / NY 15 / South Ave.)	6-3	NYSDOT	H	To monitor traffic operations at the interchange
	Install Queue Warning at key corridor areas	EB I-490 in advance of Exit 15 (South Ave.)	6-4	NYSDOT	H	This area has high traffic volumes and a higher frequency of crashes, where an incident may cause significant congestion impacts
		WB I-490 in advance of Exit 13 on ramp from Inner Loop / Plymouth Ave.	6-5	NYSDOT	H	This area has high traffic volumes and a higher frequency of crashes, where an incident may cause significant congestion impacts
	Implement Ramp Metering	Exit 13 WB I-490 Ramp from Brown St.	6-6	NYSDOT	L	This is a congestion point during PM peak periods. There is significant entering volume from this ramp and sufficient storage exists on the ramp.

Figure 19: ITS Device Recommendations for Section 6 (Exit 13 (Inner Loop) to Exit 15 (NY-15, NY-31, South Ave.)

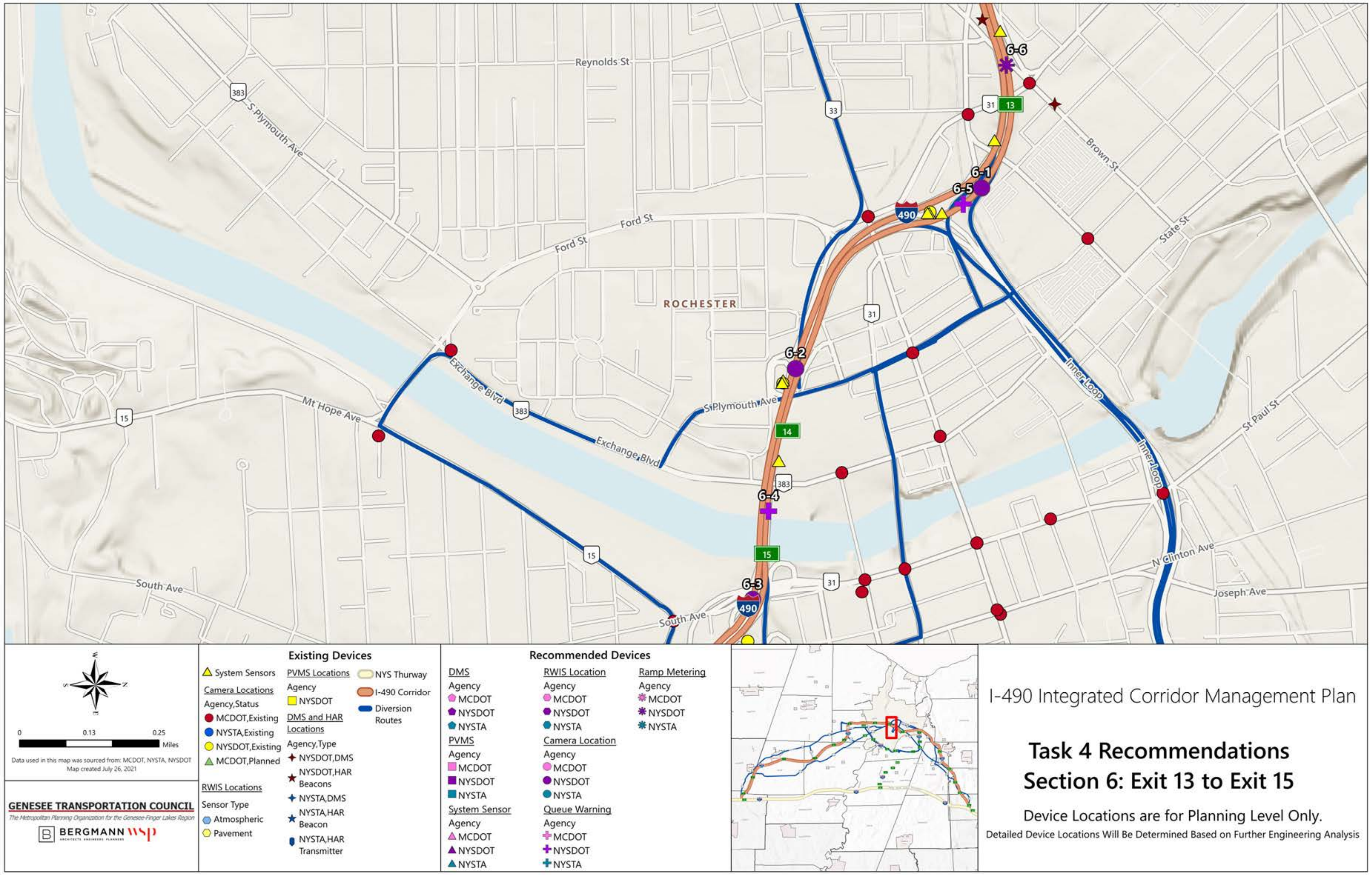
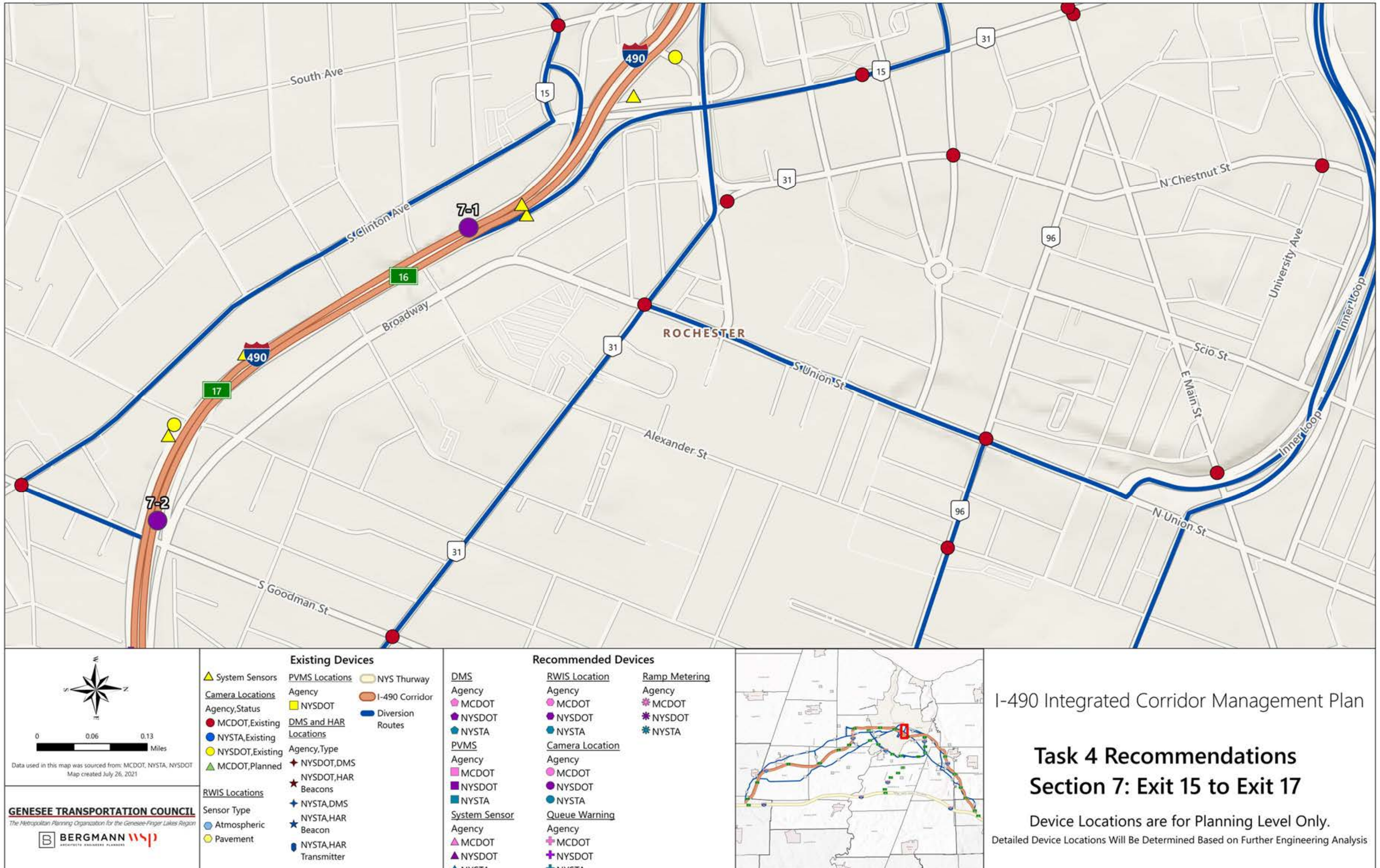


Figure 20: ITS Device Recommendations for Section 7 (Exit 15 (NY-15, NY-31, South Ave.) to Exit 17 (Goodman St.))



5.2.1.7 Section 7: Exit 15 (NY-15, NY-31, South Ave.) to Exit 17 (Goodman St.) – refer to Figure 20

Table 42: ITS Device Recommendations for Section 7 (Exit 15 (NY-15, NY-31, South Ave.) to Exit 17 (Goodman St.)

Map Section	Strategy	Deployment Location	Number	Agency	Priority	Reason
7	Install CCTV cameras at key corridor locations and interchanges	I-490 at Exit 16 (NY 15 / Clinton Ave.)	7-1	NYSDOT	H	To monitor traffic operations at the interchange
		I-490 at Exit 17 (Goodman St. / Broadway)	7-2	NYSDOT	H	To monitor traffic operations at the interchange

5.2.1.8 Section 8: Exit 17 (Goodman St.) to Exit 20 (Winton Rd.) – refer to Figure 21

Table 43: ITS Device Recommendations for Section 8 (Exit 17 (Goodman St.) to Exit 20 (Winton Rd.))

Map Section	Strategy	Deployment Location	Number	Agency	Priority	Reason
8	Install CCTV cameras at key corridor locations and interchanges	I-490 at Exit 18 (NY 31 / Monroe Ave.)	8-1	NYSDOT	H	To monitor traffic operations at the interchange
		I-490 at Exit 19 (Culver Rd.)	8-2	NYSDOT	H	To monitor traffic operations at the interchange
	Implement queue warning at key corridor areas	WB I-490 in advance of Culver Rd. (Exit 19)	8-3	NYSDOT	H	This area has high traffic volumes and a higher frequency of crashes, where an incident may cause significant congestion impacts
		EB I-490 in advance of Monroe Ave. (Exit 18)	8-4	NYSDOT	H	This area has high traffic volumes and a higher frequency of crashes, where an incident may cause significant congestion impacts

Figure 21: ITS Device Recommendations for Section 8 (Exit 17 (Goodman St.) to Exit 20 (Winton Rd.))

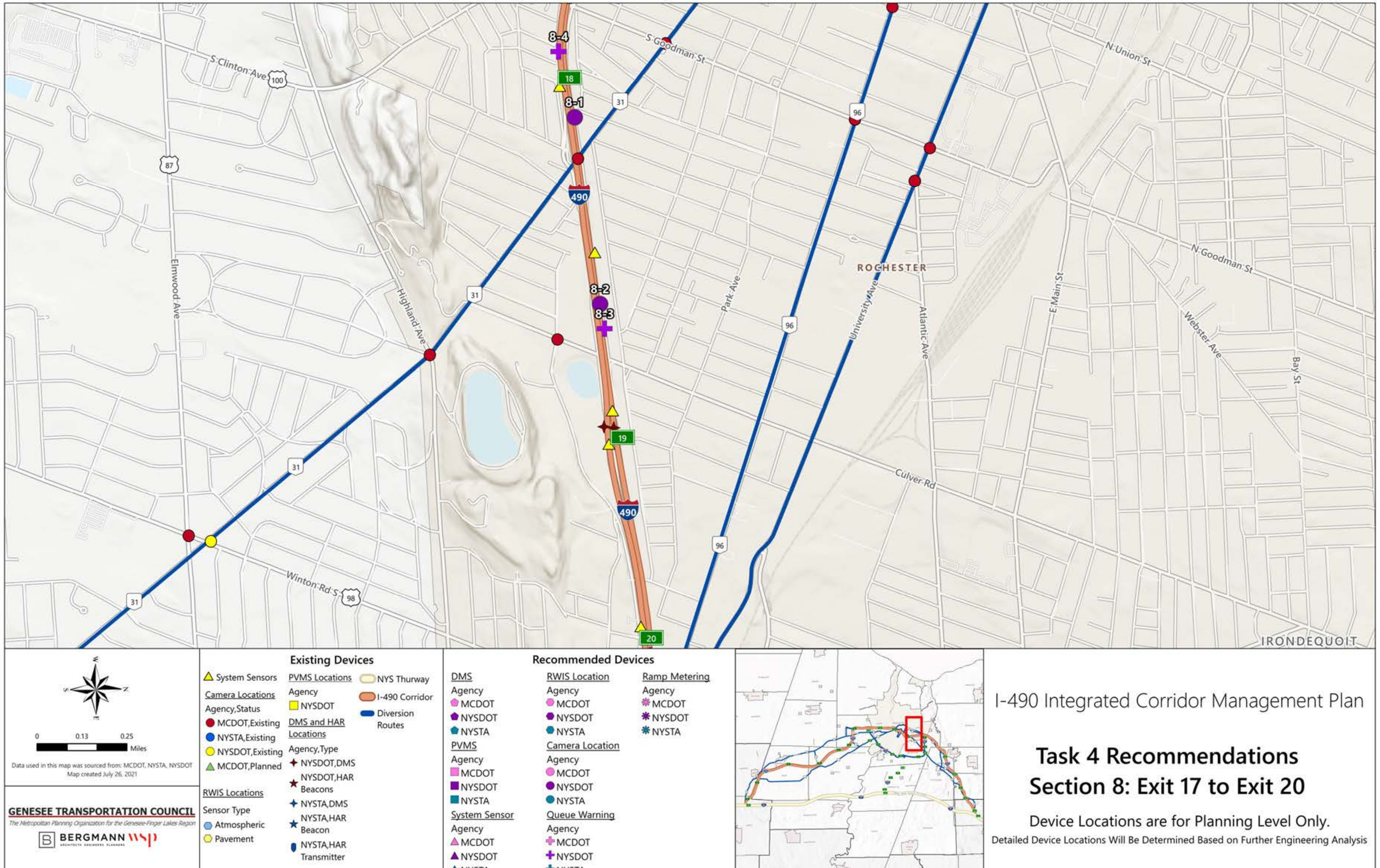


Figure 22: ITS Device Recommendations for Section 9 (Exit 20 (Winton Rd.) to Exit 22 (Penfield Rd.))

