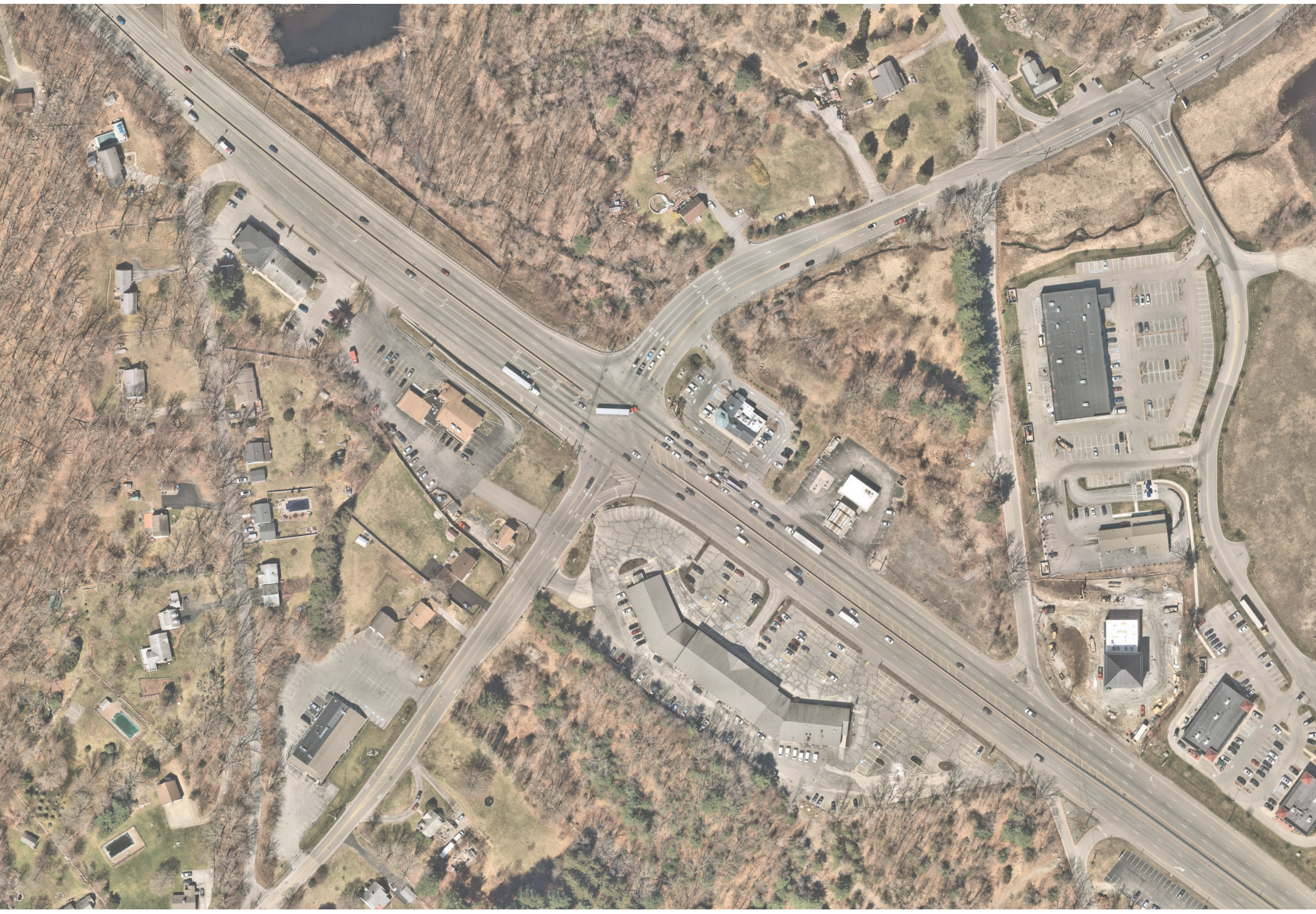

Route 146 Corridor Vision Study

Prepared for:

massDOT Office of Transportation Planning

Prepared by:

Bowman

September 2025

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Acknowledgments

The preparation of this report has been funded in part through grant[s] from the Federal Highway Administration, U.S. Department of Transportation, under the State Planning and Research Program, Section 505 [or Metropolitan Planning Program, Section 104(b)] of Title 23, U.S. Code. The contents of this report do not necessarily reflect the official view or policies of the Massachusetts Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Chapter 1: Existing Conditions

1.1 Introduction

1.1.1 Background

The Route 146 Corridor Vision Study is a conceptual planning study to evaluate the existing and future traffic volumes on the Worcester-Providence Turnpike (Route 146), develop long-term capital improvement measures, and assess when projected growth volumes would trigger different capital improvements. Along Route 146 from State Route 122A in Millbury to the Rhode Island State Line in Millville and Uxbridge, there have been several recent developments that impact the volumes on Route 146 as well as several planned future developments. Beyond specific planned development growth, additional regional growth is expected to occur. With recent development, there have been increases to truck volumes which have strained the Route 146 and Boston Road intersection, along with other points in the corridor. Previous plans and improvements have occurred in the corridor, specifically the Route 146 Transportation Study (2005) and the 2013 Route 146 at Boston Road Intersection Reconstruction and Widening Project, which are used to inform this study.

1.1.2 Study Purpose

At the completion of this study, suggestions on improvements will be made based on different growth scenarios that can form the basis for a master plan of corridor improvements. A main purpose of this study is to understand at what point it is necessary and/or critical that Route 146 becomes a grade-separated intersection with frontage roads at Boston Road. The configuration of potential grade separation will be defined through this study. Considerations for improving pedestrian and bicycle access will be assessed with suggested improvements.

1.2 Study Area

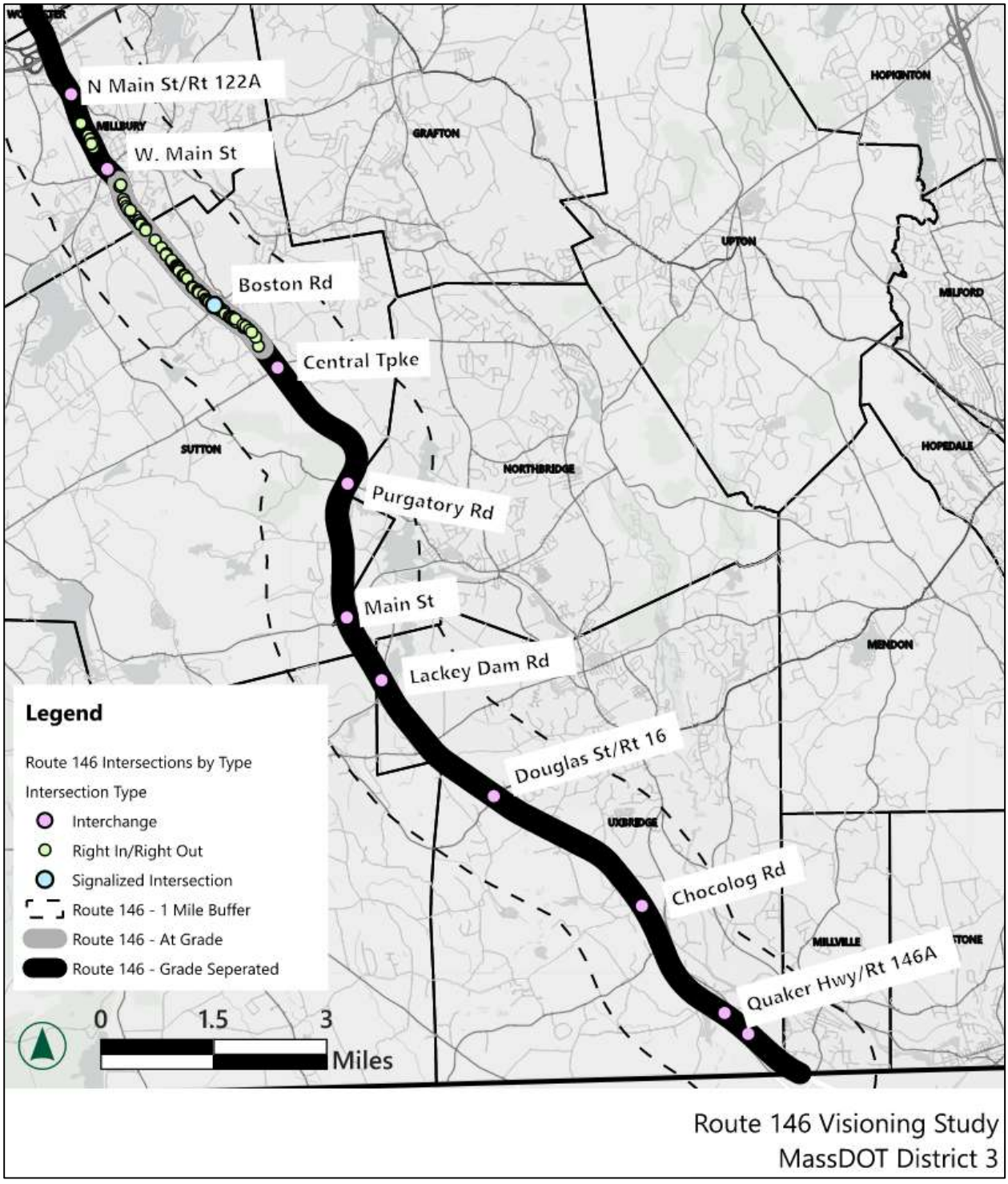
1.2.1 Corridor

Route 146 runs north-south from the City of Worcester to the Massachusetts/Rhode Island State Line. It is classified as an urban principal arterial and is under MassDOT jurisdiction. The study corridor runs along Route 146 from the Massachusetts/ Rhode Island State Line in Millville and Uxbridge to State Route 122A in Millbury. Route 146 is mostly grade-separated and limited access except for approximately four miles from just north of the Central Turnpike in Sutton to just south of the Route 122A interchange in Millbury. In that section, the West Main Street interchange in Millbury is grade-separated and there is one major intersection that is under signal control at Boston Road in Sutton. In this section of Route 146 there are several access

points that are right-turn in/out only to access commercial and residential areas. Figure 1.2-1 shows the study area and intersections throughout the corridor.

Route 146 runs through many communities in the Blackstone River Valley including Millbury, Sutton, Northbridge, Douglas, Uxbridge, and Millville. When Route 146 is grade-separated, it is typically two lanes in each direction, northbound and southbound, with a grass median or a jersey barrier separating traffic. For the at-grade intersections and access points, there are added turn lanes and acceleration/deceleration lanes.

Figure 1.2.-1: Route 146 Study Corridor



1.2.2 Active Transportation and Transit Access

Transit

The study area includes one bus route operated by the Worcester Regional Transit Authority (WRTA). WRTA Route 4 serves The Shops at Blackstone Valley via Millbury Street, and runs from Union Station in Worcester to Route 146/122A, through Millbury Center, to The Shops at Blackstone Valley. There are a total of nine bus stops in the study area, one at The Shops at Blackstone Valley and eight in Millbury Center. The route runs about once an hour from around 6:00am to around 10:00pm Monday through Saturday, and on Sunday from 10:00am to 5:30pm.

None of the proposed or new industrial developments are supported by transit.

Bicycle Facilities

While existing bicycle facilities are limited within the study area, new and expanded facilities are envisioned in a few locations.

In the north, the Blackstone River Greenway is an existing shared use path that travels from Worcester, under I-90, and ends at a parking lot and trailhead on North Main Street in Millbury.

In the south, the Southern New England Trunkline Trail (SNETT) begins near Route 146 in Millville and runs approximately 2.5 miles east to the Town of Blackstone; this portion of the SNETT is also a segment of the Blackstone River Greenway. MassDOT envisions a westward expansion of the SNETT as part of the Priority Trail Vision Network, upon further development and funding. It would involve the trail traveling under Route 146, on Elmwood Avenue in Uxbridge or on Route 146A, south of Elmwood Avenue.

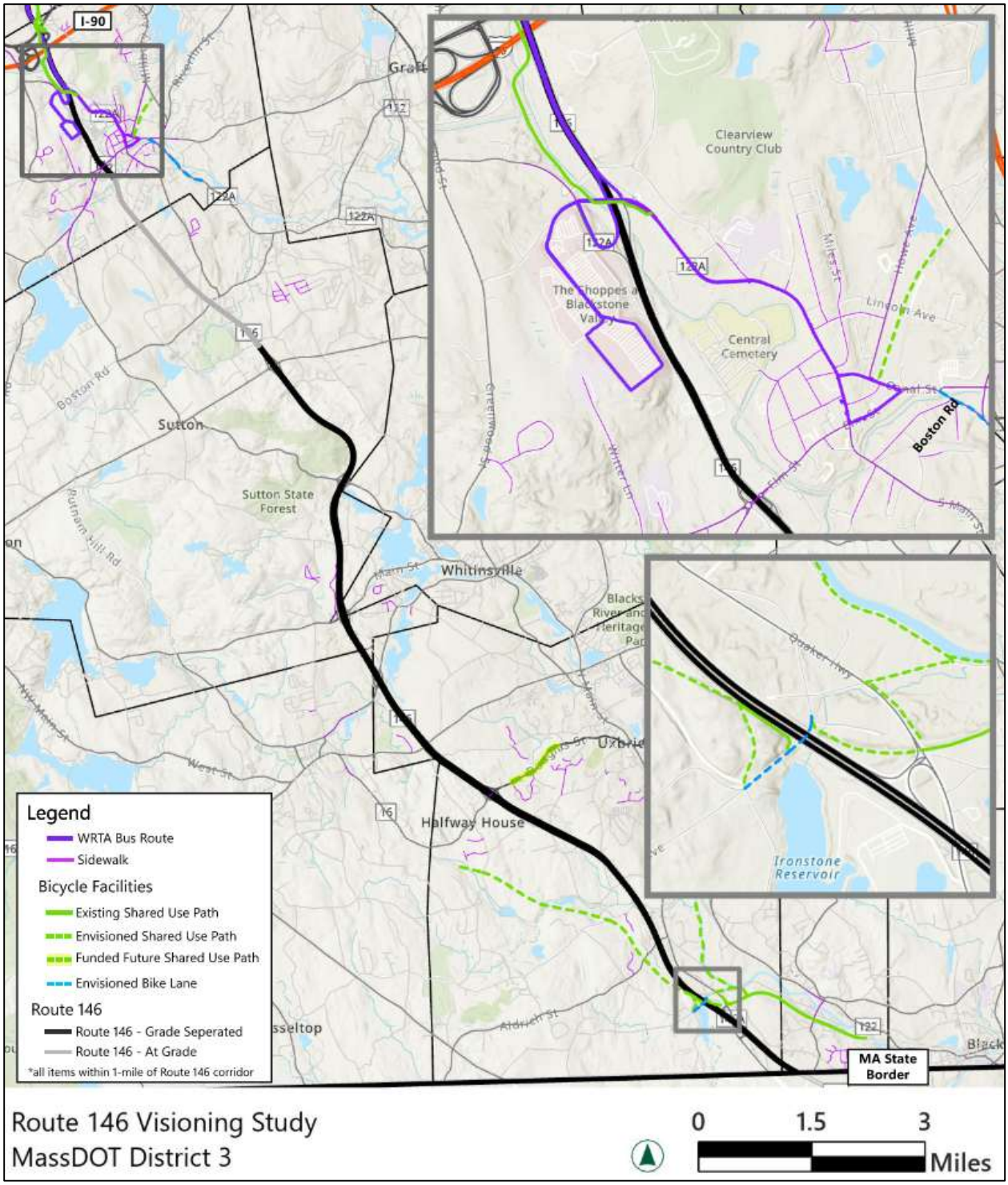
In the middle of the study area, MassDOT Project #610931 would construct a Shared Use Path along Douglas Street (Route 16) in Uxbridge and is programmed for 2027. This planned shared use path would connect to the new Amazon Warehouse in Uxbridge.

Pedestrian Facilities

Sidewalks are generally sparse within the study area, except in Millbury, where sidewalks traverse Elm Street underneath Route 146, connecting Millbury Center in the northeast with neighborhoods to the southwest, on the other side of Route 146. Sidewalks that are available in the study area do not have crossings at any intersections with Route 146.

The described transit routes, bicycle facilities, and pedestrian facilities are shown in Figure 1.2-2.

Figure 1.2-2: Transit and Active Transportation Routes in Study Area



1.2.3 Truck Routes

Route 146 is a major connection between the Massachusetts/Rhode Island State Line and the City of Worcester. One concern on the route recently has been the increase in truck volumes with the many existing and planned developments. At meetings with stakeholders and the public, impacts of increased truck traffic were raised and are a major concern for the study area communities.

1.2.3.1 Regional Truck Routes

Regionally, the recent growth in trucking can be attributed to increased demand for on-line goods catalyzed by the Covid-19 pandemic and sustained in subsequent years. The sustained growth in retail delivery services, through large on-line retailers, has resulted in the construction of more local distribution centers, which generate more truck trips in the region. Route 146 is an important link for trucks and combines with other routes in the study area region to provide a regional truck network. To the north of the study area is I-90 which travels east-west. Route 122A intersects with Route 146 in Millbury and then continues to the east of Route 146 until it connects with Route 122. Route 122 then continues south, paralleling Route 146 until the Massachusetts/Rhode Island State Line. Route 16 travels east-west in southern Massachusetts and intersects with Route 146 in Uxbridge. Also in Uxbridge, Route 98 intersects with Route 146. Route 146A travels parallel to Route 146 in Uxbridge as well, until it intersects it near the Rhode Island State Line. Central Turnpike is an east-west roadway connecting Route 146 and Route 122. While not an interstate, highway, or state route, Central Turnpike is a major local roadway and has been noted by local stakeholders as having a large amount of truck traffic. A review of 2022 data from the MassDOT Traffic Count database shows that total heavy vehicles comprise 20% of traffic on Central Turnpike, of which 4% are the largest heavy vehicles with three or more axles. These routes are shown in Figure 1.2-3.

1.2.3.2 Truck Exclusions

Near the study area there are a limited number of truck exclusions, all within Millbury. At the start of the study area, near the intersection of Route 122A, there are a handful of residential streets with a 24-hour exclusion for any vehicle over 2.5 tons. Those streets are Park Hill Avenue, Martin Street, Hamilton Street, Cherry Street, and Waters Street. To the east of the Route 146 and Boston Road intersection, Buttonwood Avenue has a 24-hour exclusion for any vehicle over 2.5 tons. Throughout the rest of the study area there are no other exclusions. These truck exclusions are shown in Figure 1.2-4.

The Central Massachusetts Metropolitan Planning Organization (CMMPO) *Highway Freight Accommodation Assessment Study: Southeast Transportation Planning Subregion*, identified which towns within the subregion had bylaws concerning trucks. In the study area Millbury, Millville, and Northridge have truck restrictions, while Douglas, Sutton, and Uxbridge do not. Millbury's restrictions are related to protecting sidewalks and curbing from heavy equipment

and parking restrictions. In Millville, routes must be approved for truck traffic and those routes will be reviewed by the police and/or Highway Departments to determine safety and road conditions. In Northbridge, trucks are prohibited on Water Street and there cannot be construction or idling of trucks from 6:00pm to 8:00am.

Figure 1.2-3: Truck Routes in Surrounding Region

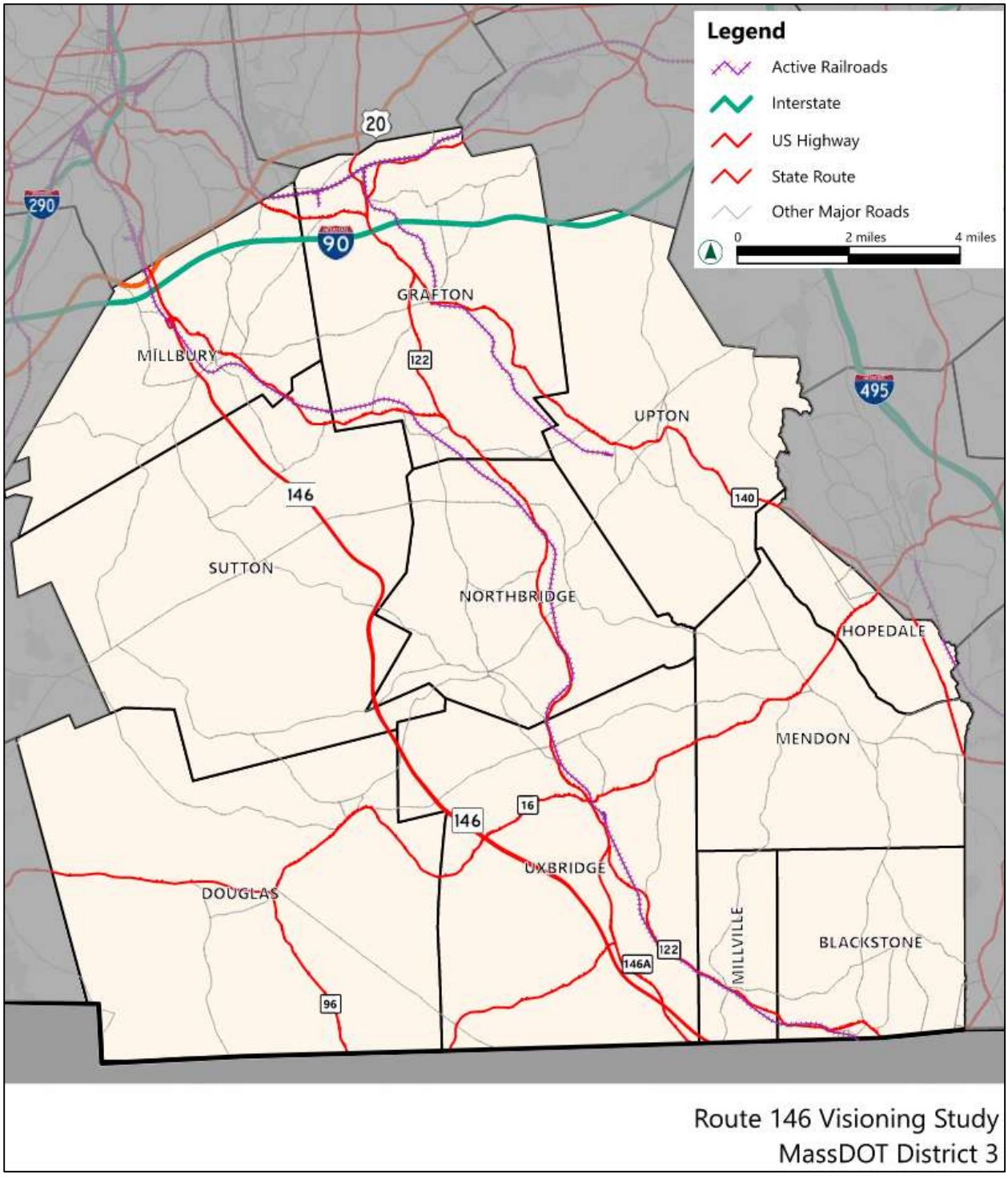
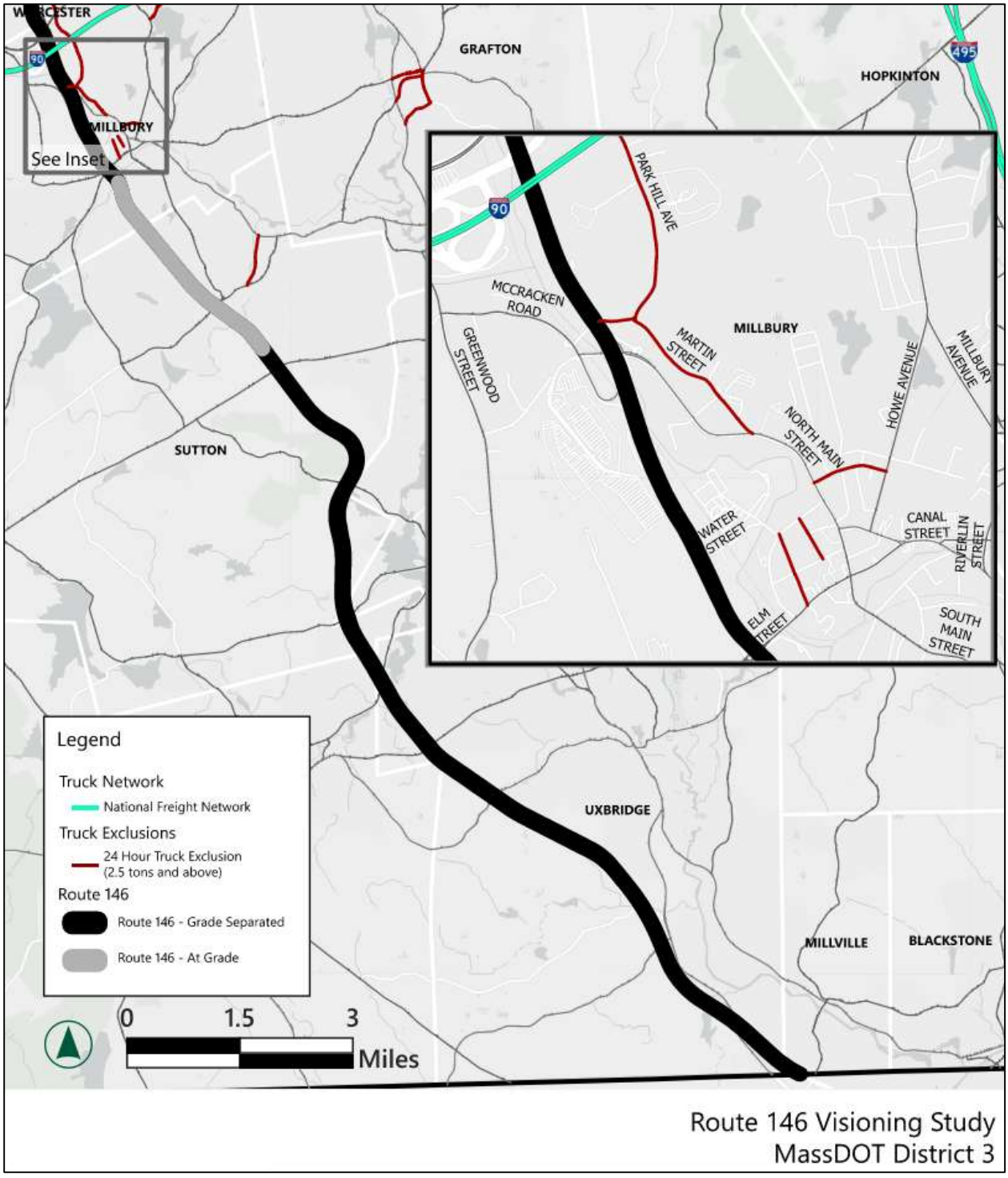


Figure 1.2-4: Truck Exclusions Network



1.2.3.3 Trucking Data: Existing and Future

In the CMMPO *Highway Freight Accommodation Assessment Study: Southeast Transportation Planning Subregion* Truck Vehicle Miles Traveled (VMT) in the towns were compared, a summary of which is provided in Table 1.2-1. Due to the state routes traveling through many towns, it can be difficult to tell which route the VMT are on. The study utilized the region's Travel Demand Model to depict 2020 truck VMT based on field data and projected 2030, 2040, and 2050 heavy vehicle VMT. In the forecast models, Millbury, Uxbridge, and Sutton had the top three VMTs, respectively. Route 146 is a contributing link to the towns with the top three truck VMT.

