Corridor Planning Study

TEC File No. T1088

Main Street (Route 28)

North Reading, Massachusetts

Prepared for: **Town of North Reading**
235 North Street
North Reading, Massachusetts 01864-1298

Prepared by: **TEC, Inc.**
146 Dascomb Road
Andover, Massachusetts 01810

I have reviewed this document as it relates to the proposed design and have determined the design to be safe for public health and welfare in conformity with accepted engineering standards.

COMMONWEALTH OF MASSACHUSETTS
SAMUEL W. GREGORIO
CIVIL
No. 51109
REGISTERED PROFESSIONAL ENGINEER

Samuel W. Gregorio, PE, PTOE, RSP_1
Senior Design Engineer

March 28, 2022

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ACRONYMS

AAB	Architectural Access Board
ADA	Americans with Disabilities Act
APS	Accessible Pedestrian Signal
ATC	Advanced Transportation Controller
ATR	Automatic Traffic Recorder
EPDO	Equivalent Property Damage Only
FAST Act	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
FYA	Flashing Yellow Arrow
HCM	Highway Capacity Manual
HSIP	Highway Safety Improvement Program
IMPACT	Interactive Mapping Portal for Analysis and Crash Tracking
ITS	Intelligent Transportation Systems
LOS	Level of Service
MAPC	Metropolitan Area Planning Council
MassDOT	Massachusetts Department of Transportation
MBTA	Massachusetts Bay Transportation Authority
MEV	Million Entering Vehicles
MUTCD	Manual on Uniform Traffic Control Devices
MVMT	Million Vehicle Miles Travelled
NCHRP	National Cooperative Highway Research Program
NEMA	National Electric Manufacturing Association
PDDG	Project Development and Design Guide
ROW	Right of Way
RPC	Regional Planning Commission
SHLO	State Highway Layout
SHSP	Strategic Highway Safety Plan
SUP	Shared Use Path
TIP	Transportation Improvement Program
TMC	Turning Movement Count
TWLTL	Two Way Left Turn Lane
V/C	Volume to Capacity
VPD	Vehicles per Day
VPH	Vehicles per Hour

I. INTRODUCTION

TEC, Inc. (TEC) has been retained by the Town of North Reading, Massachusetts (the "Town") to evaluate the existing and future traffic operations, traffic safety, and transportation infrastructure along the Main Street corridor through North Reading, Massachusetts. Main Street, a principal arterial corridor signed as State Route 28 and maintained by the Massachusetts Department of Transportation (MassDOT), serves as the primary commercial and industrial corridor within the Town. Its land use density along both edges of the road drives a significant portion of the Town's tax-revenue base, commuter distribution, and overall vehicular traffic. The corridor also serves as a key by-pass route for Interstate 93 (I-93), which parallels the corridor two miles to the west.

Route 28 is one of the most important regional arterial corridors in the Greater Boston North roadway network, yet its vehicle-oriented design is becoming less effective at serving the transportation needs of all users. During peak commuter periods, Main Street becomes congested, not due to the corridor's cross-section, but the layout and functionality of the existing infrastructure. Bicycle and pedestrians avoid the corridor altogether and utilize longer, more circuitous routes, which adds travel time and makes multi-modal use less attractive. Bicyclists particularly are discouraged from using Main Street because of a lack of safe facilities and a lack of physical separation between bicycle lanes and highspeed traffic. As the Town of North Reading grows and evolves, so must the Main Street corridor.

PURPOSE AND NEED

The purpose of the corridor planning study is to outline challenges to the existing traffic operations, traffic safety, and transportation infrastructure project while identifying potential infrastructure modifications and countermeasures to improve traffic control, overall flow, and safety within the corridor's current paved footprint wherever possible. Where possible, the study will describe potential opportunities for conformance with industry standards, including the *Manual on Uniform Traffic Control Devices for Streets and Highways* (*MUTCD*), the Massachusetts Architectural Access Board (AAB), Americans with Disabilities Act (ADA), and the Massachusetts Highway Department (now MassDOT) *Project Development and Design Guide* (*PDDG*) where feasible.

The Route 28 corridor provides access between Interstate 95 (I-95) to the south in Reading and Interstate 495 (I-495) to the north in Andover while paralleling I-93. This is an important system linkage between I-95 and I-495. The focused 2.6-mile section of Route 28 within North Reading, signed as Main Street, contains multiple signalized intersections spaced 900 to 3,300 feet apart, and provides access to numerous commercial, residential, office, and industrial developments along the corridor. Due to the close spacing of the intersections and an aging traffic signal system, queues from one intersection can often extend into adjacent intersections. Although

these intersections are intended to operate within a coordinated signal system, and have reserve capacity in most cases, the current coordinated timing plans provide poor progression of traffic platoons between the intersections, and often vehicles must stop at multiple intersections along the corridor. This is in part caused by outdated changes to the coordination plans that have occurred piecemeal as part of several public and private projects over the past decade as additional development has occurred along the corridor. In addition, there is unreliable communication between signal controllers and the existing signal equipment is outdated.

The Main Street corridor is also difficult to traverse for pedestrians and bicyclists due to the poor condition of the pedestrian infrastructure and lack of separated bicycle facilities. Much of the existing pedestrian signal equipment along the corridor does not comply with the *MUTCD* or the AAB standards and much of the equipment is no longer operational. Although pedestrian curb ramps are provided at most crosswalks along Main Street, a considerable number of these ramps are not currently AAB-compliant. There are no dedicated bicycle lanes along the corridor, and shoulders are too narrow to allow for efficient bicycle travel, requiring bicyclists share accommodations within the vehicular travel lanes. The corridor does not currently support public transportation services; although the heavy mixed-use nature of the corridor conveys an opportunity to accommodate public transportation.

Along with the Main Street corridor in its entirety, the bounded area for this planning study includes the following key signalized intersections:

1. Main Street (Route 28) / Burroughs Road / Stop & Shop Driveway
2. Main Street (Route 28) / North Street
3. Main Street (Route 28) / Lowell Road (Route 62)
4. Main Street (Route 28) / Winter Street (Route 62)
5. Main Street (Route 28) / Ocean State Job Lot Driveway
6. Main Street (Route 28) / North Reading Plaza Driveway
7. Main Street (Route 28) / Park Street

Study Goals

The goal of this corridor planning study is to identify traffic operational and safety characteristics and challenges along the Main Street Corridor and provide the Town of Reading with several conceptual design opportunities to enhance the user experience for all modes of transportation, including vehicles, bicycles, and pedestrians. The study focuses on the following major items:

- Provision of adequate vehicular capacity through dedicated turning lanes and intersection signalization
- Improved traffic progression through updated coordination between traffic signals in a manner that is cost effective, requires less maintenance, and is adaptable to the changing traffic demands to improve air quality in the area
- Considerations for a Complete Streets design approach to provide safe and efficient access for all roadway users

- Improved safety characteristics at intersections
- Installation of clear and compliant signage and other traffic control devices

Overall, improvement recommendations along the corridor will be detailed in a manner that is compatible with the State Transportation Improvement Program (TIP) for potential inclusion for future funding.

CONSISTENCY WITH PREVIOUS DOCUMENTS AND PROJECTS

Consistency with North Reading – Main Street Short-Term 2016-2021 Economic Development Strategy

In 2016, the Town of North Reading and the Metropolitan Area Planning Council (MAPC) issued its Main Street Economic Development Strategy[1] which focused on a key ¾-mile stretch of Main Street between Northbridge Drive to the north and the North Reading Plaza to the south. The purpose was to develop a short-term economic development strategy plan identifying actions the Town can take to set the right conditions to attach development around the underutilized parcels along Main Street in the vicinity of Route 62 (Lowell Road to Winter Street). Developed through the community planning process, the plan provided recommendations related to zoning, public investment, and infrastructure. Regarding infrastructure, the strategy highlighted a need to make Main Street into a *"slower-speed, safe typical Main Street where it is safe for pedestrians, shoppers, and adds value to nearby properties. Ideally, a redesigned roadway will include one or more prominent crosswalks connecting development, safe sidewalks, potentially bicycle paths, arrival gateway improvements…"*

Tying-In to Recent Corridor Work

Directly south of North Reading, the Town of Reading has concurrently been evaluating transportation options along the Route 28 corridor. MassDOT utilized a need for resurfacing along the Main Street corridor within the Town of Reading to conduct a Road Diet Pilot Project. The goal of this project is to reduce the number of crashes and severity of crashes along this heavily traveled corridor, by testing new infrastructure elements to slow down vehicle speeds and simplify left turns. Resurfacing work and the Road Diet Pilot took place on two sections of Route 28. The north section began at the Reading/North Reading town line and extended to Charles Street. The south section began at the Massachusetts Bay Transportation Authority (MBTA) Commuter Rail tracks and continued south to I-95. The work bypassed Reading Square.

As part of the Road Diet Pilot, pavement markings have been reconfigured within the existing roadway curb-to-curb width to simplify turning movements for cars by creating a center two-way left-turn lane. The hope was to reduce parts of North and South Main Street from four (4) lanes to three (3) lanes to improve safety for people traveling along the corridor. Lane configurations

[1] *Town of North Reading Main Street (Route 28 at 62) Short Term 2016-2021 Economic Development Strategy*; Metropolitan Area Planning Council; Boston, MA; June 2016.

varied slightly at different points of the corridor as part of the pilot program; however, the general format of the lane configuration is shown in Exhibit 1.

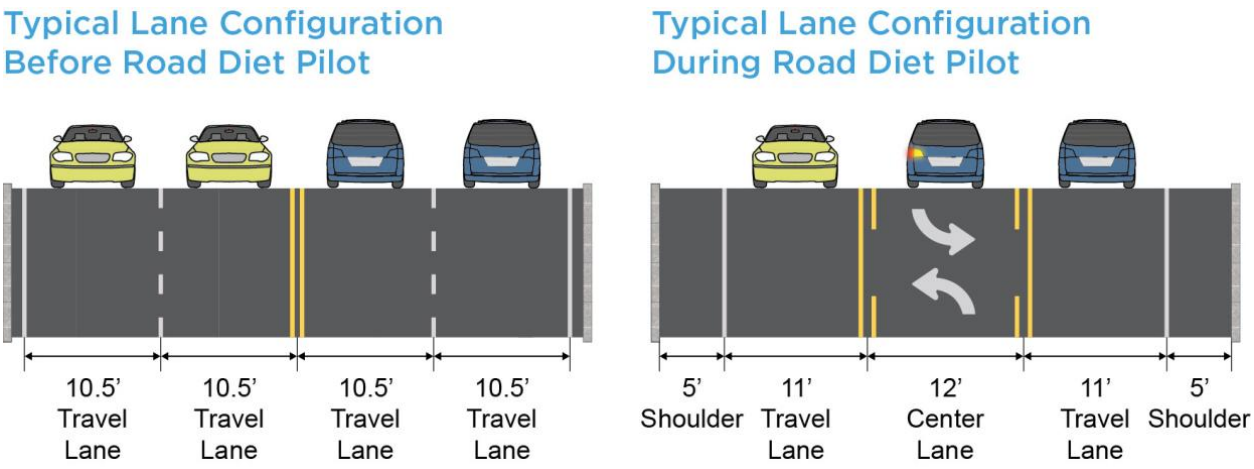


Exhibit 1: Typical Lane Configuration of Route 28 Road Diet Pilot [From MassDOT Project Page[2]]

Although a similar road diet along Main Street in North Reading is not a foregone outcome of this Main Street corridor planning study, the implementation and results of Reading's implementation of a road diet are examined as a potential improvement opportunity based on the proximity and nature of the previously installed corridor improvement.

PUBLIC OUTREACH

The Town of North Reading has solicited public input in the evaluation of corridor characteristics through a public survey. The survey was meant to refine the goals and develop the priorities for the project to ensure that it best meets the needs of abutters, residents, business owners and other stakeholders. The survey provided respondents the ability to provide personal feedback on the operations and safety of the existing corridor. The survey also highlighted respondents' thoughts on the walkability and likeability of the corridor, as state and/or federal funding of future improvements are partially tied to utilizing Complete Street design methods.

The deadline to submit the survey was October 1, 2021. Overall, the survey provided input from 570 individual respondents. The findings of the survey have been summarized and considered in this corridor planning study to assist in identified specific needs and identify specific opportunities.

METHODOLOGY OF TRAFFIC IMPACT ANALYSIS

This report satisfies the requirements set forth by the MassDOT for the development of traffic studies for corridor operations. Included are a review of existing and future traffic conditions with and without the proposed geometric and infrastructure improvements, safety analysis,

[2] https://www.mass.gov/info-details/about-the-route-28-resurfacing-and-road-diet-pilot-project-in-reading

intersection capacity and queue analysis, and a description of conceptual improvements for the several opportunities identified to enhance traffic operations and safety along Main Street. This study examines traffic volume projections under base year conditions (2021) and under a 10-year design horizon (2032) and includes an evaluation of conditions without improvements and with improvements under each defined opportunity. The findings and recommendations for the improvements are based on the detailed traffic impact and safety analysis included in this study.

II. EXISTING CONDITIONS

TRAFFIC STUDY AREA

A comprehensive field inventory of existing traffic conditions along the study area corridor was conducted during various site visits by TEC staff between March and May 2021. The field investigations consisted of direct observations of traffic flows, existing roadway geometrics, study area safety concerns, and intersection operating characteristics.

Study Area Intersections

The study area for this corridor planning study consisted of the section of Main Street between the Reading Town Line and the Andover Town Line, which included the following key signalized intersections:

1. Main Street (Route 28) / Burroughs Road / Stop & Shop Driveway
2. Main Street (Route 28) / North Street
3. Main Street (Route 28) / Lowell Road (Route 62)
4. Main Street (Route 28) / Winter Street (Route 62)
5. Main Street (Route 28) / Ocean State Job Lot Driveway
6. Main Street (Route 28) / North Reading Plaza Driveway
7. Main Street (Route 28) / Park Street

The study area limits, and key intersections are shown graphically in Figure 1.

GEOMETRY AND INFRASTRUCTURE

The field inventory included collection of existing roadway geometrics, pedestrian and bicycle accommodations, traffic volumes, and safety data for the existing study area. A description of the existing roadway and intersection inventories is provided below. TEC also conducted a complete inventory of traffic signal and pedestrian signal equipment, including their general compliance with current standards and overall condition.

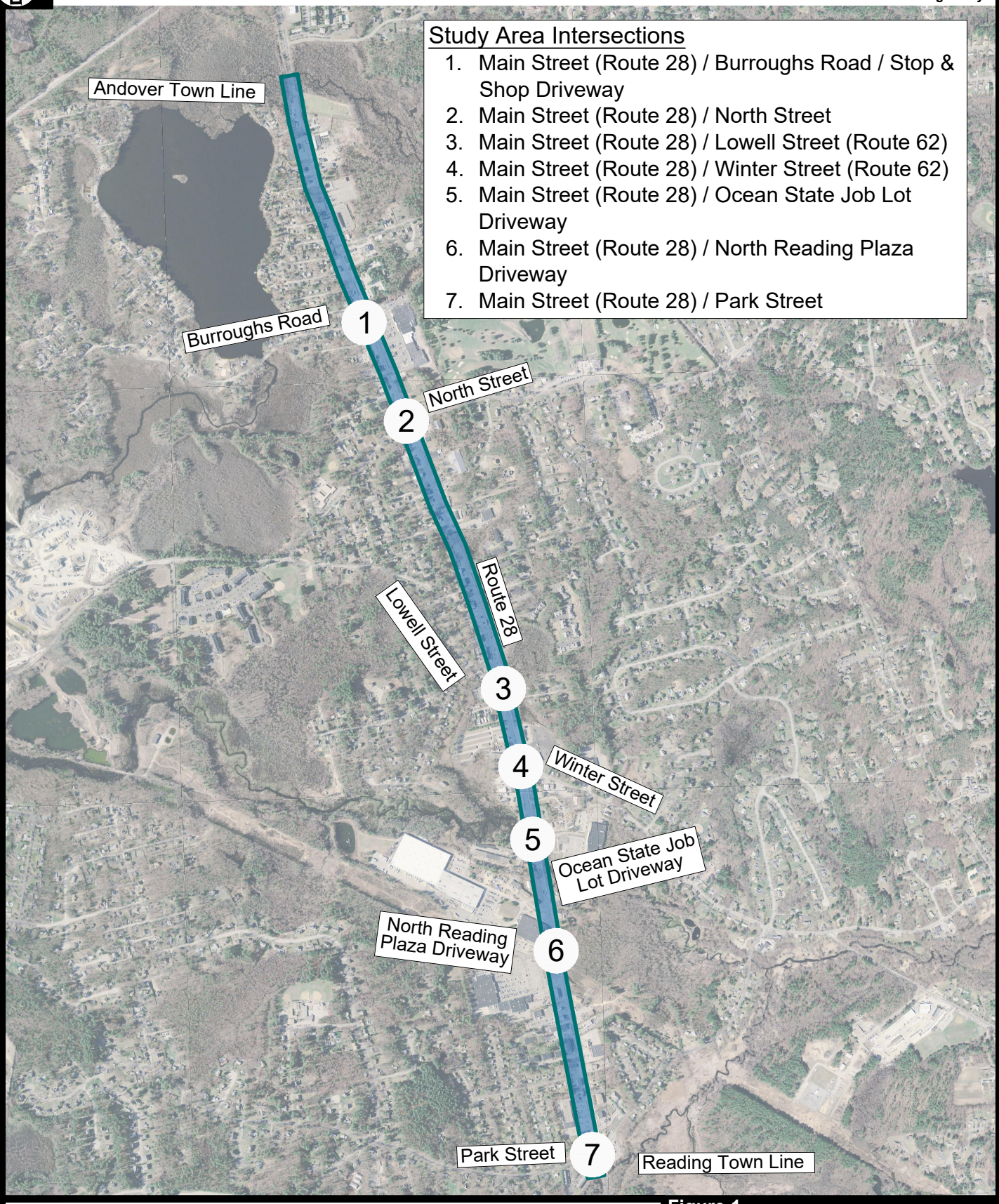


Figure 1

Project Location Map & Study Area Intersections

TEC, Inc.
146 Dascomb Road
Andover, MA 01810
978-794-1792
www.TheEngineeringCorp.com

Main Street Corridor Description

Main Street, signed as State Route 28, is a four-lane, northwest-southeast urban principal arterial corridor under the jurisdiction of MassDOT. Enforcement of traffic regulations is conducted by the Town of North Reading Police Department. For the purpose of this study, the cardinal direction of the corridor will be referred to as north-south. Main Street serves as the primary commercial and industrial corridor within the Town, as well as a key by-pass route for I-93 which parallels the corridor two miles to the west. Direct connections to Main Street from I-93 are present through Park Street, Lowell Road (Route 62), and North Street. Directional flow along the corridor is separated by a marked centerline.

Vehicle speed along the corridor is signed and regulated by MassDOT through Speed Zone Regulation #4073 and #4073-B. The regulated bidirectional speed is 40 miles per hour (mph) from the Reading Town Line to Leclair Street (approximately 420-feet north of the Burroughs Road) and 45 mph from Leclair Street to the Andover Town Line. A graphical depiction of the MassDOT speed regulation and signage layout along the corridor is provided in Figure 2. A copy of the speed regulations is provided in Appendix A.

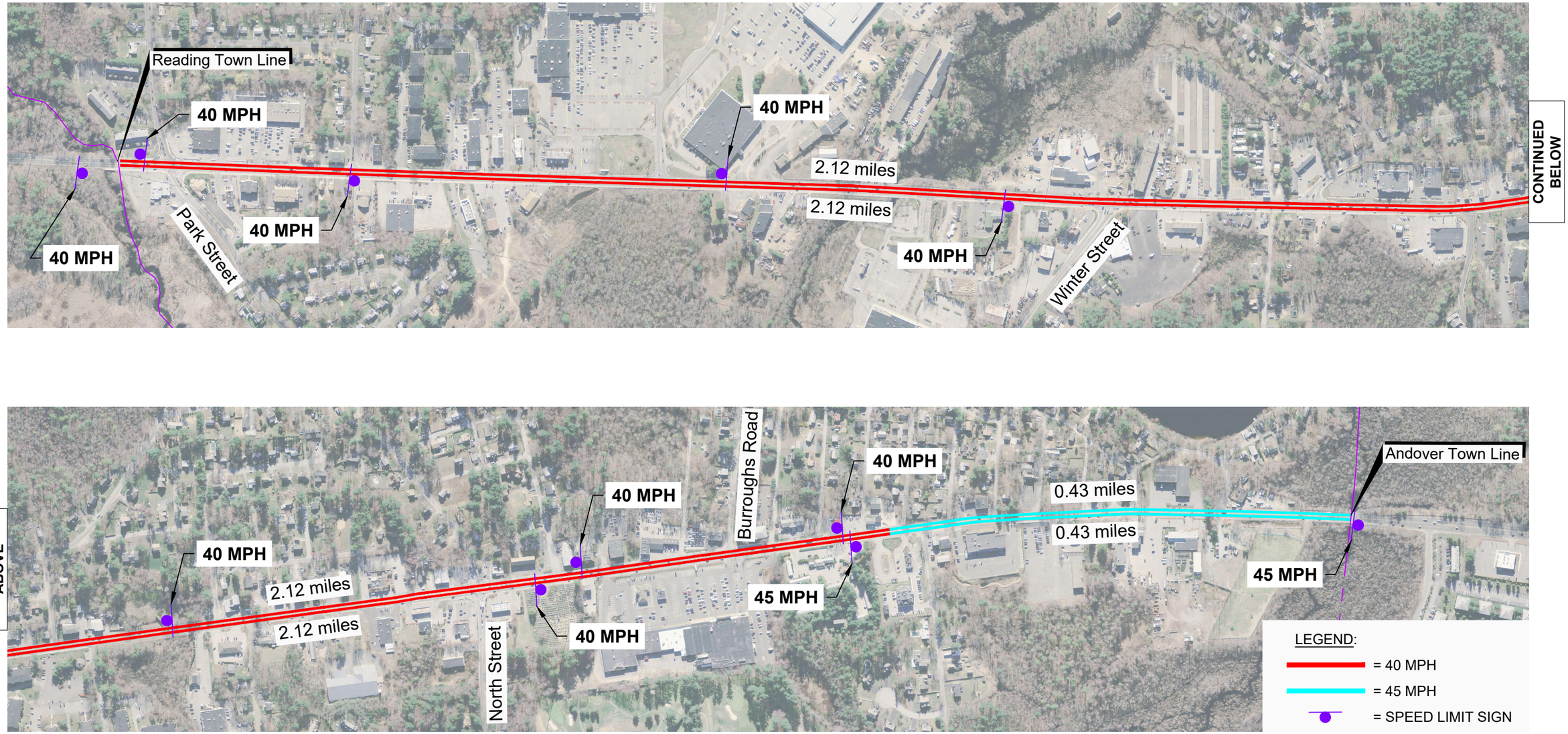
The roadway width is generally 50-feet curb-to-curb within a consistent 66-foot State Highway Layout (SHLO). A summary of the SHLO parameters is outlined in Table 1 with baseline stationing running from the Andover Town Line to the Reading Town Line. Overall, there has historically been minimal alterations to the SHLO layout since the state acquisition; however, several additional layouts plans are noted in the area (not listed below) which defined specific permanent easements outside of the SHLO on various private properties.

Table 1 - Main Street - State Highway Layout Summary

Layout Number	Starting Station	Ending Station	Acceptance Date	SHLO Width
195	0+00 (Andover)	26+40	6/17/1897	66’
331	26+40	38+00	9/14/1898	66’
7409	38+00	42+87	7/28/1998	66’
331	42+87	53+29.25	9/14/1898	66’
594	53+29.25	88+50	6/26/1901	66’
646	88+50	93+00	10/9/1901	66’
1355	93+00	93+60.1	4/25/1911	66’
7008	93+60.1	94+77.21	9/5/2000	66’
3319	94+77.21	99+23.57	7/4/1939	66’
1355	99+23.57	105+00	4/25/1911	66’
802	105+00	134+00	8/112/1903	66’
2797	134+00	134+62.09 (Reading)	6/22/1931	66’

Land uses along the corridor range from light to heavy commercial, a large quantity of retail and restaurants, several industrial uses, and limited residential uses. Much of the businesses along the corridor have individual curb-cuts for property access which results in a large quantity of curb-cuts overall and a degradation of access management along each side of the corridor. Intermittent sidewalks are present along both sides of Main Street within the Town and no formal bicycle accommodations are provided along the corridor. The sidewalks that are present range from a significantly poor condition to above average condition. A graphical depiction of pedestrian accommodations along the corridor is provided in Figure 3.

1"=500'



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The Engineering Corp
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Figure 2

Existing MassDOT Special Speed Regulations and Signage

Main Street (Route 28)
North Reading, Massachusetts

1"=500'

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Figure 3

Corridor Pedestrian Accommodations

Main Street (Route 28)
North Reading, Massachusetts

Exhibit 2 provides a depiction of the typical cross-section of the corridor between the Andover and Reading Town Lines. Overall, the 50-foot curb-to-curb width consists of four (4) 12-foot travel lanes, two per direction, and 1-foot shoulders along both roadway edge. Much of the corridor vertically separates sidewalk from the roadway surface with a mix of asphalt berm and granite curb. Where no sidewalk is present, asphalt berm is generally present; however, the age of the infrastructure has resulted in much of the berm to be leveled off to where it appears to be absent. This asphalt berm settling or leveling is also present within some locations where berm separates the roadway from sidewalk.

