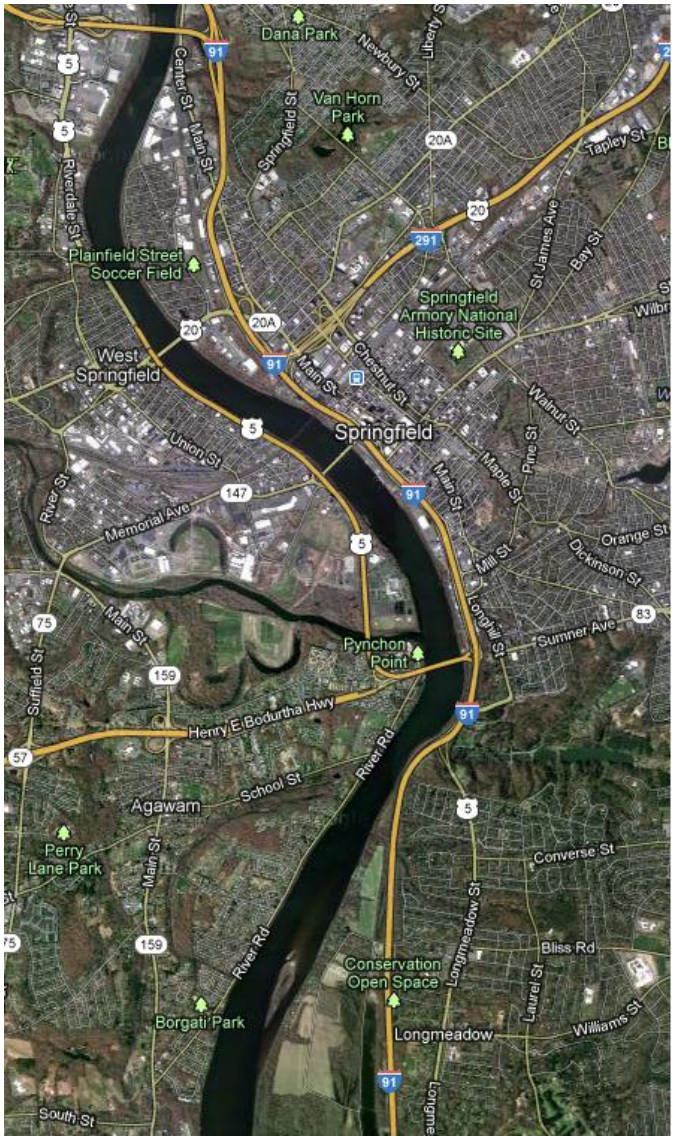
Interstate Route I-91 Corridor Planning Study

Springfield, Massachusetts: Interchanges 1 through 5.

Existing Conditions Report

Photography by PVPC Staff



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Prepared in cooperation with the Massachusetts Department of Transportation and the U.S. Department of Transportation. The views and opinions of the Pioneer Valley Planning Commission expressed herein do not reflect those of the Massachusetts Department of Transportation or the U.S. Department of Transportation.

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I. INTRODUCTION

Recently, District 2 of the Massachusetts Department of Transportation (MassDOT) Highway Division identified a need for a study for the I-91 corridor from interchange 1 at Route 5 South through interchange 5 at Broad Street. This section of I-91 currently exhibits numerous short weaving areas, non-standard geometrical features, restrictive sight distances, heavy traffic volumes, and high travel speeds all of which have resulted in congestion and safety problems.

A conceptual design study for this section of Interstate Route I-91 was prepared in 1998 by a consultant for the former MassHighway department. Further study was recommended to analyze the impacts and benefits of select design alternatives in greater depth. Four out of the seven initial design alternatives were recommended for further consideration to address traffic and safety concerns along this corridor. MassDOT is planning to utilize consultant services for an alternatives analysis study to address the safety and congestion issues experienced along this section of the highway. An adjacent project recently commissioned by MassDOT is located just north of our study area. It aims to reconstruct the highway superstructure of the aging viaduct section of I-91.

The goal of this study is to improve the efficiency of the regional transportation system, improve access for all transportation modes, improve safety, and maintain regional air quality. It is important to engage stakeholders in the planning process to facilitate cooperative decision making for a solution that will meet today's needs and challenges in the study area. The Interstate Route I-91 Corridor Existing Conditions Study reviews previous corridor studies, updates transportation data, and analyzes traffic volumes and safety patterns.

I.1 STUDY AREA

The study area includes Interstate Route I-91 from the Connecticut State Line to its connection with East Columbus Avenue at Broad Street. This stretch of the highway includes interchanges 1 through 5. The South End Bridge and the Agawam Rotary are also included since they are integral to regional traffic flow and would provide a link to alternate routing for north/south traffic. In addition, the study area includes a buffer area covering local streets potentially impacted by a change in traffic patterns one mile east of I-91 and 1.5 mile west of I-91 to include Route 5 as an alternate route. The buffer stretches north to the viaduct section of I-91 in the vicinity of Union Street (Figure 1).

I.1.1 Roadway Network

In the study area, I-91 is located along the east side of the river. It provides three lanes in both directions except for the vicinity of interchange 3 where it is reduced to two lanes. In the southbound direction it turns into two lanes between the highway exit ramp and the highway entrance ramp at interchange 3 north of the South End Bridge and remains as such till the highway entrance ramp south of the bridge. For about a mile in the northbound direction due to topographic restrictions of a high cliff to the east, I-91 Northbound is reduced to two lanes starting just before Mile Marker 3, well before the Longmeadow curve. It returns briefly to three lanes in the vicinity of interchange 2 before it is reduced again to two lanes and remains as such till the entrance ramp at interchange 3 north of the South End Bridge. I-91 Northbound is three lanes for a short distance between the highway entrance and exit ramps of interchange 2, where the right most lane serves exiting traffic at Exit 2 then becomes a dedicated lane for Exit 3.

The roadway dimensions change in both direction along I-91 as travel and shoulder widths vary throughout the study area. According to the, Travel width, as represented by surface width on the MassDOT highway route log website, is the measurement of a traveled way in feet, excluding shoulders and auxiliary lanes (http://services.massdot.state.ma.us/mrla/RouteSelection.htm). This website as well as the traffic section staff at district 2 were consulted for guidance based on highway construction plans during the compilation of the data displayed in Figure 2. This diagram displays average surface and shoulder widths of the roadway sections depicted.

In the southbound direction, the surface widths range between 24 and 36 feet, the right shoulder ranges between 2 and 12 feet, and the left shoulder ranges between 2 and 4 feet. In the northbound direction the travel width ranges between 24 and 36 feet, the right shoulder ranges between 0 and 10 feet, and the left shoulder ranges between 2 and 4 feet. Gore areas range between 0 and 12 feet. Auxiliary lane is 12 feet.

Figure 1 - Study Area Map

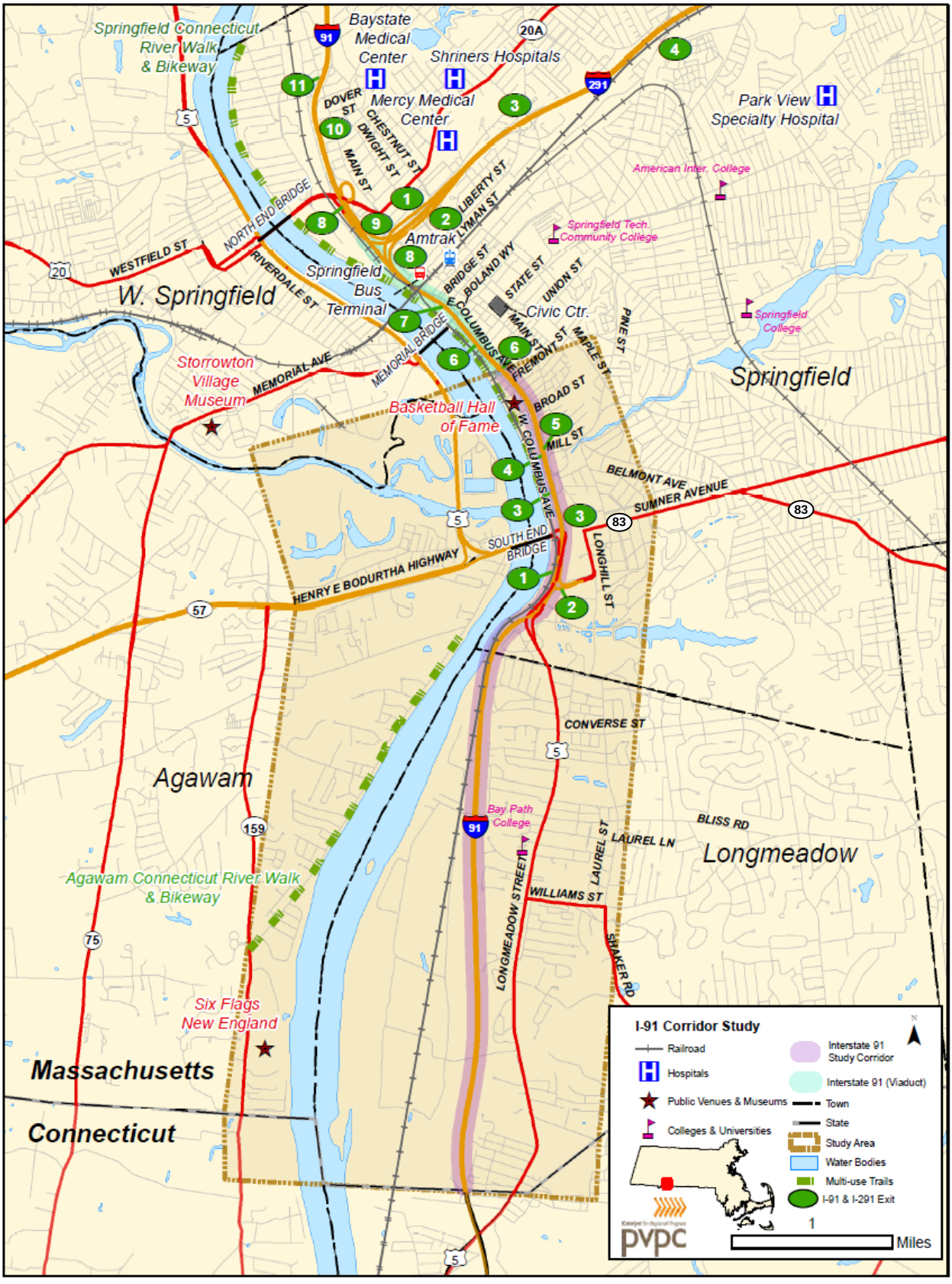
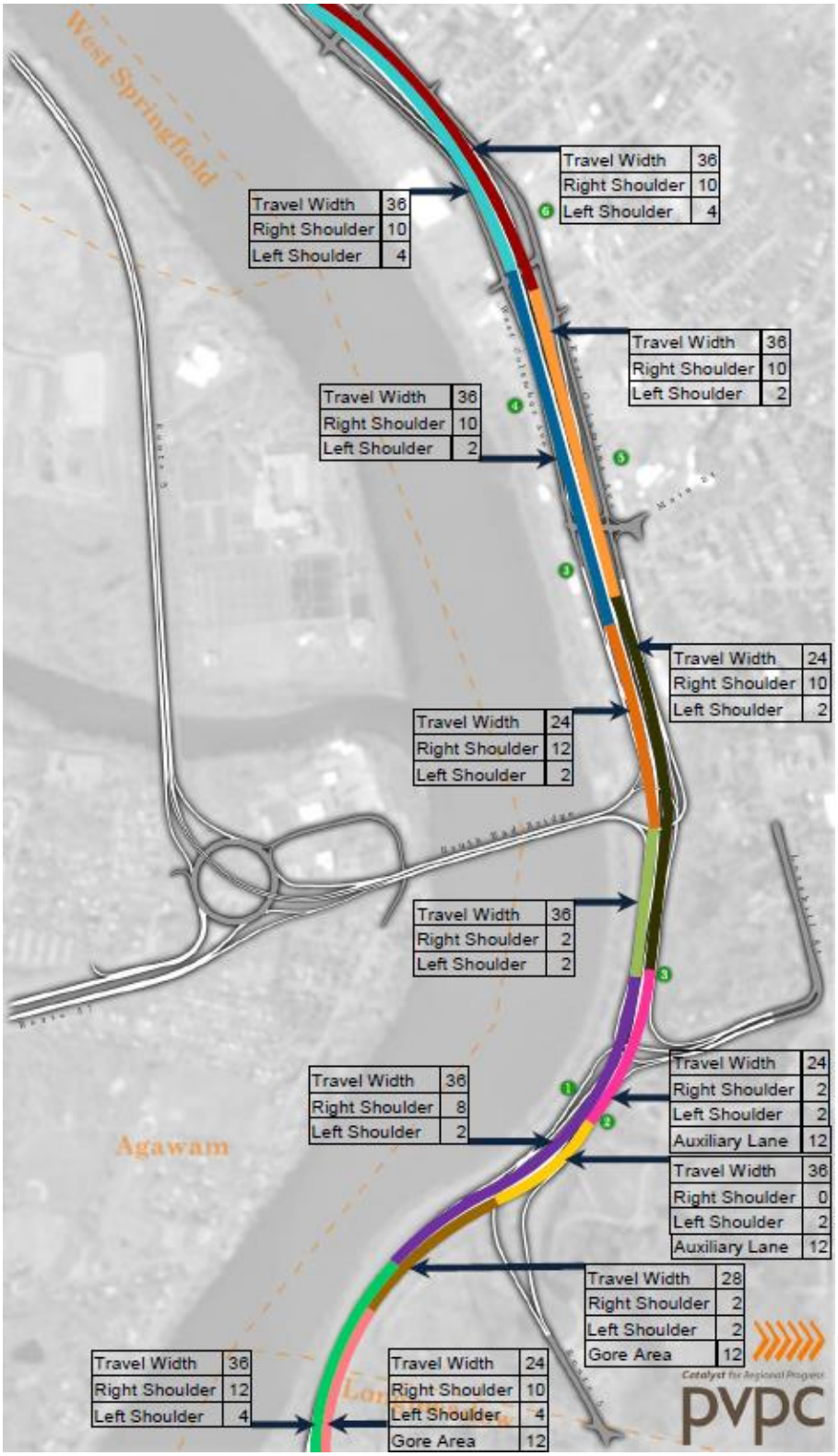


Figure 2 - Interstate 91 Variable Travel and Shoulder Widths within the Study Corridor.



Interstate 91 changes from three to two travel lanes in the vicinity of Mile Marker 3 in the northbound direction. While the pavement width remains consistent in this area, the roadway is defined by two marked travel lanes, one painted gore area, and a paved shoulder of varying widths.

It should be noted that if vertical elements exceed 6 inches (i.e. guardrail, wall, barrier, curb), 2 feet of that shoulder is not considered useable and may be deemed sub-standard. For instance, where there may be a 4 foot left shoulder and 10 foot right shoulder, and guardrail on both sides, it is possible that there is a "usable" shoulders of only 2' and 8' respectively. This could be the case along several stretches of the highway. A thorough review of barrier heights and conditions would be needed to identify locations where usable shoulder widths do not meet minimum acceptable standards. According to 2006 MassHighway Design Guide, the minimum acceptable standard of usable width is 4 feet for a left shoulder, 2 feet for a right shoulder, and 12 feet lane width for an urban freeway.

Northbound and southbound lanes are separated by a THRIE beam guardrail separating traffic from a grass or paved median. The posted speed limit on I-91 is 65 miles per hour from the Connecticut State Line till just before the Longmeadow curve where it is reduced and alternates between 55 and 45 MPH through various sections of the highway through Longmeadow and Springfield. I-91 has five off-ramps in the southbound direction and four in the Northbound direction. The proximity of the on and off-ramps creates several weaving sections on the highway in both directions as well as on the parallel roads; East Columbus Avenue and Hall of Fame/West Columbus Avenue.

West Columbus Avenue was renamed Hall of Fame Avenue in September of 2009. However, it is still referred to by its original name on many maps. Therefore, this report will use both names for easy reference and consistency with previous literature. East Columbus Avenue and Hall of Fame/West Columbus Avenue operate as one-way pairs and provide two to three travel lanes. These frontage roads parallel I-91 throughout the study area connecting the I-91 ramps to the local street system and a variety of land uses. Their posted speed limit is 30 mph. East Columbus Avenue is one-way in the northbound direction and Hall of Fame/West Columbus Avenue is one-way in the southbound direction.

Route 5 near the Springfield/Longmeadow line is contiguous with I-91 for some distance between Interchange 1 and Interchange 3 at the South End Bridge, approximately 2000 feet. Route 5 Southbound joins I-91 Southbound from the South End Bridge till interchange 1 exit ramp. Route 5 Northbound joins I-91 Northbound from interchange 2 highway entrance ramp till interchange 3 exit ramp, then travels west over the South End Bridge. Route 5 in Springfield provides one travel lane in the northbound direction and two lanes in the southbound direction beyond the I-91 Interchange 1 off-ramp until its intersection with Western Drive/Forest Glen Road in Longmeadow. South of this intersection, Route 5 (Longmeadow Street) becomes one lane in both directions.

The South End Bridge connects the east and west banks of the Connecticut River, and the City of Springfield with the Town of Agawam. Two lanes of traffic are provided in each direction. The bridge provides a sidewalk for pedestrians along its northern edge, as an extension of the sidewalk along Hall of Fame/West Columbus Avenue in Springfield. This sidewalk connects with River Road in Agawam via a stairwell from the bridge level. However, it does not provide bicycle access between the two communities. The bridge splits on the eastern side of the river to provide a full interchange at Exit 3 to I-91 (Figure 3).

Figure 3 - South End Bridge Arial View.

II. PREVIOUS STUDIES REVIEW

Several previous studies cover different aspects of the study area. In this section, a summary of the information provided by both recent and historic studies is included for reference. The five referenced studies include:

- **Interstate 91 Corridor Study: An Impact Analysis of the Cultural Landscape**. Pioneer Valley Planning Commission, June 1990.
- **Conceptual Design Study for I-91 (Exit 1 (Route 5 South) to Exit 5 (Broad Street).** Prepared for Mass Highway by Vollmer Associates, 1998.
- **Springfield Flood Evacuation Study**. Pioneer Valley Planning Commission, September 2011.
- **West Columbus Avenue Urban Renewal and Riverfront Redevelopment, Springfield - Massachusetts.** Draft Environmental Impact report prepared by Vanasse Hangen Brusltin et al. August 1997.
- **Summary of Alternatives, Agawam Rotary, Intersection of Routes 5,57, River Road and Meadow Road.** MassHighway Department (now MassDOT Highway Division)**.**

II.1 INTERSTATE 91 CORRIDOR STUDY: AN IMPACT ANALYSIS OF THE CULTURAL LANDSCAPE

The study covered the area immediately impacted by the new highway as well as adjacent areas indirectly impacted in the western Massachusetts's three counties traversed by I-91. The study included a historic overview of the I-91 corridor from planning and construction through 1990 and reviewed the zoning bylaws of the corridor communities. The study also analyzed past as well as future impacts the highway had visually and in terms of displacement, growth and development patterns. Finally, it provided recommendations for preserving the Pioneer Valley's character while benefiting from the improved access.

The attractions of the Pioneer Valley to settlers over the years have been its natural beauty, water resources, fertile soils, and diversity of lifestyles. The Connecticut River provided a major north-south access route running through the center of the valley and linking its three counties: Franklin, Hampshire, and Hampden. Hampden County contains the urbanized core of the region with the majority of its population in the cities of Springfield, Holyoke and Chicopee.

This corridor played a role in the historic and economic development of this region as Interstate I-91 runs along the same route as the river. Over the past fifty years, since its construction, I-91 has replaced the river in its function as the main access route linking the three counties to the State of Vermont to the north and the State of Connecticut to the south.

The following is a summary of the five major components of this study:

II.1.1 Project Orientation

The study area included the area immediately impacted during the construction of the highway as well as the area indirectly impacted after its completion. This comprised a corridor that varied in width from one mile in the south to two miles in the north. The interstate highway itself runs from the Connecticut State Line to the south to the Vermont State Line border to the north. A total of 28 interchanges connect this limited access highway with local streets in the communities it runs through. The following is a list of interchanges that fall within the area of interest in the current I-91 study area. The location of some on and off-ramps have changed or reversed since the original report was completed 23 years ago. Therefore, these descriptions have been revised accordingly.

Exit 1 (southbound only) – Route 5 South, Forest Park/Longmeadow
Exit 2 (northbound only) – Route 83, Forest Park/East Longmeadow
Exit 3 – Route 5 North, Columbus Avenue/Agawam
Exit 4 – (southbound only) Main Street /Springfield
Exit 5 (northbound only) – Broad Street/Springfield
Exit 6 – Union Street/Springfield Center

II.1.2 Historic Review of the I-91 Highway Construction

This included site location factors as well as current problems and impacts caused by the highway. The desire line offering the most direct route between major destinations for this highway followed the already established north-south transportation routes by native Americans along the Connecticut River and its surrounding areas. Colonists followed the same route and took advantage of the fertile floodplain soils and established their homes there. They improved the trails for cart travel and used the river for shipping. In the 19th century, the river and its tributaries were used to generate power for the mills that sprung around its banks. Springfield, Holyoke, Chicopee and Northampton became manufacturing centers. The railroad paralleled this route's north-south alignment to connect these centers. In the early 20th century this land route became a US Highway – Route 5. With the popularity of automobile travel increasing, cities began to grow and people started moving into the suburbs which increased their dependence on the automobile which, in turn, required better roads.

In the late thirties, highway planners tried to solve traffic problems by introducing the limited access expressways concept. President Roosevelt initially believed that a highway system would improve travel, aid economic growth, and create construction jobs. Afterwards, he started to view it as a matter of national defense. In the fifties, President Eisenhower found the system not meeting the needs of the time. He viewed traffic congestion as an impediment to defense transport and economic growth, so he expanded the concept to a National System of Interstate and Defense Highways.

Route 5 experienced congestion through the 1940's.Therefore, the Massachusetts Department of Public Works and the Federal Bureau of Public Roads developed a 1953 master highway plan that included the relocation and improvement of this road. A few years later, the plan changed to create the new superhighway Interstate 91, with the passage of the Federal-aid Highway Act of 1956. In addition to accomplishing the above mentioned goals, the highway would improve access to urban farm markets for rural communities. It was expected to eliminate congestion in towns and cities from through-traffic and reverse suburbanization of commercial traffic. It was also expected to encourage tourism by being scenic. This required careful planning by the communities along the freeway to preserve their character and scenic vistas from the highway-triggered developments. In 1965, the State DPW Commissioner urged communities to update their master plans and zoning regulations as quickly as possible to preserve the natural beauty of the Connecticut Valley.

The selection of the new highway path was controversial, especially in urban centers. Local and state officials debated proposed routes until its completion in 1970. In the beginning, the highway was supposed to run along the western side of the river for its entire length. Influential residents in Suffield, Connecticut wanted to protect their town from the highway and persuaded officials to change it to the eastern side of the river at Longmeadow and Springfield.

A regional chamber of commerce objected to the new route for fear of loss in tourist traffic. Springfield officials and residents were concerned that too many homes and businesses would be demolished to make room for the new road. A state representative suggested that the highway should bypass Springfield by running on the western side of the river to prevent losses of businesses. There was opposition to the interstate routing selection in the town of Whately. The north-south abandoned railroad provided a suitable right-of-way through Hatfield, Whately, and Deerfield. Initial proposals routed it to the west of its present alignment to keep demolition to minimum. A proposal to route the freeway on the east side of the river from Springfield to South Hadley was opposed by West Springfield and Holyoke fearing loss of business. Holyoke succeeded in protecting its downtown from being demolished and advocated for a western alignment.

Concerned residents of the Forest Park neighborhood and Longhill Street took their case to court to protect the park and historic buildings from being torn down by the highway project. The result was that the interchange was pushed back to Longhill Street and the city received a settlement from the state for the land and museum building that was demolished to make room for the highway exit. A big debate about the routing of the highway through Springfield's North End neighborhood focused on the conflict it created with an urban renewal project already in place. Other restrictions included an existing major pumping station along the river's northern city section. The mayor was concerned about the potential displacement of 5000 residents by the state's proposed freeway routing in the north end. The Columbus Avenue section of the highway used the right-of-way of the rail yard to reduce demolition. The location of

the bridge between Springfield and West Springfield was debated to maximize benefits of connecting to the Massachusetts Turnpike. Towns to the north were also concerned that the freeway would cut through the Oxbow and the flood plains of the Northampton Meadows because it could act as a dike hampering flow.

Construction of the highway started in the north and proceeded south. The Springfield section was the last to be completed because of the densely populated area and increasing controversy about land takings and demolition. The resulting demolition carved a block-wide corridor between the downtown and the river, cutting off the City from its riverfront. Construction of I-91 from the Connecticut State Line to the Vermont State Line took over ten years and was completed on December 8, 1970 at a cost of $155 million. One year later, traffic increased 50% along this new freeway.

II.1.3 Visual Assessment of the Corridor

This described I-91 while travelling from south to north and noted the existing conditions and impacts, recording them with photographs and slides. Six case study sites were included to represent various settings such as: urban-residential, urban-commercial, suburban, small village center, and rural. The case study of the Longmeadow-Forest Park area covers the changes brought upon by the highway and Exits 1 and 2.

Longmeadow's historic building structures and character were spared most adverse impacts of highway construction but it was cut off from its meadow lands previously used for farming and leisure along the river bank. Springfield lost a historically significant museum and its residents were cut off from the King Phillip's Stockade site when it became too dangerous to cross the interchange to reach the now separated picnic area from Forest Park. Forest Park itself lost its serene vistas to the noise and emissions from highway traffic that sped around its cliffs.

<u>Highway Impacts:</u>

- Loss of buildings and properties. In Springfield, both new as well as historic commercial, industrial, residential, and municipal structures were destroyed displacing many families and businesses. This changed the character of the downtown area drastically.
- Damage of archeological sites in agricultural lands historically cultivated by native and colonial inhabitants.
- Disruption of the natural environment such as hindering the spawning and migration of shad as a result of construction activities such as altering slopes, dredging the river for gravel, mining for fill, and relocating rivers and streams.
- Creation of new ponds and changing topography where fill was extracted from wetlands and floodplains to build up the road bed. An example; the cove for the Oxbow marina.
- Alteration of floodplains and restricting the flow of flood waters in the Spring.
- Rerouting rivers and creating new wetlands thus changing the drainage patterns.
- Loss of agricultural land, especially in the northern section of the highway.
- Reduced traffic along the old highway and local arterial roads.
- Environmental damage due to violations by highway contractors dumping fill over top soil.
- Visually and physically cutting of the City from the surrounding hills and the riverfront with the elevated expressway as the water table would not allow the construction of a depressed highway. This prevented Springfield from benefiting from the newly recognized value of riverfront properties.
- Damage of the cityscape with the destruction of trees and lawns at Court Square in Springfield.
- Loss of major industries in Springfield including Indian Motorcycle, Buxton, Hood, and Package Machinery.
- Deterioration of buildings as retail stores moved out of downtown.
- Middle-class residents moved further east into Pine Point and Sixteen Acres neighborhoods.
- New modern style buildings were constructed on cleared sites and used for the Baystate West Mall, the civic center, newspapers, and post office.
- Property development near the interchanges took the form of motels, restaurants, gas stations and shops. This enforced the trend of businesses going away from downtown in many affected towns. This also increased strip developments and commercial decentralization.

- Loss of local landmarks in the form of historic bridges, old parishes, etc.
- Reduction in congestion within towns and cities from the reduction of through-traffic.
- Created safety and flow problems most acutely noticed at Springfield's downtown exit and entrance ramps area where Columbus Avenue meets Boland Way (formerly known as Vernon Street). The roads in the vicinity of exits 6 and 7 have been reconfigured several times since the construction of the freeway to improve traffic flow efficiency.
- Decreased traffic along the old highway, Route 5, caused decreased business as stores and services became less visible to passing motorists and the higher speeds on the new highway led to fewer stops from travelers on the limited access highway.
- Congestion relief was short lived. A short time after construction, congestion became a problem on I-91 at the southern end between Longmeadow and Connecticut and widening the highway in Connecticut was being planned by 1974.

II.1.4 Zoning Bylaw Review

The strengths and weaknesses of each bylaw were reviewed in the areas of performance standards to assess the potential land use impacts caused by I-91. There are ten interchanges in Springfield along the corridor. Interchanges 1, 2, and 3 are zoned business to the west of the corridor and residential to the east. Both interchanges 4 and 5 are surrounded by industrially zones land, while interchanges 6 and 7 are in the business district. Interchanges 8, 9, 10 are surrounded by a mixture of district types. Industrial land dominates interchange 11.

Zoning Bylaw recommendations included: reduction in sign size and height standards, a requirement for additional off-street parking with any building expansion, elimination of front yard parking requirements for businesses and industrial uses, a more stringent landscaping requirement for large parking areas in non-residential uses, and the consideration to adopt a site plan review bylaw for specified business and/or industrial uses along the corridor.

II.1.5 Recommendations.

To benefit from the improved access without losing the character of the Pioneer Valley region, the following set of recommendations were developed to address highway impacts:

Highway Planning and Construction:

- Hold informational meetings early in the planning and design process.
- Directly involve the local planning boards and historical commissions and the Massachusetts Historical Commission in all aspects of planning and design.
- Incorporate open space and local design themes into the planning and design phase whenever possible.

Highway Aesthetics and Improvements:

- Integrate landscaping into the layout and physical setting of the highway
- Develop a more formalized series of rest areas along the highway.

Highway Land Use and Zoning:

- Adopt commercial corridor siteplan approval standards with required Traffic Impact Statements.
- Improve zoning controls for signs, parking, landscaping, siteplan approval and design.
- Billboard amortization and removal.
- Encourage open space community developments.

II.2 CONCEPTUAL DESIGN STUDY FOR I-91

In 1997, attempts to relieve traffic congestion and reduce crashes along I-91 through improved signs and pavement markings and the reconstruction of several signalized intersections at key locations were not highly successful. Therefore, the MassHighway Department began considering long range solutions. This 1998 conceptual design study by Vollmer Associates focused on the I-91 corridor from Exit 1 to Exit 5. It evaluated 1997 existing and 2020 no build traffic conditions and reviewed a variety of design concepts ranging from improvements at specific interchange locations to larger corridor improvements.

The study inventoried natural and man-made constraints and sensitive resources along the corridor. These included: land use, topography/steep slopes, water bodies, developed areas, and parks. It used as a base map the MassHighway's 1996 Safety Improvement Plan (Project # IM-91-1 (146)). I-91 is situated approximately 50 feet higher than the river on its east bank. Its distance from the river ranges between 100 to 200 feet between Exits 1 and 3. The railroad tracks also separate the river from the highway, while a retaining wall separates the highway from railroad between Exits 1 and 2. Forest Park is located on the east side of the highway between Exits 1 and 2, while residential areas along Longhill Street are approximately 60 feet higher than the highway.

II.2.1 Design Concept Alternatives

Six design concepts were developed as part of the study. Four concepts were recommended for further consideration and are summarized in Table 1. An Origin-Destination survey was deemed necessary for quantifying the evaluation of the roadway network and its critical intersections, weaving sections, and ramps under any design development.

The following is a complete list of conceptual designs developed, ranging from minimal build to large scale:

- Concept 1.0 included: closing of Exit 3 Northbound on-ramp, constructing a new ramp north of Main Street (reversal of Exit 4 off-ramp), closing the Exit 3 Southbound off-ramp. Closing the Exit 5 Southbound both off and on-ramps at Broad Street (Figure 4).
- Concept 1.1 included: extending East Columbus Avenue to south of Exit 1 (Route 5), constructing East Columbus Avenue east of Exit 3 loop ramps, eliminating Longhill Street on-ramp to I-91 Southbound, closing Exit 3 inner loop ramp to I-91 Northbound, constructing West Columbus Avenue connection at Longhill Street (Exit 2), constructing overpass (braided ramp) of the southbound on-ramp at interchange 4 Main Street) with the southbound off-ramp to South End Bridge, and maintain the Exit 5 ramp configuration from concept 1.0 (Figure 5).
- Concept 2.0 included: constructing a northbound off-ramp to Longhill Street beginning south of Route 5 and passing under Route 5 then continuing parallel to I-91, providing a Route 5 connection to Longhill Street on a new ramp, eliminating the southbound on-ramp between Interchanges 2 and 3, extending West Columbus Avenue south of Exit 1, eliminating the northbound off-ramp to the South End Bridge, reconstructing East Columbus Avenue east of Exit 3 and constructing a new overpass to provide a connection to the South End Bridge, providing a one-way street system with Mill Street Westbound and Main Street Eastbound, relocating the southbound off-ramp at Main Street, constructing a southbound ramp to the South End Bridge, closing and/or altering Exit 5 ramps at Broad Street.
- Concept 3.0 included: extending East Columbus Avenue to the south of Exit 1 (Route5), reconstructing Exit 2 as a diamond interchange with East Columbus Avenue and Longhill Street, reconstructing West Columbus Avenue from Exit 1 to 3 and providing access at the new diamond interchange, reconstructing East Columbus Avenue east of Interchange 3 loop ramps, eliminating the southbound on-ramp from West Columbus Avenue (Main Street Exit), eliminating the northbound on and off-ramps from and to Broad Street, and eliminating the southbound off-ramp to Broad Street (Figure 6).
- Concept 4.0 included: eliminating access to Longhill Street, reconstructing East Columbus and West Columbus Avenues between Exits 2 and 3, reconstructing the Mill Street underpass to East Columbus Avenue, creating a one-way street network on Mill and Main Streets, relocating the southbound off-ramp to Main Street approximately 700 feet north, eliminating the southbound off ramp and northbound on-ramp at Broad Street.
- Concept 5 included: constructing a new interchange approximately 1500 feet south of Exit 1, constructing a connector road from Route 5 to I-91 at the new interchange, eliminating Longhill Street access to I-91, improving I-91 geometry between Exits 1 and 3, providing a local connection between Route 5 and Longhill Street, constructing an overpass for the southbound off ramp over the northbound on-ramp to the South End Bridge, eliminating and altering on and off-ramps at Interchanges 4 and 5.

- Concept 6.0 included: constructing a new interchange 600 feet south of Exit 1, constructing a new bridge over the Connecticut River that reconnects Route 5 and Route 57, constructing an interchange of Route 5/57 on the west side of the river, extending East and West Columbus Avenues to the south of Exit 1, constructing a diamond interchange at Longhill Street and Columbus Avenue, eliminating the Longhill Street connection to I-91, removing the South End Bridge, eliminating Exit 3 (South End Bridge Interchange), and improving I-91 geometry (Figure 7).

The four design concepts recommended for further analysis are presented in Figures 3-6. Roadway sections were color coded yellow, green, and pink to represent segments respectively identified for roadway construction, bridge construction, and demolition. Even though design concept 6.0 was projected to require the highest budget to accomplish, it was estimated to provide the most benefit compared to other concepts in the original conceptual study. Therefore, it was presented at the end of this section of the study in a site context map (Figure 8). Design concept 6.0 was also superimposed over an aerial view to identify through its location some of the impacts it would have upon its surroundings (Figure 9). Future studies would need to assess the feasibility of these alternatives, their benefits with regards to current roadway conditions and land uses as well as future land development and growth patterns.

Table 1 - Conceptual Designs Identified by 1998 Corridor Study for Further Consideration.

Concept 1.0 (Figure 4)	**Concept 1.1 (Figure 5)**	**Concept 3.0 (Figure 6)**	**Concept 6.0 (Figure 7)**
• close Interchange 3 Northbound on-ramp • construct a new on-ramp north of Main Street (reverse of Exit 4 off-ramp) • close Exit 3 Southbound off-ramp • Close Exit 5 Southbound off-ramp and on-ramp at Broad Street	• extend East Columbus Avenue to south of Exit 1 (Route 5) • reconstruct East Columbus Avenue east of Interchange 3 loop ramps, eliminating Longhill Street on ramp to I-91 Southbound • close Interchange 3 inner loop ramp to I-91 Northbound • reconstruct West Columbus Avenue connection at Longhill Street (Interchange 2) • construct an overpass (braided ramp) for the Southbound on-ramp at Interchange 4 Main Street with the Southbound off-ramp to the South End Bridge • maintain the Exit 5 ramp configuration from concept 1.0	• extend East Columbus Avenue to the south of Exit 1 (Route5) • reconstruct Exit 2 as a diamond interchange with East Columbus Avenue and Longhill Street, • reconstruct West Columbus Avenue from Exit 1 to 3 and provide access at the new diamond interchange • reconstruct East Columbus Avenue east of Interchange 3 loop ramps • eliminate the Southbound on-ramp from West Columbus Avenue north of interchange 3 • eliminate the Northbound on-ramp and off-ramp from and to Broad Street • eliminate the Southbound off-ramp to Broad Street.	• construct a new interchange 600 feet south of Exit 1 • construct a new bridge over the Connecticut River that reconnects Route 5 and Route 57 • construct an interchange of Route 5/57 on the west side of river • extend East and West Columbus Avenues to the south of Exit 1 • construct a diamond interchange at Longhill Street and Columbus Avenue • eliminate the Longhill Street connection to I-91 • remove the South End Bridge, eliminating Interchange 3 (South End Bridge Interchange) • improve I-91 geometry
1998 Cost Estimate = $4.5	1998 Cost Estimate = $8.5-28.5	1998 Cost Estimate = $27	1998 Cost Estimate = $64
2013 Cost Estimate = $7	2013 Cost Estimate = $13.2-44.4	2013 Cost Estimate = $42	2013 Cost Estimate = $99.7

*Cost Estimates in Million Dollars. 2013 Project Cost Adjustment Factor for Inflation (3%/year) = 1.56.

Figure 4 - Design Concept 1.