5.2.1.9 Section 9: Exit 20 (Winton Rd.) to Exit 22 (Penfield Rd.) – refer to Figure 22

Table 44: ITS Device Recommendations for Section 9 (Exit 20 (Winton Rd.) to Exit 22 (Penfield Rd.))

Map Section	Strategy	Deployment Location	Number	Agency	Priority	Reason
9	Install CCTV cameras at key corridor locations and interchanges	I-490 at Exit 20 (Winton Rd.)	9-1	NYSDOT	H	To monitor traffic operations at the interchange
	Install RWIS at key corridor areas	Install RWIS Station on I-490 in the vicinity of I-590 (Exit 21)	9-2	NYSDOT	H	There were approximately 130 snow and ice related crashes along I-490 in this area (in 5-year analysis period).
	Implement Ramp Metering	WB I-490 ramp from Winton Rd. (Exit 20)	9-3	NYSDOT	L	This is a congestion point during AM peak period. There is significant entering volume from this ramp

5.2.1.10 Section 10: Exit 22 (Penfield Rd.) to Exit 25 (NY-31F) – refer to Figure 23

Table 45: ITS Device Recommendations for Section 10 (Exit 22 (Penfield Rd.) to Exit 25 (NY-31F))

Map Section	Strategy	Deployment Location	Number	Agency	Priority	Reason
10	Install DMS at key diversion areas	NY 441 WB in advance of I-490	10-1	NYSDOT	M	Traffic volumes on I-490 increase west of NY 441. NY 96 can be a good diversion route if there is an incident or delays on I-490
		WB I-490 in advance of NY 441 (Exit 23)	10-2	NYSDOT	H	This area has a higher frequency of crashes, where an incident may cause congestion impacts
	Install CCTV cameras at key corridor locations and interchanges	I-490 at Exit 22 (Penfield Rd.)	10-3	NYSDOT	H	To monitor traffic operations at the interchange
		WB I-490 in advance of NY 441 (east of Exit 23)	10-4	NYSDOT	H	This area has high traffic volumes and a higher frequency of crashes, where an incident may cause congestion impacts
		I-490 at Exit 24 (East Rochester)	10-5	NYSDOT	H	To monitor traffic operations at the interchange
	Implement queue warning at key corridor areas	WB I-490 in advance of NY 441 (Exit 23)	10-6	NYSDOT	H	This area has high traffic volumes and a higher frequency of crashes, where an incident may cause congestion impacts
		EB I-490 in advance of Penfield Rd. (Exit 22)	10-7	NYSDOT	H	This area has high traffic volumes and a higher frequency of crashes, where an incident may cause congestion impacts
	Implement Ramp Metering	WB I-490 Ramp from NY 441 (Exit 23)	10-8	NYSDOT	L	This is a congestion point during AM and PM peak periods. There is significant entering volume from this ramp with a short merge distance.

Figure 23: ITS Device Recommendations for Section 10 (Exit 22 (Penfield Rd.) to Exit 25 (NY-31F))

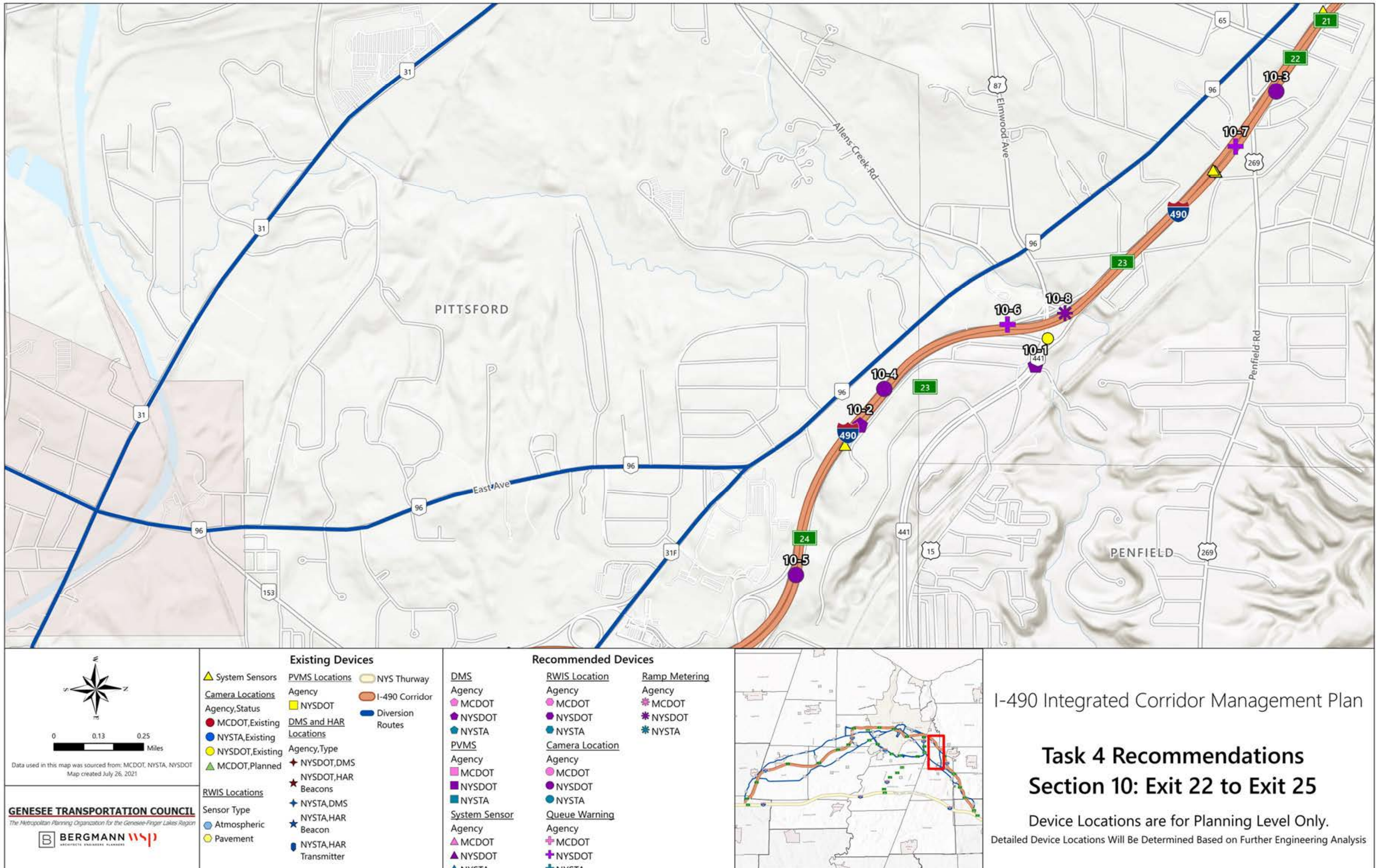
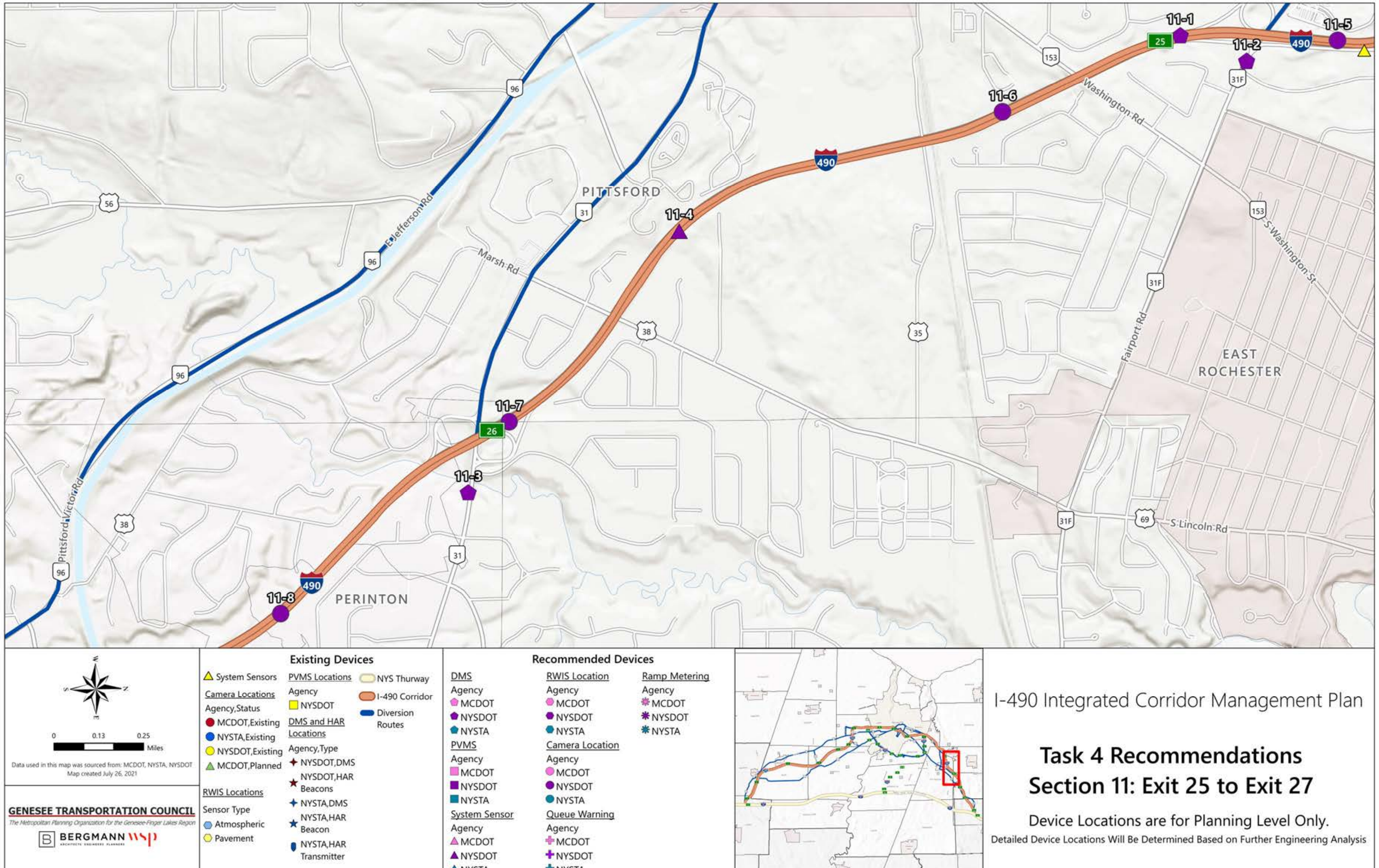


Figure 24: ITS Device Recommendations for Section 11 (Exit 25 (NY-31F) to Exit 27 (NY-96, Bushnell's Basin)



5.2.1.11 Section 11: Exit 25 (NY-31F) to Exit 27 (NY-96, Bushnell's Basin) - refer to Figure 24

Table 46: ITS Device Recommendations for Section 11 (Exit 25 (NY-31F) to Exit 27 (NY-96, Bushnell's Basin))