Table 1.2-1: Top Truck Vehicle Miles Traveled throughout Region

Town	Truck Vehicle Miles Traveled (VMT)				Contributing Truck Routes	
	2020	2030	2040	2050	Main Route	Contributing Routes
Millbury	29,588	29,333	30,367	31,801	US Route 20	Route 146, Route 122, Route 122A
Uxbridge	28,846	28,377	29,264	30,328	Route 146	Route 16, Route 98, Route 122, Route 146A
Sutton	24,986	23,984	24,963	25,980	--	Route 146, Route 122A

Source: CMMPO *Highway Freight Accommodation Assessment Study: Southeast Transportation Planning Subregion*

Another analysis that the CMMPO *Highway Freight Accommodation Assessment Study: Southeast Transportation Planning Subregion* completed was to find potential highway bottlenecks based in Origin/Destination (O/D) pairs. In this model there are three stages that relate to a different amount of increasing O/D pairs in a highway segment. From this analysis, the whole length of Route 146 was found to become a traffic bottleneck in all stages and expected to have effects on all vehicle types.

1.3 Previous Studies Review

1.3.1 Executive Office of Transportation: Route 146 Transportation Study (2005)

The 2005 Route 146 Transportation Study looked at existing conditions and developed alternatives to create a long-term plan for corridor improvements, some of which have since been implemented. Issues identified along Route 146 included excessive crashes, high peak hour vehicle queues, lack of available space to accelerate and decelerate when leaving and entering Route 146, difficult turning geometry for trucks, and unsafe pedestrian access.

Some general recommendations for the whole corridor included continuing to allow curb cut access, providing improved signage for U-turn locations, and using Central Turnpike to make U-turns from Route 146 south to north. Instead of U-turns at Central Turnpike, U-turns are now allowed at Route 146 southbound and Boston Road allowing for vehicles to reverse direction and travel northbound. Additional specific recommendations from this study are listed below:

Route 146 and Elm Street/Elmwood Street and West Main Street Improvements

- Adding a roundabout aligned with the Route 146 on and off ramps connecting Elm Street, Elmwood Street and West Main Street. (Implemented)

Route 146 and Boston Road Improvements

- Partially grade-separated half-diamond interchange with Route 146 northbound and southbound at grade with a bridge carrying Boston Road over Route 146, and an intersection at Boston Road with Route 146 southbound ramps. Route 146 northbound ramps would connect to the Boston Road and Pleasant Valley Road/Dudley Road intersection. (Not Implemented)

Route 146 from Boston Road to Central Turnpike

- Adding frontage roads on both sides of Route 146 with slip ramps to connect Route 146 to Boston Road and to the Central Turnpike. (Not Implemented)

Long Term Corridor Plan

- Adding frontage roads from Route 122A in Millbury to the Boston Road intersection, that parallel Route 146 and all curb cut access would be from the frontage roads, making Route 146 a fully limited access highway. (Not Implemented)

1.3.2 Central Massachusetts Regional Planning Commission: Route 146 Futures Study (2006)

The Route 146 Futures Study by the Central Massachusetts Regional Planning Commission (CMRPC) is built off information defined in the Route 146 Transportation Study, published in 2005. The study sought to improve safety, economic opportunities, and develop a realistic plan for the future of this highway corridor. Specifically, this report explored the existing access to the highway along the corridor in the at-grade section. The report acknowledges recommendations made in the 2005 study for intersection improvements, however, believes that they are not suitable for creating a fuller picture for the future of Route 146, due to the recommendations mostly focusing on specific improvements at a few of the intersections/interchanges, instead of the entire corridor.

The following alternatives were evaluated by the study.

Alternative 1: No action

- Expected increase to congestion and crashes
- Decrease in land development due to poor access

Alternative 2: Single lane frontage roads on both sides of Route 146 between West Main Street and Boston Road, with a crossover bridge at Deborah Road (Deborah Drive currently)

- Significant cost and land takings
- Would improve safety and land development opportunities

Alternative 3: Constructing frontage roads and slip ramps north of the West Main Street/ Elm Street/ Elmwood Street interchange

- Lower cost associated with it due to minimal land takings
- Improves safety on Route 146 while allowing for access to commercial properties

Alternative 4: Expanding Route 146 to have a wider median and the option for frontage roads on both sides

- High cost and high land takings are associated with this alternative
- Allows for flexibility with future opportunities

Alternative 5: Route 146 be completely access controlled with frontage roads on both sides

- High cost and disruptive to surrounding residential and commercial developments
- Would make all of Route 146 in Massachusetts access controlled

From analysis of the different alternatives, the study recommended the alternative where single lane frontage roads are constructed on both sides of Route 146 between West Main Street and Boston Road. The CMRPC also decided that the intersection improvements proposed in the 2005 study, outlined in Section 1.3.1 above, should also be completed. To date, only the intersection improvements at West Main Street that were proposed in the 2005 study have been completed. These improvements included adding a roundabout aligned with the Route 146 on and off ramps connecting Elm Street, Elmwood Street, and West Main Street.

1.3.3 2013 Interim Improvements at Boston Road

In 2010 a Functional Design Report (FDR) study was completed for interim improvements to the Route 146 and Boston Road intersection. The study acknowledged that the long-term solution is grade separation, however an interim project is occurring to improve the safety and flow of the intersection. The following describes improvements implemented at the intersection which remain in place today as well as other considered improvements that were not implemented.

Improvements Implemented

- Adding a third through lane for both directions of Route 146
- Adding an additional left-turn lane on Route 146 southbound
- Extending the right-turn lane on both approaches from Boston Road
- Dedicated left-turn lane at the Boston Road eastbound approach
- Two left-turn lanes at the Boston Road westbound approach
- Jughandle left turn which includes left turning and U-turn traffic to exit at Pleasant Valley Road, turn left at the intersection of Boston Road and Pleasant Valley Road, then continue to the Boston Road and Route 146 intersection

Improvements Considered but Not Implemented

- Extending the existing left-turn lane on Route 146 northbound to increase the storage capacity. This was not implemented since the jug handle left turn was found to be more effective and economical.

1.3.4 Central Massachusetts Regional Planning Commission Long Range Transportation Plan: 2050 Connections

2050 Connections is the CMRPC's Long Range Transportation Plan (LRTP) that was approved in July 2023 by the Central Massachusetts Metropolitan Planning Organization. This is a comprehensive plan that addresses transportation needs in the region for the next 25 years. Based on census data and future projections, population and employment are increasing continuously through 2050. With those increases, vehicle miles traveled will also increase throughout the region.

Included in this plan are results from public outreach efforts and public comments. Engagement with the public was through the CRMPC website, the 2050 Connections Hubsite, presentations, meetings (virtual and in-person), and tabling events. Some comments specifically related to the study area include:

- Congestion mitigation is needed on Route 146, specifically at the Boston Road intersection
- Concerns about increased freight and trucking due to developments
- Making Route 146 and Boston Road a grade-separated interchange
    - Identified as a major infrastructure project predicted to happen between 2041 and 2045.

1.4 Existing Conditions Summary

To understand the different study intersections better and assess existing roadway conditions, a desktop assessment was performed using Google Maps.

1.4.1 Study Intersections

In the study area, there are three primary study intersections:

- Route 146 and Boston Road
- Boston Road and Pleasant Valley Road/ Dudley Road
- Route 146 and Lackey Dam Road

These intersections were chosen based on future planned developments to be discussed in Chapter 2, and how those will impact the Route 146 corridor. Each intersection is described in more detail below.

1.4.1.1 Route 146 and Boston Road

Route 146 and Boston Road is the only signalized, at-grade intersection within the study area. Boston Road is classified as an urban minor arterial based on MassDOT's functional classification. It runs east-west within the Town of Sutton, with the primary service being residential with some commercial areas near the intersection of Route 146. A double yellow line separates the different directions of travel on Boston Road and the directions of travel along Route 146 are separated with a center median. At the Route 146 intersection, Boston Road has a 25 Miles Per Hour (MPH) speed limit. In the vicinity of Boston Road, Route 146 has a posted speed limit of 40 MPH. At the intersection there are no pedestrian and bicycle facilities available. The lane geometry of all approaches is shown in Figure 1.4-1.

1.4.1.2 Boston Road and Pleasant Valley Road/ Dudley Street

Boston Road and Pleasant Valley Road/Dudley Road is the next intersection on Boston Road to the east of Route 146. This intersection is of interest since northbound vehicles on Route 146 wanting to turn left onto Boston Road westbound use Pleasant Valley Road for a jug handle left turn, given that left turns are prohibited at the Boston Road intersection. Vehicles exit onto Pleasant Valley Road, about 800 feet south of Boston Road, then turn left onto Boston Road and continue through the intersection with the westbound through movement. Travel in opposite directions on Boston Road is separated by a double yellow line. Pleasant Valley Road has no posted speed limit, while Dudley Road has a posted speed limit of 30 MPH and Boston Road has a posted speed limit of 25 MPH. There are currently no pedestrian or bicycle facilities at the intersection. The roadway geometry of the intersection is shown in Figure 1.4-2.

Figure 1.4-1: Route 146 and Boston Road Intersection Geometry

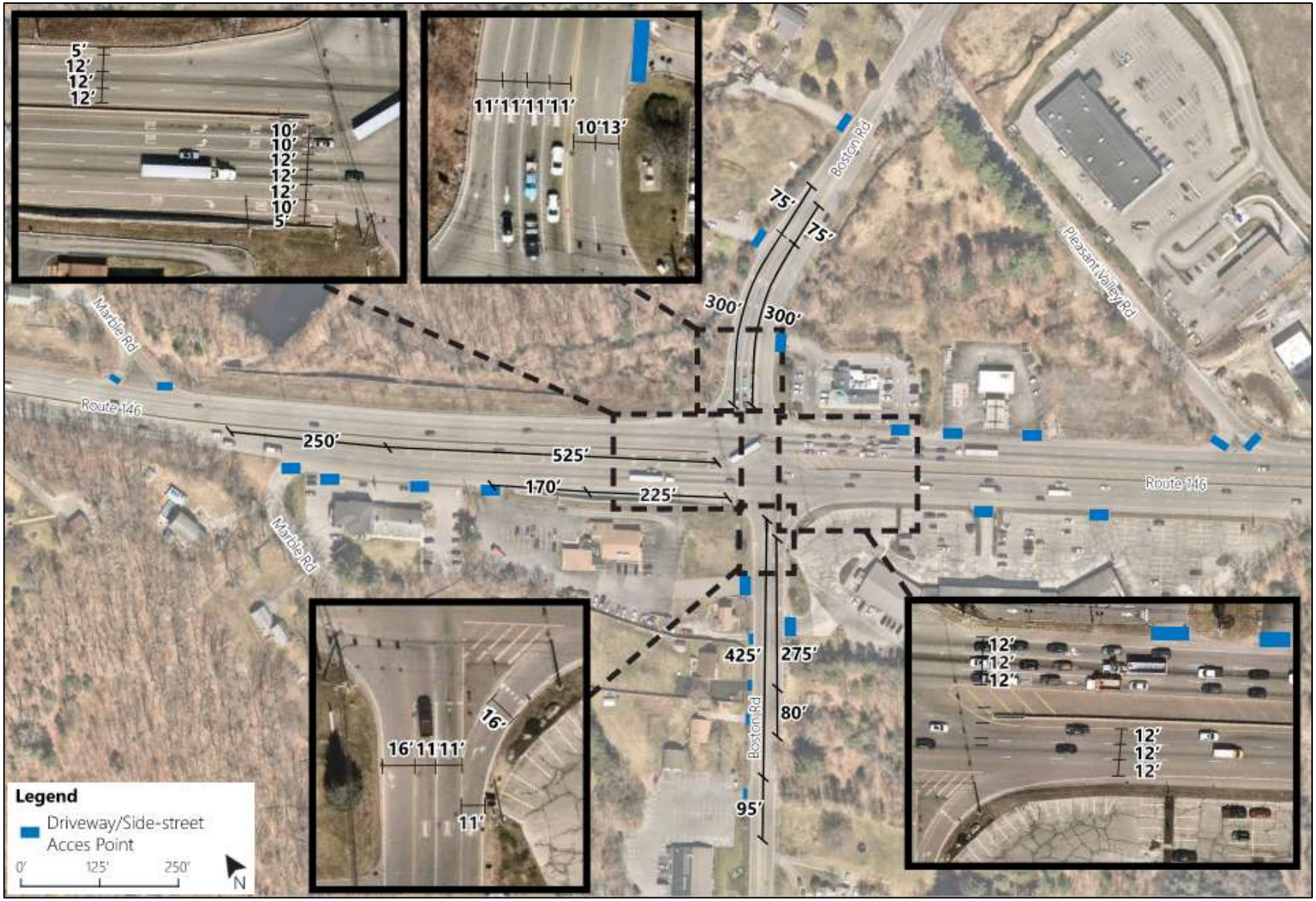


Figure 1.4-2: Boston Road and Pleasant Valley Road/ Dudley Road Intersection Geometry

Route 146 and Lackey Dam Road

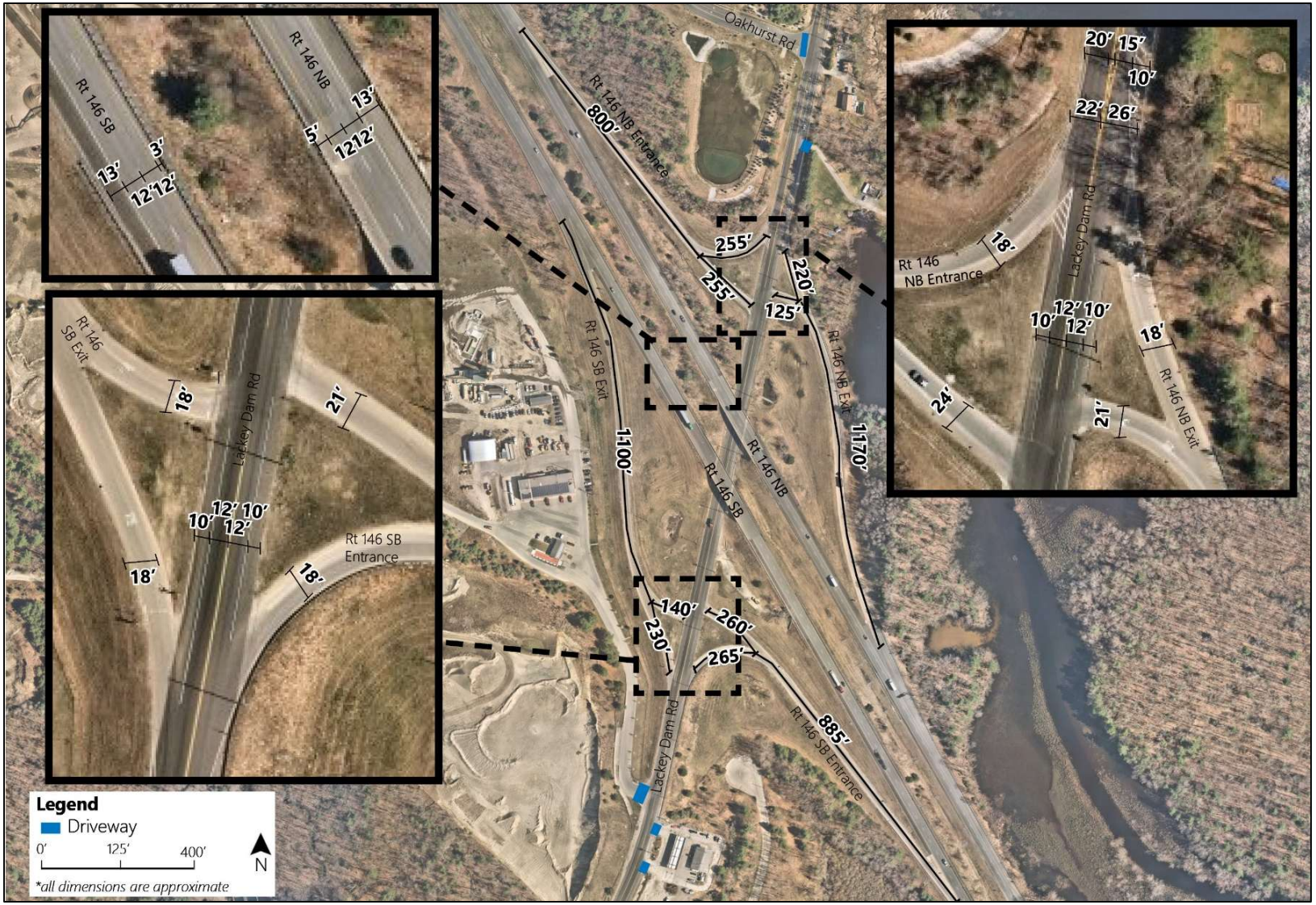
Route 146 at Lackey Dam Road is a grade-separated diamond interchange with Lackey Dam Road at grade and Route 146 on an overpass. This interchange is located approximately 8 miles to the north of the Massachusetts/Rhode Island State Line. Lackey Dam Road has one lane in each direction with a posted speed limit of 35 MPH. It has a functional classification as an urban minor arterial, based on MassDOT's Functional Classification. Sidewalks are present on Lackey Dam Road underneath the Route 146 overpasses but do not connect to other locations along Lackey Dam Road. There are currently no bicycle facilities present. Route 146 has both southbound and northbound ramps connecting with Lackey Dam Road Each are described in more detail below.

Route 146 southbound ramps are located to the west of the overpass and meet Lackey Dam Road at an unsignalized intersection. The southbound exit is one lane that splits into a left-turn lane that is stop controlled, and a channelized right-turn lane that is under yield control. The southbound entrance ramp has a single receiving lane for westbound left-turning traffic and a channelized right-turn lane for eastbound right-turning traffic. There are no dedicated turn lanes on Lackey Dam Road and all movements occur from the single shared lane.

Route 146 northbound ramps are located to the east of the overpass and meet Lackey Dam Road at an unsignalized intersection. The northbound exit is one lane that splits into a left-turn lane that is stop controlled and a channelized right-turn lane that is under yield control. The northbound entrance ramp has a single receiving lane for eastbound left-turning traffic and a channelized right-turn lane for westbound right-turning traffic. There are no dedicated turn lanes on Lackey Dam Road and all movements occur from the single shared lane.

The existing geometry for the southbound and northbound ramps at Lackey Dam Road is shown in Figure 1.4-3.

Figure 1.4-3: Route 146 and Lackey Dam Road Intersection Geometry



1.5 Volumes

1.5.1 Existing Traffic Volumes

Understanding how traffic is moving through the corridor is crucial for further analysis related to roadway and safety improvements. For the study intersections, traffic count data was gathered through various sources, as shown in Table 1.5-1 below.

Table 1.5-1: Traffic Count Sources

Count Source	Date	Location(s)
Unified Parkway Development	February 2023	Route 146 and Boston Road
Unified Parkway Development	February 2023	Boston Road and Pleasant Valley Road/Dudley Road
New Counts	September 2024	Route 146 and Lackey Dam Road – Northbound and Southbound Ramps

Route 146 and Boston Road / Boston Road and Pleasant Valley Road

The 2023 counts were adjusted to reflect Existing 2024 conditions using seasonal factors, background growth, and volume balancing. For the seasonal adjustment, MassDOT 2022 Seasonal Factors were applied based on the MassDOT Functional Classification.

To consider the background growth from 2023 to 2024, a review of other developments in the area and traffic counts from the MassDOT Traffic Count portal were used. Central Massachusetts Regional Planning Commission (CMRPC) estimates that traffic volumes will increase 1.34 percent and 1.45 percent per year for weekday morning and weekday evening peak period, respectively. When reviewing the Annual Average Daily Traffic (AADT) data from the MassDOT Traffic Count Portal for counts on Boston Road east and west of the intersection, there was a 2.2 percent increase in traffic volumes between 2022 and 2023. Considering CMRPC estimates and the data from the MassDOT Traffic Count Portal, a 2 percent annual growth rate was applied to reflect 2024 conditions.

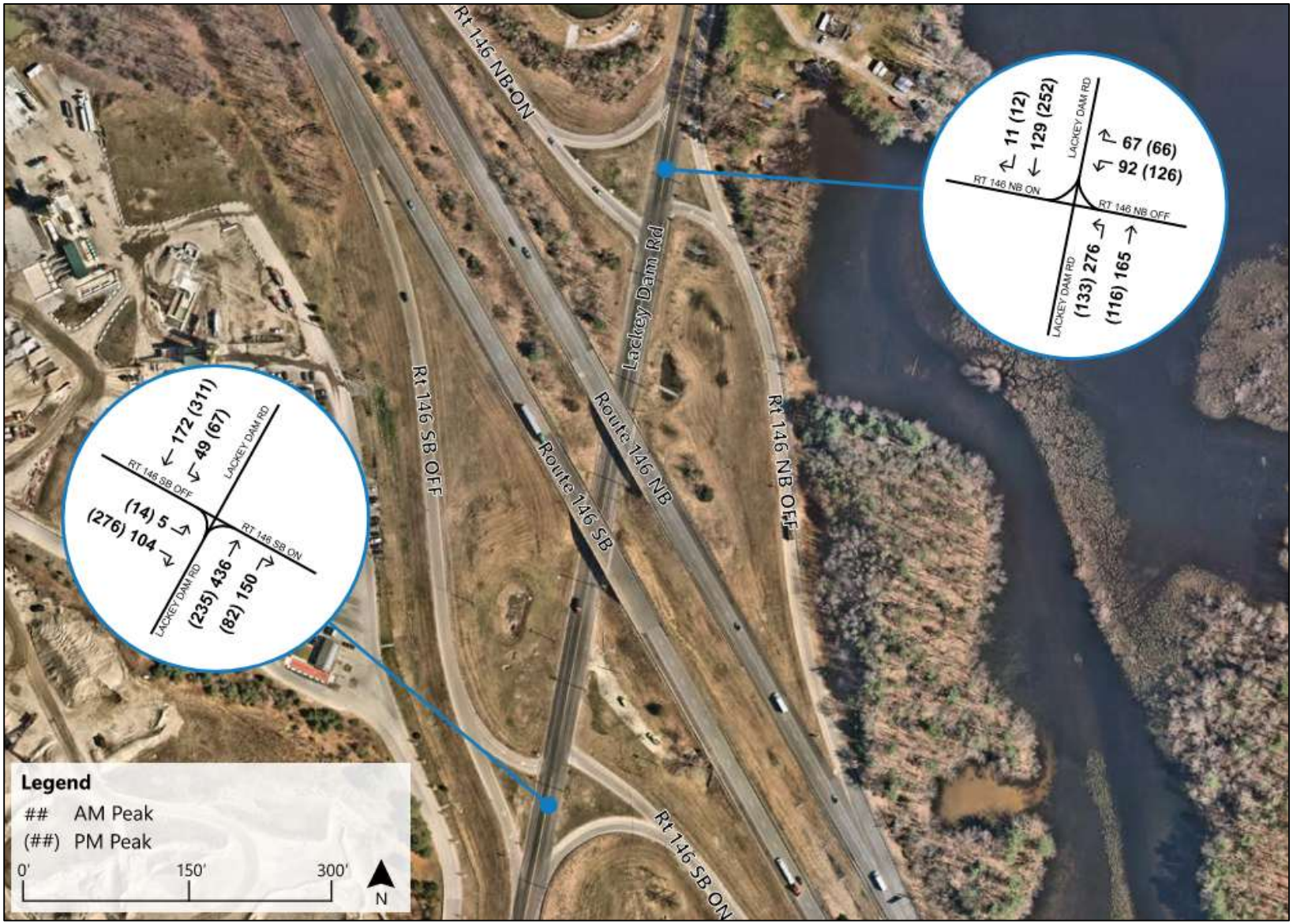
Route 146 and Lackey Dam Road

The 2024 counts were adjusted using the MassDOT 2022 Seasonal Factors based on the MassDOT Functional Classification and balanced. Turning movement counts completed at Route 146 and Lackey Dam Road northbound and southbound ramps are included in Appendix A.

Existing Volume schematics are shown in Figures 1.5-1 and 1.5-2.

Figure 1.5-1: Existing Peak Hour Volumes at Route 146 and Boston Road

Figure 1.5-2: Existing Peak Hour Volumes at Lackey Dam Road and Route 146



1.6 Safety Review

Crash data available from the recent MassDOT Road Safety Audit (RSA) at Boston Road and Route 146 was reviewed for relevant findings and recommendations that may inform this study. Additionally, the remainder of the study corridor was reviewed for additional high-crash clusters. A summary of this review and assessment is provided below.

1.6.1 Crash Data

Crash Clusters

A corridor-wide review of MassDOT top crash locations was performed, and the following locations and cluster types were identified:

Boston Road at Route 146

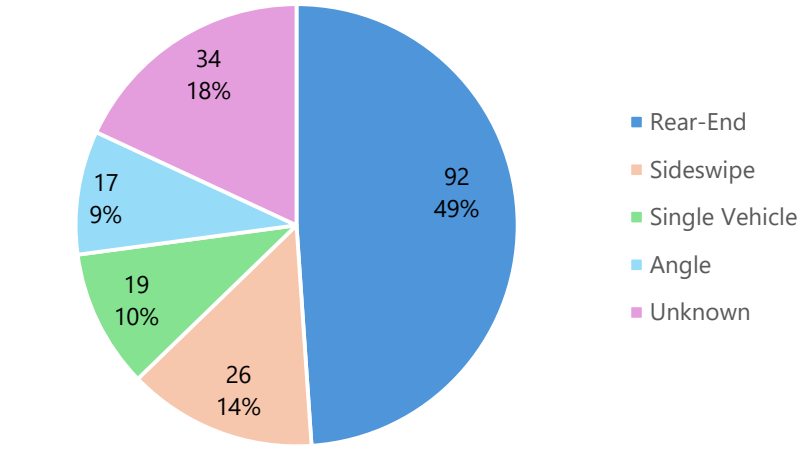
- 2019-2021 Highway Safety Improvement Program (HSIP) Crash Cluster
- 2019-2021 Top 200 Crash Cluster (Ranked 56th)

No additional high-crash clusters are present along the Route 146 study corridor.