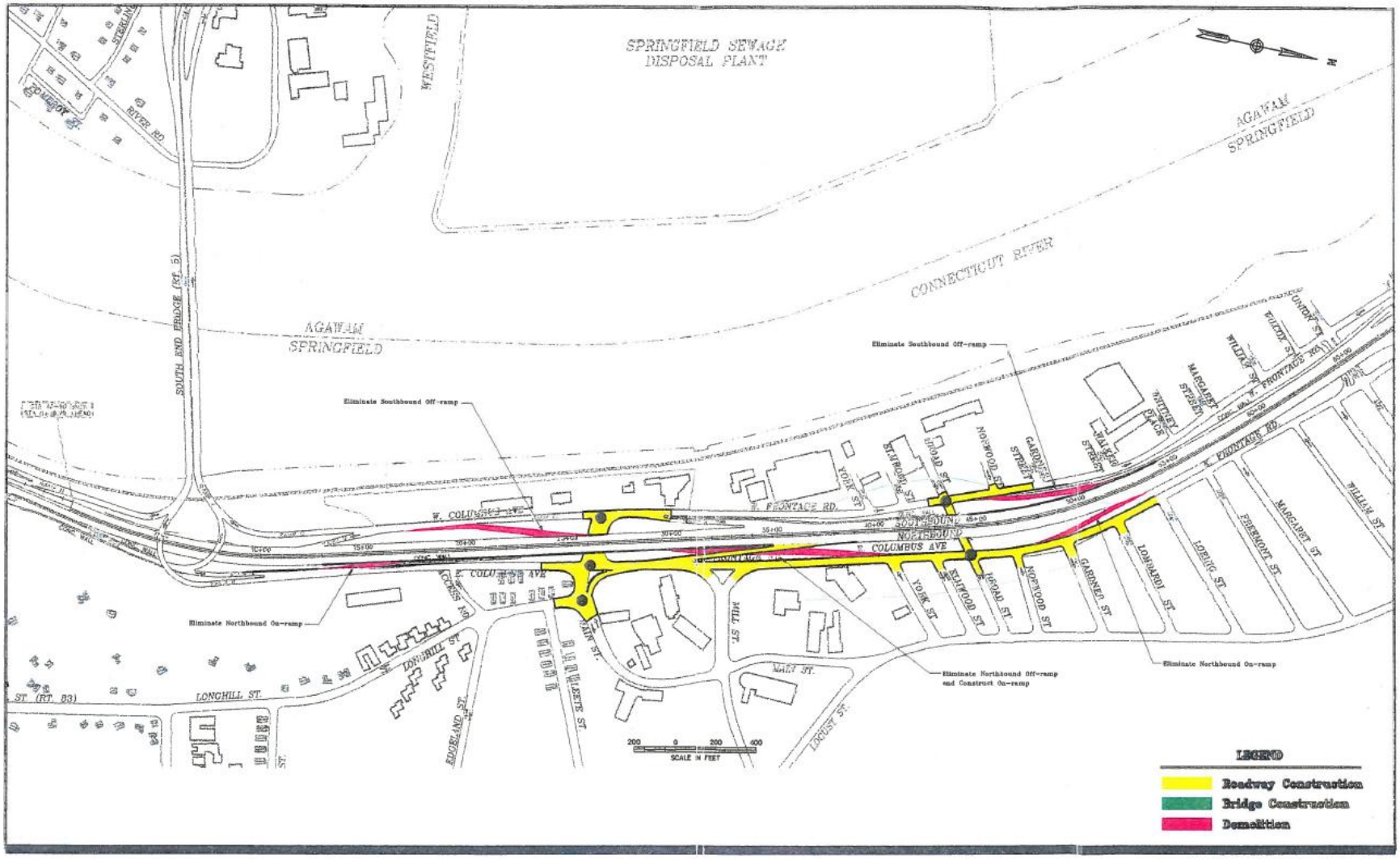
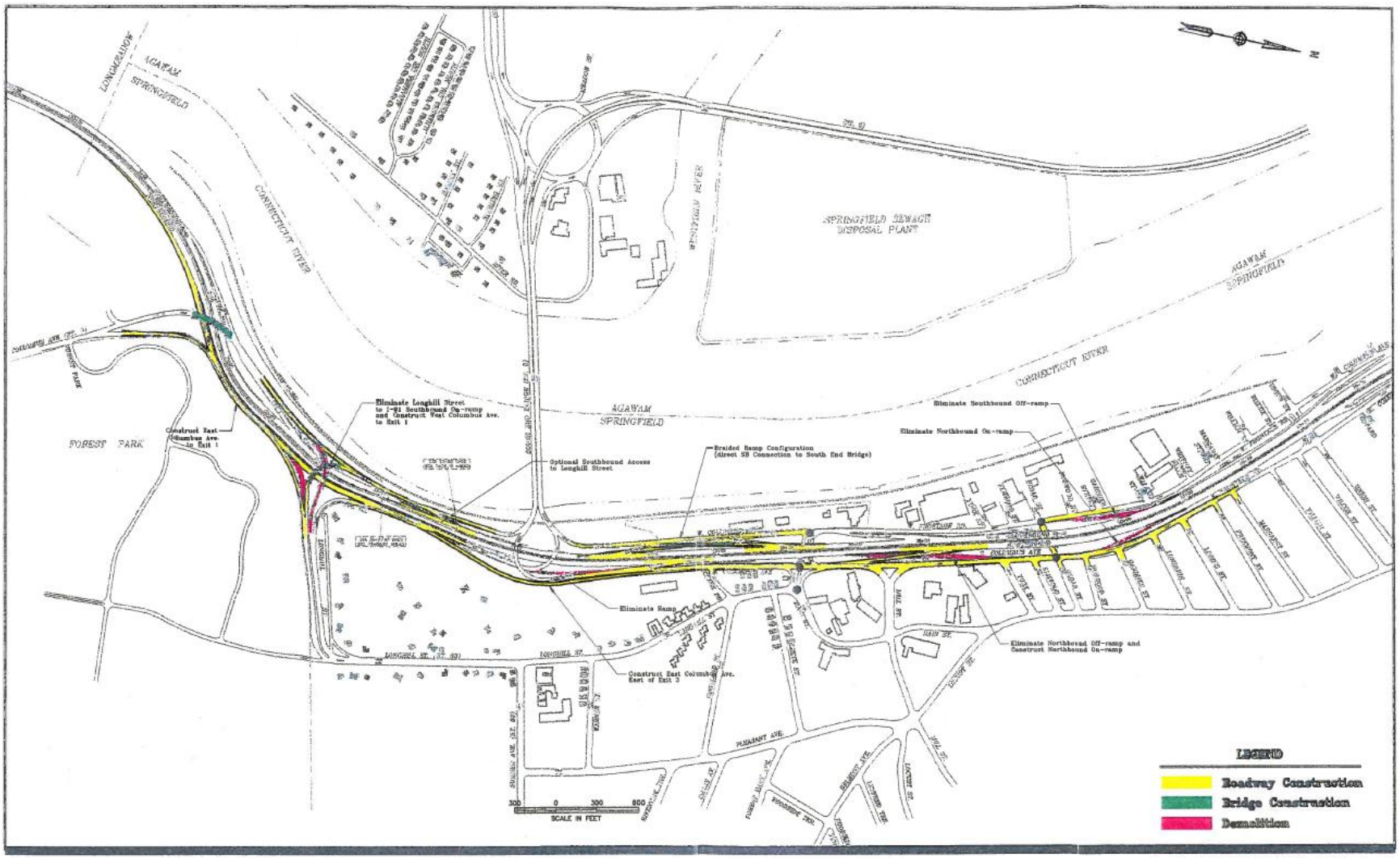


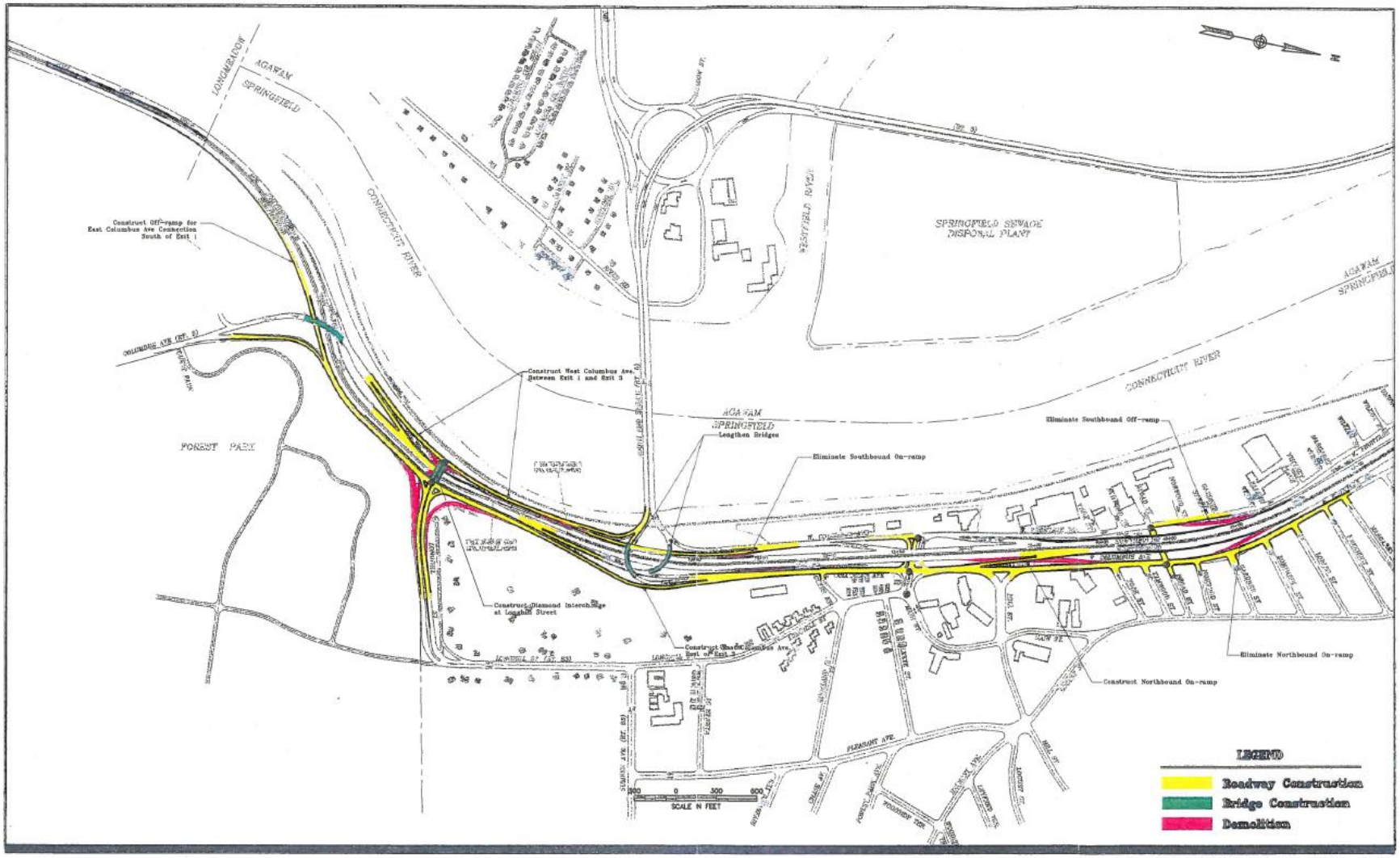
Figure 5 - Design Concept 1.1.



MASS HIGHWAY

I-91 SPRINGFIELD EXIT 1-5
CONCEPT 1.1
SCALE 1"=300' JULY, 1998

Figure 6 - Design Concept 3.



MASS HIGHWAY

I-91 SPRINGFIELD EXIT 1-5
CONCEPT 3.0
SCALE 1"=300' JULY, 1998

Figure 7 - Design Concept 6.

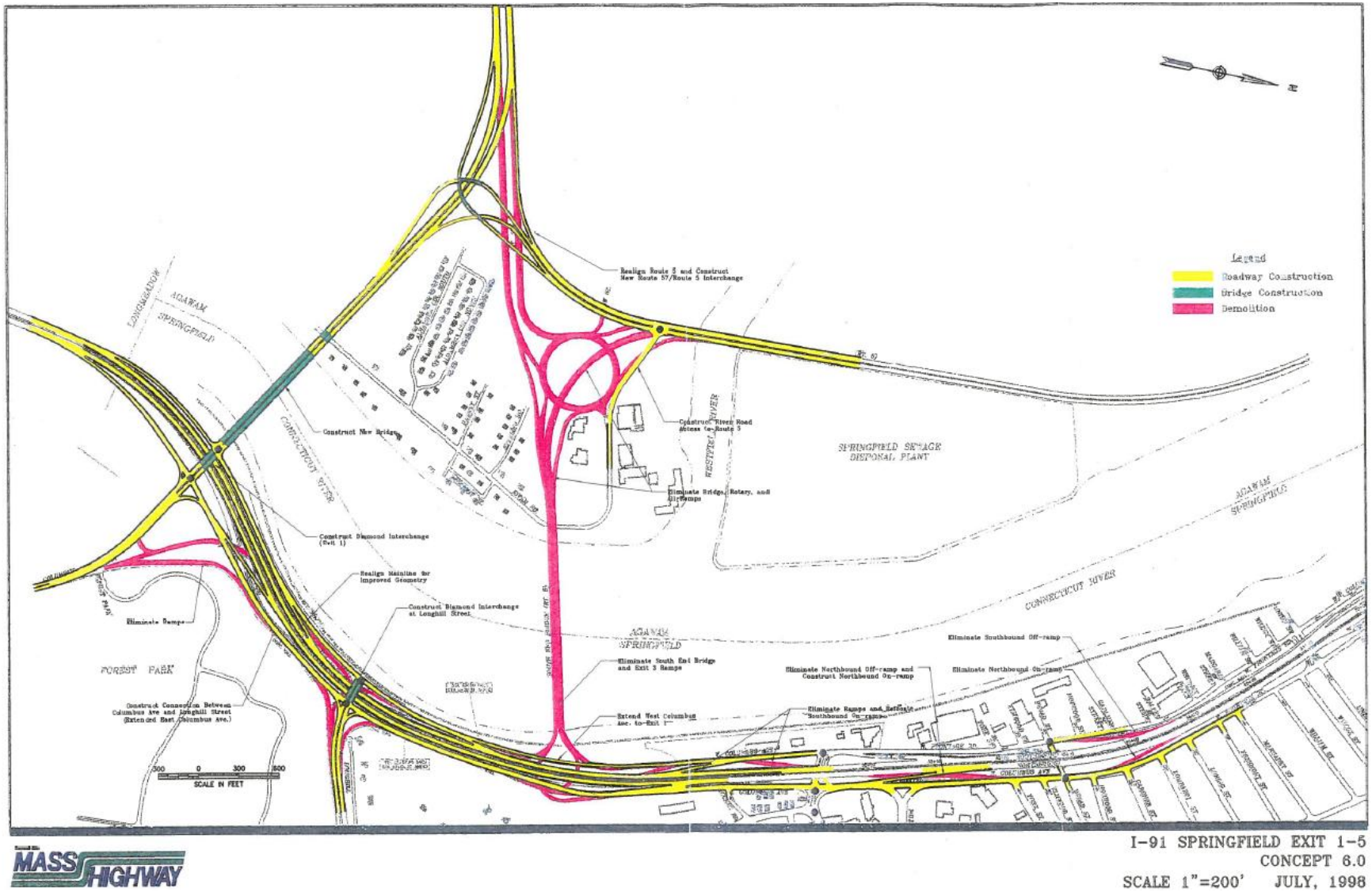


Figure 8 - Design Concept 6 in the Current Site Context.

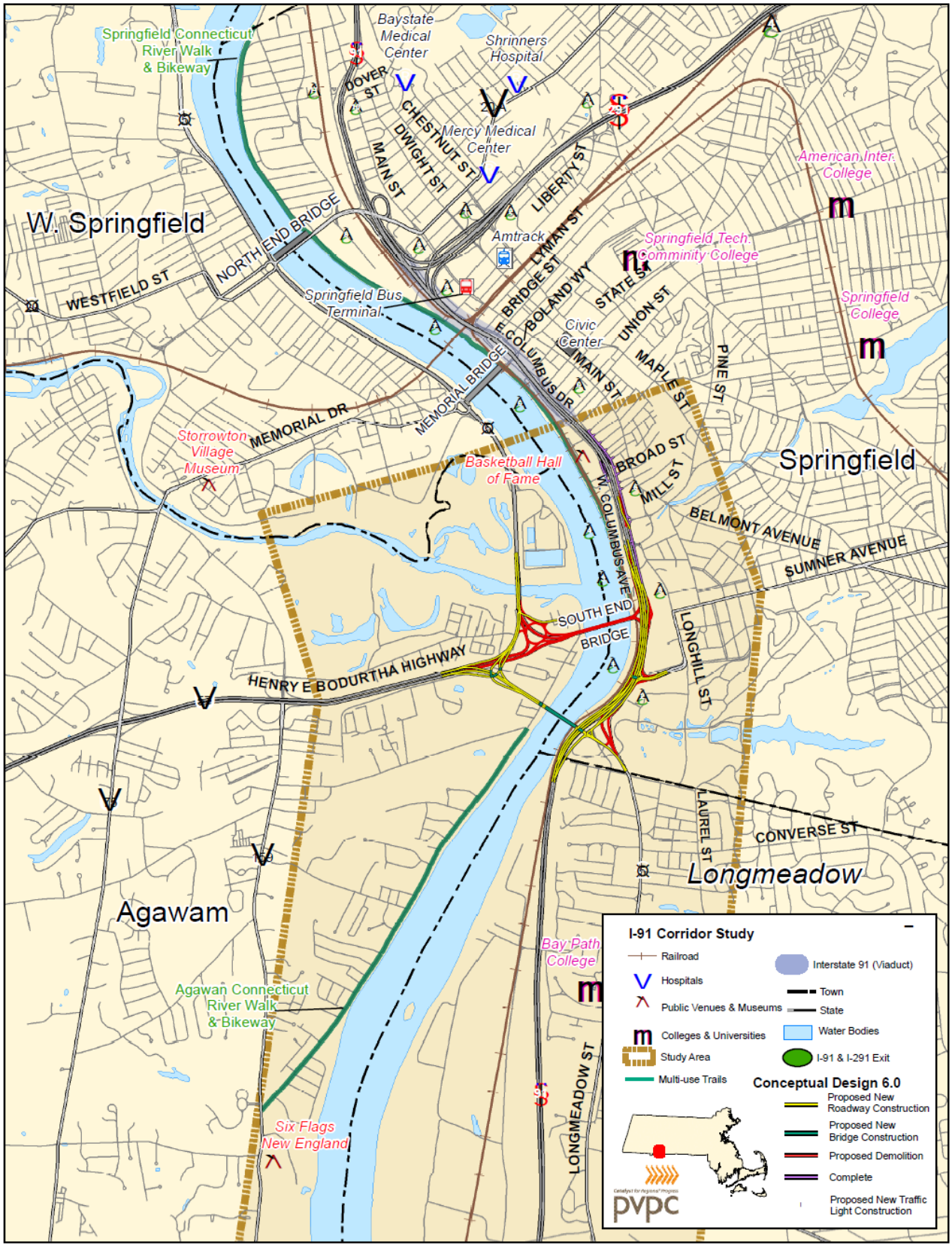
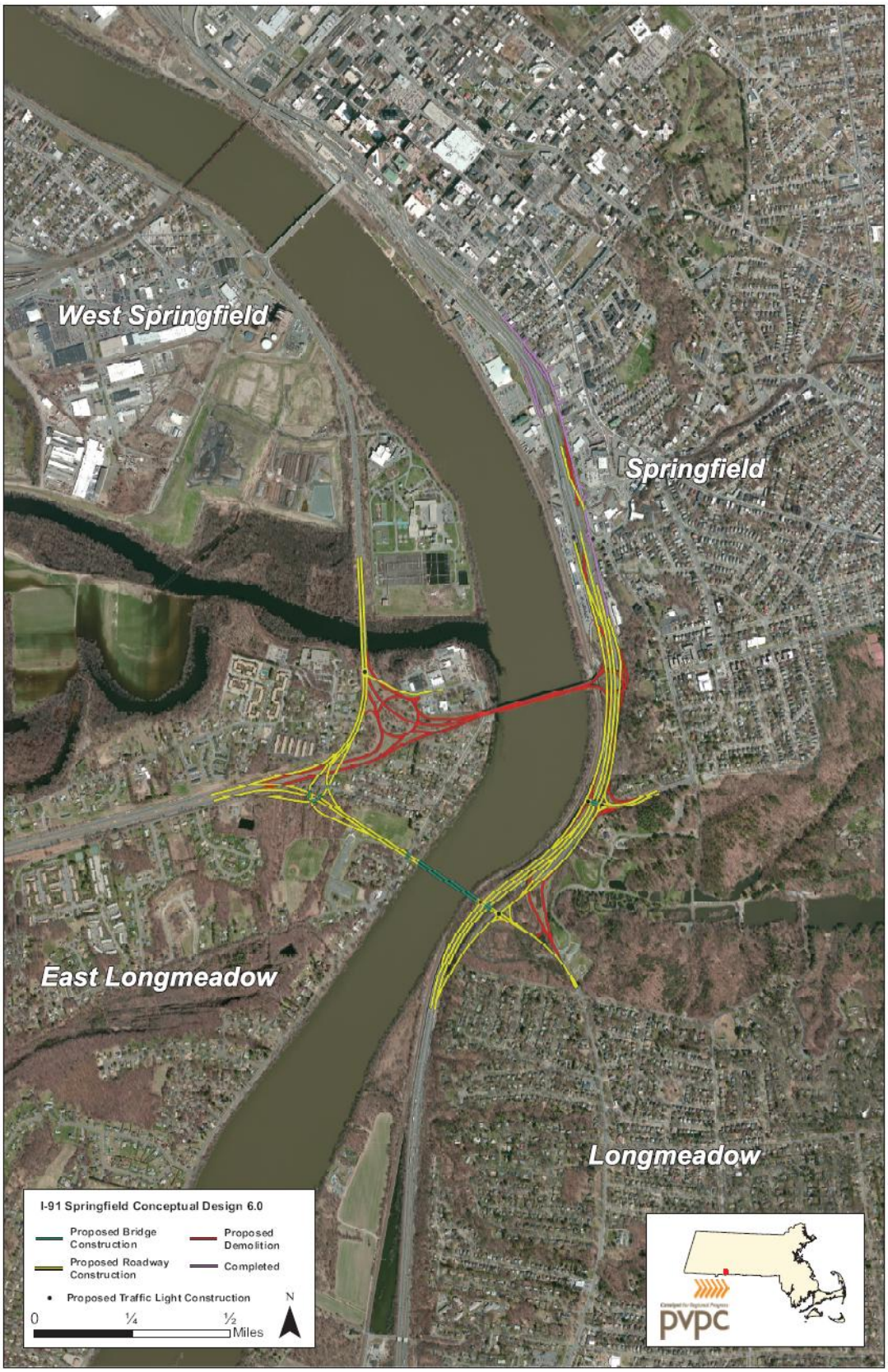


Figure 9 - Design Concept 6 Superimposed Over Site Aerial View.



II.3 SPRINGFIELD FLOOD EVACUATION STUDY

This 2011 study by the Pioneer Valley Planning Commission included an analysis of three flood scenarios one of which was located in the South End neighborhood in the southwest corner of the city along the Connecticut River. Planned detour routes set by the emergency preparedness team were viewed in conjunction with roadway segments inaccessible to vehicular traffic during a flood. The regional travel model provided an analysis of traffic flow changes in the flood zone and surrounding roadways. The traffic impact analysis identified locations that would experience an increase in congestion.

The City of Springfield's Predisaster Mitigation Map developed by the Pioneer Valley Planning Commission was utilized to identify areas that could be impacted by flooding. This map includes the 100 and 500-year flood zones as well as hazardous dams, locations with hazardous materials, and sensitive receptors such as hospitals and schools.

The Mill River conduit flood scenario study area is located in the southwest corner of the City at the lower section of the South End neighborhood. This area falls within the I-91 corridor study and therefore it is highlighted here. After reviewing the flood maps, elevation of bridges, highway, and topography the following assumptions were made:

Inaccessible Roadways:

- No Access to Julia Buxton (South End) Bridge from Interstate 91 Southbound lane
- East and West Columbus Avenue from Julia Buxton Bridge to State Street
- Main Street from Longhill Avenue to State Street
- Longhill Avenue from Main Street to Edgeland Street
- Mill Street from East Columbus to Pine Street
- Union Street from Main Street to Maple Street
- Side streets surrounded by State Street, Maple Street, Mill Street, and East and West Columbus Avenues.

Accessible Roadways:

- Julia Buxton Bridge from Interstate 91 North bound
- Julia Buxton Bridge from points west
- Route 5 bridge over Westfield River in Agawam

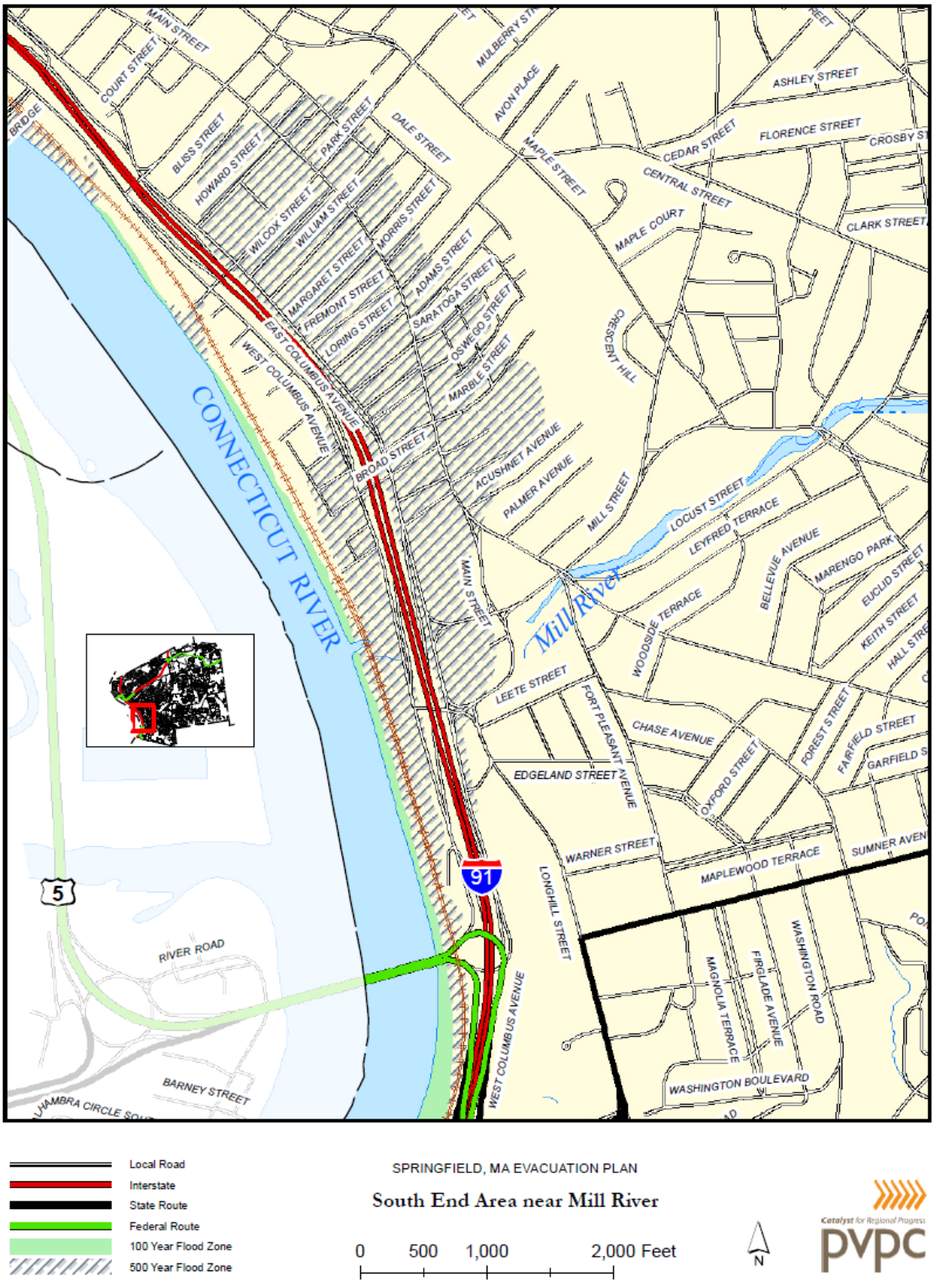
Under these assumptions, businesses, communities and services likely to be impacted by a flood in this area include the following sensitive receptors:

- Schools including Zanetti Elementary School, etc.
- Churches including St. Joseph's Church, First Spiritualist Church, Springfield Rescue Mission, etc.
- Densely settled residential neighborhood
- Several gas stations including Main Street Gas Station, Auto Craft Sales, etc.
- Environmental Protection Agency Tier-Two hazardous material locations.
- Major Automobile sales locations which may leak chemicals from vehicles. About a thousand vehicles are estimated to be currently held at these locations. Auto sales businesses include several Balise Auto dealerships, and Bear Auto.
- Rail Access along the Connecticut River would be interrupted. This will disrupt passenger as well as freight rail service beyond a regional scale.
- Several Combined Sewer Overflow locations along the Connecticut River
- Public service agencies such as the HAP Housing and the Caring Health Center.

II.3.1 Existing Conditions

The Mill River flows west from Watershops Pond into the Connecticut River. The Bay State Plumbing and Heating Dam constricts the Mill River as it passes under Locust Street. The dam is approximately 16 feet high. A 500 year Flood Zone surrounds the area where the Mill River meets the Connecticut River. This Flood Zone extends roughly from the intersection of Longhill Street and East Columbus Avenue north to Howard Street (Figure 10).

Figure 10 - Mill River Conduit Flood Scenario Location Map.



The landscape is highly urbanized and industrial. From the Watershops Pond Dam, the river travels under Allen Street, Hancock Street, and Mill Street with progressively less clearance at each crossing. Upon reaching the intersection of Mill Street, Belmont Avenue, Locust Street, and Fort Pleasant Avenue, the Mill River passes the Baystate Plumbing and Heating Dam and enters a culvert. The river emerges to daylight, approximately 200 feet later, after passing under the intersection. Approximately 200 feet later, the Mill River again enters a tunnel that travels under Main Street, a shopping complex, East Columbus Avenue, Interstate 91, and West Columbus Avenue. Just west of Interstate 91, the river finally emerges into a three sided concrete channel just before the confluence with the Connecticut River.

II.3.2 Flood Process

A flood of much of the land near the Bay State Plumbing and Heating Dam as well as land within the 500 Year Flood Zone would occur as a result of a failure at the dam. The dam's hazard level is listed as a Significant Hazard Dam. It has been rated by the Massachusetts Office of Dam Safety. The date of the last inspection is not available. If the dam fails, water will cascade down the river corridor in the midst of an urban environment. Residential, commercial, and industrial structures sit within 50 linear feet of the river in several locations. The general topography of the land is close to the level of the river, therefore flood waters would interfere with both public and private infrastructure.

The culverts that direct the Mill River under Locust Street and under Interstate 91 may hold up to flood waters. Water that cannot be accommodated is expected to overflow onto city streets and private property. However, pressure on the walls and roof of the culvert could undermine its structure. If the dam fails completely, it is possible that the street surface would crumble into the culvert and cause severe damage to the roadway. At either case, flooding would occur along the lowest lying lands in the South End neighborhood.

Much of the South End neighborhood lies in the 500 Year Flood Zone. The area framed by Interstate 91 on the west, Howard Street on the north, about one half block east of Main Street and the beginning of Longhill Street in the south define the 500 Year Flood Zone. Large portions of land between Interstate 91 and the Connecticut River, including much of West Columbus Avenue, are also included in the 500 Year Flood Zone. If either Mill Street or Interstate 91 culverts were to fail, it can be expected that this 155 acre area would flood.

II.3.3 Evacuation Logistics

Railroad impacts would be severe without an alternative to the existing route. If railroad tracks are taken out of service by a flood, this will halt service for the entire north/south corridor, which currently connects our region with Vermont and Canada to the north and Connecticut and beyond to the south.

When much of the South End neighborhood becomes inundated with water, travel on surface roads would also be restricted. Interstate 91 and Maple Street would be the closest north/south roadways available. State Street and Route 83, locally known as Sumner Avenue, would be the closest available east to west corridors. Interstate 91 is a viaduct through this area, whereas State Street, Sumner Avenue, and Maple Street run on higher ground.

Interstate 91, while remaining open in both directions, would have a number of entrance and exit ramps inaccessible. Southbound highway entrances remaining open would be the on-ramps from Interstate 391, Interstate 291, Plainfield Street, and the Julia Buxton Bridge (South End Bridge) at Exits 12, 8, 9 and 3 respectively. While entrance to I-91 Southbound just north of the South End Bridge would remain open, the only bridge access would be through a closed segment of West Columbus Avenue. The southbound entrance to the highway from West Columbus Avenue just south of Union Street at Exit 5 would be closed.

Southbound highway exits remaining open would be off-ramps at Exits 10, 8, 7, 3 and 1. These connect I-91 with Bernie Avenue, I-291, West Columbus Avenue just north of Memorial Bridge, West Columbus Avenue just north of the South End Bridge, and Route 5 south into Longmeadow. Exit 4 off-ramp Southbound would be closed to West Columbus Avenue just north of Main Street.

Northbound on-ramp entrances at Exits 1, 2, 3, 7, 8, and 9 remain open. They would connect I-91 to Route 5 in Longmeadow, Route 83, the South End Bridge, East Columbus Avenue just north of State Street, Interstate 291, and Plainfield Street. No northbound entrances would be closed.

Northbound off-ramps at Exits 2, 8, 9, 10, and 12 remain open and they would connect I-91 to Route 83, the South End Bridge, Interstate 291, Plainfield Street, Main Street at Dover Street, and Interstate 391. Northbound off-ramps at Exits 3, 4, and 5 would be closed to East Columbus Avenue between Main and Bruno Street, between York and Mill Street, and between Margaret and Freemont Streets.

Major routes in and out of the city center would remain open. Access to West Springfield, Agawam and all points west of the City of Springfield would remain available over the Memorial and South End Bridges as well as via Interstate 91 Northbound from Springfield to West Springfield.

Access into Longmeadow and all points south of the city of Springfield would remain available. From the downtown area, vehicles would have to travel to Harrison Avenue via Boland Way, turn towards the Connecticut River, travel under Interstate 91 and turn left onto West Columbus Avenue. The entrance onto I-91 south at Exit 5 lies outside the 500 year flood zone.

Access to points east of the city would, for the most part, remain open. Access to Interstate 291 and Route 20 eastbound would remain open. Travel to Route 83 from I-91 South, exiting onto West Columbus Avenue and traveling up Longhill Avenue would be inaccessible.

From the downtown area, vehicles traveling east would have detour options. The first would direct a motorist from State Street onto Maple Street, left on Mill Street, bearing right onto Dickinson Street, then Route 83. However, motorists able to access I-91 south may not realize they would not be able to take their preferred route home after they pass a closed exit. Information about detours would need to be relayed to motorists on I-91 via the Massachusetts Department of Transportation variable message signs.

The best routing option is to direct traffic to stay on I-91 south until Exit 1 towards Route 5 South into Longmeadow. Traffic destined for East Longmeadow and all points east would be directed through Forest Park until the first stop sign after the Barney Estate, then up a hill to the left and onto Longhill Street and Route 83. This route has fewer turns and a shorter detour. Another advantage of this route is that roads traveled are not city streets, thus they may experience less afternoon commuter traffic.

Traffic traveling into the flooded area from the Forest Park neighborhood would also have to be rerouted. Vehicles traveling inbound on Longhill Street would be directed right onto Edgeland Street and left onto Fort Pleasant Avenue. Vehicles traveling inbound on Fort Pleasant Avenue would be directed right onto Blake Hill, across Belmont Avenue and onto Leyfred Terrace. Vehicles traveling inbound on Belmont Avenue would be directed right on Leyfred Terrace. All vehicles would converge on Leyfred Terrace, turn left on Woodside Terrace, right on Locust Street, left on Mill Street over the Mill River (well above the flood zone) and right onto Maple Street. Police Officer assistance may be necessary to assist traffic through detour routes.

Vehicles traveling inbound on Dickinson Avenue and Orange Street should be directed away from both the flooded area and away from the mass of vehicles detoured from Longhill Street, Fort Pleasant Avenue, and Belmont Avenue. Vehicles from Dickinson Avenue and Orange Street should be directed right onto Hancock Street and left onto Walnut Street. Walnut Street leads to State Street where traffic will disperse. Vehicles from Dickenson Avenue and Orange Street should not be directed onto Maple or Central Streets, even though it provides a shorter detour to avoid converging with detoured traffic from the city's south side.

II.3.4 Analysis of Traffic Impacts

II.3.4.1 Impact on Bridges

The flood zone in Scenario 2 includes Exit ramps 3 and 4. Thus, southbound traffic on I-91 will not be able to reach West Columbus Avenue or the South End Bridge. Therefore, more vehicles traveling west across the Connecticut River will alternatively use the North End Bridge or Memorial Bridge towards West Springfield to get across Route 5. Consequently, some southbound traffic on I-91 will be diverted onto Route 5 (Table 2).

Table 2 - Estimated Traffic Volume Change on Bridges Across the Connecticut River.

Street Name	Daily Traffic Volume (Existing Conditions)	Daily Traffic Volume (Flood Scenario)	Percentage Change
Memorial Bridge (Westbound)	20,759	24,292	+17%
South End Bridge (Westbound)	25,936	15,131	- 42%
Route 5 (Southbound between North End Bridge and Memorial Bridge)	12,396	14,619	+18%
Route 5 (Southbound between Memorial Bridge and South End Bridge)	16,710	23,457	+40%

Traffic volumes will not change significantly for the eastbound traffic on the three bridges across the river. However, in order to avoid getting onto the no-access segments of I-91 between the Memorial Bridge and the South End Bridge, eastbound traffic from the Memorial Bridge would need to continue straight onto Harrison Avenue instead of turning right onto West Columbus Avenue. Eventually, vehicular traffic on West Columbus Avenue would have to turn left onto State Street because the I-91 on-ramp will be flooded past that location. Eastbound traffic on the South End Bridge will be inclined to turn right towards Route 83 to avoid the flood zone.

II.3.4.2 Impact on I-91

The area impacted by the flood cuts off the I-91 on-ramps and off-ramps that are connected to the segment of the highway between the Memorial Bridge and the South End Bridge. To reach the urban core of the city and its local streets, vehicular traffic on I-91 could get off the highway either before entering this no-access segment or after going through this segment of the highway. Therefore, traffic diverts onto I-291 and Route 83, which are connected to the I-91 Exit 8 and 2 ramps outside of the inundated zone. The travel demand model shows traffic volume increases on the interchange connecting I-91 and I-291, as well as Route 83 connecting I-91 (Table 3). Vehicular traffic from East Columbus Avenue and West Columbus Avenue between State Street and the South End Bridge would drop down to zero due to water inundation and inaccessibility.

Table 3 - Estimated Traffic Volumes Change on I-91 Exits Outside the Flood Zone.

Street Name	Daily Traffic Volume (Existing Conditions)	Daily Traffic Volume (Flood Scenario)	Percentage Change
I-91 (Southbound between Memorial Bridge and South End Bridge)	47,080	32,538	-30%
Route 83 connecting I-91 (Westbound)	9,044	16,092	+78%
Route 83 connecting I-91 (Eastbound)	10,346	16,524	+60%

II.3.4.3 Impact on Local Streets

A significant increase in traffic volume is expected to occur on major urban streets due to traffic diverted from Main Street. This is especially true for urban arterials and collectors adjacent to Main Street, such as: Maple Street, State Street, Pine Street and Walnut Street (Table 4).

Once individuals move out of the flood zone, this area will not produce or attract further trips for the travel demand model. This means that previously occurring trips into or out of this flood impacted area will no longer happen. Therefore, a drop in traffic volume should be expected on some streets. An example would be Belmont Avenue and Locust Street because they connect directly to Main Street (Table 5). A similar decrease in traffic volume is seen on Forest Park Avenue as it connects to East Columbus Avenue through Leete Street.

Table 4 - Increase in Traffic Volumes and Congestion on Urban Streets.

Street Name and Traffic Direction		Existing Conditions		Flood Scenario		Traffic Volume Percentage Change
		Daily Traffic Volume	V/C	Daily Traffic Volume	V/C	
Maple St. between Central St. and Mulberry St.	WB EB	8,385 5,986	1.66 1.18	12,283 9,970	2.43 1.97	+46% +67%
State St. between School St. and Walnut St.	WB EB	7,675 7,152	1.20 1.12	12,163 10,939	1.91 1.72	+58% +53%
Pine St. between Walnut St. and Central St.	SB NB	1,847 2,168	0.37 0.43	7,207 6,832	1.42 1.35	+290% +215%
Taylor St. between Spring St. and Chestnut St.	SWB NEB	2,081 1,282	0.51 0.32	6,080 4,658	1.50 1.15	+192% +263%

** WB: westbound, EB: eastbound, SB: southbound, NB: northbound, SWB: southwest bound, NEB: northeast bound, NWB: northwest bound, SEB: southeast bound.*

Table 5 - Decrease in Traffic Volume and Congestion on Urban Streets.