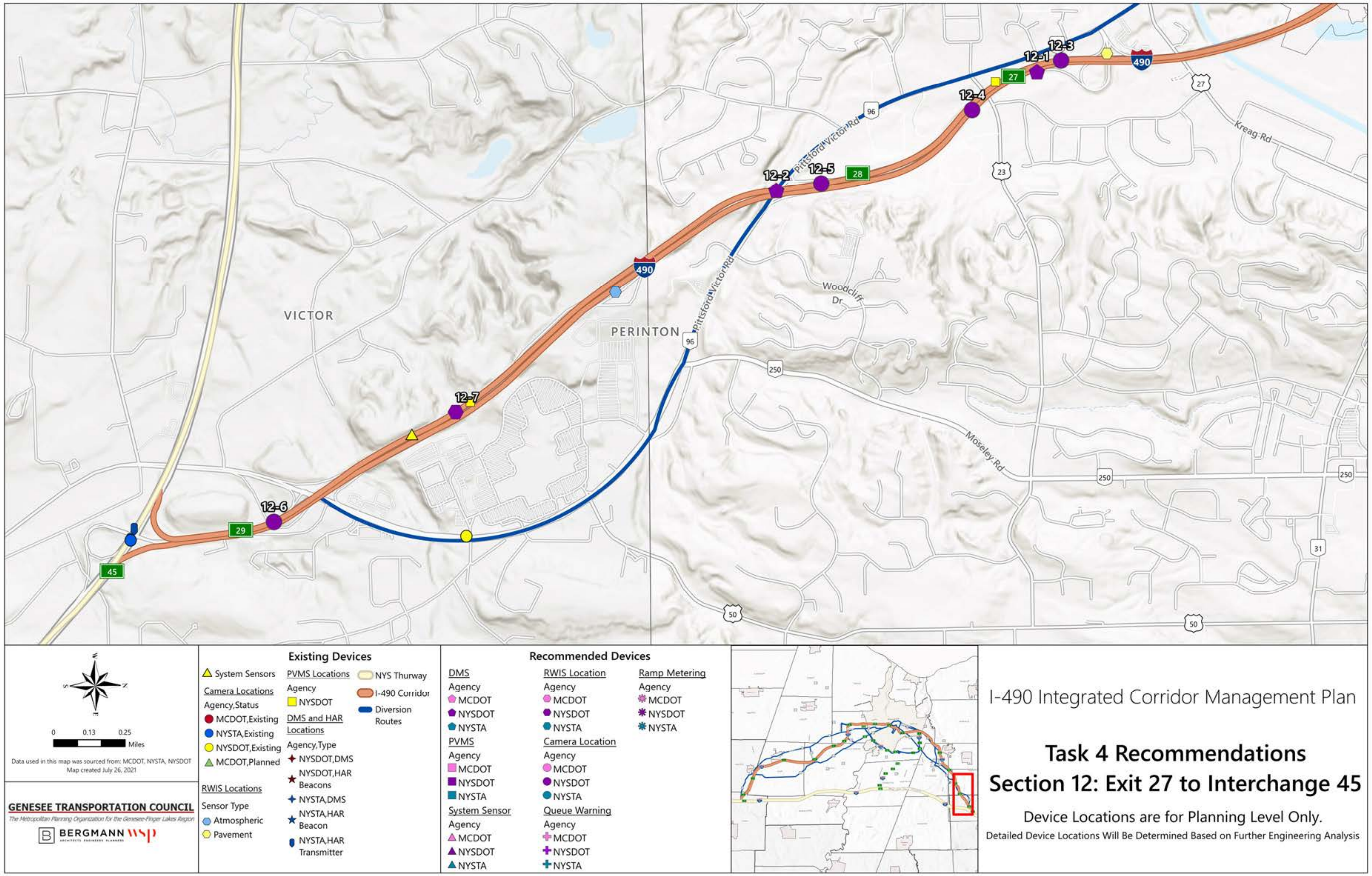
Map Section	Strategy	Deployment Location	Number	Agency	Priority	Reason
11	Install DMS at key diversion areas	WB I-490 in advance of NY 31F (Exit 25)	11-1	NYSDOT	H	Traffic volumes on I-490 increase west of exit 25 and NY 31F and NY 96 can be a good diversion route if there is an incident or delays on I-490
		NY 31F WB in advance of I-490 (Exit 25)	11-2	NYSDOT	M	Traffic volumes on I-490 increase west of NY 31F. NY 31F can be a good diversion route if there is an incident or delays on I-490
		NY 31 WB in advance of I-490 (Exit 26)	11-3	NYSDOT	M	Traffic volumes on I-490 increase west of NY 31. NY 31 can be a good diversion route if there is an incident or delays on I-490
	Install detection sensors at key corridor locations	I-490 from Exit 23 (NY 441) to I-90 Interchange 45	11-4	NYSDOT	H	This area has a higher frequency of crashes, where an incident may cause congestion impacts
	Install CCTV cameras at key corridor locations and interchanges	I-490 at Exit 25 (NY 31F)	11-5	NYSDOT	H	To monitor traffic operations at the interchange
		WB I-490 in advance of NY 31F (east of Exit 25)	11-6	NYSDOT	H	This area has a higher frequency of crashes, where an incident may cause congestion impacts
		I-490 at Exit 26 (NY 31)	11-7	NYSDOT	M	To monitor traffic operations at the interchange
		WB I-490 in advance of NY 31 (east of Exit 26)	11-8	NYSDOT	H	This area has a higher frequency of crashes, where an incident may cause congestion impacts

5.2.1.12 Section 12: Exit 27 (NY-96, Bushnell's Basin) to Thruway Interchange 45 – refer to Figure 25

Table 47: ITS Device Recommendations for Section 12 (Exit 27 (NY-96, Bushnell's Basin) to Thruway Interchange 45)

Map Section	Strategy	Deployment Location	Number	Agency	Priority	Reason
12	Install DMS at key diversion areas	WB I-490 in advance of Exit 27 (NY 96 - Bushnell's Basin)	12-1	NYSDOT	M	Traffic volumes on I-490 increase west of Exit 27 and NY 96 can be a good diversion route if there is an incident or delays on I-490
		EB I-490 in advance of Exit 28 (NY 96)	12-2	NYSDOT	M	If there is an incident or closure of I-90, NY 96 can serve as a good diversion route
	Install CCTV cameras at key corridor locations and interchanges	I-490 at Exit 27 (NY 96 - Bushnell's Basin)	12-3	NYSDOT	M	To monitor traffic operations at the interchange
		WB I-490 in advance of NY 96 (east of Exit 27)	12-4	NYSDOT	H	This area a higher frequency of crashes, where an incident may cause congestion impacts
		I-490 at Exit 28 (NY 96)	12-5	NYSDOT	M	To monitor traffic operations at the interchange
		I-490 at Exit 29 (NY 96 - Victor)	12-6	NYSDOT	M	To monitor traffic operations at the interchange
	Install RWIS at key corridor areas	Install RWIS Station on I-490 between Exit 27 (NY 96 - Bushnell's Basin) and Exit 29 (NY 96 - Victor)	12-7	NYSDOT	H	There were approximately 170 snow and ice related crashes along I-490 in this area (in 5-year analysis period).

Figure 25: ITS Device Recommendations for Section 12 (Exit 27 (NY-96, Bushnell's Basin) to Thruway Interchange 45)



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5.2.2 ITS Device Infrastructure - Arterials

This section presents recommendations for application on arterials to improve arterial mobility. In every case, the recommendation is for the implementation of Intelligent Traffic Signal Control along the length of the arterials where diversion from I-490 will occur. Intelligent Traffic Signal Control will provide the RTOC and its operators to know, in real-time, the condition of the arterial as well as allow for the real-time control of the traffic signals.

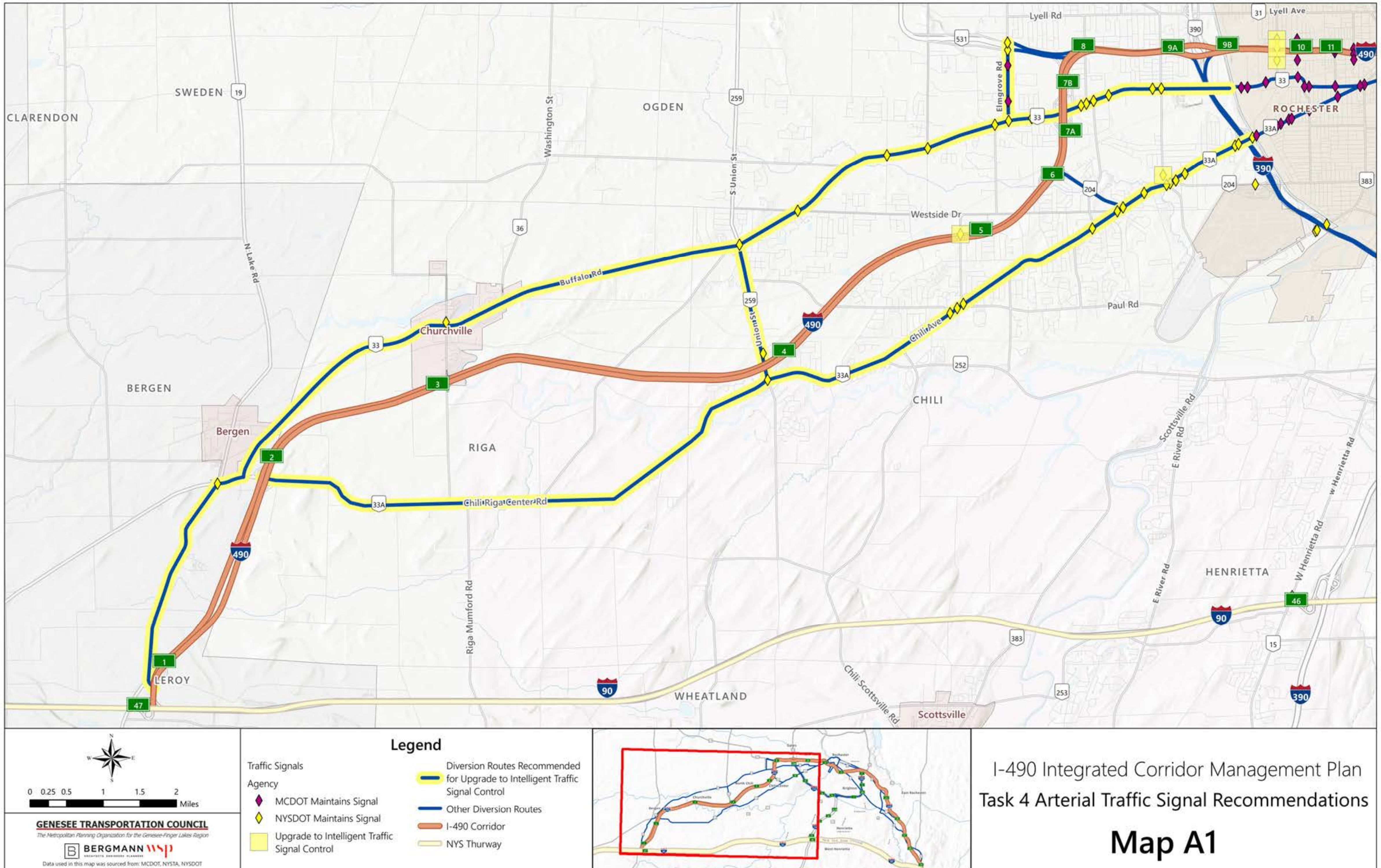
Due to the geographic extent of the corridor the arterial recommendations are displayed in three maps (Figure 26, Figure 27, and Figure 28).

5.2.2.1 Map A1: NY 33, NY 33A, NY-259, Elmgrove Rd., I-490 Interchanges at Exits 5 and 10 – refer to Figure 26

Table 48: Arterial Recommendations Along NY-33, NY-33A, NY-259, Elmgrove Rd., and I-490 Interchanges at Exits 5 and 10

Map	Strategy	Deployment Location	Agency	Priority	Reason
A1	Install intelligent traffic signal control	NY 33A from NY 204 to City of Rochester line	NYSDOT	H	This is an important diversion route and should be monitored for traffic flow
		NY 33 from Elmgrove Rd. (CR 158) to City of Rochester line	NYSDOT	H	This is an important diversion route and should be monitored for traffic flow
		NY-259 from I-490 to NY-33	NYSDOT	H	This is an important diversion route and should be monitored for traffic flow
		Elmgrove Rd. from NY-33 to NY-531	NYSDOT, MCDOT	H	This is an important connection at the I-490/NY-531 interchange
		I-490 Exits 5 and 10 Interchange signals	NYSDOT	M	While not critical diversion routes, intelligent traffic signal control at the interchanges would provide more efficient incident management along I-490

Figure 26: Intelligent Traffic Signal Control Recommendations for NY 33, NY 33A, NY-259, Elmgrove Rd., I-490 Interchanges at Exits 5 and 10



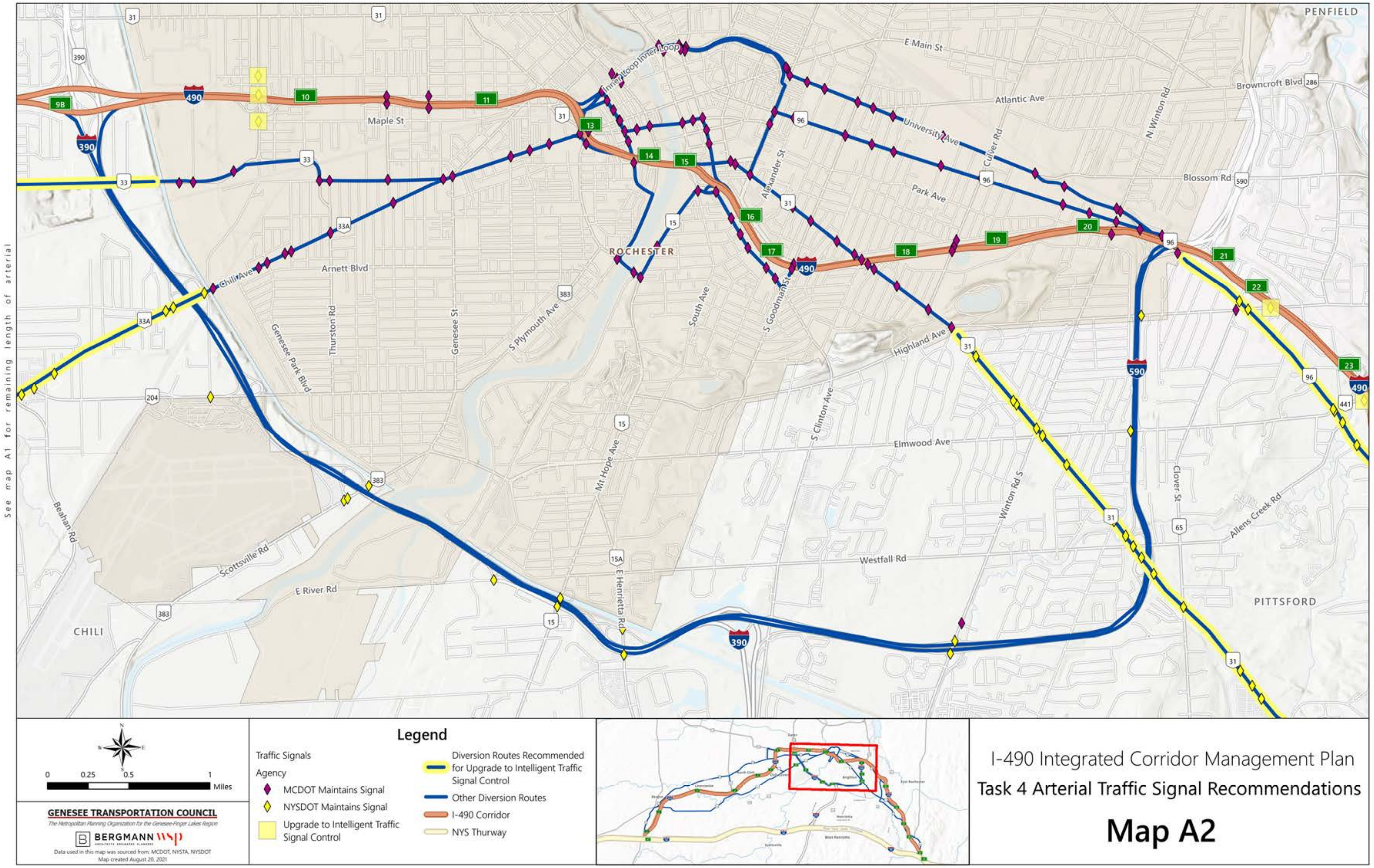


Figure 27: Intelligent Traffic Signal Control Recommendations for NY-33, NY-33A, NY-31, NY-96, I-490 Interchanges at Exits 10, 22, and 23