Intersection Crash Data

For Boston Road and Route 146, crash data from the 2022 MassDOT Road Safety Audit (RSA) for the intersection was reviewed. The audit identified 188 crashes for the period of January 2017 to May 2022. The RSA notably includes the latest available accepted crash years for analysis purposes, and as of the writing of this report, MassDOT's crash portal notes that any crash records or data provided for the years after 2021 are subject to change at any time and are not to be considered up-to-date or complete. From the RSA analysis, rear-end crashes were the most prevalent at the intersection, with sideswipe crashes and single vehicle crashes the next most prevalent, respectively. The distribution of crash types is shown in Figure 1.6-1.

Figure 1.6-1: Crash Distribution by Type, Route 146 and Boston Road (January 2017 to May 2022)

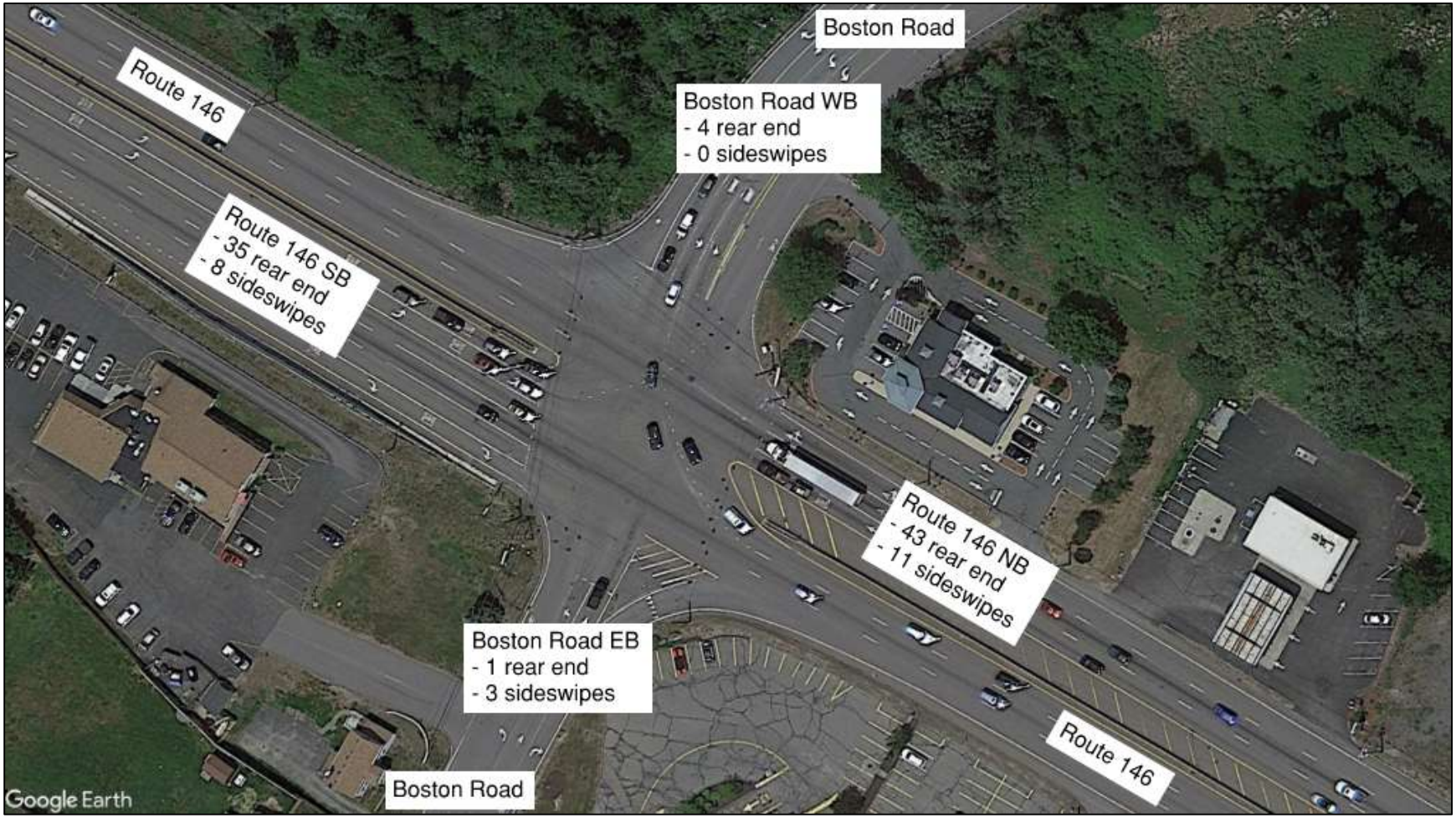


Source: MassDOT Road Safety Audit for Worcester-Providence Turnpike (Route 146) at Boston Road, October 25, 2022.

Most reported crashes occurred on Route 146, with vehicles traveling northbound or southbound. In terms of rear-end collisions, 43 crashes of that type occurred on Route 146 northbound and 35 occurred on Route 146 southbound. The second most common type of crash were sideswipes. Eleven sideswipe crashes occurred in the northbound direction and eight sideswipes occurred in the southbound direction. Crash types by approach are shown in Figure 1.6-2.

On Route 146 northbound, left turns are not allowed, however six reported crashes involved illegal left turns, or U-turns from Route 146 northbound onto Boston Road. 29 injuries were reported on Route 146 while two injuries were reported on Boston Road. Heavy vehicles are also a concern on Route 146, with 10% of reported crashes involving heavy vehicles. At this intersection, there are no reported crashes involving pedestrians or bicyclists.

Figure 1.6-2: Crash Distribution by Approach (January 2017 to May 2022)



Source: MassDOT Road Safety Audit for Worcester-Providence Turnpike (Route 146) at Boston Road, October 25, 2022.

1.6.2 Road Safety Audit Findings and Recommendations

Boston Road and Route 146

From the Road Safety Audit completed in October of 2022, seven safety issues were identified along with possible safety enhancements. The safety issues were related to rear end crashes, turning movements, inadequate guide signage, curb cuts, emergency vehicle preemption, pedestrian and bicycle facilities, and driver behavior. Proposed enhancements were then evaluated on their time frame for completion and cost. The time frame was classified as short-term, mid-term, or long-term. Short-term safety enhancements have a time frame of less than one year. Mid-term safety enhancements would take one to three years to complete. Safety enhancements requiring more than three years to complete are considered long-term. Cost was classified similarly: low cost is less than $10,000, medium cost is $10,001 to $50,000, and high cost is more than $50,000. A summary of each safety issue, possible causes, and potential enhancements is below.

Rear-end Crash Mitigation

As mentioned in Section 1.6.1, Crash Data, rear-end crashes accounted for almost half of the crashes at the Boston Road and Route 146 intersection, resulting in a safety concern from the RSA. It was suggested that this could be related to Route 146 and Boston Road being the only signalized intersection on Route 146 in Massachusetts, vehicles speeding, long vehicle queues during peak periods, and/or insufficient clearance time. Potential enhancements identified include:

Long-Term Project and High-Cost

- Grade-separated interchange with frontage roads

Mid-Term and Low-Cost Project

- Evaluating the location of overhead signage on Route 146 southbound

Short/Mid-Term and Low/High-Cost Project

- Consider implementing "no turn on red" restrictions or acceleration lane for right turns from Boston Road westbound onto Route 146 northbound

Short-Term and Low-Cost Projects

- Additional advanced warning signage to alert drivers of intersection ahead
- Evaluating the clearance signal timings
- Installing "Signal Ahead" pavement markings
- Improving lane assignment signage

- Evaluating right-turn-on-red movements from Boston Road westbound onto Route 146 northbound

Turning Movement Crash Mitigation

Turning movements were another safety issue identified in the RSA. As mentioned in the crash data, six crashes were due to illegal left turns or U-turns from the Route 146 northbound approach. Safety concerns were related to the green ball signal head indication instead of directional arrow indications, lack of broken white lane line pavement markings for tracking turns for the dual left-turn lanes on Route 146 southbound and Boston Road westbound, the wide painted median on the Route 146 northbound approach, and Boston Road eastbound and westbound right-turn movements. Potential enhancements identified include:

Long-Term and High-Cost Project

- Grade-separated interchange with frontage roads

Long-Term and Medium-Cost Project

- Raised median to help drivers identify that the median is not a drivable area

Mid-Term and High-Cost Project

- Evaluating placement of additional signage and adding overhead signage to improve lane assignment indication

Mid-Term and Medium-Cost Project

- Street lighting at intersection of Route 146 and Pleasant Valley Road

Short-Term and Low-Cost Projects

- Improving lane tracking pavement markings
- Adding delineators on Route 146 northbound to mark the painted median
- Changing the signal heads to vertical green arrows in the northbound direction for clarity on the allowed movements
- Improving lane tracking pavement markings for left turns from Route 146 southbound and Boston Road westbound
- Evaluating right-turn-on-red restriction for the Boston Road westbound approach

Signage Issues & Mitigations

Inadequate guide signage is another safety issue that was identified in the RSA, especially at the Route 146 northbound approach at Pleasant Valley Road and at Boston Road. Concerns are related to signs not being located soon enough in advance or too late to adjust your movement,

signs being obscured by other signage, visibility of signs in lanes besides the right lane. Potential enhancements include:

Short/Mid-Term and Low/High-Cost Project

- Evaluating signage being added on the median or overhead

Short-Term and Low-Cost Projects

- Evaluating location of signage
- Adding signage farther south on Route 146 northbound
- Relocating signage that is obscured
- Improving signage for the jug handle left turn from Route 146 onto Pleasant Valley Road

Curb-cut Access Issues & Mitigations

Curb cuts for different access points along Route 146 and Boston Road occur frequently around the intersection. Illegal turns out of these driveways is a concern on Boston Road, while lack of signage is a concern for access points on Route 146 and Boston Road. South of the intersection on Route 146 northbound there are access points for Pleasant Valley Road and Galaxy Pass. Due to a lack of acceleration lanes, shop entrances, and the right-turn only onto Pleasant Valley Road, there is a lot of weaving traffic. Some enhancements include:

Long-Term and High-Cost Projects

- Evaluating the implementation of acceleration and deacceleration lanes along Route 146
- Evaluating extending the right-turn only lane for Pleasant Valley Road to be an acceleration lane for vehicles existing Galaxy Pass

Short-Term and Low-Cost Projects

- Installing new signage along the median on Route 146 to indicate left turns are prohibited
- Adding flex posts on Boston Road, especially by the Bank of America driveway to reinforce the prohibition of left turns

Emergency Vehicle Preemption Issues & Mitigations

Another concern is that emergency vehicle preemption at the intersection does not work properly. Specifically on the Boston Road approaches there have been issues activating pre-emption, increasing response times. Potential enhancements identified include:

Mid-Term and Low-Cost Project

- Considering advance emergency vehicle detection on Boston Road approaches

Short-Term and Low-Cost Project

- Evaluating the current system and implementing upgrades

Pedestrian and Bicycle Accommodation Issues & Mitigations

Currently at the intersection of Route 146 and Boston Road, there is a lack of pedestrian and bicycle facilities. There are no sidewalks or marked crosswalks provided at the intersection. In the RSA, pedestrian safety concerns are related to pedestrians sometimes crossing the intersection without marked crossings. Bicycle facilities consist of sharrows on Boston Road for movements away from the intersection. On the Route 146 northbound approach and both approaches from Boston Road, there are bicycle symbols and bicycle detection. However, all bicycle facilities are unprotected, combined with vehicle movements, and do not connect to regional bicycle facilities. Potential enhancements identified include:

Long-Term and Medium-Cost Project

- Evaluating the addition of crosswalks, sidewalks, and pedestrian signal equipment

Long-Term and Low/Medium-Cost Project

- Evaluating adding bicycle facilities that would connect to the surrounding transportation network and future planned bicycle facilities

Driver Behavior Issues & Mitigations

The final safety issue identified in the RSA is related to driver behavior. Concerns include speeding through the intersection, being distracted, and not following speed reduction signs. Potential enhancements identified include:

Mid-Term and Low-Cost Project

- Evaluating the implementation of rumble strips on both Route 146 approaches

Short-Term and Low-Cost Projects

- Providing law enforcement near the intersection of Route 146 and Boston Road
- Public education to alert drivers of reduced speed limits and traffic patterns at the intersection
- Evaluating the location of "Reduced Speed Limit Ahead" signage on Route 146 northbound

Short-Term and Medium-Cost Project

- Evaluating the use of digital feedback signage on all approaches to the intersection

1.7 Operational Analysis

Existing operational analysis at the study intersections was conducted using Synchro 11 and Synchro 12 software, based on the latest Highway Capacity Manual methodologies. Inputs to the model included:

- Roadway Geometry / Lane Widths
- Signal timing and phasing
- Vehicle volumes
- Peak Hour Factors (PHF)
- Heavy vehicle percentage
- Percent grade

Vehicle operations at the different study intersections were modeled using these inputs and are described below for each intersection.

Route 146 at Boston Road

During the morning peak hour, the intersection has an overall Level of Service (LOS) E and a volume-to-capacity (v/c) ratio of 0.91. This result indicates that the intersection is close to reaching theoretical capacity and is experiencing high levels of delay. By comparison, during the afternoon peak hour, the overall intersection operates at a significantly better LOS C and v/c ratio of 0.76. In the afternoon, the intersection is operating better than the morning peak hour but still experiences long delays along Boston Road east and westbound (LOS E) and on Route 146 at the southbound left-turn (LOS E).

A key capacity constraint is in the morning peak period, when the northbound through and shared right-turn movement is operating at LOS F and has a v/c ratio of 1.13, resulting in an approach that is over capacity and failing. During the afternoon peak period, the northbound through and right movement improves to LOS D and has a v/c ratio less than one, indicating it is operating within the limits of capacity with moderate delays. During both the morning and afternoon peak periods, the southbound left turn on Route 146 operates at LOS E, with moderately long delays; however, queue lengths are accommodated by existing storage lanes. Along Boston Road, the through and left-turn movements for both approaches operate at LOS E during both the morning and afternoon peak periods.

The existing conditions Synchro analysis for the intersection is shown in Table 1.7-1 and in Appendix B.

Boston Road at Pleasant Valley Road and Dudley Road

During the morning peak period, the Boston Road approaches are operating at LOS A, while Pleasant Valley Road and Dudley Road operate at LOS B, indicating that all approaches experience minor delays during the morning peak hour. During the afternoon peak period, the Boston Road approaches operate at LOS A, while Pleasant Valley Road is LOS C and Dudley Road is LOS B, indicating that delay is slightly higher during the afternoon peak period, especially on Pleasant Valley Road. During the afternoon peak period, the jug-handle left-turn movement from Pleasant Valley Road to Boston Road westbound peaks when the conflicting through traffic on Boston Road is also at its greatest, increasing delay on Pleasant Valley Road.

The existing conditions Synchro analysis for the intersection is shown in Table 1.7-1 and in Appendix B.

Lackey Dam Road and Route 146 Southbound Ramps

All approaches except the southbound left, experience LOS A conditions, with minimal to no queues. The approach turning left from the Route 146 southbound exit ramp onto Lackey Dam Road operates at LOS C during the morning and afternoon peak periods.

The existing conditions Synchro analysis for the intersection is shown in Table 1.7-2 and in Appendix C.

Lackey Dam Road and Route 146 Northbound Ramps

All approaches except the northbound left, experience LOS A conditions, with minimal to no queues. The approach turning left from the Route 146 northbound exit ramp onto Lackey Dam Road operates at LOS B during the morning and afternoon peak periods.

The existing conditions Synchro analysis for the intersection is shown in Table 1.7-2 and in Appendix C.

Table 1.7-1: Route 146 and Boston Road Existing Conditions Synchro Analysis

			Weekday Morning					Weekday Afternoon				
Intersection	**Approach**		**LOS[1]**	**Delay[2]**	**V/C[3]**	**50th Q[4]**	**95th Q[5]**	**LOS**	**Delay**	**V/C**	**50th Q**	**95th Q**
Route 146 at	EB	L	E	68.0	0.56	69	95	E	64.6	0.46	49	112
Boston Road		T	E	68.1	0.70	121	145	E	60.6	0.49	65	133
		R	A	0.1	0.05	0	0	A	0.0	0.03	0	0
	WB	L	E	62.5	0.60	69	117	E	57.2	0.72	125	209
		T	E	61.7	0.59	96	174	E	58.7	0.65	128	232
		R	B	19.1	0.66	24	115	B	11.0	0.50	0	61
	NB	T/TR	F	98.1	1.13	772	1064	D	40.7	0.87	364	516
	SB	L	E	62.1	0.61	75	121	E	56.5	0.66	107	187
		T	B	15.6	0.51	227	320	C	20.7	0.72	379	536
		R	A	0.1	0.04	0	0	A	1.5	0.05	0	13
	Overall		*E*	*62.1*	*0.91*			*C*	*33.7*	*0.76*		
Boston Road at	EB	LT/TR	A	8.3	0.01	n/a	0	A	8.7	0.01	n/a	0
Pleasant Valley Road and	WB	LT/TR	A	7.7	0.00	n/a	0	A	8.0	0.01	n/a	0
Dudley Road	NB	LTR	B	14.7	0.32	n/a	35	C	24.0	0.47	n/a	60
	SB	LTR	B	11.7	0.09	n/a	8	B	14.4	0.20	n/a	18

1 Level-of-Service
2 Average vehicle delay, in seconds
3 Volume to capacity ratio; intersection capacity utilization reported for overall
4 50th percentile queue based on Synchro outputs, in feet
5 95th percentile queue based on Synchro outputs, in feet
n/a Not applicable

Table 1.7-2: Route 146 and Lackey Dam Road Existing Conditions Synchro Analysis

			Weekday Morning					Weekday Afternoon				
Intersection	**Approach**		**LOS[1]**	**Delay[2]**	**V/C[3]**	**50th Q[4]**	**95th Q[5]**	**LOS**	**Delay**	**V/C**	**50th Q**	**95th Q**
Lackey Dam Road at	EB	TR	A	0.0	0.43	n/a	0	A	0.0	0.20	n/a	0
Worcester-Providence Turnpike (Route 146)	WB	LT	A	2.0	0.06	n/a	5	A	1.4	0.06	n/a	5
SB Ramps	SB	L	C	17.2	0.02	n/a	3	C	15.0	0.04	n/a	3
		R	A	9.9	0.13	n/a	10	A	0.0	0.00	n/a	0
Lackey Dam Road at	EB	LT	A	5.6	0.27	n/a	28	A	4.6	0.13	n/a	10
Worcester-Providence Turnpike (Route 146)	WB	TR	A	0.0	0.11	n/a	0	A	0.0	0.17	n/a	0
NB Ramps	NB	L	B	12.0	0.19	n/a	18	B	12.3	0.21	n/a	20
		R	A	9.7	0.10	n/a	8	A	0.0	0.00	n/a	0

1 Level-of-Service
2 Average vehicle delay, in seconds
3 Volume to capacity ratio
4 50th percentile queue based on Synchro outputs, in feet
5 95th percentile queue based on Synchro outputs, in feet
n/a Not applicable

1.8 Alternatives Development Framework

The following section outlines criteria that guide alternatives development, analysis and recommendations. The relevance of each evaluation criteria is established based on existing issues and deficiencies identified as part of this study and prior studies, as summarized below.

Accommodation of Traffic Growth

An alternative's ability to accommodate traffic growth is a function of roadway capacity which is influenced by the number and type of lanes and intersection control type. Adequate capacity allows for the movement of people and goods through the study area and supports future growth in the area. The existing operations at Boston Road and Route 146 have been evaluated and capacity constraints at specific peak hours and for specific movements are documented in Section 1.7. Overall, the intersection is already approaching capacity limits at present day.

Safety

The intersection of Boston Road and Route 146 has a significant crash history that warranted a study in the form of a Road Safety Audit. The ability to address these issues through alternatives is therefore an important evaluation criteria. From the Road Safety Audit completed in October of 2022, seven safety issues were identified along with possible safety enhancements and mitigation measures. The issues and proposed mitigation measures are described in Section 1.6 and are categorized as follows:

- Rear-end Crash Mitigation
- Turning Movement Crash Mitigation
- Signage Issues & Mitigations
- Curb-cut Access Issues & Mitigations
- Emergency Vehicle Preemption Issues & Mitigations
- Pedestrian and Bicycle Accommodation Issues & Mitigations
- Driver Behavior Issues & Mitigations

Vehicle Operations

Vehicle operations at the intersection are a result of demand, available capacity and queues. To quantify the operations of the intersection, units of measurements could be the amount of delay drivers experience, typically in seconds, when traveling through the intersection and the length of queues experienced. This amount of delay then correlates to level of service (LOS) grade. At Route 146 and Boston Road, in the critical peak hour, the overall intersection currently operates at LOS E with individual movements operating at LOS E or worse, as detailed in Section 1.7. At the Route 146 ramps and Lackey Dam Road, both ramps operate at LOS D or better throughout both peak hours, as detailed in Section 1.7.

Multi-modal Connections and Transit Access

Multi-modal connections allow for active transportation methods, not in a motorized vehicle. In the northern part of the study area there is one bus route servicing Millbury Center and the Shops at Blackstone Valley. Throughout the study area there are sparse bicycle and pedestrian facilities. Transit access and active transportation facilities are described in more detail in Section 1.2.2.

1.8.1 Evaluation Criteria

The proposed criteria and associated measurements included in Table 1.8-1 form the basis of a comparative analysis of future roadway improvement alternatives. Criteria include quantitative and qualitative metrics, considering all modes of travel.

Table 1.8-1: Route 146 Corridor Vision Study Evaluation Criteria

Evaluation Criterion	Measurement / Assessment
Accommodation of Traffic Growth	• Roadway and intersection geometry / lanes • Roadway type (e.g. grade-separated, at-grade, frontage road)
Safety	• Potential to address location crash history • Turn radii constraints
Vehicle Operations	• Level of Service / Delay • Queue length
Multi-modal Connections	• Opportunities to expand connectivity with existing and future planned infrastructure for vulnerable roadway users.
Transit Access	• Opportunities to improve transit access • Quality of service
Cost	• Preliminary Opinions of Probable Construction Cost (OPCC)

1.8.2 Methodology

A key focus of alternatives development is determining at what point of time and development intensity will grade separation of Route 146 at Boston Road become critical. Likewise, if future volumes induce capacity constraints at existing interchanges, other locations may be impacted and require improvements at specific levels of future growth. Future land use scenarios to be developed and evaluated are generally defined below:

- Scenario 1) Initial Growth Condition: All planned and permitted projects plus background traffic growth.

- Scenario 2) Medium-term Growth Condition**:** Initial planned growth plus medium-term growth potential.
- Scenario 3) Long-term Growth Condition**:** Initial planned growth plus long-term growth.

Boston Road at Route 146 – Grade Separation Sensitivity Testing

Traffic modeling of the above scenarios will provide a sensitivity analysis for impacts of future growth and whether associated improvement opportunities to be considered will scale to accommodate future vehicle operations. As the existing conditions at Boston Road and Route 146 already exhibit capacity constraints, a focused sensitivity test is required to determine the interim traffic growth levels that require grade separation of the intersection. Process steps for sensitivity testing of traffic operations at Boston Road and Route 146 are outlined as follows:

1. Identify critical capacity constraints
    a. Identify and distribute added traffic from each land-use scenario and model operations of Boston Road at Route 146 under peak conditions for each scenario.
    b. Identify points of critical capacity constraints at the intersection (i.e. movements, conflicting volumes, lanes) for focused traffic capacity sensitivity test.
2. Stress test traffic operations
    a. Incrementally increase existing traffic volumes for constrained areas identified in step 1b, based on linear growth trends implied by the three land-use scenarios.
    b. Determine points of failure in traffic operations based on:
        i. Incremental growth (i.e. volume of trips generated through the intersection)
        ii. Projected timeframe as related to the land-use scenarios

Boston Road at Route 146 Road Safety Audit Recommendations

Potential improvement measures identified by the RSA and summarized in Section 1.6.2 of this report will be considered in the development of alternatives. While all potential improvements will be considered, alternatives development will focus on long-term improvement measures to address safety issues.

Previous Study Recommendations

Recommendations from previous studies summarized in Section 1.3 of this report will be considered in the development of alternatives. The relative age of the recommendations will be considered in terms of the applicability to the current roadway configuration and future needs of the corridor, to be identified through analysis of future land use scenarios.

Stakeholder Input

Input from stakeholders, summarized in Section 1.9 of this report will be considered in the development of alternatives. Stakeholder input ranges from general concerns and suggestions to individual needs identified at specific locations. This input will be referenced throughout the alternative development process to help align alternatives with local needs. In particular, information regarding the locations where land use changes and proposed or planned development would trigger various capital improvements along the corridor will inform development of future land use scenarios and the alternatives.