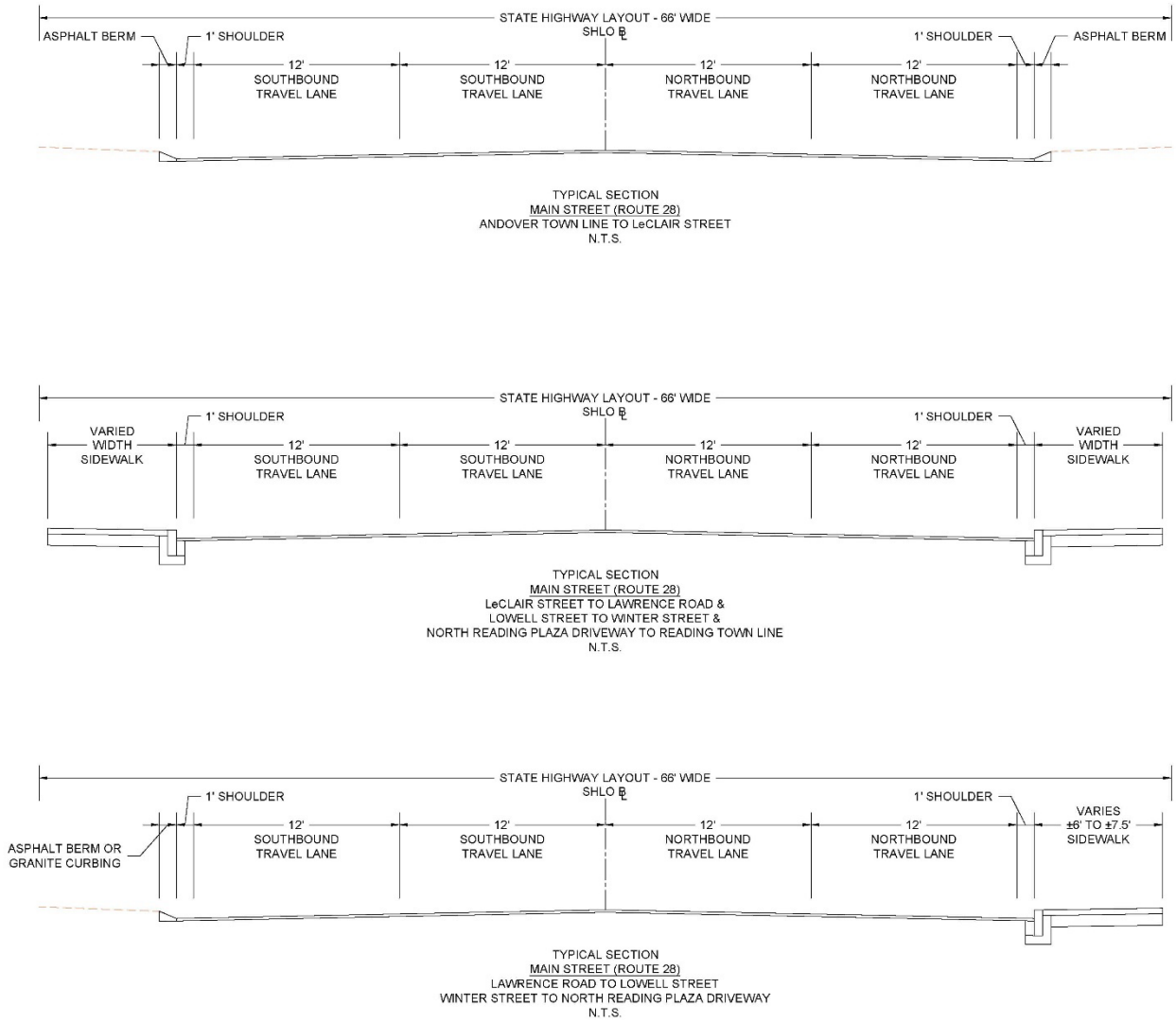


Exhibit 2: Typical Cross-Sections of Main Street from Andover Town Line to Reading Town Line

Key Intersections

Main Street / Burroughs Road / Stop & Shop Driveway

Burroughs Road and the Stop & Shop Driveway intersect Main Street to form a four-way, fully actuated signalized intersection. The Burroughs Road eastbound approach consists of a single general-purpose travel lane with directional flow separated by a marked centerline. The Stop & Shop Driveway westbound approach consists of a shared left-turn/through lane and an exclusive right-turn lane, with directional flow separated by a raised landscaped island. The Main Street northbound and southbound approaches consist of a shared left-turn/through lane and a shared through/right-turn lane with directional flow separated by a marked centerline.

Sidewalks are provided along both sides of Main Street and along the northerly side of Burroughs Road. Crosswalks are present across all intersection approaches; however, no pedestrian signal equipment is provided for the crossing across the Stop & Shop Driveway. Pedestrian curb ramps are provided at the ends of each crosswalk; however, each ramp appears to not comply with AAB standards. Some non-complaint components observed include absence of tactile warning devices, transition slopes in excess of 7.5%, a lack of 36-inch clearance around objects within the sidewalks from level surfaces, and pedestrian push buttons not accessible from a level surface. Three of the four intersection corners currently have apex style ramps. Field observations indicated seventeen (17) pedestrians traveling through the intersection during the 12-hour weekday count period across each crossing location.

There are no formal bicycle accommodations at the intersection. Field observations indicated a limited number of bicycles traveling through the intersection during the 12-hour weekday count period (3 bicycles observed).

The traffic signal at this location is operating on an Eagle EPAC300 model TS1 controller. Coordination between the traffic signal at this location and the North Street to the south is provided. The intersection is serviced with connections for inductive wire loop detection (Saratoga brand equipment) and emergency vehicle preemption (3M Opticom brand equipment). Loop detectors are installed to incorporate dilemma zone detection for the higher speed Main Street movements. Retroreflective backplates were recently installed at the intersection. Some components of the traffic signal at this location are antiquated and/or in need of upgrades. The following deficiencies were observed during field visits:

- The pedestrian clearance interval is currently programmed as 13 seconds Flashing Don't Walk with a 2 second Don't Walk clearance. Current MassDOT pedestrian clearance interval recommendations for the location is 20 seconds

Flashing Don't Walk and 4 seconds Don't Walk (24 second total clearance). The Walk time at this location is also programmed at a short 5 seconds.

- The National Electric Manufacturing Association (NEMA) TS1 controller system is antiquated and should be upgraded to a TS2 at minimum, if not an Advanced Transportation Controller (ATC) system.
- Based on direct observation, it appears that the loop detector for the Main Street northbound and northbound left-turn phases are faulting.
- No overhead signal housings are provided for the Stop & Shop Driveway eastbound approach.
- The Left Turn Yield on Green Ball (R10-12) sign facing Main Street northbound along the mast arm is currently faded. A similar R10-12 sign facing Main Street southbound is current broken off its mount and needs replacement.
- No emergency vehicle preemption is provided for the Burroughs Road eastbound approach.
- The paint on various pedestrian signal housings has significant chipping which may lead to faster deterioration and rusting.
- Some pedestrian push buttons at the intersection are out of the 10-inch AAB-standard reach of a level surface.

Main Street / North Street

North Street intersects Main Street to form a four-way, fully actuated signalized intersection. Both the North Street eastbound and westbound approaches consist of an exclusive left-turn lane and a shared through/right-turn lane with directional flow separated by a marked centerline. Both the Main Street northbound and southbound approaches consist of an exclusive left-turn lane, a through lane, and a shared through/right-turn lane. Directional flow along Main Street is separated by a marked centerline. A heavy vehicle exclusion is present along North Street west of the intersection.

Sidewalks are provided along both sides of Main Street and along the northerly side of North Street. Crosswalks are present across all intersection approaches. Pedestrian curb ramps are provided at the ends of each crosswalk; however, each ramp appears to not comply with AAB standards. Some non-complaint components observed include lack of level landing areas for wheelchair turns, absence of tactile warning devices, transition slopes in excess of 7.5%, and pedestrian push buttons not accessible from a level surface. Field observations indicated seventeen (17) pedestrians traveling through the intersection during the 12-hour weekday count period across each crossing location.

There are no formal bicycle accommodations at the intersection. Field observations indicated a limited number of bicycles traveling through the intersection during the 12-hour weekday count period (3 bicycles observed).

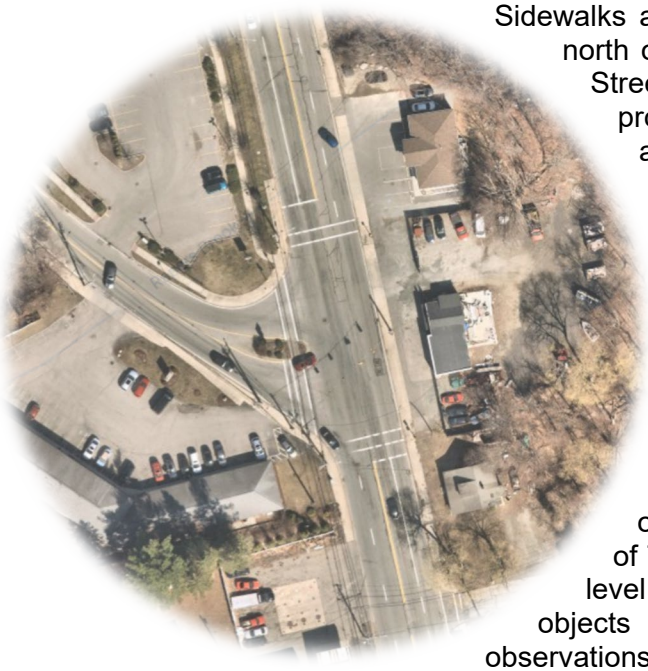
The traffic signal at this location is operating on an Econolite Colbolt model TS2-Type 1 controller. The intersection serves as the master location for coordination with the intersection of Main Street / Burroughs Road / Stop & Shop Driveway. An Eagle MARC300 master controller unit is present in the signal cabinet. The intersection is serviced with connections for inductive wire loop detection (EDI brand equipment) and emergency vehicle preemption (3M Opticom brand equipment). Loop detectors are installed to incorporate dilemma zone detection for the higher speed Main Street movements. Retroreflective backplates were recently installed at the intersection. Flashing yellow arrow (FYA) operations are in effect for North Street eastbound and westbound left-turn permissive phasing. Some components of the traffic signal at this location are antiquated and/or in need of upgrades. The following deficiencies were observed during field visits:

- The pedestrian clearance interval is currently programmed as 17 seconds Flashing Don't Walk with a 3 second Don't Walk clearance. Current MassDOT recommendations for the location is 16 seconds Flashing Don't Walk and 4 seconds Don't Walk (20 second total clearance).
- Based on direct observation, it appears that the loop detector for the North Street westbound movement may not be operational; however, no 'fault' was observed on the loop amplifier within the controller cabinet.
- The through movement signal housing overhead for both the North Street westbound and eastbound approaches are both within 40-feet of the stop line. This short distance is allowable as a post mounted signal housing for the through movement is provided otherwise within the cone-of-vision.
- The paint on various pedestrian signal housings and pedestal posts has significant chipping which may lead to faster deterioration and rusting.
- 8-inch pedestrian signal indications are provided at the intersection. All indications lack countdown capabilities. Portions of the LEDs within some housings are non-operational.
- Some pedestrian push buttons at the intersection are out of a 10-inch AAB-standard reach of a level surface. Multiple push buttons are more than 10-feet away from the opening of the associated ramp.

Main Street / Lowell Road (Route 62) / Nick O'Brian's Service Driveway

Lowell Road, signed as State Route 62, and the Nick O'Brian's Service Driveway intersect Main Street to form a four-way, fully actuated signalized intersection. South of the intersection, Main Street is concurrently signed as Route 62. The Lowell Road eastbound approach consists of a single general-purpose travel lane. The width of the approach allows vehicles to stack in two lanes and therefore, the approach operates as a shared left-turn/through lane and an exclusive right-turn lane. Directional flow along Lowell Road is separated by a raised landscaped median. The Nick O'Brian's Service Driveway westbound approach consists of a single general-purpose travel lane with directional flow unmarked. Both the Main Street northbound and southbound

approaches consist of a shared left-turn/through lane and a shared through/right-turn lane with directional flow separated by a marked centerline.



Sidewalks are provided along the easterly side of Main Street north of the intersection and along both sides along Main Street south of the intersection. Sidewalks are also provided along both sides of Lowell Road. Crosswalks and pedestrian signal equipment are present across the eastbound, northbound, and southbound approaches. No formal crosswalk or pedestrian signal equipment is provided across the Nick O'Brian's Service Driveway as the driveway is constructed as a standard "sidewalk through driveway." Pedestrian curb ramps are provided at the ends of each crosswalk; however, each ramp appears to not comply with AAB standards. Some non-complaint components observed include lack of level landing areas for wheelchair turns, absence of tactile warning devices, transition slopes in excess of 7.5%, pedestrian push buttons not accessible from a level surface, and a lack of 36-inch clearance around objects within the sidewalks from level surfaces. Field observations indicated sixteen (16) pedestrians traveling through the intersection during the 12-hour weekday count period across each crossing location.

There are no formal bicycle accommodations at the intersection. Field observations indicated a limited number of bicycles traveling through the intersection during the 12-hour weekday count period (3 bicycles observed).

The traffic signal at this location is operating on an Eagle EPAC300 model TS2-Type 1 controller. The intersection is serviced with connections for inductive wire loop detection (EDI brand equipment) and emergency vehicle preemption (3M Opticom brand equipment). Retroreflective backplates were recently installed at the intersection. Some components of the traffic signal at this location are antiquated and/or in need of upgrades. The following deficiencies were observed during field visits:

- The signal phasing at the intersection does not follow NEMA protocols where the eastbound / westbound is programmed together as Phase Φ3 instead of separate phasing.
- Vehicular clearance intervals are consistent phase-to-phase and do not meet current MassDOT and/or *MUTCD* standards.
- The pedestrian clearance interval is currently programmed as 27 seconds Flashing Don't Walk with a 2 second Don't Walk clearance. Current MassDOT recommendations for the location is 27 seconds Flashing Don't Walk and 4 seconds Don't Walk (31 second total clearance). The Walk time at this location is also programmed at a short 5 seconds.
- No overhead signal housings are provided for the Nick O'Brian's Service Driveway westbound approach.

- The Left Turn Yield on Green Ball (R10-12) sign and mounting bracket facing Main Street northbound are missing.
- The paint on various pedestrian signal housings and pedestal posts has significant chipping which may lead to faster deterioration and rusting. Specifically, the paint for those housings along the span wire. Several housings a top the lower pedestal posts appear to be in above-average condition while even on deteriorated posts. One pedestal post on the intersection's northeast corner appears to be new.
- There is a mix of 8-inch single and dual 8-inch pedestrian signal indications at the intersection. All indications lack countdown capabilities.
- The crosswalk across Lowell Road is in excess of 100-feet which requires indications on the pedestrian signals to be at minimum 9-inches in height per *MUTCD* standards.
- Some pedestrian push buttons at the intersection are out of a 10-inch AAB-standard reach of a level surface. In addition, all pedestrian push button signage at the intersection is either completely faded or missing.

Main Street / Winter Street (Route 62) / Reading Lumber Driveway

Winter Street, signed as State Route 62, and the Reading Lumber Driveway intersect Main Street to form a three-way, four-legged, fully actuated signalized intersection. North of the intersection, Main Street is concurrently signed as Route 62. The Reading Lumber leg on the westerly side of Main Street is one-way exiting the intersection. The Winter Street westbound approach consists of a single general-purpose travel lane. The width of the approach allows vehicles to stack in two lanes and therefore, the approach operates as a shared left-turn/through lane and an exclusive right-turn lane. Directional flow along Winter Street is separated by a raised landscaped median. Both the Main Street northbound and southbound approaches consist of a shared left-turn/through lane and a shared through/right-turn lane with directional flow separated by a marked centerline.

Sidewalks are provided along the easterly side of Main Street south of the intersection and along both sides along Main Street north of the intersection. Sidewalks are also provided along both sides of Winter Street. Crosswalks and pedestrian signal equipment are present across the westbound, northbound, and southbound approaches. No formal crosswalk or pedestrian signal equipment is provided across the Reading Lumber Driveway as the driveway is constructed as a standard "sidewalk through driveway." Pedestrian curb ramps are provided at the ends of each crosswalk; however, each ramp appears to not comply with AAB standards. Some non-complaint components observed include lack of level landing areas for wheelchair turns, absence of tactile warning devices, transition slopes in excess of 7.5%, pedestrian push buttons

not accessible from a level surface, and a lack of 36-inch clearance around objects within the sidewalks from level surfaces. Field observations indicated a slightly higher number of pedestrians traveling through the intersection during the 12-hour weekday count period across each crossing location (15 pedestrians observed total). Seven (7) pedestrians crossed between 11:00 AM and 12:00 PM which may be related to two restaurants on the intersection corners.

There are no formal bicycle accommodations at the intersection. Field observations indicated a limited number of bicycles traveling through the intersection during the 12-hour weekday count period (3 bicycles observed).

The traffic signal at this location is operating on a relatively new Siemens m60 model TS2-Type1 controller installed in 2016. Coordination between the traffic signal at this location and Ocean State Job Lot Driveway to the south is provided; however, the coordination timing and time of day parameters do not match the other locations in the coordination stream. The intersection is serviced with connections for inductive wire loop detection (EDI brand equipment) and emergency vehicle preemption (3M Opticom brand equipment). Retroreflective backplates were recently installed at the intersection. Some components of the traffic signal at this location are antiquated and/or in need of upgrades. The following deficiencies were observed during field visits:

- The signal phasing at the intersection does not follow NEMA protocols where the southbound mainline is programmed to Phase Φ5 as opposed to Phase Φ6.
- The pedestrian clearance interval is currently programmed as 25 seconds Flashing Don't Walk. Current MassDOT recommendations for the location is 22 seconds Flashing Don't Walk and 4 seconds Don't Walk (26 second total clearance). The Walk time at this location is also programmed at a short 5 seconds.
- The paint on various pedestrian signal housings and pedestal posts has significant chipping which may lead to faster deterioration and rusting.
- The Main Street southbound inside signal housing is a 4-section housing to support protected-permitted phasing with a "bi-model" yellow/green arrow indication. This set-up is 1) different from many 5-section housings along the corridor for the similar movement, and 2) provides a bi-model indication which can be challenging for color-blind users to decipher the ongoing phase interval changes.
- There is a mix of 8-inch single and dual 8-inch pedestrian signal indications at the intersection. All indications lack countdown capabilities.
- The pedestrian signal housing on the intersection northeast corner (adjacent to Kitty's Restaurant) was not active during the signal inventory.
- Some pedestrian push buttons at the intersection are out of a 10-inch AAB-standard reach of a level surface. An additional push button is more than 10-feet away from the opening of the associated ramp. In addition, all pedestrian push button signage at the intersection is either completely faded or missing.

Main Street / Ocean State Job Lot Driveway

The Ocean State Job Lot Driveway intersects Main Street to form a three-way, fully actuated signalized intersection. The Ocean State Job Lot Driveway westbound approach consists of an exclusive left-turn and exclusive right-turn lane with directional flow separated by a raised landscaped island. The Main Street northbound approach consists of a through lane and a shared through/right-turn lane while the Main Street southbound approach consists of shared left-turn/through lane and a through lane. Directional flow along Main Street is separated by a marked centerline.

Sidewalks are provided along easterly side of Main Street at the intersection. No sidewalks are provided along the Ocean State Job Lot Driveway. Pedestrians accessing the plaza do so via the Winter Street driveway on the north side of the property. A pedestrian crossing is provided across the Ocean State Job Lot Driveway; however, no crosswalk is formally marked. Pedestrian curb ramps are provided at the ends of the crossing; however, each ramp appears to not comply with AAB standards. Some non-complaint components observed include absence of tactile warning devices, transition slopes in excess of 7.5%, and no signal accommodations for pedestrians. Field observations indicated a limited number of pedestrians traveling through the intersection during the 12-hour weekday count period (8 pedestrians observed). All eight (8) pedestrians crossed the Ocean State Job Lot Driveway and all eight (8) occurred before 2:00 PM.

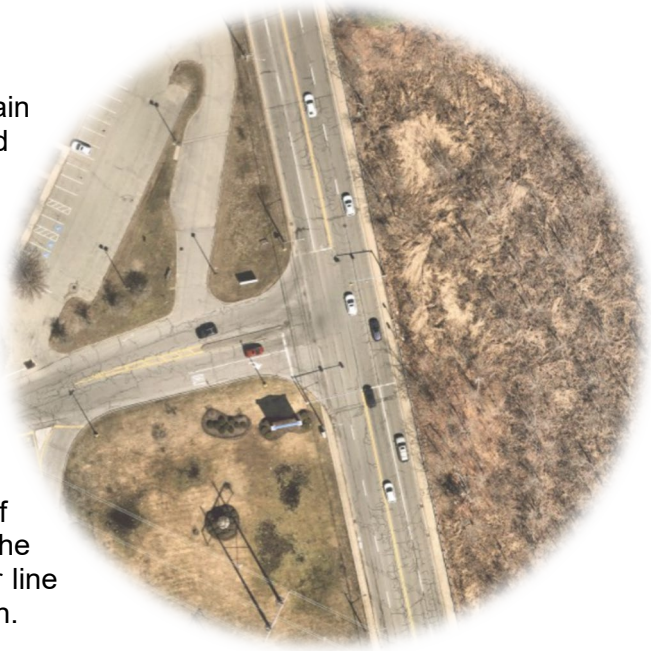
There are no formal bicycle accommodations at the intersection. Field observations indicated a limited number of bicycles traveling through the intersection during the 12-hour weekday count period (1 bicycle observed).

The traffic signal at this location is operating on a relatively new Siemens m60 model TS2-Type1 controller installed in 2017. Coordination between the traffic signal at this location and the North Reading Plaza to the south is provided; however, coordination is currently inactive. The intersection is serviced with connections for inductive wire loop detection (EDI brand equipment) and emergency vehicle preemption (3M Opticom brand equipment). Retroreflective backplates were recently installed at the intersection. Some components of the traffic signal at this location are antiquated and/or in need of upgrades. The following deficiencies were observed during field visits:

- The signal phasing at the intersection does not follow NEMA protocols where the southbound mainline is programmed to Phase Φ5 as opposed to Phase Φ6.
- Vehicular clearance intervals do not meet current MassDOT and/or *MUTCD* standards.

- No overhead signal housings are provided for the Ocean State Job Lot Driveway westbound approach. One signal housing for the Main Street northbound inside lane is well off-center from the travel lane as it is mounted to the mast arm for southbound movements.
- The Left Turn Yield on Green Ball (R10-12) sign and mounting bracket facing Main Street southbound are missing.
- The paint on various pedestrian signal housings and pedestal posts has significant chipping which may lead to faster deterioration and rusting.
- There is currently no pedestrian signal equipment or phasing for the pedestrian crossing across the Ocean State Job Lot Driveway westbound approach.

Main Street / North Reading Plaza Driveway



The North Reading Plaza Driveway intersects Main Street to form a three-way, fully actuated signalized intersection. The North Reading Plaza Driveway eastbound approach consists of an exclusive left-turn lane and an exclusive right-turn lane with directional flow separated by a raised asphalt island. The Main Street northbound approach consists of a shared left-turn/through lane and a through lane while the Main Street southbound approach consists of a through lane and a shared right-turn/through lane. Directional flow along Main Street is separated by a marked centerline. There is a significant visible amount of pavement cracking on the approaches to the intersection, especially along the Main Street gutter line against the North Reading Plaza Driveway approach.

Sidewalks are provided along both sides of Main Street south of the intersection and along the easterly side of Main Street north of the intersection. No sidewalks are provided along the North Reading Plaza Driveway. Pedestrian accessing the plaza do so via the driveway for the Joe Fish Restaurant on the south side of the property, south of the North Reading Plaza Driveway. No crosswalks or pedestrian curb ramps are provided at the intersection. Field observations indicated no pedestrians traveling through the intersection during the 12-hour weekday count period. There are no formal bicycle accommodations at the intersection. Field observations indicated a limited number of bicycles traveling through the intersection during the 12-hour weekday count period (3 bicycles observed).

The traffic signal at this location is operating on an Eagle EPAC300 model TS1 controller. The intersection serves as the master location for coordination with the intersection of Main Street / Ocean State Job Lot Driveway. An Eagle MARC300 master controller unit is present in the signal cabinet. The intersection is serviced with connections for inductive wire loop detection (EDI and Saratoga brand equipment) and emergency vehicle preemption (3M Opticom brand equipment). Loop detectors are installed to incorporate dilemma zone detection for the higher speed Main Street movements. Retroreflective backplates were recently installed at the

intersection. Some components of the traffic signal at this location are antiquated and/or in need of upgrades. The following deficiencies were observed during field visits:

- The NEMA TS1 controller system is antiquated and should be upgraded to a TS2 at minimum, if not an ATC system.
- The signal phasing at the intersection does not follow NEMA protocols where the northbound and southbound mainline is programmed to Phase Φ1 and Phase Φ5, respectively, as opposed to Phase Φ2 and Phase Φ6.
- Vehicular clearance intervals (yellow time and all-red time) are consistent phase-to-phase and do not meet current MassDOT and/or *MUTCD* standards.
- No overhead signal housings are provided for the North Reading Plaza Driveway eastbound approach.
- The Left Turn Yield on Green Ball (R10-12) sign and mounting bracket facing Main Street northbound are missing.
- The paint on various pedestrian signal housings and pedestal posts has significant chipping which may lead to faster deterioration and rusting.