5.2.2.2 Map A2: NY-33, NY-33A, NY-31, NY-96, I-490 Interchanges at Exits 10, 22, and 23 – refer to Figure 27

Table 49: Arterial Recommendations Along (portions of) NY-33, NY-33A, NY-31, NY-96, and I-490 Interchanges at Exits 22 and 23

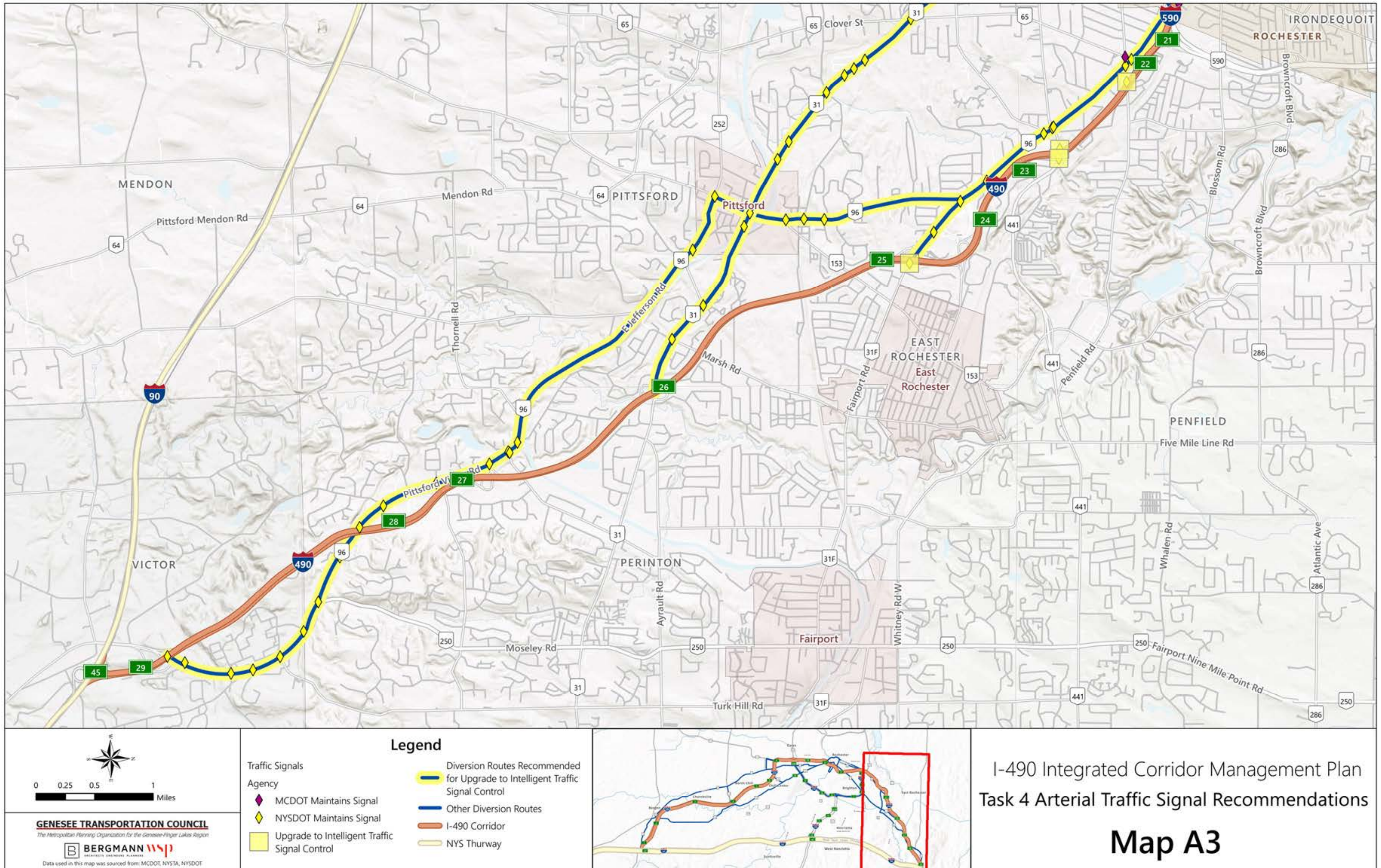
Map	Strategy	Deployment Location	Agency	Priority	Reason
A2	Install intelligent traffic signal control	NY 33A from NY 204 to City of Rochester line (eastern end only – refer to Map A1 for entire route)	NYSDOT	H	This is an important diversion route and should be monitored for traffic flow
		NY 33 from Elmgrove Rd. (CR 158) to City of Rochester line (eastern end only – refer to Map A1 for entire route)	NYSDOT	H	This is an important diversion route and should be monitored for traffic flow
		NY-31 from I-490 to City of Rochester line (western portion only– refer to Map A3 for remaining portion)	NYSDOT	H	This is an important diversion route and should be monitored for traffic flow
		NY-96 from I-490 (Exit27) to University Ave. (northern portion only– refer to Map A3 for entire route)	NYSDOT	H	This is an important diversion route and should be monitored for traffic flow
		I-490 Exits 22 and 23 Interchange signals	NYSDOT	M	While not critical diversion routes, intelligent traffic signal control at the interchanges would provide more efficient incident management along I-490

5.2.2.3 Map A3: NY-31, NY-96, I-490 Interchanges at Exits 22, 23 and 25 – refer to Figure 28

Table 50: Arterial Recommendations Along (portion of) NY-31, NY-96, and I-490 Interchanges at Exits 22, 23 and 25

Map	Strategy	Deployment Location	Agency	Priority	Reason
A3	Install intelligent traffic signal control	NY-31 from I-490 to City of Rochester line (eastern portion only– refer to Map A2 for remaining portion)	NYSDOT	H	This is an important diversion route and should be monitored for traffic flow
		NY-96 from I-490 (Exit27) to University Ave.	NYSDOT	H	This is an important diversion route and should be monitored for traffic flow
		I-490 Exits 22, 23 and 25 Interchange signals	NYSDOT	M	While not critical diversion routes, intelligent traffic signal control at the interchanges would provide more efficient incident management along I-490

Figure 28: Intelligent Traffic Signal Control Recommendations for NY-31, NY-96, I-490 Interchanges at Exits 22, 23 and 25



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5.2.3 Field Communications Infrastructure

High speed communications are essential to communicate with and command the ITS device infrastructure. The following are the recommendations to improve and enhance this necessary communication.

Table 51: Field Communications Infrastructure Recommendations

Map Section	Strategy	Deployment Location	Agency	Priority	Reason
1	Install Fiber Optic and other communications at key diversion areas	Install Communication on NY 259 (Union St.) between NY 33A and NY 33	NYSDOT	M	If there is an incident on I-490 east or west of NY 259 this can serve as a diversion route
1-2		Install Communication on NY 531 from I-490 exit 8 to Elmgrove Rd. (CR 158).	NYSDOT	H	There are several I-490 crashes with Increasing traffic volumes that will make this an important diversion route
1-4		Install Communication on I-490 from Interchange 47 to Exit 9 (I-390)	NYSDOT	H	There are several crashes in this section to warrant surveillance
1-4		Install Communications on NY 33 from Elmgrove Rd. (CR 158) to City of Rochester line, connect with MCDOT communications	NYSDOT	H	There are several I-490 crashes with Increasing traffic volumes that will make this an important diversion route.
3-4		Install Communications on NY 33 A from NY 204 to City of Rochester line, connect with MCDOT communications	NYSDOT	M	This could become an important diversion Route if there are incidents on I-490 East of NY 204
8-11		Install Communications on NY 31 from Exit 26 to City of Rochester line, connect with MCDOT communications.	NYSDOT	H	There are several I-490 crashes with Increasing traffic volumes that will make this an important diversion route
9-12		Install Communications on NY 96 from Exit 27 to University Ave.	NYSDOT	H	There are several I-490 crashes with Increasing traffic volumes that will make this an important diversion route
10-12		Install Communication on I-490 from Exit 23 (NY 441) to I-90 Interchange 45	NYSDOT	H	There are several crashes in this section to warrant surveillance

5.2.4 ITS Device Infrastructure Summary

Table 52 illustrates the summary of ITS Device Infrastructure including existing and recommended devices. These quantities are planning-level estimates as the actual number of CCTV cameras and RWIS stations may differ following further engineering study.

Table 52: ITS Device Infrastructure Summary

Device Type	Existing*	Recommended	Total
RWIS	3	3	6
DMS	7	6*	13
PVMS	7	None	7
HAR	0	None	4
Ramp Meters	0	3	3
Cameras	14	34	48

*Note: This table includes devices located on I-490 only. There are 4 additional DMS recommended on diversion routes approaching I-490, as well as existing DMS, PVMS, HAR, and Cameras along diversion routes.

5.3 Operations and Policy

5.3.1 Traffic and Incident Management

The following recommendations in Table 53 address agency and interagency needs to improve operational cooperation and collaboration. They consist of policy and technical recommendations to improve traffic management and support ICM.

Table 53: Operations and Policy Recommendations

Strategy	Objective	Priority	Justification
Coordinated Traffic and Incident Management Practices	Formalized and regularly scheduled TIM meetings	H	Coordination and collaboration between NYSDOT, MCDOT and first responders are key to successful incident management
	Formalized process for SOP review and updates	H	State-of-the-Practice SOPs in traffic and incident management improve day-to-day operations.
Improved Incident Management Response	TIM and on-scene State-of-the-Practice assessment and training	H	Continuing education through training for RTOC staff and responders will improve traffic and incident management
	Quick Clearance Policy (Quick Clearance is the practice of rapidly and safely removing temporary obstructions – including disabled or wrecked vehicles, debris, and spilled cargo - from the travelway)	H	Increase the safety for incident responders by minimizing their exposure to adjacent passing traffic, reduce the probability of secondary incidents, and relieve overall congestion levels and delay
	HazMat Incident Coordination	H	Increase interagency coordination among state, county, and local agencies to resolve HazMat incidents
Data Quality and Management	The archival practices of each agency should be aligned with one each other and with national trends Identify the data to be archived, its respective definitions, and units / geographic references Develop a data archiving architecture (e.g., connecting and integrating separate data archives as maintained through a "virtual data warehouse") Adopt standards for data formats, sharing and archiving practices among the agencies (or NYSDOT/MCDOT/RTS) and in accordance with national trends Implement a Decision Support System (DSS)	H	Real-time data archiving should be employed to improve the operational capabilities of the RTOC through improved performance measurement, while supporting other agency functions such as planning and modeling Integration of the expressway and arterial networks are critical to successful ICM. A DSS is a computerized system that utilizes the captured data and utilizes business rules to assist operators in response plan decision making, and strategy across NYSDOT and MCDOT.

5.3.2 Asset Management

Successful ICM relies on a combination of technological and human resources. Many technological resources are required for successful ICM operations; these resources have been discussed in detail previously in this Tech Memo. They are expensive and put significant burden on an agency to maintain given the continuous changes in technology and interoperability between systems and devices.

The technological assets require continuous monitoring and maintenance. Applying the principles of asset management can help NYSDOT and MCDOT maintain a state of good repair for the technology they will deploy and have been deployed. Further, employing state-of-the-art transportation asset management principles will make future investment decisions more effective.

An Asset Management Plan is intended to make certain an organized and coordinated maintenance capability is in place to achieve the sustainable benefits for ITS deployment. This includes the identification of best practices, development of regional guidance for configuration management of equipment and software and creation of a preventative maintenance plan.

The transportation network can thus be likened to a “three-legged stool” that cannot effectively serve customer needs if any of these three legs is missing or is underemphasized (too short) relative to the others. ITS is a tool to support the “operations leg” and must be considered and treated as an important asset of equal importance to the infrastructure.

The development and deployment of operational strategies and the supporting of ITS devices must not use a “set it and forget it” approach. Critical to delivering customers safe and efficient transportation systems is being sure that the ITS-based tools deployed are in proper working order, and an organized and coordinated maintenance effort is in place to proactively maintain the good working order of the systems and their elements.

Table 54: Asset Management Recommendations

Strategy	Objectives	Priority	Justification
Asset Management Plan that includes: A schedule of preventative maintenance and inspection of all ITS equipment A timeline that prioritizes the replacement of aging / obsolete and legacy equipment so that new equipment can be incorporated into upcoming contracts	Increased standardization / centralization of hardware / software systems to improve operational efficiency and reduce redundant effort	H	Preventative maintenance and asset management will protect NYSDOT's and MCDOT's significant investment in traffic management tools so that the best service is provided to their traveling customers
Coordinated Maintenance Policy	Increased standardization / centralization of hardware / software systems to improve operational efficiency and reduce redundant effort	H	A policy for ITS maintenance should be developed by all stakeholders (NYSDOT, MCDOT, RTS) in order to best service and maintain the deployed ITS hardware and software deployed
Asset Maintenance Best Practices	Increased standardization / centralization of hardware / software systems to improve operational efficiency and reduce redundant effort	H	Maximize the life of NYSDOT and MCDOT ITS tools by utilizing best practices for ITS hardware and software maintenance and configuration management

5.4 Regional ITS Architecture

The Regional ITS Architecture is a plan for the implementation of ITS in the nine-county Genesee Transportation Council (GTC) planning region. The architecture covers the stakeholders, systems and services provided by ITS currently and planned over the next decade. It was developed to support coordinated and prioritized ITS deployment that was identified in response to updates of the long-range transportation plan and the programming of transportation projects.