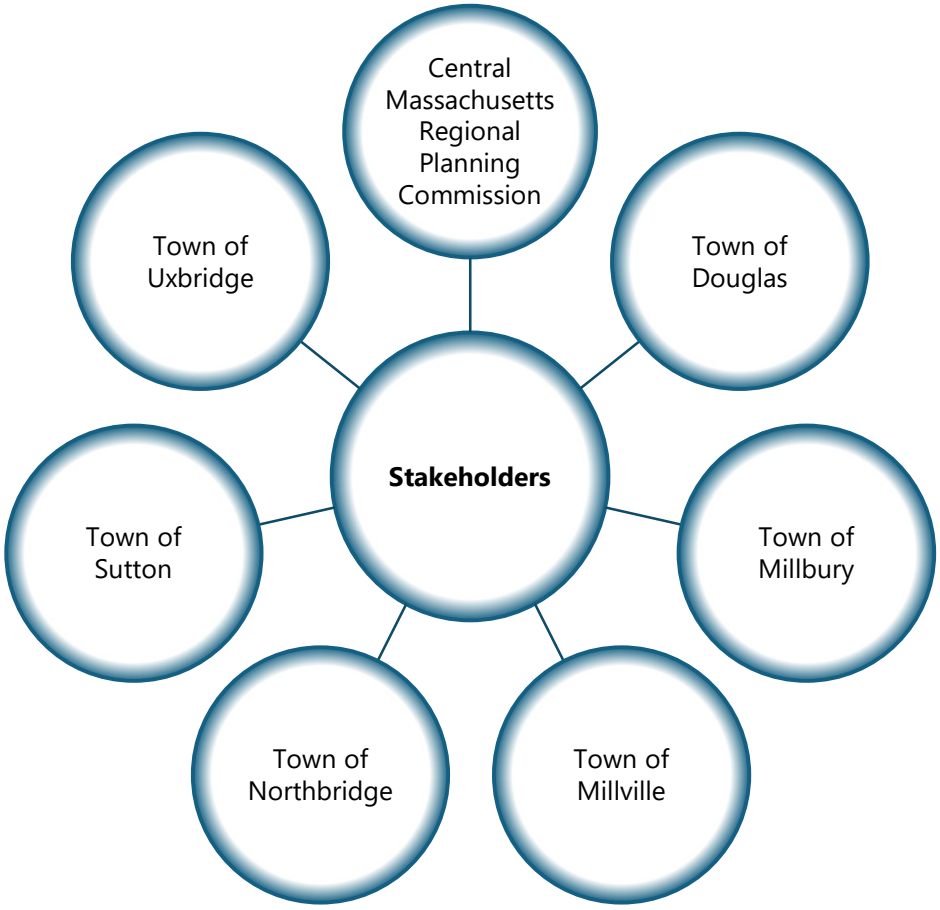
1.9 Stakeholder Interviews

This section provides an overview of the stakeholder interviews and summarizes the major findings. In total, seven stakeholder interviews[1] were conducted wherein interview participants (Figure 1.9-1) were asked to share their experiences and perceptions regarding the Route 146 corridor between Route 122A in Millbury and the Rhode Island State Line in Millville and Uxbridge. The main purpose of the stakeholder interviews was to solicit information regarding the locations where land use changes and proposed or planned development would trigger various capital improvements along the corridor, identify what those improvements might be, and develop alternatives to mitigate congestion from future changes, which will serve as a basis for a transportation master plan for corridor improvements.

The complete stakeholder interview questionnaires are included in Appendix D.

[1] The interviews were conducted September 4 through September 11, 2024, via Microsoft Teams call. The duration of each interview was about 45 minutes.

Figure 1.9-1: Stakeholder Interview Participants



The following are major findings from the stakeholder interviews:

1. Several stakeholders indicated that the list of potential residential/commercial development projects compiled by the project team, found in Appendix E, will have significant impacts on the traffic along Route 146 in the near future. The representatives from the town of Milbury also indicated that they are actively marketing several vacant land parcels along Route 146 and near The Shops at Blackstone Valley for development which would further enhance the travel activity in the region.
2. Stakeholders brought up traffic safety concerns at several locations within the region, with some of the prominent locations including:
    - Route 146 and Douglas Street (Route 16) (Exit 6), Route 146 and West Main Street/Elmwood Street/Elm Street (Exit 16),
    - Route 146 and North Main Street (Route 122A) (Exit 17),
    - Route 146 and Sycamore Street,

- Route 146 and Herricks Lane, and
- Route 146 and Boston Road

3. The Boston Road intersection is the most challenging section of the corridor in terms of congestion and safety according to most stakeholders. Stakeholders also mentioned the need for better signage which would help drivers navigate more safely on Route 146.
4. One of the most common concerns that was expressed during the course of discussions was the increasing freight (truck) traffic along the corridor. The increase in truck traffic is attributed to the increasing number of warehouses in the region (a number of warehouses are proposed to open in the near future as well). Truck drivers driving too fast and not yielding at pedestrian crossings are causing safety concerns for the pedestrians. Further, trucks are causing congestion not just on Route 146 but Route 122 as well. Some stakeholders indicated that there is a need of encouraging railroad connections for freight to get trucks off the road.
5. With the increasing number of trucks, rest areas could be needed in the future.
6. Mixed opinions were received in regard to the need for bicycle and pedestrian infrastructure. Some stakeholders emphasized expanding sidewalks and bike lane networks along the corridor, especially at crossing points near local destinations like grocery stores and shopping areas. On the contrary, some stakeholders indicated that there is not much pedestrian/bicyclist activity in the region as it is predominantly industrial and thus no additional infrastructure along Route 146 is needed. Most stakeholders encouraged the project team to consider completing the Blackstone River Bikeway, a regional bikeway connecting downtown Worcester, Massachusetts, to India Point Park in Providence, Rhode Island.
7. Lack of public transportation was the only equity issue raised by the participants. The towns of Douglas, Millbury, Northbridge and Sutton are part of the Worcester Regional Transit Authority (WRTA) service area, but only Millbury and Northbridge have fixed route service. Millville and Uxbridge are not served by public transit. The Town of Sutton stated that many businesses have hired workers that live in other towns. In the absence of public transportation, workers need to use personal vehicles which in turn increases congestion.
8. In relation to public transportation, representatives from Central Massachusetts Regional Planning Commission (CMRPC) mentioned that the region is aging. Thus, it would be beneficial to support the travel needs of senior citizens via public transit.
9. A need to protect wildlife, wetlands and water bodies (e.g. Blackstone River) along with the corridor improvement initiatives was also mentioned by some of the stakeholders during the interviews.
10. Route 146 passes through residential areas at some locations. Thus, there is a need to mitigate noise pollution.

11. For future public engagement, stakeholder interview participants suggested potential meeting locations as mentioned below:
    - Northbridge: Townhall
    - Douglas: Resource Room
    - Uxbridge: High schools and regional vaccination clinics
    - Sutton: Townhall and senior centers
    - CMRPC: Pleasant Valley Country Club
    - Milbury: Milbury Public School, senior centers, libraries and fire stations
12. Some stakeholders also recommended community organizations that could assist with effective public engagement efforts. For example, the Town of Uxbridge identified local biking groups and the conservation commission as valuable resources. Similarly, the Town of Sutton highlighted the senior resource team and church/school communities. CMRPC mentioned the Blackstone Chambers group.

Chapter 2: Scenario Planning

2.1 Task Goals

Task 2 considers various development scenarios to identify the potential operational impacts on the Route 146 corridor and how different land use buildout scenarios would affect the corridor. The starting point for determining the scenarios was to identify developments currently in the planning and permitting process that are expected to be constructed in the near term. From there, additional potential developments, including parcels likely to be redeveloped, were identified for inclusion in higher growth development scenarios. The process for identifying the development potential and assessing their impacts on Route 146 are described below.

2.2 Development Review

2.2.1 Known Developments

Many developments, mainly industrial and residential, are in various stages of planning in the vicinity of the Route 146 study area. A total of 24 known developments were analyzed to estimate the added traffic to Route 146 and how that would impact the corridor. The 24 developments were compiled from a list compiled by the Central Massachusetts Regional Planning Commission (CMRPC) and information provided during stakeholder interviews. Of the known developments, most were residential or industrial. The developments are located throughout the whole study corridor, with Uxbridge, Sutton and Milbury containing the majority of the developments. Summaries of the developments are in Table 2.2-1 and Table 2.2-2 below. Details of the known developments and their respective land use can be found in Appendix E.

Table 2.2-1: Development Locations

Development Location						
Uxbridge	Sutton	Millbury	Douglas	Grafton	Northbridge	Multiple Towns
6	6	4	2	1	1	4

Table 2.2-2: Type of Development

Development Category					
Industrial	Residential	Services	Retail	Mixed Use	Total Developments
9	10	2	1	2	24

2.2.2 Potential Developments

A Land Use and Zoning Analysis was conducted for the Route 146 corridor and is included in Appendix F. The analysis focused on quantifying existing land uses, the land value as investment potential, the development opportunity afforded by zoning, and redevelopment potential in each town.

In the study area, existing residential land uses account for about half of the land area (53.3%). The next largest shares of land use are industrial (11.2%), commercial (8%), and mixed-use areas (7.8%). The remaining land area is exempt from redevelopment (15%), which includes parks, schools, and government-owned properties. Land categorized as "other" (4.7%) includes uses such as Right-of-Way, utility infrastructure, or private infrastructure.

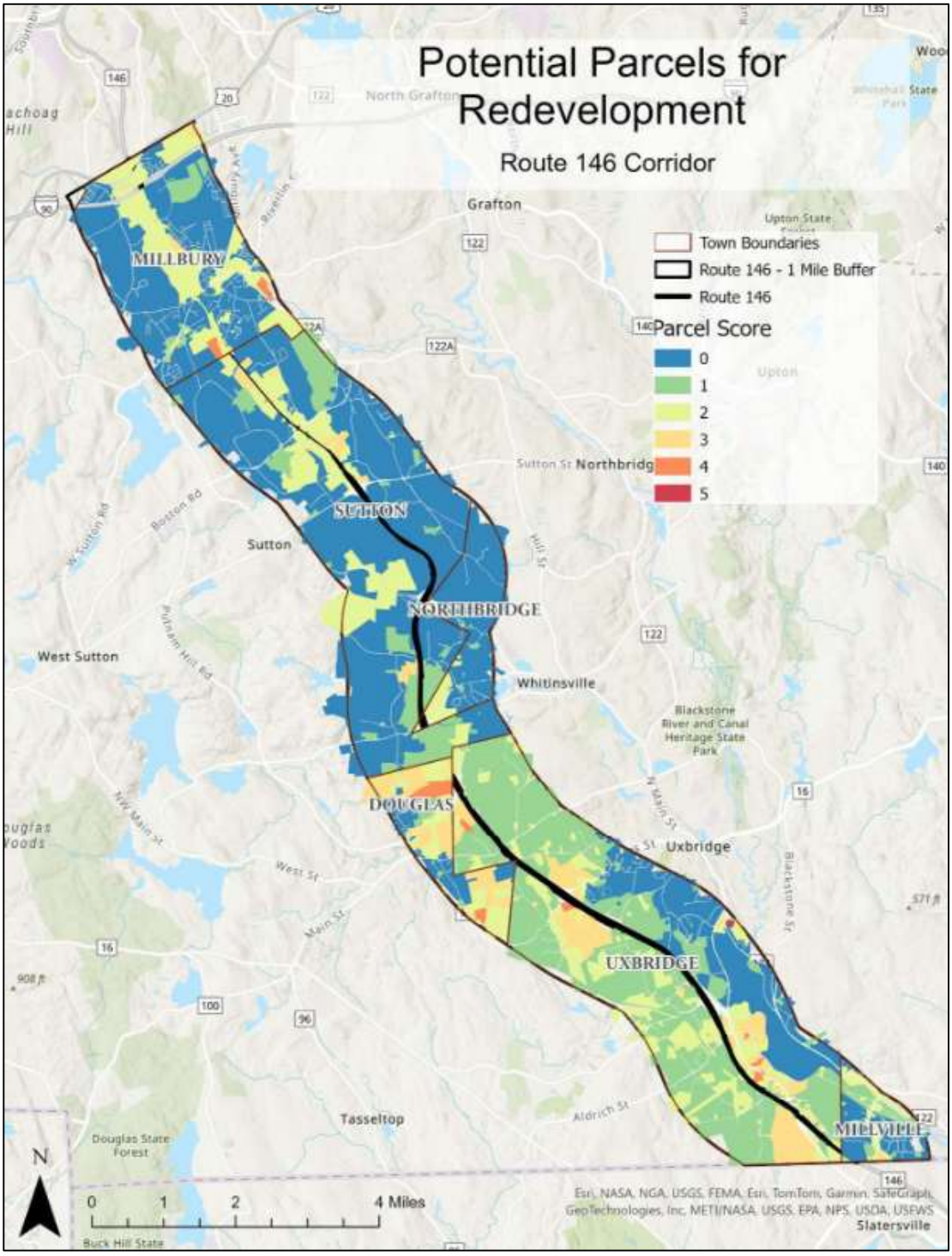
Land value affects redevelopment potential, and land value per acre throughout the towns in the study area, was analyzed to determine where lower-cost land may promote future redevelopment. This analysis found that the cost per acre varied between towns, with the median cost around $111,100 per acre. Millbury and Northbridge had the highest median land values at around $169,000 and $178,000 per acre, respectively. Douglas, Millville, and Sutton are in the middle range of land value at around $82,200, $102,600, and $91,600 per acre, respectively. The parcels in Uxbridge had the lowest land value in the study area, with a median land value of around $70,600 per acre,

Zoning regulations for each town can be subject to change in the future and provide an indicator of current development potential. Each town's zoning regulations were reviewed, and it was found that Douglas was the most favorable for development with each zone allowing for multiple uses. Sutton, Uxbridge, Millbury, and Northbridge have more zoning regulations resulting in more constraints to development. Millville's zoning regulations offer the least flexibility in development types and size. In the zoning regulations, all buildings have to be less than four-stories tall and only three zoning districts are allowed, where as other towns have more districts allowed. This results in small-scale developments being encouraged throughout Millville.

The redevelopment opportunity analysis considered the zoning regulations, land-to-building ratios, planned developments, and land vacancy. Planned developments include projects previously identified throughout the study area. The land-to-building ratio identifies parcels that could be favored for redevelopment due to the land value being greater than the building value, resulting in a ratio greater than one. When completing this analysis for all parcels, Sutton and Northbridge have the highest number of parcels with ratios above one, showing that these towns provide the greatest opportunity for redevelopment. Another factor analyzed was the number of vacant parcels in each town where new development could occur. Uxbridge has the largest amount of vacant land of all the towns and accounts for 5% of the land in the study area. Towns with low to no developable vacant lots would rely more heavily on redevelopment or infill for future growth.

To identify redevelopment potential, parcels were categorized based on the criteria described above and then given a score of zero to five from least to greatest development potential, respectively. By combining the different criteria and assigning a score, parcels that are more likely to be developed and support the future growth of the corridor are identified. A map of parcel scoring for the study corridor is included in Figure 2.2-1. The scoring is from zero to five based on a compilation of categorized scores for factors impacting development potential, including: zoning regulations, land-to-building value, the development pipeline, and vacant land. For zoning regulations, points were awarded based on how permissive or restrictive they are for new developments. Land-to-building value was scored based on the resulting ratio between the value of the land and the building value as a measure of redevelopment potential. The current development pipeline was reviewed, and parcels were assigned a point if they had developments identified. Lastly, if a parcel had developable vacant land a point was awarded. Scores were compiled into values ranging from zero to five, with parcels with higher scores having the highest development potential. From this analysis, Uxbridge and Douglas are towns that show a high potential for development in the near term, while Uxbridge and Millbury have the greatest overall development potential. The complete Land Use and Zoning Analysis report is included in Appendix F.

Figure 2.2-1: Parcel Scores throughout Study Area



2.3 Future Scenario: All Known Developments

Future scenario testing was used to determine when grade separation of Boston Road becomes critical. The baseline future condition includes existing roadway volumes, with volumes from all known developments layered on top. When analyzing the future scenario with known developments, it was found that the intersection of Boston Road and Route 146 would fail before all known developments are constructed. The process and results for this scenario are explained in the following section. As adding more growth to an already failing system would not provide meaningful information, additional development scenarios were not tested for the existing Boston Road intersection. Instead, additional growth scenarios were tested for the grade-separated alternatives to provide an assessment of the capacity for growth provided by grade separation.

The methodology to forecast growth from all known developments as well as the operational findings are provided in the sections to follow.

2.3.1 Trip Generation and Distribution

The trip generation and distribution process utilized information provided by traffic impact studies, where available. Where prior studies had not been completed, trip generation and distribution estimates were developed. A summary of the prior studies used can be found in Appendix G. To assess trip generation and distribution, developments were split into three different groups as described below and listed in Table 2.3-1.

1. Developments with information provided from prior studies
    a. Trip generation and distribution obtained from prior studies
    b. Trip generation obtained from prior studies and trip distribution developed
2. Developments where trip generation and distribution was developed using the Institute of Transportation Engineers (ITE) Trip Generation process and existing routing patterns
3. Developments that are outside of the study area

Table 2.3-1: Development Groups for Trip Generation and Distribution

Development Group Methodology	Development Name
1a. Trip generation and/or distribution obtained from prior studies	Lackey Dam Logistics
	Blackstone Logistics Center
	Unified Parkway
	Residence at Pleasant Valley Crossing
	Northeast Great Dane - Trailer Repair Facility
1b. Trip generation obtained from prior studies and trip distribution developed	Zipp Industrial Park
	Rice Pond Village 40B
	19 Canal
	Clearview
	Xtra Mart Expansion
	Singletary Arms
	Big Y Supermarket
2. Trip generation and distribution developed	Cubes at Gilboa
	Cubes at Pyne
	Pleasant Valley Crossing Phase 2
	139 Campanelli Drive
	Amazon
	Cresco Lab (Cultivate)
	North Village Condominiums 40B Project
	40B Armsby Road
	Route 146S 40B
3. Outside of study area boundary - trip generation not included in study	The Woodlands at Village of the Americas
	Fisherville Terrace
	Stone Hill Condominiums

For each group, a different process was applied to estimate the trips added to Route 146 and at the study intersections, as described below.

Development Group 1

For the twelve developments in this group, project reports were referenced that included trip generation and/or trip distribution. The trip distribution was directly applied to the network where applicable. Where necessary, existing traffic patterns were used to extend project trips through the study network.

Development Group 2

The nine developments in this group required the use of Institute of Transportation Engineers (ITE) Trip Generation Manual 11th Edition to find the entering and exiting trips during peak periods. To distribute trips originating from a wide range of locations throughout the study area, Route 146 was split into two segments: a northern segment from Route 146/Route 122 to Purgatory Road and a southern segment from Purgatory Road to the Rhode Island Border. For each segment, the existing proportions of northbound and southbound traffic were used to estimate directionality of project traffic entering from and exiting to Route 146 during the two peak periods. A proportion of project traffic was then diverted to interchanges throughout the corridor based on the proportions of Average Annual Daily Traffic (AADT) for each interchange. The resulting volumes were then distributed through study intersections at Lackey Dam Road and at Boston Road for traffic analysis purposes.

Development Group 3

These projects were outside of the one-mile buffer around Route 146 and these developments are not included in the trip generation and distribution for the study intersections at Boston Road and Lackey Dam Road.

2.3.2 All Known Developments Volume Scenario

With all known developments constructed, the total amount of trips added to the intersection of Route 146 and Boston Road was estimated to be 1,196 vehicles during the morning peak hour and 1,842 vehicles in the afternoon peak hour. At Boston Road and Pleasant Valley Road/Dudley Road an estimated 718 morning peak hour trips and 1,145 afternoon peak hour trips are added. At the Lackey Dam Road interchange, 762 vehicles and 829 vehicles could be added during the morning peak hour and afternoon peak hour, respectively, if all developments occur.

2.3.3 Planned Roadway Improvements

The Unified Parkway development and the proximity to the intersection of Route 146 and Boston Road includes mitigation to help accommodate additional trips to and from the development. At Route 146 and Boston Road, the number of westbound right-turn lanes will increase from one to two, and removal of the channelized eastbound right-turn island will result in a through lane and a shared through/right lane. These improvements were included when modeling capacity analysis for future year scenarios, including known developments and the sensitivity test.

2.4 Operational Analysis

Future operational analysis for the All Known Developments scenario was conducted at the study intersections using Synchro 11 software, based on the latest Highway Capacity Manual methodologies, consistent with the Existing Conditions operational analysis presented in Section 1.7.

Vehicle operations are described below for each study intersection.

Route 146 and Boston Road

The additional traffic from all known developments causes the intersection to fail with an overall Level-of-Service (LOS) F grade and high intersection delays for most individual movements during the morning peak hour. In the afternoon peak, the overall intersection operation is LOS E and reaches overall capacity limits for the intersection, while individual movements are significantly over capacity with high delays. The operational analysis of the intersection with all known developments is in Table 2.4.-1 and Synchro reports are in Appendix B.

Boston Road and Pleasant Valley Road/Dudley Road

Under existing conditions, Pleasant Valley Road is used for northbound connections to Boston Road, accommodating left turns and U-turns and the majority of right turns from Route 146 onto Boston Road. With the additional traffic from all known developments accessing Boston Road, movements along Boston Road operate at LOS A or B during the morning and afternoon peak hours. Northbound movements on Pleasant Valley Road operate at LOS F, experience high delays, and are over capacity during both peak periods. Dudley Road operates at LOS C during the morning peak hour and LOS F during the afternoon peak hour. The operational analysis of the intersection with all known developments is shown in Table 2.4-1 and Synchro reports are in Appendix B.

Route 146 and Lackey Dam Road

With the additional trips added to the interchange, specific turning movement operations degrade. At the southbound ramp, the left-turning movement operates at LOS E in the morning peak hour, due to the location of developments along Lackey Dam Road and associated demand for the movement. For the northbound ramp during the morning and afternoon peak periods, operations remain at LOS D or better in all periods. The operational analysis at Lackey Dam Road with the added volume from all known developments is in Table 2.4-2 and Synchro reports are in Appendix C.

Conclusions - Capacity for All Known Developments

At Route 146 and Boston Road the intersection is projected to fail during the morning peak hour with users expected to experience high delays, congestion, and extensive queues. Along with the overall intersection being over capacity, multiple individual movements are also projected to be

over capacity. Given the poor operations, grade separation is projected to be necessary before all known developments are constructed, to accommodate the traffic demand at Route 146 and Boston Road. A subsequent sensitivity analysis was conducted to determine the percentage of known development that exceeds capacity of the existing intersection configuration.

At the ramps connecting Route 146 to Lackey Dam Road, movements along Lackey Dam Road would operate at acceptable conditions with the added trips from all known developments. Movements from the Route 146 ramps would experience more congestion and delay with the added trips. With all new developments the interchange would still operate at acceptable conditions, but signalization of the ramps may be considered to accommodate significant increases to turning movements to and from the ramps.

Table 2.4-1: Boston Road and Route 146 All Known Developments Operational Analysis

			Weekday Morning					Weekday Afternoon				
Intersection	**Approach**		**LOS[1]**	**Delay[2]**	**V/C[3]**	**50th Q[4]**	**95th Q[5]**	**LOS**	**Delay**	**V/C**	**50th Q**	**95th Q**
Route 146 at	EB	L	F	101.9	0.77	95	114	E	77.3	0.55	64	118
Boston Road		T/TR	F	87.9	0.89	152	142	E	58.6	0.47	81	118
	WB	L	F	119.1	0.98	122	214	F	230.3	1.39	408	537
		T	F	94.1	0.80	143	265	E	74.1	0.81	225	326
		R	E	58.5	0.86	116	211	C	20.2	0.74	80	147
	NB	T/TR	F	109.9	1.16	1219	1296	F	84.7	1.08	739	900
	SB	L	F	368.3	1.70	380	476	F	145.6	1.17	308	454
		T	B	13.0	0.53	285	303	C	22.0	0.69	448	561
		R	A	0.9	0.03	0	6	A	1.5	0.06	0	14
	Overall		*F*	*100.4*	*1.05*			*E*	*76.9*	*1.00*		
Boston Road at	EB	LT/TR	A	8.9	0.01	n/a	0	B	12.3	0.02	n/a	0
Pleasant Valley Road and	WB	LT/TR	A	8.8	0.00	n/a	0	A	9.0	0.01	n/a	0
Dudley Road	NB	LTR	F	104.5	1.09	n/a	380	F	629.7	2.25	n/a	698
	SB	LTR	C	20.7	0.19	n/a	18	F	193.1	1.05	n/a	158

1 Level-of-Service
2 Average vehicle delay, in seconds
3 Volume to capacity ratio; intersection capacity utilization reported for overall
4 50th percentile queue based on Synchro outputs, in feet
5 95th percentile queue based on Synchro outputs, in feet
n/a Not applicable

Table 2.4-2: Route 146 and Lackey Dam Road All Known Developments Operational Analysis

			Weekday Morning					Weekday Afternoon				
Intersection	**Approach**		**LOS[1]**	**Delay[2]**	**V/C[3]**	**50th Q[4]**	**95th Q[5]**	**LOS**	**Delay**	**V/C**	**50th Q**	**95th Q**
Lackey Dam Road at	EB	TR	A	0.0	0.53	n/a	0	A	0.0	0.46	n/a	0
Worcester-Providence Turnpike (Route 146)	WB	LT	A	1.3	0.08	n/a	8	A	1.7	0.11	n/a	10
SB Ramps	SB	L	E	36.3	0.34	n/a	35	D	32.7	0.24	n/a	23
		R	C	21.2	0.67	n/a	128	A	0.0	0.00	n/a	0
Lackey Dam Road at	EB	LT	A	6.5	0.43	n/a	55	A	7.2	0.42	n/a	53
Worcester-Providence Turnpike (Route 146)	WB	TR	A	0.0	0.18	n/a	0	A	0.0	0.26	n/a	0
NB Ramps	NB	L	C	21.8	0.57	n/a	90	C	17.2	0.41	n/a	50
		R	B	11.1	0.20	n/a	18	A	0.0	0.00	n/a	0

1 Level-of-Service
2 Average vehicle delay, in seconds
3 Volume to capacity ratio
4 50th percentile queue based on Synchro outputs, in feet
5 95th percentile queue based on Synchro outputs, in feet
n/a Not applicable

2.5 Known Developments Sensitivity Analysis

A sensitivity analysis was completed to determine when grade separation at Route 146 and Boston Road is necessary based on volume growth from known developments. Boston Road and Pleasant Valley Road/Dudley Road was also tested to understand when it may be necessary to implement a traffic signal.

As stated in Section 2.3.2, with known developments, 1,196 vehicles per hour (vph) and 1,842 vph are added to the intersection of Route 146 and Boston Road during the morning peak hour and afternoon peak hour, respectively. Relative to existing conditions, 1,196 vph represents a 26% increase in traffic volume at the intersection during the morning peak hour. In the afternoon peak hour, 1,842 vph corresponds to a 42% volume increase. A summary of the sensitivity test related to the percent of development growth and total vehicles added to the intersection is shown in Table 2.5-1 and Table 2.5-2.

Table 2.5-1: Morning Peak Hour Sensitivity Test Growth Increments – Boston Road and Route 146

						100% Development 1,196 vph 26% Volume Growth						
Percent of Developments	0%	18%	36%	55%	73%	91%		109%	128%	146%	164%	182%
Total Vehicles Added	0	218	436	654	872	1,090		1,308	1,525	1,743	1,960	2,181
Volume Growth for Sensitivity Test	0%	5%	10%	15%	20%	25%		30%	35%	40%	45%	50%

Table 2.5-2: Afternoon Peak Hour Sensitivity Test Growth Increments – Boston Road and Route 146

									100% Development 1,842 vph 42% Volume Growth			
Percent of Developments	0%	12%	25%	37%	49%	62%	74%	86%	98%		111%	123%
Total Vehicles Added	0	227	454	681	906	1,134	1,359	1,585	1,813		2,040	2,269
Volume Growth for Sensitivity Test	0%	5%	10%	15%	20%	25%	30%	35%	40%		45%	50%

The known developments would represent an approximately 26% volume increase in the morning peak hour and a 42% volume increase in the afternoon peak hour. The sensitivity test includes growth in both peak hours of up to 50%, which exceeds known developments. This process further stressed portions of the intersection that were under capacity to better understand the progression of intersection failure and to inform the development of alternatives.