Street Name and Traffic Direction		Existing Conditions		Flood Scenario		Traffic Volume Percentage Change
		Daily Traffic Volume	V/C	Daily Traffic Volume	V/C	
Belmont Ave. between Mill St and Summer Ave.	WB EB	9,322 8,712	1.46 1.37	4,154 4,085	0.65 0.64	-55% -53%
Locust St. between Belmont Ave. and Mill St.	WB EB	5,503 5,060	1.36 1.25	--------- ---------	------ ------	--------- ---------
Forest Park Ave. between Summer Ave. and Leete St.	WB EB	6,566 4,734	1.62 1.17	1,731 1,902	0.43 0.47	-74% -60%

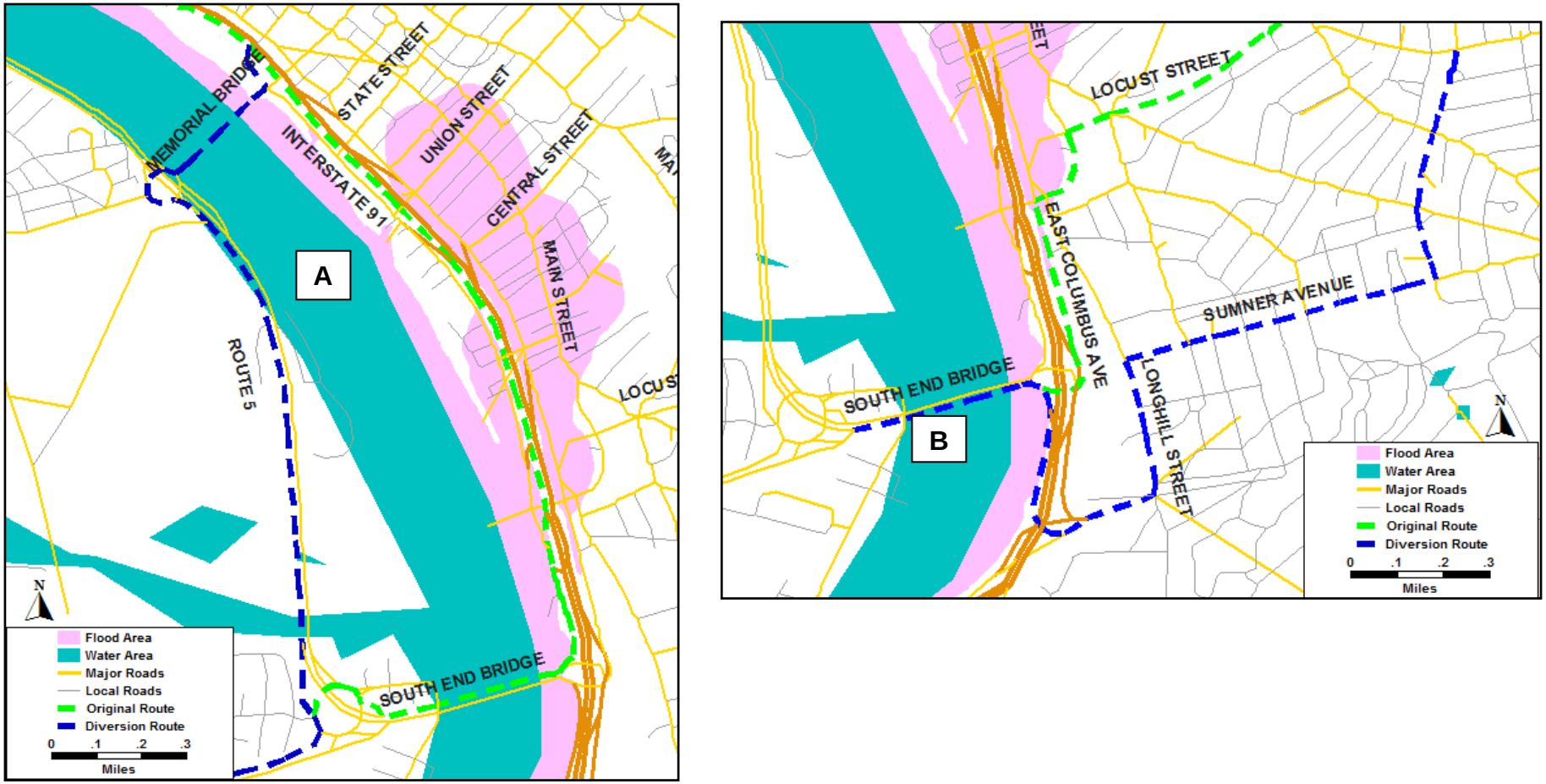
** WB: westbound, EB: eastbound, SB: southbound, NB: northbound*

II.3.5 Identification of Diversion Routes

Traffic diversion routes are plotted to visualize route changes due to an evacuation. Green dotted lines represent an original route taken by vehicles during a normal day, and blue dotted line represent diversion a route due to inaccessible roadways during a flood. Diversion Route A shows vehicular traffic moving away from West Columbus Avenue onto Route 5 via the Memorial Bridge. Vehicular traffic from the west coming from the South End Bridge would divert from its normal straight path towards Locust Street onto Route 83 to access the south eastern section of the city through Sumner Avenue (Figure 11).

Pre-disaster evacuation routes would lead people onto State Street and I-291, according to initial emergency plans. However, the travel model simulation showed that diverted traffic caused congestion to the north of the flood impacted area on roads such as State Street, Spring Street, and Magazine Street. On the other hand, roadways southeast of the flood impacted area appeared less congested. This suggests that it maybe better to plan evacuation routes towards the south through Belmont Avenue and Locust Street, as they did not appear to be affected by diverted traffic.

Figure 11 - Traffic Diversion Route A and B.



II.3.6 Pre-disaster Preparedness for the Springfield Levies

The Department of Public Works monitors the soundness of structures designed to protect the city and its residents from a water flood. Their routine work includes various steps to prevent a flood scenario from occurring to the extent possible. They have identified the following existing conditions and needs.

- The Department of Public Works regularly checks the condition of the levee structures put in place along the river banks in Springfield. In anticipation of a flood event, personnel will patrol the levy system along the banks to detect any sand boils or tree roots alerting to required repairs.
- The city's levies have already received certification for the 100-year flood, but the 500-year flood levels have not yet been evaluated.
- The Department of Public Works submits a quarterly report to the Army Corps of Engineers and will be a developing a flood manual.
- To allow the existing flood wall to work in the case of a flood, three closures are required along the Riverfront Park and across the railroad tracks.
- Identified barriers to continued monitoring and repairs to the levy system include a wall tilt due to construction and heavy equipment in the north section. Another barrier is the inhibited access to the river bank by existing businesses along the river in the middle and south sections. The city may need to reclaim access to the river front at the Bassett Boat Company in the North End and the Balise Auto dealership in the South End.

II.3.7 Recommendations for Addressing Transportation Issues

- Flooding in the South End neighborhood may cause chemical leaks from gas stations and auto dealership and repair lots that would create a potential fire hazard. Such businesses located in the flood zone should be advised about the need for creating an emergency plan to minimize potential risks associated with a flood.
- Alternative transport for regional and interstate freight and passenger rail along the North-South corridor needs to be explored. The disruption to railways through Springfield in the event of a flood would require either trucking of goods or bussing of passengers to their ultimate destinations. Establishing a contingency plan for such an event would be beneficial.

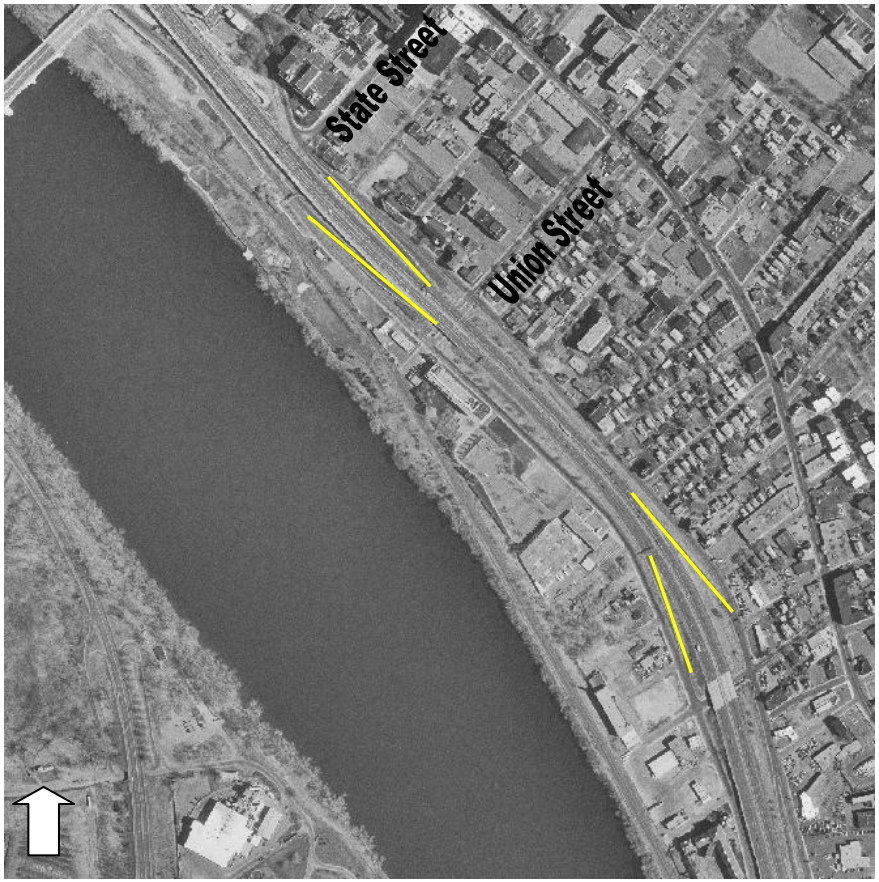
II.4 WEST COLUMBUS AVENUE URBAN RENEWAL AND RIVERFRONT REDEVELOPMENT

A draft environmental impact report, prepared by Vanasse Hangen Brustlin and other consultants in August 1997 for the West Columbus Avenue Urban Renewal and Riverfront Redevelopment project, included analysis of traffic operations for existing conditions as well as the build out scenario of an expanded Basketball Hall of Fame. This project included information on four highway ramp reversal improvements being advanced by the former MassHighway Department in the vicinity of Exit 6 on both sides of Interstate I-91 (Table 6). These ramp reversals were designed to address safety issues at weave segments caused by the close proximity of highway entrance and exit points. Also, the new highway design provided improved access to the redevelopment site at Riverfront Park. The ramp reversal project was completed in 2002. The Exit 6 on and off-ramps are highlighted on the aerial imagery in Figure 12 to show the change in roadway design before and after ramp reversal.

Table 6 - I-91 Ramp Reversals Around Exit 6, Completed in 2002.

Direction	Old Ramp	New Ramp
I-91 Southbound	On-ramp south of State Street	Off-ramp north of Union Street
I-91 Southbound	Off-ramp south of Union Street	On-ramp south of Union Street
I-91 Northbound	On-ramp north of Broad Street	Off-ramp south of Union Street
I-91 Northbound	Off-ramp south of State Street	On-ramp north of Union Street

Figure 12 - Before and After Ramp Reversal (Imagery 1997 MassGIS, ©2013 Terra Metrics).



Original Design Before Ramp Reversal

Current Design After Ramp Reversal

II.5 SUMMARY OF ALTERNATIVES, AGAWAM ROTARY, INTERSECTION OF ROUTES 5, 57, RIVER ROAD AND MEADOW ROAD

The South End Bridge (Julia Buxton Bridge) connects the communities of Agawam and Springfield and serves as a fundamental link between Route 5, Route 57 and I-91. Traffic along these main corridors has increased dramatically, causing congestion along the bridge and highway. In the vicinity of the bridge, Interstate 91 reduces from three lanes of travel in each direction to two. A number of difficult weaving movements also exist in this area, which when combined with high traffic volumes contribute to congestion and safety problems. Exit ramp traffic from the South End Bridge to the Route 5/57 rotary experiences severe peak hour congestion and long delays. The intersection of this ramp and the Route 5/57 rotary is also listed as one of the Top Crash Locations in Massachusetts.

A study for the Route 5/57 rotary was commissioned by MassDOT and feasible improvement alternatives are being developed to improve congestion and safety in this area. A previous study conducted in 2002 looked at six different design alternatives (Figures 13 to 19). One of the original alternatives was revisited and modified in 2004. A recent alternative included a diverging diamond design (Figure 20). The list of the alternatives and their 2013 estimated is presented in Table 7.

Recently, the rotary area underwent pavement marking improvements and alternations. The project involved road widening, removal of existing pavement markings, placement of new markings, installation of new traffic signs, removal and resetting of existing sloped granite edging and curb, and the installation of new drainage structures (Figure 21). The ramp widening from the rotary to the bridge was completed in the summer of 2012.

Table 7 - Rotary Design Alternatives.

Alternative	**2013 Cost Estimate** (Million)
1A modified	$ 14.4
1A	$ 10.7
1B	$ 21.6
2	$ 19.1
3A	$ 11.4
3B	$ 32.7
4	$ 37.2
Diverging Diamond	$ 12.9

Figure 13 - Design Alternative 1A Modified, Agawam.

Figure 14 - Design Alternative 1A, Agawam.

Figure 15 - Design Alternative 1B, Agawam.

Figure 16 - Design Alternative 2, Agawam.

Figure 17 -Design Alternative 3A, Agawam.

Figure 18 - Design Alternative 3B, Agawam.

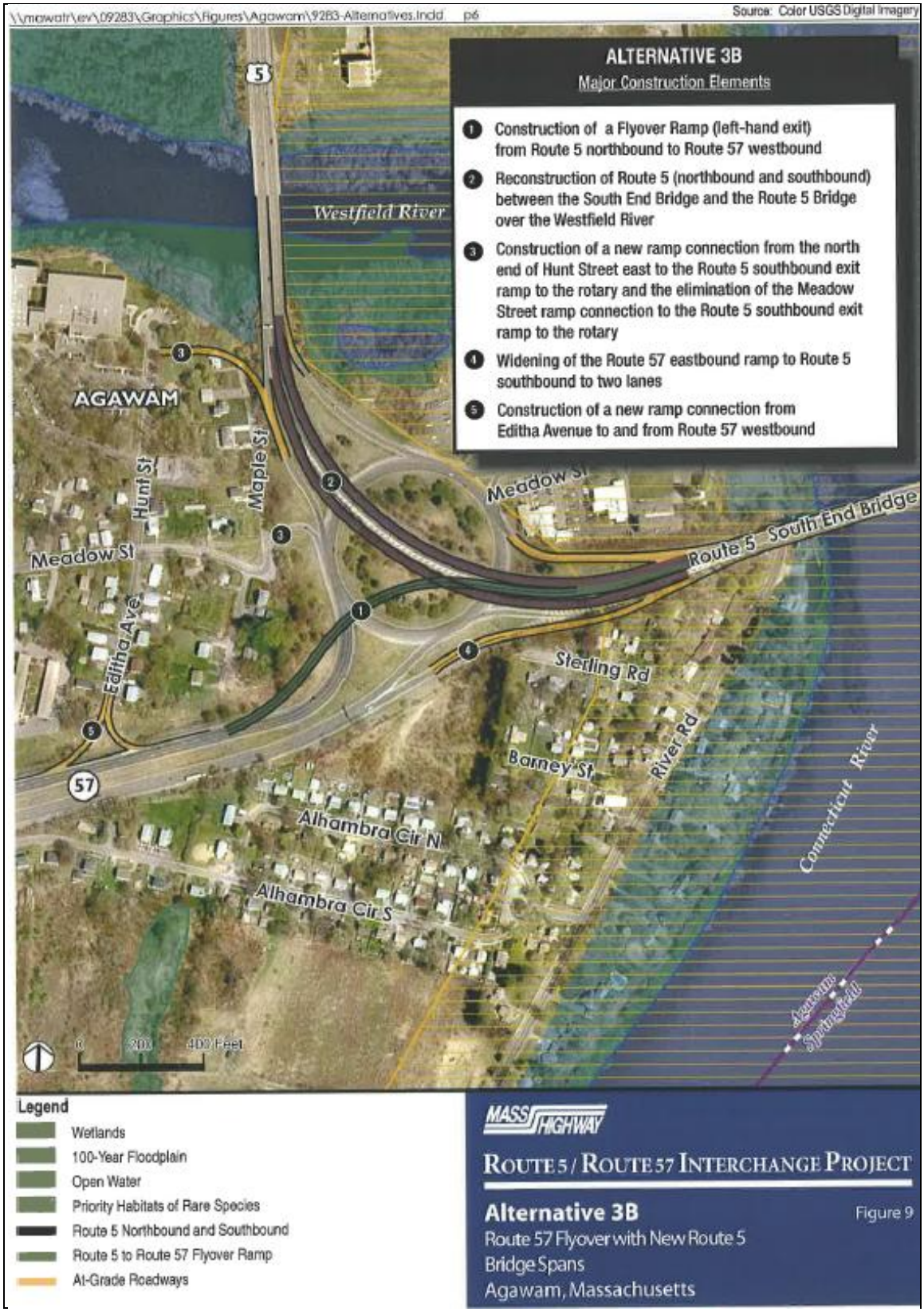


Figure 19 - Design Alternative 4, Agawam.

Figure 20 - Diverging Diamond Interchange Design Alternative, Agawam.

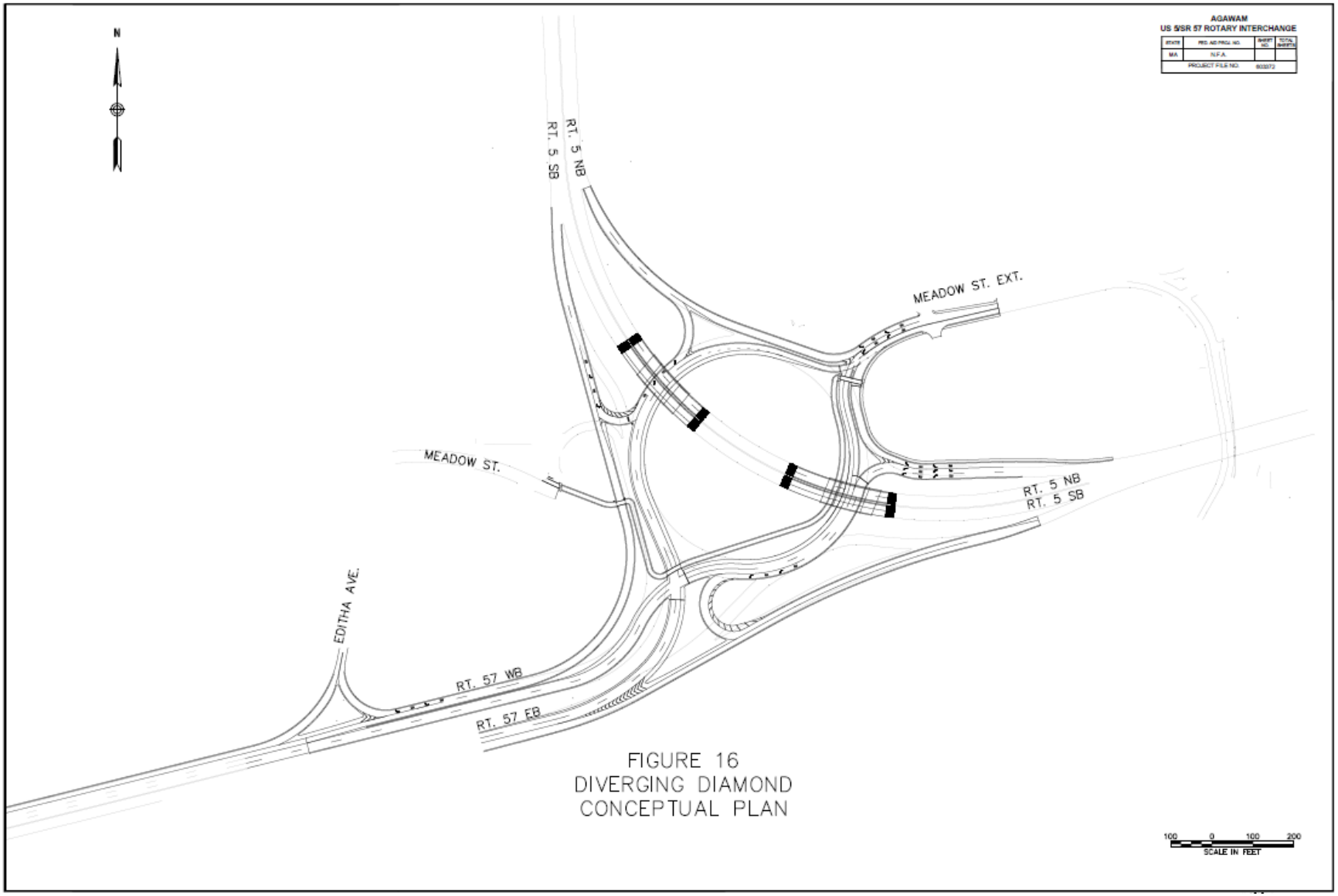
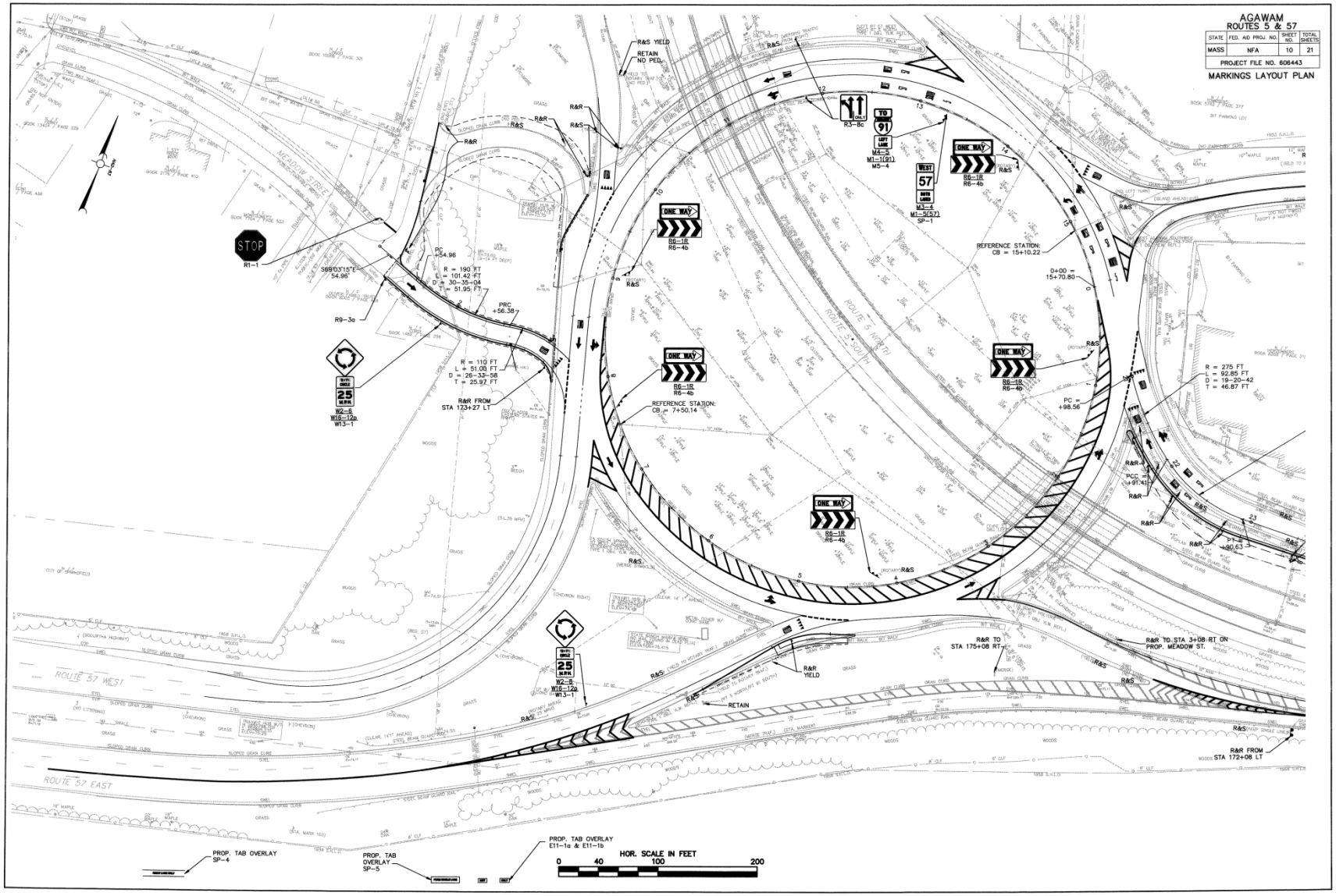


Figure 21 - Route 5 and 57 Markings Layout Plan, Agawam.



III. EXISTING TRANSPORTATION CONDITIONS

This section provides a technical evaluation of the transportation components of the study area. It includes a presentation of the data collected, crash experience and operations analyses to the overall performance and safety of the I-91 corridor.

III.1 DATA COLLECTION

Comprehensive field data collection was conducted for this study by the Pioneer Valley Planning Commission. A compilation of data from various sources is presented in this report. This included previous historic data collected by the Massachusetts Department of Transportation and its affiliated agencies and consultants for projects in and around the study area. This activity consisted of obtaining traffic volumes, crash experience, and observations of traffic patterns along the I-91 corridor.

A historic count table was developed for locations in the study area. New traffic counts included daily traffic counts and turning movement counts. Turning movement counts were conducted at major intersections for the morning and afternoon peak hours, whereas the daily counts were conducted over several days to obtain an Average Daily Count. A select number of daily traffic count locations included information on vehicle classification and average travel speeds. The PVPC staff collected a large portion of the data used in this report. Additional data was obtained from the Massachusetts Department of Transportation and their consultants. The following is a summary of each of the traffic count types and the information gathered.

III.1.1 Daily Vehicle Volume

Vehicle volume data was collected for use in the transportation analysis to measure travel demand on an average weekday. Average Daily Traffic (ADT) volumes were compiled for a typical weekday over 48-hour periods at various mid-block locations within the study area using Automatic Traffic Recorders (ATRs). Since traffic volumes tend to fluctuate over the course of a year, the MassDOT develops traffic volume adjustment factors to reflect monthly variations. These factors were examined to determine how traffic conditions in the study area compare to average month conditions in accordance with the month that an intersection was counted. All ADT volumes were factored to represent Average Annual Daily Traffic (AADT) levels.

Traffic counts at exit ramps were obtained from MassDOT. Hourly and total volumes were calculated from the data provided. Turning movement counts were manually obtained at select locations by the PVPC staff. Supplemental data was obtained from Precision Data Industries, LLC (PDI) for Vanasse Hangen Brustlin, Inc. (VHB) and the MassDOT Highway Division. A summary of most recent data gathered is listed in Table 8. A comprehensive table of data gathered during the past 10 years with location descriptions and actual count sheets are included in the Appendix B.

The most recent traffic counts available for locations along the I-91 Corridor in Springfield and Longmeadow are displayed on the map in Figure 22, which reflects daily traffic volumes. The dates of these counts ranged from 1997 to 2012. The map shows the two-way AADT on I-91 as well as its ramps. Ramp data displayed was collected in 2009. Directional Daily Traffic Counts are color coded by source of data as displayed on the study area map. Taking the variation in dates of traffic count years into account, the AADT along the highway showed that traffic volumes were higher further away from the southern border of the City of Springfield. In general, overall traffic volumes increased from the south towards the north of the study corridor as vehicles approached the highway interchanges leading to the Massachusetts Turnpike, I-90. A summary of daily ADT volumes on just I-91 is presented in Figure 23.

Table 8 - Daily Traffic Volumes.

Site Code	Latest Count	Source	Daily Volume	Interval Length	Direction	AM Peak		PM Peak	
						Time	Volume	Time	Volume
26	6/19/2012	MassDOT	79,580	15 min	NB	7:15 to 8:15	2,775	4:45 to 5:45	3,600
					SB	7:00 to 8:00	3,195	4:30 to 5:30	3,149
2190	7/6/2011	MassDOT	23,043	15 min	NB	8:15 to 9:15	582	4:45 to 5:45	968
					SB	8:00 to 9:00	850	4:15 to 5:15	947
2201	9/16/2010	MassDOT	35,532	15 min	EB	7:15 to 8:15	1,827	4:30 to 5:30	1,161
					WB	7:45 to 8:45	1,325	4:45 to 5:45	1,892
2202	8/3/2009	MassDOT	34,622	1 hr	NB	8:00 to 9:00	1,490	5:00 to 6:00	1,487
					SB	7:00 to 8:00	976	4:00 to 5:00	1,682
2453	7/3/2009	MassDOT	22,786	1 hr	NB	No discernable morning/afternoon peaks			
					SB				
2828	2/28/2006	MassDOT	9,235	1 hr	NB	9:00 to 10:00	691	5:00 to 6:00	789
					N/A	-	-	-	-
2829	2/25/2009	MassDOT	10,688	1 hr	EB	7:00 to 8:00	403	3:00 to 4:00	335
					WB	8:00 to 9:00	391	3:00 to 4:00	502
9298	9/4/2006	PVPC	12,083	15 min	N/A	-	-	-	-
					SB	8:00 to 9:00	675	2:00 to 3:00	915
9299	9/4/2006	PVPC	10,653	15 min	NB	7:45 to 8:45	785	3:30 to 4:30	711
					N/A	-	-	-	-
9300	9/4/2006	PVPC	9,488	15 min	NB	8:00 to 9:00	1,097	3:15 to 4:15	678
					N/A	-	-	-	-
R15607	9/14/2012	MassDOT	16,433	15 min	N/A	-	-	-	-
					SB	7:45 to 8:45	1,761	3:15 to 4:15	1,361
VHB - 92014									
A,B	12/7/2009	VHB	9,686	15 min	NB	7:15 to 8:15	672	4:30 to 5:30	1,003
					SB	7:15 to 8:15	818	4:30 to 5:30	1,160
C	12/7/2009	VHB	5,811	15 min	NB	7:30 to 8:30	745	4:30 to 5:30	528
					N/A	-	-	-	-
D	12/7/2009	VHB	6,271	15 min	N/A	-	-	-	-
					SB	7:30 to 8:30	345	4:30 to 5:30	759
E	12/7/2009	VHB	1,552	15 min	EB	8:00 to 9:00	150	4:45 to 5:45	139
					N/A	-	-	-	-
G	12/7/2009	VHB	4,319	15 min	EB	7:15 to 8:15	634	4:30 to 5:30	407
					N/A	-	-	-	-
H	12/7/2009	VHB	16,204	15 min	NB	6:45 to 7:45	1,029	3:15 to 4:15	1,259
					N/A	-	-	-	-
I	12/7/2009	VHB	9,317	15 min	EB	7:30 to 8:30	371	2:15 to 3:15	316
					WB	8:30 to 9:30	315	3:15 to 4:15	506
J	12/7/2009	VHB	16,680	15 min	EB	7:15 to 8:15	1,859	4:30 to 5:30	1,330
					N/A	-	-	-	-
K	12/7/2009	VHB	3,076	15 min	N/A	-	-	-	-
					SB	7:15 to 8:15	435	4:45 to 5:45	218
VHB - 123129									
1,2	12/14/2012	VHB	54,882	15 min	EB	7:30 to 8:30	2,559	4:30 to 5:30	2,464
					WB	7:15 to 8:15	1,731	4:15 to 5:15	2,182
3	12/14/2012	VHB	21,935	15 min	NB	7:15 to 8:15	1,752	4:30 to 5:30	1,601
					N/A	-	-	-	-
4	12/14/2012	VHB	14,414	15 min	EB	7:15 to 8:15	1,450	4:30 to 5:30	1,223
					N/A	-	-	-	-
5	12/14/2012	VHB	3,311	15 min	N/A	-	-	-	-
					SB	8:00 to 9:00	136	5:00 to 6:00	464
6	12/14/2012	VHB	15,486	15 min	NB	7:15 to 8:15	1,639	2:30 to 3:30	1,072
					N/A	-	-	-	-
7	12/14/2012	VHB	7,701	15 min	N/A	-	-	-	-
					SB	7:15 to 8:15	542	4:00 to 5:00	629
8	12/14/2012	VHB	10,026	15 min	N/A	-	-	-	-
					SB	8:00 to 9:00	615	3:45 to 4:45	899
9	12/14/2012	VHB	2,095	15 min	NB	7:45 to 8:45	217	3:30 to 4:30	148
					N/A	-	-	-	-
10	12/14/2012	VHB	3,695	15 min	NB	8:00 to 9:00	495	5:00 to 6:00	256
					N/A	-	-	-	-
11	12/14/2012	VHB	5,047	15 min	N/A	-	-	-	-
					SB	8:00 to 9:00	211	4:15 to 5:15	597
12	12/14/2012	VHB	11,756	15 min	NB	7:30 to 8:30	813	3:45 to 4:45	981
					N/A	-	-	-	-
13	1/8/2013	VHB	4,598	15 min	N/A	-	-	-	-
					SB	8:00 to 9:00	351	4:45 to 5:45	374
14	12/14/2012	VHB	5,413	15 min	NB	7:45 to 8:45	251	4:30 to 5:30	661
					N/A	-	-	-	-
15,16	12/14/2012	VHB	23,549	15 min	EB	7:30 to 8:30	992	4:30 to 5:30	875
					WB	7:30 to 8:30	601	4:30 to 5:30	1,557
17,18	1/8/2013	VHB	63,242	15 min	NB	7:30 to 8:30	2,126	4:30 to 5:30	2,489
					SB	7:15 to 8:15	1,774	4:00 to 5:00	2,753
19	12/14/2012	VHB	7,301	15 min	N/A	-	-	-	-
					SB	7:45 to 8:45	829	4:30 to 5:30	601
38	12/14/2012	VHB	7,611	15 min	NB	7:15 to 8:15	754	2:30 to 3:30	527
					N/A	-	-	-	-

Figure 22 - I-91 Study Corridor Daily Traffic Volumes.

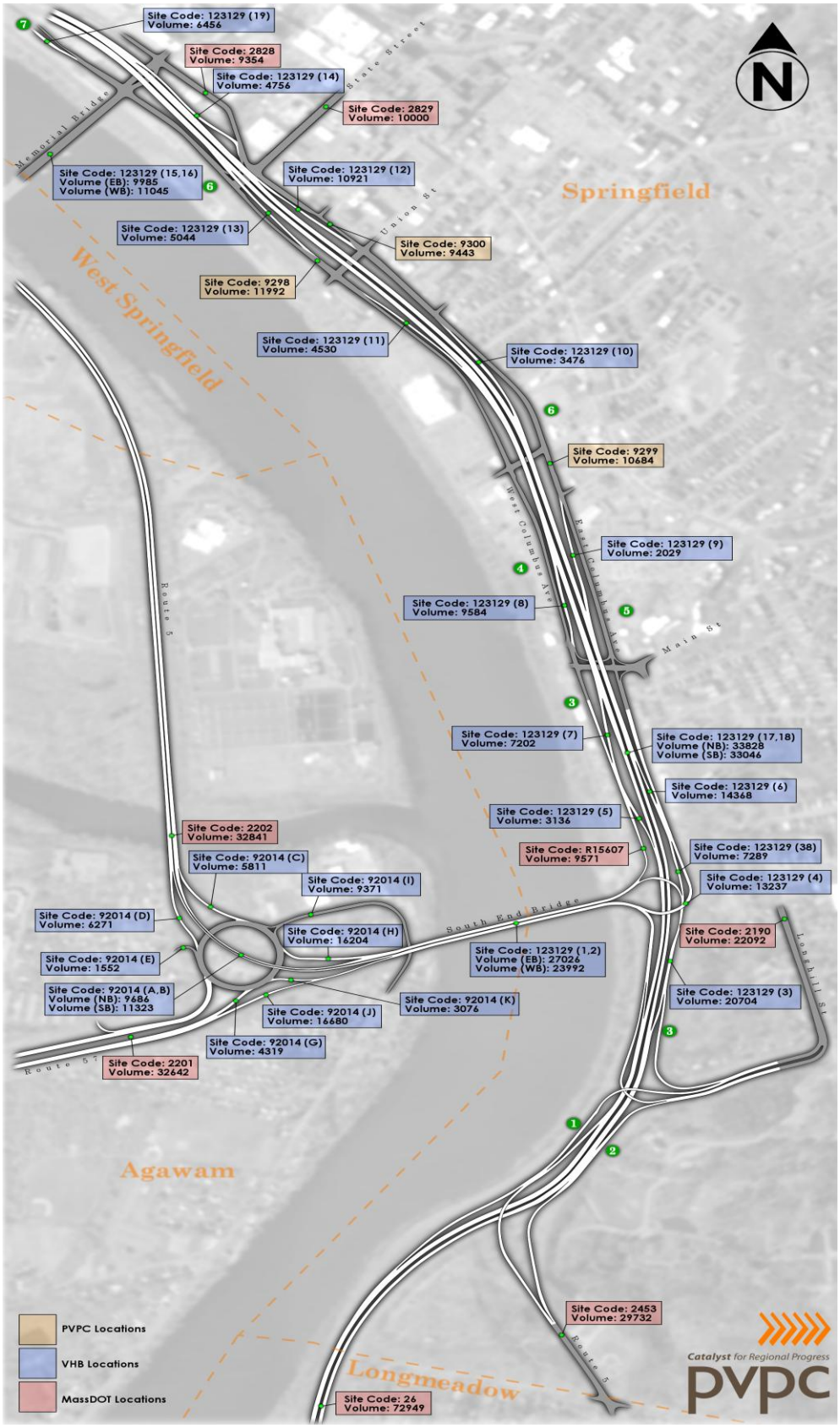
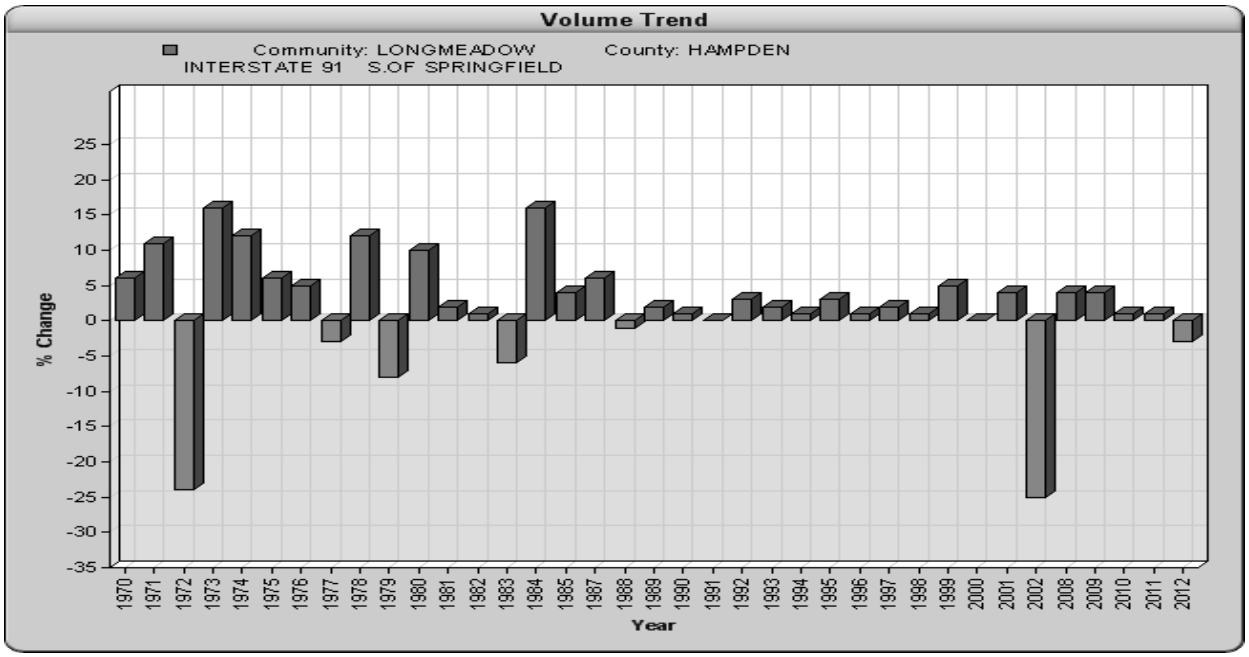


Figure 23 - Interstate Daily Traffic Volumes.