Updates are needed to the current architecture, which was last updated in 2018, to address:

- The strategies identified for deployment as part of the I-490 ICM project, and
- Changes to ARC-IT from the last update.

Table 55 provides a set of suggested changes to the regional ITS architecture to address the Recommended Strategies shown in Section 2.5. The suggested changes are based on information in the current architecture RAD-IT file. This table has the following columns:

- ICM Strategy- short name of strategy
- Stakeholders- stakeholders involved in ITS deployment to address the strategy
- Elements- names of systems taken from the RAD-IT file which will be involved in implementing the strategy
- Service Package - ITS architectures are organized around a set of ITS services, which are called Service Packages in ARC-IT. A service package shows the portion of the overall architecture involved in providing a specific service. The table uses service package acronyms from ARC-IT. The regional architecture has regionally customized versions of the service packages. This column shows the version of the service package in the regional architecture that addresses the strategy. For the most part these service packages are already in the regional architecture, but there are a few suggested additions as shown in the next column.
- Architecture Changes - This column summarizes the suggested changes to the RAD-IT file so that the architecture will address the services that are a part of each strategy.

Table 55: Architecture Changes to Address ICM Strategies

ICM Strategy	Stakeholders	Elements	Service Package	Architecture Changes
Additional DMS Deployment	NYSDOT	NYSDOT Dynamic Message Signs (DMS)	TM06	SP is a part of Architecture
		Regional Traffic Operations Center (RTOC)		Add to TM06 along with DMS interface
	MCDOT	MCDOT Dynamic Message Signs (DMS)		
		MCDOT Computerized Traffic Control System (CTCS)		Add to TM06 along with DMS interface
				In addition, these are the only field devices needed in the SP. Should remove the other ones (CCTV and RWIS)
Additional CCTV Deployment	NYSDOT	NYSDOT Closed-Circuit Television (CCTV) Traffic Cameras	TM01	SP is a part of Architecture
		Regional Traffic Operations Center (RTOC)		Add to TM01 along with DMS interface

ICM Strategy	Stakeholders	Elements	Service Package	Architecture Changes
	MCDOT	MCDOT Closed-Circuit Television (CCTV) Traffic Cameras		
		MCDOT Computerized Traffic Control System (CTCS)		Add to TM01 along with DMS interface
	New York State Thruway Authority (NYSTA)	NYS Thruway Closed-Circuit Television (CCTV) Traffic Cameras		
		NYS Thruway Statewide Operations Center (TSOC)		
				In addition, these are the only field devices needed in the SP. Should remove the other ones (DMS and RWIS)
Smart Traffic Signal	MCDOT	MCDOT Computerized Traffic Control System (CTCS)	TM03	SP is a part of Architecture
				Should consider adding a traffic signal element, which would interface to the CTCS.
Additional Vehicle Data Collection Sensors	NYSDOT	Regional Traffic Operations Center (RTOC)	TM01	Need to add this element to the Service Package
		NYSDOT Detection Sensors		Need to add this element to the Service Package
		MCDOT Computerized Traffic Control System (CTCS)		Need to add this element
				Should consider adding a traffic sensor element, which would interface to the CTCS.
Additional Roadway Weather Monitoring	NYSDOT	NYSDOT Traffic Signals and Highway Maintenance Dispatch	MC04/ WX01	Need to add this element to the WX01 Service Package

ICM Strategy	Stakeholders	Elements	Service Package	Architecture Changes
		NYSDOT Road Weather Information System (RWIS) Stations		Need to add this element to the MC04 Service package
Decision Support System	NYSDOT	Regional Traffic Operations Center (RTOC)	TM07	Service Package Interface is in Architecture.
	MCDOT	MCDOT Computerized Traffic Control System (CTCS)		
Enhanced Communications	NYSDOT	NYSDOT Communications Infrastructure		These two elements logically would be part of an enhanced communications project. One is mapped to ITS Field Equipment and one mapped to TMC. For Service Packages could use the standard ones like TM01, TM03, and TM06
	MCDOT	MCDOT Communications Infrastructure		A logical approach is to show these elements connected to the actual field devices, which you have, and also to the TMCs, which you have not.
Modal Integration	RTS, NYSDOT	RTS Monroe Campus and Operations Center	PM02	Add PM02, Smart Park and Ride, to cover services for the Park and Ride lot by I-490 and NY 31F near the St. John Fisher campus. This lot is owned by NYSDOT and functions as an RTS Connection Hub with real-time transit information for passengers.
		RTS Advanced Traveler Information System (ATIS)	PT08	Add the Transit App, which is currently available and provides real-time information and trip planning for RTS.

ICM Strategy	Stakeholders	Elements	Service Package	Architecture Changes
Queue Warning	NYSDOT	NYSDOT Traffic Sensors	VS08	Suggest adding VS08 Service Package with these three elements, which would use the non-connected vehicle aspects of the SP.
		NYSDOT DMS		
		RTOC		
Ramp Metering	NYSDOT	RTOC	TM05	Suggest adding VT05 Service Package with these elements to address ramp metering.
		NYSDOT Traffic Sensors		
		NYSDOT Ramp Meters		Suggest adding this element for the ramp meters.

Since the last update of the regional architecture, ARC-IT has been updated to version 9.0 which was released November 2020. The following are a suggested set of changes to be made to the Regional Architecture (as defined in the RAD-IT file) in order to bring it up to the current version of ARC-IT

- The RAD-IT file should be converted to the current version of RAD-IT, which will pick up minor changes in element mapping to physical objects, information flows, and service package components. In addition, this conversion will allow the Communications tab to be populated with a newly defined set of communication solutions, which was one of the primary updates from earlier versions of ARC-IT. These new communications solutions provide a more organized way of describing standards for each interface that address data, management, and security aspects of the interface.
- ARC-IT 9.0 added ten new service packages. These new service packages should be reviewed to determine whether they should be programmed to support future ITS deployments along the I-490 corridor.
- The mapping of field device elements to ARC-IT physical objects should be reviewed. A number of the field device elements are mapped to Traffic Management Center (or other Centers), resulting in a number of center-to-center type information flows going to/from field elements (e.g., the element NYSDOT Closed-Circuit Television (CCTV) Traffic Cameras). Following a revision of the element mapping it is suggested that the interfaces for those elements be reviewed and updated to be just appropriate center to field (or field to field if that exists) information flows.

5.5 Future Study

The recommendations proposed herein will have a significant impact on the operation and efficiency of the I-490 corridor in the future. Other strategies that were examined were not recommended at present because their need and benefit will be affected by the recommendations proposed. Each warrant further examination as the ICM evolves. Those strategies that will likely require further study in the future include:

- Transit Signal Priority (see section 4.1.8)
- Bus Rapid Transit (see section 4.1.9)
- Modal Integration (see section 4.1.10)
- Staffing: As recommendations are implemented and ICM evolves, it would be prudent to perform a task analysis to examine the need for additional NYSDOT or MCDOT professional staff as well as examining skill sets for current and future staff. For instance, a need for a data scientist may develop as more, and different types of, data are collected and used to measure performance and manage proactively.

6 SUMMARY AND NEXT STEPS

The RTOC, and specifically NYSDOT's and MCDOT's operational capabilities, have a sound foundation for ICM, but several gaps and needs still exist to improve the program's core services – traffic and incident management – and ultimately provide an ICM program.

The recommendations herein have been formulated to improve both aspects of pro-active advanced traffic management. While many of the recommendations herein are fundamental ITS or traffic management treatments like ITS field devices, these are critical to improving the RTOC's capabilities in providing best-practice traffic and incident management. Others, specifically the active traffic management recommendations such as ramp metering, queue warning, modal integration to name a few, are more complex. While these are recommended in the report, they require much further engineering analysis.

Much discussion in this report centers around the disparate systems that are in operation from the RTOC. On their own, these systems, namely Foundation III (the expressway advanced traffic management system) and MCDOT's traffic signal system (TransSuite), are sound systems that provide the service that was intended. However, ICM and traffic and incident management dictate that these systems – and the NYSDOT traffic signal systems – be integrated together to achieve ICM, and any further engineering analysis moving forward on bettering the traffic management service on the corridor focus on this effort.

Moving forward toward deployment from this report, the next step is to develop a project or set of projects to implement the ICM plan. Specific steps in developing a project or set of projects are needed to further develop what the system will do and how it will perform. Project development includes the systems engineering process, including developing the concept of the system, identifying system requirements, and the design process. A critical first step, which this report provides sufficient detail to inform, is the development of the Concept of Operations (ConOps).

A ConOps is a document that describes how a system will be used and identifies the fundamental needs of all stakeholders involved throughout the lifecycle of a system. It also considers different use cases or scenarios for how the system will operate. A ConOps is essential to success, as it serves as the repository of needs and helps ensure that all aspects of the system lifecycle from design, implementation, maintenance, and upgrades, support those needs. The ConOps allows for stakeholders to understand how the system is to be developed, maintained, and operated; it also identifies users and system capabilities in an easy-to-understand format.

APPENDIX

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NYSDOT Traffic Signals Operated and Maintained by MCDOT

SCHEDULE II
LIST OF INTERSECTIONS

State Intersections Operated and Maintained Bv Monroe County DOT:
X = Location with a traffic signal controller

Signal Owner NYSDOT #	Intersection Description	Maintenance Provider MCDOT #
X 36A	Rte. 104 & Glenora Dr. & Kodak Drwy	1
X 31A	Rte. 104 & Bonesteel Street	2
X 16A	Rte. 104 & Bernice Street	3
X 15A	Rte. 104 & Dewey Avenue	4
X 14A	Rte. 104 & Woodside Street & Hanford LanMRoad	17
X 13A	Rte. 104 & Palm Street	18
X 12A	Rte. 104 & Primrose Street & Kodak Drwy.	19
X 9A	Rte. 104 & Lake Avenue	20
X 9.1A	Rte. 104 & Ridgeway Avenue	21
X 8A	Lake Avenue & Ridgeway Avenue	26
X 41A	Lake Avenue & Flower City Park	27
X 7A	Lake Avenue & Seneca Parkway (EB)	28a
7.1A	Lake Avenue & Seneca Parkway (WB)	28b
X 6A	Lake Avenue & Augustine Street	29
X 32AS	Lake Avenue & Nazareth Academy School Ped Crossing	30
X 5A	Lake Avenue & Driving Park Blvd.	31
X 42A	Lake Avenue & Lexington Avenue	32
X 4A	Lake Avenue & Glendale Park	33
X 3.5A	Lake Avenue & Ravine Avenue	34
X 3A	Lake Avenue & Phelps Avenue	35
X 2A	Lake Avenue & Ambrose Street & Jones Avenue	36
X 52A	Rte. 104 (BB) & St. Paul (NE)	38
X 28A	Rte. 1490 (WB) & Culver Road	113a
28.1A	Rte. 1490 (EB) & Culver Road	113b
X 27A	Rte. I490 (WB) & Monroe Avenue	142a
27.1A	Rte. I490 (EB) & Monroe Avenue & Field Street	142b
X 29A	Rte. 1490(EB) & Goodman Street	154a
29.1A	Rte. 1490 (WB) & Goodman Street	154b
X 1A	Lake Ave/State St./Smith St. & Lyell Avenue	211
X 239	Rte. 1490 (WB) & Plymouth Avenue	227
X 237	Plymouth Avenue & Allen Street (Rte. I490 EB)	228
X 19A	Inner Loop (EB) & State Street	229a
19.1A	Inner Loop (WB) & State Street	229b
X 278	Plymouth Avenue & Spring Street	240
X 24A	Plymouth Avenue & Broad Street	243
X 279	Rte. 1490 (EB) & Plymouth Avenue & Troup Street	244
X 281	Clinton Avenue & Byron Street	245
X 26A	Inner Loop/Howell & Monroe Avenue/Chestnut	247
X 413	Plymouth Ave. & Church Street	269
X 238	Rte. 1490 (EB) & Griffith Street & South Avenue	284
X	Plymouth Avenue & Main Street	291
X 245	Rte. 1490 (EB) & Brown Street & Allen Street	319a
244	Rte. 1490 (EB) & Brown Street & Wilder Street	319b

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SCHEDULE II
LIST OF INTERSECTIONS

State Intersections Operated and Maintained Bv Monroe County DOT (continued):
X = Location with a traffic signal controller

Signal Owner NYSDOT #	Intersection Description	Maintenance Provider MCDOT #
X 464P	Rte. 104 & Kodak Drwy	356
X 324	Hylan Drive & I-390 SB Ramps	453
X 324.1	Hylan Drive & I-390 NB Ramps	454
X 34A	Rte. 104 (BB) & Culver Road	476a
35A	Rte. 104 (WB) & Culver Road	476b
X 217	Rte. 104 (WB) & Portland Avenue	477a
217.1	Rte. 104 (EB) & Portland Avenue	477b
X 40A	Rte. 104 (WB) & Carter Street	478a
40.1A	Rte. 104 (BB) & Carter Street	478b
X 39A	Rte. 104 (WB) & Hudson Avenue	479a
39.1A	Rte. 104 (BB) & Hudson Avenue	479b
X 38A	Rte. 104 (WB) & Seneca Avenue	480a
38.1A	Rte. 104 (BB) & Seneca Avenue	480b
X 37A	Rte. 104 (WB) & Clinton Avenue	481a
37.1A	Rte. 104 (BB) & Clinton Avenue	481b
X 335P	Rte. 104 & Kodak Drwy & Plaza Drwy	482
X 70	Rte. 104 & Stone Road & Corona Road	483
X 423	Rte. 104 & Buckman Drive	484
X 83	Rte. 104 & Hoover Drive	485
X 225	Rte. 104 & 390 Outer Loop NB Off Ramps (West Sijnal)	486a
225.1	Rte. 104 & 390 Outer Loop NB Off Ramps (East Signal)	486b
X 341	Rte. 104 & NY 390 Outer Loop SB Ramp	487
X 67	Rte. 104 & Latona Road & Fetzner Road	488
X 292	Rte. 104 & Somerworth Drive & Standish Drive	489
X 161	Rte. 104 & Duxbury Road & Greece Ridge Mall	491
X 293	Rte. 104 & Mitchell Road	493
X 20	Rte. 104 & Long Pond Road	494
X 99	Rte. 104 & Harvest Drive & Ridgemont Plaza E. Driveway	495
X 101	Rte. 104 & Tully Lane & Ridgemont Plaza W. Driveway	496
X 204	Rte. 104 & Mason Avenue & Marshall's Driveway	497
X 284	Rte. 104 & North Avenue	498
X 189	Rte. 104 & Elmgrove Road & North Greece Road	499
X 240	I-490 (BB) & Ames Street	522a
240.1	I-490 (WB) & Ames Street & Wilder Street	522b
X 385	Lake Avenue & LOSP	557
X 173	Rte. 104 (WB) & Goodman Street	562a
174	Rte. 104 (BB) & Goodman Street	562b
X 492	Pattonwood Drive & Thomas Avenue	596
X P	Rte. 104 & Buckman Plaza	639
X 412P	Rte. 104 & Elmgrove Plaza	641
X 70.1	Rte. 104 & Stoneridge Plaza	655
X 384	Rte. 104 & Eastman Avenue	657

Total = 70 locations with controllers and 15 locations without controllers.