2.5.1 Methodology

A baseline scenario was created by optimizing the signal timings in Synchro to provide a consistent comparison across the sensitivity analysis. The existing AM and PM peak hour volumes were increased in 5% increments up to 50% total volume growth and the impacts to intersection operations were modeled. Two metrics of intersection performance were considered to understand impacts of traffic growth: volume to capacity (v/c) ratios and overall intersection Level of Service (LOS). The v/c ratios were recorded for the different lane groups under the increased volume scenarios. A v/c ratio was noted if it was greater than or equal to 1.05, meaning the approach is more than exceeding the capacity available. Overall intersection delay in seconds per vehicle was recorded and converted to the associated LOS grade.

The same process was completed at Pleasant Valley Road since northbound left turns and U-turns must go to Pleasant Valley Road and then Boston Road to complete those movements.

2.5.2 Route 146 and Boston Road Sensitivity Results

Morning Peak Hour (Critical Peak)

On Route 146, the northbound through/right movement exceeded a volume to capacity ratio of 1.05 at a 15% increase from the existing morning peak volumes. This approach was already near capacity under existing conditions and is reasonably the first movement to fail as traffic grows.

The next movement to fail is the westbound left, at a 45% increase from existing morning peak volumes. At a 50% increase from existing volumes the westbound left, westbound through, and northbound through/right are all failing with multiple other movements close to failure as well, as seen in Table 2.5-3.

Considering the overall intersection delay and LOS, the intersection is nearing capacity limits (LOS E) at a 15% increase in volume, which represents roughly half of the known developments. At about a 26% increase in volumes, the intersection reaches LOS F. Each of these critical points of growth and their LOS can be seen in Figure 2.5-1.

Afternoon Peak Hour

In the afternoon peak hour, the only approach at the Route 146 and Boston Road intersection that reaches capacity is the northbound through/right movement, as seen in Table 2.5-4. This occurs at a 40% increase in existing volume, which corresponds to about 98% of all known development traffic.

During the evening peak hour, the intersection begins at LOS C; however, it does not reach failure with the maximum volume increase of 50%, as seen in Figure 2.5-2. At a 50% increase in volumes, which corresponds to 123% of known development traffic, the intersection is approaching LOS F. At around a 38% increase in volume, the intersection operates at LOS E. The morning peak hour would control future improvements since the afternoon peak hour has more capacity for volume growth.

Table 2.5-3: Morning Peak Hour Capacity Utilization

		Percent of Capacity Utilized (%)										
Boston Road Eastbound	Left	69%	74%	77%	80%	83%	85%	87%	90%	93%	96%	100%
	Thru/Right	67%	71%	74%	77%	81%	84%	86%	89%	94%	97%	101%
Boston Road Westbound	Left	73%	77%	82%	85%	87%	90%	94%	98%	102%	105%	109%
	Thru	76%	81%	84%	86%	89%	92%	94%	97%	101%	104%	109%
	Right	64%	69%	73%	77%	80%	83%	85%	89%	92%	95%	99%
Route 146 Northbound	Thru/Right	95%	97%	102%	107%	112%	117%	122%	127%	132%	137%	142%
Route 146 Southbound	Left	68%	72%	76%	78%	80%	83%	84%	88%	90%	92%	95%
	Thru	46%	48%	50%	52%	55%	57%	59%	62%	64%	66%	69%
	Right	3%	3%	3%	3%	3%	3%	3%	4%	4%	4%	4%
Volume Increase		Existing	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%

Figure 2.5-1: Morning Peak Hour (Critical Peak) Intersection Delay

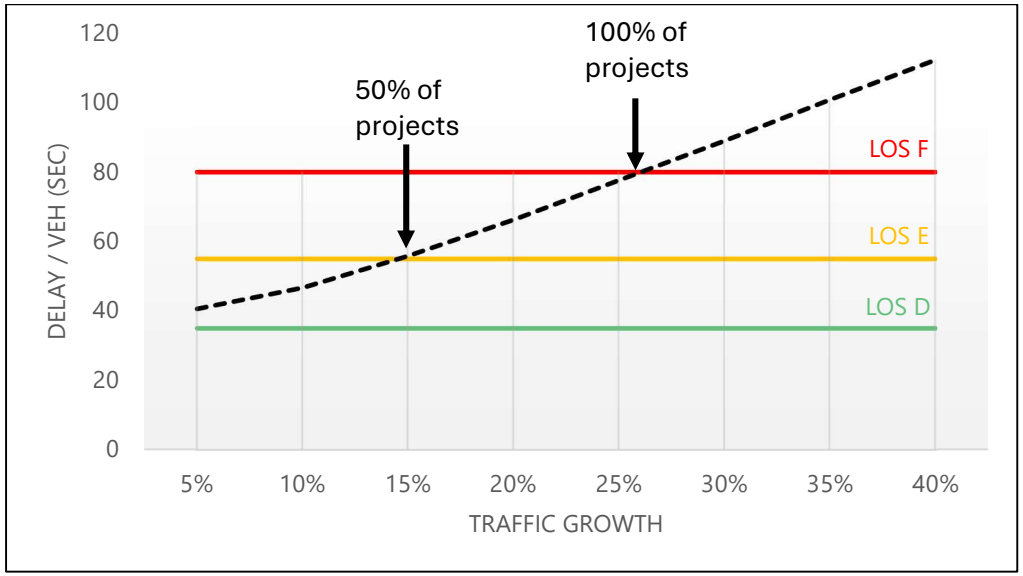
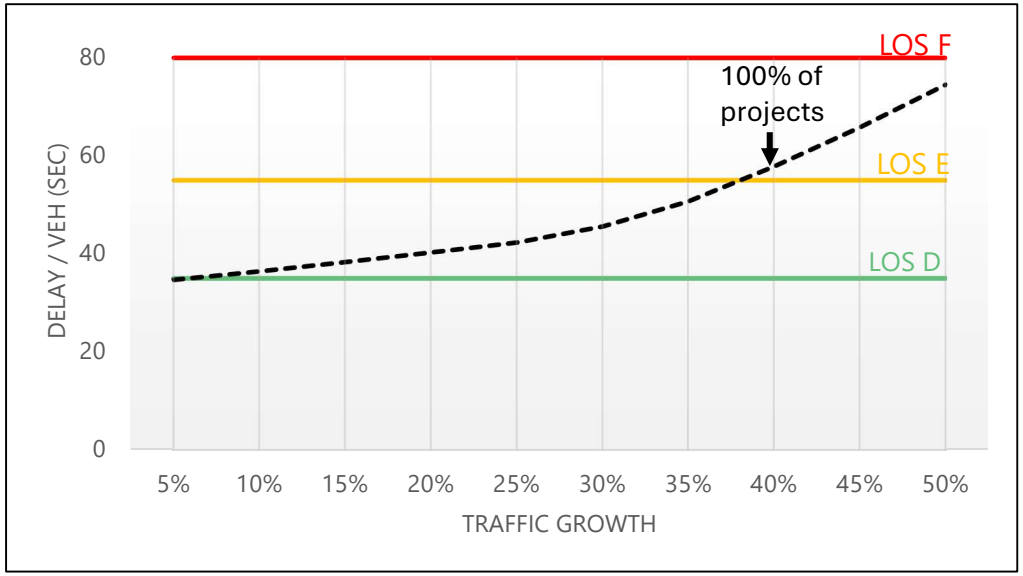


Table 2.5-4: Afternoon Peak Hour Capacity Utilization

		Percent of Capacity Utilized (%)										
		Existing	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
Boston Road Eastbound	Left	47%	50%	53%	57%	61%	65%	68%	70%	72%	74%	77%
	Thru/Right	43%	46%	49%	53%	56%	59%	60%	61%	63%	65%	65%
Boston Road Westbound	Left	70%	73%	76%	79%	82%	85%	88%	90%	93%	95%	98%
	Thru	69%	71%	74%	76%	78%	81%	83%	84%	85%	87%	90%
	Right	36%	37%	38%	39%	39%	40%	41%	41%	42%	42%	43%
Route 146 Northbound	Thru/Right	86%	88%	90%	91%	93%	94%	98%	102%	107%	112%	116%
Route 146 Southbound	Left	65%	67%	70%	72%	75%	79%	81%	83%	84%	86%	89%
	Thru	71%	74%	76%	78%	81%	83%	86%	90%	93%	97%	100%
	Right	5%	6%	6%	6%	6%	7%	7%	7%	7%	8%	8%

Figure 2.5-2: Afternoon Peak Hour Intersection Delay



2.5.3 LOS by Development Growth Increments - Route 146 and Boston Road

In the morning peak hour, the traffic generated by all known developments, as described in Section 2.3.2, would increase the volume at the intersection by a total of 1,196 vehicles/hour. In relation to the sensitivity analysis, the volumes from all known developments represent a 26% increase in volume at the intersection. If about half of anticipated developments occur, the intersection would have multiple failing movements and have an overall intersection LOS E, as seen in Table 2.5-5. If all known developments occur, the intersection would fail with multiple failing movements.

Table 2.5-5: Traffic Volume Growth & LOS by Percent of Development – Morning Peak

Morning Peak Hour Sensitivity Testing			**Percent of All Known Developments**
Percent Volume Increase	**Volume Change from Existing**	**LOS**	
Baseline	0	D	0%
10%	436	D	36%
15%	654	E	55%
20%	872	E	73%
25%	1,090	E	91%
30%	1,308	F	109%
Additional Volume from All Known Developments: **1,196 vph**			

For the afternoon peak hour, it is projected that an additional 1,842 vehicles/hour would be added to the intersection from all known developments. This added volume would represent around a 40% increase from existing conditions and the intersection would operate at LOS E, as seen in Table 2.5-6. At a 50% increase from existing conditions, which exceeds known development potential, operations in the afternoon peak hour are at LOS E. The morning peak hour would dictate the need for improvements, since it reaches capacity with a lesser increase in volume.

Table 2.5-6: Traffic Volume Growth & LOS by Percent of Development – Afternoon Peak

Afternoon Peak Hour Sensitivity Testing			Percent of All Known Developments
Percent Volume Increase	**Volume Change from Existing**	**LOS**	
Baseline	0	C	0%
10%	454	D	25%
35%	1,585	D	86%
40%	1,813	E	98%
45%	2,040	E	111%
Additional Volume from All Known Developments: **1,842 vph**			

2.5.4 Boston Road and Pleasant Valley Road/Dudley Road Sensitivity Test Results

Pleasant Valley Road and Dudley Road currently operate under stop control, while approaches on Boston Road are free flowing. Operations on Pleasant Valley Road and Dudley Road were reviewed since those approaches are affected by increased volumes prior to grade separation. Existing volumes at Boston Road and Pleasant Valley Road/Dudley Road were increased by 5% increments to a 50% increase. If all developments occur, 718 vph and 1,145 vph are added to this intersection during the morning and afternoon peak hour, respectively. A summary of incremental percent growth for the sensitivity test related to the percent of development growth and total vehicles added to the intersection is shown in Table 2.5-7 and Table 2.5-8.

Table 2.5-7: Morning Peak Hour Sensitivity Test Growth Increments – Boston Road and Pleasant Valley Road/Dudley Road

Percent of Developments	0%	6%	12%	19%	25%	31%	37%	44%	50%	56%	62%
Total Vehicles Added	0	45	88	133	179	226	268	314	357	402	448
Volume Growth for Sensitivity Test	**0%**	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**	**35%**	**40%**	**45%**	**50%**

Table 2.5-8: Afternoon Peak Hour Sensitivity Test Growth Increments – Boston Road and Pleasant Valley Road/Dudley Road

Percent of Developments	0%	5%	10%	14%	19%	24%	29%	34%	39%	43%	48%
Total Vehicles Added	0	53	112	165	219	280	332	386	441	498	554
Volume Growth for Sensitivity Test	**0%**	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**	**35%**	**40%**	**45%**	**50%**

Morning Peak Hour

None of the movements at Boston Road and Pleasant Valley Road reach capacity with up to a 50% increase in volume in the morning peak hour, as seen in Table 2.5-9. The northbound movement, which is carrying the traffic from Route 146, would reach a v/c ratio of 0.67 at a 50% increase from existing morning peak volumes, which relates to 62% of developments occurring.

Table 2.5-9: Boston Road and Pleasant Valley Road/Dudley Road Capacity Utilization

	Percent of Capacity Utilized (%)	
	NB	**SB**
	LTR	**LTR**
Existing Volume	30%	10%
5%	33%	11%
10%	35%	13%
15%	38%	14%
20%	42%	15%
25%	45%	17%
30%	48%	18%
35%	53%	20%
40%	57%	23%
45%	61%	24%
50%	67%	27%

Afternoon Peak Hour

At the Boston Road and Pleasant Valley Road intersection, the northbound movement fails at a 45% increase from existing afternoon peak traffic volumes or around 43% of developments occurring, as seen in Table 2.5-10. The southbound movement does not reach capacity.

Table 2.5-10: Boston Road and Pleasant Valley Road/Dudley Road Capacity Utilization

	Percent of Capacity Utilized (%)	
	NB	SB
	LTR	LTR
Existing Volume	42%	24%
5%	47%	27%
10%	53%	30%
15%	58%	33%
20%	64%	38%
25%	72%	42%
30%	80%	47%
35%	88%	51%
40%	97%	58%
45%	108%	64%
50%	121%	74%

2.5.5 Boston Road and Pleasant Valley Road/Dudley Road Sensitivity Test Analysis

Signalization of Boston Road at Pleasant Valley Road/Dudley Road is a possible solution to improve operations with the increased volumes from all known developments under the existing roadway configuration. In the morning peak hour, the intersection does not reach capacity and failure. In the afternoon peak hour, the intersection is over capacity at a 45% increase from existing volumes, which is 498 additional vehicles. If all developments occur, an estimated 1,145 additional trips would be added to the intersection during the afternoon peak hour. If less than half of the developments occur, the intersection would be over capacity and failing.

2.6 Multimodal Connections

Opportunities for pedestrian and bicycle transportation in the project area are numerous, though to date, few of these initiatives have materialized. Existing pedestrian and bicycle infrastructure is limited, despite the number of destinations within the project area that a local resident might want to access by biking or walking. The existing and envisioned pedestrian and bicycle infrastructure is depicted in Figure 2.6-1 and described below.

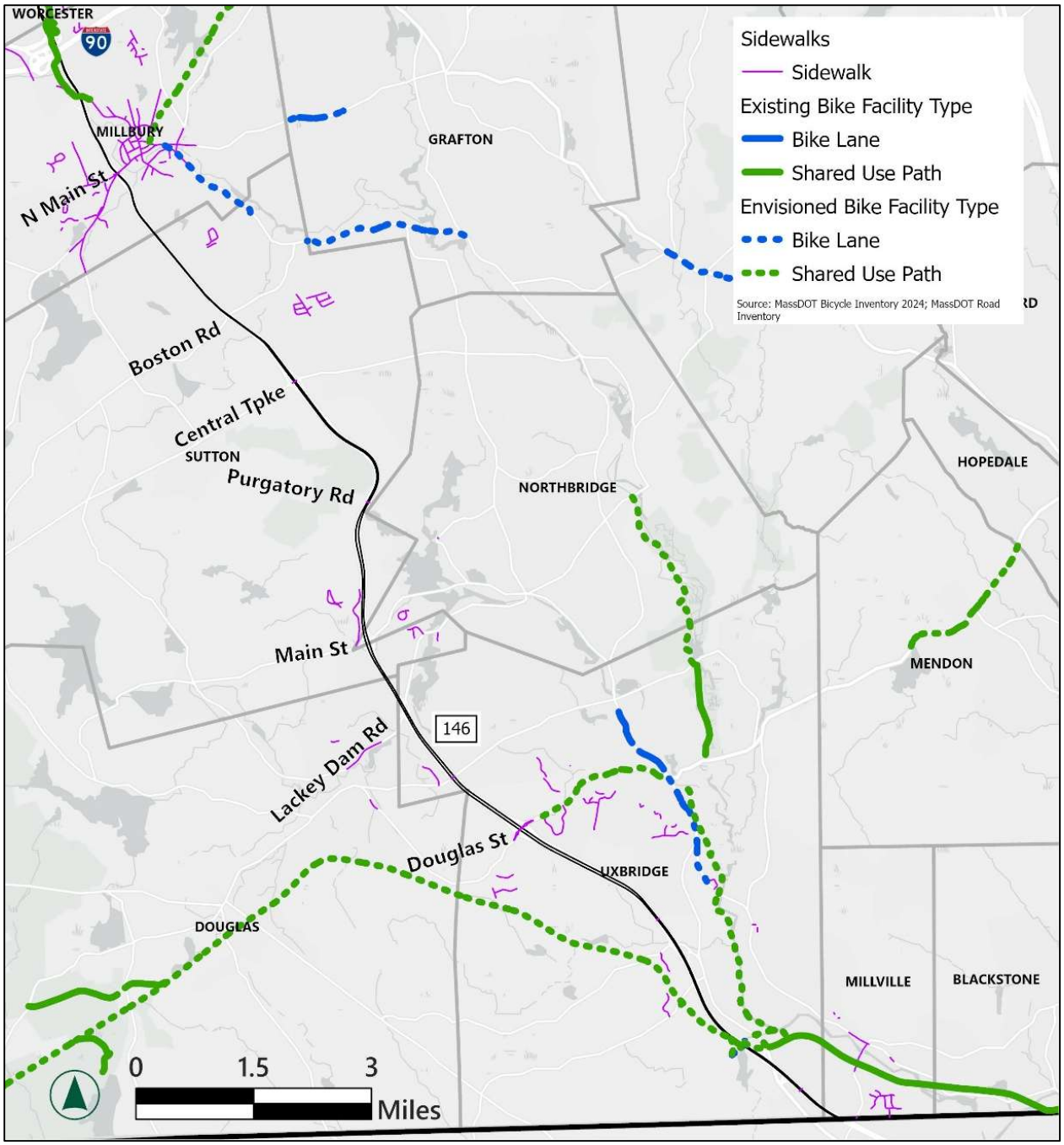
Potential walking or biking destinations within the study area include:

- Millbury Junior/Senior High School
- Shaw Elementary School, Millbury
- Elmwood Street Elementary School, Millbury
- Downtown Millbury
- The Shops at Blackstone Valley Plaza, Millbury
- Uxbridge High School, Uxbridge
- Lackey Pond Wildlife Management Area, Uxbridge
- West End Creamery, Northbridge
- Purgatory Chasm State Reservation, Sutton
- Douglas High School, Douglas
- Douglas Middle School, Douglas
- Douglas Village, Douglas

For those choosing to walk or bike, existing infrastructure allows high comfort car-free travel to only a few of these locations.

The most notable example of bike-ped infrastructure in the Blackstone Valley is the Blackstone River Greenway (also called the Blackstone River Bikeway and the Blackstone Valley Bikeway). This facility was first proposed in the 1980s as a 48-mile off-road route connecting communities from Worcester to Providence, to be a combination of rail-trail, rail-with-trail, canal towpath, and paths on other rights-of-way. To date, on the Massachusetts side of the state line, approximately 6.2 miles of shared-use path have been completed: 3.7 miles in Uxbridge, Millville, and Blackstone connecting to the Rhode Island border (segment 1), and 2.5 miles in Worcester and Millbury (segments 6 & 7). The Massachusetts Department of Conservation and Recreation (DCR) conducted a feasibility study for Segment 2, from the current northern end of the trail in Uxbridge to DCR's Riverbend Farm property, to assess route options and impacts. That project is found on MassDOT's Massachusetts Bicycle Facility Inventory as an envisioned shared-use path. Segments 3, 4, and 5, from Riverbend Farm to the southern terminus of the existing trail in Millbury, are currently on hold. Design and permitting for these segments was suspended due to the environmental impacts and complexity of routing a shared-use path through the communities between Uxbridge and Millbury.

Figure 2.6-1: Existing and Envisioned Walking and Bicycling Facilities



The study area includes other examples of pedestrian and bicycle infrastructure:

- The Coppola Street / Buxton Street bridge over Route 146 in Uxbridge includes a sidewalk on its south side but no sidewalk connections
- The Mill Street bridge over Route 146 in Uxbridge includes a sidewalk on its south side but no sidewalk connections
- The Douglas Street roundabouts and underpass in Uxbridge feature curb-separated sidepaths on both sides of the street from Campanelli Drive in the west to approximately 501 Douglas Road in the east
- The Hartford Avenue West bridge over Route 146 in Uxbridge includes a sidewalk on its north side but no sidewalk connections
- The Purgatory Road bridge over Route 146 in Sutton includes a sidewalk on its north side but no sidewalk connections
- The Central Turnpike bridge over Route 146 in Sutton includes a sidewalk on its north side but no sidewalk connections
- The Elmwood Street / West Main Street / Elm Street underpass of Route 146 in Millbury includes two roundabouts (both with sidewalks) which connect to sidewalks that lead further east into downtown Millbury and west to the entrances to the town's two elementary schools (Shaw Elementary and Elmwood Street Elementary)
- The North Main Street (SR 122A) bridge over Route 146 includes a sidewalk on its south side which connects directly to the Blackstone River Greenway on the east end of the span.

In addition to these existing sidewalks in the study area, there is interest in building more facilities for those who walk or bike:

- In Uxbridge, the rehabilitation of approximately two miles of Route 16 (Douglas Street) from Taft Hill Road to a point just west of Main Street, is to include a shared-use path (funded for construction) on the north side of the roadway. This would connect with the existing sidepaths that traverse the roundabouts and underpass at Route 146
- Also in Uxbridge, bike lanes have been planned for the Elmwood Avenue underpass of Route 146 as part of the connection between portions of the Southern New England Trunkline Trail (SNETT), a partly developed rail-trail

- The Town of Millbury has expressed interest in extending the Blackstone River Greenway, from its current terminus on North Main Street (SR 122A) near Route 146 exit 17, further south toward downtown Millbury
- During public meetings, interest has been expressed in having better accommodations for pedestrians and bicyclists for a future replacement of the Boston Street crossing.

In the project area, there are nineteen crossings of Route 146. Eight are bridges over the highway, including one exclusive bike-ped bridge which carries the Blackstone River Greenway over Route 146 in Millbury, directly adjacent to the bridge that also carries North Main Street (Route 122A) over Route 146, approximately six-tenths of a mile south of the Mass Pike. Of the other eighteen, eight crossings have no highway interchanges with Route 146, making them inherently safer for vulnerable road users, as there are fewer potential conflict points. These are Smith Street and Mendon Road in Sutton, and Hartford Avenue West, Pond Street, Mill Street, Aldrich Street (State Route 98), Elmwood Avenue, and Coppola Street / Buxton Street in Uxbridge. Of these, Mendon Road could potentially serve as a connection for people walking and biking, as it connects residential areas and employment centers on both sides of Route 146. Hartford Avenue West connects the villages of East Douglas and North Uxbridge, a distance of four miles, which is a reasonable biking distance. Mill Street can be part of a route leading from west of Route 146 to Uxbridge High School for students who opt to walk or bike. Elmwood Avenue in the vicinity of Route 146 has already been identified for future bike lanes.

Boston Road is not presently accessible for pedestrians as there are no sidewalks or crosswalks. Bicycles can travel in vehicle lanes, but there are no separate bicycle accommodations near the intersection. A newly designed, grade-separated interchange at Boston Road should incorporate low-stress accommodations for both pedestrians and bicyclists. Whether designed as a diamond interchange or a Single Point Urban Interchange (SPUI), elements including sidewalks, separated bike lanes, lead pedestrian intervals, and ADA-compliant curb ramps and pedestrian signals, can be integrated to make this crossing appealing to those who don't travel by car.

However, for improved pedestrian and bicycle accommodations across Route 146 to be optimized, the abutting municipalities would need to expand the network onto local roadways to complete connections for the end users.

From stakeholder interviews there are varying views on multimodal connections in the different municipalities. The Town of Douglas is concerned that there isn't enough road width for dedicated bike lanes and there are not public transit options available. Millville is mainly industrial so there are not a lot of areas active with pedestrians. Northbridge would like to explore more options that would rejuvenate the bikeway. In Millbury the Blackstone River Greenway ends at the beginning of the study area and there is progress being made on a shared use path along North Main Street that would connect to downtown. However, there is still a need for the connection between the Blackstone River Greenway and downtown Millbury to be a priority. In Sutton, there is a desire for more multimodal options, such as sidewalks for

pedestrians and bike lanes for bicyclists. Stakeholders in Sutton also expressed the need for more support and funding for the Blackstone River Greenway. In Uxbridge along Douglas Street (Route 16) there are two roundabouts that have sidewalks and marked crossings for pedestrians. The Central Massachusetts Regional Planning Commission (CMRPC) noted that pedestrians and bicyclists do not feel safe along Route 146A and completion of the Blackstone River Greenway could improve that by providing an alternative route to use. CMRPC stakeholders also noted that pedestrians attempt to cross at the Boston Road intersection but it is very dangerous due to lack of pedestrian infrastructure. From the stakeholder interviews there is an overwhelming desire for the completion of the Blackstone River Greenway. Other stakeholders have varying opinions on addressing multimodal needs within their town based on existing infrastructure and land uses.

2.7 Stakeholder Meeting

At the stakeholder meeting in November 2024 feedback was provided for work completed on task 1 and task 2. Feedback was related to the PowerPoint presentation created for Public Meeting #1 and some technical feedback. Notes from the meeting are summarized below:

- Study Area Comments
    - Confirm how the study area was established
    - Note that Central Turnpike and Douglas Street (Route 16) has existing impacts related to heavy vehicles
    - I-90 is not included in the study area
- Graphics Comments
    - Consider concepts of Route 146 grade separation from prior studies
    - Make operational graphics easier to understand with color coding
    - Improve the development overview graphic by removing development names and adding color coding based on development types
- Development Comments
    - Include intersection improvements from the Unified Parkway development into future scenario modeling
    - Confirm developments name and status.

Feedback given in this meeting was implemented into the public presentation and task reports.