Main Street / Park Street

Park Street intersects Main Street to form a four-way, fully actuated signalized intersection. The Park Street eastbound approach consists of exclusive left-turn lane, a through lane, and channelized right-turn lane. The Park Street westbound approach consists of a shared through/left-turn lane and a channelized right-turn lane. Directional flow along Park Street is separated by a marked centerline. Both the Main Street northbound and southbound approaches consist of a shared left-turn/through lane and a shared through/right-turn lane with directional flow separated by a marked centerline. There is a significant visible amount of pavement cracking at locations on the approaches to the intersection.

Sidewalks are provided along both sides of Main Street, along both sides of the Park Street northbound approach, and on the northerly side of the Park Street eastbound approach. Crosswalks and pedestrian signal equipment are present across all intersection approaches. Pedestrian curb ramps are provided at the ends of each crosswalk; however, each ramp appears to not comply with AAB standards. Some non-complaint components observed include lack of level landing areas for wheelchair turns, absence of tactile warning devices, transition slopes in excess of 7.5%, pedestrian push buttons not accessible from a level surface, and a lack of 36-inch clearance around objects within the sidewalks from level surfaces. Field observations indicated a limited number of pedestrians traveling through the intersection during the 12-hour weekday count period (4 pedestrians observed).

There are no formal bicycle accommodations at the intersection. Field observations indicated a limited number of bicycles traveling through the intersection during the 12-hour weekday count period (3 bicycles observed).

The traffic signal at this location is operating on a relatively new Siemens m60 model TS2-Type1 controller installed in 2016. No coordination between the traffic signal at this location and the North Reading Plaza to the north is provided. The intersection is serviced with connections for inductive wire loop detection (EDI brand equipment) and emergency vehicle preemption (3M Opticom brand equipment). Retroreflective backplates were recently installed at the intersection. Some components of the traffic signal at this location are antiquated and/or in need of upgrades. The following deficiencies were observed during field visits:

- The pedestrian clearance interval is currently programmed as 12 seconds Flashing Don't Walk. Current MassDOT recommendations for the location is 11 seconds Flashing Don't Walk and 4 seconds Don't Walk (15 second total clearance).
- The Left Turn Yield on Green Ball (R10-12) sign and mounting bracket facing Main Street northbound are missing.
- The paint on various pedestrian signal housings and pedestal posts has significant chipping which may lead to faster deterioration and rusting.
- The Main Street northbound inside signal housing is a 4-section housing to support protected-permitted phasing with a "bi-model" yellow/green arrow indication. This set-up is 1) different from many 5-section housings along the corridor for the similar movement, and 2) provides a bi-model indication which can be challenging for color-blind users to decipher the ongoing phase interval changes.
- There is a mix of 8-inch and 16-inch countdown pedestrian signal indications at the intersection.
- Pedestrian signal housing "P5" was currently not active during the signal inventory.
- Some pedestrian push buttons at the intersection are out of a 10-inch AAB-standard reach of a level surface. In addition, some pedestrian push button signage at the intersection is completely faded.
- Overhead signal indications are provided. However, backplates are not provided to assist against solar glare, especially along the Park Street westbound and Main Street southbound which are within the solar field during parts of the day.

PUBLIC TRANSPORTATION

There are currently no public transportation routes or accommodations provided along Main Street within North Reading. The Town of Reading Elder Services, through the Pleasant Street Center, operates van transportation to/from several locations within the Town and along Main Street. The van service is not meant to be medical transportation and riders must be able to board with minimal assistance. The service is free for Reading seniors and non-seniors with disabilities. All rides must be scheduled 24-hours in advance.

III. TRAFFIC VOLUMES

Traffic volume data for this report was obtained from manual Turning Movement Counts (TMCs) and supplemented with Automatic Traffic Recorder (ATR) counts conducted at the study area intersections. The details of the data collection effort for this project are described below.

TRAFFIC COUNTS

Turning Movement Counts

To establish existing traffic volume conditions, manual TMCs were conducted at the key study intersection on Thursday March 18, 2021, during a typical weekday between 7:00 AM and 7:00 PM and on Saturday, March 20, 2021, during a typical Saturday midday peak hour (11:00 AM to 1:00 PM). Area schools were in remote sessions during the time of the traffic counts. The counts represent a reasonable reflection of traffic within COVID-19 pandemic conditions without school in regular session. These counts have been upwardly adjusted to a non-COVID-19 level.

A detailed summary of the TMCs, partitioned into 15-minute intervals, is provided within Appendix B.

Additional TMCs were completed in October 2021 at the two Main Street intersections with both Winter Street and Lowell Street, while area schools were back in regular session, to assess the effect of COVID-19 over time and as compared to the traffic volumes completed in March 2021. Both the October and March 2021 traffic volumes were observed to be comparable and therefore no further evaluation of the October 2021 traffic volumes were utilized within this study.

Automatic Traffic Recorder Counts

Automatic Traffic Recorder (ATR) counts were conducted at several locations along Main Street concurrently with the TMCs from Thursday, March 18, 2021 through Saturday, March 20, 2021 for a continuous 72-hour period. Additional ATR counts were conducted along key side-street approaches to Main Street from 12:00 PM on Wednesday, March 17, 2021 to 12:00 PM on Thursday, March 18, 2021. The timeframe for the side-street approaches was offset from the TMCs because the ATRs are roadway tube set-ups and light snow was predicted for the Thursday night, where plowing operations could damage the roadway tubes. For reference to these and other counts conducted as part of the study, the forecasted light snow did not occur. The following locations were evaluated for volume, speed, and vehicle classification by ATR:

- Main Street, north of North Street
- Main Street, between Lowell Road and Winter Street
- Main Street, north of Park Street
- North Street, east of Main Street
- Lowell Road, west of Main Street
- Winter Street, east of Main Street
- Park Street, west of Main Street

A detailed summary of the ATR data, partitioned into 60-minute intervals, is provided within Appendix C.

TRAFFIC VOLUME ADJUSTMENTS

Traffic volumes and area businesses have been significantly affected by and since the onset of the COVID-19 pandemic. TEC understands that traffic volumes in the area may be artificially lower than a standard non-pandemic time period. The following section provides a summary of the traffic volume adjustments.

COVID-19 Pandemic Adjustments

To establish a normalized traffic volume condition that could reasonably be expected without the COVID-19 pandemic, TEC compared traffic volumes using present and historical traffic volumes collected along Main Street at the three (3) locations:

- Main Street, north of North Street (2015: Main Street, north of Sullivan Road)
- Main Street, between Lowell Road and Winter Street (2015: Main Street, south of Nichols Street)
- Main Street, north of Park Street (2015: Main Street, north of Kingston Street)

TEC then utilized MassDOT published year-by-year annual growth data between 2015 and 2019. The data indicates that for principal arterials, traffic volumes between 2015 and 2016 grew 1.3%, between 2016 and 2017 grew 1.1%, between 2017 and 2018 grew 1.4%, and between 2018 and 2019 grew 0.4%.

In accordance with MassDOT standards, traffic volumes are typically adjusted to average-month conditions. To account for seasonal adjustment, TEC utilized MassDOT's weekday seasonal and axle correction factors as published in 2015 (date of historical counts) and 2019 (most recent publication). The factors provide a month-to-month overview of traffic volumes statewide by roadway functional classification and land (urban vs. rural) type. For principal arterials, traffic volumes in the month of May 2015 were approximately 8% higher than average month conditions and in March 2019 (utilized for March 2021 counts) were approximately 2% higher than average-month conditions. Therefore, the March 2015 traffic volumes were downwardly adjusted by 8% and the March 2020 were downwardly adjusted by 2% to reflect an average month condition. The compiled seasonal adjustment data is provided in Appendix D.

The seasonally adjusted traffic volumes were upwardly increased by the growth rates year by year to reflect a comparative Base Year comparison, or the year prior to the onset of COVID-19 (2019). Upon review of the March 2021 traffic volumes and the adjusted 2015 traffic volumes, daily traffic along Main Street was shown to have decreased by 47.68% as a result of the COVID-19 pandemic. Traffic volumes specifically decreased by 58.49% and 44.22% for the weekday morning and weekday evening peak hours, respectively. Therefore, the March 2021 traffic volumes were upwardly increased by 58.49% during the weekday morning peak hour, 44.22% during the weekday evening peak hour, and 47.68% during all other time periods (includes Saturday midday peak hour) to reflect a non-COVID-19 Base Year Condition. This factor was also applied to all commercial driveway entering and exiting movements, which is not standard practice. TEC determined that the factor should apply in this case as the indoor restrictions imposed by COVID-19 similarly affected area business as well as general travel. Whereas locations similar to Wal-Mart (North Reading Plaza) still retained overall business, much of this business was driven to online purchasing and indoor foot traffic was temporarily diminished.

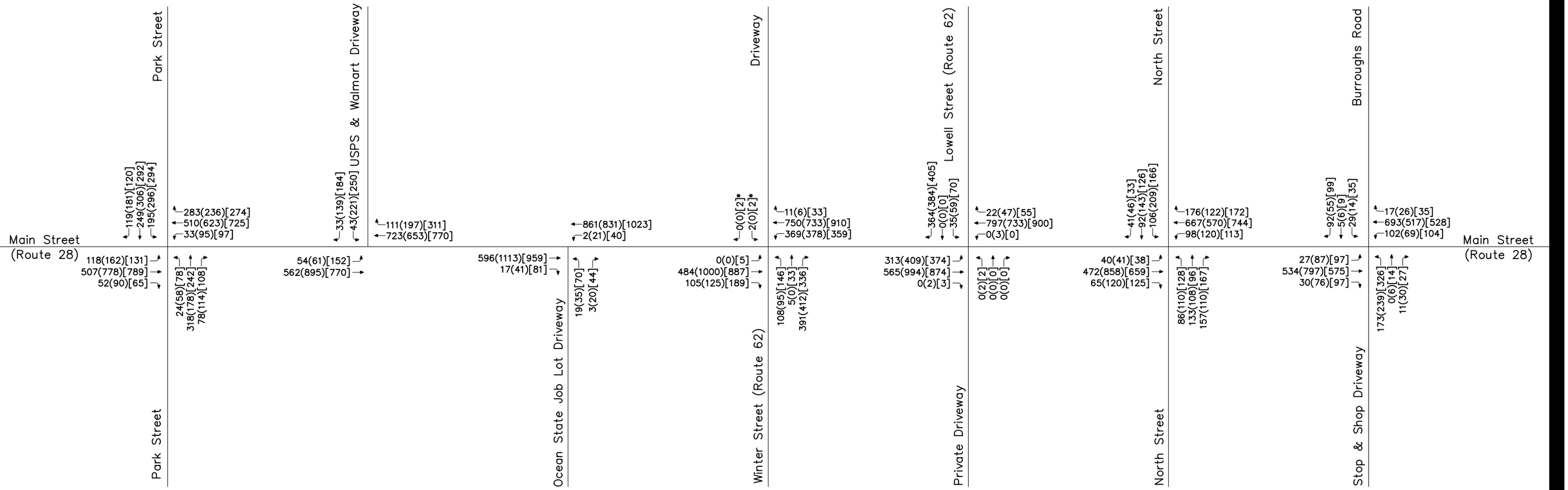
The compiled COVID-19 adjustment data, including the 2015 comparative ATRs is provided in Appendix E. The resulting Base Year Conditions weekday morning, weekday evening, and Saturday midday peak hour traffic volume network is illustrated in Figure 4. Per MassDOT guidelines, the adjusted non-COVID-19 Base Year is considered to be 2019. A summary of the weekday ATR traffic data is presented in Table 2. A summary of the Saturday ATR traffic data is presented in Table 3.

Table 2 – Existing Weekday ATR Traffic Volume Summary

Location	Weekday Traffic Volume[a]	Weekday Morning Peak Hour			Weekday Evening Peak Hour		
		Traffic Volume[b]	K Factor[c]	Directional Distribution[d]	Traffic Volume	K Factor	Directional Distribution
Main Street, north of North Street	19,250	1,540	8.0%	61.1% SB	1,675	8.7%	51.8% NB
Main Street, btw Lowell Road & Winter Street	27,545	2,010	9.3%	56.5% SB	2,395	8.7%	54.6% NB
Main Street, north of Park Street	23,030	1,500	6.5%	53.7% SB	1,870	8.1%	55.4% NB
North Street, east of Main Street	8,410	655	7.8%	60.9% WB	785	9.3%	55.4% EB
Lowell Road, west of Main Street	9,830	680	6.9%	54.2% EB	790	8.0%	52.2% EB
Winter Street, east of Main Street	10,570	905	8.6%	52.1% WB	975	9.2%	53.7% EB
Park Street, west of Main Street	13,140	1,185	9.0%	56.2% WB	1,270	9.7%	55.8% EB

[a] Daily traffic expressed in vehicles per day as adjusted by COVID-19
[b] Hourly traffic expressed in vehicles per hour
[c] Percent of daily traffic volumes which occurs during the peak hour
[d] Percent of peak-hour volume in the predominant direction of travel

Not to Scale



XXX(XXX)[XXX] = WEEKDAY AM(WEEKDAY PM)[SATURDAY MIDDAY]

* = ILLEGAL TURNING MOVEMENT

Figure 4

**Base Year Condition
Weekday Morning, Weekday Evening, and Saturday Midday
Peak Hour Traffic Volumes**

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Table 3 – Existing Saturday ATR Traffic Volume Summary

Location	Saturday Traffic Volume[a]	Saturday Midday Peak Hour		
		Traffic Volume[b]	K Factor[c]	Directional Distribution[d]
Main Street, north of North Street	19,570	1,725	8.8%	57.7% SB
Main Street, btw Lowell Road & Winter Street	27,750	2,495	9.0%	50.5% SB
Main Street, north of Park Street	24,590	2,235	9.1%	50.3% NB

[a] Saturday traffic expressed in vehicles per day as adjusted by COVID-19
[b] Hourly traffic expressed in vehicles per hour
[c] Percent of daily traffic volumes which occurs during the peak hour
[d] Percent of peak-hour volume in the predominant direction of travel

Main Street carries approximately 19,250 to 27,545 vehicles per day (vpd) on an average weekday with the highest level of volume appearing between the Lowell Road and Winter Street approaches of Route 62. The weekday morning represents 6 to 9% of the daily traffic load while the weekday evening peak hour represents 8 to 9% of the daily traffic load. The directional distribution of traffic along Main Street is weighted towards southbound in the weekday morning peak period and towards northbound during the weekday evening peak period. This is consistent with traffic to/from the metro-Boston area. The weekday daily cumulative distribution of traffic volumes along each Main Street segment is depicted in Exhibits 3 through 5.

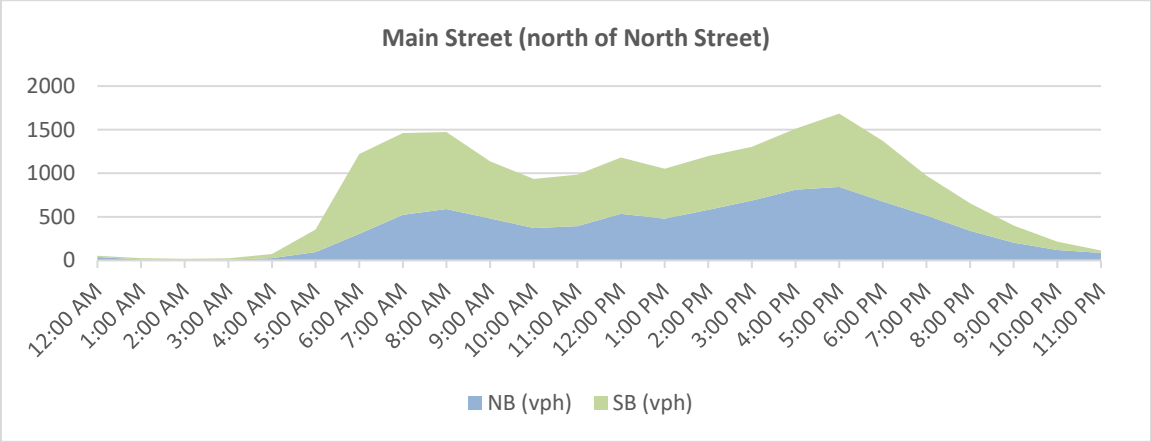


Exhibit 3: Daily Cumulative Distribution of Traffic Volumes along Main Street, north of North Street

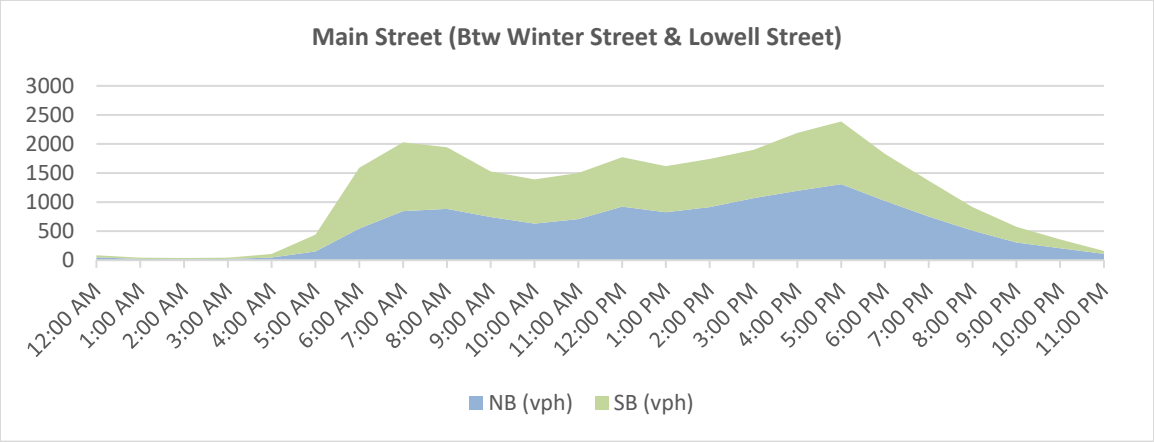


Exhibit 4: Daily Cumulative Distribution of Traffic Volumes along Main Street, between Lowell Road and Winter Street

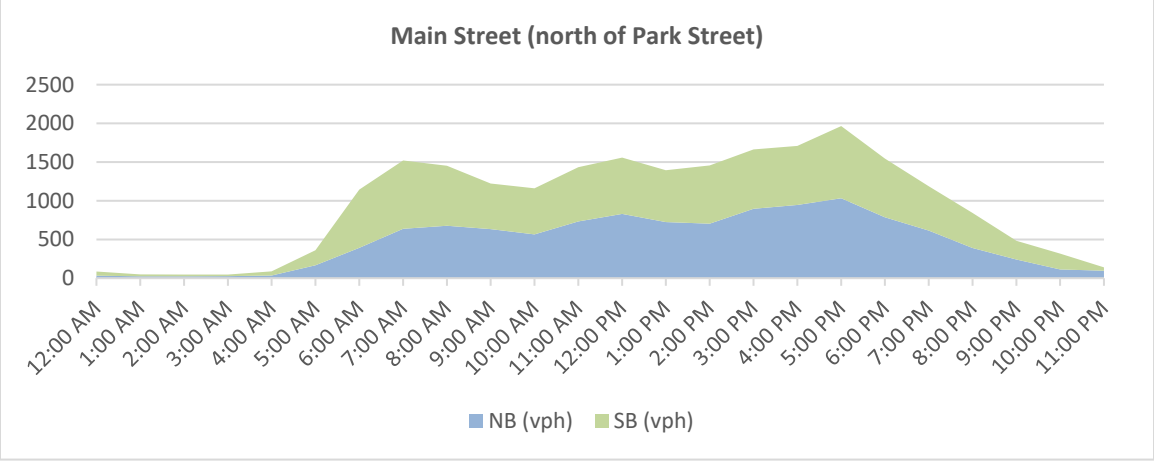


Exhibit 5: Daily Cumulative Distribution of Traffic Volumes along Main Street, north of Park Street

Throughout the Main Street corridor, the traffic volume is measured as increasing steadily over the course of the day until the weekday evening peak period before decreasing rapidly. Spikes in traffic volumes are seen during the weekday morning peak hour and the midday lunchtime peak hour. On a typical Saturday, the daily traffic volumes are consistent with a standard weekday. Directional distribution for locations south of Lowell Road, regress to a 50-50 split along the heavy retail corridor.

North Street, west of Main Street, carries approximately 8,410 vpd on an average weekday. The weekday morning represents approximately 8% of the daily traffic load while the weekday evening peak hour represents approximately 9% of the daily traffic load. The directional distribution of traffic along North Street is weighted towards westbound in the weekday morning peak period and towards eastbound during the weekday evening peak period. This is consistent with traffic to/from Interstate 93 via Lowell Road to the west.

Lowell Road, west of Main Street, carries approximately 9,830 vpd on an average weekday. The weekday morning represents approximately 7% of the daily traffic load while the weekday evening peak hour represents approximately 8% of the daily traffic load. The directional distribution of traffic along Lowell Road is weighted towards eastbound during both the weekday morning and weekday evening peak periods. This would suggest that Lowell Road serves as a main artery towards the Route 28 corridor, but not towards I-93 which may be due to its rural curvature in nature as opposed to other I-93 link roadways such as Park Street.

Winter Street, east of Main Street, carries approximately 10,570 vpd on an average weekday. The weekday morning represents approximately 8.5% of the daily traffic load while the weekday evening peak hour represents approximately 9% of the daily traffic load. The directional distribution of traffic along Winter Street is weighted towards westbound in the weekday morning peak period and towards eastbound during the weekday evening peak period. This is consistent with traffic to/from Main Street and I-93 via Concord Street to the west.

Park Street, west of Main Street, carries approximately 13,140 vpd on an average weekday. The weekday morning represents approximately 9% of the daily traffic load while the weekday evening peak hour represents approximately 10% of the daily traffic load. The directional distribution of traffic along Park Street is weighted towards westbound in the weekday morning peak period and towards eastbound during the weekday evening peak period. This is consistent with traffic to/from I-93 via Concord Street to the west.

FUTURE YEAR CONDITIONS

To determine traffic volumes under future year conditions, baseline traffic volumes in the study area were projected to the year 2032 to provide a 10-year design horizon (13-years from 2019 Base Year traffic volumes). Traffic volumes on the roadway network at that time would include existing traffic, new traffic due to general background traffic growth, and traffic related to specific developments by others expected to be completed by 2032. Consideration of these factors resulted in the development of the 2032 Future Year Condition traffic volumes.

Background Traffic Growth

Traffic growth is a function of the expected land development in the immediate area and the surrounding region. Several methods can be used to estimate this growth. A procedure frequently employed estimates an ambient growth rate for the area roadways and applies that percentage to all mainline and side street traffic volumes. The drawback to such a procedure is that some turning volumes may grow at either a higher or a lower rate at particular intersections.

An alternative procedure identifies the location and type of planned development, estimates the traffic to be generated, and assigns it to the area roadway network. This procedure produces a more realistic estimate of growth for local traffic. However, the drawback of this procedure is that the potential growth in population and development external to the study area would not be accounted for in the traffic projections.

To provide a conservative analysis framework, both procedures were used.

General Ambient Growth

As previously mentioned, MassDOT published year-by-year annual growth data between 2015 and 2019 indicates that traffic volumes grew by approximately 1.0% per year on average between 2015 and 2019. To provide a conservative analysis scenario, a 1.0% per year compounded annual background traffic growth rate was used to account for potential future traffic growth external to the study area and any presently unforeseen development. Count station data has been included in Appendix F.

Specific Developments by Others

TEC coordinated with the Town of North Reading Community Planning Department to identify nearby private and public development projects in the vicinity of the study area that were either in the planning process or were approved by the Planning Board at the time of the traffic volume counts. Based on these discussions, the Town of North Reading did not identify any specific project that would add substantial traffic to the Main Street corridor over the existing volumes.

Main Street Economic Development Strategy

In 2016, the Town of North Reading and the MAPC issued its Main Street Economic Development Strategy[3] which focused on a key ¾-mile stretch of Main Street between Northbridge Drive and to the north and the North Reading Plaza to the south. The purpose was to develop a short-term economic development strategy plan identifying actions the Town can take to set the right conditions to attach development around the underutilized parcels along Route 28 in the vicinity of Route 62 (Lowell Road to Winter Street). Developed through the community planning process, the plan looked at recommendations related to zoning, public investment, and infrastructure.