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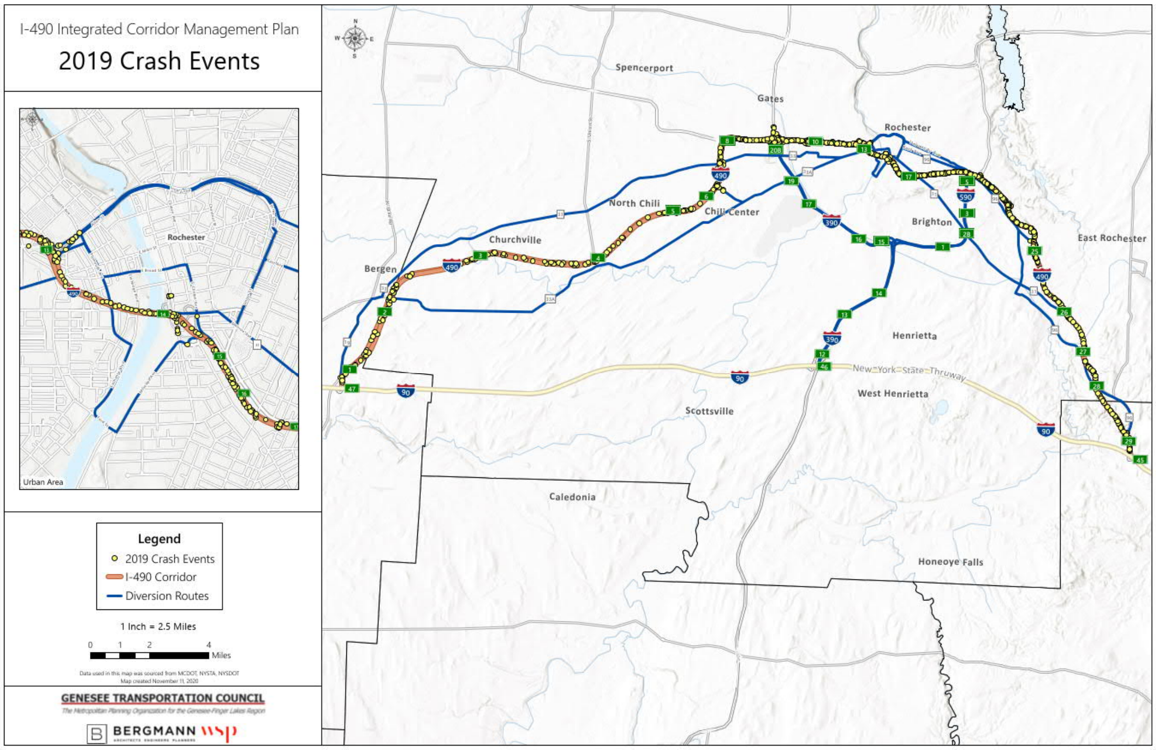
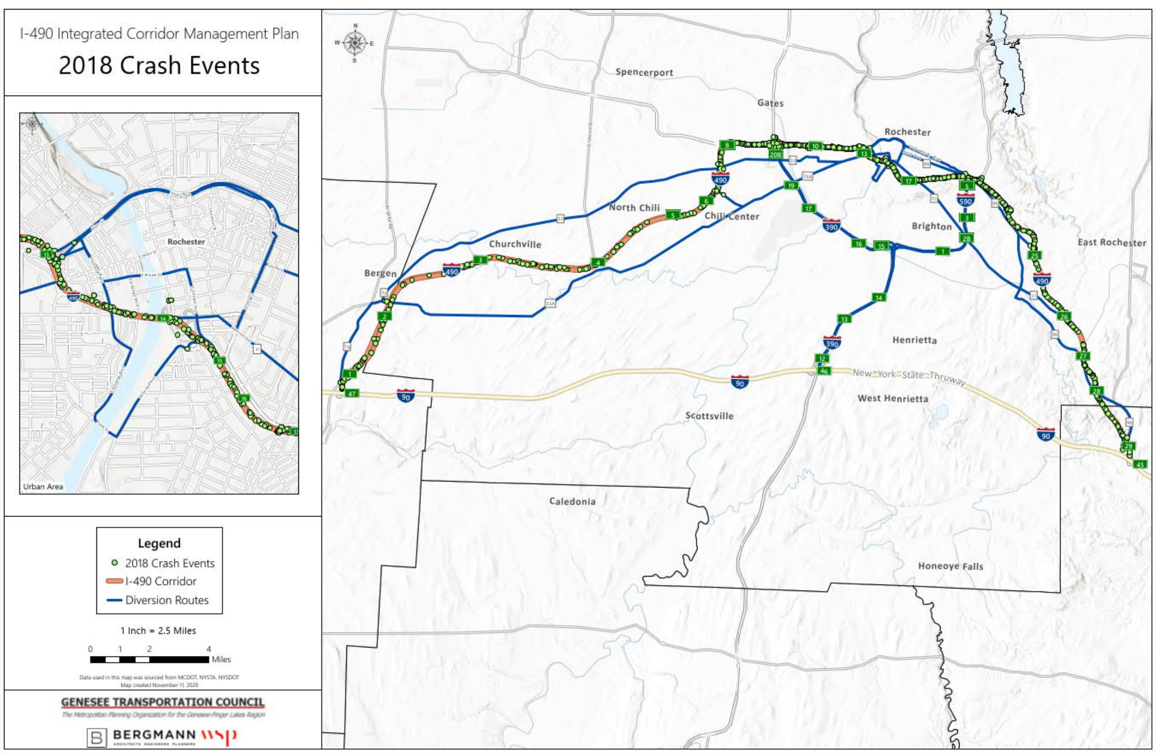
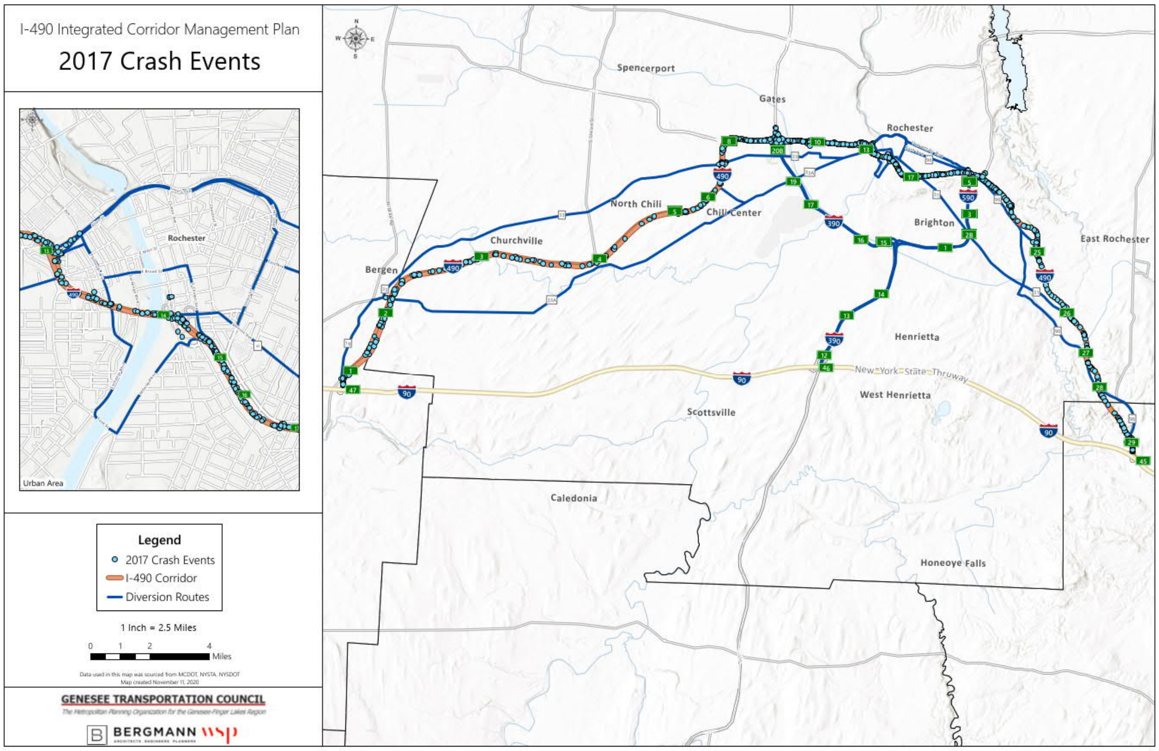
Spatial Crash Data