Historical traffic counts conducted by the PVPC and MassDOT were used in this report. The year a count was conducted is displayed between parentheses next to the total traffic volume at that location. MassDOT's website of the Transportation Data Management System provided a useful tool for visualizing traffic data available. It can be accessed at the following address http://mhd.ms2soft.com/tcds/tsearch.asp?loc=Mhd. Volume trends over the past forty years for I-91 in Longmeadow at the counting point south of Springfield shows an increase in traffic in the mid seventies and eighties and a decrease in traffic during the last decade (Figure 24).

Two major drops in traffic volumes, a decrease of 25%, are noted in 1972 and 2002 which can be attributed to highway construction projects just north of the count location. This first drop in traffic volume may be attributed to the construction of the last I-91 section through downtown Springfield between 1965 and 1970, The second drop in traffic volume is attributed to the rehabilitation project of the South End Bridge between 2001 and 2007. The South End Bridge was originally constructed in 1954.

Figure 24 - Historic Volume Trends for I-91 in Longmeadow.



Source: MassDOT Transportation Data Management System

A detailed look at traffic volumes over the last ten years shows variations in traffic volume between points along I-91 (Figure 25). Seven permanent counting sites provided historic data for I-91 from locations near Exit 13B to Exit 1. Two other locations recorded traffic counts on I-391 and I-291 to provide a full picture of traffic flow from and to I-91 in the study area. Traffic volume changes over the years for both the northern and southern edges of the study corridor are presented in the two graphs obtained from MassDOT (Figure 26 and 27).

Six of the I-91 count locations were further analyzed by their hourly traffic counts. A graph showing the directional hourly count and site codes for each of these locations is included in this section. The graphs show peak hour traffic occurring between 6-9am and 3-7pm. In most locations, traffic is reduced between these peak periods. However, the closer I-91 gets to its intersection with I-90, traffic volume showed a continued increase throughout the day until it reached its evening peak hour period. This is clearly evident for traffic in the northbound direction, whereas southbound traffic displays two distinct morning and evening peaks. This could be attributed to the southbound traffic being from commuters and students with fixed arrival schedules. Northbound traffic volume leaving the main urban area would include vehicles trying to reach the Massachusetts Turnpike in addition to regular commuter traffic that maybe staggered in the afternoon.

Figure 25 - Historic Average Annual Daily Traffic Volume along the I-91 Corridor.

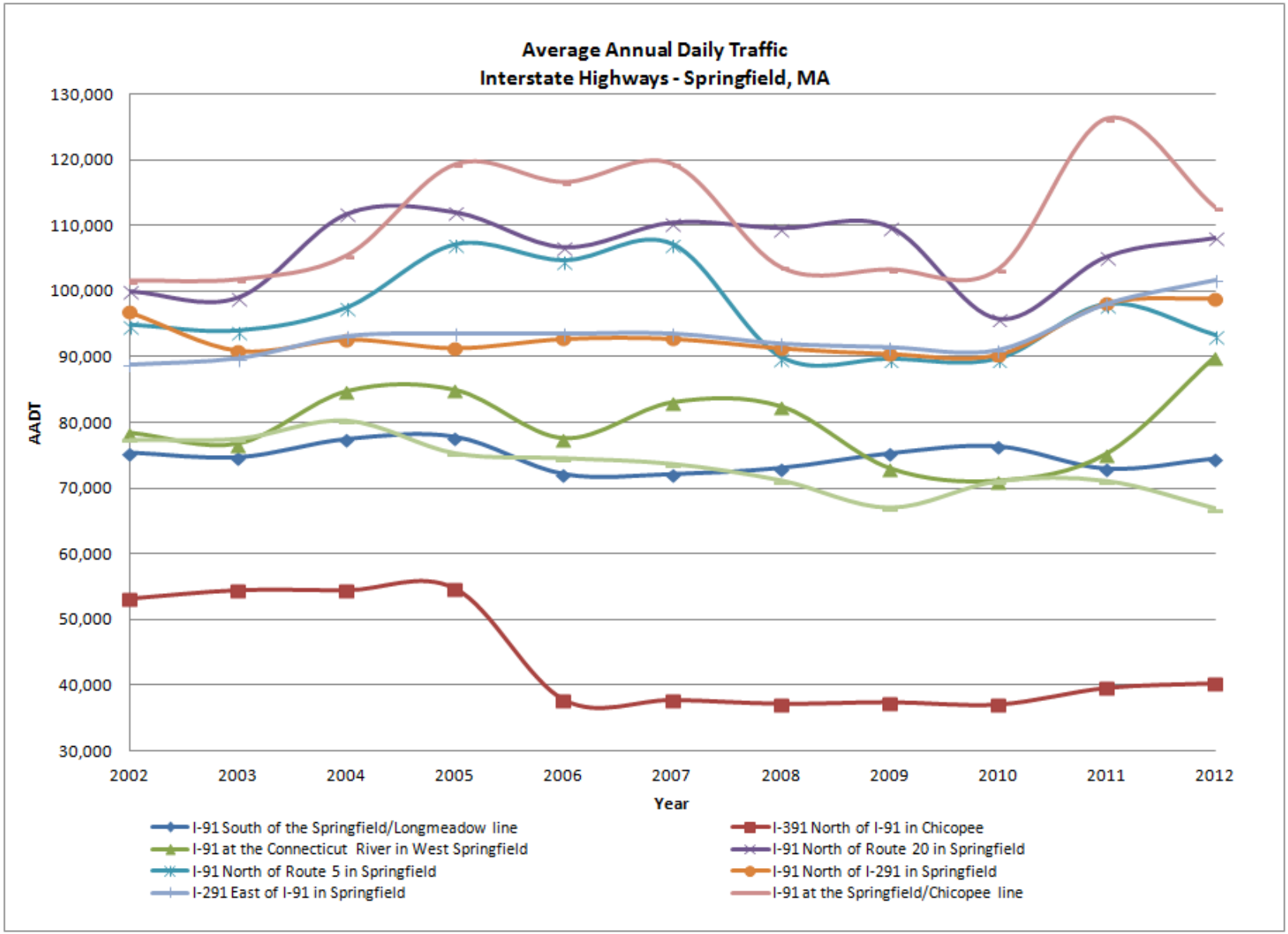
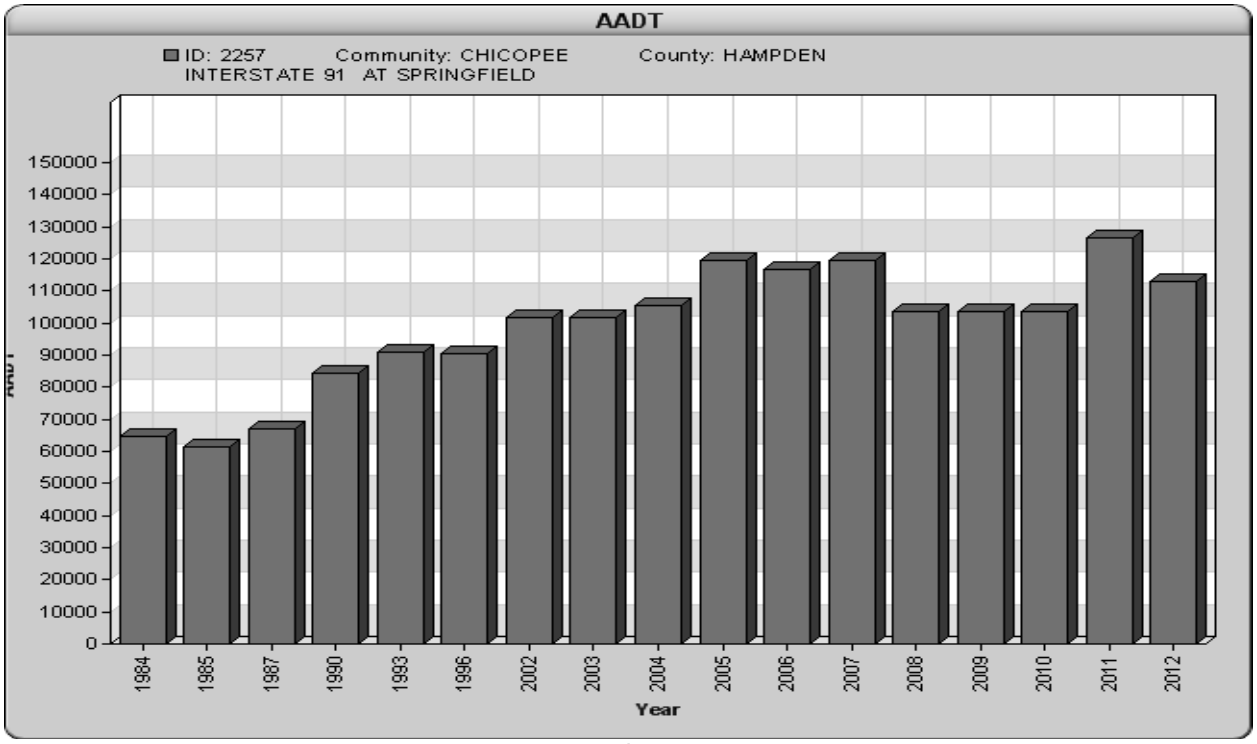
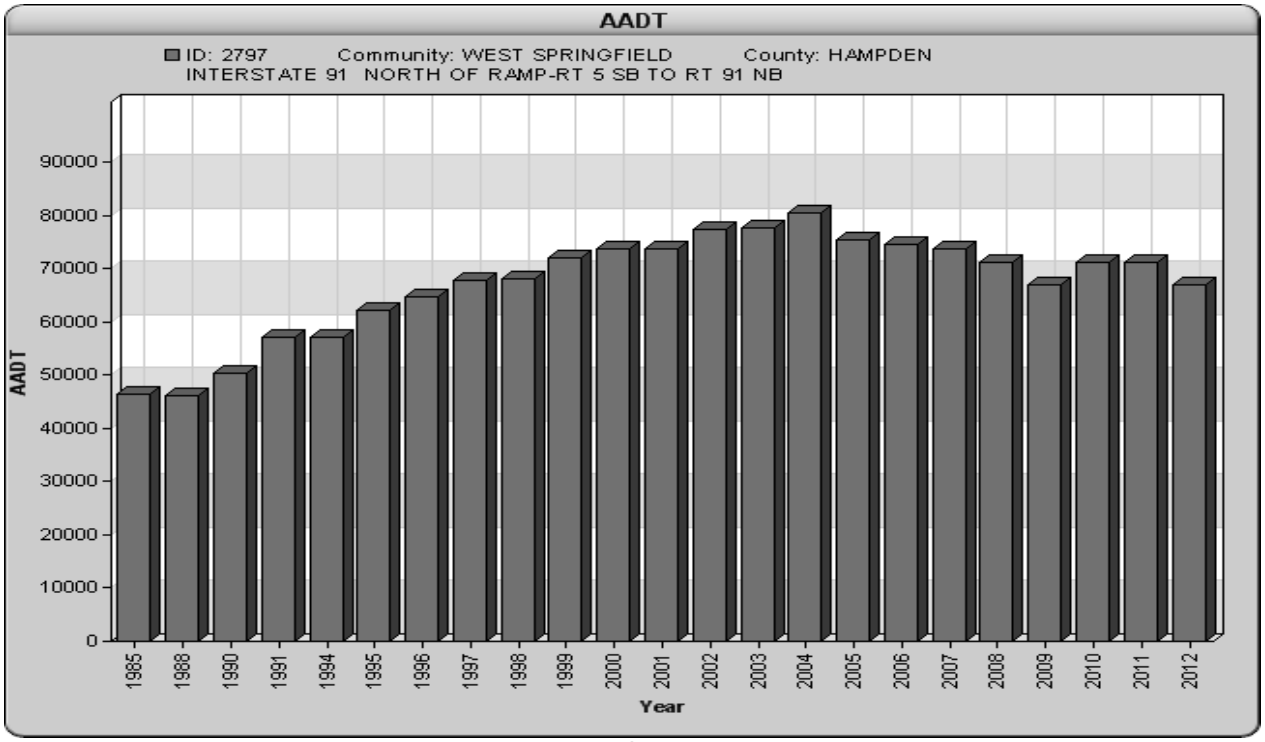


Figure 26 - Annual Average Traffic Volume Near the Chicopee Border of I-91 Corridor.



Source: MassDOT Transportation Data Management System

Figure 27 - Annual Average Traffic Volume Near the Longmeadow Border of I-91 Corridor.

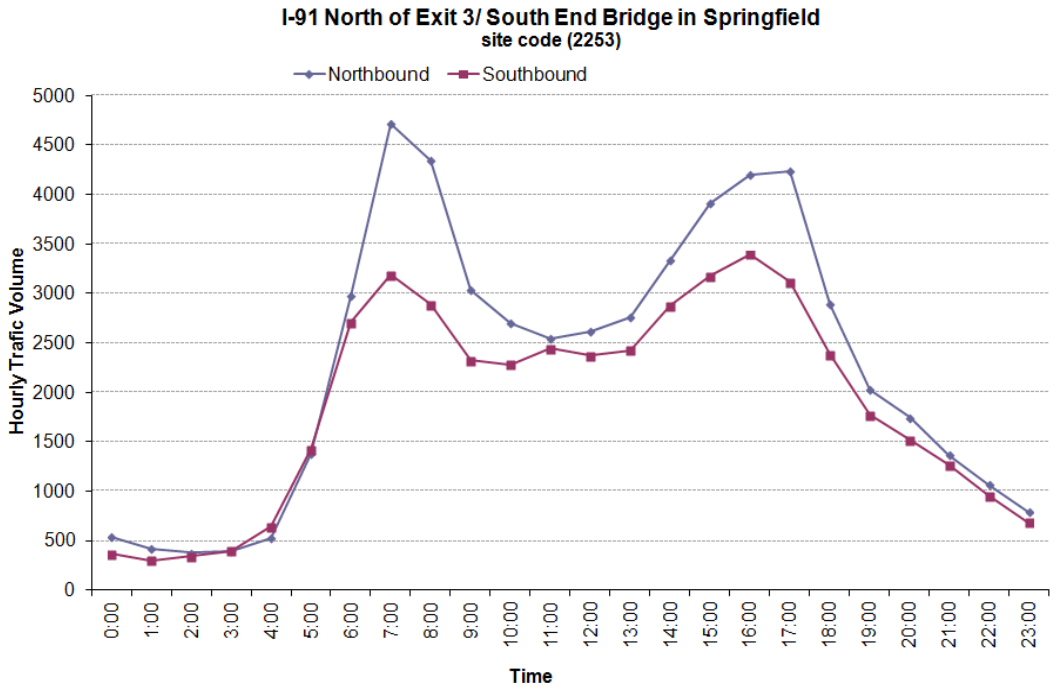


Source: MassDOT Transportation Data Management System

III.1.2 Hourly Vehicle Volumes

Directional hourly traffic volumes for I-91 in the vicinity of Exit 3 and the South End Bridge show that there were larger traffic volumes in the southbound direction compared to northbound (Figure 28). The difference is more pronounced during the peak hour where it almost doubles during the afternoon peak travel period. Two peak periods were observed to from 7am to 8am and from 4pm to 5pm for this location. Spanning the section of I-91 between Exit 3 and Exit 13 there are five additional locations with directional hourly traffic volumes available. These are included in Appendix A and show variations in peak hour and traffic flows along the highway.

Figure 28 - Interstate I-91 Directional Hourly Traffic Volumes Near the South End Bridge.



Peak Hour Volumes

Manual Turning Movement Counts (TMC's) were conducted at critical intersections in the study area between the months of September 2012 and February 2013. The TMC's were conducted during the peak commuter periods. The peak periods occur during the morning hours of 7:00 AM to 9:00 AM and the afternoon hours of 4:00 PM to 6:00 PM. TMC's were conducted to identify the highest four consecutive 15-minute periods of traffic through the intersection for each location. These consecutive peak 15-minute periods constituted the "Peak Hour Volume". The peak hour of traffic volume represents the most critical period for operations and will be the focus for some of the analyses conducted.

Based on MassDOT data, traffic volumes collected during certain months are estimated to be either higher or lower than the annual average. Therefore, the traffic count data were adjusted to reflect average month conditions. Street addresses of count locations for TMC data are listed in Table 9. TMC locations are also mapped on Figure 29. Turning movement count data for the morning and afternoon peak hours are summarized later on in this section. A location map with associated site codes of TMC locations is included for reference in Appendix A. Summaries and complete traffic count data sheets are included in the Appendices.

Table 9 - List of Available Turning Movement Counts.

Turning Movement Count Locations		
Community	**Street**	**Cross Street**
Springfield	West Columbus Avenue	Broad Street
Springfield	East Columbus Avenue	Broad Street
Springfield	I-91	Exit 1 SB
Springfield	I-91	Exit 2 NB to Route 83
Springfield	I-91	Exit 3 NB to Route 5 West
Springfield	I-91	Exit 3 SB to Route 5
Springfield	I-91	Exit 4 SB to West Columbus Avenue
Springfield	I-91	Exit 5 NB to East Columbus Avenue
Springfield	I-91	Exit 6 NB to East Columbus Avenue and Union Street
Springfield	I-91	Exit 6 SB to West Columbus Avenue and Union Street
Springfield	I-91	Exit 7 SB to West Columbus Avenue
Springfield	Sumner Avenue	Longhill Street
Springfield	West Columbus Avenue	Main Street
Springfield	East Columbus Avenue	Main Street
Springfield	West Columbus Avenue	Memorial Bridge
Springfield	East Columbus Avenue	Memorial Bridge (Boland Way)
Springfield	East Columbus Avenue	State Street
Springfield	East Columbus Avenue	Union Street
Springfield	West Columbus Avenue	Union Street
Longmeadow	Route 5	Forest Glen Road

Source: PVPC, MassDOT, PDI for VHB

Detailed traffic flow analysis were completed for locations with a higher number of crashes identified in subsequent sections of this report. One such location occurs in the vicinity of Exit 3. Traffic movements between Route 5 and I-91 and its frontage roads are of particular interest. The traffic flow diagram for morning and evening peak hour traffic is shown below (Figure 30). Larger traffic volumes in the northbound direction in the morning suggest a commute pattern towards Springfield and beyond that is reversed in the afternoon. Traffic volume increases in the afternoon towards Agawam. Commuters appear to be heading north in the morning and south and west in the evening.

Figure 29 - Peak Hour Turning Movement Count Locations.

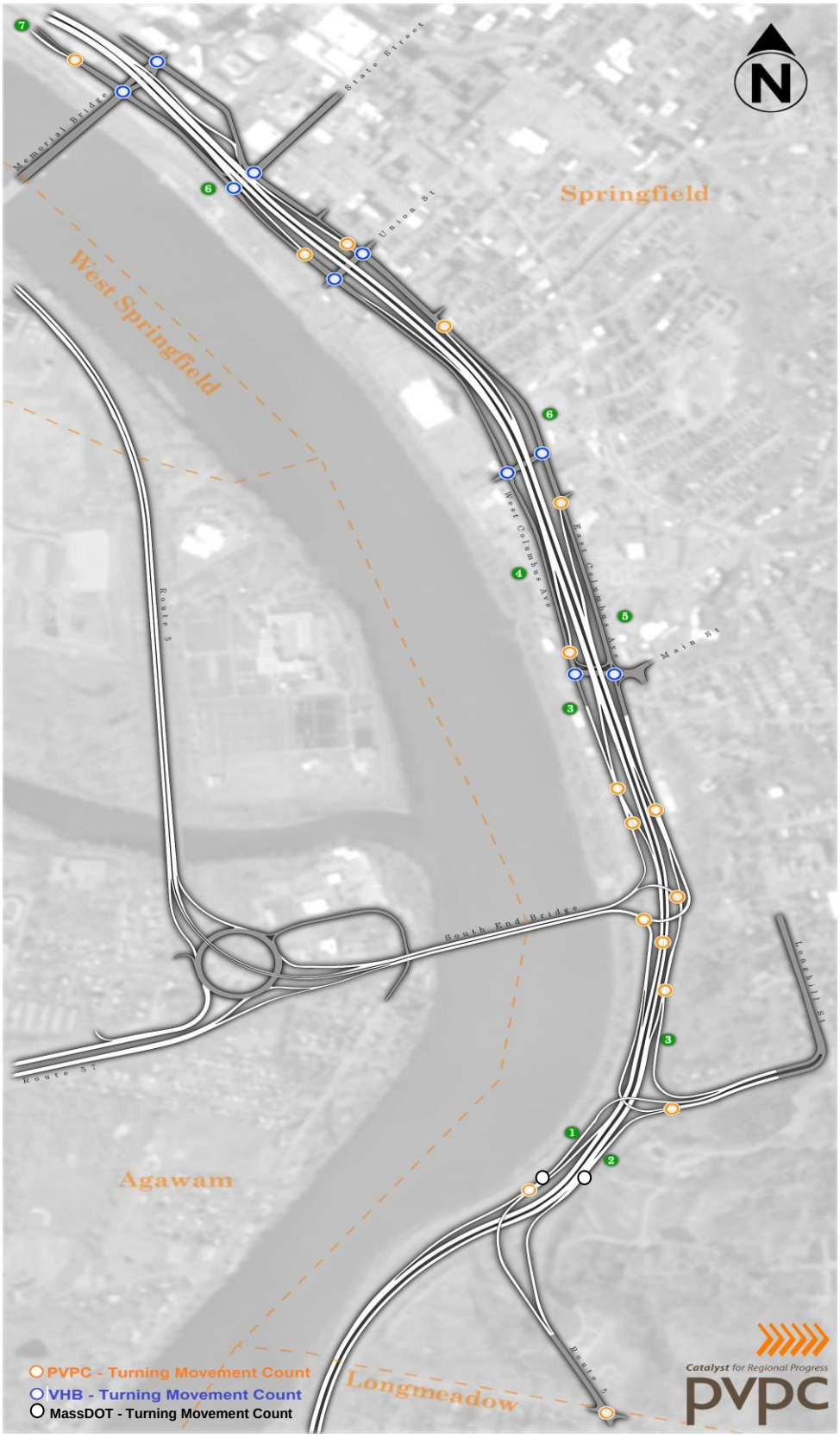
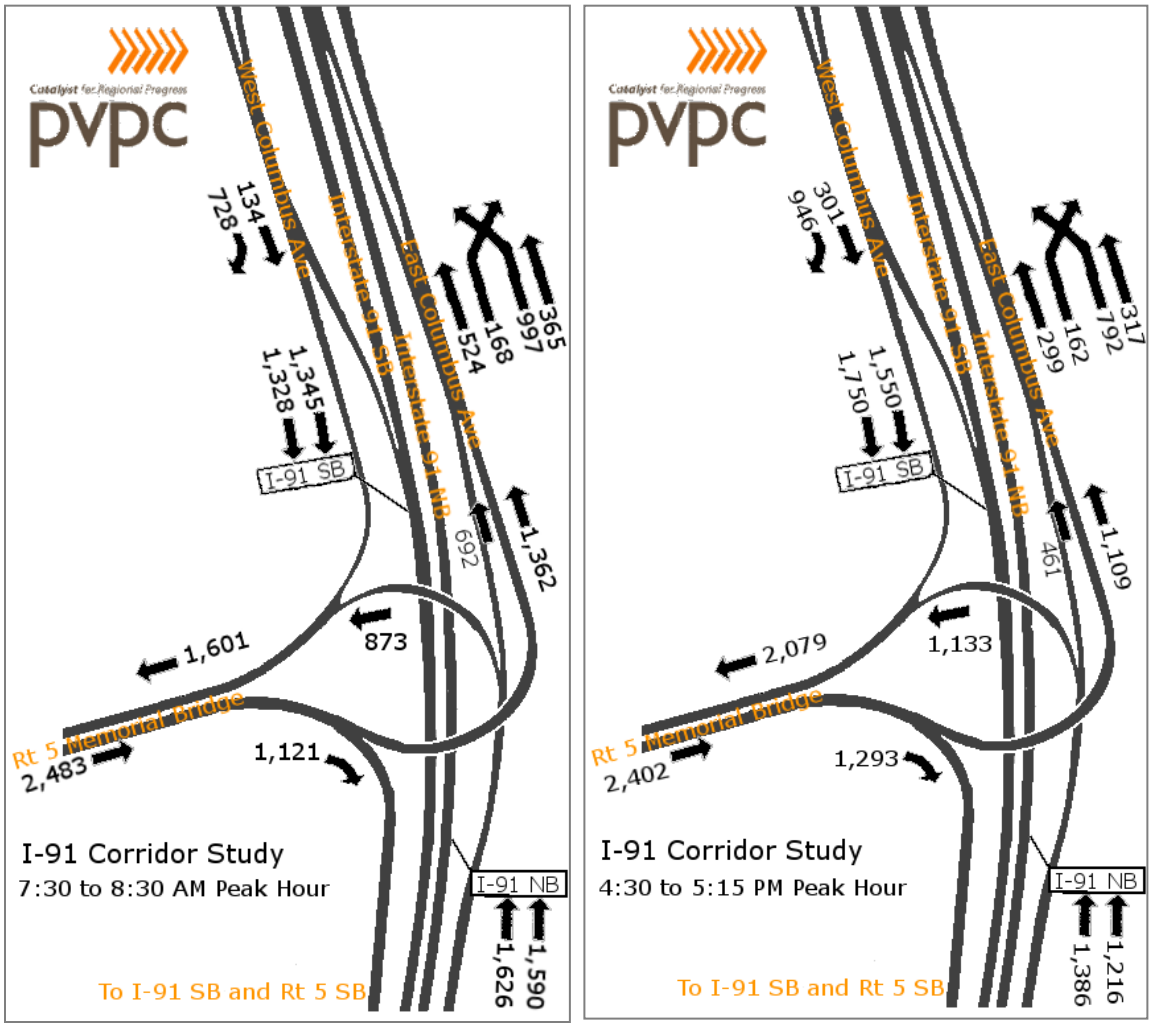


Figure 30 - Turning Movement Counts Around Interchange 3 on I-91.



Traffic data collected in the vicinity of the South End Bridge area of I-91 was gathered using video which was then complied into turning movement. Complete traffic counts were conducted from 7 AM to 9 AM and from 4 PM to 6 PM. The above peak hour flow diagrams involved data manipulation to adjust for slight variations in peak hour between various counting points along the highway. Also, adjustments for counting traffic on different days of the week were made as the completed traffic flow diagrams required consistency between the peak hour periods. PVPC balanced traffic volumes as appropriate.

Traffic volume maps for the Interstate 91 corridor were created from the balanced traffic counts available for the highway as well as for intersections and ramps along the corridor. Morning and afternoon peak flows around the I-91 corridor are depicted in the study area maps displayed below (Figures 31 and 32). The morning peak hour period is from 7:15 AM to 8:15 AM, and the afternoon peak hour period is from 4:30 PM to 5:30 PM. Data was acquired from a variety of sources as described previously in this report.

Figure 31 - Interstate 91 Corridor Morning Peak Hour Traffic Volumes.

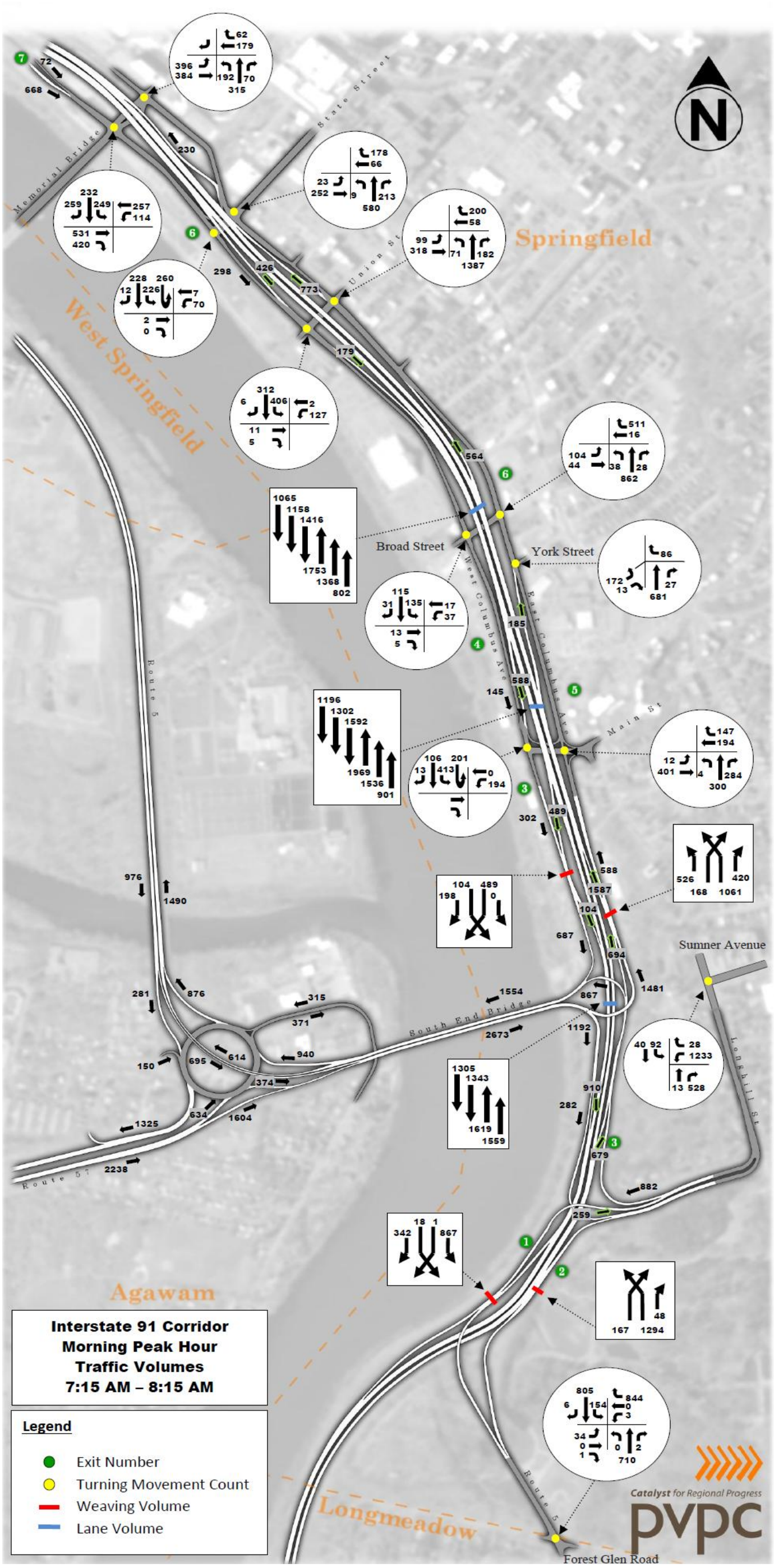
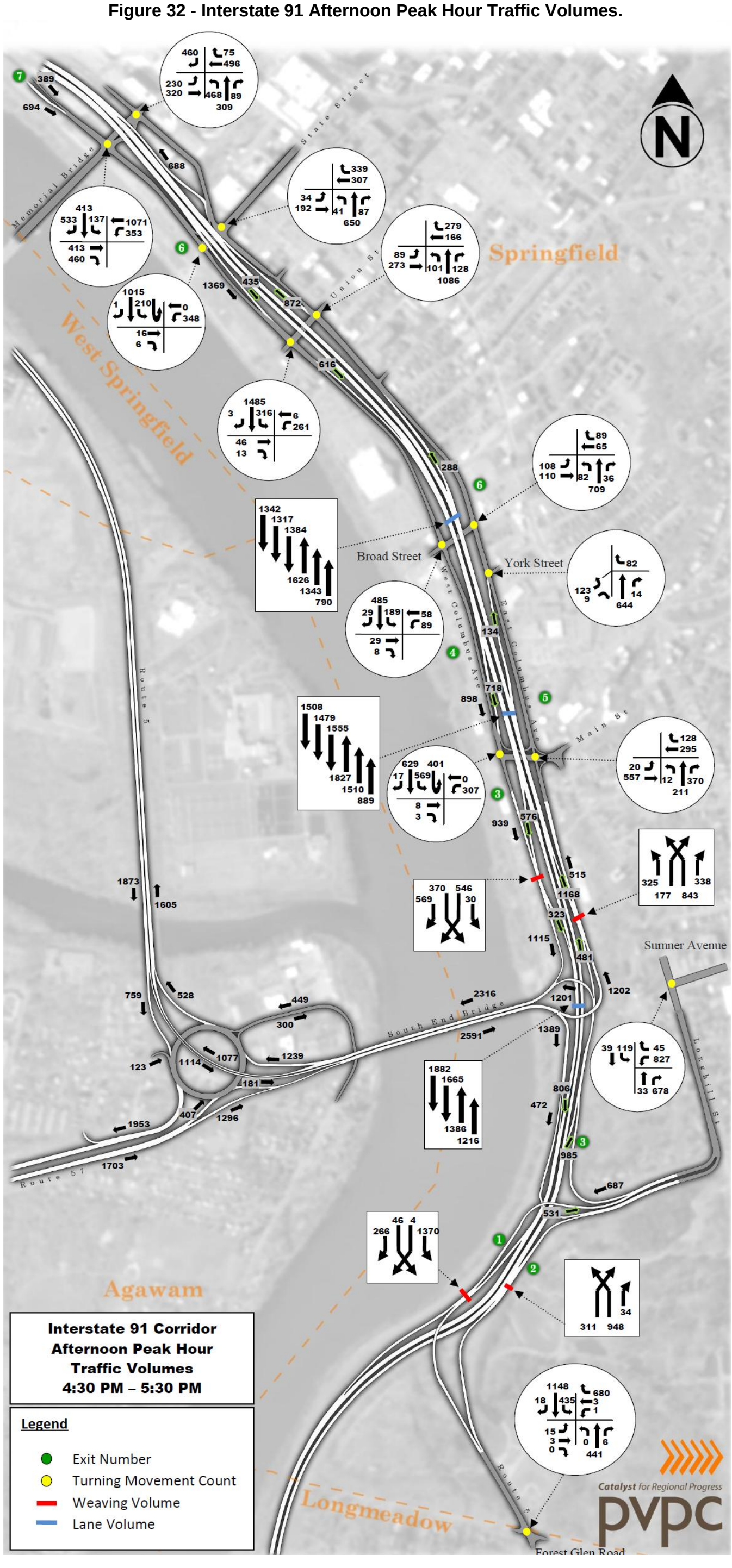


Figure 32 - Interstate 91 Afternoon Peak Hour Traffic Volumes.



III.1.3 Vehicle Classification

The highest percentages of heavy vehicles occurred on Converse Street in the Town of Longmeadow (Figure 33). Converse Street experiences 8.4% heavy vehicles at the TMC count location west of Laurel Street and 7.6% heavy vehicles east of Laurel Street (Table 10). This street connects to Route 5 near its connection with I-91. It brings traffic in and out of Longmeadow via Laurel Street. The whole area is predominantly residential and the local bus route has stops along Converse Street. Converse Street is classified as a Rural Major Collector, whereas Laurel Street is classified as a Rural Minor Collector. Longmeadow Street (Route 5) is classified as an Urban Principal Arterial. Traffic congestion is frequently experienced in this area, which falls among the top 15 bottleneck areas in the region (Bottlenecks – As Defined by the Congestion Management Process for the Pioneer Valley. PVPC, March 2011). The Federal Highway Administration (FHWA) defines a congestion bottleneck as "A localized section of highway that experiences reduced speeds and inherent delays due to a recurring operational influence or a nonrecurring impacting event" (http://www.ops.fhwa.dot.gov/bn/lbr.htm#g3). If congestion occurs along an entire corridor, then the corridor is considered congested. Likewise, if the corridor is experiencing congestion only at a specific location, then the corridor is considered a congestion bottleneck.

Figure 33 - Bottleneck Location in the Town of Longmeadow.

During the morning peak travel period, the middle lane out of three lanes on I-91 in the vicinity of Exits 4 and 5 experiences 18% heavy vehicles in the southbound direction and 14.5% in the northbound direction. South of the South End Bridge the heavy vehicle percentage dropped to 15.5% in the southbound direction and 11% in the northbound direction during the morning peak period.