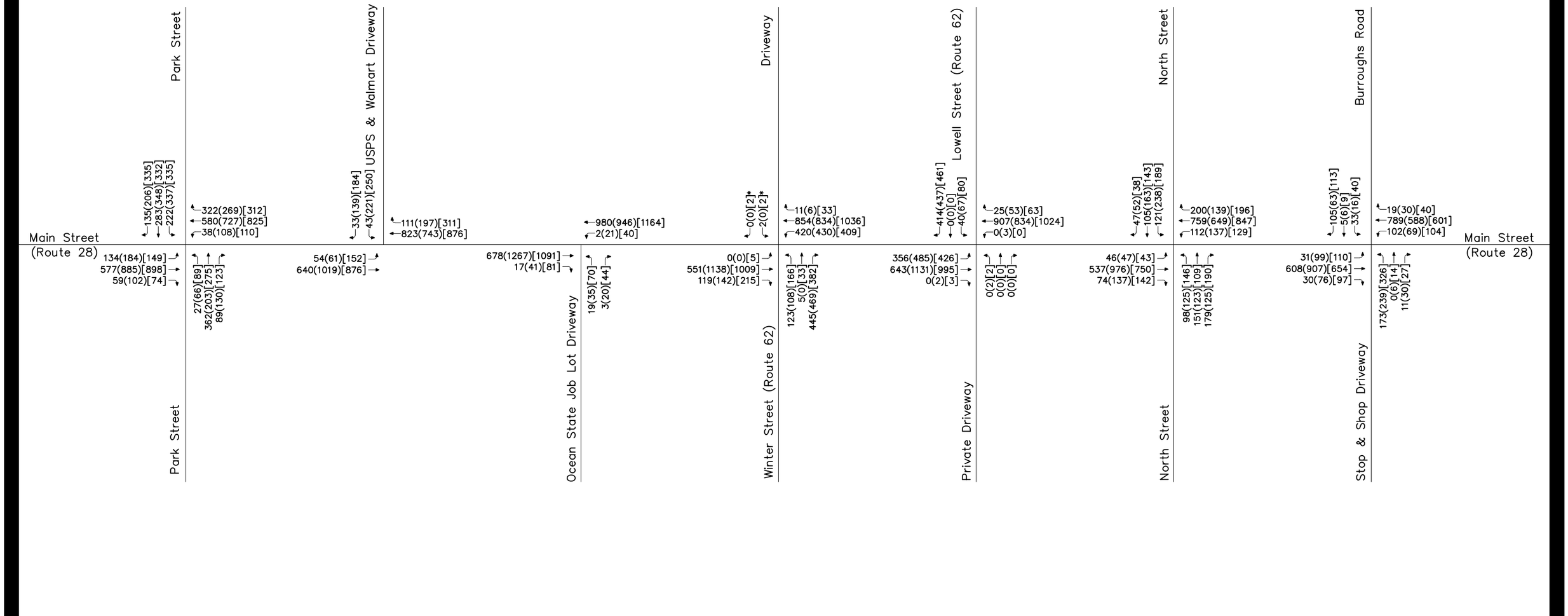
The analyses provided in the Main Street Economic Development Strategy indicted that the study area could physically accommodate a reasonable share of market supportable housing, retail, office, and restaurant developments over the several parcel groupings. At the time of this corridor planning study, no specific redevelopment within the study area had been identified. Therefore, no projection of future traffic potential was included beyond the 1.0% per year annual growth rate.

2032 Future Year Traffic Volumes

The 2032 Future Year Condition traffic volumes were obtained by applying a 1.0% compounded annual growth rate to the Base Year Condition traffic volumes over the 13-year design horizon period and adding the traffic associated with the specific development by others. The resulting 2032 Future Year Condition traffic volume network is presented in Figure 5.

[3] *Town of North Reading Main Street (Route 28 at 62) Short Term 2016-2021 Economic Development Strategy*; Metropolitan Area Planning Council; Boston, MA; June 2016.

Not to Scale



XXX(XXX)[XXX] = WEEKDAY AM(WEEKDAY PM)[SATURDAY MIDDAY]

* = ILLEGAL TURNING MOVEMENT

Figure 5

**2032 Future Year Condition
Weekday Morning, Weekday Evening,
and Saturday Midday
Peak Hour Traffic Volumes**

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IV. TRAFFIC SAFETY EVALUATION

A traffic safety analysis was conducted for the Main Street corridor and several key signalized intersections. The traffic safety analysis included the compilation and examination of corridor speeds, corridor vehicle classification breakdown, study intersection crash data, and a general safety review with consideration given to items on the MassDOT Safety Review Prompt List.

VEHICLE PARAMETERS

Vehicle Speeds

Vehicle travel speeds were collected and reviewed as part of the ATR counts in March 2021. Table 4 summarizes the measured travel speed data. Roadway surface conditions were generally dry and weather conditions were generally clear / cloudy during the collection of roadway speeds. Although snow did not occur, snow had been in the forecast as previously noted.

Table 4 – Existing Main Street Vehicle Speed Summary

Location	Average Speed	85th Percentile Speed	10 MPH Pace	% Vehs in Pace	% Vehs ≥ 40 MPH
Main Street, north of North Street					
Northbound	35 mph	40 mph	30-39 mph	70.5%	16.1%
Southbound	37 mph	42 mph	32-41 mph	68.3%	5.5%
Main Street, between Lowell Road and Winter Street					
Northbound	33 mph	39 mph	29-38 mph	67.7%	11.4%
Southbound	32 mph	37 mph	28-37 mph	71.8%	6.3%
Main Street, north of Park Street					
Northbound	36 mph	41 mph	32-41 mph	70.1%	25.5%
Southbound	34 mph	40 mph	30-39 mph	61.5%	16.3%

The data shows that the average travel speeds on Main Street are consistently below the posted speed limit of 40 mph. Approximately 5 to 25% of vehicles are operating at or above the speed limit. The 85th percentile speeds along Main Street are consistently 37 and 42 mph, consistent with the posted speed limit.

Vehicle Classification

Vehicle classification was collected and reviewed as part of the ATR counts in March 2021. Table 5 summarizes the percentage of heavy vehicles traveling along the Main Street mainline daily and during the weekday morning and weekday evening peak hours.

Table 5 – Existing Main Street Vehicle Classification Summary

Location	Weekday Traffic Volume[a]	Heavy Vehicle Percentage		
		Daily	AM Peak Hour	PM Peak Hour
Main Street, north of North Street	18,609	3.4%	0.6%	5.3%
Main Street, btw Lowell Road & Winter Street	26,629	4.5%	1.4%	6.5%
Main Street, north of Park Street	22,264	4.6%	2.1%	6.0%

[a] Daily traffic expressed in vehicles per day as adjusted by COVID-19

Main Street carries a consistent 3.5% to 4.5% level of heavy vehicles on a typical weekday. Only a small percentage of these vehicles are classified as buses. During the weekday morning peak hour, Main Street carries between 0.5% and 2.0% heavy vehicles. During the weekday evening peak hour, Main Street carries between 5% and 6.5% heavy vehicles.

CRASH DATA

Crash data for the study intersections and segments were compiled and analyzed for a five-year period (2015 - 2019) on file from MassDOT on their Interactive Mapping Portal for Analysis and Crash Tracking (IMPACT) website. Data was excluded for 2020 and 2021 as these represent years during the COIVD-19 pandemic where the characteristics of the typical driver and their interaction with the roadway was greatly modified. The motor vehicle crash data was reviewed to determine if any crash trends exist within the project area.

HSIP Eligibility

The U.S. Congress enacted the “Fixing America’s Surface Transportation Act” (FAST) Act in 2015. This act provides guidance and funding for the implementation of a State Highway Safety Improvement Program (HSIP); continuing upon the past SAFETEA-LU legislation from 2005. As part of this Program, all states are required to develop a Strategic Highway Safety Plan (SHSP). MassDOT guidelines require a Road Safety Audit (RSA) be conducted where HSIP-eligible crash clusters are present within the bounds of a transportation improvement project. An intersection is defined as HSIP-eligible if the intersection is within the top five (5) percent of clusters in its respective Regional Planning Commission (RPC) boundaries based on Equivalent Property Damage Only (EPDO).

EPDO ranks crashes based on the crash severity for the current 2017-2019 HSIP year of crash data. Within this current methodology, any type of injury crash (including fatal, incapacitating,

non-incapacitating and possible) has a weighting of 21 points as compared to a property damage only crash, which has a weighting of 1 point. The current MAPC threshold for HSIP-eligibility is 113[4] for the 2019 HSIP year. Based on the published MassDOT IMPACT database, the intersection of Main Street / Winter Street is designated as a 2017-2019 HSIP Crash Cluster (current year of eligibility). The intersection of Main Street / Park Street has previously been a HSIP crash cluster for the 2014-2016 (current EPDO methodology) and the intersection of Main Street / North Street has previously been a HSIP crash cluster for the 2013-2015 (out-of-date EPDO methodology) within the MAPC boundaries.

The crash data indicates that the intersections of Main Street / Park Street and Main Street / North Street may in fact be HSIP eligible in the current year of eligibility based on the data presented in the MassDOT IMPACT database. Further evaluation of individual crash reports for each of these intersections will be needed to determine if the HSIP-eligibility thresholds are met and whether a Road Safety Audit may need to be conducted in advance of any design project along the corridor.

Crash Rate Worksheet

In addition to examining the number of crashes on the study corridor, an intersection and corridor crash rate was calculated to compare the occurrence of crashes to the volume of traffic passing through the audit intersections and along the segment. The crash rate per million entering vehicles (MEV) for intersections and per million vehicle miles travelled (MVMT) for corridor segments was calculated using the weekday evening peak hour volumes from the TMCs (adjusted for COVID-19), a calculated K-factor obtained from the ATR counts (adjusted for COVID-19), and the total years of analyzed crash data. The crash rate at the intersections was compared to the statewide and district-wide averages published by MassDOT in June 2018 for intersections and July 2020 for roadway segments to determine the significance of the crash occurrence. The statewide average for signalized intersections is 0.78 crashes per MEV, and the District 4 average is 0.73 crashes per MEV. The average crash rate per MVMT on a principal arterial in an urban setting is 3.58 crashes per MVMT. Intersection crash rates were calculated at those locations where traffic volumes were collected. Intersection and corridor crash rates are summarized in Table 6.

[4] EPDO for MAPC of 113 denoted by MassDOT Traffic and Safety Engineering Section.

Table 6 – Crash Rates by Intersection

Location	Total Crashes (2015-2019)	EPDO [a] (2017-2019)	Crash Rate [b] (2015-2019)	Statewide Avg	District Wide Avg
Main Street / Burroughs Road	14	49	0.37	0.78	0.73
Main Street / North Street	38	**124**	0.76	0.78	0.73
Main Street / Lowell Road	12	66	0.23	0.78	0.73
Main Street / Winter Street	36	**143**	0.67	0.78	0.73
Main Street / Ocean State Job Lot	3	22	0.07	0.78	0.73
Main Street / North Reading Plaza	13	26	0.29	0.78	0.73
Main Street / Park Street	34	**141**	0.53	0.78	0.73

[a] EPDO rank only based on crash data from HSIP-eligible 2017 through 2019 complete years from IMPACT online database
[b] Crash rate only based on crash data from 2015 through 2019 complete years.

A summary of the vehicle crash data for intersections and roadway segments are provided in Tables 7 and 8, respectively. Detailed crash data is provided in Appendix G.

Intersection Crash Summary

Main Street / Burroughs Road / Stop & Shop Driveway

The intersection of Main Street / Burroughs Road / Stop & Shop Driveway experienced fourteen (14) crashes over the five-year study period. The 2017-2019 EPDO for this intersection based on data provided on the MassDOT IMPACT database was calculated at 49, well below the HSIP threshold of the MAPC. The crash rate was calculated at 0.37 crashes per MEV which is significantly lower than the statewide and district-wide averages for signalized intersections. Ten (10) of the crashes at this intersection were angled type crashes, which may be the result of the permissive left-turn phasing at the traffic signal. The intersection did experience one (1) crash that involved a cyclist. Half of crashes (7 of 14) noted failure to yield the right of way as the contributing factor in the crash.

The intersection of Main Street / Burroughs Road / Stop & Shop Driveway experienced one (1) fatal crash outside the five-year study period which occurred on Thursday, March 19, 2020 at 6:30 AM. An employee of the Stop & Shop who lived across the street from the plaza was struck and killed while walking across Main Street. The crash does not appear in the documented crash summaries.

Main Street / North Street

The intersection of Main Street / North Street experienced 38 crashes over the five-year study period. The 2017-2019 EPDO for this intersection based on data provided on the MassDOT IMPACT database was calculated at 124, which is significantly higher than the HSIP threshold of the MAPC. Based on this level of EPDO, the intersection may in fact be HSIP-eligible. Further evaluation of the individual crash reports will be necessary to determine HSIP-eligibility. The crash rate was calculated at 0.76 crashes per MEV which is comparable to the statewide and district-wide averages for signalized intersections. Just under half of the crashes (17 of 38) were angled type crashes, which may be a result of the permissive signal phasing at the intersection. An additional thirteen (13) crashes were rear-end crashes. The intersection did experience one (1) crash that involved a pedestrian. Approximately 30% of the crashes occurred between the

three-hour time block of 6:00 AM to 9:00 PM. Approximately one-quarter of crashes (9 of 38) noted driver inattention or distraction as the contributing factor in the crash.

Table 7 – Intersection Crash Data Summary

Parameter		Main Street / Park Street	Main Street / North Reading Plaza Dwy	Main Street / Ocean State Job Lot Dwy	Main Street / Winter Street
Crash Year	2015	8	2	0	10
	2016	5	5	1	3
	2017	6	5	2	4
	2018	7	1	0	11
	2019	8	0	0	8
	TOTAL	***34***	***13***	***3***	***36***
Average Annual Crashes (2015-2019)		***6.80***	***2.60***	***0.60***	***7.20***
EPDO (2017-2019)		***141***	***26***	***22***	***143***
Rate per MEV		***0.53***	**0.29**	***0.07***	***0.67***
Manner of Crash	Angle	17	2	2	7
	Rear-end	9	5	1	18
	Single Vehicle	4	0	0	2
	Sideswipe	3	5	0	7
	Head-On	1	0	0	2
	Ped / Bike	0	0	0	0
	Other / Not Reported	0	1	0	0
	TOTAL	***34***	***13***	***3***	***36***
Road Surface Conditions	Dry	23	10	3	25
	Wet	9	1	0	10
	Snow / Ice	2	2	0	1
	Other / Unknown	0	0	0	0
	TOTAL	***34***	***13***	***3***	***36***
Crash Severity	Property Damage	24	11	2	27
	Non-Fatal Injury	9	1	1	8
	Fatal Injury	1	0	0	0
	Not Reported	0	1	0	1
	TOTAL	***34***	***13***	***3***	***36***
Day of Week	Monday-Friday	29	10	2	30
	Saturday-Sunday	5	3	1	6
	TOTAL	***39***	***13***	***3***	***36***
Time of Day	6:00AM-9:00AM	2	2	0	3
	9:00AM-12:00PM	5	4	1	6
	12:00PM-3:00PM	11	2	1	8
	3:00PM-6:00PM	2	3	0	8
	6:00PM-9:00PM	13	2	1	9
	9:00PM-6:00AM	1	0	0	2
	TOTAL	***34***	***13***	***3***	***36***

Table 7 – Intersection Crash Data Summary (Continued)

Parameter		Main Street / Lowell Road	Main Street / North Street	Main Street / Burroughs Road
Crash Year	2015	4	8	3
	2016	2	7	2
	2017	0	11	4
	2018	4	8	1
	2019	2	4	4
	TOTAL	***12***	***38***	***14***
Average Annual Crashes (2015-2019)		***2.40***	***7.60***	***2.80***
EPDO (2017-2019)		***66***	***124***	***49***
Rate per MEV		***0.23***	***0.76***	***0.37***
Manner of Crash	Angle	3	17	10
	Rear-end	4	13	1
	Single Vehicle	0	4	1
	Sideswipe	5	2	1
	Head-On	0	1	0
	Ped / Bike	0	1	1
	Other / Not Reported	0	0	0
	TOTAL	***12***	***38***	***14***
Road Surface Conditions	Dry	9	30	12
	Wet	3	6	2
	Snow / Ice	0	2	0
	Other / Unknown	0	0	0
	TOTAL	***12***	***38***	***14***
Crash Severity	Property Damage	8	30	10
	Non-Fatal Injury	4	8	4
	Fatal Injury	0	0	0
	Not Reported	0	0	0
	TOTAL	***12***	***38***	***14***
Day of Week	Monday-Friday	8	28	14
	Saturday-Sunday	4	10	0
	TOTAL	***12***	***38***	***14***
Time of Day	6:00AM-9:00AM	1	4	0
	9:00AM-12:00PM	3	5	2
	12:00PM-3:00PM	2	8	4
	3:00PM-6:00PM	2	6	3
	6:00PM-9:00PM	4	11	5
	9:00PM-6:00AM	0	4	0
	TOTAL	***12***	***38***	***14***

Main Street / Lowell Road / Nick O'Brian's Service Driveway

The intersection of Main Street / Lowell Road / Nick O'Brian's Service Driveway experienced twelve (12) crashes over the five-year study period. The 2017-2019 EPDO for this intersection based on data provided on the MassDOT IMPACT database was calculated at 66, well below the HSIP threshold of the MAPC. The crash rate was calculated at 0.23 crashes per MEV which is significantly lower than the statewide and district-wide averages for signalized intersections. Five (5) of the crashes at this intersection were sideswipe crashes while an additional four (4) were rear-end crashes. Consistent with the intersection with Winter Street, the angled approach of Lowell Road may be a significant contributor to the rear-end crashes while quick lane changes to by-pass left turns from Main Street to Lowell Road where no turn lanes exist may be

a significant contributor to sideswipe crashes. One-quarter of crashes (3 of 12) noted failure to yield the right of way as the contributing factor in the crash.

Main Street / Winter Street / Reading Lumber Driveway

The intersection of Main Street / Winter Street / Reading Lumber Driveway experienced 36 crashes over the five-year study period. The 2017-2019 EPDO for this intersection based on data provided on the MassDOT IMPACT database was calculated at 143, well above the HSIP threshold of the MAPC. The intersection is currently recognized as 2019 HSIP-eligible by MassDOT and MAPC. The crash rate was calculated at 0.67 crashes per MEV which is lower than the statewide and district-wide averages for signalized intersections. Half (18 of 36) of the intersection crashes were rear-end crashes. This may be a result of a large number of vehicles taking a right from Winter Street westbound where the approach angle forces drivers to look far over their shoulder potentially resulting in a short-stop for a leading vehicle and the trailing vehicle unaware of the short-stop. This may also be an occurrence for the Main Street southbound left-turns, another heavy volume movement, where the leading vehicle is inching forward waiting for gaps as the trailing vehicle is unaware of the short-stop. An additional seven (7) crashes were angled type crashes and seven (7) were sideswipe crashes. The sideswipe crashes may be indicative of quick lane changes for vehicles on the four-lane Main Street corridor where both no auxiliary turn lanes are provided, and heavy turning movements are present. The daily distribution of crashes is consistent with daily traffic volume fluctuation as noted in Table 7.

Main Street / Ocean State Job Lot Driveway

The intersection of Main Street / Ocean State Job Lot Driveway experienced three (3) crashes over the five-year study period. The 2017-2019 EPDO for this intersection based on data provided on the MassDOT IMPACT database was calculated at 22, well below the HSIP threshold of the MAPC. The crash rate was calculated at 0.07 crashes per MEV which is significantly lower than the statewide and district-wide averages for signalized intersections. Based on the low level of crash occurrences at this location, the data indicates that there are no notable crash trends.

Main Street / North Reading Plaza Driveway

The intersection of Main Street / North Reading Plaza Driveway experienced thirteen (13) crashes over the five-year study period. The 2017-2019 EPDO for this intersection based on data provided on the MassDOT IMPACT database was calculated at 26, well below the HSIP threshold of the MAPC. The crash rate was calculated at 0.29 crashes per MEV which is significantly lower than the statewide and district-wide averages for signalized intersections. Five (5) of the crashes were rear-end crashes while an additional five (5) were sideswipe crashes. The sideswipe crashes may be indicative of higher speeds along the four-lane cross-section where the expectation of a red signal indication is lessened by the lower level of side-street traffic. This may also be a contributing factor for the rear-end crashes as drivers may not be expecting a red indication at this traffic signal. Driver inattention / districted driving was noted as a contributing factor to three (3) crashes.

Main Street / Park Street

The intersection of Main Street / Park Street experienced 34 crashes over the five-year study period. The 2015-2017 EPDO for this intersection based on data provided on the MassDOT IMPACT database was calculated at 141, which is significantly higher than the HSIP threshold of the MAPC. Based on this level of EPDO, the intersection may in fact be HSIP-eligible. Further evaluation of the individual crash reports will be necessary to determine HSIP-eligibility. The crash rate was calculated at 0.53 crashes per MEV which is significantly lower than the statewide and district-wide averages for signalized intersections. Half (17 of 34) of the intersection crashes were angled type crashes which may be a result of the permissive signal phasing at the intersection. Nine (9) crashes as reported were rear-end (or similar) type crashes, four (4) crashes as reported were single vehicle crashes, and three (3) crashes as reported were sideswipe crashes. A significant portion of the crashes (70%) occurred in either the three hours immediately before or after each the weekday evening peak hours (11 from 12:00 PM to 3:00 PM and 13 from 6:00 PM to 9:00 PM). Only four (4) of the crashes occurred during either the weekday morning or weekday evening peak hours indicating that that commuter congestion may not be the main factor in the cause of crashes at this location. The overwhelming contributing factor, as reported, to crash occurrence at the intersection was the failure to yield the right-of-way.

The intersection experienced one (1) fatal crash during the five-year study period which occurred on Saturday, January 27, 2018 at 12:31 PM.

Corridor Segment Crash Summary

Main Street from Burroughs Road / Stop & Shop Driveway to North Reading / Andover Town Line

The Main Street corridor from Burroughs Road to the Town Line experienced twenty-nine (29) crashes over the five-year study period. The crash rate for this segment was calculated at 1.49 crashes per MVMT which is significantly lower than the statewide and district-wide averages for principal arterial in an urban setting. Approximately half of the crashes (14 of 29) were angled type crashes, which may correlate to entering and exiting movements to/from the several side-streets within this residential-centric section of the corridor. Approximately 40% of the crashes (12 of 29) occurred during the midday hours (12:00 PM to 3:00 PM) where congestion may not be a major contributing factor.

Main Street from North Street to Burroughs Road / Stop & Shop Driveway

The Main Street corridor from North Street to Burroughs Road experienced twenty-seven (27) crashes over the five-year study period. The crash rate for this segment was calculated at 3.59 crashes per MVMT which is comparable to the statewide and district-wide averages for principal arterial in an urban setting. More than half of the crashes (14 of 27) along this segment were angled type crashes. One (1) of the crashes at this location involved a pedestrian crossing Main Street not at a signalized intersection. The primary contributing factor, as reported, to crash occurrence was the failure to yield the right-of-way.

Main Street from Lowell Road / Nick O'Brian's Service Driveway to North Street

The Main Street corridor from Lowell Road to North Street experienced 56 crashes over the five-year study period. The crash rate for this corridor segment was calculated at 2.75 crashes per MVMT which is slightly lower than the statewide and district-wide averages for principal arterial in an urban setting. Approximately half of the crashes (25 of 56) were angled type crashes which may correlate to entering and exiting movements to/from the several commercial / retail businesses within this segment without the benefit of exclusive turn-lanes on the Main Street mainline. 28% of the crashes occurred when the road surface was wet or snow-covered.

Main Street from Winter Street / Reading Lumber Driveway to Lowell Road / Nick O'Brian's Service Driveway

The Main Street corridor from Winter Street to Lowell Road experienced eighteen (18) crashes over the five-year study period. The crash rate for the corridor segment was calculated at 2.34 crashes per MVMT which is lower than the statewide and district-wide averages for principal arterial in an urban setting. More one-quarter of the crashes (5 of 18) were sideswipe crashes, which may be a result of the vehicle weaving that occurs between each leg of the Route 62 approaches at Lowell Road and at Winter Street. Just below half of the crashes (8 of 18) occurred immediately after the evening peak hours (6:00 PM to 9:00 PM) suggesting that congestion may not be a significant contributing factor to the crash experience. The primary contributing factor, as reported, to crash occurrence at the intersection was the failure to yield the right-of-way.

Main Street from Ocean State Job Lot Driveway to Winter Street / Reading Lumber Driveway

The Main Street corridor from Ocean State Job Lot Driveway to Winter Street experienced eleven (11) crashes over the five-year study period. The crash rate for the corridor segment was calculated at 1.89 crashes per MVMT which is significantly lower than the statewide and district-wide averages for principal arterial in an urban setting. More than 80% (9 of 11) were angled type crashes with an additional two (2) rear-end crashes. Based on the low level of crash occurrences in this area, the data indicates that there are no notable crash trends.

Main Street from North Reading Plaza Driveway to Ocean State Job Lot Driveway

The Main Street corridor from the North Reading Plaza Driveway to the Ocean State Job Lot Driveway experienced thirteen (13) crashes over the five-year study period. The crash rate for the corridor segment was calculated at 1.40 crashes per MVMT which is significantly lower than the statewide and district-wide averages for principal arterial in an urban setting. More than half of the crashes (7 of 13) were angled type crashes with an additional four (4) rear-end crashes. Approximately one-quarter (3 of 13) of the crashes occurred during raining weather conditions or on wet pavement. Based on the low level of crash occurrences in this area, the data indicates that there are no notable crash trends.

Main Street from Park Street to North Reading Plaza Driveway

The Main Street corridor from Park Street to the North Reading Plaza Driveway experienced 84 crashes over the five-year study period. The crash rate for the corridor segment was calculated

at 4.75 crashes per MVMT, which is significantly higher than the statewide and district-wide averages for principal arterial in an urban setting. Approximately one-third of the crashes (25 of 84) occurred during or immediately after the lunch-time hours (12:00 PM to 3:00 PM), which may correlate to entering and exiting movements to/from the several restaurant establishments within this segment without the benefit of exclusive turn-lanes on the Main Street mainline. The primary contributing factor, as reported, to crash occurrence in this area was the failure to yield the right-of-way.