I-490 Integrated Corridor Management Plan
2017 Crash Events
Legend
2017 Crash Events
I-490 Corridor
Diversion Routes
1 Inch = 2.5 Miles
Urban Area
Rochester
Spencerport
Gates
North Chili
Chili Center
Churchville
Bergen
Brighton
East Rochester
Henrietta
West Henrietta
Scottsville
Caledonia
Honeoye Falls
New York State Thruway
GENESEE TRANSPORTATION COUNCIL
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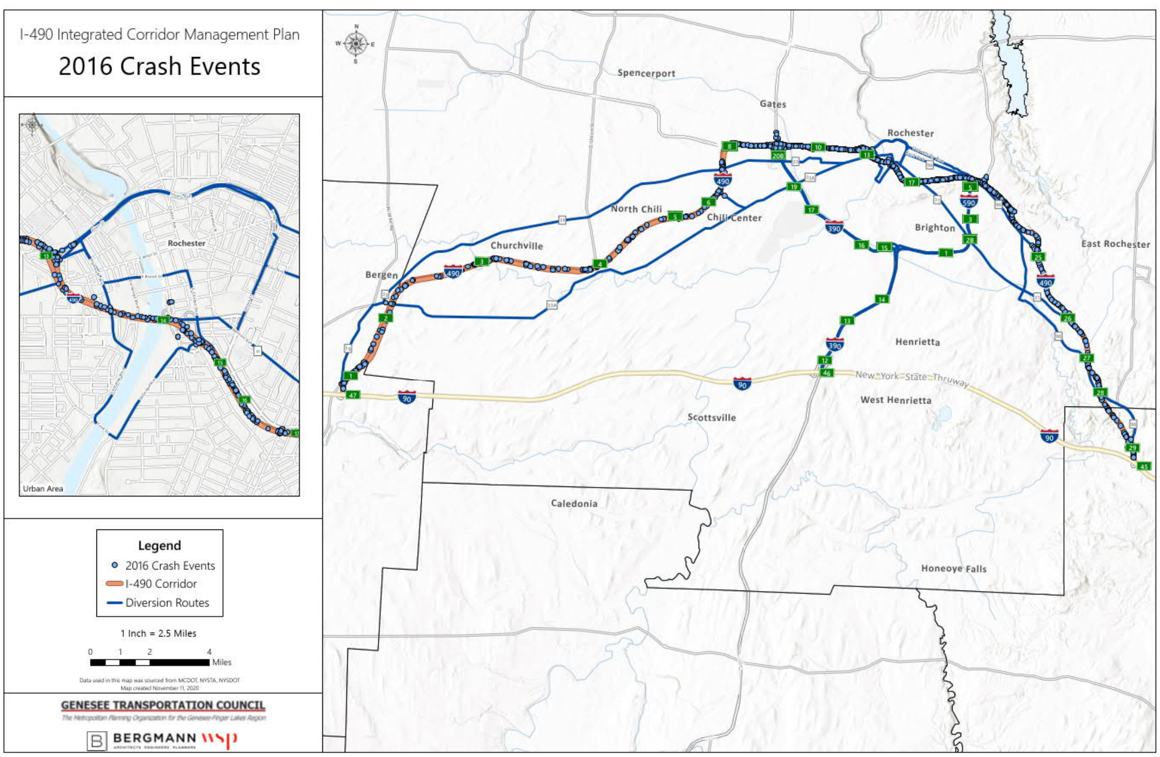
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2016 Crash Events
Legend
2016 Crash Events
I-490 Corridor
Diversion Routes
1 Inch = 2.5 Miles
Urban Area
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Spencerport
Gates
North Chili
Chili Center
Churchville
Bergen
Brighton
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West Henrietta
Scottsville
Caledonia
Honeoye Falls
New York State Thruway
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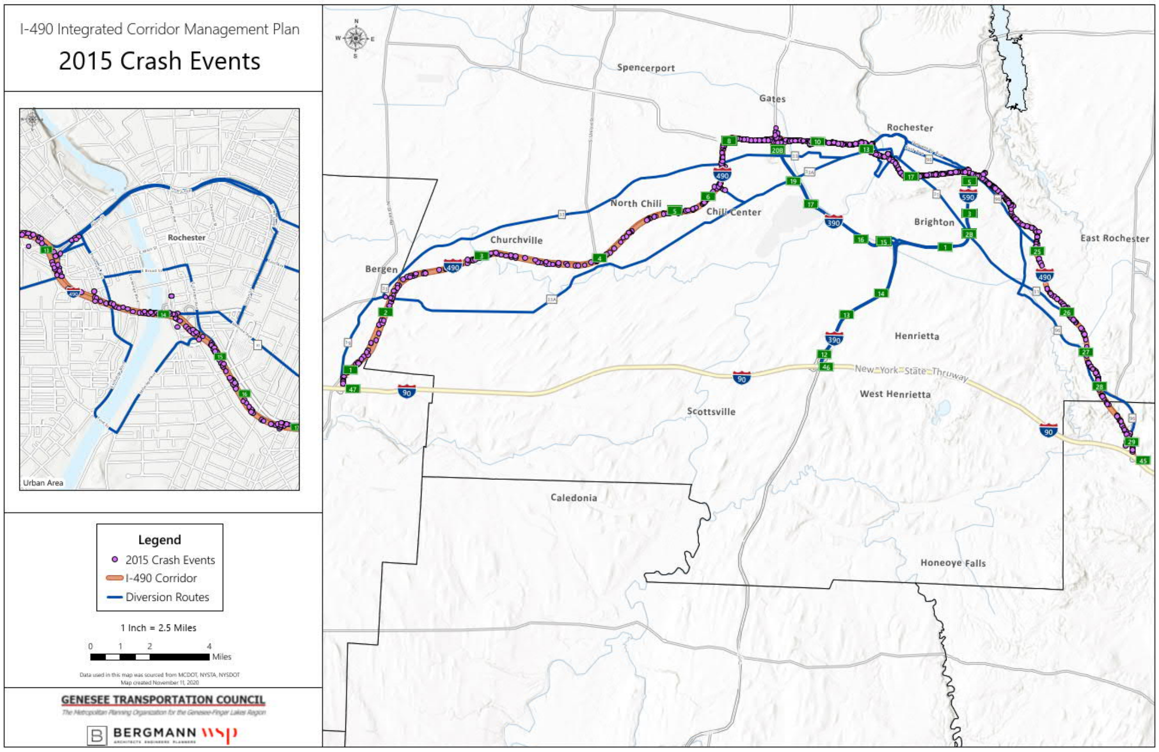
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2015 Crash Events
Legend
2015 Crash Events
I-490 Corridor
Diversion Routes
1 Inch = 2.5 Miles
Miles
Urban Area
Rochester
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Spencerport
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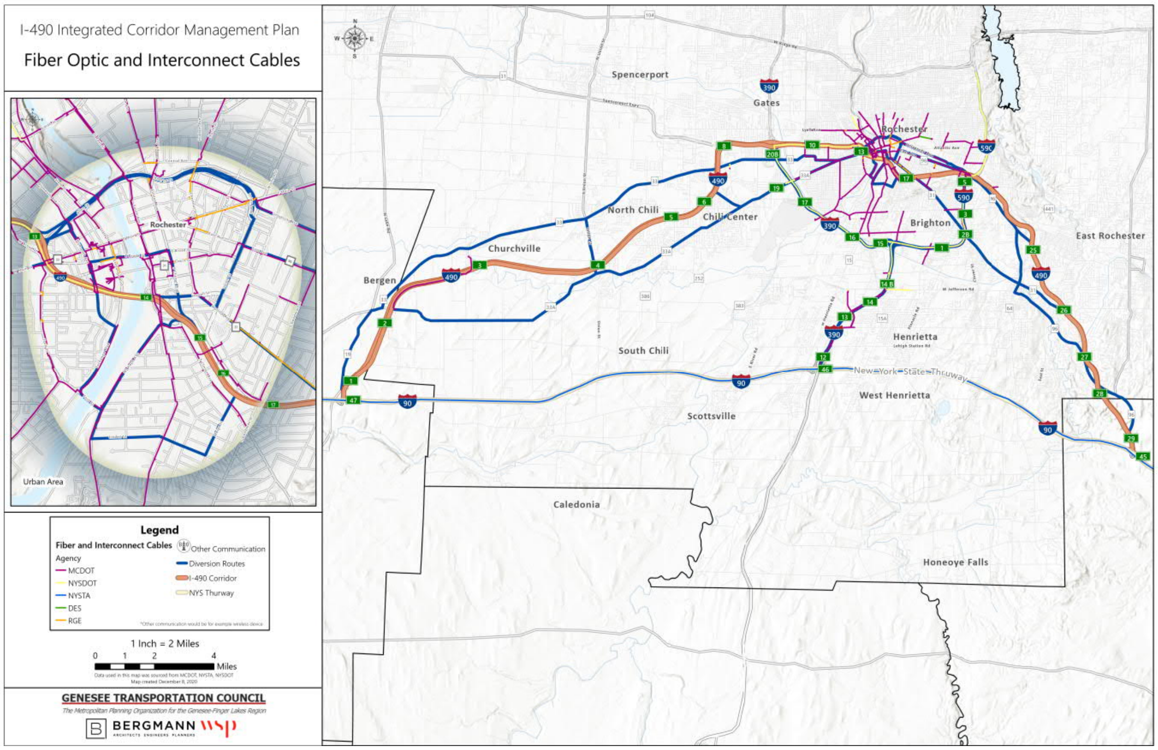
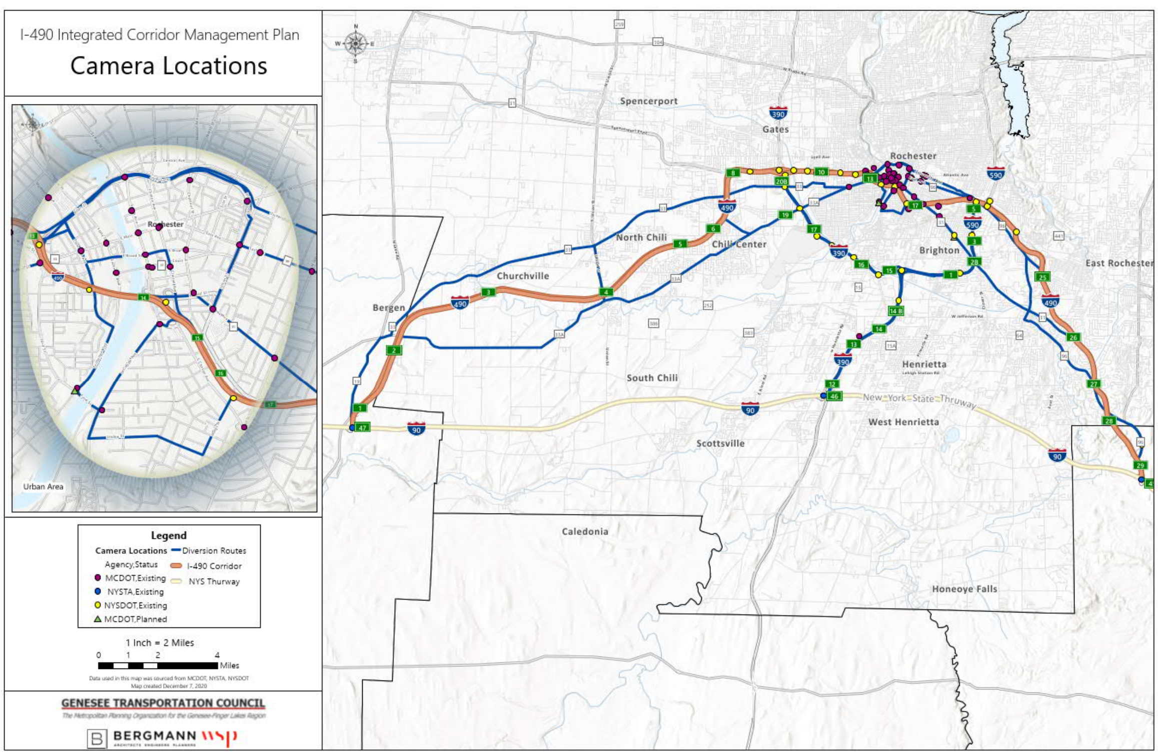
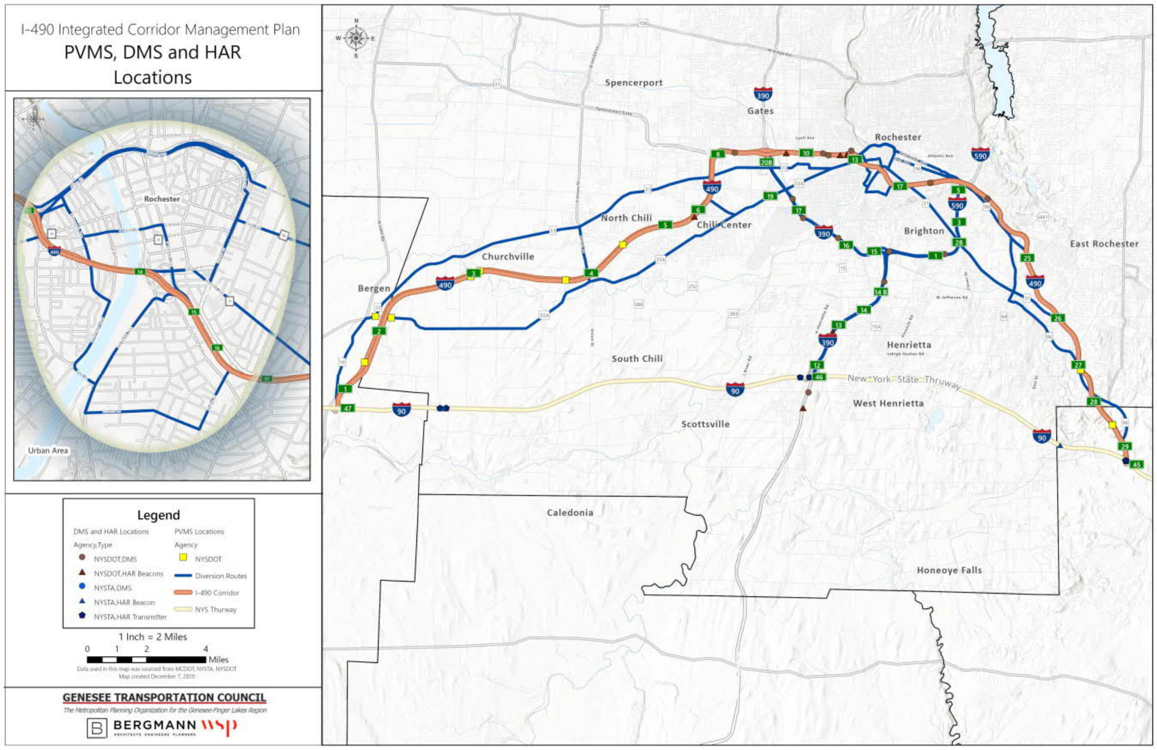
North Chili
Chili Center
Churchville
Bergen
Brighton
East Rochester
Henrietta
New York State Thruway
West Henrietta
Scottsville
Caledonia
Honeoye Falls

ITS Device Maps



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PVMS, DMS and HAR Locations
Rochester
Urban Area
Legend
DMS and HAR Locations
Agency,Type
NYSDOT,DMS
NYSDOT,HAR Beacons
NYSTA,DMS
NYSTA,HAR Beacon
NYSTA,HAR Transmitter
PVMS Locations
Agency
NYSDOT
Diversion Routes
I-490 Corridor
NYS Thurway
1 Inch = 2 Miles
0 1 2 4 Miles
Data used in this map was sourced from MCDOT, NYSTA, NYSDOT
Map created December 7, 2020
GENESEE TRANSPORTATION COUNCIL
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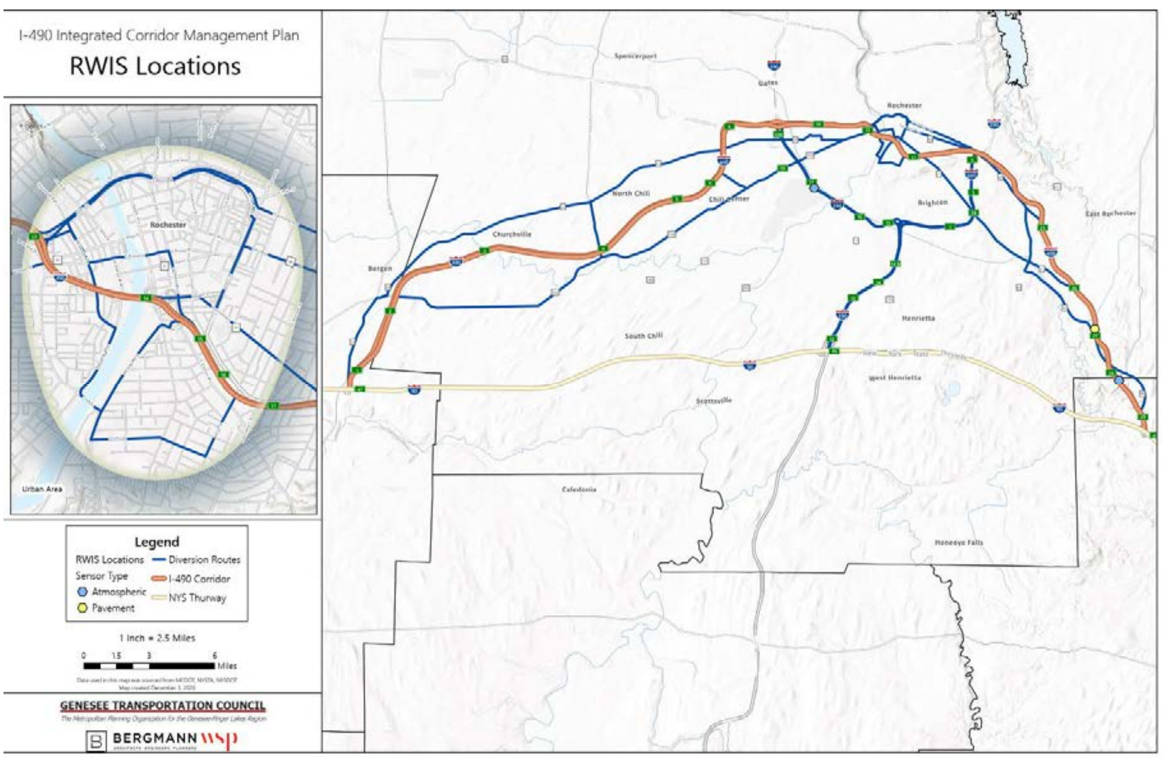
Gates
Rochester
North Chili
Chili Center
Churchville
Bergen
Brighton
East Rochester
South Chili
Henrietta
New York State Thruway
West Henrietta
Scottsville
Caledonia
Honeoye Falls