2.8 Public Meeting

In December 2024 the first public meeting for the Route 146 Corridor Vision Study was conducted. At this meeting the Study team introduced the Route 146 Corridor Vision Study, reviewed existing conditions, and reviewed future growth scenarios that would affect the corridor. To gain specific feedback, breakout room discussions occurred to hear individual experiences and issues throughout the corridor. The meeting also included a public comment section allowing attendees to ask questions or provide more insight into how the corridor is currently functioning. Attendees were also provided with the project webpage and project email, allowing them to submit comments and questions that come up in the future. A summary of comments and concerns heard at the meeting is provided in Figure 2.8-1 and the complete meeting notes are in Appendix H.

Specific concerns regarding the Route 146 and Boston Road intersection were brought up during the meeting. At Route 146 and Boston Road it was noted that some drivers worry about vehicles traveling southbound (downhill) on Route 146 being unable to stop in time at the signal, resulting in drivers on Boston Road taking extra caution before entering Route 146, even with the green indication. There were also discussions that at Boston Road and Pleasant Valley Road it is sometimes difficult to turn left onto Boston Road due to lighting and there is a worry of it becoming more difficult with added developments. Attendees also mentioned that the turnoff for Pleasant Valley Road is not adequately signed, resulting in drivers along northbound Route 146 traveling to Millbury or attempting an illegal left turn at Boston Road.

At Central Turnpike there are concerns about increased truck traffic, the interchange becoming an area for U-turns, and it being used as a cut-through to Interstate 395. There is also a worry about the difficulty of turning left onto Central Turnpike due to increased volumes and sun glare impacting the view.

Additional comments were related to specific developments in the corridor or nearby. In Sutton, the public is concerned with the sight distance for entering Route 146 and the lack of acceleration/deceleration lanes available when turning into the development. Residents In Grafton and the northeast section of Sutton, where the Fisherville Terrace housing development is planned, are noticing increased volumes and high speeds during commuting hours with people trying to avoid the Boston Road intersection.

Overall comments that apply to the whole corridor were also brought up at the meeting. People noted that there are underutilized truck stops throughout the corridor. With the increase in vehicle and truck traffic, residents are worried that there may be more distracted driving or dangerous driving to bypass truck traffic. While the study area corridor ends at the Massachusetts/Rhode Island border, there are concerns about developments south of Boston Road and into Rhode Island, and their impacts on the Boston Road intersection. Residents are

also worried about sight distance for business driveways and the lack of acceleration/deceleration lanes.

Comments heard from the public meeting were considered along with existing and future operational analysis to develop alternatives in the section to follow.

Figure 2.8-1: Public Meeting Comment Summary

Route 146 Public Meeting Comments/Feedback Received

Safety Concerns

- Increase in commuter traffic using neighborhood roads to avoid congestion at Boston Road (example: Leland Hill Road and Dodge Hill Road)

Safety Concerns

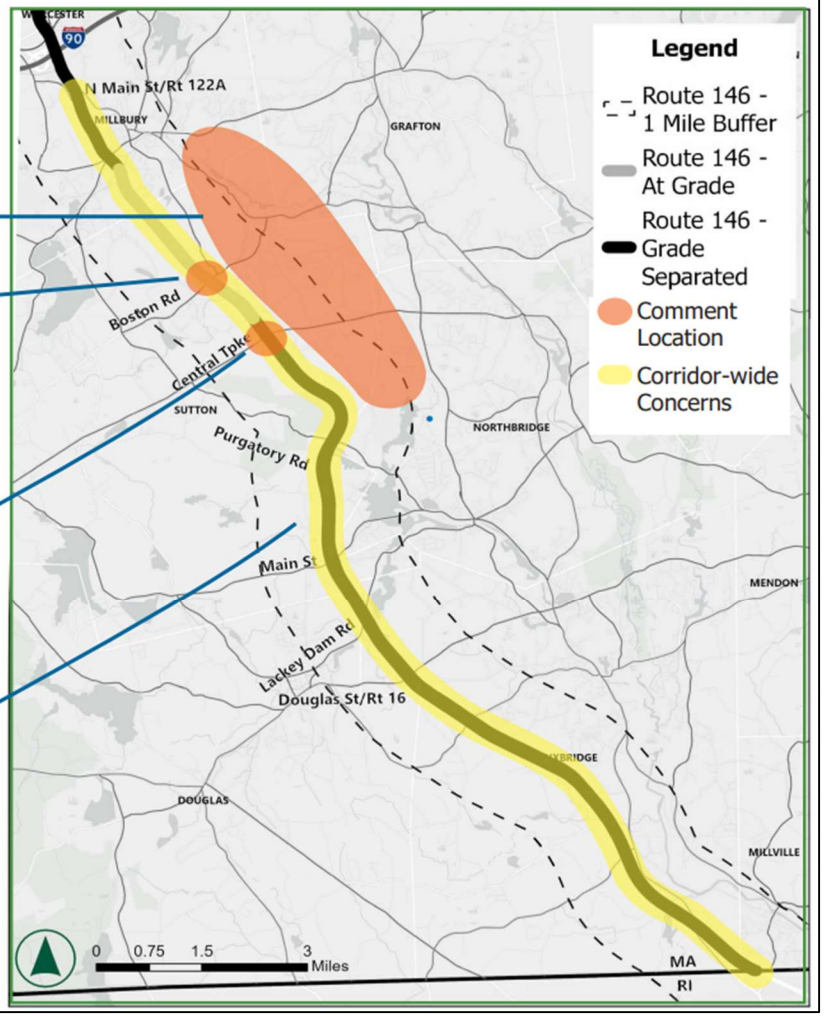
- Increased truck traffic
- U-turns
- Becoming cut-through to I-395
- Left turns are difficult due to sun glare and traffic volumes
- Signage improvements needed for left turn to Boston Road westbound

Safety Concerns

- Increased truck traffic
- U-turns
- Becoming cut-through to I-395
- Left turns are difficult due to sun glare and traffic volumes

Corridor-wide Concerns

- Truck traffic increasing – safety, environmental, and noise impacts
- High speeds
- Commuter cut-through traffic in neighborhoods
- Driveway access/egress safety and sight lines
- Lack of acceleration/deceleration lanes
- Underutilized rest areas
- Traffic and safety impacts of future growth



Chapter 3: Alternatives Development and Analysis

3.1 Task Goals

Chapter 3, Alternatives Development and Analysis, will focus on grade separation at Route 146 and Boston Road, potential capacity constraints at Lackey Dam Road and Route 146 ramps, and multimodal opportunities throughout the corridor. The need for grade separation at Route 146 and Boston Road was established in Chapter 2 when analyzing the operations of the intersection with existing volumes and volumes from all known developments. Analysis in Chapter 2 at Lackey Dam Road with existing volumes and volumes from all known developments, also resulted in potential capacity constraints which will be evaluated further in Chapter 3. Chapter 3 corridor wide multimodal improvements are discussed based on needs and deficiencies detailed in Chapter 2.

The Alternatives Development and Analysis task allowed for different scenarios for grade separation to be considered for the Boston Road intersection and compared them based on the established evaluation criteria. Each alternative is a possible solution to addressing the congestion and safety concerns at the Route 146 and Boston Road intersection. Throughout the task, multimodal opportunities, potential environmental considerations, right-of-way impacts, and construction costs were evaluated. The alternatives were reviewed through an evaluation matrix and criteria for the matrix and how each alternative performs is explained in detail throughout the report.

3.2 Grade Separation Concepts for Boston Road

3.2.1 Comparison to 2005 Grade Separation Concepts

In 2005, the Executive Office of Transportation published the Route 146 Transportation Study. In this study, grade separation concepts for Route 146 and Boston Road were explored and specific challenges were identified. In the 2005 report, Boston Road was proposed to cross over Route 146 and Pleasant Valley Road was used to provide connections to Boston Road, as shown in the excerpted figure below. Business development since the time of that study has created new challenges for crossing Boston Road over Route 146 and new access points along Pleasant Valley Road make it less effective as a connecting roadway. The following excerpts from the previous Route 146 Transportation Study expand on the specific challenges identified for roadway geometries, safety, and grades.

Roadway Geometry and Safety

From Route 146 Transportation Study section 2.2.3:

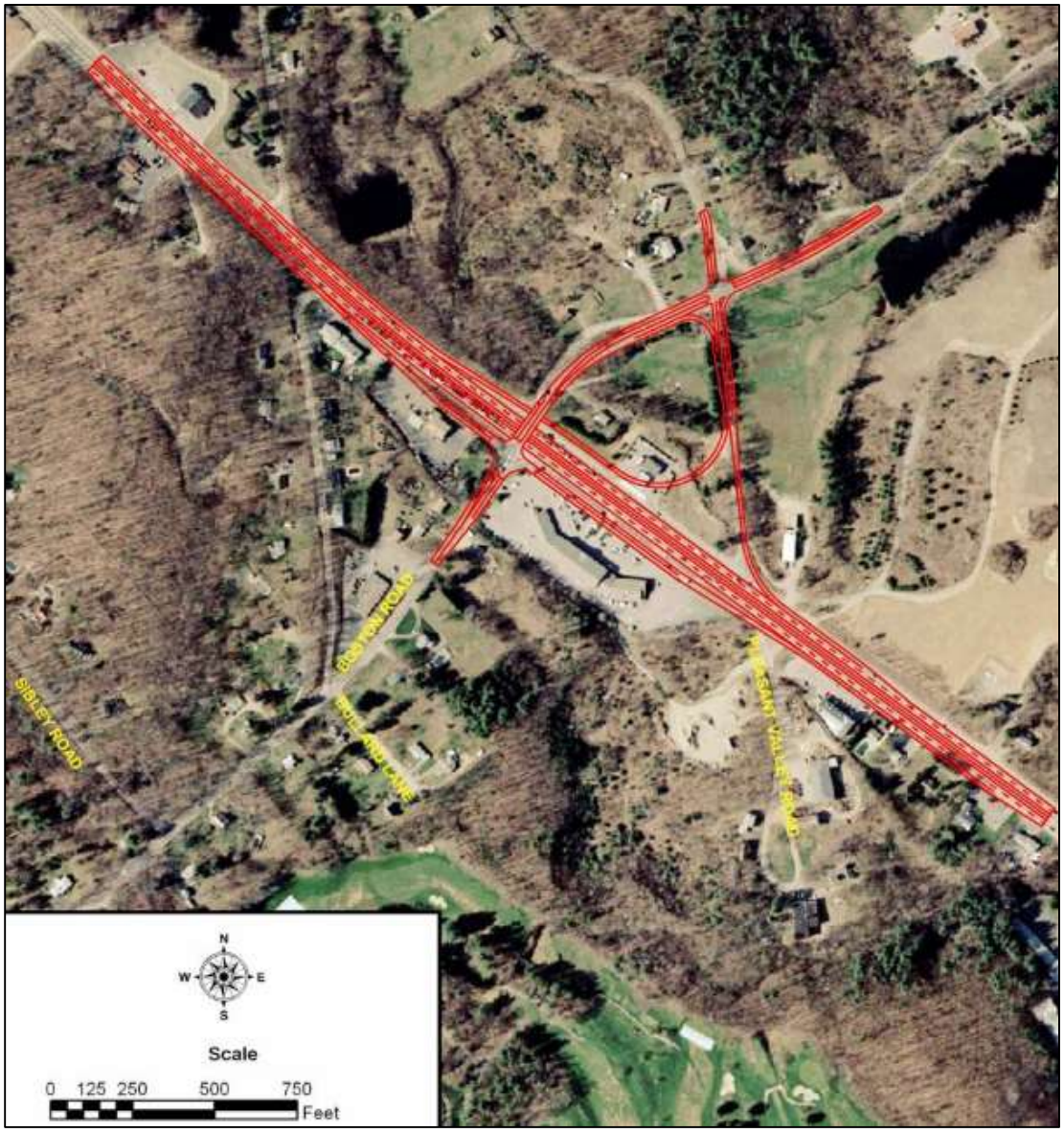
"This intersection [Boston Road] is the only signalized intersection along Route 146 between the Massachusetts Turnpike and the Rhode Island border. Sight distances could be a problem for the southbound approach, since Route 146 passes over a hill prior to the intersection. There is a red light warning sign to alert vehicles to the traffic light. The Boston Road westbound approach has a limited sight distance, with the roadway approaching the intersection on a curve. The eastbound approach has a commercial driveway parallel with the stop line. The driveway is an entry-only, but could cause safety problems for vehicles attempting to make a left from Boston Road eastbound."

Grades

From Route 146 Transportation Study section 2.3:

"The steeper sloping areas are located out of the study area, with a heavy concentration of steep hills east of Route 146 along Boston Road. Construction costs usually rise when building along steeper grades. As a general rule, construction costs are minimized when grades are 6% or less."

Figure 3.2-1: Route 146 Overpass Concept from Route 146 Transportation Study (2005)



Route 146 Transportation Study (December 2005)

3.2.2 Overpass Configuration

As alternatives for grade separation were developed for this study, we reviewed the concepts from the prior study, the roadway grades, and current access for adjacent businesses. As a result of that evaluation, it was determined that carrying Route 146 over Boston Road would preserve access to adjacent businesses, minimize environmental impacts along Boston Road, and allow the connecting ramps to serve as frontage roads. All of the grade-separated alternatives use this configuration.

3.2.3 Diamond Interchange

Throughout the alternative's development process, multiple variations of a diamond interchange were conceptualized. For a typical diamond interchange concept, there are ramps that run roughly parallel to the main roadway (Route 146) and connect to the local road (Boston Road) with some form of traffic control. Lackey Dam Road is an example of a traditional diamond interchange with widely spaced ramps to provide separation between the surface road connections. Given the existing conditions along Route 146 near Boston Road, a traditional diamond interchange is not feasible without significant right-of-way and environmental impacts. For these reasons, the diamond interchange concepts all used a tight diamond configuration.

Given that all interchange alternatives would use a tight diamond configuration, the variations considered different means of intersection traffic control for the ramp termini. Fully signalized variations included separate signalized ramp intersections and a combined single point signalized intersection. Variations with partial signalization included a roundabout at the northbound ramp intersection with a signal at the southbound ramp intersection, and a signal at the northbound ramp intersection with a roundabout at the southbound ramp intersection.

3.2.3.1 *Signalized Tight Diamond Interchange*

The first signalized diamond interchange variation that was considered was a tight diamond interchange with signalized intersections at each ramp termini. There would be two closely spaced intersections with signals along Boston Road in Sutton, serving the Route 146 southbound ramps and the Route 146 northbound ramps, respectively. For each intersection, Route 146 is an overpass and the intersections along Boston Road are at grade. Lane configurations for this concept were chosen based on the existing right-of-way, lane configurations at the existing at grade intersection, and the projected traffic volumes with Route 146 overpass traffic removed. Route 146 would have two lanes in each direction with a median between opposing lanes. The Route 146 overpass configuration for the tight diamond interchange concept is shown in Figure 3.2-2.

At the Route 146 southbound ramps and Boston Road intersection in Sutton, the southbound ramp approach would have two lanes: one dedicated left-turn lane, and one multipurpose lane allowing left-turn, through, and right-turn movements. The receiving Route 146 southbound ramp would have two receiving lanes that merge into one lane for entrance onto Route 146. On Boston Road the eastbound approach would have two lanes: one through lane, and one shared through/right lane. The Boston Road westbound approach would have three lanes: one through lane, and two left-turn only lanes. The southbound off-ramp approaching Boston Road would also serve as a frontage road providing access to Tony's Sutton Pizza Restaurant. The southbound on-ramp would similarly serve as a frontage road providing access to the Sutton Square Shopping Plaza. The specific connection point for this ramp to Route 146 southbound would need further evaluation in the design development process and should consider the proximity to Pleasant Valley Road and the Central Turnpike off-ramp.

At the Route 146 northbound ramps and Boston Road intersection, the northbound approach would have one multipurpose lane for left-turn, through, and right-turn movements. The northbound exit ramp would begin prior to Pleasant Valley Road, and would serve as a frontage road maintaining access to Pleasant Valley Road and businesses along Route 146 northbound, approaching the intersection. The northbound Route 146 entrance ramp would have one receiving lane. The Boston Road eastbound approach would have three lanes: one left-turn lane, and two through lanes. The Boston Road westbound approach also would have three lanes: one right-turn lane, and two through lanes. The Boston Road lane configurations for the tight diamond interchange concept are shown for the overpass in Figure 3.2-2 and for the underpass in Figure 3.2-3.

Figure 3.2-2: Tight Diamond Interchange Concept - Overpass View

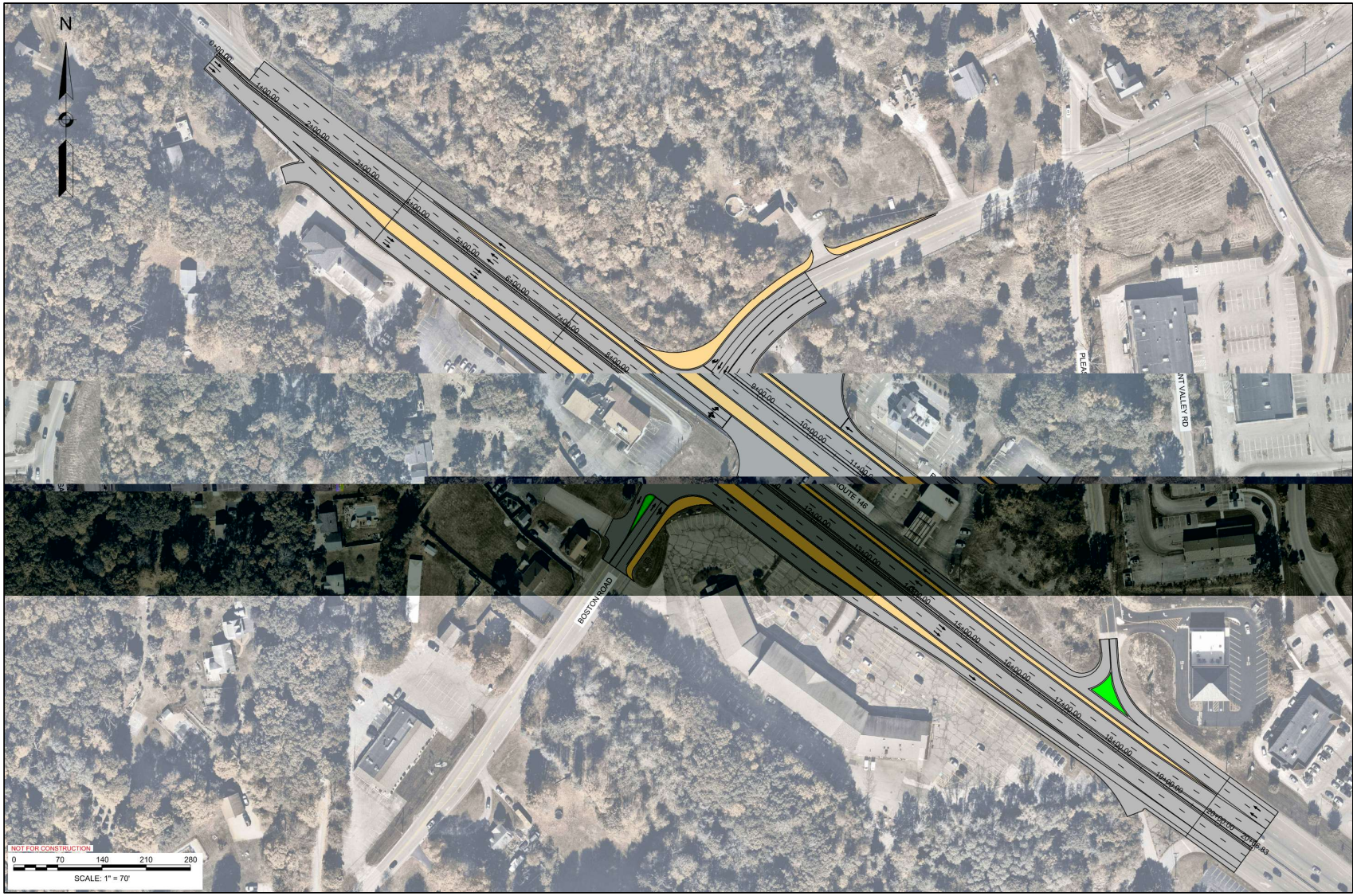


Figure 3.2-3: Tight Diamond Interchange Concept - Underpass View

3.2.4 Single Point Diamond Interchange

A single point diamond interchange was evaluated with both northbound and southbound ramps connecting to Boston Road at a single signalized intersection. Identical to the tight diamond interchange, the Route 146 overpass would have two lanes in both directions, with opposing lanes separated by a median, as seen in Figure 3.2-4. The ramps would connect to Route 146 in the same manner and would also serve as frontage roads providing access to the adjacent businesses and intersecting roadways along Route 146.

The Route 146 southbound ramp approach to the single intersection on Boston Road would have two dedicated left-turn lanes, a through lane, and a right-turn lane. The Route 146 northbound ramp approach would have a single left-turn lane and a shared through and right-turn lane. Unlike a traditional single point interchange, the through movement to continue onto the on-ramp is needed due to the business and local road connections to the ramps. For receiving lanes on the on-ramps, the southbound ramp would have two lanes that merge into one before connecting to Route 146 and the northbound ramp would have one lane for its entire length.

The Boston Road eastbound approach would have one left-turn lane, two through lanes, and a channelized right-turn lane. There would be two eastbound receiving lanes on the opposite side of the intersection. The Boston Road westbound approach would have two left-turn lanes, one through lane, and a channelized right-turn lane, with one westbound receiving lane on the far side of the intersection.

The channelized right-turn movements for all movements would be under yield control. All other movements at the intersection are controlled through signalization. A concept sketch of the single point diamond interchange underpass is in Figure 3.2-5.

Figure 3.2-4: Single Point Diamond Interchange Concept – Overpass View

Figure 3.2-5: Single Point Diamond Interchange Concept – Underpass View

3.2.4.1 Other Diamond Interchange Concepts

Other concepts considered a combination of roundabouts and signalized intersections on Boston Road. One concept considered a roundabout for the Route 146 southbound ramps intersection and a signalized intersection at the Route 146 northbound ramps. The other alternative considered a signalized intersection for the Route 146 southbound ramps intersection and a roundabout at the Route 146 northbound ramps. Traffic analysis performed on these roundabout concepts could result in vehicle queues that would not dissipate fully, spilling over into the adjacent intersection. The existing right-of-way was also not adequate for the land required for a signal and a roundabout and there would be impacts to abutting commercial properties. For these reasons, the concepts with a combination of signals and roundabouts were eliminated from further analysis.

A single larger roundabout configuration was also considered for the connection between the Route 146 ramps and Boston Road. This alternative would still have Route 146 grade-separated and crossing above Boston Road. When considering future growth from known developments, a single-lane roundabout is expected to have failing operations based on preliminary feasibility assessments, and a two-lane roundabout is expected to be necessary. A single roundabout configuration would have significant right-of-way impacts, regardless of the single-lane or two-lane configuration, and was therefore not advanced for further consideration.

3.3 Boston Road Grade Separation Operational Analysis – with All Known Developments

Operation analysis for the grade separation alternatives was conducted for the proposed intersections using Synchro 12 software, based on the latest Highway Capacity Manual methodologies, consistent with the Existing Conditions operational analysis presented in Section 1.7 and the All Known Developments operational analysis present in Section 2.4.

Vehicle operations for each intersection are described below for the All Known Developments scenario. Synchro reports for both grade separation alternatives are in Appendix B.

3.3.1 Signalized Tight Diamond Interchange

Route 146 Southbound Ramps and Boston Road

During the morning and afternoon peak hours, this intersection would operate at overall Level-of-Service (LOS) C. In the morning peak hour, all approaches would operate at LOS C or better with no movements nearing capacity. In the afternoon peak hour, the southbound left turn would operate at LOS D, while all other approaches would operate at LOS C or better. The operational analysis of this intersection is shown in Table 3.3-1.

Route 146 Northbound Ramps and Boston Road

In the morning and afternoon peak hours, this intersection would operate at overall LOS A. In the morning peak hour, all approaches would be LOS B or better. In the afternoon peak hour, all approaches would operate at LOS C or better. The operational analysis of the intersection is shown in Table 3.3-1.

Boston Road and Pleasant Valley Road/Dudley Road

In the morning and afternoon peak hours, the approaches along Boston Road would operate at LOS A. In the morning peak hour, the approaches from Pleasant Valley Road and Dudley Road would operate at LOS C. In the afternoon peak hour, the Pleasant Valley Road approach would operate at LOS C, and the Dudley Road approach would operate at LOS F. The operational analysis of the intersection is shown in Table 3.3-1.

3.3.2 Single Point Diamond Interchange

Route 146 Ramps and Boston Road

In the morning and afternoon peak hours, this intersection would operate at overall LOS C. The southbound through approach would operate at LOS E in both peak hours, while all other approaches in both peak hours would operate at LOS D or better. The operational analysis for the single point diamond interchange is shown in Table 3.3-2.

Boston Road and Pleasant Valley Road/Dudley Road

In the morning and afternoon peak hours, the approaches along Boston Road would operate at LOS A. In the morning peak hour, the approaches from Pleasant Valley Road and Dudley Road would operate at LOS C. In the afternoon peak hour, the Pleasant Valley Road approach would operate at LOS C, and the Dudley Road approach would operate at LOS F. The operational analysis of the intersection is shown in Table 3.3-2.