Table 8 – Main Street Corridor Crash Data Summary

Parameter		Park Street to North Reading Plaza Dwy	North Reading Plaza Dwy to Ocean State Job Lot Dwy	Ocean State Job Lot Dwy to Winter Street	Winter Street to Lowell Road
Crash Year	2015	12	4	3	6
	2016	17	2	1	5
	2017	13	4	1	2
	2018	21	1	2	2
	2019	21	2	4	3
	TOTAL	***84***	***13***	***11***	***18***
Average Annual Crashes (2015-2019)		***16.80***	***2.60***	***2.20***	***3.60***
Rate per MEV		***4.75***	***1.40***	***1.89***	***2.34***
Manner of Crash	Angle	36	7	9	8
	Rear-end	25	4	2	4
	Single Vehicle	7	0	0	0
	Sideswipe	13	0	0	5
	Head-On	3	0	0	1
	Ped / Bike	0	1	0	0
	Other / Not Reported	0	1	0	0
	TOTAL	***84***	***13***	***11***	***18***
Road Surface Conditions	Dry	58	10	8	16
	Wet	20	3	2	2
	Snow / Ice	6	0	1	0
	Other / Unknown	0	0	0	0
	TOTAL	***84***	***13***	***13***	***18***
Crash Severity	Property Damage	63	9	11	15
	Non-Fatal Injury	20	4	0	3
	Fatal Injury	0	0	0	0
	Not Reported	0	0	0	0
	TOTAL	***84***	***13***	***11***	***18***
Day of Week	Monday-Friday	63	9	8	17
	Saturday-Sunday	21	4	3	1
	TOTAL	***84***	***13***	***11***	***18***
Time of Day	6:00AM-9:00AM	13	1	0	4
	9:00AM-12:00PM	9	2	1	1
	12:00PM-3:00PM	25	3	4	3
	3:00PM-6:00PM	18	2	2	2
	6:00PM-9:00PM	15	5	3	8
	9:00PM-6:00AM	4	0	1	0
	TOTAL	***84***	***13***	***11***	***18***

Table 8 – Main Street Corridor Crash Data Summary (Continued)

Parameter		Lowell Road to North Street	North Street to Burroughs Road	Burroughs Road to Town Line
Crash Year	2015	6	4	4
	2016	13	6	2
	2017	16	6	11
	2018	8	7	7
	2019	13	4	5
	TOTAL	***56***	***27***	***29***
Average Annual Crashes (2015-2017)		***11.20***	***5.40***	***5.80***
Rate per MEV		***2.75***	***3.59***	***1.49***
Manner of Crash	Angle	25	14	14
	Rear-end	14	8	4
	Single Vehicle	2	2	6
	Sideswipe	11	1	5
	Head-On	2	1	0
	Ped / Bike	0	1	0
	Other / Not Reported	2	0	0
	TOTAL	***56***	***27***	***29***
Road Surface Conditions	Dry	40	22	23
	Wet	12	5	5
	Snow / Ice	4	0	1
	Other / Unknown	0	0	0
	TOTAL	***56***	***27***	***29***
Crash Severity	Property Damage	41	23	22
	Non-Fatal Injury	12	4	7
	Fatal Injury	0	0	0
	Not Reported	3	0	0
	TOTAL	***56***	***27***	***29***
Day of Week	Monday-Friday	45	24	19
	Saturday-Sunday	11	3	10
	TOTAL	***56***	***27***	***29***
Time of Day	6:00AM-9:00AM	4	7	6
	9:00AM-12:00PM	9	1	6
	12:00PM-3:00PM	18	7	12
	3:00PM-6:00PM	10	4	2
	6:00PM-9:00PM	12	6	2
	9:00PM-6:00AM	3	2	1
	TOTAL	***56***	***27***	***29***

V. TRAFFIC WARRANTS

TRAFFIC SIGNAL WARRANTS

Traffic signal warrant analyses were conducted for each of the seven (7) existing signalized intersections along Main Street within North Reading to document the signal warranting condition. TEC performed the traffic signal warrant analyses based on criteria contained within the *MUTCD*[5]. The *MUTCD* contains eight warrants for evaluating the need for installation of a traffic signal. The two multi-hour volume-related warrants were evaluated to determine whether a traffic signal is warranted at the four intersections described above. These warrants include:

- Warrant 1: Eight-Hour Vehicular Volume
- Warrant 2: Four-Hour Vehicular Volume

For the purposes of this analysis, TEC utilized 12-hour TMCs conducted at each of the Main Street traffic signals to assess the warranting condition over a typical weekday. Existing volumes were adjusted to account for COVID-19.

Warrant Adjustments

Vehicle Speed and/or Population Center

Locations along Main Street, north of Park Street, and along Main Street, north of North Street each experience an 85th percentile speed in excess of 40 mph. This condition is not experienced in the immediate vicinity of Lowell Road and Winter Street (Route 62 cross-over). For the condition where the 85th percentile speed is in excess of 40 mph, the *MUTCD* states:

> *"If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the traffic volumes in the 70 percent columns in Table 4C-1 may be used in place of the 100 percent columns." (MUTCD - Sect 4C.02 ¶05 for Warrant 1) and "If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community*

[5] *Manual on Uniform Traffic Control Devices (MUTCD)* – Federal Highway Administration / U.S. DOT – 2009 Edition.

> *having a population of less than 10,000, Figure 4C-2 may be used in place of Figure 4C-1." (MUTCD - Sect 4C.03 ¶03 for Warrant 2)*

The above referenced reduction in traffic volumes is prescribed as an "Option" and is only applied to the warrant where the mainline speed is a hinderance to the side-street flow of traffic and/or the remote location of the existing/proposed traffic signal is suggesting a lower threshold for signalization. For the purposes of this corridor planning study and the 85th percentile speed being close to 40 mph, no credit was taken for this parameter in warranting the exiting traffic signal locations along Main Street.

Right-Turn Side-Street Traffic Volumes

Several side-streets along the Main Street corridor consist of a single general-purpose travel lane. For this approach geometry, the *MUTCD* states:

> *"The study should consider the effects of the right-turn vehicles from the minor-street approaches. Engineering judgment should be used to determine what, if any, portion of the right-turn traffic is subtracted from the minor-street traffic count when evaluating the count against the signal warrants." (MUTCD - Sect 4C.01 ¶8)*

TEC recognizes the need to apply a reasonable reduction in right turning traffic when justified based on the location, geometry, traffic operations, and level of opposing traffic. Multiple side-street approaches experience a significant portion of the overall traffic as right-turns; however, the level of conflict from vehicle speeds, limited sight lines based on approach angle, and traffic volumes on the Main Street mainline necessitate only a percentage reduction in right turning traffic from the following locations:

- Lowell Road eastbound (50% reduction)
- Winter Street westbound (50% reduction)

It is TEC's engineering judgement that a reduction in right turning traffic from the following locations is not warranted:

- Burroughs Road eastbound - right turning traffic volumes are regularly blocked within single general-purpose travel lane by approach left-turns and through movements.
- Park Street eastbound – right turning traffic volumes are regularly blocked from the channelized right-turn lane by high volumes within the shared left-turn / through lane.
- Park Street westbound – right turning traffic volumes are regularly blocked from the channelized right-turn lane by high volumes within the shared left-turn / through lane.
- North Street westbound - right turning traffic volumes are regularly blocked within the shared through / right-turn lane by approach through movements.
- North Street eastbound - right turning traffic volumes are regularly blocked within the shared through / right-turn lane by approach through movements.

Number of Travel Lanes

Several side-street approaches to Main Street consist of a through lane and plus one left-turn or right-turn lane. For this approach geometry, the *MUTCD* states:

> *"The site-specific characteristics should dictate whether an approach is considered as one lane or two lanes … For example … if engineering judgment indicates that it should be considered a one-lane approach because the traffic using the left-turn lane is minor, the total traffic volume approaching the intersection should be applied against the signal warrants as a one-lane approach. The approach should be considered two lanes if approximately half of the traffic on the approach turns left and the left-turn lane is sufficient length to accommodate all left-turn vehicles." (MUTCD - Sect 4C.01 ¶09)*

Several side-street approaches along the Main Street corridor consist of multi-lane approaches were the measured volume of traffic within the auxiliary turn-lane warrants analysis of the side-street approach as two lanes in terms of the given traffic signal warrant condition. This includes:

- North Street eastbound - traffic volume in left-turn lane is generally comparable, if not higher, to the overall through movement.
- Park Street eastbound – traffic volume in left-turn lane is generally comparable, if not higher, to the overall through movement.

Right Turn Side-Street Traffic Volumes with Second Travel Lane

Several side-streets along the Main Street corridor consist of a separated right-turn lane. For this approach geometry, the *MUTCD* states:

> *"…engineering judgment and rationale should be applied to a street approach with one through/left-turn lane plus a right-turn lane. In this case, the degree of conflict of minor-street right-turn traffic with traffic on the major street should be considered. Thus, right-turn traffic should not be included in the minor-street volume if the movement enters the major street with minimal conflict. The approach should be evaluated as a one-lane approach with only the traffic volume in the through/left-turn lane considered." (MUTCD - Sect 4C.01 ¶10)*

Several side-street approaches along the Main Street corridor consist of multi-lane approaches were the measured volume of traffic within the auxiliary turn-lane warrants analysis of the side-street approach as two lanes in terms of the given traffic signal warrant condition. This includes:

- Stop & Shop Driveway westbound – right-turn traffic volumes removed from traffic signal warrant analysis based on exclusive right-turn lane and limited conflict.
- Ocean State Job Lot Driveway westbound – right-turn traffic volumes removed from traffic signal warrant analysis based on exclusive right-turn lane and limited conflict.

- North Reading Plaza Driveway eastbound – right-turn traffic volumes removed from traffic signal warrant analysis based on exclusive right-turn lane and limited conflict.

Warrant Results

The following section summarizes the warranting conditions of the existing traffic signal locations along Main Street. Similar to traffic volume projections, the traffic signal warrant analyses assume that commercial driveway entering and exiting volumes increase proportionally with the COVID-19 adjustment factor. Although this COVID-19 adjustment factor is included, each of the three corresponding locations involving a higher-volume side-street (North Reading Plaza Driveway, Ocean State Job Lot Driveway, and Stop & Shop Driveway) would not change the outcome of the overall signal warranting condition if removed. The signal warrant analysis worksheets are included in Appendix H.

Main Street / Burroughs Road / Stop & Shop Driveway

Based on the COVID-19 adjusted traffic volumes, the intersection of Main Street / North Street meets the criteria for a traffic signal under both Warrant 1 and Warrant 2.

Main Street / North Street

Based on the COVID-19 adjusted traffic volumes, the intersection of Main Street / North Street meets the criteria for a traffic signal under both Warrant 1 and Warrant 2.

Main Street / Lowell Road / Nick O'Brian's Service Driveway

Based on the COVID-19 adjusted traffic volumes, the intersection of Main Street / Lowell Road / Nick O'Brian's Service Driveway meets the criteria for a traffic signal under both Warrant 1 and Warrant 2.

Main Street / Winter Street / Reading Lumber Driveway

Based on the COVID-19 adjusted traffic volumes, the intersection of Main Street / Winter Street / Reading Lumber Driveway meets the criteria for a traffic signal under both Warrant 1 and Warrant 2.

Main Street / Ocean State Job Lot Driveway

Based on the COVID-19 adjusted traffic volumes, the intersection of Main Street / Ocean State Job Lot Driveway does not meet the criteria for a traffic signal under either Warrant 1 or Warrant 2. Under the existing zoning and based upon the known previous usage on the site (previously a Stop & Shop), a new tenant could occupy the gross floor area of the retail usage and produce a significant amount of traffic that is not currently observed at the intersection with Main Street. As a traffic signal is not warranted at this location, TEC recommends that the Town consider removal of this traffic signal location as a long-term improvement, pending redevelopment of the Ocean State Job Lot site.

Should the site be redeveloped, based on the underdeveloped nature of the property, signal warrants should be reevaluated with traffic volumes projected from the redeveloped land use. At a minimum, any long-term project along Main Street should seek to construct subsurface traffic signal infrastructure at this location should any future land use warrant a traffic signal at this driveway. This will allow for the construction of a new traffic signal at this location without a need to trench into a resurfaced or reconstructed roadway.

Main Street / North Reading Plaza Driveway

Based on the COVID-19 adjusted traffic volumes, the intersection of Main Street / North Reading Plaza Driveway meets the criteria for a traffic signal under both Warrant 1 and Warrant 2.

Main Street / Park Street

Based on the COVID-19 adjusted traffic volumes, the intersection of Main Street / Park Street meets the criteria for a traffic signal under both Warrant 1 and Warrant 2.

VI. PUBLIC OUTREACH

Public opinion on the Main Street corridor in North Reading was solicited using a public survey, which was publicly advertised on the Town's website and social media. A QR Code to the survey was available on both the website and social media to allow for ease of access for those with cellular phones. The solicitation for public input was set up at this early stage to help refine the goals and develop the priorities for a future project to ensure that it best meets the needs of abutters, residents, business owners and other stakeholders.

PUBLIC SURVEY

A survey was utilized to gather public input and insight from those who use the Main Street corridor or are otherwise familiar with the roadway. It was launched on August 5, 2021, and was publicly available online through Friday, October 1, 2021. In total, 570 participants (568 online and 2 on printed hard copies) had responded to the survey in the 8-week period.

Question 1

What is your future vision for Route 28? In other words, what should the focus for improvements and development along Route 28?

- **Commercial business focus**
- **Walkable mixed-use community focus**
- **Commuter vehicle focus**
- **Other (please specify)**

Out of 570 survey participants, 553 (97%) chose to answer the question and select a focus for improvements and developments along Route 28. Participants were also allowed to offer suggestions regarding the matter, and several (43) provided their specific input. Exhibit 6 graphically depicts how respondents answered.

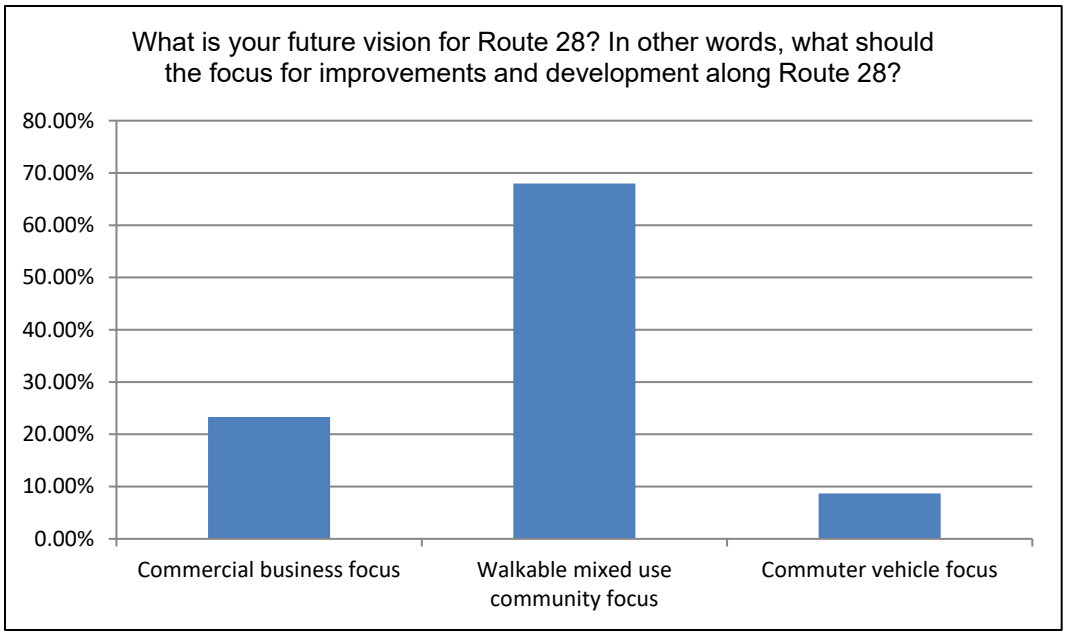


Exhibit 6: Response to Survey Question 1

Overwhelmingly, the most popular answer to Question 1 was to have a walkable mixed-used community focus for Route 28 improvements. More than two-thirds (376 of 553) of the responses indicated this option. The second most popular choice, which almost a quarter (129 of 553) of the respondents chose, was the commercial business focus. The least chosen focus was the commuter vehicle focus which was selected by 48 of the total 553 participants. Those who opted to provide other focus for improvements indicated a need for improved aesthetics, pedestrian/bicycle accommodations, enhanced downtown commercial area, and better roadway infrastructure along the corridor. Three (3) respondents did directly note no desire for improvement along Main Street. There were also direct statements to both an agreement and disagreement to change Route 28 in its operations to the current Road Diet in Reading to the south.

Question 2

In your opinion, what transportation improvements are necessary along Route 28 to achieve this vision? (check all that apply)

- **Improved pedestrian accommodations / safety**
- **Improved bicycle accommodations / safety**
- **Facilitate access to abutting residential and commercial uses**
- **Reduce travel speeds**
- **Facilitate commuter vehicular travel through the corridor**
- **Reduce congestion for vehicles**
- **Other (please specify)**

Out of 570 survey participants, 544 (95%) chose to answer the question and select at least one necessary transportation improvement along Route 28. Participants were allowed to select as

many improvements as they chose, and many selected more than one option. Exhibit 7 graphically depicts how respondents answered.

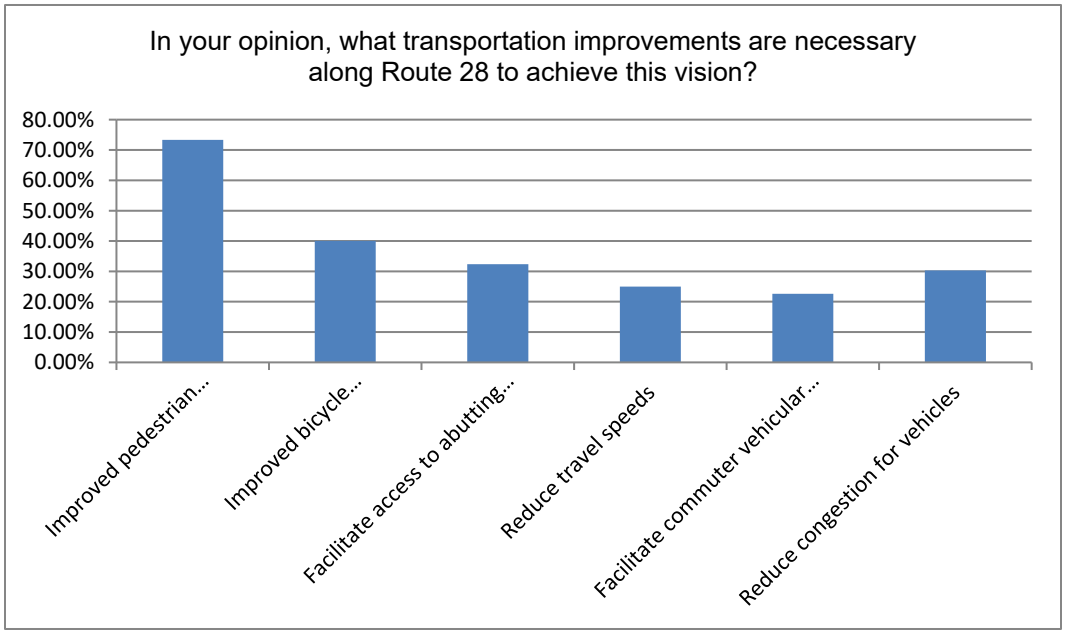


Exhibit 7: Responses to Survey Question 2

Overall, the top necessary transportation improvement along Route 28 was determined to be improving pedestrian accommodations/safety along the corridor, which almost three-quarters (399 of 544) of the participants selected. Improving bicycle accommodations/safety (40%), facilitating access to abutting residential and commercial uses (32%), and reducing congestion for vehicles (30%) were the next most popular choice of the respondents. Similarly, there were also direct statements to both an agreement and disagreement to change Route 28 in its operations to the current Road Diet in Reading to the south.

Question 3

What is your relationship to the project?

- **Direct abutter**
- **Resident of intersecting side street**
- **Interested North Reading resident**
- **North Reading business owner**
- **Route 28 commuter**
- **Other (please specify)**

Out of 570 survey participants, 566 (99%) chose to answer the question and identified their relationship to the project. 398 (70%) were interested North Reading residents, 112 (20%) were residents of an intersecting side street, and the remaining 10% consisted of a mix of direct abutters, North Reading business owners and Route 28 commuters.

Question 4

What is your current level of comfort walking along Route 28?

- **Very comfortable**
- **Somewhat comfortable**
- **Neutral**
- **Somewhat uncomfortable**
- **Extremely uncomfortable**

Out of 570 survey participants, 564 (99%) chose to answer the question and indicated their comfort level walking along Route 28. Exhibit 8 graphically depicts how respondents answered.

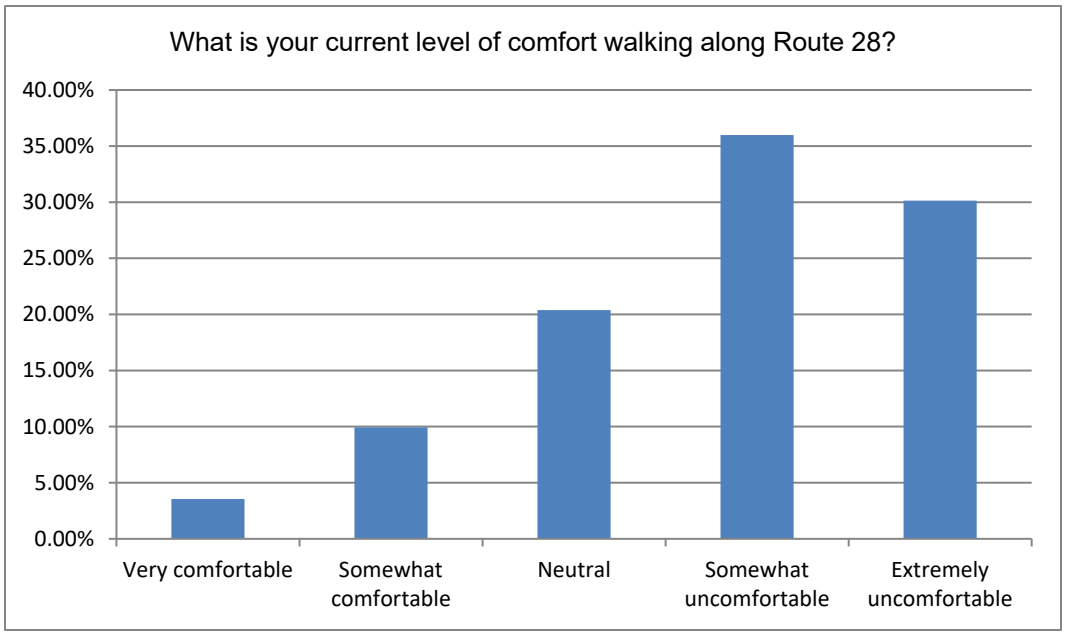


Exhibit 8: Responses to Survey Question 4

As shown in Exhibit 8, the majority of the respondents felt "somewhat uncomfortable" (36%) or "extremely uncomfortable" (30%) walking along the corridor. Only approximately 14% of respondents rated their experience as "very comfortable" or "somewhat comfortable." Note that the higher level of "neutral' respondents may include those participants who may have not experienced walking along the corridor.

Question 5

What is your current level of comfort bicycling along Route 28?

- **Very comfortable**
- **Somewhat comfortable**
- **Neutral**
- **Somewhat uncomfortable**
- **Extremely uncomfortable**

Out of 570 survey participants, 555 (97%) chose to answer the question and indicated their comfort level bicycling along Route 28. Exhibit 9 graphically depicts how respondents answered.

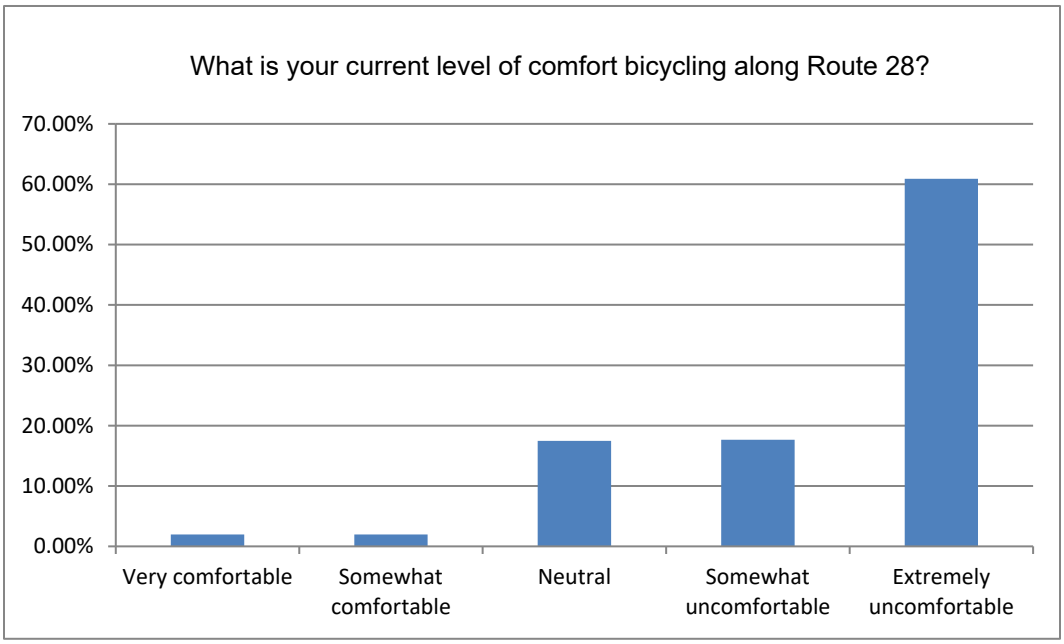


Exhibit 9: Responses to Survey Question 5

Exhibit 9 graphically depicts how respondents answered. Overwhelmingly, 338 of the respondents, which accounts for 60% of the total, indicated that they feel "extremely uncomfortable" bicycling along the corridor. The options "somewhat uncomfortable" and "neutral," which were chosen by 98 and 97 respondents, respectively, were the next most selected indication. Only approximately 4% of respondents rated their experience as "very comfortable" or "somewhat comfortable." Note that the higher level of "neutral' respondents may include those participants who may have not experienced bicycling along the corridor.