I-490 Integrated Corridor Management Plan
RWIS Locations
Rochester
Urban Area
Legend
RWIS Locations
Sensor Type
Atmospheric
Pavement
Diversion Routes
I-490 Corridor
NYS Thurway
1 Inch = 2.5 Miles
0 1.5 3 6 Miles
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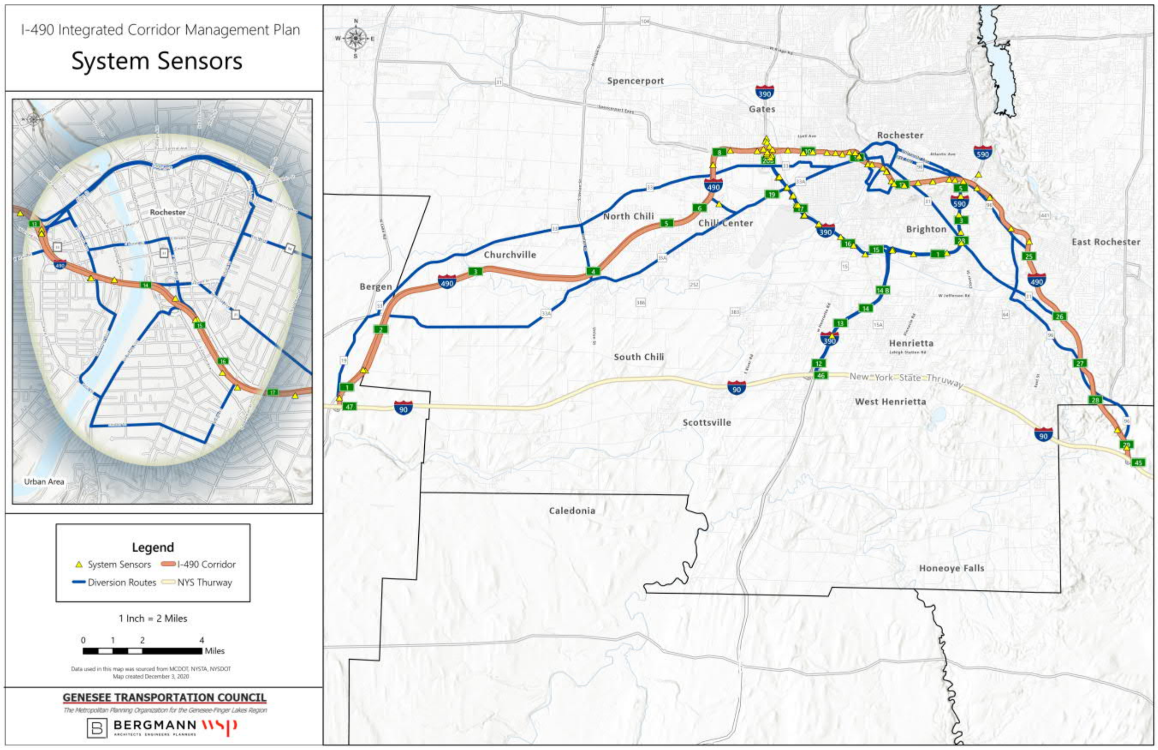
Honeoye Falls


I-490 Integrated Corridor Management Plan
System Sensors
Rochester
Urban Area
Legend
System Sensors
I-490 Corridor
Diversion Routes
NYS Thurway
1 Inch = 2 Miles
0 1 2 4 Miles
Data used in this map was sourced from MCDOT, NYSTA, NYSDOT
Map created December 3, 2020
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East Rochester
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Henrietta
New York State Thruway
West Henrietta
Scottsville
Caledonia
Honeoye Falls

I-490 Typical Ramp and Shoulder Geometry

I-490 Typical On-Ramp and Mainline Shoulder Geometry - EB

Project #: 30900407
Date: 12/10/2020

I-490 Eastbound					
Interchange No.	Ramp Geometry (ft.)		Shoulder Geometry (ft.)		Notes
	Width	Storage Length	Inside Width	Outside Width	
Int 47 (Toll to I90 On ramp)	32	1285	-	10	
Int 1 (From Toll to 490)	-	-	4	12	
Int 1 (From 19)	32	1250	7	13	
Int 2 (From 33 EB)	32	1100	6	12	
Int 2 (From 33 WB)	32	950	6	12	(Approx .25mi past the Sheridan Rd Overpass there is 800' of inner shoulder that expands to 12', then shortens to 6' until the next interchange)
Int 3 (From Churchville Riga Rd)	30	725	10	5	
Truck Weigh Station	-	-	5	12	
Attridge Rd Overpass	-	-	6	10	
Int 4(From Union St)	32	685	6	10	At 490 over RR Crossing, Inside shoulder widens to 16', outside shoulder shrinks to 2'. Each resume to 6' and 10' after crossing.
Int 5 (From Chill Center Coldwater Rd)	30	855	6	10	
Int 6 (From 204 WB)	30	1500	6	11	On ramp enters at 490 bridge over RR. Inner and outer shoulders are initially 2' wide. They widen to 6' and 11' after the RR crossing.
Int 7 (From 33 EB)	32	1380	6	11	On ramp enters as 490 bridges over 33. Inner shoulder and outer shoulders 5' wide on bridge and remain until exit 7B where they widen to 6' and 11' respectively.
Int 8 (From 531 EB)	32-38	2160	6	10	Ramp Width varies from 32'(bridge width)-38'(ground width)
Exit 9A	-	-	4	11	
Exit 9B	-	-	5	10	
Int 9 (From 390 SB)	40	840	6	11	
Int 9 (From 390 NB)	32	1400	11	10	Initially inner shoulder width is 6' and outer 10'. Once 490 clears river, inner shoulder widens to 11' with concrete barrier and outer shoulder remains 10'
Int 10 (From Mt. Reed Blvd)	26	810	5	10	
Int 11 (From Wilder St)	18	720	6	10	
Int 13(From Allen St)	20	400	6	10	Initially outside shoulder <1' as On ramp merges with 490 under RR crossing, widens to 10' until next interchange.
Int 13 (From Inner Loop)	20	1350	5	10	
Ford St/Boys Club Pl	12	160	5	11	
Int 14 (From S Plymouth Ave)	20	700	5	6	
Exit 15	-	-	5	10	
Int 15 (From I490 WB)	20	1885	5	10	
Int 15 (From HWY 31/South Ave)	15	1465	5	10	
Int 15 (From Byron St)	26	775	5	11	
Int 15 (From South Ave)	22	2340	5	11	
Int 17 (From S Goodman St)	18	650	5	10	
Int 18 (From Monroe Ave)	15	650	5	11	
Int 19 (From Culver Rd)	18	875	5	12	
Int 20 (From 590 NB)	26	950	5	9	
Int 21 (From 590 SB)	24	1710	5	11	
Int 21 (From E Highland Dr)	26	1405	5	11	
Exit 23	-	-	5	12	
Int 23 (From Linden Ave)	28	860	6	10	
Int 24 (From W Commercial St)	25	2260	6	10	
Int 25 (From Fairport Rd)	25	1785	6	10	
Int 25 (From Loop Rd)	25	2000	6	10	
Int 26 (From 31/Palmyra Rd)	28	1345	8	10	
Int 27 (From Pitttsford Victor Rd)	32	620	5	11	Outside shoulder narrows to 8' width after 490 passes over Garnsey Rd. Remains until Pitsford Rd Overpass where there is 670' stretch of 490 where the Inner Shoulder widens to 12' and outside shoulder to 8'. Returns to 5' and 11' until next interchange
Service Rd	-	-	6	10	
Int 29 (From 96 SB)	32	580	4	9	Ramp Width narrows from 36'to 32' as converges with 96 NB
Int 29(From 96 NB)	32	720	4	9	Ramp Width narrows from 36' to 32' as converges with 96 SB
Int 29(From Toll to 490 WB)	-	-	-	20	Outside shoulder is gore leading up to toll booth

Notes
Storage length measured from theoretical gore to approximate location of Ramp Meter
Shoulder and Ramp Widths measured from each edge of roadway to striping.

I-490 Typical On-Ramp and Mainline Shoulder Geometry - WB

Project #: 30900407
Date: 12/10/2020

Interchange No.	Ramp Geometry (ft.)		Shoulder Geometry (ft.)		Notes
	Width	Storage Length	Inside Width	Outside Width	
Int 1 (From Toll to I90 On ramp)	-	-	-	10	
Int 1 (From 19)	30	560	-	10	
Int 2 (From 33 EB)	32	880	6	11	
Int 2 (From 33 WB)	30	1120	6	11	
Int 3 (From S Main St)	32	840	6	10	
Truck Weigh Station	-	-	5	10	Outisde shoulder narrows to approximately 2' and inner shoulder widens to 14' as 490 crosses over Black creek. Shoulders return to 5' and 10' until next interchange.
Int 4(From Union St)	30	865	6	9	
Int 5 (From Chill Center Coldwater Rd)	30	1110	6	11	Outside shoulder narrows to approximately 2' while inside shoulder widens to 14' as 490 crosses over RR. Shoulders return to 6' and 11' until the next interchange.
Int 6 (From 204 WB)	40	3970	6	10	
Int 7 (From 33 EB)	28	1600	6	10	Shoulders Narrow <1' as 490 crosses over RR, and as cross over 204. Shoulders return to 6' and 10' width until next interchange.
Int 7 (From 33 WB)	32	1445	6	10	
Int 8 (From 531 EB)	26	1700	6	11	
Int 9 (From 390 SB)	32	1150	4	10	
Int 9 (From 390 NB)	30	1030	5	10	
Int 10 (From Mt. Reed Blvd)	24	865	8	10	
Int 11 (From Campbell St)	15	325	4	10	On ramp enters at 490 bridge over RR. Inner and outer shoulders are initially 2' wide. They widen to 4' and 10' after the RR crossing and remain until next interchange.
Int 13(From Brown/Campbell St)	35	760	5	10	On Ramp storage length measured out to W Broad St entrance. Outside shoulder widens to 14' around M.P. 21 (Ames St Overpass) until next interchange.
Int 13 (From Inner Loop)	32	920	5	10	Initially inside and outside shoulders over Platt St are <1'. Once 490 clears Platt street, shoulders widen to 5' and 10' respectively
Int 13 (From Allen St)	32	1135	5	10	
Int 16 (From Howell St)	12	700	6	10	Initially Inside and outside shoulders approximately 5' wide until Exit 14. Then widen to 6' and 10' until next interchange.
Int 17 (From S Goodman St)	16	760	6	10	
Int 18 (From Monroe Ave)	18	715	6	10	
Int 19 (From Culver Rd)	16	735	6	10	
Int 20 (From Winton Rd NB)	25	635	6	9	
Int 20 (From Winton Rd SB)	25	680	6	9	
Int 20 (From 590 NB)	26	1410	6	9	
Int 21 (From 590 SB)	26	1345	6	9	
EXIT 21	-	-	6	9	
Int 22 (From Penfield Rd)	25	535	7	7	
INT 23 (From Linden Ave SB)	34	1200	6	10	
Int 23 (From Linden Ave NB)	34	1050	6	10	
Int 24 (From W Commercial St)	26	3065	6	11	
Int 25 (From Fairport Rd)	26	3275	6	11	
Int 26 (From Pittsford Palmyra Rd)	24	1330	9	10	Shoulders narrow <5' at bridge over Marsh Rd, then widen to 9' and 10' until Washington Rd Overpass.Inner shoulder narrows to 6' after washingotn rd overpass until next interchange.
Int 27 (From Pitttsford Victor Rd)	32	655	9	12	Shoulders narrow <5' over river, then widen to 9' and 12' until next interchange.
Int 28 (From 96 NB)	32	1035	6	9	
Service Rd	-	-	6	9	Approximately .2 miles after service ramp, inner shoulder widens to 14' for approximately 740'. Then narrows to 6' until next interchange.
Int 29 (From 96 SB)	25	1175	6	10	Approximately .25 miles after on ramp, inner shoulder widens to 13' for approximately 800'. Then narrows to 6' until service ramp.
Int 29(From 96 NB)	28	2635	6	9	
Int 29(From Toll to 490 WB)	-	-	5	8	
Int 45 (I90 to I490)	45	1070	-	12	

Notes
Storage length measured from theoretical gore to approximate location of Ramp Meter
Shoulder and Ramp Widths measured from each edge of roadway to striping.

[i] https://www.census.gov/data/tables/time-series/demo/popest/2010s-total-metro-and-micro-statistical-areas.html
[ii] https://www.census.gov/data/tables/time-series/dec/c2010sr-01.html
[iii] https://mobility.tamu.edu/umr/congestion-data/
[iv] https://www.myrts.com/Portals/0/RGRTA_2019-22%20Comp%20Plan_FINAL.pdf
[v] https://www.nfta.com/media/jdubj5z3/metroperformancereport2020.pdf
[vi] https://www.ridedart.com/about-dart
[vii] https://www.gbnrtc.org/reports?rq=integrated%20corridor
[viii] https://iowadot.gov/desmoinesicm/pdf/DesMoines-ICM-ProgramConOps.PDF