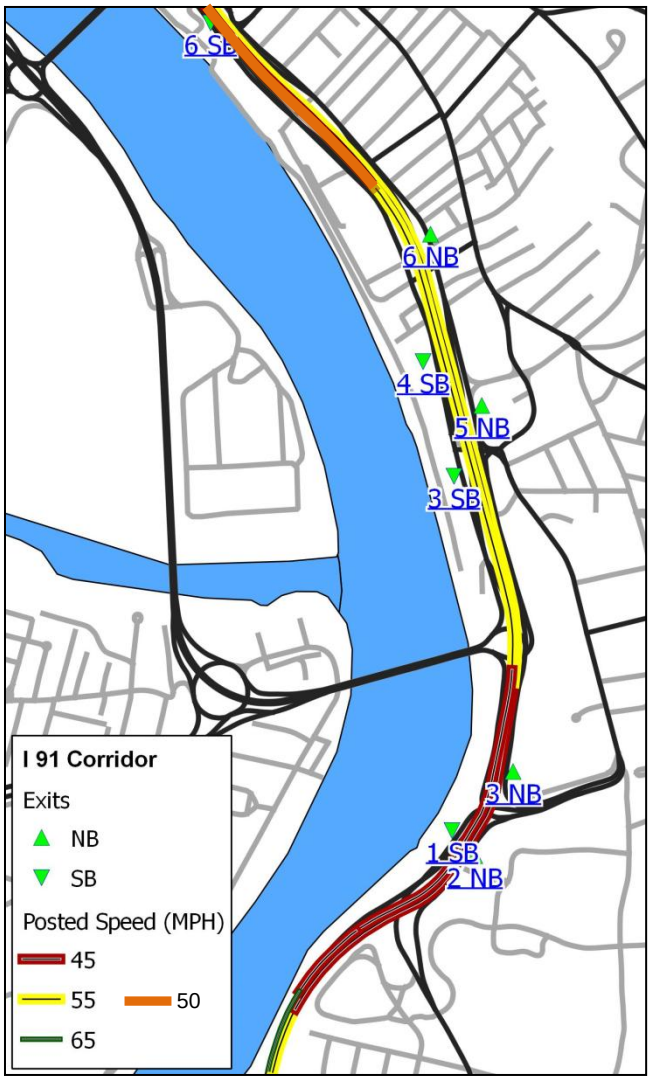
Table 10 - Percentages of Vehicles by Class

Vehicle Classifications Percentages												
Community	Street	Location	Direction	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	> 3 Axle	Total	Heavy
Springfield	Court St	W/O Main St	WB	1.6%	92.5%	4.9%	0.2%	0.3%	0.5%	0.1%	1,257	1.0%
			EB	3.0%	88.8%	6.4%	0.1%	0.5%	1.0%	0.2%	1,249	1.8%
Springfield	Longhill Rd	S/O Sumner Ave	NB	1.2%	84.4%	11.1%	0.2%	1.7%	0.5%	1.0%	9,785	3.3%
			SB	8.4%	80.7%	7.9%	0.1%	1.0%	1.0%	0.9%	11,183	3.0%
Springfield	Mill St	E/O Pine St	WB	1.2%	86.2%	9.3%	0.4%	2.1%	0.5%	0.3%	3,236	3.3%
			EB	1.0%	86.3%	9.6%	0.4%	1.7%	0.3%	0.6%	2,412	3.1%
Springfield	West Columbus Ave	N/O Union St	SB	3.3%	82.6%	9.0%	0.7%	1.3%	1.3%	1.8%	12,112	5.1%
			-	-	-	-	-	-	-	-	-	
Springfield	East Columbus Ave	S/O Broad St	NB	2.6%	82.4%	9.9%	0.9%	1.9%	1.2%	1.1%	11,121	5.1%
			-	-	-	-	-	-	-	-	-	0.0%
Springfield	East Columbus Ave	N/O Union St	NB	3.1%	85.1%	7.6%	0.5%	1.2%	1.0%	1.5%	9,722	4.2%
			-	-	-	-	-	-	-	-	-	
Agawam	Meadow St	E/O Main St	EB	14.6%	76.9%	6.7%	0.6%	0.6%	0.3%	0.1%	1,413	1.7%
			WB	0.6%	86.8%	10.3%	0.2%	1.3%	0.5%	0.3%	1,232	2.4%
Longmeadow	Converse St	W/O Laurel St	EB	2.1%	63.6%	25.9%	0.4%	5.6%	0.7%	1.7%	8,560	8.4%
			WB	2.0%	74.2%	15.8%	0.6%	3.3%	1.1%	3.0%	3,398	8.0%
Longmeadow	Converse St	E/O Laurel St	EB	6.7%	67.7%	18.0%	0.3%	4.9%	1.3%	1.1%	8,273	7.6%
			WB	2.5%	80.5%	12.4%	0.4%	1.9%	1.0%	1.3%	8,196	4.6%
Longmeadow	Laurel St	N/O Converse St	NB	6.6%	67.6%	18.5%	0.2%	2.5%	3.8%	0.8%	9,928	7.3%
			SB	2.9%	82.5%	11.2%	0.1%	1.2%	1.5%	0.6%	2,694	3.4%
Longmeadow	Laurel St	S/O Converse St	SB	1.3%	82.1%	13.4%	0.1%	1.9%	1.0%	0.3%	1,921	3.2%
			NB	0.6%	86.4%	11.3%	0.1%	1.2%	0.2%	0.3%	4,598	1.8%

III.1.4 Posted Speed Limits

The posted speed limit on I-91 ranges from 45 to 65 miles per hour. Posted speed along Interstate 91 within the study area, between Exit 1 and 5, is lower than the common highway speed of 65 Miles Per Hour (MPH). This is a result of the winding nature of the roadway, its design geometry, traffic volumes, and ramp density. The posted speed along this corridor varies between 45 MPH and 55 MPH. A representation of the speed zones within the study corridor is provided in abstract form below for visual reference only and does not provide precise start and end zones of the various posted speed zones. (Figure 34). The posted speed limits adhere to the Commonwealth of Massachusetts Special Speed Regulation # 7379B and 7379C that were passed in 1995 and 1996, that provide precise mile markers and references to distances from state and city borders (Appendix A).

Figure 34 - Posted Speeds for I-91 Corridor



Posted Speed on I-91 Northbound:

The northbound posted speed limit is 65 MPH from the Connecticut State line and changes to 55 MPH just before Mile Marker 3.0, in Longmeadow. Approximately a third of a mile later, the posted speed limit drops further down to 45 MPH in the vicinity of Western Avenue in Longmeadow and lasts for three quarters of a mile. Then the posted speed increases back to 55 MPH just before the South End Bridge on-ramp for about a mile and a third of a mile through the remainder of the study area including Exit 5.

Posted Speeds on I-91 Southbound:
Though beyond the scope of the study corridor, it is worth noting that the posted speed limit is 50 MPH in both directions of I-91 through the viaduct section of the highway. It is also 50 MPH from the Memorial Bridge to the Basketball Hall of Fame. After the Basketball Hall of Fame the speed limit is raised to 55 MPH for about a mile until the South End Bridge. Then the posted speed limit is lowered to 45 MPH just past the bridge for about three quarters of a mile until a point just after the King Philips Stockade Park. From this point until the Connecticut border, the posted speed returns to the typical 65 MPH.

As for local streets within the study area, speeds vary depending on the street's functional class and location. Although posted speeds included 30 and 35 miles per hour, traffic counts showed that certain locations experienced vehicles traveling at much higher speeds. The highway frontage roads, East Columbus Avenue and Hall of Fame/West Columbus Avenue, as well as Longhill Road in Springfield, and Converse Street in Longmeadow had a high percentage of traffic travelling 10 MPH over the speed limit. Such an increase in driving speeds could lead to unsafe travel conditions for pedestrians, cyclists and other drivers in a dense urban area where streets are flanked by a variety of commercial and residential activities. Data table is included in Appendix A.

III.1.5 Travel Time and Speed Field Data

Vehicular travel time data provide a snapshot for the overall operating conditions along a given roadway. Data collected as part of this process allow for a variety of congestion measures to be established to help compare the level of congestion along the corridor to other locations in the region. Travel time data collection methods and a description of congestion measures used are described below.

Global Positioning System (GPS) Travel Time Data:

The PVPC staff collected travel time data on Interstate 91 during the month of May 2013. Data was collected over several days; the 17th, 21th, 24th, and 30th of May, 2013. Travel time data was gathered for both northbound and southbound directions during the morning and afternoon peak hours; from 7:00AM to 9:00AM and from 4:00PM to 6:00PM. For each two-hour data collection period, drivers collecting data were instructed to travel with the flow of traffic but not to exceed posted speed limits.

Staff collected auto travel time data using a Qstarz Global Positioning System (GPS) travel recorder while by performing multiple runs of the corridor. The travel time data was then downloaded for evaluation and analysis using TravTime™ 2.1 software by GeoStats. The speed, direction, and time of recorded data points were summarized for each travel time run. The I-91 corridor was divided into segments marked by highway exits to identify pockets of congestion within the study area. A base map, including defined segment locations and speed limits, was created on TravTime™ 2.1 prior to data download. Data points were then evaluated in terms of Travel Speed, Travel Time, Travel Time Index, in addition to other congestion measures identified in the regional Congestion Management Process (CMP).

Travel Time Index is a ratio of an average peak travel time to a free-flow travel time. Index values can be used as an indicator of the magnitude of extra travel time spent during a trip. A travel time index of 1.0 represents free-flow travel conditions in which there are no delays. Any traffic congestion would cause an increases in the travel time index. For example, a value of 1.20 means that the average peak travel time is 20% longer in duration than the free-flow travel time.

$$\text{Travel Time Index} = \frac{(\text{Actual Travel Time})}{(\text{Free Flow Travel Time})}$$

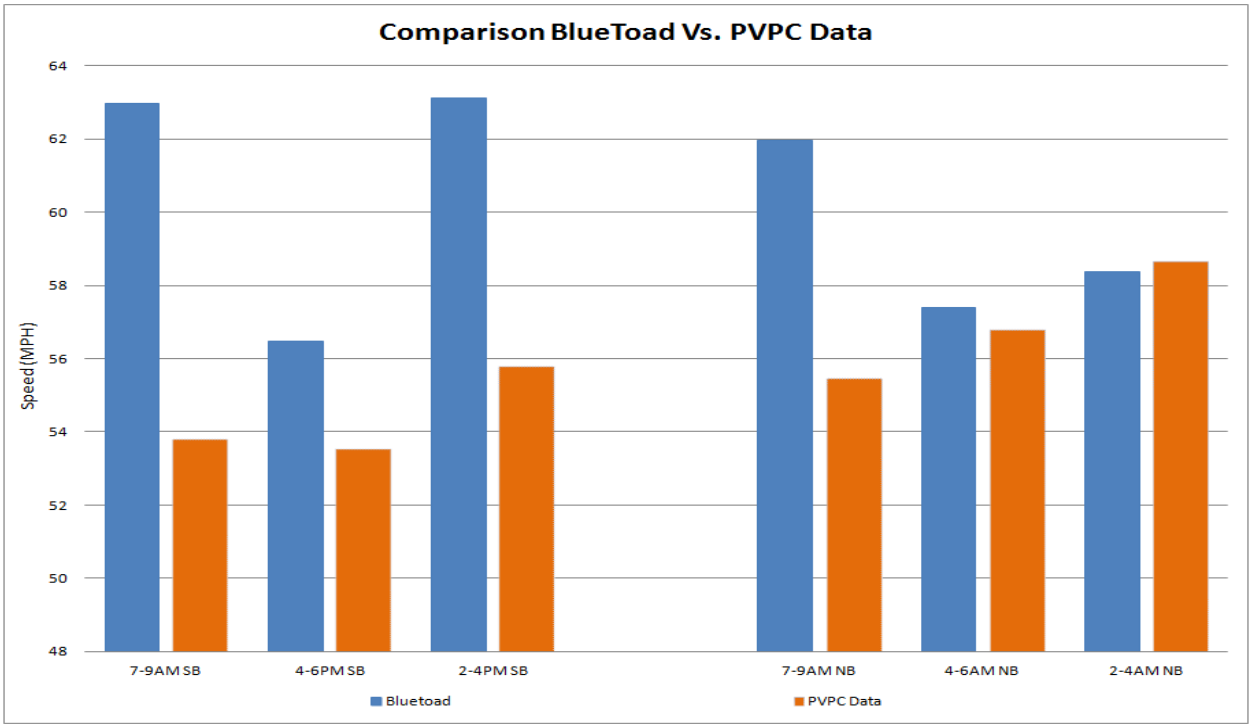
Bluetooth Travel-Time Origination And Destination (BlueTOAD) Data:

PVPC staff accessed the BlueTOAD travel time database collected by the University of Massachusetts Regional Traveler Information Center (RTIC). This data is collected from sensors that detect anonymous communication signals emitted from Bluetooth devices inside vehicles travelling along I-91. Sensors installed at several locations along the highway allow analysts to calculate vehicular travel time. Travel time calculations using this technology are based upon subsequent detections of communication signals at fixed points along a corridor. Since distance is known between detection points, speed can be calculated by dividing the distance between two sensor points by the time it takes a vehicle to traverse that distance.

In the Springfield area there are currently 2 sensors located on I-91; one at Exit 1 and the other is located near the Brush Hill Avenue crossing over I-91. Data is collected for both northbound and southbound directions of travel. Travel time data saved in the RTIC database are aggregated and processed on a minute by minute basis. The data collected include travel speed and travel time per minute.

PVPC staff extracted data for corresponding dates and time periods described previously in the GPS travel time data collection method. To analyze the effectiveness of each data set, travel time and speed data were compared between the GPS and BlueTOAD data collection methods (Figure 35). The GPS data collected by PVPC staff showed speed changes due to congestion at various points near exits along the I-91 corridor in Springfield, whereas the BlueTOAD data did not provide an accurate picture of the driving experience along I-91 corridor. In several locations along I-91, travel speeds fluctuated during peak travel periods. The Bluetoad data failed to show these fluctuations in travel speed due to the limited number of sensors installed along this section of I-91.

Figure 35 - Comparison between GPS and BlueTOAD Vehicular Speed Data.



As mentioned in the previously, the limited number of sensors along the I-91 corridor in Springfield gives an incomplete picture about the driving experience along this section of the highway. Whereas the GPS travel time and speeds can be collected in vehicle at various points along the corridor. The speed data was charted for points near each of the highway exits in this corridor. The following two graphs showed high speeds along the northern portion of I-91 near exit 13 (Figure 36). On the other hand, speeds decreased as the probe vehicle traveled south (Figure 37). Several speed fluctuations were observed between exits 12 and exit 4. Exit 8, which connects I-91 with I-291, experienced major fluctuations in speed. A similar pattern in speeds was observed in both the northbound and southbound directions depending on the time of day.

The absence of BlueTOAD sensors at each exit or at least at the three major exits (12, 8, and 4) does not reveal what actually happens during peak travel times along the I-91 corridor. In its current format, the BlueTOAD data only provides an average travel time and speed per minute for the entire corridor. Therefore it camouflages any extremes in travel conditions. For example, if vehicles are able to travel at or above posted speeds along the northern sections of I-91 near exit 13, while these same vehicles experience delay along the southern sections of I-91, taking an average vehicular speed of the whole corridor would hide these two observations in the traffic condition assessment and thus misrepresent actual traffic conditions.

Figure 36 - GPS and BlueTOAD Collected Vehicular Speeds along I-91 Northbound.

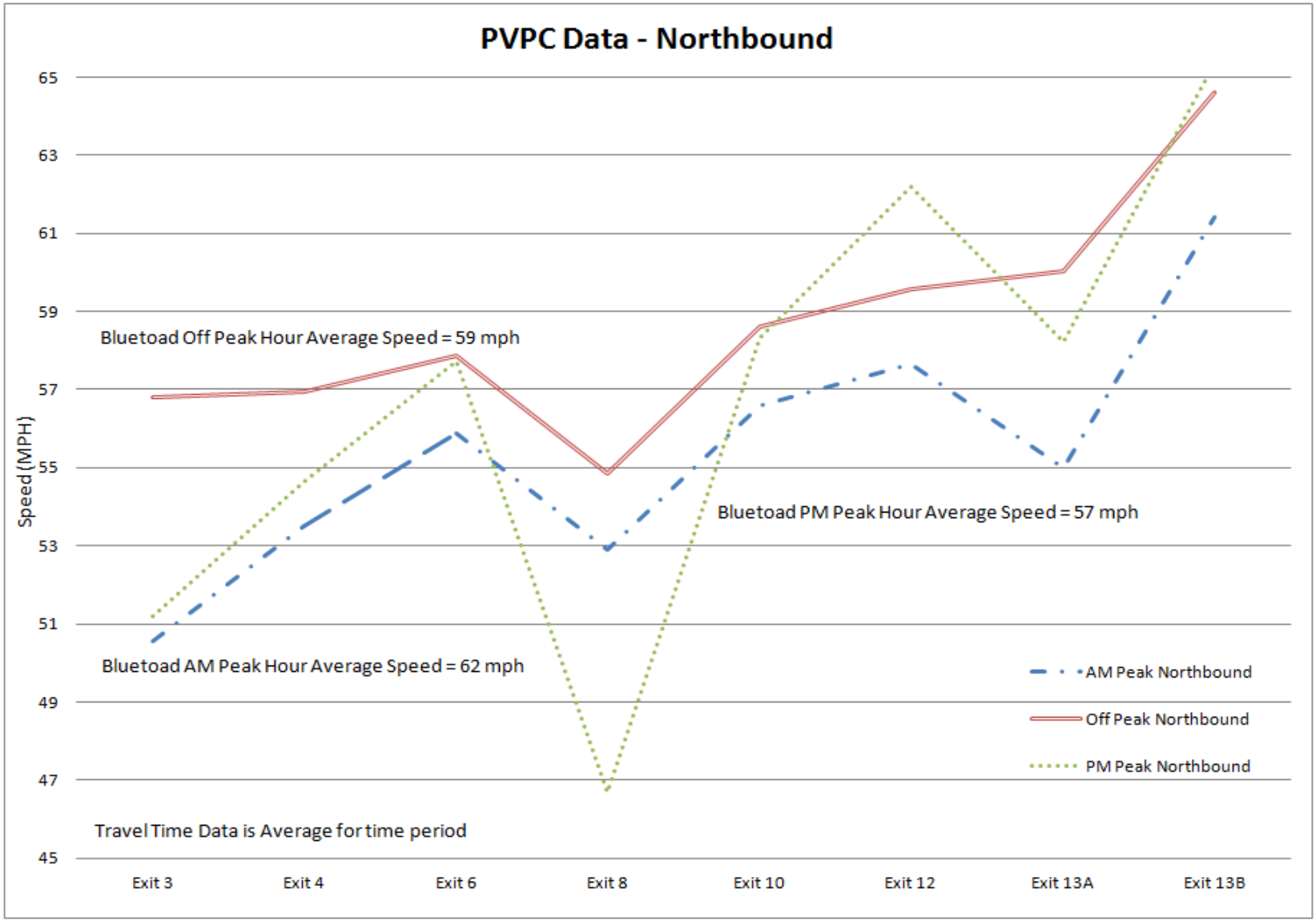
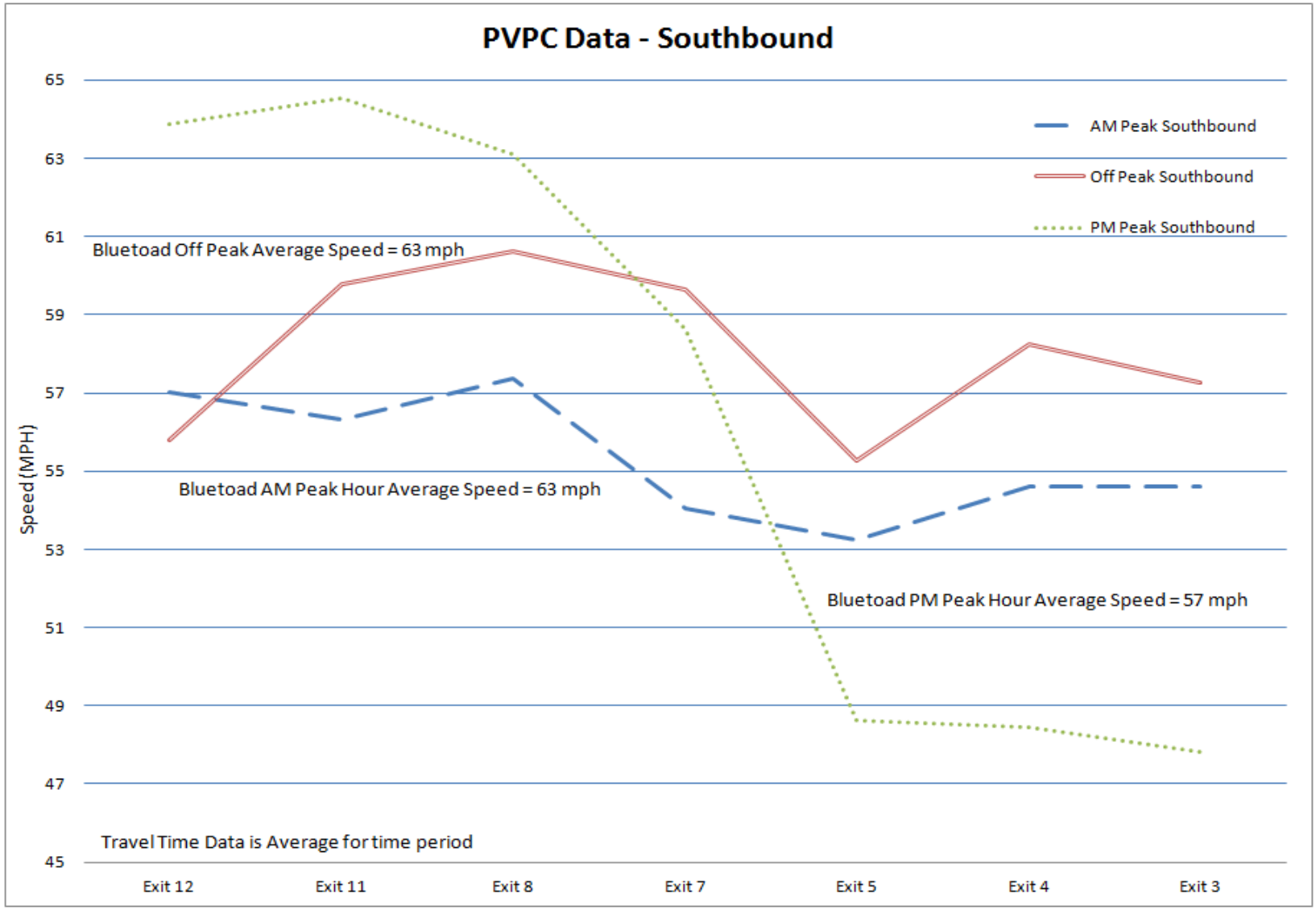


Figure 37 - Comparing GPS and BlueTOAD Collected Vehicular Speeds along I-91 Southbound.



As demonstrated previously, vehicular travel speeds calculated from the extensive GPS data collected by a probe vehicle gave better results than the limited data collected with BlueTOAD technology for this corridor study. Measuring travel time on a segment by segment bases between highway exits helps identify specific locations along I-91 where congestion is regularly experienced. This information would be useful to help reduce congestion and improve traffic flow and safety along the I-91 corridor.

III.1.6 Green House Gas Emmissions

The Pioneer Valley Planning Commission staff collected air samples to measure the levels of carbon dioxide along the I-91 corridor. This section of the study report describes the effort undertaken and the analysis results of field tests. Green house gas (GHG) emissions from automobiles is a major source of air pollution. Specific points in the vicinity of highway exits were measured to identify locations that require further attention.

Emissions from automobiles occur in the troposphere. This is the lowest atmospheric layer encompassing cities, towns, roads, and most human activities other than some aircraft flights. The first atmospheric layer is where weather occurs. The troposphere extends from the earth's surface up to 5 to 9 miles dependent on season. The troposphere is well-mixed and its composition is 78% Nitrogen, 21% Oxygen, 1% Argon, 0.036% Carbon Dioxide (CO2), varying amounts of water vapor depending on altitude and temperature, and minute amounts of a number of trace gases. Introduction of additional CO2 directly impacts this chemical composition of the troposphere, which is subjected to vertical mixing. This vertical mixing allows pollutants to be introduced into the atmosphere.

Transportation accounts for one third (33%) of CO2 emissions in the United States. The majority of this source of emissions, 80%, comes from cars and trucks traveling on roadways. Almost all of this increase is due to human activity. Concentrations of greenhouse gases are measured by volume in parts per million (ppm), parts per billion (ppb), or parts per trillion (ppt). In other words, a concentration of 1 ppb for a given gas means there is one part of that gas in 1 billion parts of a given amount of air. Before the industrial era began in the late 1700s, CO2 concentrations in the atmosphere measured approximately 280 parts per million (ppm). Concentrations have risen steadily since then, reaching 391 ppm in 2011, a 40% increase. CO2 represents about 95% of all mobile-source GHG emissions.

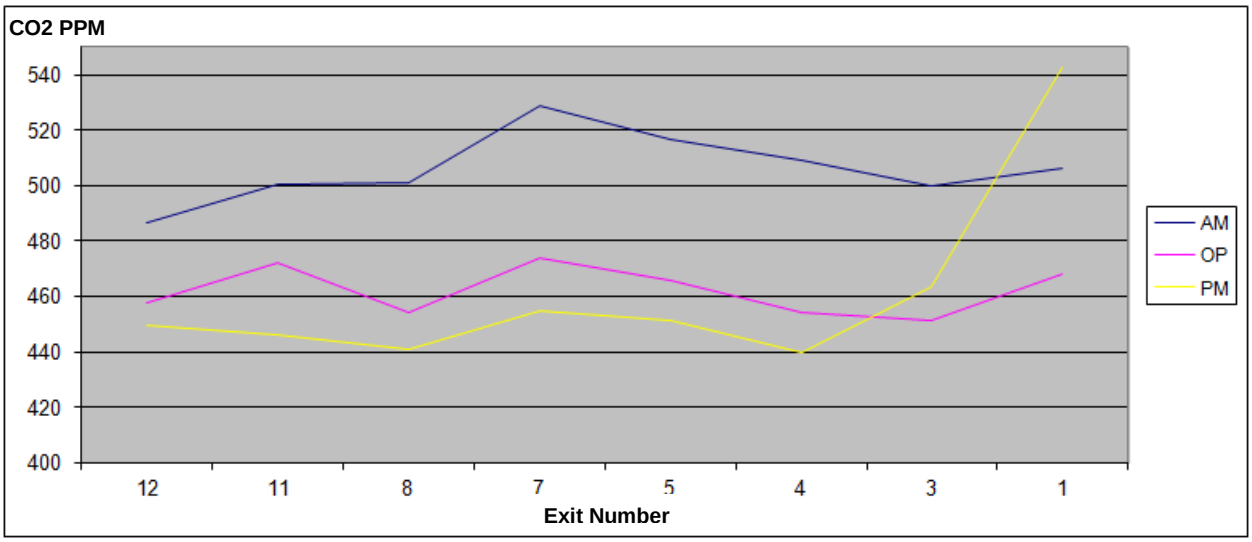
Vehicle Emissions Along the I-91 Corridor

As traffic congestion increases Carbon Dioxide also increases. Carbon Dioxide emissions are sensitive to the type of driving occurring. Traveling at a steady speed will result in much lower emissions than stop and go driving patterns. For example, on a highway when travel speeds are reduced due to congestion vehicles experience frequent acceleration and deceleration events over a short travel distance, which in turn correlates with higher grams per mile emission rates. And when vehicles travel at higher speeds they experience higher engine loads which result in higher emissions rates. However, a steady velocity of 45 to 50 mph produces the minimum grams per mile of CO2 emissions.

For taking mobile observations of CO2 emissions along Interstate 91 a Picarro 2301 cavity ring-down spectrometer and mobile monitoring kit were utilized to collect samples at approximately 1 second intervals. The unit was secured in the rear of a compact car and fed the units inlet tube to the car's front bumper. The unit's mobile monitoring kit has a built in high precision GPS that records the exact location of where a sample was taken. This data was extracted from the unit and mapped using the provided latitude and longitude coordinates. A total of 3 observations were performed for this study during the morning rush hour 7:08-8:45 AM (6/5), off peak time, 2:36-3:39 PM (5/30), and afternoon rush hour 4:44-5:46 PM (5/17). Each field drive along I-91 followed the same loop passing through Longmeadow, Springfield and West Springfield from Exit 1 to Exit 13B.

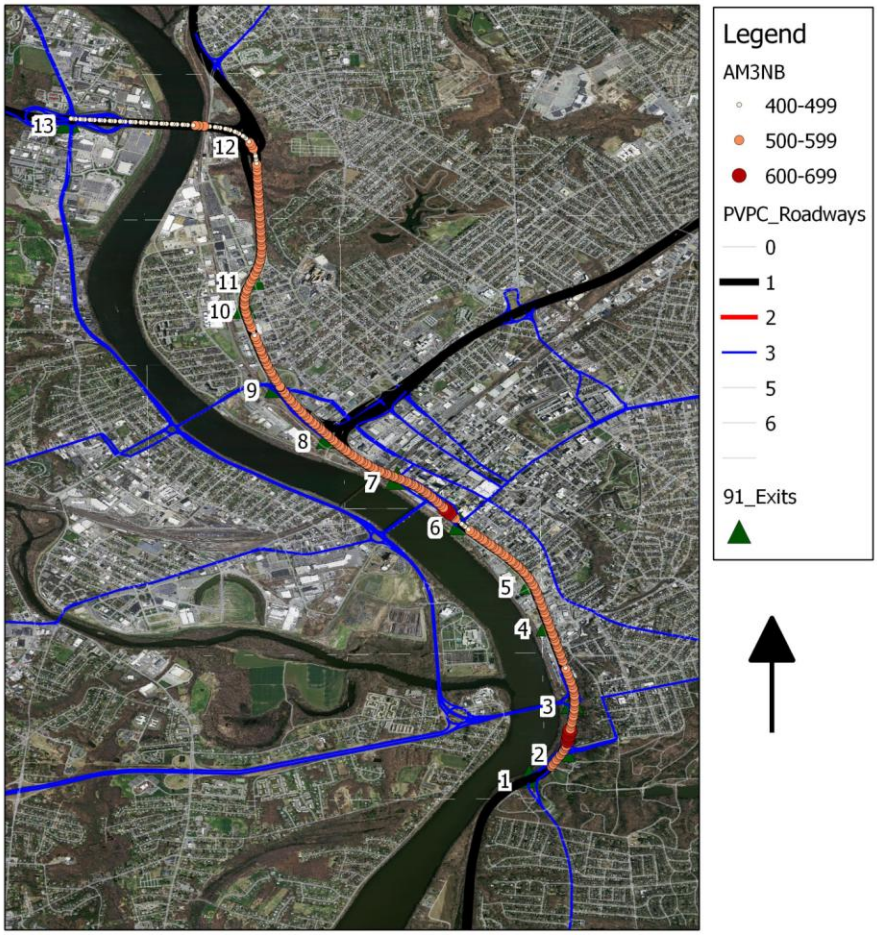
The CO2 readings were charted for each of the three times of day by direction. The chart below shows the variation in CO2 readings taken on I-91 during various times of the day (Figure 38). The X axis lists I-91 exit numbers and the Y axis represents the level of CO2 in parts per million. Data points in this chart represent the average CO2 levels between exit locations. For example, the data point at Exit 4 represents the average CO2 emissions from Exit 3 to Exit 4. The intensity levels of CO2 along the highway is depicted over an aerial map of the corridor area for the morning peak traffic period (Figure 39). Additional charts and maps representing CO2 readings during various times of the day are included in Appendix A.

Figure 38 - Carbon Dioxide Levels along I-91.



AM: Morning Peak Hour, OP: Off Peak Hour, PM: Afternoon Peak Hour.

Figure 39 - Carbon Dioxide Intensity on I-91 Northbound during Morning Traffic Peak Hour.



Travel speed observations and CO2 level measurements along the I-91 corridor study area show that congestion and the acceleration/deceleration events increase emissions between Interchanges 1 and 9. There are many on/off ramps between Interchanges 1 and 9 within a short distance from one another, including a connection to Interstate 291. Therefore, the volume of merging traffic from and to these ramps negatively impacts the ability of vehicles to maintain steady travel speeds, which results in higher emissions. Traffic moves more steadily between Interchanges 9 and 13 in both directions of the highway. Due to the steadier vehicular speeds, emissions are lower between Interchanges 9 and 13. Despite the fact that vehicular travel speeds are closer to the recommended 45 to 50 mph between Exits 1 and 9, acceleration/deceleration events prevent vehicles from maintaining a steady pace.

III.1.7 Highway Weave Analysis

Five locations posed potential weaving challenges to drivers along the I-91 Corridor within the study area. This was particularly evident in the vicinity of closely spaced on and off-ramps. The five locations identified for further analysis were located near Interchanges 1 through 5 (Table 11). Aerial views of the identified locations were depicted in Google Maps (Figures 40 to 43).

Table 11 - Highway Sections with Weave Challenges.

	Section	Description
1	I-91 Southbound Interchange 3 on-ramp and Hall of Fame Avenue at Interchange 4 off-ramp.	Vehicles from the I-91 Southbound Interchange 4 off-ramp attempting to go to Route 5 Northbound weave with vehicles already travelling along the Hall of Fame Avenue attempting to go to the I-91 Southbound on-ramp.
2	I-91 Northbound on-ramp near Interchange 3.	Traffic coming from Route 5 Southbound attempting to go to I-91 weave with traffic coming from I-91 Northbound and Route 83 attempting to go onto East Columbus Avenue and Main Street.
3	I-91 Southbound Interchange 3 on-ramp and Interchange 1 off-ramp.	Vehicles coming from Route 5 Southbound heading towards I-91 Southbound weave with vehicles from I-91 Southbound going to the Route 5 Southbound/Longmeadow off-ramp.
4	I-91 Southbound on and off-ramps at Interchange 1.	Traffic from I-91 Southbound to Route 5 Southbound weave with traffic coming from Route 83 that is getting onto I-91 Southbound or going to Route 5 Southbound.
5	I-91 Northbound near Interchange 2.	Vehicles entering I-91 Northbound from Route 5 Northbound weave with vehicles exiting I-91 Northbound towards Route 83.

Analyses conducted were based on the 2010 Highway Capacity Manual (HCM) and were completed using the Highway Capacity Software (HCS 2010) to determine the Level of Service (LOS) under existing conditions. The density of the segment is a key factor in calculating the level of service. Density is defined as passenger cars per mile per lane. It is calculated by dividing the vehicle volume per lane by the average speed of all vehicles in the weaving segment. In section 1 and 2, weaves occurred on East Columbus Avenue and Hall of Fame/West Columbus Avenue, therefore the Multilane Highway/Collector-Distributor Roadways criteria was used from the Highway Capacity Manual 2010. Whereas, sections 3, 4, and 5 of the highway experienced weaves on I-91 or Route 5 and 83, therefore the Freeway criteria was used for density in relation to LOS (Table 12).

Table 12 - Level of Service Definitions for Weaving Segments.

	Multilane Highways or Collector-Distributer Roadways	Freeways
Level of Service	Density (Passenger Cars / Mile / Lane)	Density (Passenger Cars / Mile / Lane)
A	0-12	0-10
B	>12-24	>10-20
C	>24-32	>20-28
D	>32-36	>28-35
E	>36	>35
F	Demand Exceeds Capacity	Demand Exceeds Capacity

Source: Highway Capacity Manual 2010, TRB.

A summary of the level of service results is included in Table 13. Following is a list of general assumption made during these analyses. The assumptions were based upon common analysis practices by other transportation agencies for similar highway structures.

1. Maximum capacity of the highway segment is assumed to be 2100 passenger cars per hour per lane for a highway with posted speed of 55 miles per hour.
2. Free-flow speed is based on posted speed plus 5.
3. Minimum segment speed is based on posted speed minus 5.
4. Terrain is assumed to be level.
5. Weaving segment length is assumed to be 300 feet for weaving sections 4 and 5. However, the actual length of these two highway weaving segments was measured from the aerial photography to be 216 and 276 feet consecutively, which is less than the 300 minimum standard allowed by the HCM software.

Table 13 - Level of Service Summary for Weaving Sections along I-91.

	Section	AM Peak Hour (LOS)	PM Peak Hour (LOS)
1	I-91 Southbound Interchange 4 off-ramps and Interchange 3 on-ramps.	B	C
2	I-91 Northbound on-ramp near Interchange 3.	E	C
3	I-91 Southbound Interchange 3 on-ramp and Interchange 1 off-ramp.	D	D
4	I-91 Southbound on and off-ramps at Interchange 1.	B	C
5	I-91 Northbound near Interchange 2.	B	B

The worst level of service among the five highway weave sections analyzed appears to be section 2 along East Columbus Avenue near the I-91 Northbound on-ramp past Interchange 3 during the morning peak hour. This section is currently operating at a level of service E. Section 3 along I-91 Southbound between the highway on-ramp from the South End Bridge and Exit 1 experienced a level of service D during both the morning and afternoon peak hours. During the afternoon peak hour sections 1, 2, and 4 operated at a level of service C. Whereas sections 1, 4, and 5 operated at a level of service B during the morning peak hour. Section 5 operated at a level of service B during the afternoon peak hour as well. Freeway weaving analysis worksheets are included in Appendix A.

In general, the Level of Service analysis showed acceptable density levels for the five sections identified as areas of weaving challenges to vehicles. In reality, several of these sections experienced downstream traffic congestion due to vehicular traffic backed up upstream. This is particularly evident at the South End Bridge in Agawam and Route 5 in Longmeadow. These often congested locations create travel conditions that exacerbate weave challenges, especially during times of special events such as the Big E in West Springfield. In addition, an influx of traffic often occurs during the seasonal operations of the amusement park in Agawam and the academic session at the college in Longmeadow. Therefore, extra attention needs to be given to the identified weaving sections when considering solutions to alleviate congestion and improve safety, even though the level of service analysis does not point to major traffic flow issues.

Figure 40 - Weave Analysis Section Number One.

Imagery ©2012 Terra Metrics, Map data © 2012 Google.

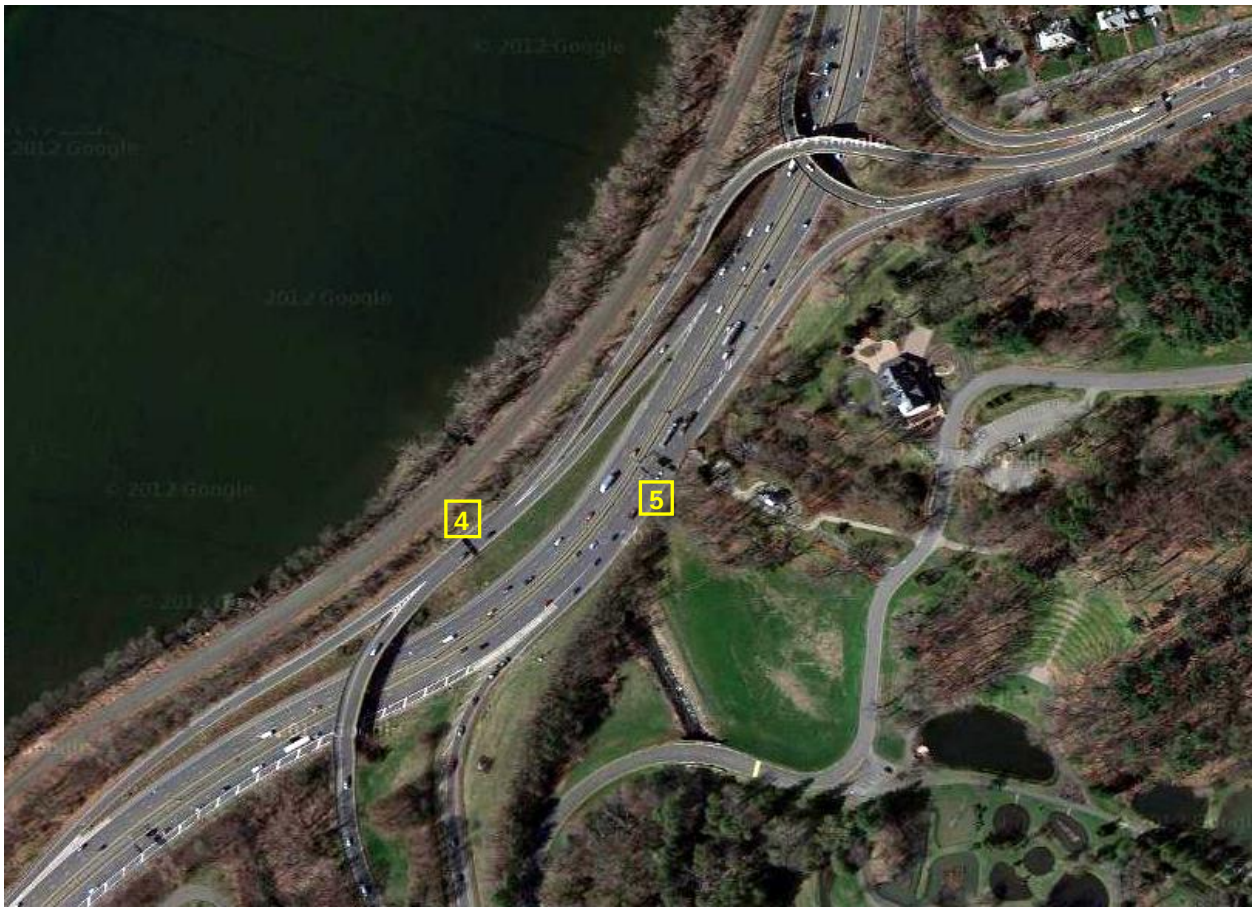
Figure 41 - Weave Analysis Section Number Two.

Imagery ©2012 Terra Metrics, Map data © 2012 Google.

Figure 42 - Weave Analysis Section Number Three.

Imagery ©2012 Terra Metrics, Map data © 2012 Google.

Figure 43 - Weave Analysis Section Number Four and Five.



Imagery ©2012 Terra Metrics, Map data © 2012 Google.