Question 6

Do you believe Route 28 users would benefit from having continuous sidewalks on both sides of the roadway for pedestrians?

- **Significant benefit**
- **Small benefit**
- **Sidewalks along Route 28 are unlikely to be used**

Out of 570 survey participants, 566 (99%) chose to answer the question. Exhibit 10 graphically depicts how respondents answered.

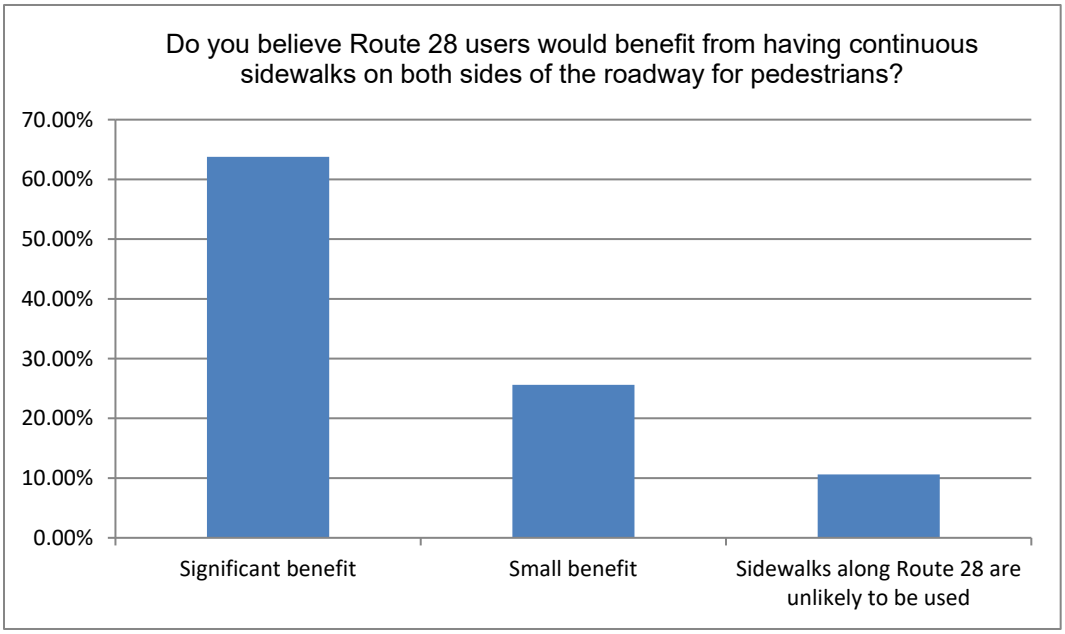


Exhibit 10: Responses to Survey Question 6

The corridor was viewed to significantly benefit from having continuous sidewalks on both sides of the roadway for pedestrians by more than half (64%) of the respondents. More than a quarter (26%) viewed the installation as a small benefit to the corridor. The remaining 10% indicated that the sidewalks along Route 28 are unlikely to be used.

Question 7

Do you believe Route 28 users would benefit from having buffered on-road bicycle lanes in both directions of travel?

- **Significant benefit**
- **Small benefit**
- **On-Street bicycle lanes are unlikely to be used**

Out of 570 survey participants, 564 (99%) chose to answer the question. Exhibit 11 graphically depicts how respondents answered.

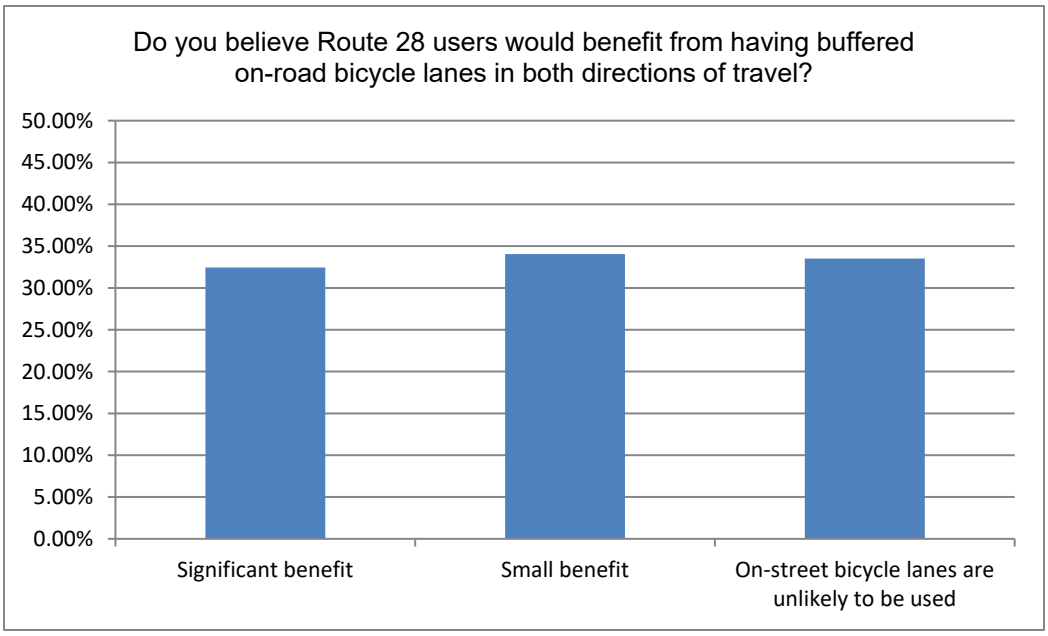


Exhibit 11: Responses to Survey Question 7

The respondents' views regarding the benefits the corridor will obtain when buffered on-road bicycle lanes are to be constructed along Route 28 were split. The option for bicycle lanes providing small benefits to the corridor was chosen by 34% (192 of 564) of the respondents. Similarly, 34% (189 of 564) of the participants indicated that on-street bicycle lanes are unlikely to be used. The remaining 183 respondents, which accounts for 32% of the total responses, indicated the bicycle lanes would provide a significant benefit to the corridor.

Question 8

MassDOT recently reconfigured Route 28 in the Town of Reading to provide a center two-way left-turn lane and one vehicle travel lane in each direction, enabling larger shoulders for pedestrian and bicycle use. If you have traveled this section of Route 28, what is your impression of this roadway configuration?

- **It feels very comfortable**
- **It is somewhat more comfortable than the prior condition**
- **Neutral / do not use this roadway**
- **This configuration would not work in North Reading**
- **Any additional thoughts would be appreciated**

Out of 570 survey participants, 555 (97%) chose to answer the question. Exhibit 12 graphically depicts how respondents answered.

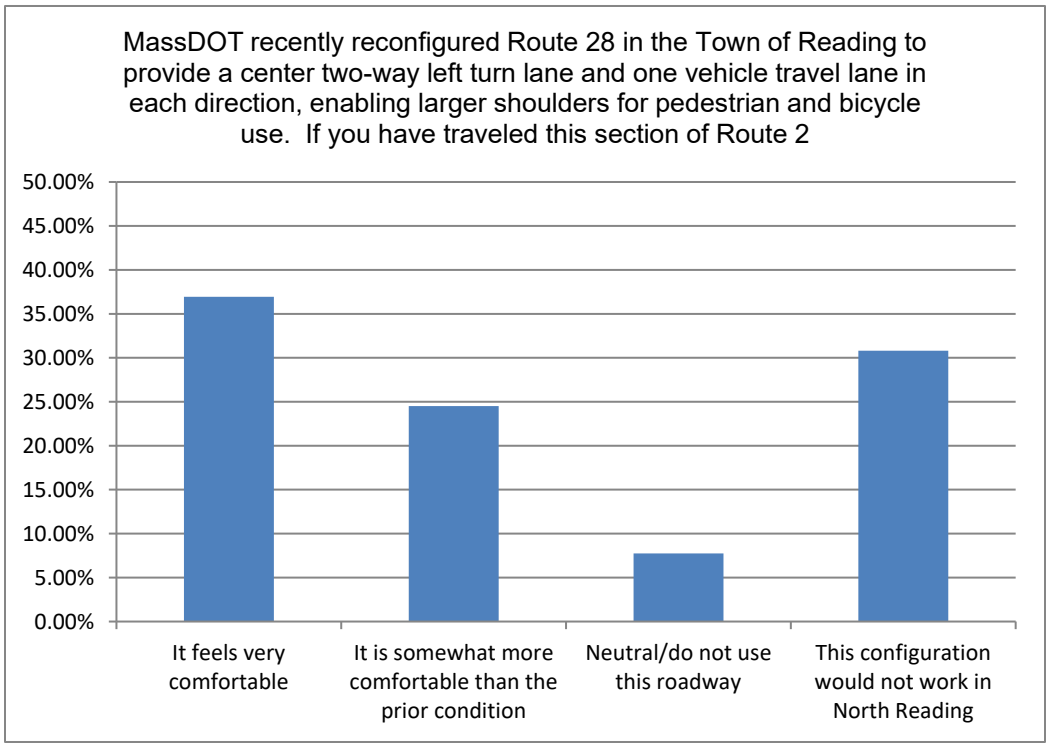


Exhibit 12: Responses to Survey Question 8

More than a third (205 of 555) of the respondents indicated that they felt comfortable traveling along Route 28 in Reading after the reconfiguration, while almost a quarter (136 of 555) felt somewhat comfortable using the corridor compared to the prior condition. 30% (171 of 555) indicated that this configuration would not work in North Reading, while the remaining eight percent (43 of 555) remained neutral or did not use Route 28.

Participants were also allowed to provide additional thoughts regarding the matter. Overall, the comments provided by the participants were mixed. Keywords that were promoted by these respondents were “congestion,” “driver confusion,” and “safety.” Many respondents noted that the two-way left-turn lane added to driver confusion while others noted slower travel speeds and the decrease in potential to getting “stuck behind someone trying to make a left turn.” Comments also noted a potential to increase traffic on the residential street should congestion be an issue with a lane reduction.

Question 9

What is your overall level of support for the construction of any pedestrian and bicycle improvements along Route 28?

- **Very supportive**
- **Somewhat supportive**
- **Neutral**
- **Somewhat unsupportive**

- **Very unsupportive**

Out of 570 survey participants, 567 (99%) chose to answer the question. Exhibit 13 graphically depicts how respondents answered.

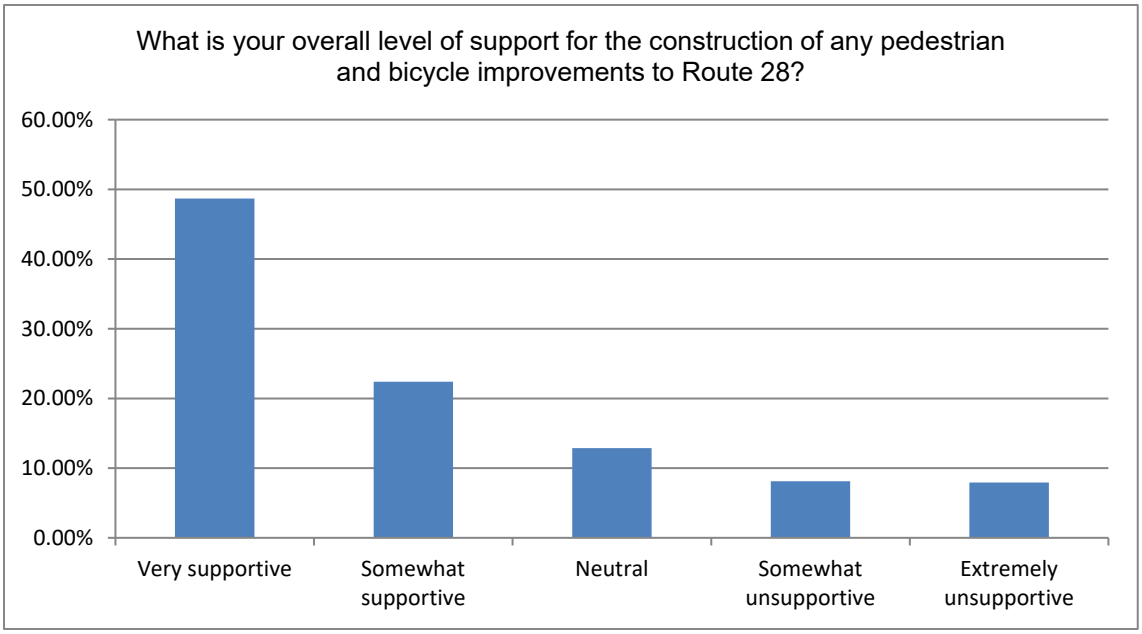


Exhibit 13: Responses to Survey Question 9

Overall, the majority of the survey respondents supported the construction of pedestrian and/or bicycle improvements along Route 28, with almost half (276 of 567) of the responses being very supportive and more than a fifth (127 of 576) being somewhat supportive of the construction.

Other Comments

The final survey question allotted respondents to provide any general comments related to the corridor and potential corridor improvements. TEC and the Town of North Reading reviewed each comment and singled-out keywords and/or interpretation of keywords to guide the production of potential corridor improvement opportunities while concurrently looking at the overall process within the community. Keywords are graphically depicted in Exhibit 14. In general, the most common keywords that were identified as:

- Pedestrian Accommodations,
- Redevelopment,
- Make Pedestrian Friendly,
- No Bike Lanes,
- Sidewalks,
- Congestion, and

- Aesthetics

Although similar, the most common keyword(s) overall were in relation to the current ability for pedestrians to utilize the facilities along the corridor stemming from the keywords: “Pedestrian Accommodations,” “Make Pedestrian Friendly,” and “Sidewalks.”

Exhibit 14: Keywords identified in Other Consideration by Survey Respondents

VII. IDENTIFICATION OF CORRIDOR OPPORTUNITIES

Based on the data and information collected for the existing conditions, coordination with the Town of North Reading, and public input an assessment of operational and safety deficiencies of the Main Street corridor has been completed and improvement opportunities have been identified to address these deficiencies. The purpose of this chapter is to present the recommendations for the several improvement opportunities along the Main Street corridor. These opportunities provide various options for allocation of the roadway cross-section and the accommodation of all modes of transportation / users.

Improvement opportunities were assembled into complementary groups; including opportunities that would generally not affect the existing roadway cross-section and those that would be anticipated to affect the roadway cross-section. Although each of the opportunities included differing improvement measures, some improvement measures are not mutually exclusive to those opportunities.

The several improvement opportunities and sub-alternatives include:

- Opportunity 1: No Build (No Action)
- Opportunity 2: Existing Cross-Section Opportunities
    - Opportunity 2A – Short-Term Infrastructure Safety & Maintenance Improvements
    - Opportunity 2B – Traffic Signal Optimization and Retrofit Improvements
- Opportunity 3: Modified Cross-Section Opportunities
    - Opportunity 3A – Traffic Signal Reconstruction Improvements
    - Opportunity 3B – Roundabout Improvements (Key Locations)
    - Opportunity 3C – Pedestrian Connectivity Improvements
    - Opportunity 3D – Access Management Improvements
    - Opportunity 3E – Road Diet and Bicycle Cross-Section Improvements

OPPORTUNITY 1: NO BUILD (NO ACTION)

The No Build Condition represents the case in which the no improvements are constructed along the Main Street corridor beyond those already committed, funded, and expected to be in place by the 2032 horizon year. Under the No Build Condition, the existing roadway would bear future traffic increases, congestion, roadway deficiencies, a lack of connective pedestrian /

bicycle accommodations, and access management concerns with impacts to safety, congestion, mobility, air quality concerns, and operational characteristics. The No Build Condition includes the cost of routine maintenance though the design year and would have no associated right-of-way (ROW) impacts to the MassDOT's SHLO along Main Street. This opportunity was used as the baseline comparative opportunities for the project under future year conditions.

The No Build Condition was not considered a viable opportunity as it does not address the purpose and need factors of the Main Street corridor.

OPPORTUNITY 2: EXISTING CROSS-SECTION OPPORTUNITIES SUMMARY

Two opportunity scenarios were developed to improve the corridor's safety, mobility, pedestrian / bicycle accommodations, and operational characteristics while maintaining the existing Main Street 4-lane cross-section. For the two sub-alternatives within Opportunity 2, several short-term minor improvement measures (e.g., safety and maintenance improvements) are not mutually exclusive to that sub-alternative; but are anticipated to be completed concurrent with both sub-alternative and as part of the several sub-alternatives identified under Opportunity 3. These improvements, generally short-term and lower cost in nature, along Main Street are necessary to minimize conflicts between through traffic, turning traffic, and pedestrian/bicycle traffic, and to provide improved traffic safety by lengthening sight lines and providing new, consistent, and reasonable traffic signs and pavement markings.

Opportunity 2A – Short-Term Infrastructure Safety & Maintenance Improvements

The short-term safety and maintenance improvements that have been identified along the Main Street corridor are described in detail below. These short-term improvements are recommended as part of all improvement opportunity scenarios listed in this chapter unless superseded by a superior improvement.

General Maintenance

- Trim vegetation overgrowth along the edges of Main Street where vegetation impedes sight lines from side-streets, the path of travel for pedestrians, or visibility to traffic signal infrastructure.
- Complete filling and sealing of both minor and major cracking in the existing Main Street asphalt surface. This will extend the life of the existing pavement until a longer-term resurfacing and/or pavement reconstruction / reclamation is completed.
- Examine each stormwater catch basin / inlet structure for debris build-up and remove all build-up and in basin sediment that may obstruct proper stormwater removal from Main Street and several side-streets.

Traffic Signs and Pavement Markings

- Perform a complete retrofit of all traffic signage along the Main Street corridor between Park Street and the Andover Town Line and along the several side-street approaches to Main Street. The retrofit should commence with a full

signage and post inventory to access the condition, placement, and efficacy of each sign and post within the study area.

- Restripe all existing crosswalks, stop lines, edge lines, centerlines, and arrow markings along Main Street and the several side-street intersection approaches to Main Street as designated by the particular improvement opportunity. Where possible, pavement markings should be thermoplastic to extend the lifespan for cost efficiencies.

Pedestrian Accommodations

- Reconstruct all pedestrian curb ramps within the study area as ADA/AAB-compliant ramps with tactile warning devices. Crosswalks and stop lines (as needed) should be marked to provide a continuous path of travel between curb ramps.
- Reconstruct pedestrian pathways through channelized islands, such as at Park Street, to formalize as pedestrian ramps and avoid stormwater conflicts with pass-through islands.
- Evaluate cracking, damage, cross-slopes, and driveway transition slope along the length of the existing Main Street sidewalk and reconstruct portions of the sidewalk, as necessary.

Opportunity 2B – Traffic Signal Optimization & Retrofit Improvements

As described in Chapter II – "Existing Conditions," all seven signalized intersection locations along Main Street require retrofits to the existing traffic signal infrastructure. In addition, optimization of traffic signal timings is recommended for all locations to enhance the flow of traffic through the corridor. The following traffic signal short-term retrofit improvements are recommended as part of the preferred opportunity and under all improvement opportunity scenarios listed in this section.

Traffic Signal Retrofit Summary

Main Street / Burroughs Road / Stop & Shop Driveway

- Optimize traffic signal timings at the intersection including peak hour times, non-peak hour timings, and coordination timings.
- Reestablish coordination timings and parameters to the Main Street / North Street intersection. This may require installation of a replacement interconnect system to avoid unforeseen conduit and related costs with the current subsurface twisted-pair copper interconnect (e.g. new GPS coordination system).
- Update the pedestrian clearance interval for the exclusive pedestrian phase to be 20 seconds Flashing Don't Walk and 4 seconds Don't Walk (24 second total clearance). The Walk interval should be adjusted to 7 seconds.
- Check and repair the loop detector for the Main Street northbound and northbound left-turn phases which may be faulting.

- Replace the faded the Left Turn Yield on Green Ball (R10-12) sign facing Main Street northbound along the mast arm. Install missing R10-12 sign on new mounting bracket facing Main Street southbound along the mast arm.
- Install an emergency vehicle preemption optical detector to the intersection facing Burroughs Road eastbound. An additional preemption phase selector card will need to be supplied to the controller cabinet and preemption card rack.
- Replace all pedestrian push buttons with accessible pedestrian signal (APS) equipment with appropriate push button signage (R10-3e).
- Add pedestrian push buttons extensions at the intersection where push buttons are out of a 10-inch AAB-standard reach of a level surface.
- Consider replacement of all damaged / antiquated signal housings at the intersection. Note that the signal housings attached to the pedestal posts on the intersection's northwest corner are new and do not need immediate replacement.

Main Street / North Street

- Optimize traffic signal timings at the intersection including peak hour times, non-peak hour timings, and coordination timings.
- Reestablish coordination timings and parameters to the Main Street / Burroughs Road / Stop & Shop Driveway intersection. This may require installation of a replacement interconnect system to avoid unforeseen conduit and related costs with the current subsurface twisted-pair copper interconnect (e.g. new GPS coordination system).
- Update the pedestrian clearance interval for the exclusive pedestrian phase to be 16 seconds Flashing Don't Walk and 4 seconds Don't Walk (20 second total clearance).
- Check and repair the loop detector for the North Street westbound movement which may be faulting.
- Replace all pedestrian signal indications at the intersection with 16-inch countdown indications and housings.
- Replace all pedestrian push buttons with APS equipment with appropriate push button signage (R10-3e).
- Add pedestrian push buttons extensions at the intersection where push buttons are out of a 10-inch AAB-standard reach of a level surface.
- Install pedestrian push button stanchions, bases, and foundations at those pedestrian ramp locations were push buttons are more than 10-feet away from the opening of the associated ramp.
- Consider replacement of all damaged / antiquated signal housings at the intersection. Note that the signal housings attached to the pedestal posts on the intersection's northwest corner are new and do not need immediate replacement.
- Replace both existing pedestal posts on the intersection's northwest and southeast corners which are damaged to the point of replacement need.

Main Street / Lowell Road / Nick O'Brian's Service Driveway

- Optimize traffic signal timings at the intersection including peak hour times, non-peak hour timings, and coordination timings.
- Reestablish coordination timings and parameters to the Main Street intersections with Winter Street, Ocean State Job Lot Driveway, and North Reading Plaza Driveway. This may require installation of a replacement interconnect system to avoid unforeseen conduit and related costs with the current subsurface twisted-pair copper interconnect (e.g. new GPS coordination system).
- Update the vehicular clearance intervals for all phases programmed at the intersection to meet current MassDOT and/or *MUTCD* standards.
- Update the pedestrian clearance interval for the exclusive pedestrian phase to be 27 seconds Flashing Don't Walk and 4 seconds Don't Walk (31 second total clearance). The Walk interval should be adjusted to 7 seconds.
- Replace all pedestrian signal indications at the intersection with 16-inch countdown indications and housings. Housing for the Lowell Road crossing should have indications in excess of 9-inches per *MUTCD* standards.
- Replace missing signal module tunnel visor on housing facing Main Street southbound on intersection's southwest corner.
- Install missing R10-12 sign on new mounting bracket facing Main Street northbound along the span wire.
- Replace all pedestrian push buttons with APS equipment with appropriate push button signage (R10-3e).
- Consider replacement of all damaged / antiquated signal housings at the intersection. Note that the signal housings attached to the pedestal posts surrounding the intersection appear to be in above-average condition while the span wire signal housings appear to be in below-average condition.
- Replace all existing pedestal posts at the intersection, with exception to the intersection's northeast corner, which are damaged to the point of replacement need.

Main Street / Winter Street / Reading Lumber Driveway

- Optimize traffic signal timings at the intersection including peak hour times, non-peak hour timings, and coordination timings.
- Reestablish coordination timings and parameters to the Main Street intersections with Lowell Road, Ocean State Job Lot Driveway, and North Reading Plaza Driveway. This may require installation of a replacement interconnect system to avoid unforeseen conduit and related costs with the current subsurface twisted-pair copper interconnect (e.g. new GPS coordination system).
- Update the pedestrian clearance interval for the exclusive pedestrian phase to be 22 seconds Flashing Don't Walk and 4 seconds Don't Walk (26 second total clearance). The Walk interval should be adjusted to 7 seconds.

- Replace all pedestrian signal indications at the intersection with 16-inch countdown indications and housings.
- Replace all pedestrian push buttons with APS equipment with appropriate push button signage (R10-3e).
- Add pedestrian push buttons extensions at the intersection where push buttons are out of a 10-inch AAB-standard reach of a level surface.
- Install pedestrian push button stanchions, bases, and foundations at those pedestrian ramp locations were push buttons are more than 10-feet away from the opening of the associated ramp.
- Replace the 4-section signal housing over the Main Street southbound inside lane with a standard 5-section “doghouse” housing to match the protected-permitted left-turn housing from a shared lane along the corridor.
- Consider replacement of all damaged / antiquated signal housings as needed at the intersection. Note that the signal housings are generally in fair condition at this intersection.
- Replace all existing pedestal posts at the intersection.