Table 3.3-1: Grade Separation Operational Analysis – Tight Diamond Interchange

			Weekday Morning					Weekday Afternoon				
Intersection	**Approach**		**LOS[1]**	**Delay[2]**	**V/C[3]**	**50th Q[4]**	**95th Q[5]**	**LOS**	**Delay**	**V/C**	**50th Q**	**95th Q**
Boston Road	EB	TR	C	26.6	0.26	67	114	C	34.1	0.26	76	115
at Route 146 SB Ramps	WB	L	C	25.0	0.27	36	47	C	34.1	0.54	108	178
		T	A	3.1	0.13	7	12	A	2.6	0.20	10	12
	SB	L	C	34.7	0.59	141	208	D	50.9	0.74	240	351
		TR	B	14.9	0.48	57	122	C	30.0	0.62	145	247
	Overall		*C*	*22.9*	*0.57*			*C*	*32.2*	*0.73*		
Boston Road	EB	L	B	16.4	0.29	40	62	C	23.6	0.29	40	58
at Route 146 NB Ramps		T	A	0.6	0.19	4	3	A	0.8	0.21	3	2
	WB	T	A	9.8	0.20	42	71	B	12.5	0.44	147	185
		R	A	2.4	0.37	0	36	A	2.8	0.53	0	41
	NB	LTR	A	2.8	0.25	0	0	B	17.8	0.47	0	36
	Overall		*A*	*4.7*	*0.57*			*A*	*7.5*	*0.73*		
Boston Road at	EB	LT	A	0.3	0.01	n/a	0	A	0.4	0.02	n/a	0
Pleasant Valley Road and	WB	TR	A	0.0	0.00	n/a	0	A	0.0	0.00	n/a	0
Dudley Road	NB	TR	C	17.4	0.56	n/a	88	C	19.2	0.50	n/a	68
	SB	LTR	C	20.9	0.16	n/a	15	F	157.8	0.87	n/a	113

1 Level-of-Service
2 Average vehicle delay, in seconds
3 Volume to capacity ratio; intersection capacity utilization reported for overall
4 50th percentile queue based on Synchro outputs, in feet
5 95th percentile queue based on Synchro outputs, in feet
n/a Not applicable

Table 3.3-2: Grade Separation Operational Analysis – Single Point Diamond Interchange

			Weekday Morning					Weekday Afternoon				
Intersection	**Approach**		**LOS[1]**	**Delay[2]**	**V/C[3]**	**50th Q[4]**	**95th Q[5]**	**LOS**	**Delay**	**V/C**	**50th Q**	**95th Q**
Route 146 at	EB	L	D	37.1	0.15	41	87	C	31.7	0.14	41	86
Boston Road		T	C	28.3	0.15	46	73	D	35.8	0.17	41	68
		R	A	0.3	0.09	0	0	A	0.4	0.09	0	0
	WB	L	D	36.1	0.24	64	107	D	35.3	0.53	180	261
		T	C	29.7	0.22	68	118	D	43.9	0.53	142	221
		R	A	5.6	0.54	0	72	A	9.5	0.76	0	115
	NB	L	D	36.9	0.14	28	58	D	35.2	0.19	43	77
		TR	D	54.4	0.46	40	85	D	53.6	0.49	42	88
	SB	L	D	50.0	0.75	172	215	D	48.3	0.78	206	250
		T	E	57.0	0.39	37	79	E	56.8	0.39	37	79
		R	A	1.4	0.15	0	0	A	4.9	0.30	0	9
	Overall		*C*	*31.0*	*0.45*			*C*	*31.9*	*0.58*		
Boston Road at	EB	LT	A	0.3	0.01	n/a	0	A	0.4	0.02	n/a	0
Pleasant Valley Road and	WB	TR	A	0.0	0.00	n/a	0	A	0.0	0.00	n/a	0
Dudley Road	NB	TR	C	19.2	0.60	n/a	98	C	21.7	0.54	n/a	78
	SB	LTR	C	24.8	0.19	n/a	18	F	233.2	1.05	n/a	133

1 Level-of-Service
2 Average vehicle delay, in seconds
3 Volume to capacity ratio; intersection capacity utilization reported for overall
4 50th percentile queue based on Synchro outputs, in feet
5 95th percentile queue based on Synchro outputs, in feet
n/a Not applicable

3.4 Boston Road Grade Separation Sensitivity Analysis

To test the capacity of each alternative to accommodate future traffic volume growth in excess of the currently known development projections, additional traffic volume was added within the analysis to identify the failure points of each interchange alternative. This process would identify how each alternative operates under growth beyond known developments and if one is able to accommodate future growth better. Volumes at the intersection of Boston Road and Pleasant Valley Road/Dudley Road were also grown to understand how grade separation affects its operations, and if signalization is warranted. This testing will show how the different grade separation alternatives could react to increased volumes and determine if one has greater capacity for additional growth.

3.4.1 Methodology

The base volume used for this sensitivity test was the existing volume plus volumes identified for all known developments. These volumes were then redistributed to model the two intersections for the tight diamond interchange and the single intersection for the Single Point Diamond Interchange. For each alternative, the volumes were increased in 10% increments and modeled in Synchro. Volume to capacity (v/c) ratio, approach LOS, approach delay, movement delay and overall intersection delay were recorded for all volume increments.

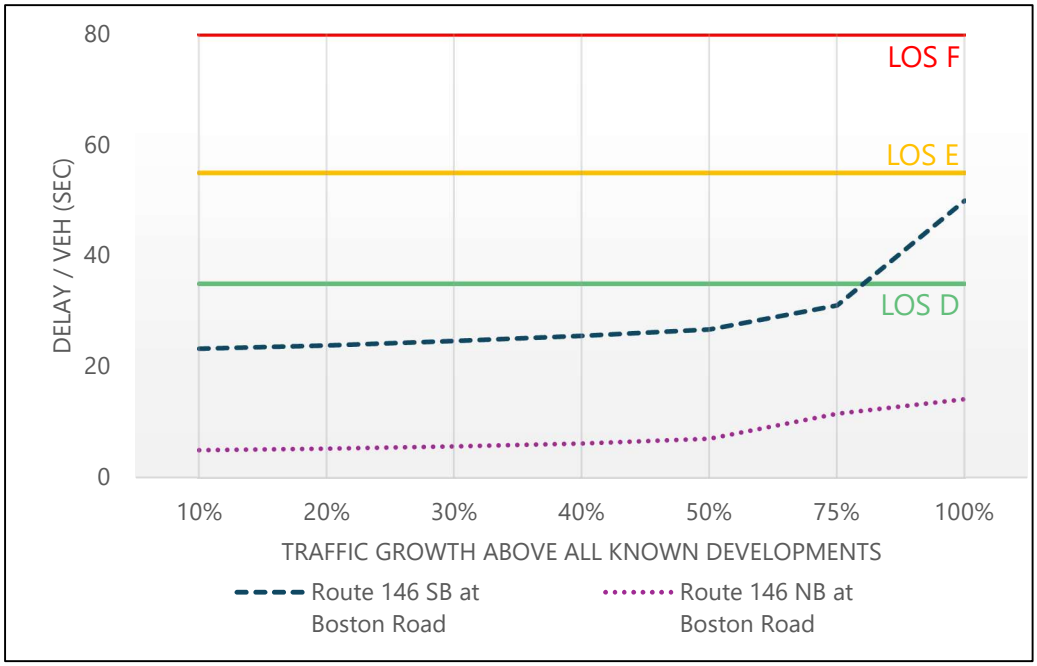
3.4.2 Signalized Tight Diamond Interchange Results

Morning Peak Hour

In the morning peak hour, volumes at both ramp intersections were grown from base conditions with all known developments to a 50% increase in 10% increments and then from 50% to 100% in 25% increments. The approach LOS and percent capacity utilized are provided in Appendix I. The Route 146 southbound ramps intersection fails at a 100% increase or double the projected traffic volumes with all known developments. Capacity of the intersection is not exceeded but would have eastbound and northbound approaches nearing capacity. The Route 146 northbound ramps intersection does not fail, and all approaches operate at LOS B with delays less than 20 seconds. The overall operations and capacity utilization results are presented in Appendix I.

To illustrate the changes in operations for both intersections, the intersection delay at each growth increment was graphed for the morning peak hour, as shown in Figure 3.4-1. At a 100% additional growth increment, the Route 146 southbound ramps intersections are near LOS E but does not reach it. For the Route 146 northbound ramps intersection, even with a 100% growth rate, it remains at LOS B.

Figure 3.4-1: Tight Diamond Interchange Morning Peak Hour Intersection Delay

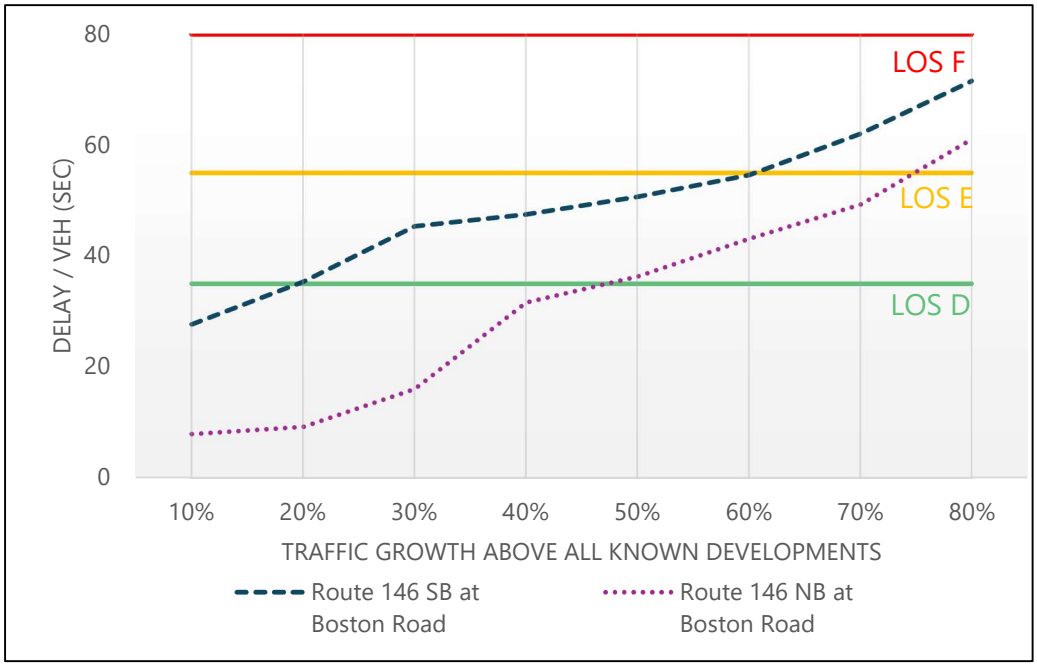


Afternoon Peak Hour

For the afternoon peak hour, volumes were grown to an 80% increase above all known developments volumes in 10% increments to reach the point of failure. The approach LOS results, and percent capacity utilized, are provided in Appendix I. At a 40% increase, both intersections are experiencing degraded operations, with the Route 146 southbound intersection operating at LOS D or worse. At an 80% increase, both intersections would have approaches operating at LOS F.

To present overall operations of the two intersections, intersection delay for the different growth increments was graphed, as seen in Figure 3.4-2. Neither ramp intersection reaches LOS F with an 80% increase, but each would have approaches that are at or close to failure. For the Route 146 southbound intersection, a 60% increase would result in overall LOS E operations, while the northbound ramps intersection would degrade to LOS E with a roughly 75% increase.

Figure 3.4-2: Tight Diamond Interchange Afternoon Peak Hour Intersection Delay



Boston Road and Pleasant Valley Road/Dudley Road

In Section 2.4, it was identified that northbound movements on Pleasant Valley Road operate at LOS F with all known developments under the existing at-grade intersection configuration of Boston Road and Route 146. In the context of a grade separation for Boston Road at Route 146, the impacts of future traffic volume growth at the adjacent unsignalized intersection of Boston Road with Pleasant Valley Road/Dudley Road in Sutton were assessed. As the unsignalized intersection operation is improved with the grade separation with all known developments, as shown in Section 3.3, the effect of additional volume growth was considered. In the morning peak hour, the Dudley Road southbound movement would be over capacity with a 30% increase above all known development and both movements would be over capacity at a 50% increase above all known developments. In the afternoon peak hour, the southbound movement would be over capacity with the volume from all known developments and both approaches would be over capacity at a 40% increase above all known developments.

3.4.3 Signalized Tight Diamond Interchange Sensitivity Analysis Summary

The afternoon peak hour is more impacted by additional growth which would result in worse operations for the intersection. Operation starts to noticeably worsen at a 30% increase which would be a 490 vehicle increase at the Route 146 southbound ramps intersection, and a 629 vehicle increase at the Route 146 northbound ramps intersection.

For the morning peak hour, the approach operations are at failure at a 100% increase at the Route 146 southbound ramps intersection. This would be an increase of 1,109 vehicles at the southbound ramps intersection, and 1,367 vehicles at the northbound ramps intersection.

With the tight diamond interchange, the Boston Road and Pleasant Valley Road/Dudley Road intersection still reaches capacity on the northbound and southbound movements before the interchange reaches capacity. The intersection may benefit from a signal to accommodate future growth.

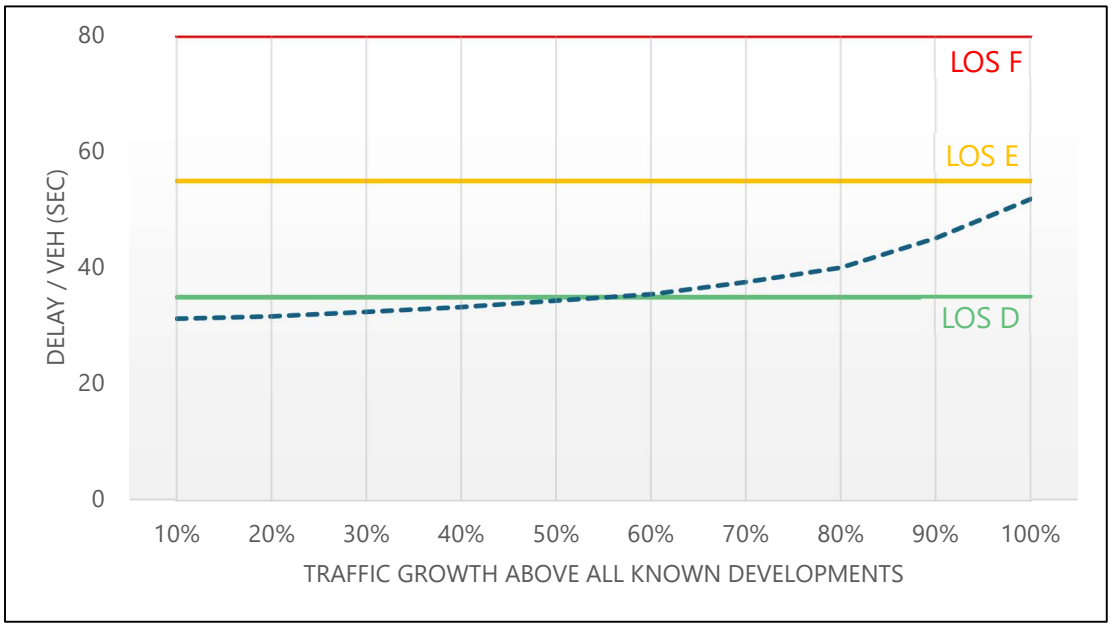
3.4.4 Single Point Diamond Interchange Results

Morning Peak Hour

For the morning peak hour, the base volumes with all known developments were increased by 100% in 10% increments. The approach LOS and percent capacity utilized are provided in Appendix I. In the morning peak hour, the level of service would begin to deteriorate with a 70% increase. At a 100% increase, the southbound approach begins to fail and would be over capacity. Other approaches and movements are at 80% capacity utilized, or less.

To present the overall intersection operations, the intersection delay with increasing volumes was graphed, as seen in Figure 3.4-3. The intersection is not near failure during the morning peak hour and operates at an LOS D until volume increases by over 55%.

Figure 3.4-3 Single Point Diamond Interchange Morning Peak Hour Intersection Delay

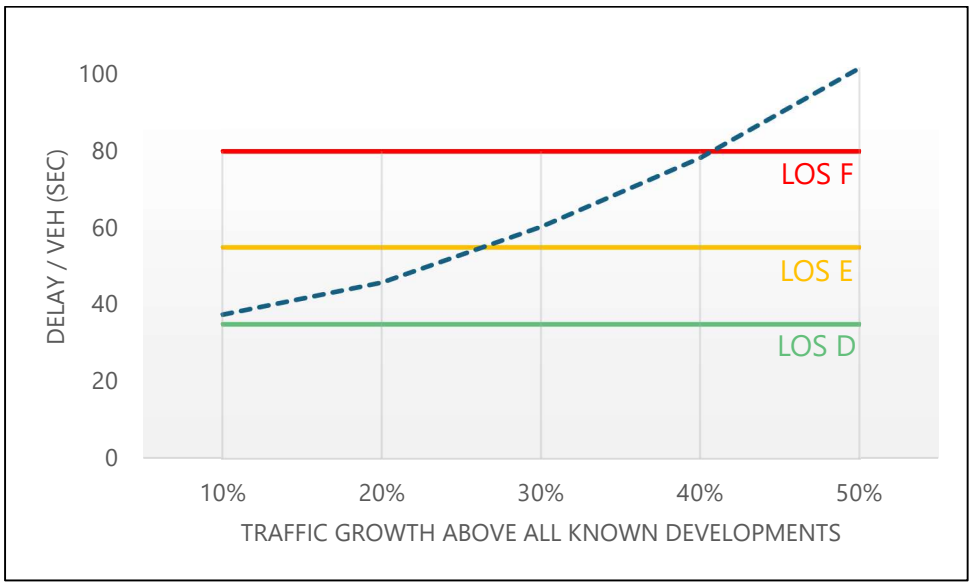


Afternoon Peak Hour

For the afternoon peak hour, the volumes were increased by 50% in 10% increments above all known development volumes. The approach LOS and percent capacity utilized are provided in Appendix I. At a 50% increase, the westbound approach would be failing, and the northbound and southbound approaches would be at LOS D and LOS E, respectively. Reviewing the volume to capacity ratio, the westbound left turn would be over capacity with a 20% increase. The westbound right turn and southbound left turn are also nearing capacity with a 50% increase.

To understand the overall intersection operations with increasing traffic volumes, the intersection delay was graphed, as seen in Figure 3.4-4. At a 30% increase, the intersection would be at LOS E and at slightly more than a 40% increase the intersection would be at LOS F.

Figure 3.4-4: Single Point Diamond Interchange Afternoon Peak Hour Intersection Delay



Boston Road and Pleasant Valley Road/Dudley Road

In the morning peak hour, the southbound movement is over capacity with a 30% increase above all known developments. The northbound movement, which has traffic from Route 146, would be over capacity at a 40% increase.

In the afternoon peak hour, the southbound movement is over capacity with the volume from all known developments and no additional growth. The northbound movement is over capacity at a 30% increase above all known developments.

3.4.5 Single Point Diamond Interchange Sensitivity Analysis Summary

In the morning peak hour, the northbound and southbound approaches would operate at LOS E at a 70% increase in volumes, which would be about 1,126 additional vehicles. When the southbound approach fails at a 100% increase, the increase would represent 1,608 additional vehicles at the intersection.

In the afternoon peak hour, the westbound left turn is over capacity at a 20% increase, which would be about 470 vehicles added to the intersection. The westbound approach would operate at LOS E at a 30% increase, which would be about 704 vehicles added. The westbound approach reaches failure at a 40% increase, which would be about 939 vehicles added to the intersection.

With the Single Point Diamond Interchange, the Boston Road and Pleasant Valley Road/Dudley Road intersection reaches capacity on the northbound and southbound movements before the

interchange reached capacity. The intersection may benefit from a signal to accommodate future growth.

3.4.6 Grade Separation Sensitivity Analysis Results

Both grade separation alternatives could accommodate the projected traffic volumes from all known developments. As shown in Figures 3.4-5 and 3.4-6, the tight diamond interchange shows greater capacity to accommodate future traffic volumes growth beyond known developments and would provide greater resiliency to absorb added growth.

Figure 3.4-5: Grade Separation Growth Past All Known Developments Comparison – Morning Peak Hour

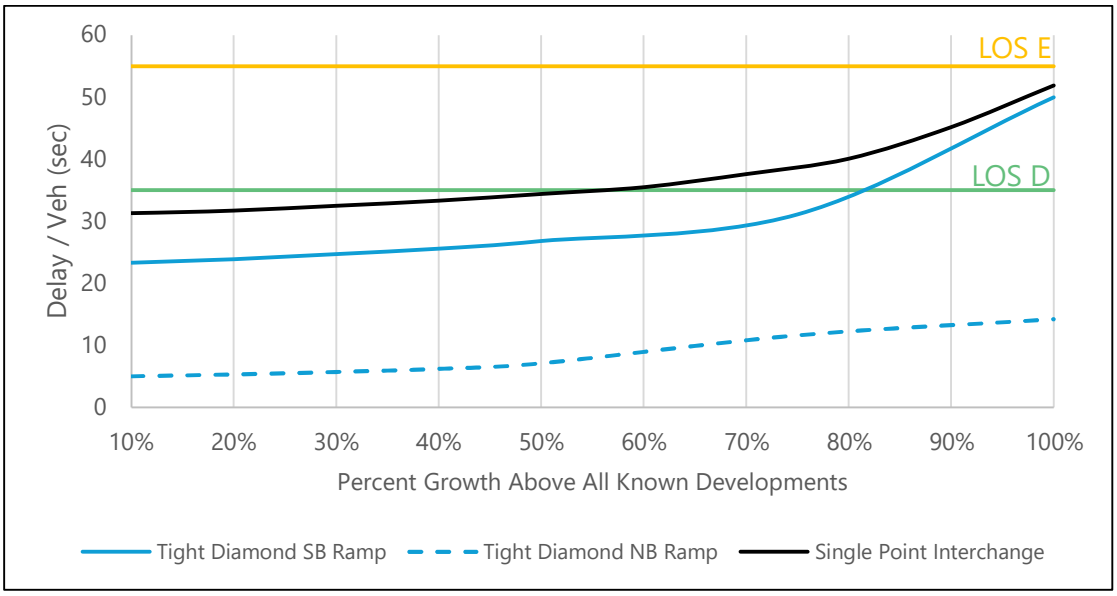
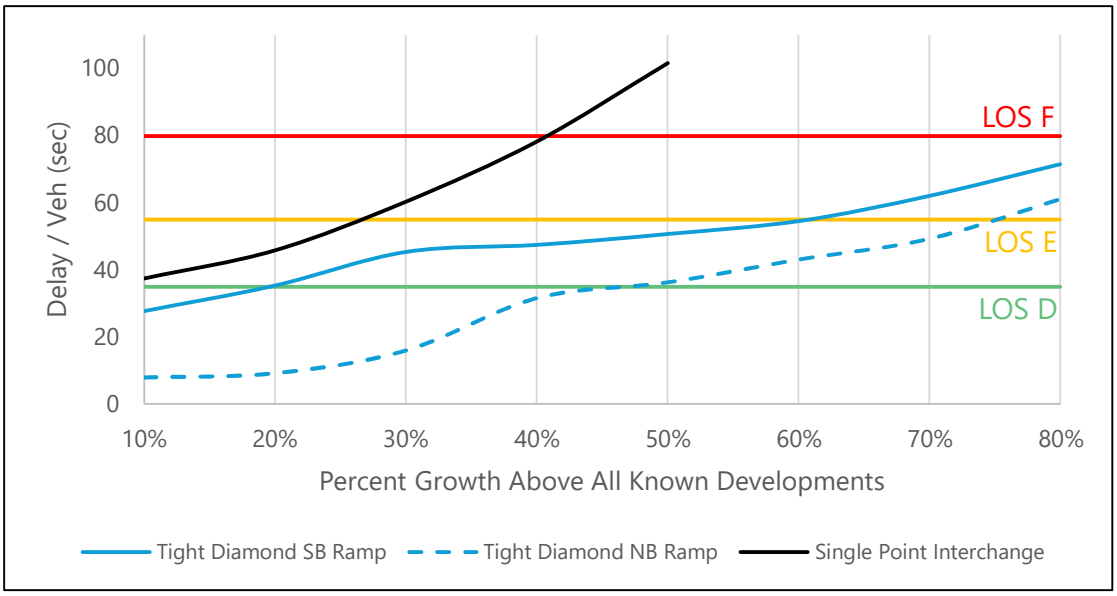


Figure 3.4-6: Grade Separation Growth Past All Known Developments Comparison – Afternoon Peak Hour



3.5 Preliminary Construction Costs at Boston Road

The preliminary construction cost in 2025 for the tight diamond interchange alternative is $62,700,000 and the preliminary construction cost in 2025 for the Single Point Diamond Interchange alternative is $90,500,000. The cost difference is attributable to the larger structure needed for the Single Point Interchange. The estimate includes rough costs for roadway pavement, driveways, sidewalks, landscaping, curbing, pavement markings, utilities, traffic signals, and the overpass structure. The preliminary construction costs for each alternative can be found in Appendix J.

3.6 Alternatives Impacts at Boston Road

3.6.1 Environmental Impacts

Environmental impacts related to the proposed grade separation at Route 146 and Boston Road are primarily concentrated in the northern portion of the project area. Based on MassMapper data, a significant wetland—classified as a wooded marsh—is located to the northeast of the intersection between Boston Road and Route 146 as shown in Figures 3.6-1 and 3.6-2. This wetland is hydrologically connected to a small stream that flows southeast through a culvert beneath Boston Road and continues toward Girard Pond. A separate stream on the opposite side of the wetland flows into Marble Pond.

The wetland and stream are protected by a 100-foot buffer zone, designated as the Adjacent Upland Resource Area under the Sutton Wetlands Protection Bylaw. Any roadway work in this

vicinity will require close coordination with the Sutton Conservation Commission due to the sensitivity of these natural resources.

Minimizing environmental impacts will require thoughtful planning, particularly with respect to net changes in impervious surface, stormwater management, grading, and culvert or drainage infrastructure. In addition, a significant vertical grade change and an existing retaining wall along Route 146 northbound, north of Boston Road, may require structural enhancements or modifications.

Both design concepts under consideration are expected to result in similar environmental impacts, as each maintains a comparable footprint within the wetland and stream buffer area. As the design advances, measures to reduce the environmental impacts, including retaining walls or adjustments to the alignment should be evaluated.

3.6.2 Right-of-Way (ROW) Impacts

ROW impacts were estimated by applying a 6- to 10-foot buffer beyond the roadway limits to account for grading and sidewalk needs. The resulting area was then compared to Sutton tax parcel data to approximate potential ROW impacts. These estimates are intended to provide a general sense of the scale of impacts and should not be interpreted as precise. Significant additional detailed survey and further design development would be required.

For both design concepts, ROW impacts occur within the northeastern, southeastern, and southwestern quadrants of the project area as shown in Figures 3.6-3 and 3.6-4. Impacts in the eastern quadrants are comparable between the two concepts, with approximately 3,200 to 3,500 square feet affected in the northeastern quadrant and about 500 square feet in the southeastern quadrant.

The primary difference lies in the southwestern quadrant, which includes the Sutton Square shopping plaza. The tight diamond interchange concept could impact approximately 11,300 square feet in this area, while the Single Point Diamond Interchange concept could affect roughly 8,900 square feet, although further design refinements could alter those impacts.

From preliminary analysis of ROW impacts, the tight diamond interchange could affect a total of approximately 15,300 square feet, and the Single Point Diamond Interchange could affect a total of 12,600 squre feet.