III.2 CRASH EXPERIENCE

Detailed information on crash data and characteristics derived from records maintained by the Massachusetts Department of Transportation were obtained and analyzed. Feedback was also solicited from State Police about field observations related to crashes on I-91. Concerns about the safety of motorists and pedestrians could require conducting travel speed analysis for specific areas as well as field analysis, manual counting, and observations relative to improving safety.

Historic crash data was gathered for the period of 2007-2009 on Interstate I-91 to identify sections of the highway with safety concerns and investigate potential solutions to problem areas. This particular stretch of I-91 has its own set of unique characteristics. It is located in the City of Springfield, which the largest city along the I-91 corridor in terms of population with a total of 153,060 residents based on the 2010 Census. This section of the highway also provides connections to other major highways and major routes such as I-291, I-391, Route 20, Route 83, Route 147, and Route 5.

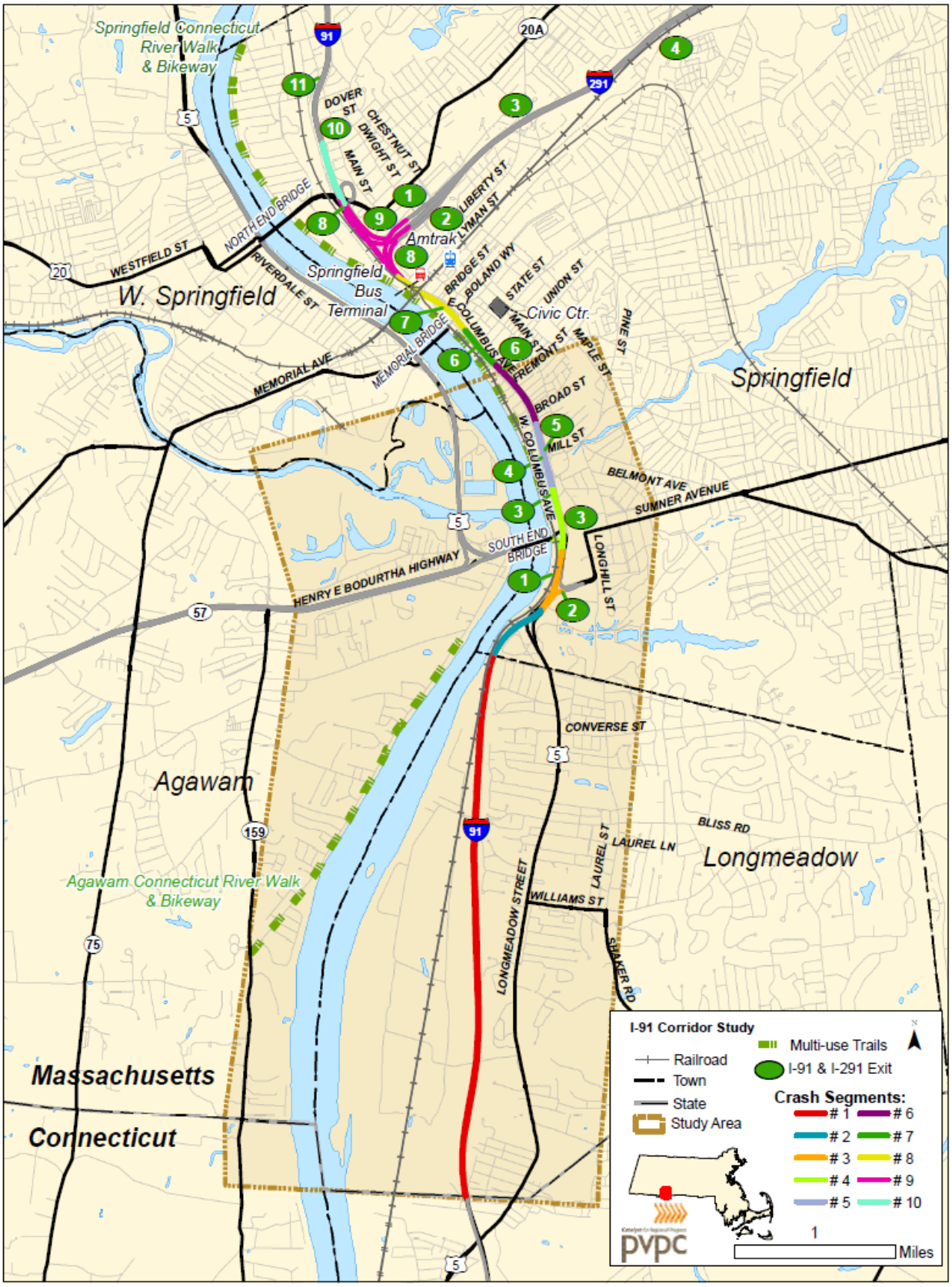
To facilitate the safety analysis of the I-91 corridor, the length of the highway has been divided into 10 geographical segments from the Connecticut State Line to Exit 10. A description of each section is provided in Table 14. The segments are color coded on the location map (Figure 44).

Table 14 - Highway Segment Descriptions.

Segment 1: I-91 in Longmeadow. Length 3.25 miles.
Segment 2: Around the northbound on-ramp 2. Length 0.52 miles north from Springfield/Longmeadow City Line. Ends right before Columbus Avenue on-ramp for I-91 north.
Segment 3: Covers northbound exits 2 and 3 and southbound exit 1. Length 0.33 miles north from end of segment 2.
Segment 4: Covers on-ramps from the South End Bridge onto I-91 southbound and northbound and on-ramp from Hall of Fame/West Columbus Avenue. Ends north of Bruno Street. Length 0.40 miles north from end of segment 3.
Segment 5: Covers northbound exit 5 and southbound exits 3 and 4. Ends north of Elmwood Street. Length 0.41 miles north from end of segment 4.
Segment 6: Includes northbound exit 6 and southbound on-ramp from Hall of Fame/West Columbus Avenue in the vicinity of Loring Street. Ends north of Union Street. Length 0.445 miles north from the end of segment 5.
Segment 7: Includes Southbound exit 6. Ends north of Court Street. Length 0.279 miles from the end of segment 6.
Segment 8: Includes northbound on-ramp from East Columbus Avenue between Bridge Street and Boland Way and southbound exit 7. Ends north of Liberty Street. Length 0.496 miles north from end of segment 7.
Segment 9: Includes northbound exits 8 and 9, and southbound exit 8. Includes on and off-ramps between I-91 and I-291. Ends at Plainfield Street overpass. Length 0.624 miles from end of segment 8.
Segment 10: Includes northbound on ramp in the vicinity of Huntington Street. Ends north of Greenwich Street loop. Length 0.393 miles north from the end of segment 9.

Comparing the total number of crashes for each segment shows that segments 1, 3, and 9 had the highest crash experience (Figure 45). This could be a result of the location of these segments in areas of high traffic. For example, segment 9 contains ramps connecting I-91 to I-291, which in turn connects with the Massachusetts Turnpike, I-90.

Figure 44 - Crash Segment Map.

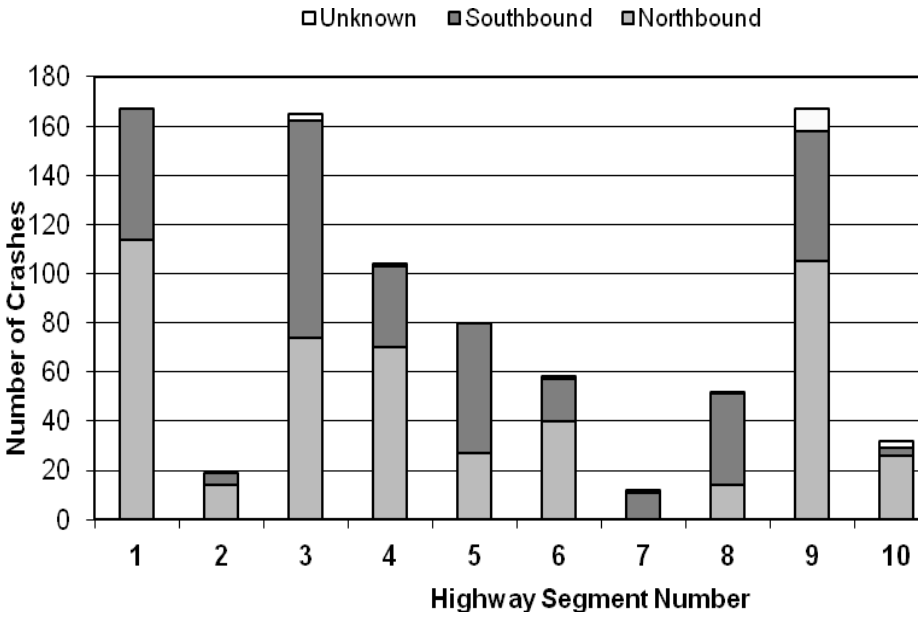


Lane drops and weaving and merging traffic along I-91 may also contribute to safety problems. Segment 1 includes the beginning of the 'Longmeadow Curve' and covers the stretch of the highway from that point till the Connecticut State Line. Segment 3 contains ramps connecting I-91 to Route 83 and Route 5, which is the alternate North-South travel corridor. It is interesting to note that these segments had a high number of rear-end crashes as well as single-vehicle property damage crashes.

Northbound collisions seemed to be more frequent than southbound collisions. Segments 1, 4, 6, 9, and 10 contained at least 75% more northbound crashes than southbound. Segment 10 and Segment 1 had double the amount of crashes occur in the northbound direction than in the southbound direction of the highway. Segment 7 had the lowest crash totals followed by Segment 2 and Segment 10.

Segment 3, between the Route 83 on ramp to I-91 NB and the Route 5 EB off ramp, had a high number of crashes. This area is partially dangerous because of cars coming on the highway and cars slowing down to get to the off ramp. In Segment 4, the Route 5 on-ramp for I-91 NB seems to cause a lot of crashes, this could be due to the narrow bridge and sharp left turn cars are taking to get on to the highway. In Segment 8, cars on the NB on ramp from East Columbus Avenue seem to frequently have trouble merging into highway traffic due to the high traffic volume and the short amount of time cars have to merge into traffic. In Segment 9, I-91 merges with I-291; this area has high amounts of traffic. Most ramps have seen many collisions, particularly the I-91 SB on ramp from I-291 WB.

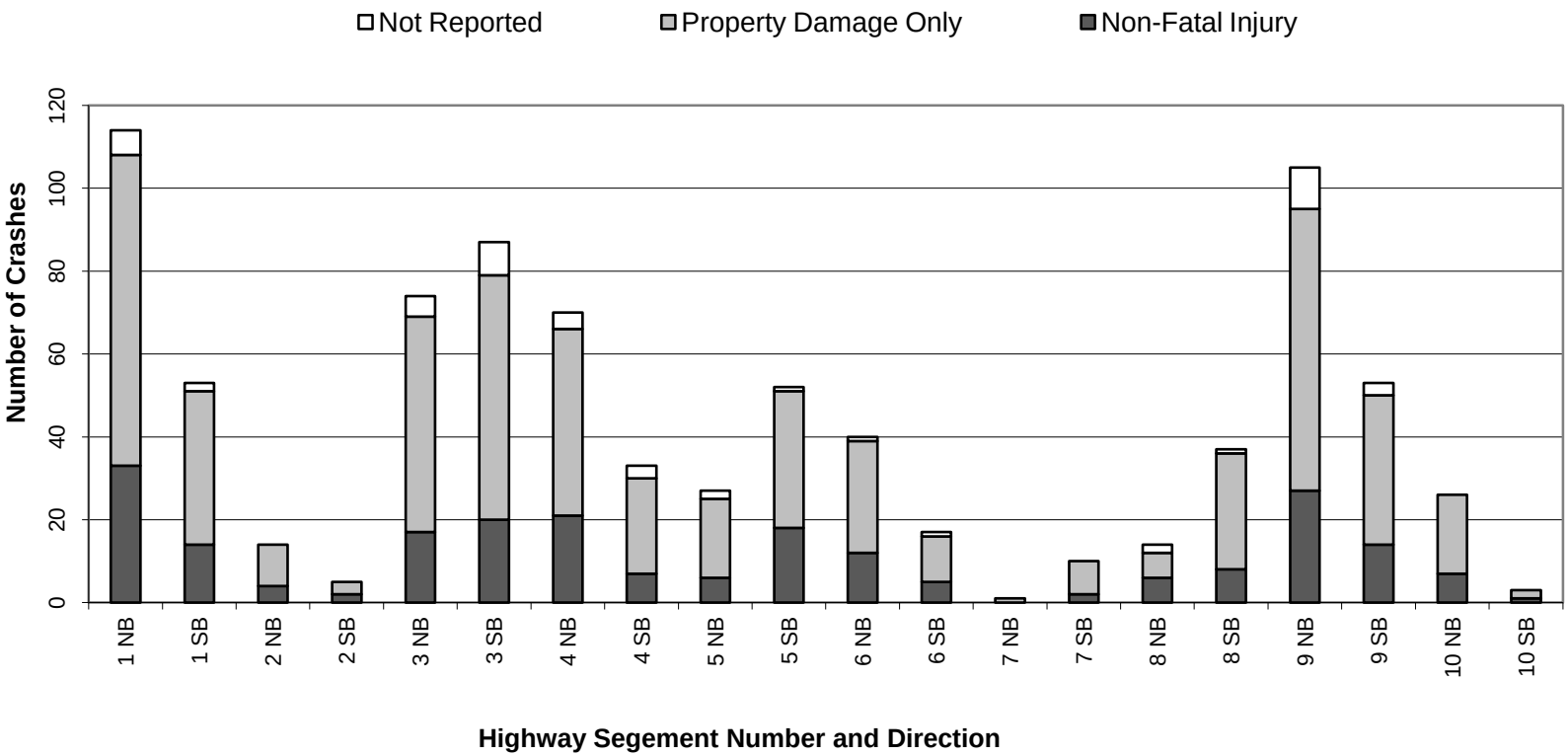
Figure 45 - Total Crashes by Highway Segment and Direction.



Crash severity analysis showed most crashes resulted in property damage only (Figure 46). About a quarter of crashes included non-fatal injuries in most of the highway segments. In general, all segments had mostly single vehicle crashes followed by non-fatal crashes with other vehicles (Figure included in Appendix A). Rear-end collisions were very common in most segments and much higher in segments connecting I-91 with major roadways. This could be associated with high traffic volumes and the need for vehicles to change lanes at higher speeds to get to a ramp.

Weather Conditions did not seem to affect the number of crashes as none of the segments showed a disproportionate amount of crashes during certain types of weather conditions (Figure included in Appendix A). The largest number of crashes occurred on a clear day, the second highest number of crashes occurred during cloudy conditions.

Figure 46 - Crashes Categorized by Severity.



(Note: Two fatal crashes occurred on I-91. One in segment 5 and segment 3 southbound)

Two fatal crashes occurred during the three year period of analysis from 2007 to 2009 (Table 15). One occurred in Segment 3 and the other in Segment 5. Both fatal crashes involved a single vehicle colliding with a guardrail in the vicinity of Exit 4 on I-91 in the southbound direction. In the first case, the fatal crash occurred shortly after midnight when a motorcyclist collided with a guardrail. The second case involved two crashes, the first of which was a rear end collision at Main and Union Streets between a taxi and a sports utility vehicle around 2 AM. After which, the driver of the sports utility vehicle fled the scene via I-91 southbound and collided with a guardrail resulting in the death of one of the passengers who was not wearing a safety belt and was ejected from the vehicle during the crash. The online news account that day reported that the driver would be sought for drunken driving and negligent operation.

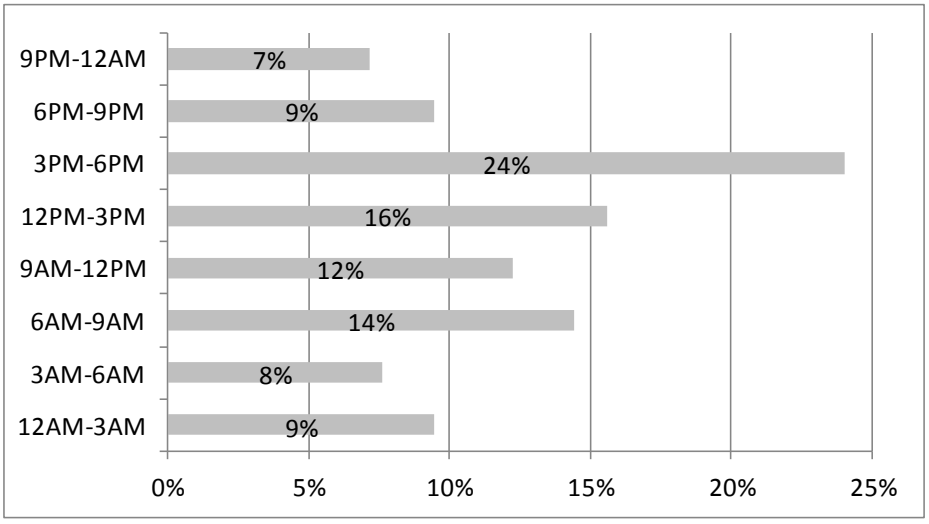
Categorizing the 866 crashes by time of day shows that the highest percentage, about a quarter, of all crashes occurred during the evening rush hour period from 3pm to 6pm (Figure 47). The study area included the following challenges to drivers:

- Having to merge into traffic after slowing down to enter an on or off-ramp.
- Poor visibility when merging onto the highway.
- The proximity of the Connecticut River to the Interstate forces the road to follow sharp turns; as exemplified by the 'Longmeadow Curve'.
- The I-91 corridor contains a number of "weave sections", creating a driving challenge that can increase the potential for vehicular crashes.

Table 15 - Fatal Crash Details.

Date	September 14, 2007	July 10, 2009
Time	12:04AM	2:10AM
Highway Segment	5	3
Number of Fatalities	1	1
Number of Non Fatalities	Not Reported	6
Manner of Accident	Single Vehicle Collision with the Guardrail	Single Vehicle Crash with the Guardrail
Direction of Travel	SB	SB
Weather Condition	Clear	Not Reported
Lighting	Dark with Lighted Roadway	Not Reported
Surface Conditions	Dry	Not Reported
Location	Exit 4 Off-Ramp	Near Exit 4 Off-Ramp

Figure 47 - Crash Distribution by Time of Day.



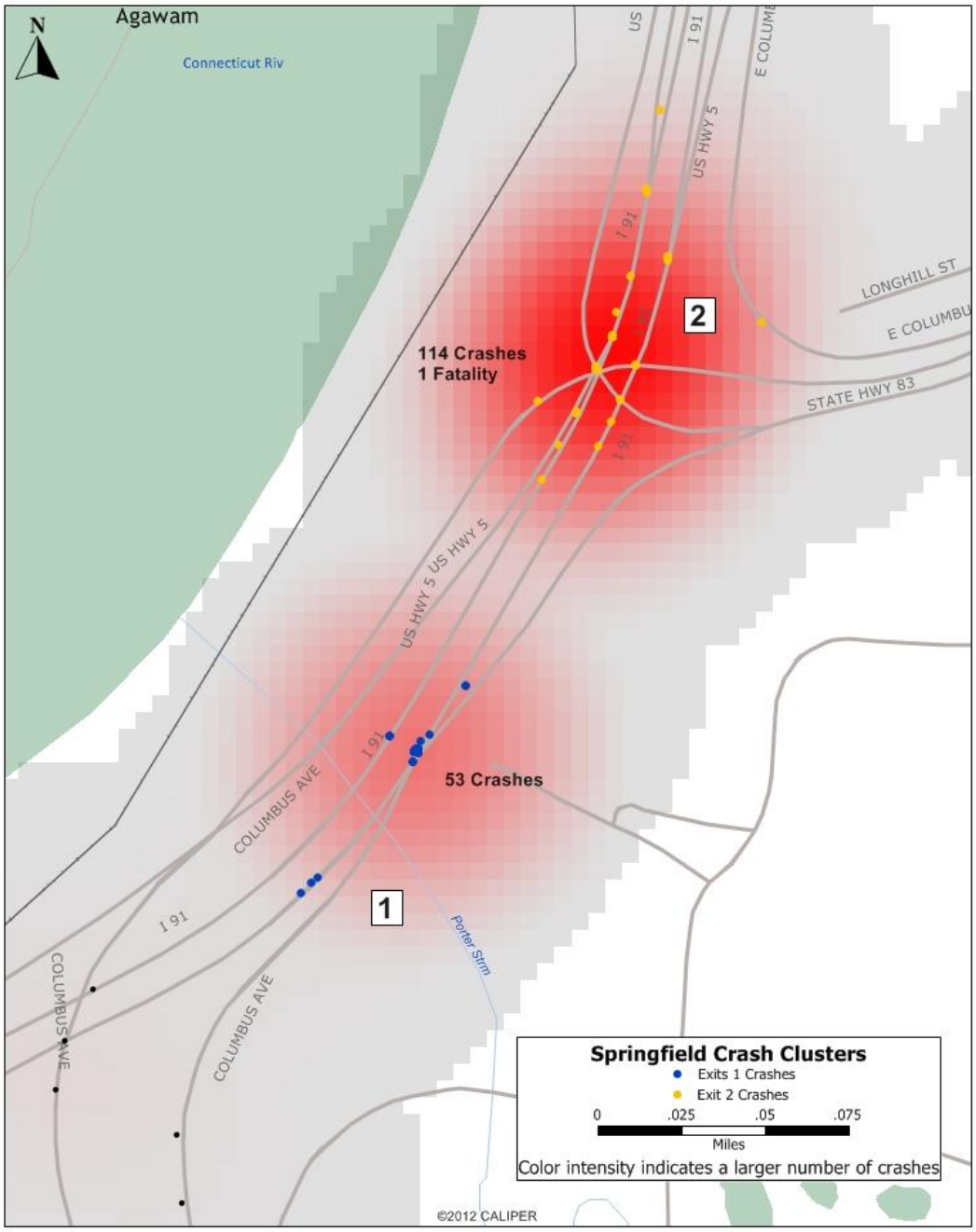
III.2.1 Crash Cluster Analysis

To further identify location factors in the I-91 crashes, the cash data was analyzed by clusters. The transportation modeling software, TransCAD, was used to identify locations that had a higher concentration of crashes. In the previous section, the highway was divided into nine equal length segments with a tenth extending all the way to the Connecticut State Line. The highway segments were useful in dividing the corridor into 10 geographic sections for analysis. The cluster analysis, on the other hand, focused on the proximity of crashes to one another in addition to their volume at certain locations. Within the study area, crashes that occurred on I-91 and within its immediate vicinity were organized into clusters using density grids. The goal was to find out what was going on at particular sections of the roadway that showed a high number of crashes. Conducting a crash density cluster analysis, five clusters were identified along the I-91 corridor (Figure 48).

Figure 48 - Crash Clusters.

A closer look at each of these clusters identifies the location of crashes in the following figures. Cluster 1 has a significantly higher number of crashes occurring in the northbound compared to the southbound direction (Figure 49). This could be attributed to a weave section between Route 5 Northbound on-ramp and Route 83 off-ramp. The Longmeadow Curve could also be a factor, in this area.

Figure 49 - Crash Locations in Cluster 1 and Cluster 2.



Clusters 2 and 3 had the highest number of crashes, 114 and 98 total crashes (Figure 49 and 50). This could have been influenced by the roadway design geometry as an added challenge to vehicles getting on and off of the highway. A high number of entry and exit points within close proximity creates merging challenges that could lead to crashes. While the volume of total crashes in cluster 5 was much less than other clusters detailed above, it did include two fatalities. One fatality occurred on the highway and the other on the frontage road (Figure 51).

Figure 50 - Crash Locations in Cluster 3.

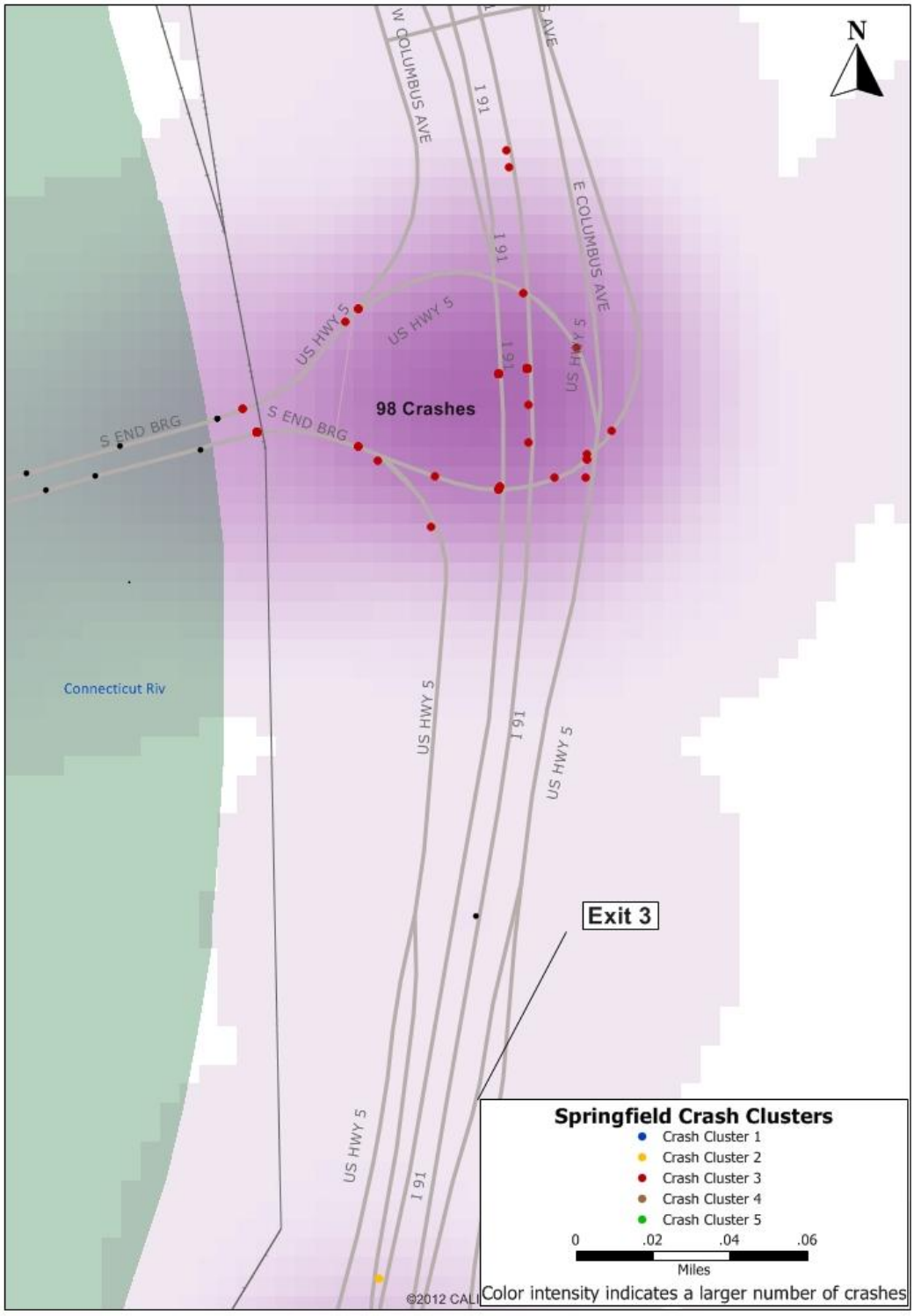
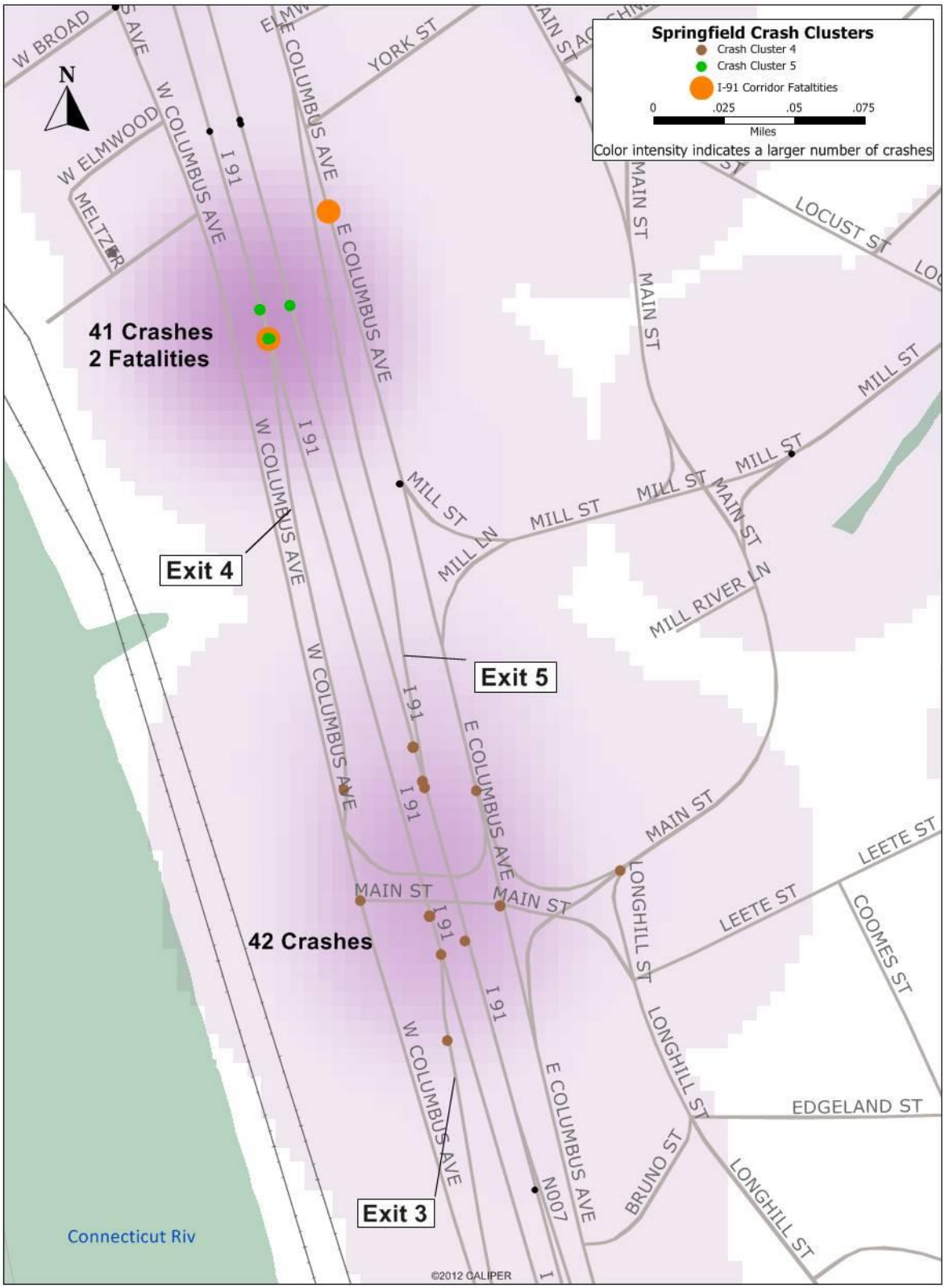


Figure 51 - Crash Locations in Cluster 4 and Cluster 5.

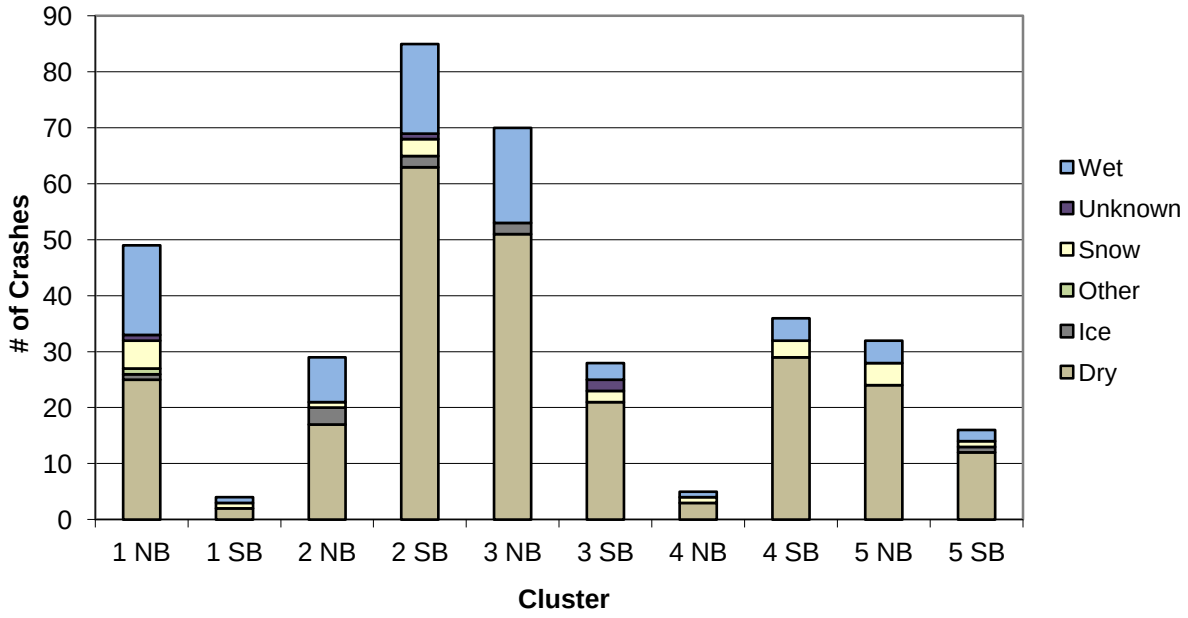


The impact of roadway conditions on the number of crashes was not very clear (Table 16). However, certain locations appeared to be more sensitive to challenging roadway surface conditions during rain, snow and ice. Cluster 1 had a third of its crashes occur during wet surface conditions (Figure 52), whereas clusters 2 and 3 had one fifth of their crashes occur during wet surface conditions. The remaining two clusters had only about tenth of their crashes during wet surface conditions. This could be due to an increased difficulty in controlling vehicles over curved roadways during adverse driving conditions.

Table 16 - Road Surface Conditions at Crash Location by Cluster.

Cluster	Direction	Dry	Ice	Other	Snow	Unknown	Wet	Sub Total	Total
1	NB	25	1	1	5	1	16	49	53
	SB	2	0	0	1	0	1	4	
2	NB	17	3	0	1	0	8	29	114
	SB	63	2	0	3	1	16	85	
3	NB	51	2	0	0	0	17	70	98
	SB	21	0	0	2	2	3	28	
4	NB	3	0	0	1	0	1	5	41
	SB	29	0	0	3	0	4	36	
5	NB	24	0	0	4	0	4	32	48
	SB	12	1	0	1	0	2	16	
Total		247	9	1	21	4	72	354	
Percent Total		70%	3%	0%	6%	1%	20%	100%	

Figure 52 - Road Surface Conditions at Crash Location by Cluster.



Weather conditions can also be a contributing factor to vehicle crashes. Crash data showed that although more than half of all crashes occurred on a clear day, a noticeable number did occur on cloudy or rainy days, 14% and 11% respectively (Table 17). One fifth of Cluster 1 crashes occurred on a rainy day, and about one fifth of Cluster 2 crashes occurred on a cloudy day. Cloudiness could reduce visibility due to a reduction in light contrast, and rain could obstruct visibility and increase stopping distance.

Table 17 - Weather Conditions during Crashes by Cluster.

Cluster	Direction	Clear	Cloudy	Rain	Sleet/ Freezing Rain	Snow	Fog/ Smoke	High Winds	Not Reported	Total
1	NB	24	4	11	1	5	1	0	3	49
	SB	1	1	1	0	1	0	0	0	4
2	NB	11	9	4	1	2	0	0	2	29
	SB	54	13	6	1	4	0	0	7	85
3	NB	43	11	11	0	0	0	0	5	70
	SB	19	5	2	0	1	0	0	1	28
4	NB	3	0	0	1	0	0	0	1	5
	SB	25	1	4	0	2	0	0	4	36
5	NB	21	4	0	0	6	0	0	1	32
	SB	11	1	0	0	3	0	0	1	16
Total		212	49	39	4	24	1	0	25	354
Percent Total		60%	14%	11%	1%	7%	0%	0%	7%	100%

Property damage only crashes were consistently the highest crash severity, accounting for about two thirds of all crashes in each cluster (Table 18). The highest percentage of injuries occurred within Cluster 2 and Cluster 3. Fatal injuries occurred in Cluster 2 and 4.

Table 18 - Crash Severity by Cluster.

Cluster	Direction	Fatal Injury	Non-Fatal Injury	Property Damage Only	Unknown	Total
1	NB	0	10	36	3	49
	SB	0	1	3	0	4
2	NB	0	7	19	3	29
	SB	1	20	56	8	85
3	NB	0	21	45	4	70
	SB	0	4	21	3	28
4	NB	0	2	3	0	5
	SB	2	12	21	1	36
5	NB	0	10	21	1	32
	SB	0	3	12	1	16
Total		3	90	237	24	354
Percent Total		1%	25%	67%	7%	100%

An analysis of the manner of collision shows that side-swipes were the third highest type of crash after single vehicle and rear-end crashes; 18%, 36% and 40% respectively (Table 19). This was particularly evident within Cluster 2 on I-91 in the southbound direction and within Cluster 3 on I-91 in the northbound direction. Comparing the volume of crashes in the northbound direction versus the southbound direction

within each individual cluster revealed that the higher number of crashes alternated between the northbound and southbound sides of I-91. The direction of the highest number of crashes within each crash cluster was as follows: Cluster 1 on I-91 northbound, Cluster 2 on I91 southbound, Cluster 3 on I-91 northbound, Cluster 4 on I-91 southbound, and Cluster 5 on I-91 northbound. This may reflect a variety of traffic flow challenges for exiting and entering traffic while trying to navigate the winding geometry of the highway.

Table 19 - Manner of Collision by Cluster.

Cluster	Direction	Angle	Front End/ Head On	Rear End	Side-swipe	Single Vehicle	Not Reported	Total
1	NB	5	0	17	5	22	0	49
	SB	0	0	2	1	1	0	4
2	NB	1	2	8	5	12	1	29
	SB	2	0	34	14	34	1	85
3	NB	1	0	32	12	25	0	70
	SB	6	0	10	4	7	1	28
4	NB	1	0	2	0	2	0	5
	SB	0	0	15	10	11	0	36
5	NB	2	0	15	7	7	1	32
	SB	0	0	6	4	5	1	16
Total		18	2	141	62	126	5	354
% Total		5%	1%	40%	18%	36%	1%	100%

During a meeting with Massachusetts State Police Officers who covered I-91 in Springfield, field notes were compared with data gathered from crash records. Their field observations attributed rear end crashes to slowing down of traffic at the South End Bridge before the Agawam Rotary. Whereas side swipe crashes resulted from vehicles changing lanes in heavy congestion during the morning and afternoon peak hours. Occurrence of crashes near highway exits leading to the city center was typical of heavy business traffic in a downtown.

The South End Bridge was a hot spot for congestion especially from 8 A.M. to 10 A.M. during the summer. In September I-91 experiences traffic congestion due to the "Big E", Eastern States Exposition, in West Springfield. During the last two weekends of September, the southbound direction of the highway can get backed up past the Basketball Hall of Fame due to Big E traffic. Additional special events traffic generators were noted to include Bright Nights in December at Forest Park in Springfield, and the 4th of July Fireworks in downtown Springfield near Memorial Bridge.

Interchange 2 along the Northbound side of the highway suffers from a design flaw that creates conflict between vehicles getting on the highway from Longmeadow and vehicles getting off the highway. In fact, the weaving distance falls short of current minimum standards.