Main Street / Ocean State Job Lot Driveway

Should the traffic signal infrastructure be retained at the intersection of Main Street / Ocean State Job Lot Driveway, the following retrofits should be completed.

- Optimize traffic signal timings at the intersection including peak hour times, non-peak hour timings, and coordination timings.
- Reestablish coordination timings and parameters to the Main Street intersections with Lowell Road, Winter Street, and North Reading Plaza Driveway. This may require installation of a replacement interconnect system to avoid unforeseen conduit and related costs with the current subsurface twisted-pair copper interconnect (e.g. new GPS coordination system).
- Update the vehicular clearance intervals for all phases programmed at the intersection to meet current MassDOT and/or *MUTCD* standards.
- Incorporate pedestrian signal phasing and timing into the existing traffic signal operations. Install pedestrian signal equipment; including, 16-inch countdown pedestrian signal housings and APS push buttons with appropriate push button signage (R10-3e).
- Install missing R10-12 sign on new mounting bracket facing Main Street southbound along the mast arm.
- Consider replacement of all damaged / antiquated signal housings as needed at the intersection. All signal housings appear to be in fair to below-average condition.
- Replace all existing pedestal posts at the intersection.

Main Street / North Reading Plaza Driveway

- Optimize traffic signal timings at the intersection including peak hour times, non-peak hour timings, and coordination timings.
- Reestablish coordination timings and parameters to the Main Street intersections with Lowell Road, Winter Street, and the Ocean State Job Lot Driveway. This may require installation of a replacement interconnect system to avoid unforeseen conduit and related costs with the current subsurface twisted-pair copper interconnect (e.g. new GPS coordination system).
- Update the vehicular clearance intervals for all phases programmed at the intersection to meet current MassDOT and/or *MUTCD* standards.
- Install missing R10-12 sign on new mounting bracket facing Main Street southbound along the mast arm.
- Consider replacement of all damaged / antiquated signal housings as needed at the intersection. All signal housings appear to be in fair to below-average condition.

Main Street / Park Street

- Update the pedestrian clearance interval for the exclusive pedestrian phase to be 11 seconds Flashing Don't Walk and 4 seconds Don't Walk (15 second total clearance). The Walk interval should be adjusted to 7 seconds.
- Replace the several 8-inch pedestrian signal housings with new pedestrian signal indications with 16-inch countdown indications and housings.
- Replace all pedestrian push buttons with APS equipment with appropriate push button signage (R10-3e).
- Add pedestrian push buttons extensions at the intersection where push buttons are out of a 10-inch AAB-standard reach of a level surface.
- Install 5" retroreflective backplates to signal housings at the intersection. Evaluate and replace the messenger wire (span wire) if needed to incorporate the additional wind loading.
- Replace the 4-section signal housing over the Main Street northbound inside lane with a standard 5-section "doghouse" housing to match the protected-permitted left-turn housing from a shared lane along the corridor.
- Install missing R10-12 sign on new mounting bracket facing Main Street northbound along the span wire.
- Consider replacement of all damaged / antiquated signal housings as needed at the intersection. All signal housings appear to be in above average to fair condition.
- Replace both existing pedestal posts on the intersection's northwest corner and one along Park Street on the southeast corner which are damaged to the point of replacement need.

A conceptual plan of these traffic signal retrofit improvements, and associated infrastructure improvements, along the Main Street corridor are depicted in Appendix I.

OPPORTUNITY 3: MODIFIED CROSS-SECTION OPPORTUNITIES SUMMARY

Five opportunities were developed to improve the corridor's safety, mobility, pedestrian / bicycle accommodations, and operational characteristics, considering options outside of maintaining the existing Main Street 4-lane cross-section. The short-term and lower cost improvements identified in Opportunity 2 and detailed above are considered included within each of the sub-alternatives identified under Opportunity 3. These improvements are necessary in any scenario to minimize conflicts between through traffic, turning traffic, and pedestrian/bicycle traffic, and to provide improved traffic safety by lengthening sight lines and providing new, consistent, and reasonable traffic signs and pavement markings.

Opportunity 3A – Traffic Signal Reconstruction Improvements

To improve efficiency, safety, and operations at each of the seven (7) corridor signalized intersection, reconstruction of each fully actuated traffic signal has been identified as a longer-term opportunity along the corridor. Whereas signal retrofit improvements are expected to improve conditions along Main Street, complete reconstruction the corridor signals will better allow for safety and mobility to remain efficient well into the future. Each newly reconstructed traffic signal should include the following:

- Installation of a new ATC traffic signal controller(s), controller cabinet(s), and ancillary cabinet equipment to provide fully functioning traffic signals compatible with future Intelligent Transportation System (ITS) capabilities. MassDOT is currently shifting its future traffic signal inventory, and much of its existing inventory, to ATC.
- Programming of multiple signal timing schemes to accommodate the differing traffic demands during the commuter peak periods. Vehicular and pedestrian clearance intervals should be recalculated based on the finalized geometry conditions.
- Installation of an intersection communication system (radio, fiber optic, twisted pair copper, etc.) that allows for streamlined coordination and allows for ability to export communications data for traffic monitoring purposes.
- Installation of new mast arm assemblies for each intersection approach to provide signal housings over each approach, provide additional capabilities to handle wind loading (over existing span wire assemblies), and provide a consistent aesthetic appeal to the Main Street corridor.
- Installation of new pedestal posts, bases, foundations, as well as new conduit and pull box network for the intersections.
- Installation of new vehicular / pedestrian signal housings and new LEDs throughout the corridor. Reset existing pedestrian countdown signal housings and retroreflective backplates as recently installed to minimize cost.
- Repositioning of pedestrian push buttons at each intersection and add new pedestrian push buttons where new sidewalk is installed or relocated to provide

compliance to ADA/AAB reach and *MUTCD* distance to ramp openings. All pedestrian push buttons should be compliant to MassDOT's APS standards.

- Installation of an enhanced detection system (video, microwave, or radar); including dilemma zone detection, allowing improved / continuous detectability and ability to export video images for traffic monitoring purposes.
- Resetting, if condition warrants, of the existing emergency vehicle preemption system at each intersection.
- Implementation of FYA where applicable along the corridor based on the finalized geometry.

All traffic signal infrastructure as part of newly constructed traffic signals should be designed to provide the minimum 1.5-foot lateral offset from face of curb as described in the MassDOT *PDDG*[6].

Opportunity 3B – Roundabout at Key Locations Improvements

Roundabout intersections are becoming more prevalent at locations across New England and within Massachusetts. Roundabouts provide a level of operations and safety that are comparable or more advantageous to traffic signals. As prescribed by the *MassDOT – Highway Division Traffic and Safety Engineering 25% Design Submission Guidelines,*[7] a roundabout was considered as an opportunity to address the operational and safety control of traffic at several key intersections along the Main Street corridor. TEC performed a planning analysis in accordance with the September 2020 MassDOT publication, *Guidelines for the Planning and Design of Roundabouts* ("Guidelines"). Per Section 2.2 of the *Guidelines*, which outlines conditions that influence roundabout implementation, site-specific characteristics of a given intersection should be considered when assessing the feasibility of a roundabout.

Further, planning-level sizing and space requirements should be considered. This is determined based on the number of entry lanes needed on each approach to accommodate the future design volumes. For this evaluation, the following criteria were used per the MassDOT *Guidelines Table 2-2 and Table 2-3*:

- A single-lane roundabout entry can accommodate a peak hour volume of between 1,350 vph and 1,800 vph (upper limit upon more detailed analysis). This is a sum of entering vehicles and circulating vehicles within the roundabout.
- A double-lane roundabout entry can accommodate a peak hour volume of between 1,800 vph and 2,600 vph (upper limit upon more detailed analysis). This is a sum of entering vehicles and circulating vehicles within the roundabout.
- Route 28 is a principal arterial roadway; therefore, a single-lane or multi-lane roundabout would need to accommodate a WB-67 semi-trailer as the design vehicle and incorporate between a 130-foot (one lane) and 165-foot inscribed diameter (two lanes).

[6] *MassHighway Project Development and Design Guide*; MassHighway (presently Massachusetts Department of Transportation – Highway Division); Boston, Massachusetts; 2006

[7] *Traffic and Safety Engineering 25% Design Submission Guidelines*; Massachusetts Department of Transportation – Highway Division; Boston, Massachusetts; Revised February 15, 2011, page 6 of 9

Both site-specific conditions and planning-level sizing and space requirements were considered for the four key intersections.

Main Street / North Street

TEC evaluated the intersection of Main Street / North Street for determination of whether the characteristics of this location would be generally advantageous for a roundabout installation. Table 9 outlines the results of this evaluation.

Table 9 – Roundabout Site-Specific Conditions – Main Street / North Street

Advantageous	Not Advantageous
Intersection has a documented safety concern – averaging more than 7 crashes per year and currently has an EPDO above the HSIP threshold for the MAPC boundaries.	Intersection is located within a coordinated arterial signal system. Inclusion of a roundabout may necessitate modifications to signal flow or signal implementation at other locations within the arterial corridor.
Intersection where a community enhancement may be desirable.	Intersection has a heavy flow of through traffic on the major street (Main Street) opposed by light moderate traffic on the minor street (North Street).
Roads with excessive speed problems, where cars routinely exceed the posted or target speed.	Intersection is adjacent to usable land use areas for area businesses where space for a roundabout may not be accommodated.
Intersection is a location where there is a need to provide a transition between land use environments – local commercial and residential north of the intersection and regional commercial to the south of the intersection.	

Based upon the above, the intersection of Main Street / North Street has conditions that are both advantageous and not advantageous for the installation of a roundabout. Therefore, a planning-level sizing and space evaluation was performed.

The North Street eastbound entry and conflict volumes range from 1,200 vehicles per hour (vph) to 1,300 vph and the North Street westbound entry and conflict volumes range from 1,100 vph to 1,550 vph. This would suggest one (1) entry lane would be needed on each approach with the potential for a second entry lane along North Street westbound. Although warranted, the space allotted on each North Street westbound approach is limited based on existing surface parking fields that would need to be modified to accommodate a second entry lane. In order to maintain the ability to provide sufficient pedestrian and bicycle accommodations within the cross-sectional limits, each North Street approach has been evaluated as a one-lane entry.

The Main Street northbound entry and conflict volumes range from 1,000 vph to 1,600 vph and the Main Street southbound entry and conflict volumes range from 1,150 vph to 1,400 vph. This would suggest one (1) entry lane would be needed on each approach with a potential for a second entry lane. Space is provided along these approaches to accommodate two entry lanes. Therefore, this opportunity has been evaluated with two entry lanes along each Main Street approach, creating a partial multi-lane roundabout.

With a partial multi-lane roundabout required, a 165-foot inscribed diameter is necessary to accommodate WB-67 trucks. This diameter would increase based on the incorporation of

pedestrian accommodations at the intersection. This roundabout size would directly conflict with the surface parking and on-site circulation for the retail establishments on all four intersection corners.

Main Street / Lowell Road / Nick O'Brian's Service Driveway

TEC evaluated the intersection of Main Street / Lowell Road / Nick O'Brian's Service Driveway for determination of whether the characteristics of this location would be generally advantageous for a roundabout installation. Table 10 outlines the results of this evaluation.

Table 10 – Roundabout Site-Specific Conditions – Main Street / Lowell Road

Advantageous	Not Advantageous
Intersection with relatively balanced traffic volumes. Although the O'Brian's Service Driveway has minimal traffic, the Lowell Road approach carries a large amount of vehicle traffic more comparable to the Main Street mainline.	Intersection is located within a coordinated arterial signal system. Inclusion of roundabout may necessitate modifications to signal flow or signal implementation at other locations within the arterial corridor.
Intersection has a high number of left-turn vehicles, specifically the Main Street northbound approach to Lowell Road.	Intersection is adjacent to usable land use areas for area businesses where space for a roundabout may not be accommodated.
Intersection where a community enhancement may be desirable.	Intersection with an acute angle. Lowell Road approaches the intersection from the northwest immediately prior to the intersection.
Roads with excessive speed problems, where cars routinely exceed the posted or target speed.	Lowell Road approaches the intersection at a significant upgrade.

Based upon the above, the intersection of Main Street / Lowell Road / Nick O'Brian's Service Driveway has conditions that are both advantageous and not advantageous for the installation of a roundabout. Therefore, a planning-level sizing and space evaluation was performed.

The Lowell Road eastbound entry and conflict volumes range from 1,250 vph to 1,350 vph and the Nick O'Brian's Service Driveway westbound entry and conflict volumes range from 1,000 vph to 1,600 vph. This would suggest one (1) entry lane would be needed on the Lowell Road eastbound approach. For the Nick O'Brian's Service Driveway, all the summed volume is conflicting volume from Main Street and therefore the driveway would be designed as a one (1) entry lane approach. With little volume exiting the driveway, the driveway could be closed off as part of a roundabout implementation. In order to maintain the ability to provide sufficient pedestrian and bicycle accommodations within the cross-sectional limits, both the Lowell Road and Nick O'Brian's Service Driveway approaches have been evaluated as a one-lane entry.

The Main Street northbound entry and conflict volumes range from 1,000 vph to 1,600 vph and the Main Street southbound entry and conflict volumes range from 1,250 vph to 1,300 vph. This would suggest one (1) entry leg would be needed on each approach with a potential for a second entry lane along Main Street northbound. Space is provided along these approaches to accommodate two entry lanes. Therefore, this opportunity has been evaluated with two entry lanes along each Main Street approach, creating a partial multi-lane roundabout.

With a partial multi-lane roundabout required, a 165-foot inscribed diameter is necessary to accommodate WB-67 trucks. This diameter would increase based on the incorporation of

pedestrian accommodations at the intersection. This roundabout size would directly conflict with the surface parking and on-site circulation for the retail establishments on all four intersection corners. TEC notes the Lowell Road eastbound approach does not intersect Main Street with a standard T-intersection. Implementation of a roundabout at this intersection may require realignment of the intersection to provide as close to a 90-degree entering angle as possible, having significant impact on the retail development on the northeast corner of the intersection.

Main Street / Winter Street / Reading Lumber Driveway

TEC evaluated the intersection of Main Street / Winter Street / Reading Lumber Driveway for determination of whether the characteristics of this location would be generally advantageous for a roundabout installation. Table 11 outlines the results of this evaluation.

Table 11 – Roundabout Site-Specific Conditions – Main Street / Winter Street

Advantageous	Not Advantageous
Intersection with relatively balanced traffic volumes. The Winter Street approach carries a large amount of vehicle traffic comparable to the Main Street mainline.	Intersection is located within a coordinated arterial signal system. Inclusion of roundabout may necessitate modifications to signal flow or signal implementation at other locations within the arterial corridor.
Intersection has a high number of left-turn vehicles, specifically the Main Street southbound approach to Winter Street.	Intersection is adjacent to usable land use areas for area businesses where space for a roundabout may not be accommodated.
Intersection where a community enhancement may be desirable.	Intersection with an acute angle. Winter Street approaches the intersection from the southeast immediately prior to the intersection.
Roads with excessive speed problems, where cars routinely exceed the posted or target speed.	Winter Street approaches the intersection at a significant downgrade.

Based upon the above, the intersection of Main Street / Winter Street / Reading Lumber Driveway has conditions that are both advantageous and not advantageous for the installation of a roundabout. Therefore, a planning-level sizing and space evaluation was performed.

The Winter Street westbound entry and conflict volumes range from 1,100 vph to 1,600 vph. This would suggest two (2) entry legs could be needed on the Winter Street westbound approach. Although warranted, the space allotted on the Winter Street approach is limited adjacent to the existing Kitty's Restaurant building. In order to maintain the ability to provide sufficient pedestrian and bicycle accommodations within the cross-sectional limits, the Winter Street approach within this opportunity has been evaluated as a one lane entry.

The Main Street northbound entry and conflict volumes range from 1,100 vph to 1,600 vph and the Main Street southbound entry and conflict volumes range from 1,300 vph to 1,400 vph. This would suggest one (1) entry leg would be needed on each approach with a potential for a second entry lane along both Main Street northbound and southbound. Space is provided along these approaches to accommodate two entry lanes. Therefore, this opportunity has been evaluated with two entry lanes along each Main Street approach, creating a partial multi-lane roundabout.

With a partial multi-lane roundabout required, a 165-foot inscribed diameter is necessary to accommodate WB-67 trucks. This diameter would increase based on the incorporation of pedestrian accommodations at the intersection. This roundabout size would directly conflict with the surface parking and on-site circulation for the retail establishments on the northeast and southeast intersection corners. TEC notes the Winter Street westbound approach does not intersect Main Street with a standard T-intersection. Implementation of a roundabout at this intersection may require realignment of the intersection to provide as close to a 90-degree entering angle as possible, having significant impact on the southeast corner of the intersection.

Main Street / Park Street

TEC evaluated the intersection of Main Street / Park Street for determination of whether the characteristics of this location would be generally advantageous for a roundabout installation. Table 12 outlines the results of this evaluation.

Table 12 – Roundabout Site-Specific Conditions – Main Street / Park Street

Advantageous	Not Advantageous
Intersection with relatively balanced traffic volumes. The Park Street approaches carry a large amount of vehicle traffic comparable to the Main Street mainline.	Intersection is adjacent to usable land use areas for area businesses where space for a roundabout may not be accommodated.
Intersection has a high number of left-turn vehicles from multiple approaches.	Intersection with an acute angle. Park Street eastbound approaches the intersection from the northeast immediately prior to the intersection.
Intersection serves as a gateway to the Main Street urbanized area from the south and the Town of Reading.	Intersection is near a sensitive site including wetland areas to the south as part of the Ipswich River.
Intersection where a community enhancement may be desirable.	
Roads with excessive speed problems, where cars routinely exceed the posted or target speed.	

Based upon the above, the intersection of Main Street / Park Street has conditions that are both advantageous and not advantageous for the installation of a roundabout. Therefore, a planning-level sizing and space evaluation was performed.

The Park Street eastbound entry and conflict volumes range from 1,250 vph to 1,700 vph and the Park Street westbound entry and conflict volumes range from 1,400 vph to 1,700 vph. This would suggest two (2) entry legs could be needed on each Park Street approach based on the higher end of the hourly volumes. Although warranted, the space allotted on each Park Street approach is limited between the adjacent properties; however, the existing roadway width may support dual entry lanes in conjunction with takings of surface parking area from these properties. In order to maintain the ability to provide sufficient pedestrian and bicycle accommodations within the cross-sectional limits, the Park Street approaches within this opportunity have been evaluated as two-lane entries.

The Main Street northbound entry and conflict volumes range from 1,300 vph to 1,900 vph and the Main Street southbound entry and conflict volumes range from 1,450 vph to 1,500 vph. This would suggest one (1) entry legs would be needed on each approach with a potential for a

second entry lane along both Main Street northbound and southbound. Space is provided along these approaches to accommodate two entry lanes. Therefore, this opportunity has been evaluated with two entry lanes along each Main Street approach, creating a full multi-lane roundabout.

With a full multi-lane roundabout required, a 165-foot inscribed diameter is necessary to accommodate WB-67 trucks. This diameter would increase based on the incorporation of pedestrian accommodations at the intersection. This roundabout size would directly conflict with the surface parking and on-site circulation for the retail establishments all four intersection corners because of the skewed nature of Park Street entering the intersection from both directions. Specifically, the distance between the back of sidewalks on the northwest and southeast corners is currently only 100 feet.

Further Evaluation of Roundabouts

This preliminary planning analysis has outlined that while roundabouts may have some characteristics that would be advantageous at the intersections, all four intersections have restricted existing available right-of-way. Construction of a roundabout of a size to accommodate the vehicular traffic on Main Street will require impacts to all adjacent property owners. In order to incorporate roundabout intersections at the above four intersection locations along Main Street, a more in-depth geometric analysis will need to be performed to determine the overall property impacts to each surrounding abutter. Further operational analysis of the opportunity to implement roundabout intersections at these four key locations has not been considered as part of this corridor planning study.

Opportunity 3C – Pedestrian Connectivity Improvements

Intermittent sidewalks are present along both sides of Main Street through the Town. Where sidewalk does exist, much of the sidewalk infrastructure is not compliant to the ADA/AAB as to width, cross-slope, or smooth surface. As a result of the 66-foot SHLO along Main Street, the opportunity exists to construct new sidewalks along the absent sections of Main Street and reconstruct existing sidewalks in-place to provide a compliant pedestrian accommodation along both sides of Main Street. This opportunity presents a potential cost savings from a full corridor reconstruction as stormwater infrastructure is present along Main Street's entire length and can be maintained.

Full reconstruction of pedestrian accommodations along Main Street would include:

- Construction of new sidewalks along absent segments for both sides of Main Street within the Town. It is preferable to construct new sidewalks with concrete to provide a visual difference between the sidewalk and roadway surface due to the wide nature of the corridor and a need to visually impair the "runway effect."
- Install 6-inch vertical granite curbing or asphalt curbing (based on preference or funding capabilities) or reset existing granite curbing to provide a 6-inch reveal, to provide vertical separation between vehicular and pedestrian traffic where new sidewalk is to be place or where old curbing is no longer providing vertical separation.
- The placement of new and retention of existing grass panels between the roadway and sidewalk should be evaluated based on other improvement

opportunities in order to provide additional buffer between vehicular and pedestrian traffic as needed.

- Reconstruct all pedestrian curb ramps within the study area as ADA/AAB-compliant ramps with tactile warning devices.
- Where space is allotted based on other improvement opportunities, consider the implementation of streetscape elements to provide a more inviting pedestrian experience, such as:
    - Formal pedestrian-level street lighting
    - Benches
    - Trash receptacles
    - Pedestrian-level wayfinding signage
    - Open pedestrian space for potential future public transportation access.

New sidewalk along Main Street in areas of the corridor where it currently does not exist will result in associated infrastructure improvement or relocation measures. This may include relocation of existing traffic signage that would be situated in the middle of new sidewalk, reconstruction of driveway aprons for the several parcels along main Street, relocation of mailboxes, and other similar work. These measures would be limited to those sections of Main Street that are within the immediate scope of work.

The cross-section of Main Street with these pedestrian connectivity improvements would be the same as the existing condition. The existing ±50-foot curb-to-curb width would not be modified. New Sidewalk would be added to those area where no sidewalks exist but remain within the current 66-foot SHLO. Some locations along the corridor may gain or retain grass panels to provide further separation between the vehicular and pedestrian traffic. A typical cross-section of the corridor is graphically shown in Exhibit 15. A conceptual plan of these pedestrian connectivity improvements, and associated infrastructure improvements, along the Main Street entire corridor are depicted in Appendix J.

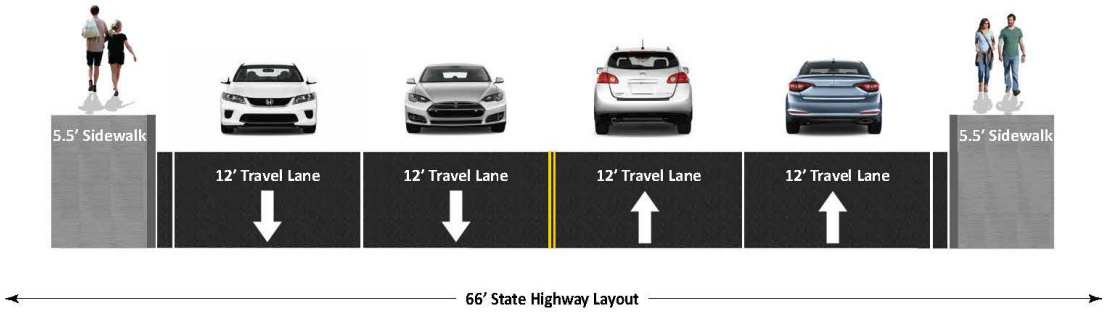


Exhibit 15: Typical Cross-Section of Main Street with Pedestrian Connectivity Improvements

Opportunity 3D – Access Management Improvements

Access management along Main Street is a key issue for both land use density, traffic operations, and overall safety. Both sides of the corridor from Town Line to Town Line consist of a substantial number of curb-cuts to area businesses and residences. Although residential driveways are more difficult to combine or reduce, an opportunity exists to review the number and location of curb-cuts to the commercial and industrial land uses along Main Street. Some key concepts for access management along the corridor include:

- Examine opportunities along the corridor where multiple curb-cuts exist within the same property boundaries to determine if a closure of one or more driveways is reasonable or feasible based on the site layout, proximity to other site driveways, and site traffic and circulation.
- Where possible, examine opportunity to narrow existing curb-cuts or relocate existing curb-cuts along the corridor within property boundaries to provide consistent driveway spacing and consistent driveway widths based on the given land use.
- Work with corridor stakeholders and corridor property owners to combine driveways through multiple properties where feasible. This may necessitate the Town to publish a Town standard for shared access easements in order to minimize hesitation from property owners related to potential future litigation.
- Evaluate the current zoning bylaw for the given zoning districts along Main Street to update the commercial and residential driveway standards in terms of driveway width, curb radii, driveway spacing (both within properties and for adjacent properties), and other key parameters.