Figure 3.6-1: Tight Diamond Interchange Environmental Impacts

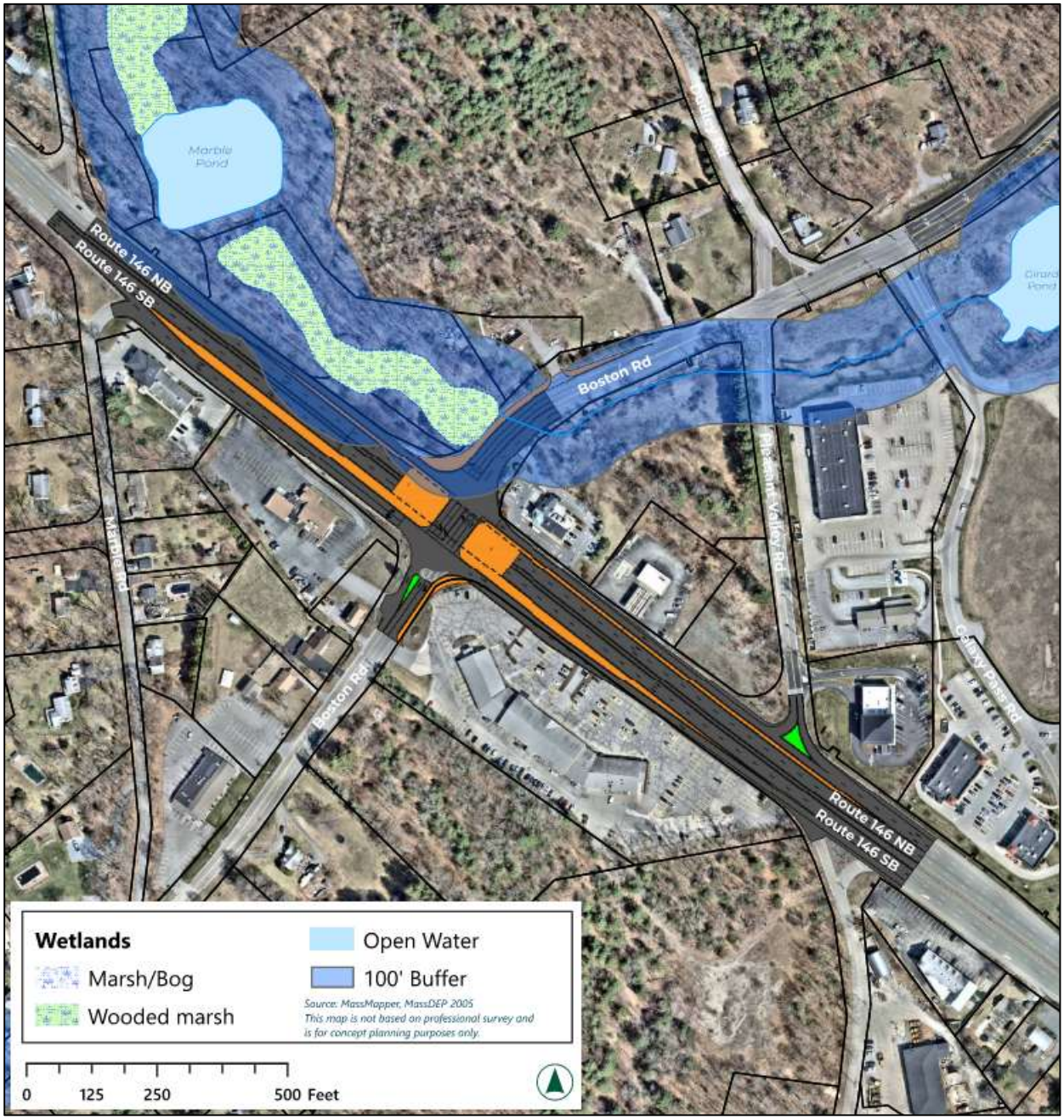


Figure 3.6-2: Single Point Diamond Interchange Environmental Impacts

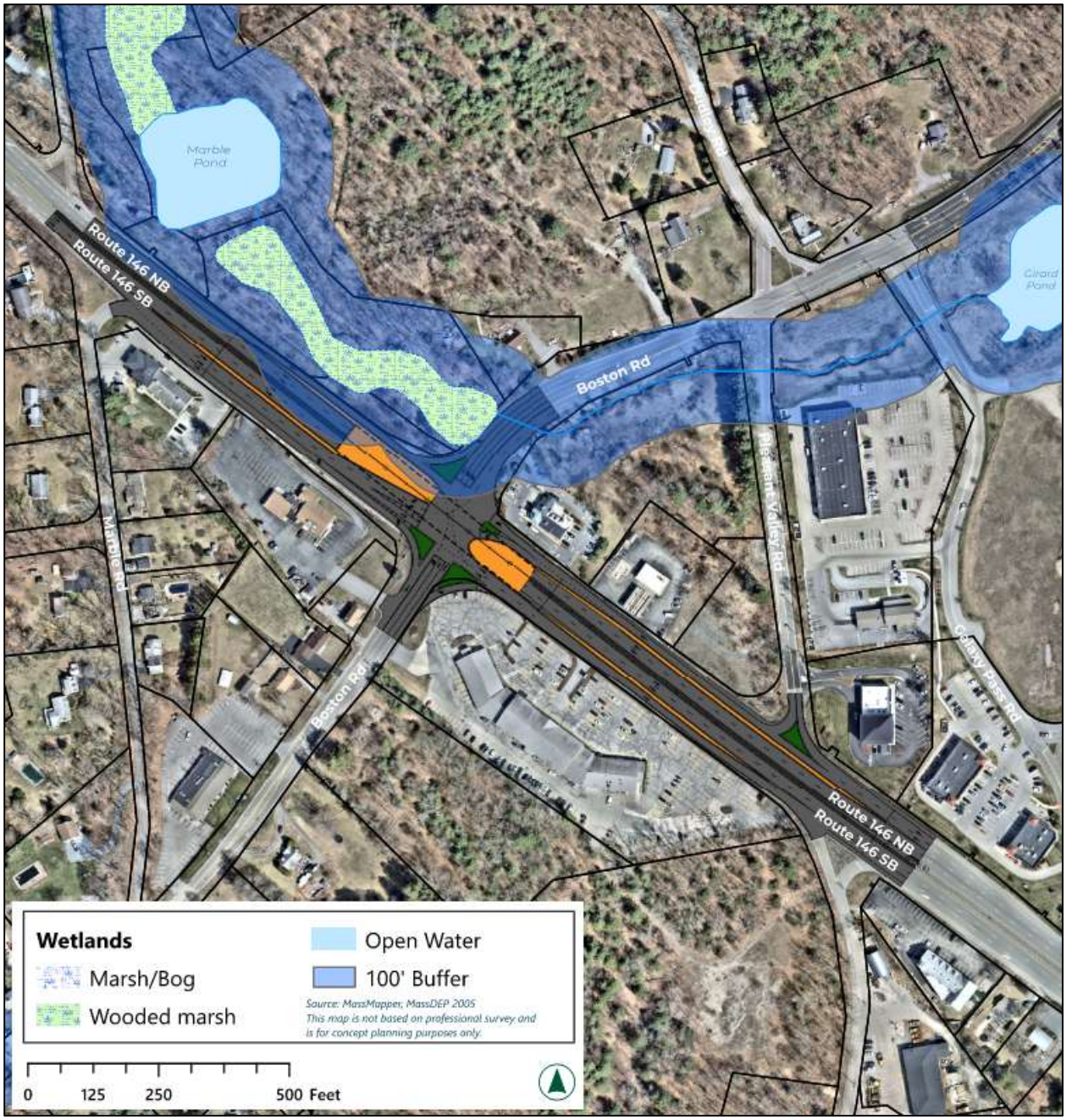


Figure 3.6-3: Tight Diamond Interchange ROW Impacts

Figure 3.6-4: Single Point Interchange ROW Impacts

3.7 Comparison of Boston Road Alternatives

The two primary alternatives for grade separation were evaluated and compared across the evaluation criteria established in Section 1. The evaluation criteria include quantitative and qualitative metrics, considering all modes of travel, and form the basis of a comparative analysis of the alternatives. The comparison of the alternatives is summarized in the evaluation matrix shown in Table 3.9-1 and described in the following sections.

Table 3.9-1: Evaluation Matrix

Evaluation Criterion	Tight Diamond Interchange	Single Point Diamond Interchange
Accommodation of Traffic Growth	• Accommodates **100%** of known development growth. • Additional capacity to accommodate **80%** more growth beyond known developments	+ Accommodates **100%** of known development growth. - Additional capacity to accommodate **50%** more growth beyond known developments
Safety	+ **High** potential to address location crash history	+ **High** potential to address location crash history
Vehicle Operations	+ **LOS B** with all known developments + **LOS D** with 50% growth beyond all known developments	+ **LOS C** with all known development - **LOS F** with 50% growth beyond all known developments
Multi-modal Connections	+ Accommodates potential for multi-modal connections at ramp intersections	+ Accommodates potential for multi-modal connections at single-point ramp intersection
Transit Access	+ Accommodates potential for transit stops on ramps/service roads and along Boston Road	+ Accommodates potential for transit stops on ramps/service roads and along Boston Road
Cost **ROW Impacts**	+ **$62,700,000** - **15,300 ft^2**	- **$90,500,000** + **12,600 ft^2**

3.7.1 Accommodation of Traffic Growth

Both interchange alternatives could provide a significant improvement to roadway capacity through grade separation and are both able to maintain acceptable operations with all known developments added to the network. The roadway capacity provided by each alternative is differentiated by the design of the ramps connecting Route 146 to Boston Road and the means to control the ramps. Overall, the tight diamond interchange alternative provides more capacity than the Single Point Diamond Interchange alternative by controlling each ramp separately with two traffic signals. While both alternatives could meet the capacity needs of all known developments, the tight diamond interchange alternative provides greater capacity for growth beyond all known developments and would provide greater resilience to absorb added growth.

3.7.2 Safety

Both alternatives have a high potential to address safety issues documented at the intersection of Boston Road and Route 146 through grade separation, which results in a significant reduction in conflicting traffic volumes and stopped vehicles at the location. In total, 92% of all reported crashes at the intersection occurred on Route 146, and of these, 80% were rear-end collisions. The grade separation of Route 146 would directly address the largest single category of observed crashes by removing the need for Route 146 through traffic to come to a stop.

3.7.3 Vehicle Operations

The tight diamond interchange has marginally better operations; however, both alternatives have acceptable operations with volume growth from all known developments, ranging from LOS B for the tight diamond interchange to LOS C for the Single Point Diamond Interchange. The alternatives are expected to meet the traffic demands of all known developments and are differentiated by their ability to provide additional capacity for growth. When tested to the point of failure, the tight diamond interchange provided the largest additional operating capacity for growth, maintaining LOS D at 50% additional growth where the Single Point Diamond Intersection fails. By comparison, the tight diamond interchange was found to reach a point of failure with 80% of additional growth.

3.7.4 Multi-modal Connections

Both alternatives can accommodate potential for multi-modal connections at ramp intersections and via the Boston Road underpass. At a conceptual level, the alternatives are equally capable of accommodating bicycle and pedestrian connections under the Route 146 overpass, but the design of these facilities would need to be coordinated with future plans for connections along Boston Road.

3.7.5 Transit Access

Both alternatives accommodate the potential for transit stops at ramps, service roads, and along Boston Road.

3.7.6 Cost and ROW Impacts

As described in Section 3.5, the preliminary construction cost for the diamond interchange alternative is $62,700,000 which is 30% lower than the preliminary construction cost for the Single Point Diamond Interchange ($90,500,000).

As described in Section 3.6.2, ROW impacts are 2,700 square feet greater for the tight diamond interchange compared to the Signle Point Diamond Interchange. The primary difference is in the southwestern quadrant of the intersection, which included the Sutton Square shopping plaza.

3.8 Lackey Dam Road

At the Lackey Dam Road interchange in Douglas, ramp intersections are currently unsignalized. Movements along Lackey Dam Road are uncontrolled and movements from the ramps are yield and stop controlled. Across both interchange ramp intersections, 762 vehicles could be added in the morning peak hour, and 829 vehicles could be added during the afternoon peak hour, if all developments occur. From analysis for the ramps with all known developments presented in Section 2, the southbound off ramp movements would experience degradation in operations to LOS E at peak. Movements along Lackey Dam Road would continue to operate at LOS A during the morning and afternoon peak hours as seen in Table 2.4-1 in Section 2. Based on this analysis, signalization of the ramps may be considered to accommodate significant increases to turning movements and address the degraded operating conditions for ramp movements. When signalization is considered for an intersection, multiple other intersection control strategies are considered, such as a roundabout. While roundabouts were not evaluated at either ramp intersection with Lackey Dam Road as part of this study, roundabouts may also address the degraded operating conditions and would need to be evaluated as part of any improvement project.

To understand how the operational capacity constraints could be affected with signals at both ramp intersections, traffic modeling was conducted with all known development volumes. With signals implemented and all known developments in place, additional lane capacity needs were tested to support the specific demand increases to and from the ramps. At the Lackey Dam Road and Route 146 southbound ramps, the geometric change would be on the Lackey Dam Road westbound approach with a dedicated through lane and a dedicated left-turn lane, instead of one shared use lane. This addition was to reduce queueing and delays incurred from a significant growth in left-turning traffic. With signalization and the additional lane capacity, this intersection would operate at LOS B during morning and afternoon peak hours.

At the Lackey Dam Road and Route 146 northbound ramps, the lane configuration for the Route 146 ramps would remain the same. The Lackey Dam Road eastbound approach would have a left-turn lane and a through lane to improve delays from left-turning vehicles accessing the Route 146 northbound on ramp. On the westbound approach there would an additional

through lane to assist with the increased traffic to and from the ramps. With these additions, the signalized intersection would operate at LOS B during morning and afternoon peak hours.

3.9 Multimodal Opportunities

There are no multimodal facilities and limited sidewalks in the immediate vicinity of Boston Road in Sutton or along Lackey Dam Road in Douglas. The alternatives developed for grade separating the Boston Road intersection are capable of accommodating bicycle and pedestrian connections under the Route 146 overpass, but the design of these facilities would need to be coordinated with future plans for connections along Boston Road. Similarly at Lackey Dam Road, there is ample right-of-way to add sidewalks or bicycle facilities, but they would also need to be informed by the plans for facilities beyond the interchange.

3.10 Stakeholder Meeting #3

At the stakeholder meeting in September 2025, feedback was provided for work completed on task 3. Feedback during the Question-and-Answer portion was recorded and is summarized below.

Meeting Q&A Summary

- The meeting concluded that the tight diamond interchange operates better and meets project goals better than Single Point Interchange.
- MassDOT discussed the purpose of the final study and how it will function as a master plan for the corridor as volumes increase. This study can help guide and inform discussions with the MPO about how to prioritize projects.
- The study does not commit MassDOT to any improvements but provides a vision for District 3 and HQ offices to follow.
- The possibility of installing a frontage road alongside Route 146 between Lackey Dam Road (exit 8) and Main Street (exit 9) was raised by a stakeholder. A question was raised regarding the possibility of adding a frontage road between exit 8 and 9. Spacing was noted as a concern and process was discussed. While it is technically possible, it was noted that it would be challenging and require more detailed analysis.

Chapter 4: Key Findings and Recommendations

4.1 Summary of Findings

Chapter 3 presents the alternatives that were considered for this project and the analysis results for those alternatives. Evaluation criteria included safety, traffic operations, right-of-way and environmental impacts, multimodal connections and transit connectivity, and cost. This chapter builds on those analysis results to present the recommended alternatives.

4.1.1 Route 146 at Boston Road

Route 146 at Boston Road in Sutton is the only signalized intersection along the entire length of Route 146. As such, it presents operational and safety concerns as it is a high crash location and the subject of a Road Safety Audit in 2022. Major intersection improvements were constructed in 2013 to increase overall capacity and improve geometry. Even with the added lane capacity, the heavy northbound volumes in the morning peak hour currently experience level-of-service (LOS) F operations and delays may increase with the anticipated development in this area. This increasing delay and the continued high crash rate were focus areas of this study.

With the prior intersection improvements constructed in 2013, additional at-grade changes to add travel lanes or address operational concerns would not provide significant benefits and grade separation is the appropriate long-term solution. Alternatives within this study considered various grade separated interchange configurations as presented in Chapter 3. Based on the evaluation criteria and associated analysis, both the tight diamond interchange and the Single Point Interchange alternatives could meet the project goals. However, the tight diamond interchange cost is significantly lower due to the shorter bridge span. It does affect a slightly larger area of adjacent properties, but those areas are located at intersection corners and in narrow strips along the edges of parking areas, and would not significantly impact the use of the adjacent property. The summary of the evaluation results is presented in Table 4.1-1.

Table 4.1-1: Evaluation Matrix

Evaluation Criterion	Tight Diamond Interchange	Single Point Diamond Interchange
Accommodation of Traffic Growth	• Accommodates **100%** of known development growth. • Additional capacity to accommodate **80%** more growth beyond known developments	+ Accommodates **100%** of known development growth. - Additional capacity to accommodate **50%** more growth beyond known developments
Safety	+ **High** potential to address location crash history	+ **High** potential to address location crash history
Vehicle Operations	+ **LOS B** with all known developments + **LOS D** with 50% growth beyond all known developments	+ **LOS C** with all known development - **LOS F** with 50% growth beyond all known developments
Multi-modal Connections	+ Accommodates potential for multi-modal connections at ramp intersections	+ Accommodates potential for multi-modal connections at single-point ramp intersection
Transit Access	+ Accommodates potential for transit stops on ramps/service roads and along Boston Road	+ Accommodates potential for transit stops on ramps/service roads and along Boston Road
Cost	+ **$62,700,000**	- **$90,500,000**
ROW Impacts	- **15,300 ft^2**	+ **12,600 ft^2**

4.1.2 Route 146 at Lackey Dam Road

Route 146 at Lackey Dam Road is an existing grade-separated interchange with traditional diamond ramps providing connections between Lackey Dam Road and Route 146. The movements from the off-ramps currently operate at LOS C or better during all peak periods. The ramp intersections are currently not high crash locations and there are no identified safety deficiencies at this time.

With the planned developments and associated traffic volume growth, the Lackey Dam Road off-ramps will experience increasing delay with the southbound off-ramp left-turn movement operating at LOS E during the morning peak hour and LOS D during the afternoon peak hour. The northbound off-ramp would continue to operate at LOS C or better with all known development traffic volume realized. All movements would remain well under capacity.

4.1.3 Multimodal Connections

Chapter 2 includes a detailed inventory of multimodal facilities in the vicinity of the Route 146 corridor. There are a total of nineteen pedestrian or bicycle connections across Route 146 within the study limits. At the primary study area locations of Boston Road and Lackey Dam Road, there are no existing pedestrian or bicycle accommodations. Any improvements at these locations should incorporate pedestrian and bicycle facilities. The design of those facilities should be coordinated with the local community to identify the availability of facilities to continue along the local roadways or to access other multimodal facilities. Local development may also increase pedestrian or bicycle demand, and the review of those projects should identify appropriate measures to provide opportunities for non-vehicular trips.

4.1.4 Route 146 Frontage Roads

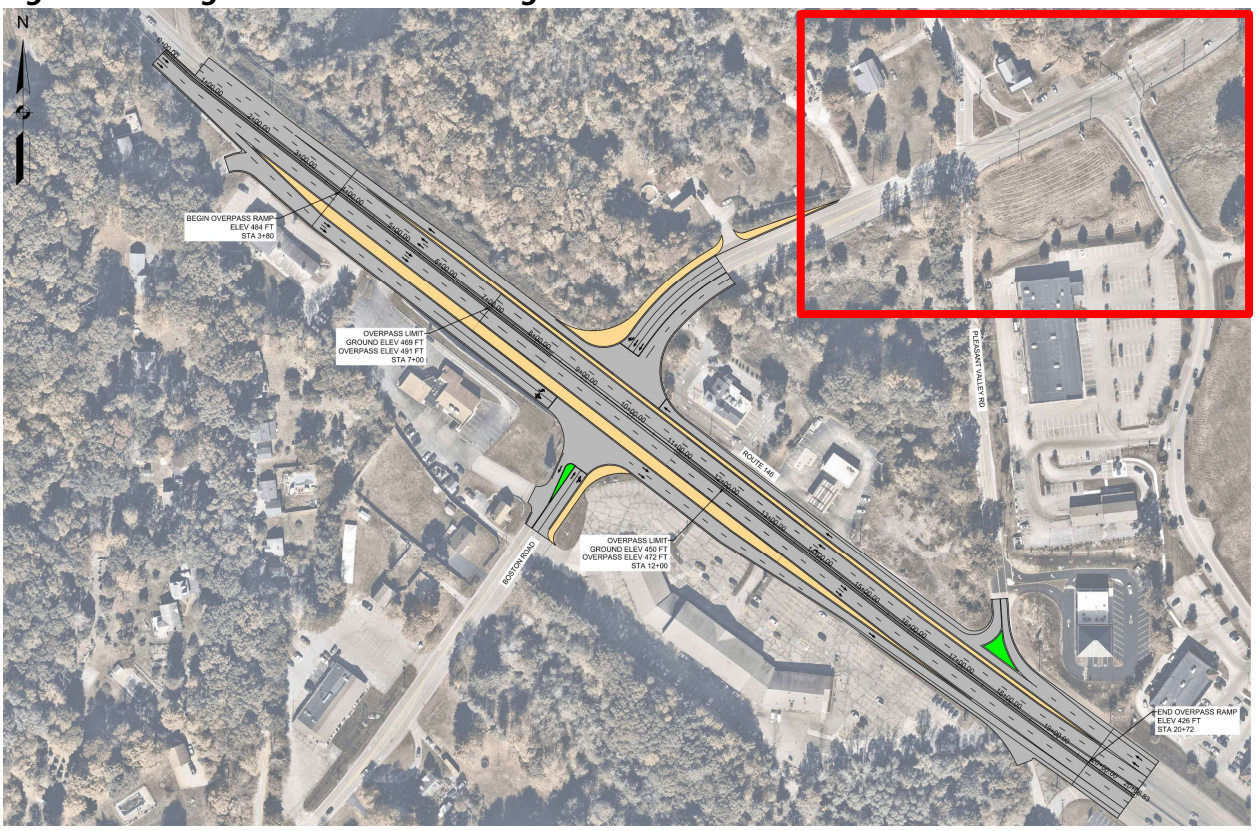
Route 146 is primarily a limited-access highway; however, there are direct access points for abutting properties and local roadways between Central Turnpike and Route 122A (North Main Street) in Millbury. The Boston Road intersection is located within this section. South of Central Turnpike and north of Route 122A, the only access to Route 146 is provided via grade-separated interchanges. The only existing frontage road along Route 146 parallels Route 146 southbound approaching Central Turnpike to accommodate Armsby Road. There is a cul-de-sac roadway that parallels Route 146 northbound at Route 122A (North Main Street) to provide access to abutting commercial properties. Any new frontage roads north of Boston Road would increase the roadway width by 30-50’ in each direction and would have right-of-way and environmental impacts, and cost would be a major consideration for any frontage road construction.

4.2 Recommendations

4.2.1 Route 146 at Boston Road

Based on the analysis results, it is recommended that the grade separation of the intersection of Route 146 and Boston Road be considered as traffic volumes continue to increase. Both the Tight Diamond and Single Point Interchange alternatives can be evaluated further, but the findings of this study show the tight diamond interchange as the preferred long-term alternative. A concept of the tight diamond interchange is in Figure 4.2-1.

Figure 4.2-1 Tight Diamond Interchange



The grade separation of Route 146 at Boston Road would be a high-cost project that requires further coordination with the local municipalities, the Central Massachusetts Regional Planning Commission, the MPO, MassDOT and FHWA, among others. While the intersection experiences heavy delays under existing conditions, most frequently during the morning peak period, grade separation may not be immediately warranted until further development occurs. As development timelines are subject to change based on economic conditions and market fluctuations, the proposed development volumes should be monitored closely for impacts on this intersection to identify the appropriate timing to advance a grade separation project. Any developments in the immediate vicinity should be designed to accommodate the future grade separated design.

Short-term and medium-term improvements for Route 146 at Boston Road would consist of pavement marking and signing or signal lens or timing modifications, as outlined in the Road Safety Audit. MassDOT should continue to monitor the condition of pavement markings and refresh them when needed to enforce proper vehicle tracking and lane usage.

4.2.2 Route 146 at Lackey Dam Road

As the off-ramp intersections do not experience significant delays or over capacity conditions even under the known future development scenario, there is no immediate need to pursue improvements for these intersections. As development projects advance, the actual and projected traffic volumes for the ramp intersections should be updated and evaluated to

consider the need for potential improvements. As traffic volume increases will likely be the result of larger development projects, specific mitigation measures to address project impacts should be considered during the project review process. While long-term improvements may consider signalization or roundabouts for the ramp intersections on Lackey Dam Road, short-term or medium-term improvements may include dedicated left-turn lanes on Lackey Dam Road to access the Route 146 on-ramps, or pedestrian and bicycle facilities to promote multimodal access along Lackey Dam Road.

4.2.3 Multimodal Connections

There are no pending multimodal connections that require added pedestrian or bicycle facilities crossing Route 146, but longer-term plans should be monitored for opportunities to provide more meaningful local and regional connections. Any roadway or development projects should evaluate the opportunity for multimodal improvements:

- Incorporate pedestrian and bicycle facilities in the design of future improvement projects on the roadways crossing Route 146.
- Coordinate the design of pedestrian and bicycle facilities with the local community to identify the availability of facilities to continue along the local roadways or to access other multimodal facilities.
- The review of development projects should identify appropriate measures to provide opportunities for non-vehicular trips.

4.2.4 Route 146 Frontage Roads

As part of the Boston Road grade-separation improvements, the on-ramps and off-ramps will serve as limited frontage roads and the exact termini must be coordinated with adjacent driveways and the southbound frontage road approaching Central Turnpike. To the north of Boston Road, a more practical approach will be to develop access management strategies to consolidate or eliminate driveways as properties are redeveloped, along with improved acceleration and deceleration lanes for driveway and local roadway access points.

4.3 Implementation Strategy

As a conceptual planning study, the Route 146 Corridor Vision Study is only the beginning of improving connectivity and mobility along the Route 146 corridor. This study examined transportation needs, as well as land use and development impacts. The result was the identification of a recommended alternative for the intersection of Route 146 and Boston Road, the tight diamond interchange, as that long-term project would achieve the study goals of improving safety, mobility and access, and traffic operations.

As the improvements identified in this study are necessitated by future development and not primarily based on existing traffic volumes and operations, immediate project advancement is not necessary. There are a number of known large development projects currently in various stages of development and there will likely be additional development along the corridor. Those projects should be closely monitored, and existing and projected traffic volumes should be evaluated to identify the need for localized improvements or to initiate the longer-term grade separation project for Route 146 at Boston Road.