III.2.2 Local Intersection Crashes

Local streets abutting I-91 were analyzed for crashes occurring within the I-91 study corridor. In general, the number of crashes that occurred along East Columbus Avenue were twice as many as the number of crashes that occurred along Hall of Fame/West Columbus Avenue. According to the Peak Hour Traffic Volume diagrams provided earlier in this report, crash volume ratios corresponded with the difference in traffic volumes along these two frontage streets. Street intersections closer to the city center experienced a higher number of crashes as seen at the intersection of East Columbus Avenue at Union Street, Boland Way, and Main Street, which experienced 55, 35, 25 crashes during a three year period from 2007 to 2009 (Figure 53).

Crash data gathered from local police reports for East Columbus Avenue and Hall of Fame/West Columbus Avenue between Exit 1 and Exit 7 is included in Appendix C. Collision diagrams were drawn from the information gathered from the police reports. A compilation of the individual collision diagrams for 11 identified intersections in the local vicinity to the I-91 corridor are also included in Appendix A. Each diagram provides a visual assessment of the types of crashes occurring and their particular locations. Certain trends of crashes appeared in the compiled collision diagrams. They pointed to dangerous intersections and factors playing a part in crashes occurring at these locations. Insight gleaned from reviewing the collision diagrams would help formulate solutions to address intersection problems that could improve safety. Collision severity, manner, light, weather, and road conditions are summarized in Table 20. Two thirds of collisions involved property damage and about a third involved personal injury. About two thirds of all collisions were angle crashes and about a third were rear-ends.

Collision trends identified for major intersections along East Columbus Avenue and Hall of Fame/West Columbus Avenue include the following:

1. Red-light running on Main Street by vehicles heading eastbound caused angle collisions with vehicles traveling northbound on East Columbus Avenue.
2. Side swipes between southbound vehicles from Hall of Fame/West Columbus Avenue while turning left onto Main Street eastbound.
3. There was no apparent trend of collisions at the Main Street and Longhill Street intersection.
4. Rear- end collisions occurred on Mill Street westbound as vehicles approached the intersection with East Columbus Avenue.
5. Angle collisions occurred between vehicles heading eastbound on Broad Street operating under a flashing red signal and vehicles traveling northbound on East Columbus Avenue operating under a flashing yellow traffic control signal.
6. Vehicles attempting a left turn onto Union Street while in the through only lane collided with vehicles traveling northbound on East Columbus Avenue.
7. Rear-end collisions occurred when vehicles traveling south on Hall of Fame/West Columbus Avenue stopped at the traffic light at the Union Street intersection.
8. Angle collisions occurred between vehicles heading westbound on State Street and vehicles heading northbound on East Columbus Avenue.
9. There was no apparent collision pattern at the intersection of State Street and Hall of Fame/West Columbus Avenue.
10. Angle collisions occurred due to lane change maneuvers by vehicles traveling northbound on East Columbus Avenue and those attempting to turn left onto Boland Way.
11. Rear-end collisions occurred when vehicles traveling southbound on Hall of Fame/West Columbus Avenue stopped at the traffic signal at Boland Way and the Memorial Bridge. These vehicles may have come from the Exit 7 off ramp who may not have slowed down in time before reaching the traffic light.

Figure 53 - Local Intersection Crashes 2007-2009.

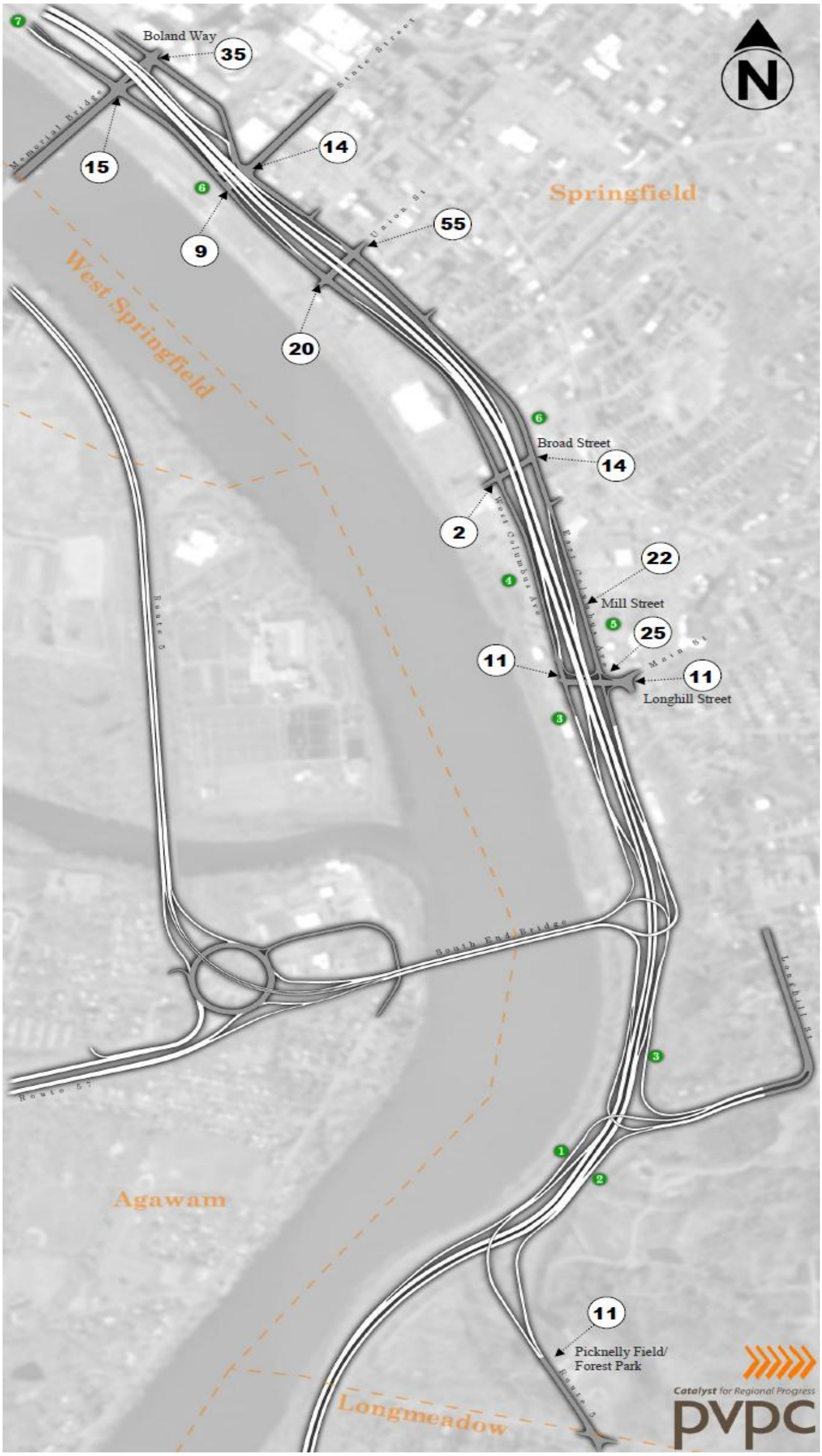


Table 20 - Local Crashes in the Vicinity of the I-91 Corridor.

	Intersection	Total Number of Crashes	Severity		Manner of Collision		Light		Weather		Road Condition	
1	Union Street at East Columbus Avenue	55	Injury	18	Angle	43	Daylight	38	Clear	25	Dry	41
			Property Damage	38	Rear-End	10	Dark/Lighted	13	Cloudy	19	Wet	15
					Non-Motorist	1	Dawn/Dusk	5	Rain	12		
					Single Vehicle	1						
					Head-On	1						
2	Union Street at West Columbus Avenue	20	Injury	6	Angle	11	Daylight	10	Clear	17	Dry	18
			Property Damage	16	Rear-End	10	Dark/Lighted	11	Cloudy	2	Wet	4
					Single Vehicle	1	Dawn/Dusk	1	Rain	3		
3	Broad Street at East Columbus Avenue	14	Injury	5	Angle	13	Daylight	8	Clear	6	Dry	8
			Property Damage	9	Rear-End	1	Dark/Lighted	4	Cloudy	4	Wet	6
							Dawn/Dusk	2	Rain	4		
4	Broad Street at West Columbus Avenue	2	Injury	0	Angle	2	Daylight	1	Clear	2	Dry	2
			Property Damage	2			Dark/Lighted	1				
5	Mill Street at East Columbus Avenue	22	Injury	8	Angle	4	Daylight	21	Clear	15	Dry	19
			Property Damage	14	Rear-End	17	Dawn/Dusk	1	Cloudy	6	Wet	3
					Single Vehicle	1			Rain	1		
6	Main Street at Longhill Street	11	Injury	1	Angle	7	Daylight	10	Clear	10	Dry	11
			Property Damage	10	Rear-End	2	Dark/Lighted	1	Cloudy	1		
					Non-Motorist	1						
					Head-On	1						
7	Main Street at East Columbus Avenue	25	Injury	18	Angle	24	Daylight	24	Clear	25	Dry	28
			Property Damage	17	Rear-End	7	Dark/Lighted	10	Cloudy	4	Wet	4
					Single Vehicle	2			Rain	3	Snowy	1
					Head-On	1			Snow	2	Wet/Icy	1
8	Main Street at West Columbus Avenue	11	Injury	5	Angle	12	Daylight	15	Clear	11	Dry	13
			Property Damage	13	Rear-End	2	Dawn/Dusk	2	Cloudy	4	Wet	3
					Non-Motorist	1			Rain	2	Snowy	1
9	Pickenelly Field at Forest Park	11	Injury	3	Rear-End	10	Daylight	10	Clear	9	Dry	9
			Property Damage	8	Non-Motorist	1	Dark/Lighted	1	Rain	2	Wet	2

The observed collision patterns point to intersections prone to certain types of collisions. Recurring trends in collisions could possibly be avoided or reduced with modifications to current traffic control devices and lane markings along East Columbus Avenue and Hall of Fame/West Columbus Avenue. A brief summary of recommendations for intersections with observed collisions trends is included below (Table 21). A more detailed discussion of challenges and suggestions follows.

Table 21 - Local Intersection Recommendations.

Intersection	Problem Trend	Recommendation
Main Street Eastbound and East Columbus Avenue	Collisions due to red-light running	Review clearance interval in signal timing.
Union Street Eastbound and East Columbus Avenue	Collisions due to red-light running	Review clearance interval in signal timing.
East Columbus Avenue and Union Street Westbound	Angle Collision due to illegal left turn from through only lane	Advance warning signs about lane designation and way finding signs.
Hall of Fame/West Columbus and Main Street Eastbound	Side swipe collisions	Review lane markings and installation of warning signs for wide turning vehicles.
Mill Street westbound and East Columbus Avenue	Rear-end collisions	Review intersection geometry and signage.
Broad Street Eastbound and East Columbus Avenue	Angle collisions during flashing yellow and red signals	Consider using fulltime signal operation if city is using flashing operation at night.
State Street Westbound and East Columbus Avenue	Angle collisions during flashing yellow and red signals	Consider using fulltime signal operation if city is using flashing operation at night.
Union Street and East Columbus Avenue	Angle collisions due to movement conflicts between lanes	Revisit lane designations and alignment on East Columbus Avenue. Advance warning sign about lane designation.
Boland Way Westbound and East Columbus Avenue	Angle collisions due to movement conflicts between lanes	Advance warning sign about lane designation. Adjust traffic signal timing of phases.
Union Street and Hall of Fame/West Columbus Avenue	Rear-end collisions	Advance warning sign on the highway at Exit 6 about traffic signal at bottom of ramp. Advance warning sign on West Columbus Avenue about preparing to stop and merge with ramp traffic at traffic signal ahead.
Boland Way Eastbound and Hall of Fame/West Columbus Avenue	Rear-end collisions	Advance warning sign on the highway at Exit 7 about traffic signal at bottom of ramp.

Review of intersection geometrical design and lane markings may improve safety at some locations. For example, adding wide lane shoulders to guide vehicles on Mill Street to reduce their speed before reaching the intersection with East Columbus Avenue would help drivers assess the need to use extra caution before turning from the minor road onto the major road. Currently Mill street has one very wide

lane that could accommodate at least two vehicles. The current street layout and slope encourages vehicles to maintain speed even though there is a stop sign.

Vehicles traveling on both Broad Street westbound and State westbound experienced angle collisions at the intersection with East Columbus northbound. Six collisions occurred when the intersection was operating under flashing traffic signal conditions, three collisions at each intersection. These collisions occurred during various times of the day between 10 AM and 6 PM while the intersection was controlled by a flashing red for eastbound and westbound traffic on the minor street and a flashing yellow for northbound traffic on the major street. The timing of these crashes are outside standard night time flashing operation. Therefore one may assume that the traffic signals were being repaired at the time. Consider using fulltime signal operation if the city is using flashing operation at night.

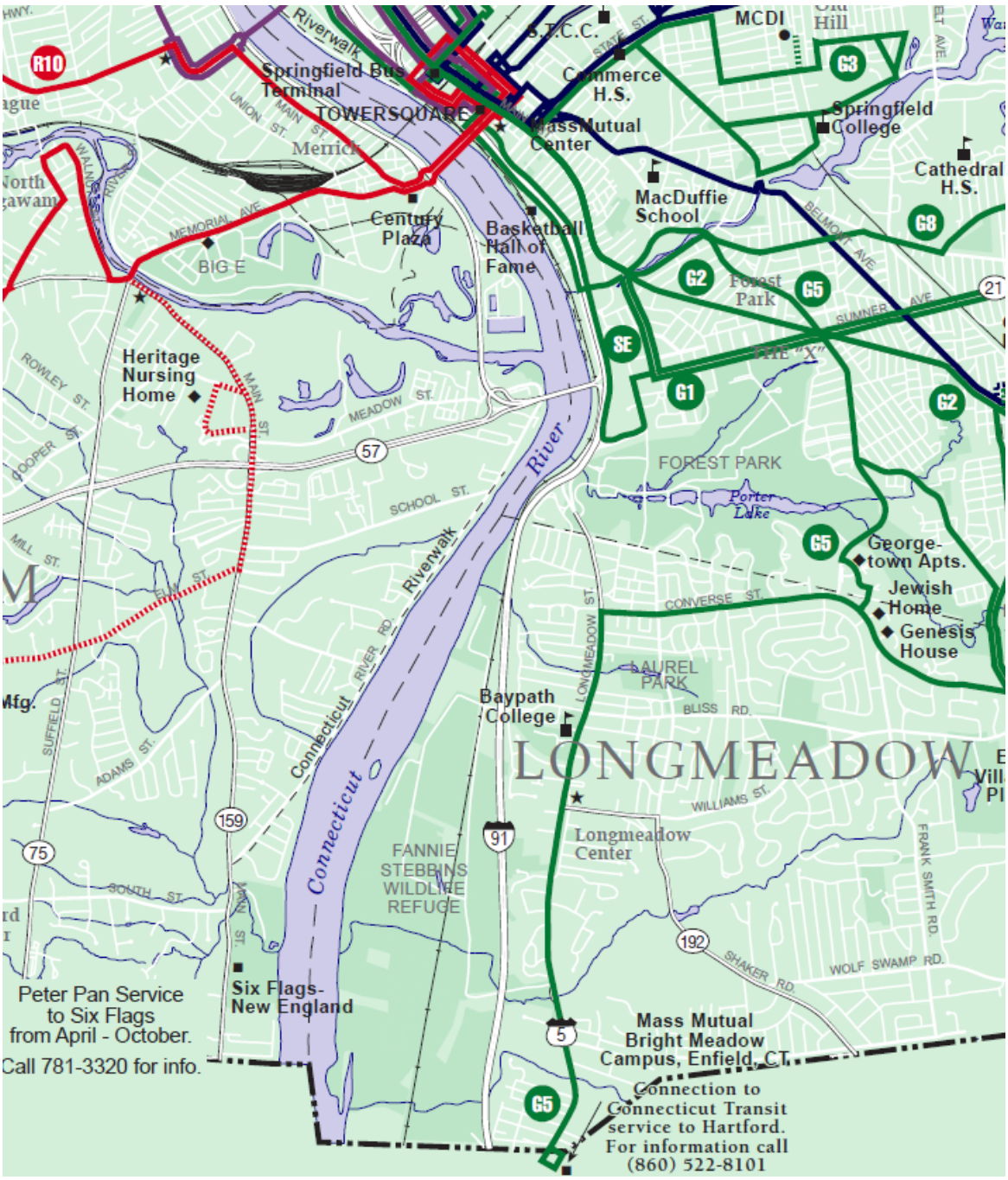
A redesign of lane alignments on East Columbus Avenue at its intersection with Union Street is needed to reduce vehicular conflict. Currently, the three lanes on East Columbus Avenue widen into four lanes just before its intersection with Union Street. The left lane is a shared left and through lane which appears to be a major factor in crashes occurring between vehicles attempting to change lanes illegally from the next lane over when they realize they are in the wrong lane for the desired destination and still attempt a left turn onto Union Street westbound. This creates conflict with through traffic in the left most lane. Advance notice in the form of yellow warning signage along the left side of the roadway to inform drivers about the left lane designation for left turning vehicles would help them plan the required maneuvers before reaching the intersection.

The short distance between the Exit 6 off ramp and the traffic signal at the intersection of Union Street and Hall of Fame/West Columbus southbound could be a factor in crashes at this intersection. Drivers who do not slow down enough before arriving at the traffic signal may contribute to rear-end collisions. The intersection is approximately 300 feet away from the base of the highway off ramp. Therefore, adequate advance warning needs to be given to drivers alerting them to the need to reduce speed and prepare to stop at the at the bottom of the ramp. Likewise, advance warning about the upcoming traffic signal on Hall of Fame/West Columbus Avenue is needed for vehicles traveling straight through the uninterrupted stretch of Hall of Fame/West Columbus Avenue Between Memorial Bridge and Union Street. Restriping of lanes and a review of their designations may also improve safety. A similar pattern of rear-end collisions occurred at the preceding intersection of Hall of Fame/West Columbus Avenue southbound and Boland Way. The distance between the base of the Exit 7 off ramp and this intersection is also approximately 300 feet. In addition, there is a parking garage entrance to the left midway before reaching the traffic signal, creating potential vehicular conflict.

III.3 TRANSIT SERVICE

The regional transit hub is located at the northern edge of the I-91 corridor's study area (Figure 54). The Springfield Bus Terminal is home to local, regional, and interstate bus service. The Pioneer Valley Transit Authority(PVTA) as well as the Peter Pan Bus Company operate their bus routes from this terminal, which is located off of East Columbus Avenue and Liberty Street. The Amtrak station is only one block to the east of the bus terminal on Lyman Street. The East-West railroad tracks cross under I-91, whereas the North-South railroad tracks run along the western edge of I-91. The railroad is used for both passenger and freight services. As a result, any future construction or realignment in the I-91 corridor could impact both existing transit and rail services.

Figure 54 - Local Bus Routes, Rail Tracks, and Bike Routes (from the PVTA System Map).



Potentially impacted routes would include all routes departing from the Springfield bus or train terminals. There are several bus routes that run through the I-91 corridor. The buses traveling these routes use either I-91 itself or its frontage and parallel roads. There are over 20 local bus routes, 8 intra and interstate bus routes, 2 passenger rail routes, and freight rail routes operating in close proximity to the study area. A sampling of this service is shown in Table 21.

Table 22 - Bus and Rail Routes within the I-91 Corridor Study Area.

Company	**Route Name**	**From**	**To**	**Roadway Used** (within study area)
PVTA	G1	Chicopee	Sumner-Allen, Springfield	Main Street
PVTA	G2	East Springfield	Belmont Street, Springfield	Main Street
PVTA	G5	Springfield Bus Terminal	Longmeadow - Enfield	Main Street, Route 5
PVTA	G8	Springfield Bus Terminal	Plumtree Road, Springfield	Main Street
PVTA	SE	Springfield Bus Terminal	Sumner-Allen, Springfield	East Columbus Avenue and Hall of Fame/West Columbus Avenue
PeterPan Bus Co.	PPP	Springfield Bus Terminal	All Points South	I-91, East Columbus Avenue and Hall of Fame/West Columbus Avenue
Greyhound Lines	GLI	Springfield	New York	I-91, East Columbus Avenue and Hall of Fame/West Columbus Avenue
Megabus		Burlington, Vermont -Amherst	Hartford-New York	I-91
Amtrak	Vermonter	Vermont-Springfield	Washington, D.C.	North-South Railroad Tracks
Amtrak	Northeast Regional	Boston-Springfield	Washington, D.C.	North-South Railroad Tracks
Multiple Companies	Connecticut River Line	North	South	North-South Railroad Tracks

III.4 NON-MOTORIZED MODES OF TRANSPORT

Springfield's Connecticut Riverwalk and Bikeway runs between the river and the railroad parallel to I-91. Access to pedestrians and bicycles is provided via at-grade railroad crossing to Riverfront Park at the end of State Street, which extends under the elevated section of I-91. There is also a below-grade pedestrian underpass within close proximity to the at-grade crossing. Direct access to this multiuse path is provided seasonally from the LA Fitness building, at the site of the old Basketball Hall of Fame. An elevator and a handicap accessible pedestrian bridge over the active rail line connect the trail with recreational facilities on the other side of the railroad tracks (Figure 55). The path runs along the river from Riverside Road until just before the South End Bridge. Another multi-use path on the western side of the river is the Agawam Riverwalk and Bikeway. These two paths are part of regional network providing access to non-motorized modes of transport with goal of meeting both recreational as well as travel needs of people of all ages and abilities. No bicycle and pedestrian connection is currently provided between these two facilities.

Figure 55 - Connecticut Riverwalk and Bikeway in Springfield.

III.5 PARKING

The City of Springfield commissioned a Parking Access and Management Plan in the 1990's. This Plan identified parking spaces available in many downtown surface lots and parking garages. Many parking lots are located in close proximity to the I-91 corridor (Table 23 , Figure 56). The I-91 North and South Garages are of critical importance as these structures are located beneath the viaduct section of the highway (Figure 56). The top level of the I-91 South parking garage was recently closed due to problems with loose concrete falling from the ceiling.

Figure 56 - I-91 South Parking Garage, Springfield.

The following table identifies the capacity of the parking lots within close proximity to the I-91 corridor. Map reference numbers in this table relate to parking lot locations in Figure 57.

Table 23 - Parking Capacity within the I-91 Corridor.

Reference Number from Map	Name of Parking Lot/Garage	Capacity
	Possibly Affected by Construction	
2.	Columbus Center Garage	493
4.	I-91 North Garage	1,098
5.	I-91 South Garage	680
9.	10 Centre Lot	490
17.	C&W Realty	65
	Sub-Total of Spaces	**2,826**

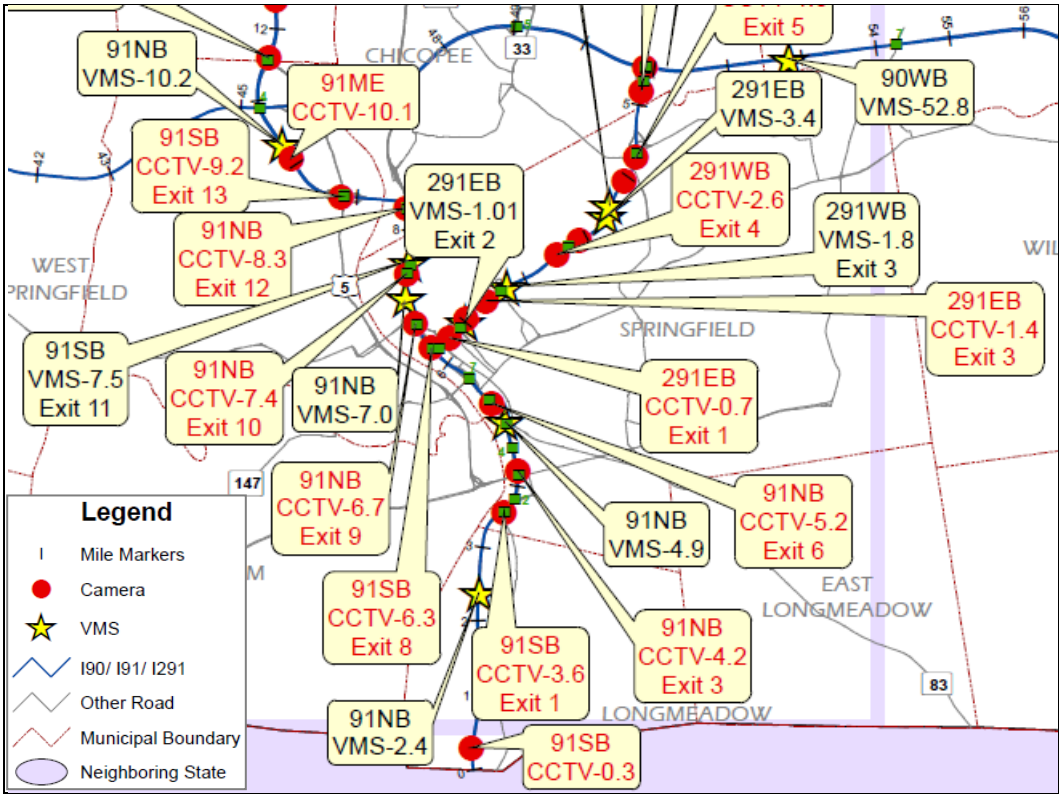
Figure 57 - City of Springfield Parking and Access Map

(Source: City of Springfield Access Management Plan)

III.6 INTELLIGENT TRANSPORTATION SYSTEMS

Within the study area, MassDOT operates Intelligent Transportation System (ITS) devices along the highway (Figure 58). Close Circuit cameras provide a live video feed for incident detection and traffic management. Electronic Variable Message Signs (VMS) provide a communication tool with the public about detours, upstream construction zones, and other important announcements. A total of 4 cameras and 2 message signs are located along the I-91 corridor with the study area. All cameras have pan, tilt, and zoom capability, while message boards can be updated remotely as necessary. The MassDOT District 2 Highway Division monitors the I-91 cameras during the day, while the MassDOT Highway Division Highway Operations Center monitors this equipment during the evening and early morning hours.

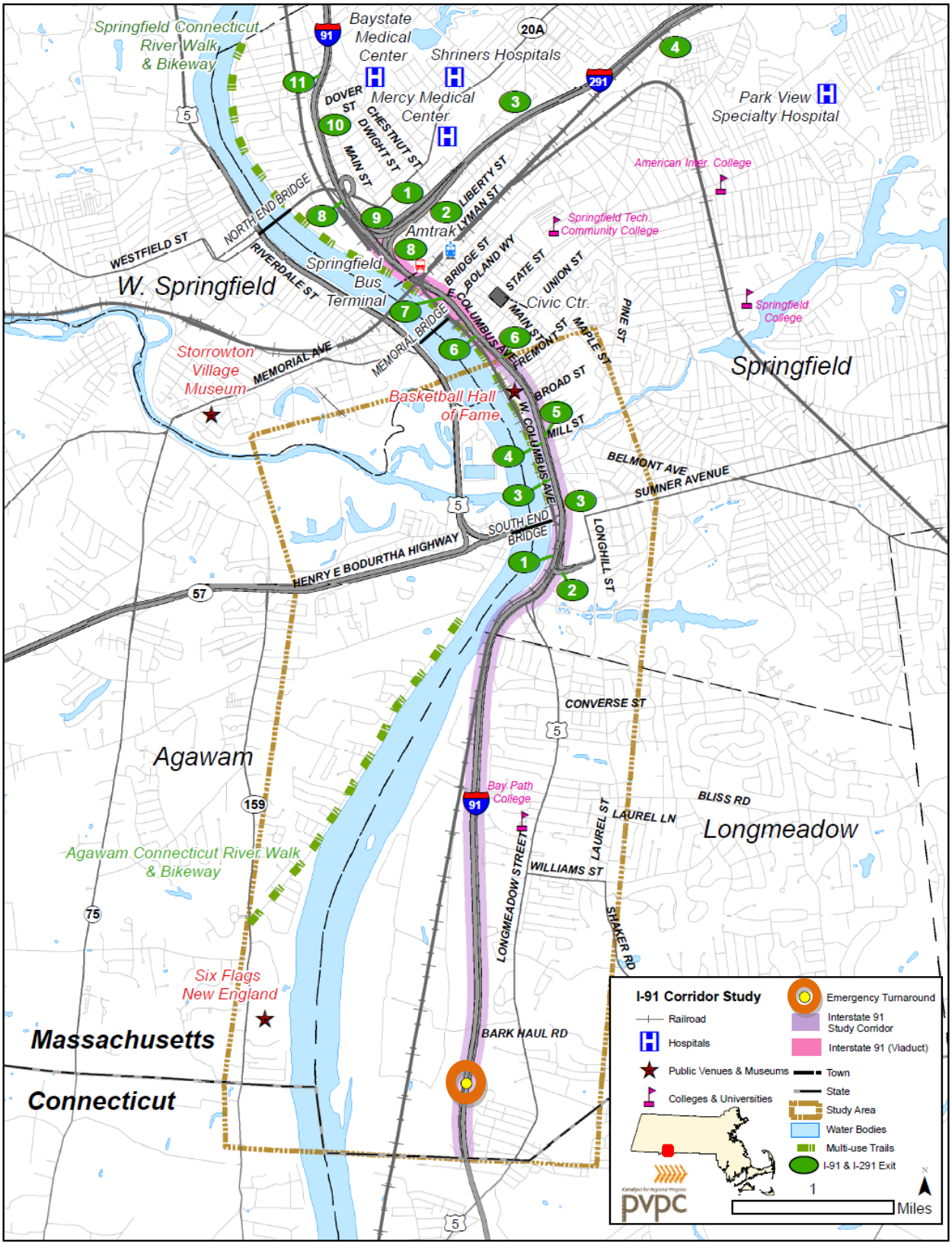
Figure 58 - Intelligent Transportation System (ITS) Devices within the Study Corridor.



III.7 EMERGENCY VEHICLE ACCESS

In the study corridor there is one highway median crossing north of the Connecticut State border just after the 0.6 Mile Marker on I-91 Northbound. The highway crossover is about one mile closer than the next highway interchange at Exit 49 on I-91 in Connecticut. It is located about three miles away from Exit 1 to the north (Figure 59). The emergency median opening is usually reserved for authorized vehicles such as law enforcement officers, emergency response personnel, road crews, and tow trucks.

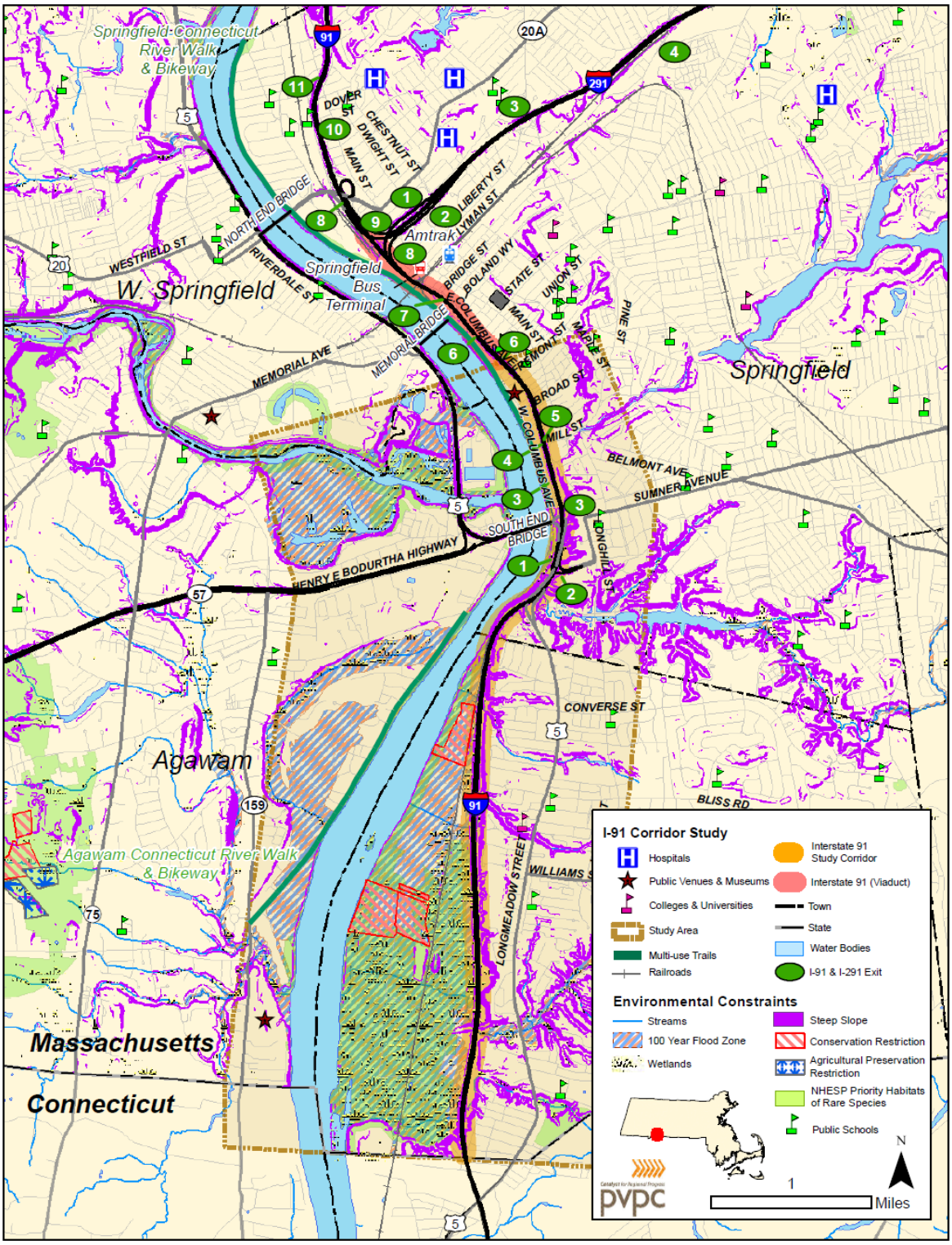
Figure 59 - Emergency Turnaround on I-91.



III.8 ENVIRONMENTRAL CONSTRAINTS

There are several environmental constraints that need to be taken into consideration during any future developed or redesign of the I-91 corridor. These include the 100 year flood zone, wetlands, steep slopes, conservation area, agricultural preservation, priority habitats of rare species (Figure 60).

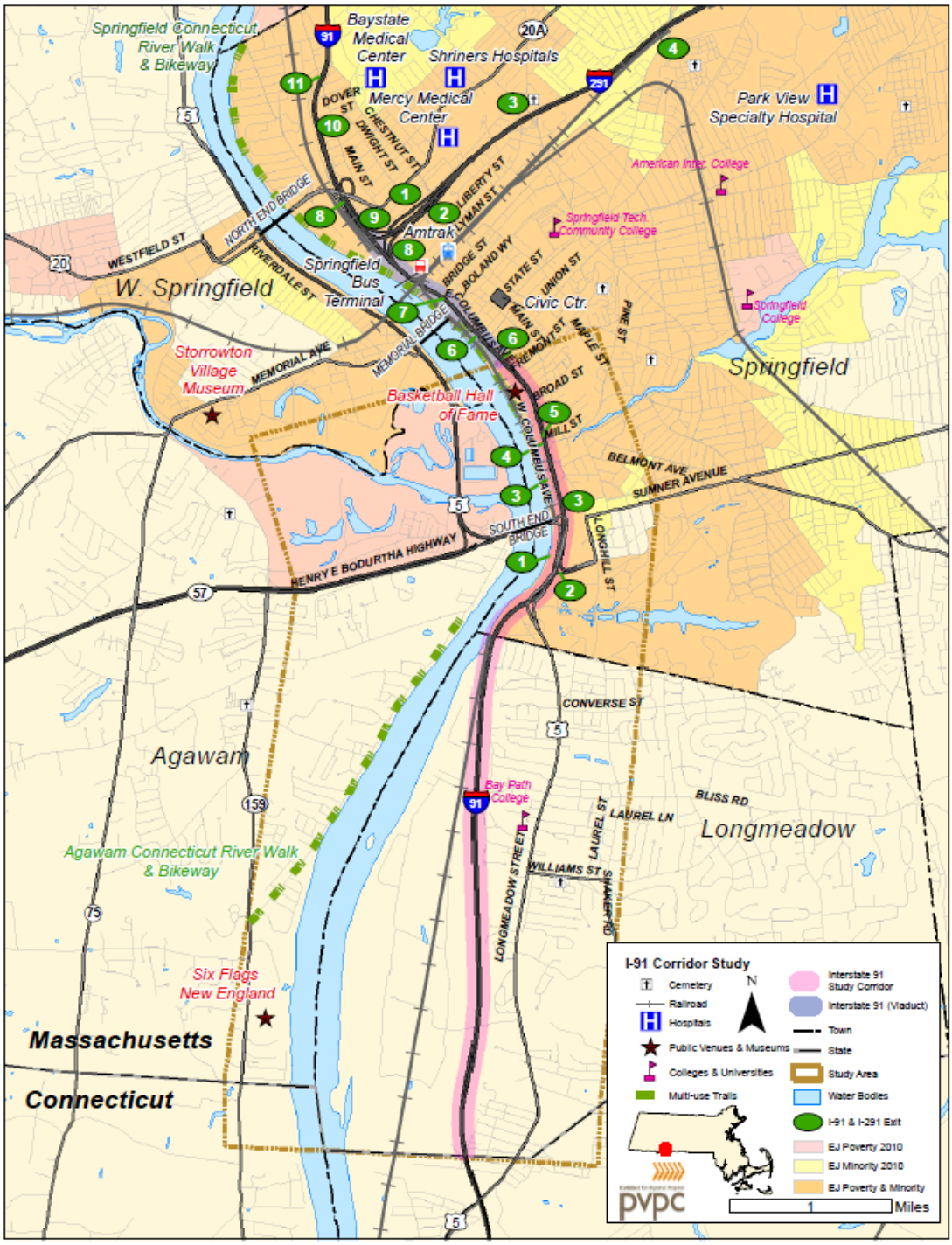
Figure 60 - Environmental Constraints along the I-91 Corridor.



III.8 ENVIRONMENTRAL JUSTICE

There are environmental justice (EJ) zones located within the I-91 corridor. These zones are found within the study area in the City of Springfield and the Town of West Springfield. The northern section of the corridor includes block groups with populations that are higher than the state average in terms of poverty and minority percentages (Figure 61). Using the 2010 census data, the environmental justice poverty zones are highlighted in pink and the minority zones are highlighted in yellow. A combination of both is represented by the orange color. Any future design alternatives would impact these two EJ groups.

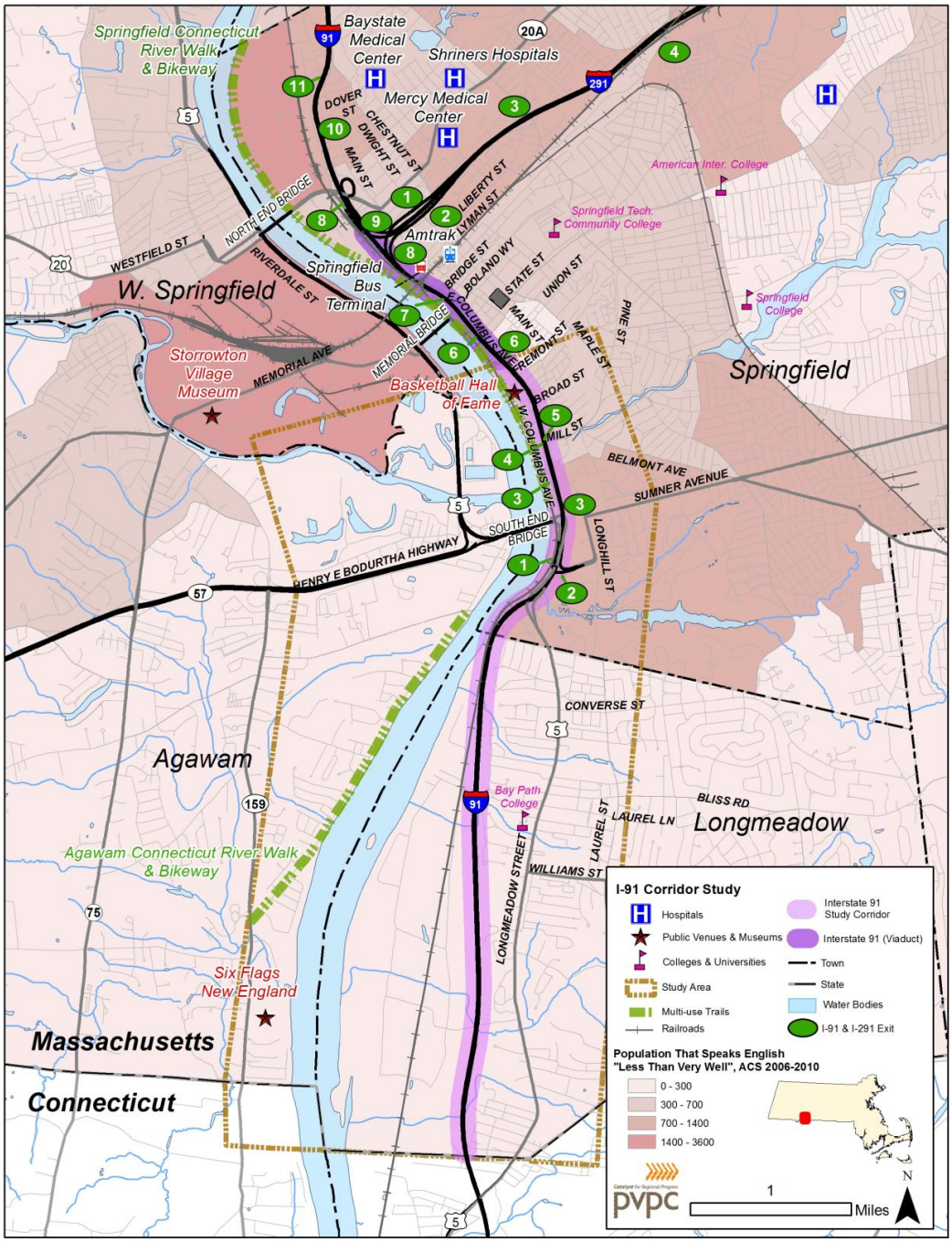
Figure 61 - Environmental Justice Zones within the I-91 Corridor.



III.9 LIMITED ENGLISH PROFICIENCY

There are various concentrations of people with limited English proficiency (LEP) within the I-91 corridor represented by color gradation on the study map (Figure 62). According to the census ACS 2006-2010 data, the highest concentration of people who spoke English "less than very well" are located north of the study area, in the North End neighborhood in Springfield and the Merrick Neighborhood in West Springfield. Zones within the study area show LEP densities between 300 and 1400 individuals. Most LEP residents in these zones spoke Spanish, followed by Vietnamese, and some Russian. Future public presentations of design alternatives may require translation services in these three languages.

Figure 62 - Limited English Proficiency Zones within the I-91 Corridor.



III.10 HIGHWAY VISUAL SURVEY OF SIGNS AND LANE MARKINGS

A visual field survey was conducted for the I-91 highway corridor by PVPC staff during the month of November 2013. The study corridor was driven several times between Exit 8 in Springfield and Exit 49 just over the Connecticut/Massachusetts state line. Observations of roadway conditions were recorded verbally as well as visually to aid in the development of a set of short-term recommendations for improving travel conditions along the I-91 corridor. The following is a list of observations made during the field survey regarding roadway signs and lane markings conditions.

I-91 Southbound From Exit 7 to the Massachusetts State Line:

1. The "no passing zone" which separates the left lane that connects I-291 to I-91 southbound is beginning to deteriorate (Figure 63).
2. There is a very short taper from three to two highway lanes just past Exit 3. I-91 is reduced to two lanes between Exits 3 and 2 (Figure 64).
3. There is no apparent advance warning signage for speed limit reduction from 55 to 45 miles an hour past exit 3 in the southbound direction (Figure 65).
4. The "Exit 1" sign was observed to be down at the Exit 1 off-ramp. It was set on the ground leaning up against the sign post (Figure 66).
5. There is strong sun glare during the late afternoon around Exit 1 on I-91 Southbound at 2:30 PM in November (Figure 67).
6. There is a very short entrance merge ramp from the interchange 2 on-ramp.
7. The speed limit returns to 65 miles an hour after the interchange 2 on-ramp, just before mile marker 3.2 (Figure 68).
8. The blue informational sign, just before mile marker 1.2, had a waviness to the edge closest to the roadway. It is possible that the damage sustained by the sign was caused by a passing truck similar or larger than the one shown in the picture, which could have been carrying a wide load extending over the barrier (Figure 69).
9. The 13'9" clearance warning sign, just before the state line, was obscured by vegetation (Figure 70).

Figure 63 - No Passing Zone in the Left Lane from I-291 to I-91 Southbound Near Exit 7.

Figure 64 - Lane Drop on I-91 Southbound past Exit 3.

Figure 65 - Speed Limit Reduction to 45 Miles Per Hour Past Exit 3 on I-91 Southbound.

Figure 66 - Exit 1 Sign Fallen on the Ground.

Figure 67 - Late Afternoon Sun Glare at Exit 1 on I-91 Southbound.

Figure 68 - Speed Limit Returns to 65 Past Exit 1 on I-91 Southbound.

Figure 69 - Exit 49 Blue Sign Bent at Lower Left Edge.

Figure 70 - Bridge Height Warning Sign Before State Line Obscured by Vegetation.

I-91 Northbound From Exit 49 in Connecticut to Exit 6 in Springfield:

1. The 'Entering Longmeadow Hampden County" Sign at mile marker 0, just before the "Massachusetts Welcomes You" sign, is obscured by vegetation (Figure 71). Many signs in this area could use vegetation clearing to promote visibility.
2. The median seems overgrown with vegetation and some of the speed limit signs on the median are set a little low. Sign height could be an issue in some areas, but mostly the issue is lack of maintenance and the fact that the location of some of the signs makes them difficult to see (Figure 72).
3. The advance Exit 2 sign for colleges just before mile marker 1.6 is partially obscured (Figure 73).
4. At mile marker 2, there is an overhead sign that shows that the right lane ends in one mile. This sign is quite prominent and very visible (Figure 74).This is followed by a clear lane merge sign (Figure 75). However, just after mile marker 2.4, the "Merge Left" signs are not clearly visible. One was obscured by the column support for the overhead message-board sign, the other was obscured by vegetation (Figures 76 and 77). Several subsequent warning signs announce that the lane is ending (Figures 78 and 79).
5. At mile marker 3, there is a "45 Mile an Hour Speed Limit Ahead" sign located at the lane drop. This sign is difficult to see unless you were searching for it because of surrounding vegetation (Figure 80). Shortly after the new reduced speed limit is posted (Figure 81)
6. In general, the lane drop has a very wide shoulder. This shoulder could be tapered to guide travelers into the lane drop more gradually than the existing roadway line markings (Figures 82 and 83).
7. There is no advance notice of the traffic weave movements between the on-ramp and off-ramp at Exit 2. There are no advance signs or pavement markings to warn travelers of upcoming vehicular movement challenges (Figure 84). Shortly after the Exit 2 off-ramp the right lane is dedicated to vehicles leaving the highway via Exit 3 (Figure 85). A regulatory sign, "This Lane Exit Only", is posted along the right shoulder of the highway after the dedicated lane marking had already begun. A third lane is introduced between the Interchange 2 on-ramp and Exit 3 off-ramp.
8. Some vehicular queuing occurred at the Exit 3 off-ramp. At the time of the survey, the Exit 3 off-ramp was reduced to one lane from its two lane original layout due to ongoing construction. This caused the vehicular queue to backup onto the Interstate at certain times (Figure 87). The highway is back to two lanes after Interchange 3 (Figure 88).
9. Posted speed limit is back to 55 miles an hour between the Interchange 3 off and on-ramps. The "55 mile an hour speed limit" sign northbound on the median near Exit 5 was falling off its pole (Figure 89).

10. The skyline along the stretch of the I-91 corridor between Interchanges 3 and 6 is cluttered with signage, which can be confusing for drivers (Figure 90). A driver would have to search hard for the sign he or she is looking for to notice it (Figure 91). Necessary directional information combined with the closely spaced highway interchanges increase the visual clutter and at times creates confusion.
11. The skyline along I-91 northbound between Exits 3 and 5 experience visual pollution from billboards rising above East Columbus Avenue to advertize various businesses and products (Figure 92). The oversized billboard signs compete with highway signage for drivers' attention and add to their distraction, which makes way finding more challenging and can increase safety problems (Figures 93, 94, and 95).

Figure 71 - Sign Obscured by Vegetation "Entering Longmeadow".

Figure 72 - Speed Limit Sign Set at Low Height and Obscured by Vegetation.

Figure 73 - Colleges' Exit Sign Set at Low Height and Obscured by Vegetation.

Figure 74 - "Right Lane Ends 1 Mile" Sign Visibly Posted Over I-91 Northbound.

Figure 75 - "Right Lane Ends 3/4 Mile" Sign Posted on the Right Side on I-91 Northbound.

Figure 76 - Warning Sign in Median is Obscured by Pole and Informational Sign to the Right Is Obscured by the Mile Marker Sign on I-91 Northbound.

Figure 77 - "Lane Ends Merge Left" Warning Sign Hidden by Signage Structure Over I-91 Northbound.

Figure 78 - "Right Lane Ends 1/4 Mile" Warning Sign Over I-91 Northbound.

Figure 79 - Lane Drop Taper on I-91 Northbound Before Exit 2.

Figure 80 - Advance Warning of Speed Limit Drop on I-91 Northbound.

Figure 81 - Speed Limit Drops from 55 to 45 Before Exit 2 on I-91 Northbound.

Figure 82 - Wide Roadway Shoulder After Lane Drop on I-91 Northbound Before Exit 2.

Figure 83 - Route 5 Bridge Over I-91 Northbound Before Exit 2.

Figure 84 - Lane Change from Two to Three Before Exit 2 on I-91 Northbound.

Figure 85 - Right Lane Is Dedicated to Exit 3 Vehicles After Exit 2 on I-91 Northbound.

Figure 86 - "This Lane Exit Only" Sign for Exit 3 on I-91 Northbound (© 2014 Google Earth Image).

Figure 87 - Traffic Congestion during Maintenance Work at Exit 3 on I-91 Northbound.

Figure 88 - Interchange between I-91 Northbound and Route 5.

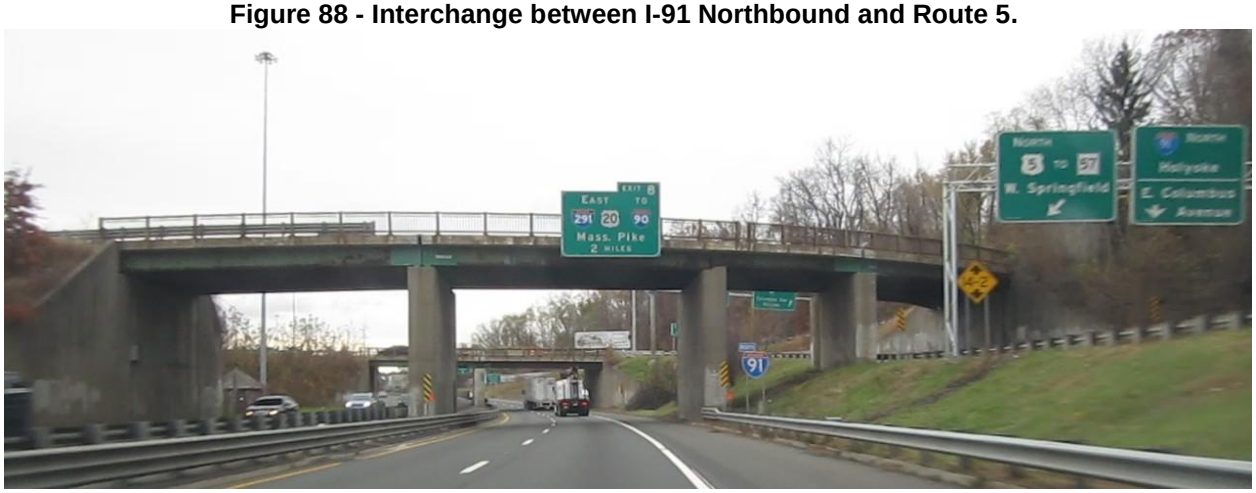


Figure 89 - Speed Limit Sign Falling Off Post past Exit 5 on I-91 Northbound.

Figure 90 - Competing Signage for Driver's Attention After Exit 3 on I-91 Northbound.

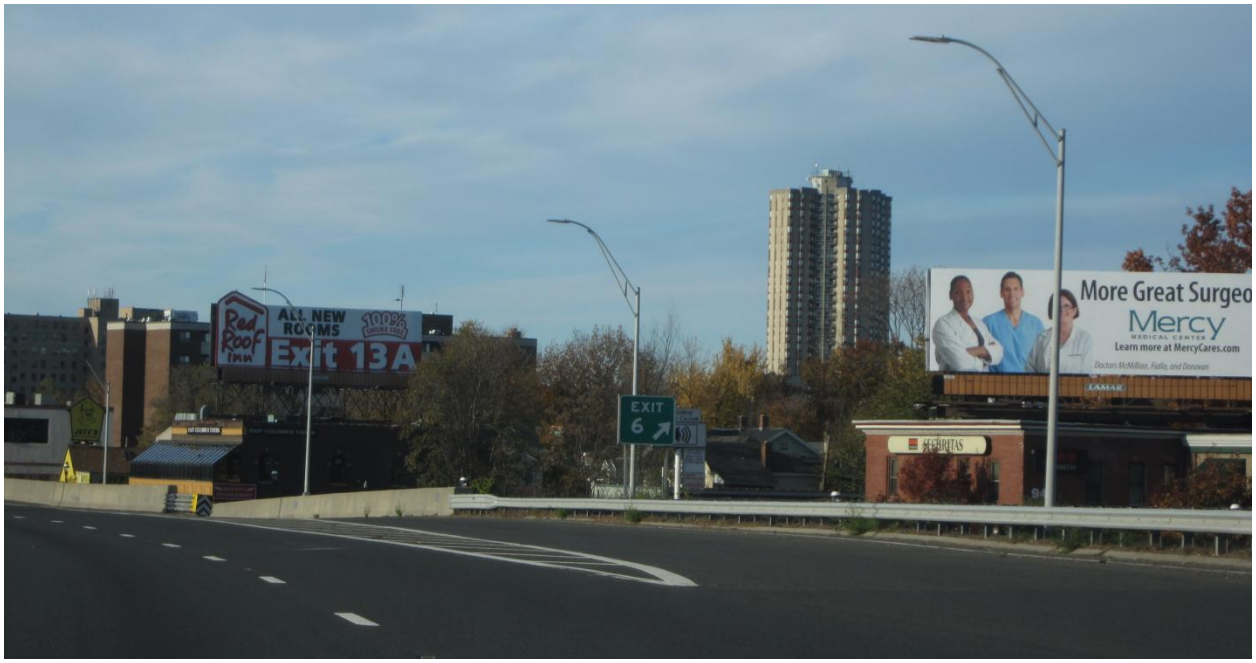
Figure 91 - Heavy Advertisements Begin at Interchange 3 On-Ramp on I-91 Northbound.

Figure 92 - Visual Clutter Detracts from Way Finding on I-91 Northbound Before Exit 5.

Figure 93 - Visual Pollution from Signage on I-91 Northbound and Frontage Road at Exit 5.

Figure 94 - Billboards Competing with Highway Signage on I-91 Northbound Before Exit 6.

Figure 95 - Billboards at the I-91 Northbound Exit 6.



IV. TRANSPORTATION RECOMMENDATIONS

This study by PVPC included an analysis of existing conditions for the I-91 corridor. A forthcoming study by consultants retained by MassDOT is planned to include long-term recommendations for the viaduct portion of the corridor and analysis of design alternatives to address current problems. In this final section of the existing conditions study a list of recommendations for short-term improvement is presented as a first step in addressing safety and congestion issues encountered along the corridor. Locations of these recommendations are pointed on the study area map in Figure 96.

IV.1 Short-Term Recommendations

1. Improve highway signage visibility with regular vegetation maintenance along the median and shoulders of the I-91 highway to reduce plant overgrowth which obscures signage.
2. Restripe the drop-down lane before Exit 3 on I-91 southbound to allow for a longer taper down of traffic using current MUTCD manual standards. Adjust lane marking to allow for slower progression from 3 to 2 lanes before exit 3 southbound, add "Exit Only Lane" markings warning signs (Figure 97 and 98).
3. Post additional signage to give advance warning of the upcoming merge and weave prior to the Interchange 2 on-ramp at an adequate distance in conformity with the Manual on Traffic Control Devices (MUTCD).
4. Add "Exit Only Lane" markings in the right lane of I-91 northbound to provide additional information to drivers (Figure 99).
5. Post an advance warning sign in the vicinity of Exit 4 southbound to warn drivers of the upcoming reduction in speed limit.
6. Raise the height of the posted speed limit signs located in the median and along the highway shoulder between the Springfield City Line and Interchange 3 along I-91 in the northbound direction (Figure 100).
7. Relocate the speed limit sign currently positioned in the right hand shoulder of the I-91 highway in the northbound direction, just after mile marker 2.4 away from the overhang signage post to increase visibility.
8. Review the signage plan along the I-91 corridor to reduce visual clutter and simplify the messaging scheme between Interchanges 2 and 6 in the northbound direction. Signage clutter could add to distracted driving and impact way finding, thus increasing safety problems.
9. Restripe lane markings before Exit 2 on I-91 northbound to help transition vehicles into the exit lane (Figure 101).
10. Consider warning signs to alert drivers of the potential for seasonal sun glare, particularly in the vicinity of Exit 1 in the southbound direction. An existing curve to the west is prone to afternoon sun glare which could impair driver vision.
11. Move the blue sign just before mile marker 1.2 on I-91 southbound further away from the edge of the highway to address potential off-road vehicle collisions.
12. The City of Springfield may want to further analyze local intersections identified in section III.2.2 regarding local intersection crashes to facilitate improvements. Examples of potential improvements could include: adjust lane markings and designations, modify signal timings and add warning signage at problem intersections that experienced clear collision patterns around the highway frontage roads of East Columbus Avenue and Hall of Fame/West Columbus Avenue.

Figure 96 - Short-Term Recommendation Locations.

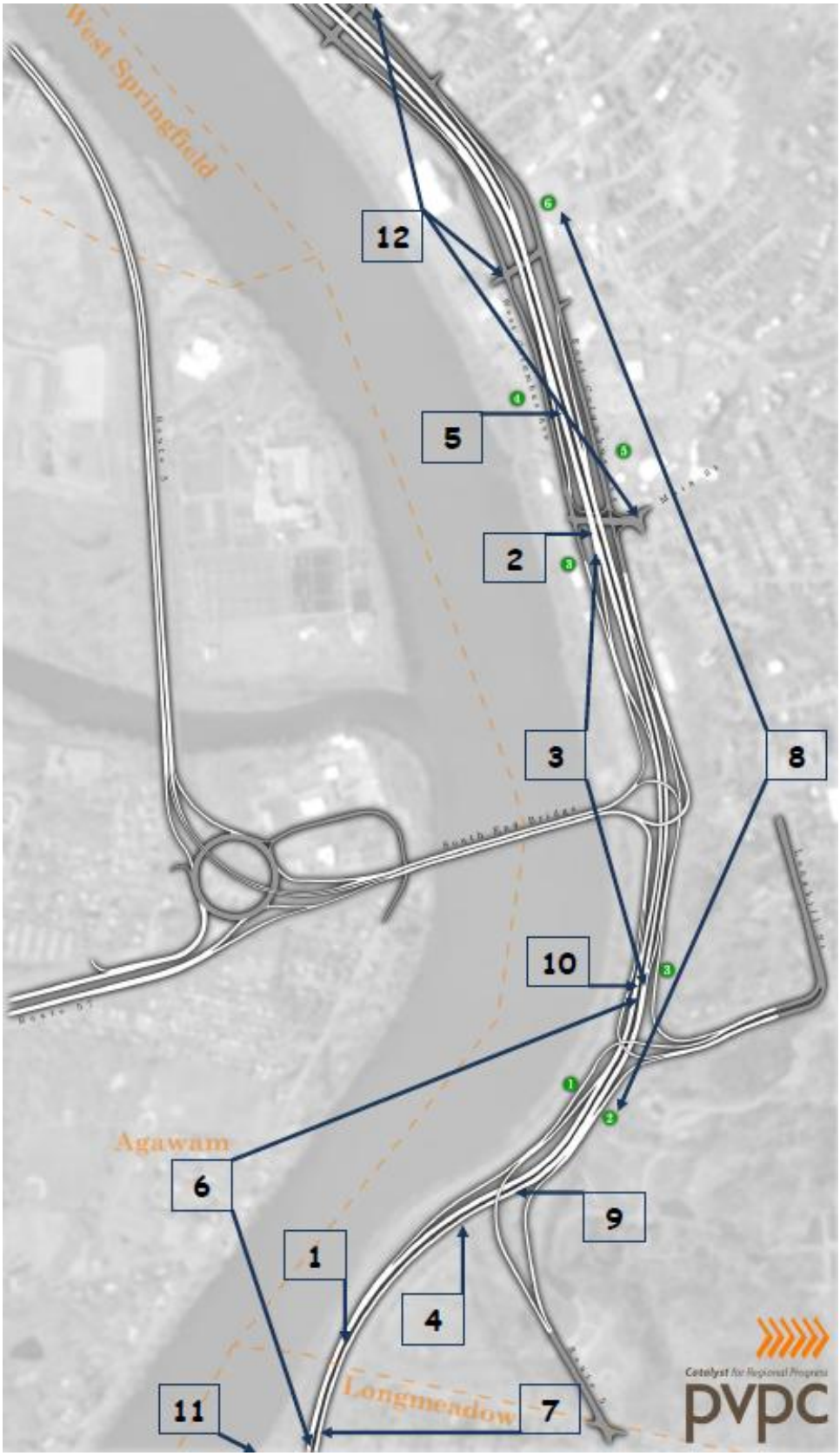


Figure 97 - Suggested Location of Signage and Markings along I-91 Southbound Before Exit 3 (USGS Ortho Imagery 2009).

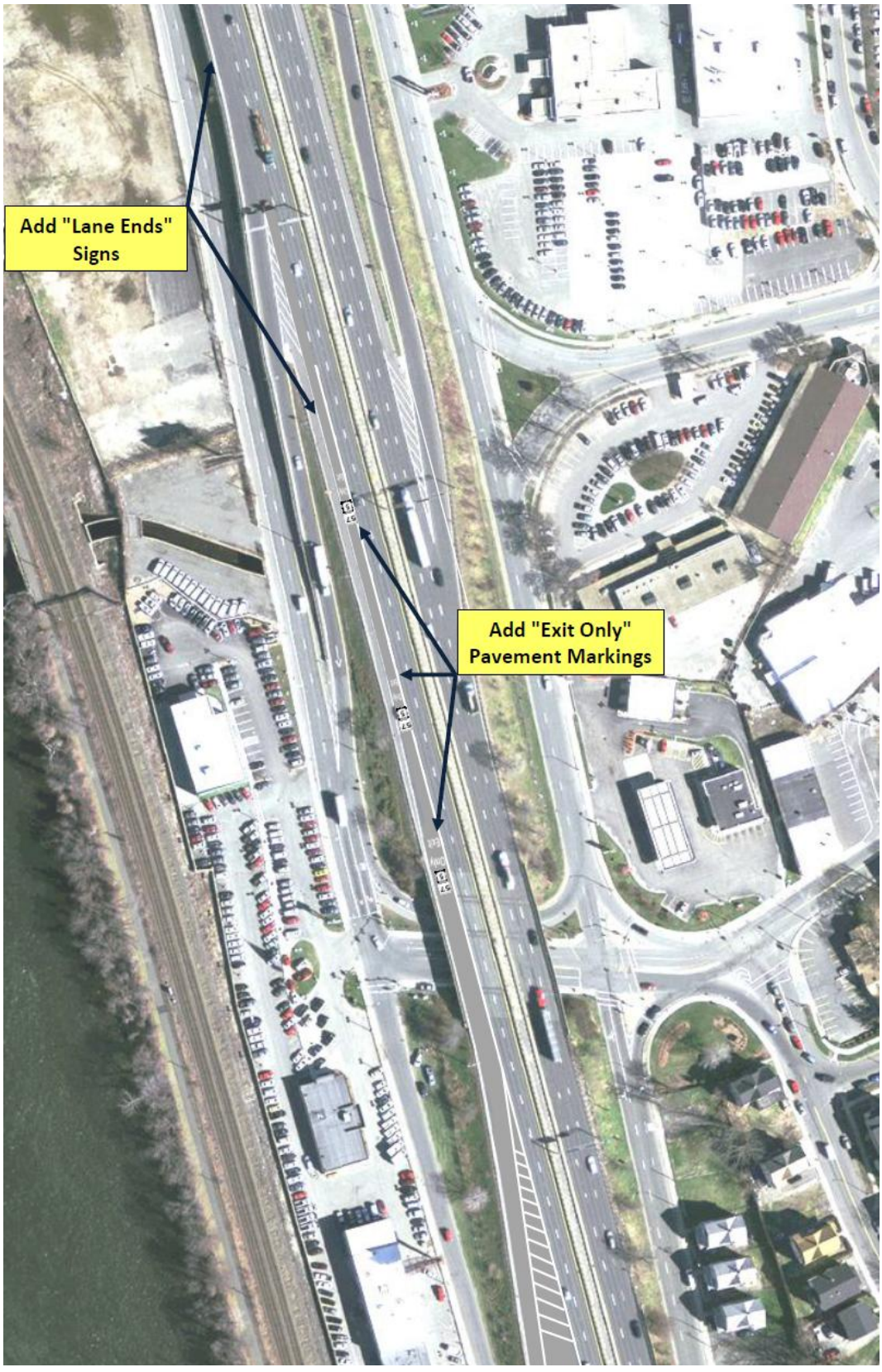


Figure 98 - Suggested "Exit Only" Markings on I-91 Southbound Before Exit 3 (© 2014 Google Earth Image).

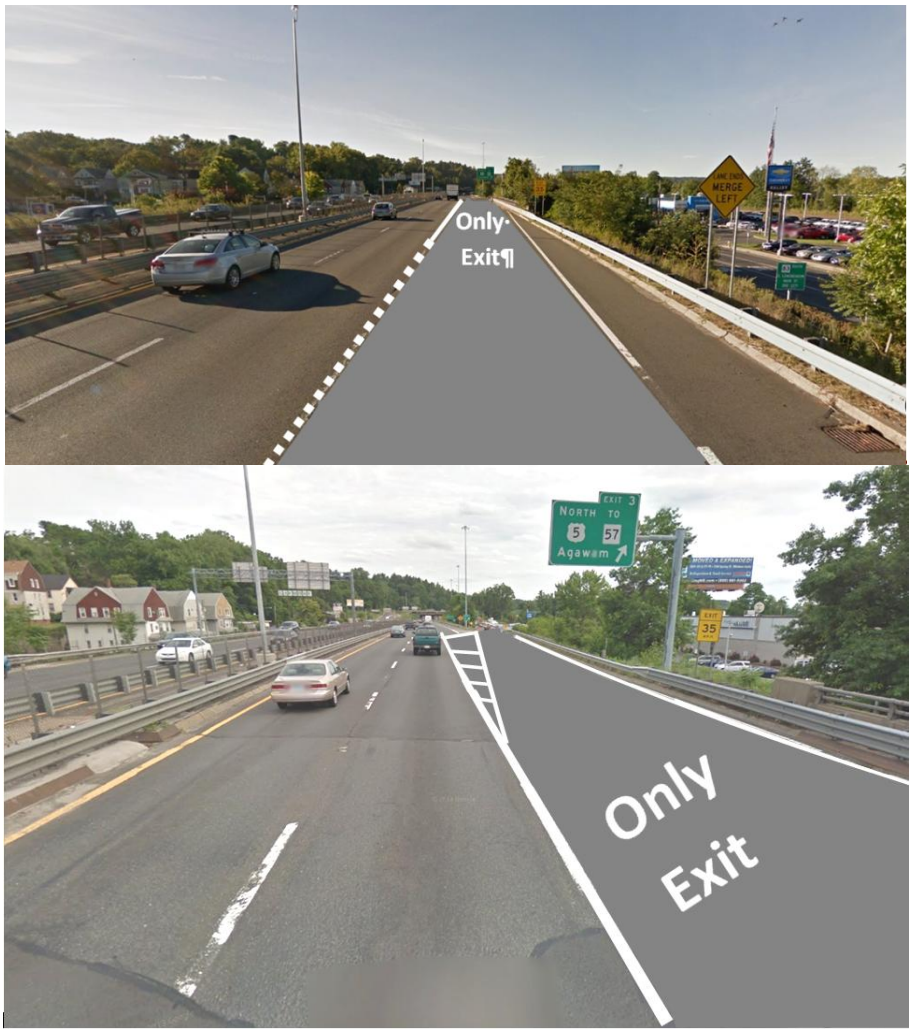


Figure 99 - Example of Pavement Marking to Designate Lane As "EXIT ONLY" Before Exit 3 on I-91 Northbound (Imagery ©2014 Terra Metrics, Map data © 2014 Google).

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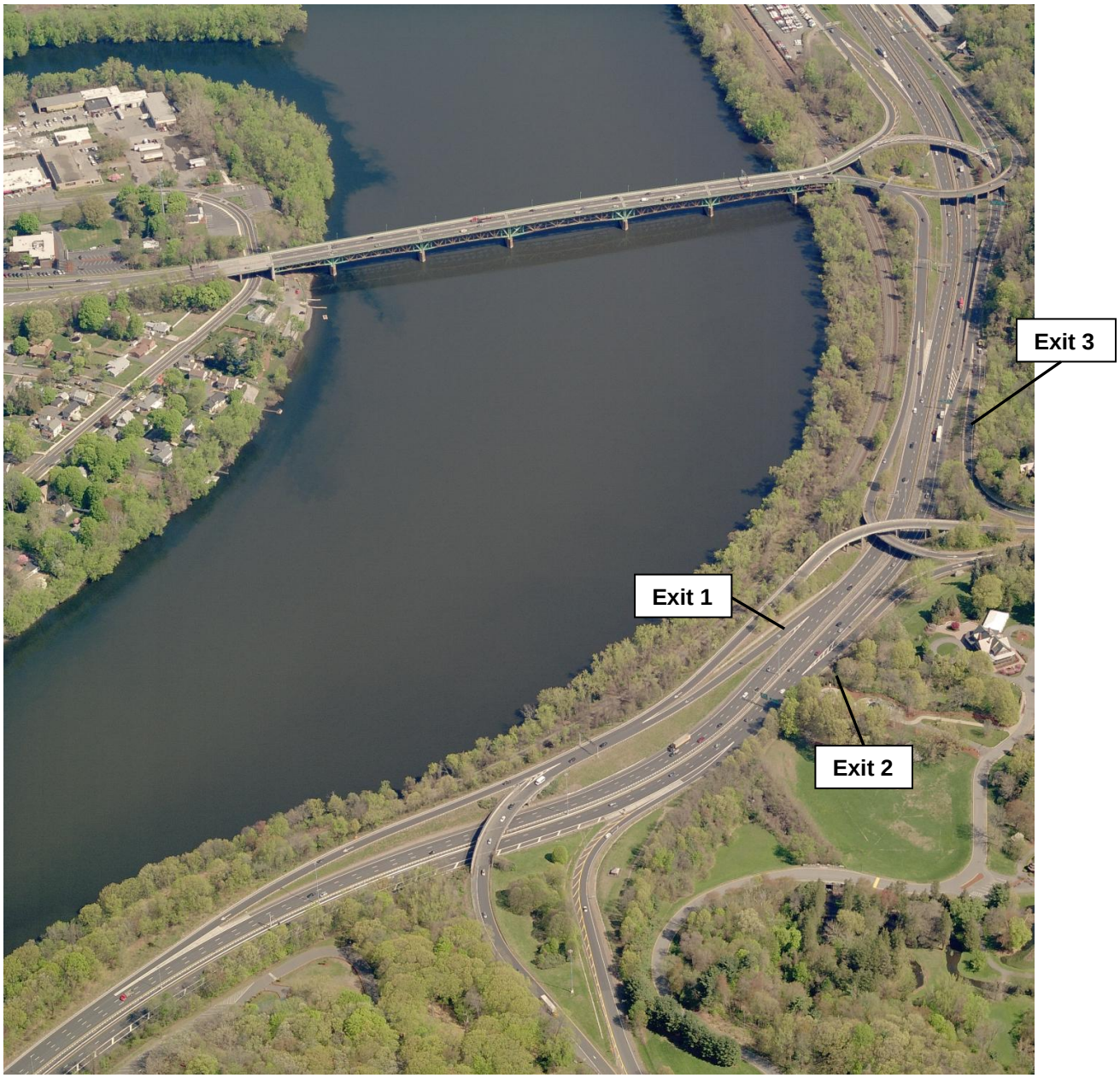
Figure 100 - Need for Speed Limit Sign Height Increase and Vegetation Maintenance on I-91 Northbound Before Exit 2.

Figure 101 - Restripe Lane Markings to Transition Vehicles into Exit Lanes on I-91 Northbound.



IV.2 Recommendations Informed by Crash Cluster Analysis

Major safety issues at each crash cluster location along the I-91 corridor were identified based on information from the cluster analysis and the corridor's visual survey. The following recommendations attempt to address the unique issues present at each of the five crash cluster locations within the study area. A brief summary of recommendations is presented in Table 24 followed by a detailed discussion of the recommendations.

Table 24 - Recommendations Addressing Crash Cluster Issues along the I-91 Corridor.

Cluster	Location	Safety Issue	Recommendation
1	I-91 Northbound	Weaving traffic	• Designate right lane "Exit Only lane". • Install a "Weave Ahead" sign before Exit 2
2	I-91 Southbound	Glare at certain times of day and year	• Give advance warning.
3	I-91 Northbound	Merging traffic	• Encourage driver to get into Exit 3 lane sooner. • Supplement exit lane designation with "Exit Lane Only" markings. • Maintain solid line. • Place prominent sign on overpass to warn drivers about merging traffic.
3	I-91 Southbound	Merging traffic and lane reduction	• Place prominent sign on overpass to warn drivers about incoming merging traffic.
4	I-91 Southbound	Merging traffic	• Give advance warning.
5	I-91 Northbound	Merging traffic	• Organize signage and reduce visual clutter.

The lack of roadside maintenance is a critical in the vicinity of cluster 1. It would be extremely beneficial to have more vegetation maintenance. Conditions observed during the fall season, in the month of November, showed that although vegetation had thinned out it was still obstructing signs of low height. Sign height being too low makes it easy to miss by drivers, especially of larger vehicles such as trucks. Signs announcing speed reduction to 55 miles per hour, lane reduction and merge could be an issue if a driver is unable to notice all of them due to their proximity. An ITS message board in that location is a potential resource for warning drivers about the upcoming changes (Figure 102). A flashing beacon could alert drivers to an important message regarding the right lane ending. The sign labeled (W4-2) in the Manual on Uniform Traffic Control Devices is located half a mile before the lane merge but is currently lost behind the message board structure. Going from dark to light causes drivers to miss signs. The sign could be placed up on the overpass to give advance warning about the upcoming merge from the on-ramp. Installing a "HEAVY MERGE" sign before Exit 2 would alert drivers about the upcoming high volume traffic weaving.

Figure 102 - Variable Message Board Over I-91 Northbound Near Exit 3.

Cluster 2 in the vicinity of Exit 2 experienced glare and vision transition issues between shade and light when passing under the elevated roadways. Transition lights for the overpasses could be studied to provide a smoother visual transition for drivers to allow the detection of highway signs that are currently difficult to read due to afternoon glare preceded by shaded areas of the highway, which makes it difficult for the human eye to readjust quickly.

The "45 MPH Ahead" speed limit sign is difficult to notice on I-91 northbound. The lane drop before Exit 2 helps vehicles get out of the way of merging and weaving vehicles ahead and serves to provide a breakdown lane in the section of the highway that does not have space for a wide shoulder. An improvement could be made by delineating the exit only lane with a wider solid white edge line through the weave section and until exit 2. The section of the I-91 highway just south of Interchange 2 and right after it passes under Route 5, widens with an additional lane but the exit lane is unmarked. Therefore, marking the right lane for Exit 3 only at that location north of Exit 2 could improve safety by reducing the potential for vehicular conflict. There is a small white sign bearing the message that this lane is an exit only lane, but it is placed in a poor location that does not give it prominence and would be difficult to notice at highway speeds. It can also be enhanced with lane markings.

Cluster 3's main issues revolve around the need to warn ramp traffic about upcoming merging traffic in the vicinity of Exit 3 northbound. Currently, there are no warning signs about the potential vehicular movement conflict on the Exit ramp (Figure 102). There is also height and shadow contrast issues along the Exit lane. Grass could be cut back in lieu of making the roadway shoulder wider when space does not permit widening. This solution may help reduce issues that may arise for drivers who do not have enough time to make a safe maneuvering decision when faced with merging traffic. The W4-1 sign indicating upcoming merging traffic from the right should be posted earlier in a more prominent location on the overpass of Route 5 East coming from the South End Bridge (Figure 103). Just past the South End Bridge, a green sign announcing the "South End Business District Exit 5" precedes a lane merge warning sign and competes with it for drivers attention due to difference in size and prominence. Switching the order of these two signs would allow the warning sign to take precedence over the informational sign.

Figure 102 - I-91 Northbound Exit 3 Ramp is Narrow and Lacks Warning Sign for Upcoming Weave.

© 2014 Google Earth Image.

Cluster 4 is located in the vicinity of Exit 5. There is currently a green sign indicating that Broad Street is in 3/4 of a mile. However, this sign is surrounded by many other signs that complete for the driver's attention which makes it difficult to notice and therefore anticipate the upcoming Exit to begin moving over to the right in preparation for exiting. There is no highway shoulder before Exit 5. Using a wider white line and pavement markings such as "STAY IN LANE" could improve safety in this area.

Figure 103 - Example of Merging Right Traffic Warning Sign to Use After Exit 3 on I-91 Northbound (Adapted from Figure 2C-8: W4-1 page 125 of the MUTCD 2009 Edition).

W4-1

In cluster 5 the "LANE ENDS MERGE LEFT" sign could be posted starting at Exit 4 to warn drivers of the upcoming change and reduce conflict between merging traffic from the highway on-ramp past Exit 4 on I-91 southbound. There are three highway lanes two of which could be designated for southbound traffic leaving the right lane for Exit 4 and 3 only. There is a very short distance between these two interchanges and the right lane seems to end abruptly after Exit 3. Designating the right lane with a solid white edge line prior to Exit 4 would provide a safer transition for exiting traffic. In addition, the transition/taper pavement markings before the Interchange 3 on-ramp should be studied to determine if this can begin sooner (Figure 98).