Opportunity 3E – Road Diet and Bicycle Cross-Section Improvements

Directly south of North Reading, the Town of Reading has been evaluating transportation options along the Route 28 corridor, which included the implementation of a Road Diet Pilot Project. The goal of this project is to reduce the number of crashes and severity of crashes along this heavily traveled corridor by testing new infrastructure elements to slow down vehicle speeds and simplify left turns. As part of the Road Diet Pilot, pavement markings have been reconfigured within the existing roadway curb-to-curb width to simplify turning movements for vehicles by creating a center two-way left-turn lane. The goal of the project was to reduce parts of North and South Main Street from four (4) lanes to three (3) lanes to improve safety for drivers traveling along the corridor.

Implementation of a similar road diet cross-section along Main Street would include:

- Reduction of travel lanes along Main Street from four-lanes to three lanes; including 11-foot northbound and southbound general-purpose travel lanes and a 12-foot two-way left-turn lane (TWLTL).
- Implement buffered bicycle lanes which would include a 5-foot bicycle lane and a 2-foot striped bicycle buffer zone in both the Main Street northbound and southbound direction.
- Reset the existing curb lines on each edge of Main Street to reduce the curb-to-

curb width and provide for a more expansive pedestrian zone which could include up to a 5-foot sidewalk and 3.5-foot grass panel (4-foot inclusive of vertical granite curbing). The maximum width noted above would define the corridor cross-section to match the existing SHLO ROW of 66-feet.

- Redefine the TWLTL in the proximity of key signalized and unsignalized intersections along the corridor to provide formal exclusive left-turn lanes on the intersection approaches.
- Reconstruct all driveways along the Main Street corridor as necessary with the relocation of the existing curb line. Use this opportunity to provide other access management countermeasures, as necessary.
- Reconstruct all pedestrian curb ramps within the study area as ADA/AAB-compliant ramps with tactile warning devices.
- Where space is allotted based on other improvement opportunities, consider the implementation of streetscape elements to provide a more inviting pedestrian experience, such as:
    - Formal pedestrian-level street lighting
    - Benches
    - Trash receptacles
    - Pedestrian-level wayfinding signage
    - Open pedestrian space for potential future public transportation access.
- The realignment of the curb lines, sidewalks, ramps, and travel lane would necessitate partial to full reconstruction for each of the traffic signals along the corridor based on the need for certain traffic signal components to be utilized by pedestrians, bicyclists, and vehicular traffic.

The cross-section of Main Street with road diet improvements would reduce the cross-section by 2-feet to 48-foot curb-to-curb. With the presence of the 66-foot SHLO, the overall back of sidewalk to back of sidewalk cross-section could be extended out to the SHLO pending width of sidewalk and associated grass panel. A typical cross-section of the corridor is graphically shown in Exhibit 16. A conceptual plan of these road diet improvements along the Main Street entire corridor are depicted in Appendix K.

Exhibit 16: Typical Cross-Section of Main Street with Road Diet Improvements

Consideration of a Shared Use Path

Shared use paths are off-road transportation infrastructure that is physically separated from motorized vehicle traffic and designed for use by users of all ages and abilities. One particular type of shared use path is a "sidepath," which are shared use paths that run adjacent to roadway. They supplement the established roadway to provide a safe and separated facility. Along a corridor such as Main Street, a shared use path would consist of an area that could be utilized by both pedestrians and bicycles while still providing direct access to the area businesses and residences.

Bicycle treatments and travel would be an essential aspect of any Main Street improvement project, especially a project utilizing state or federal funding for construction. A shared use path would typically be designed as 10-feet in width, 8-foot minimum, in order to support pedestrian flow and bidirectional bicycle flow. This treatment would allow for bicycle traffic specifically to remain out of the curb-to-curb cross-section of the principal arterial corridor. The cross-section and land use along Main Street would necessitate a 10-foot-wide shared use path along a minimum of one side of the corridor.

Under Existing Cross-Section

Under existing conditions, Main Street is generally 50-feet wide curb-to-curb centered on a 66-foot SHLO. Outside of each curb line is approximately 7-feet of space to utilize for other corridor treatments. Currently, the exiting sidewalk network exhausts much of that space. The implementation of a 10-foot-wide shared use path on each side of the Main Street corridor would require a SHLO alteration to expand the footprint of the ROW. To remain in the existing ROW and avoid an SHLO alteration, a shared use path could only be installed on one side of Main Street in conjunction with the relocation of an existing curb line and concurrently the centerline of the corridor.

Should a shared use path be implemented on one or both sides of Main Street through the corridor, there would be significant impacts to neighboring businesses and residents including driveway location, surface parking conditions, and on-site circulation.

Under Opportunity 3E Road Diet

With the implementation of a road diet as defined within Opportunity 3E, a shared use path could be implemented in place of the aforementioned on-street buffered bicycle lanes. The opportunity exists under these conditions to further narrow the corridor by relocating the curb lines and providing a wider section of shared use path in place of traditional sidewalks. Based on the cross-sectional dimensions identified for the road diet, up to 12-foot shared use paths could be provided on both sides of Main Street through the corridor while remaining in the current SHLO.

VIII. TRAFFIC IMPACT ANALYSIS

Measuring existing and future traffic volumes quantifies traffic flow within the study area. To assess quality of flow, roadway capacity and vehicle queue analyses were conducted under the following conditions:

- Base Year Conditions
- 2032 Future Year Conditions – No Build
- 2032 Future Year Conditions - Optimized Traffic Signal (Opportunity 2B)
- 2032 Future Year Conditions – Roundabouts at Key Locations (Opportunity 3B)
- 2032 Future Year Conditions – Road Diet (Opportunity 3E)

Capacity analyses provide an indication of how well the roadway facilities serve the traffic demands placed upon them, with vehicle queue analyses providing a secondary measure of the operational characteristics of an intersection or section of roadway under study. Synchro 11™ software was used to perform the analysis.

METHODOLOGY

The signalized intersection capacity and queue analysis was conducted using methodology from the *Highway Capacity Manual (HCM) 2000* due to the restrictions posed on signalized intersection analysis using more recent *HCM 6th Edition*. This includes the inability of *HCM 6th Edition* to correctly analyze non-standard-NEMA phasing, custom turn-types, and exclusive pedestrian phases which are present at the various study area intersections. To remain consistent throughout the study, all signalized intersection capacity and queue analyses were therefore conducted using *HCM 2000* methodology.

MassDOT has recognized the significant errors and deficiencies in the *HCM 6th Edition* methodology and traffic impact software such as Synchro 11 ™ when attempting to analyze traffic signals. Based on conversations with the MassDOT – Highway Division's Traffic Section, alternate methodologies to analyze capacity, delays, and queues can be conducted as long as the models are properly calibrated, and the methodology is present on MassDOT's *A Guide to Traffic Analysis Tools*[8] document.

[8] *A Guide on Traffic Analysis Tools*; Massachusetts Department of Transportation – Highway Division; Boston, MA; Revised October 5, 2012.

Levels of Service

A primary result of capacity analyses is the assignment of level of service to traffic facilities under various traffic flow conditions.[9] The concept of level of service is defined as a qualitative measure describing operational conditions within a traffic stream and their perception by motorists and/or passengers. A level of service definition provides an index to quality of traffic flow in terms of such factors as speed, travel time, freedom to maneuver, traffic interruptions, comfort, convenience, and safety.

Six levels of service are defined for each type of facility. They are given letter designations from A to F, with level of service (LOS) A representing the best operating conditions and LOS F representing the worst.

Since the level of service of a traffic facility is a function of the traffic flows placed upon it, such a facility may operate at a wide range of levels of service, depending on the time of day, day of week, or period of year.

Queue Length Analysis

Vehicle queue analyses are a direct measurement of an intersections ability to process vehicles under various traffic control and volume scenarios and lane use arrangements.

The vehicle queue analysis was performed using the Synchro 11™ intersection capacity analysis software which is also based upon the methodology and procedures presented in the *HCM 2000*. Synchro reports the 95th percentile queues for unsignalized intersections and both the 50th (average) and 95th percentile vehicle queues for signalized intersections, which are based on the number of vehicles that experience a delay of six seconds or more at an intersection and is a function of the traffic signal timing; vehicle arrival patterns during the analysis period; and the saturation flow rate. The 50th percentile or average vehicle queue is the average number of vehicles that are projected to be delayed by six seconds or more at the intersection under study during the analysis period. The 95th percentile vehicle queue is the vehicle queue length that will be exceeded only five percent of the time; or approximately three minutes out of 60 minutes during the peak one hour of the day. During the remaining 57 minutes, the vehicle queue length will be less than the 95th percentile queue length.

PARAMETERS FOR TRAFFIC IMPACT ANALYSIS

Signalized Intersections

LOS for signalized intersections is calculated using the operational analysis methodology of the *HCM 2000*. This method assesses the effects of signal type, timing, phasing, progression; vehicle mix; and geometrics on delay. LOS designations are based on the criterion of control or signal delay per vehicle. Control or signal delay can be related to driver discomfort, frustration,

[9] The capacity analysis methodology is based on the concepts and procedures presented in the *Highway Capacity Manual 6th Edition*; Transportation Research Board; Washington, DC; 2017

and fuel consumption, and includes initial deceleration delay approaching the traffic signal, queue move-up time, stopped delay and final acceleration delay.

Table 13 summarizes the relationship between LOS and control delay. The tabulated control delay criterion may be applied in assigning LOS designations to individual lane groups, to individual intersection approaches, or to entire intersections.

Table 13 – Level of Service Criteria for Signalized Intersections[(a)]

Level of Service V/C ≤ 1.00	Level of Service V/C > 1.00	Average Control Delay (s/veh)	Description
A	F	≤10.0	LOS A describes operations with very low control delay; most vehicles do not stop at all.
B	F	10.1 to 20.0	LOS B describes operations with relatively low control delay. However, more vehicles stop than LOS A.
C	F	20.1 to 35.0	LOS C describes operations with higher control delays. Individual cycle failures may begin to appear. The number of vehicles stopping is significant at this level, although many still pass through the intersection without stopping.
D	F	35.1 to 55.0	LOS D describes operations with control delay in the range where the influence of congestion becomes more noticeable. Many vehicles stop and individual cycle failures are noticeable, whereby motorists are not able to get through the signal on one cycle.
E	F	55.1 to 80.0	LOS E describes operations with high control delay values. Individual cycle failures are frequent occurrences.
F	F	>80.0	LOS F describes operations with high control delay values that often occur with over-saturation. Poor progression and long cycle lengths may also be major contributing causes to such delay levels.

[a] Source: *Highway Capacity Manual 2000*; Transportation Research Board; Washington D.C.; 2000

As prescribed by the *MassDOT – Highway Division Traffic and Safety Engineering 25% Design Submission Guidelines*[10], a roundabout was considered to address the operational and safety control of traffic at the intersection of Lowell Road / Haverhill Street / North Main Street / Poor Street and Lowell Road / Shawsheen Road / Beacon Street / Reservation Road. Information provided in the *National Cooperative Highway Research Program (NCHRP) Report 672 (Roundabouts: An Informational Guide)*[11] and the MassDOT *Guidelines for the Planning and Design of Roundabouts*[12] was utilized in this evaluation. The MassDOT *Guidelines* provides planning-level comparisons of different types of roundabouts (mini to multilane) and the corresponding best-fit roadway characteristics.

The following details an evaluation of the installation of a roundabout at each intersection as compared to the proposed traffic signal modifications.

[10] *Traffic and Safety Engineering 25% Design Submission Guidelines*; Massachusetts Department of Transportation – Highway Division; Boston, Massachusetts; Revised February 15, 2011, page 6 of 9
[11] *NCHRP Report 672 - Roundabouts: An Informational Guide, 2nd Edition*; National Cooperative Highway Research Program – Transportation Research Board; Washington, D.C.; 2010
[12] *Guidelines for the Planning and Design of Roundabouts*; MassDOT; Boston, MA; September 2020

TRAFFIC IMPACT ANALYSIS RESULTS

The results of the intersection capacity and queue analyses are summarized in Figures 6, 7, and 8 for the weekday morning, weekday evening, and Saturday midday peak hours, respectively. Detailed lane group by lane group capacity analysis tables and capacity analysis worksheets are provided in Appendix L.

Main Street / Burroughs Road / Stop & Shop Driveway

All movements at the intersection of Main Street / Burroughs Road / Stop & Shop Driveway are anticipated to operate at acceptable levels of service (LOS D or better) during the weekday morning, weekday evening, and Saturday midday peak periods under 2032 Future Year – No Build Conditions. In addition, the volume-to-capacity (V/C) ratio along each approach is expected to be well below 1.00, indicating there is adequate capacity to accommodate the future traffic volumes.

With the implementation of traffic signal timing optimization and reestablishing the corridor coordination, the intersection will continue to operate at acceptable levels of service (LOS D or better). Some individual lane group movements would be anticipated to slightly increase in delay and queue with this improvement; however, the increase is generally related to the effect of platooning vehicles along Main Street as resulting from coordination between other intersections.

With the implementation of the road diet related improvements along Main Street, the Stop & Shop Driveway approach would be expected to see an increase in delay as a result of increased demand for green time along Main Street. With the same number of vehicles accommodated within one lane in each direction, the green time along Main Street is less likely to “gap out.” During the weekday evening and Saturday midday peak periods, the Stop & Shop Driveway approach would be expected to operate at an elevated LOS E. All other lane group movements would continue to operate at acceptable levels of service (LOS D or better).

Main Street / North Street

All movements under 2032 Future Year – No Build Conditions at the intersection of Main Street / North Street are anticipated to operate at acceptable levels of service (LOS D or better) during each peak time period with the exception of the North Street eastbound left-turn during the weekday evening peak period, which is expected to operate at an elevated LOS E. The V/C ratio along each approach is expected to be well below 1.00 with exception to Main Street northbound during the weekday evening peak period. During this time period the V/C ratio is expected to be at or near 1.00, indicating that the approach will be at capacity.

Queues within the North Street eastbound and westbound left-turn lanes are expected to exceed the current storage and/or are anticipated to be blocked from entering the auxiliary turn lane by extended queues within the adjacent shared through / right-turn lanes. Auxiliary turn lanes are present along the Main Street mainline approaches, each with 200-feet of storage. It is expected that the future queues will be able to sufficiently stack within the storage length provided in each left-turn lane; however, the level of traffic within the adjacent through lane may block the turn lane along the northbound approach during the weekday evening peak hour and

along both the northbound and southbound approaches during the Saturday midday peak hours.

With the implementation of traffic signal timing optimization and reestablishing the corridor coordination, all movements, including the eastbound left-turn, would be expected to operate at acceptable levels of service (LOS D or better). Some individual lane group movements would be anticipated to slightly increase in delay and queue with this improvement; however, the increase is generally related to the effect of platooning vehicles along Main Street as resulting from coordination between other intersections.

With the implementation of the road diet related improvements along Main Street, several lane group movements at the intersection would be anticipated to experience degraded operations (LOS F) with V/C ratios in excess of 1.00. This includes the Main Street southbound through movement during the weekday morning and Saturday midday peak periods and both the Main Street northbound and southbound through movements during the weekday evening peak period. In addition, the overall intersection would be anticipated to operate at LOS F during both the weekday evening and Saturday midday peak periods with the weekday morning peak period slightly below the threshold for LOS F.

Main Street / Lowell Road / Nick O'Brian's Service Driveway

The Main Street northbound approach at the intersection of Main Street / Lowell Road / Nick O'Brian's Service Driveway operates with acceptable levels of service (LOS D or better) during the weekday morning, weekday evening, and Saturday midday peak periods under 2032 Future Year – No Build Conditions; however, the V/C ratio for this approach is at or above 1.00 during these time periods. This is caused by the elevated left-turning volume where the inside shared left-turn/through travel lane operates as a "de facto" left-turn lane. For the purpose of the analyses, the lane designations were modified to evaluate this inside travel lane as an exclusive left-turn lane.

Queues along the Main Street northbound approach during the weekday evening peak period are expected to be approximately 655-feet, which is only slightly less than the storage provided between the signalized intersections of Lowell Road and Winter Street. The width of the Lowell Road eastbound approach does allow for vehicles to stack in two travel lanes. The queue present along this approach is expected to slightly extend past the by-passing storage area by approximately one (1) to two (2) vehicles depending on the time of day or by the positioning of how the vehicles stack.

With the implementation of traffic signal timing optimization and reestablishing the corridor coordination, the intersection will continue to operate at acceptable levels of service (LOS D or better). Some individual lane group movements would be anticipated to slightly increase in delay and queue with this improvement; however, the increase is generally related to the effect of platooning vehicles along Main Street as resulting from coordination between other intersections.

With the implementation of the road diet related improvements along Main Street, the Lowell Street eastbound approach and the Main Street southbound approach would be expected to see an increase in delay as a result of increase demand for green time along Main Street. With the same number of vehicles accommodated within one lane in each direction, the green time

along Main Street is less likely to "gap out." During the Saturday midday peak periods, both the Lowell Street and Main Street southbound approaches are expected to operate at a degraded LOS F. All other lane group movements and all other time periods would continue to operate at acceptable levels of service (LOS D or better).

Main Street / Winter Street / Reading Lumber Driveway

Several movements at the intersection of Main Street / Winter Street / Reading Lumber Driveway are anticipated to operate at elevated or degraded levels of service (LOS E or F) under 2032 Future Year – No Build Conditions. Depending on the time period, this challenge to traffic operations occurs on different movements; however, the Main Street southbound left-turn experiences this elevated or degraded level of service during all major peak periods. Overall, the intersection is anticipated to operate at LOS E during the weekday evening peak period and LOS F during the Saturday midday peak period. Queues along the Main Street southbound approach during the weekday evening and Saturday midday peak periods are expected to by approximately 400-feet with the Main Street southbound through movement approaching 750-feet during the Saturday midday peak period.

With the implementation of traffic signal timing optimization and reestablishing the corridor coordination, the intersection will continue to operate at acceptable levels of service (LOS D or better). Some individual lane group movements would be anticipated to slightly increase in delay and queue with this improvement; however, the increase is generally related to the effect of platooning vehicles along Main Street as resulting from coordination between other intersections.

With the implementation of the road diet related improvements along Main Street, both the Main Street northbound through and southbound left-turn movements would be expected to see degraded levels of service (LOS F). Winter Street is also anticipated to experience LOS F during the Saturday midday peak period. The V/C ratios for the overall intersection would increase to greater than 1.00 in both the weekday evening and Saturday midday time periods indicating the intersections would be in excess of capacity during peak periods of the typical day.

Main Street / Ocean State Job Lot Driveway

As a result of the limited use nature of the Ocean State Job Lot Driveway, all lane group movements at the intersection are anticipated to operate at acceptable levels of service (LOS D or better) for each time period and each opportunity scenario. The overall operations at the intersection may change based on the land usage of the retail space and whether any future redevelopment scenario is moved forward on the parcel of land. Prior to Ocean State Job Lot, Stop & Shop had occupied the retail space. It is projected that operations at the intersection were significantly more challenging with the previous high-intensity supermarket land use. Further evaluation of the intersection of Main Street / Ocean State Job Lot Driveway will be needed prior to the scope of any major improvements at the intersection.

Main Street / North Reading Plaza Driveway

All movements at the intersection of Main Street / North Reading Plaza Driveway are anticipated to operate at acceptable levels of service (LOS D or better) during the weekday morning,

weekday evening, and Saturday midday peak periods under 2032 Future Year – No Build Conditions. In addition, the volume-to-capacity (V/C) ratio along each approach is expected to be well below 1.00, indicating there is adequate capacity to accommodate the projected traffic volumes. The 95th percentile queues along the North Reading Plaza Driveway westbound approach are anticipated to extend up to seven (7) vehicles during the weekday evening peak hour and eleven (11) vehicles during the Saturday midday peak hour. Each of these queue lengths extend past the first major drive aisle of the parking lot.

With the implementation of traffic signal timing optimization and reestablishing the corridor coordination, the intersection will continue to operate at acceptable levels of service (LOS D or better). Some individual lane group movements would be anticipated to slightly increase in delay and queue with this improvement; however, the increase is generally related to the effect of platooning vehicles along Main Street as resulting from coordination between other intersections. Overall optimization changes in signal timing are not anticipated to affect the queueing along the North Reading Plaza Driveway.

With the implementation of the road diet related improvements along Main Street, all movements at the intersection of Main Street / North Reading Plaza Driveway would be anticipated to operate at acceptable levels of service (LOS D or better). The most noticeable feature, similar to other locations along the corridor, is an extension of queue length along Main Street.

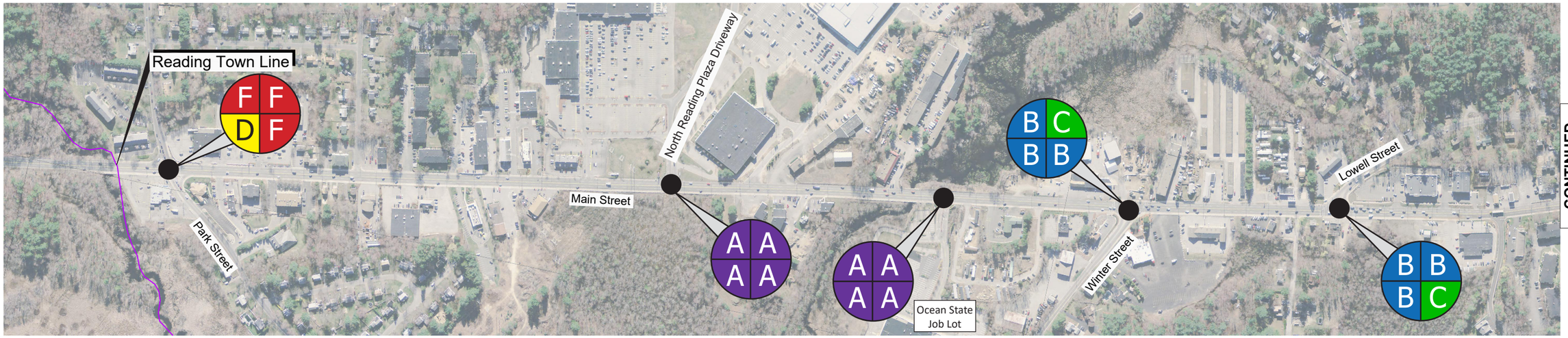
Main Street / Park Street

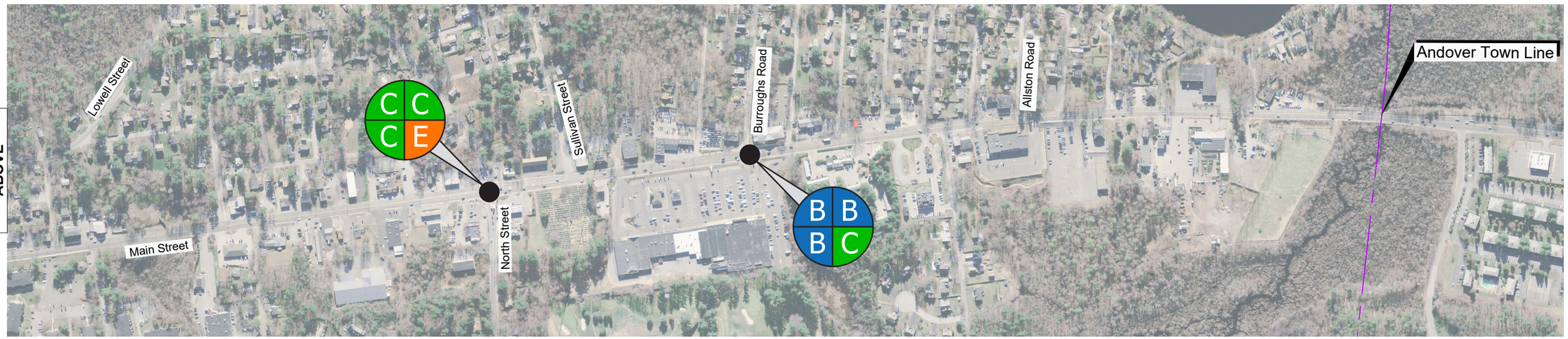
Several movements at the intersection of Main Street / Park Street are anticipated to operate at elevated or degraded levels of service (LOS E or F) during each time peak time period under 2032 Future Year – No Build Conditions. The degraded LOS is experienced on each approach, including when V/C ratios are well in excess of 1.00. Specifically, the Main Street southbound approach experiences a delay per vehicle in excess of 200 seconds during each of the three peak periods. Queues along the Park Street eastbound are anticipated to extend past the available storage during each peak period as well. Queues along all intersection approaches are expected to be long; specifically, the 95th percentile queues along Main Street are expected to be in excess of 1,000-feet in both directions during the weekday evening and Saturday midday peak periods.

With the implementation of traffic signal timing optimization and reestablishing the corridor coordination, movements at the intersection during the weekday morning and weekday evening peak periods will continue to operate at elevated or degraded levels of service; however overall operations are expected to improve proportionally. During the weekday morning peak hour, timing adjustments result in a significant improvement to operations along Main Street southbound. Upon evaluating opportunities to optimize signal timings at the intersection during the Saturday midday peak period, no optimization scheme within the existing geometry is anticipated to alter the degraded operations of the intersection.

With the implementation of the road diet related improvements along Main Street, nearly all movements at the intersection still experience elevated or degraded levels or service (LOS E or F). Overall, a slight decrease in control delay per vehicle would be experienced during the weekday morning and weekday evening peak periods while the Saturday midday peak period would be expected to see worsening conditions with the road diet in place.

North 1"=500'





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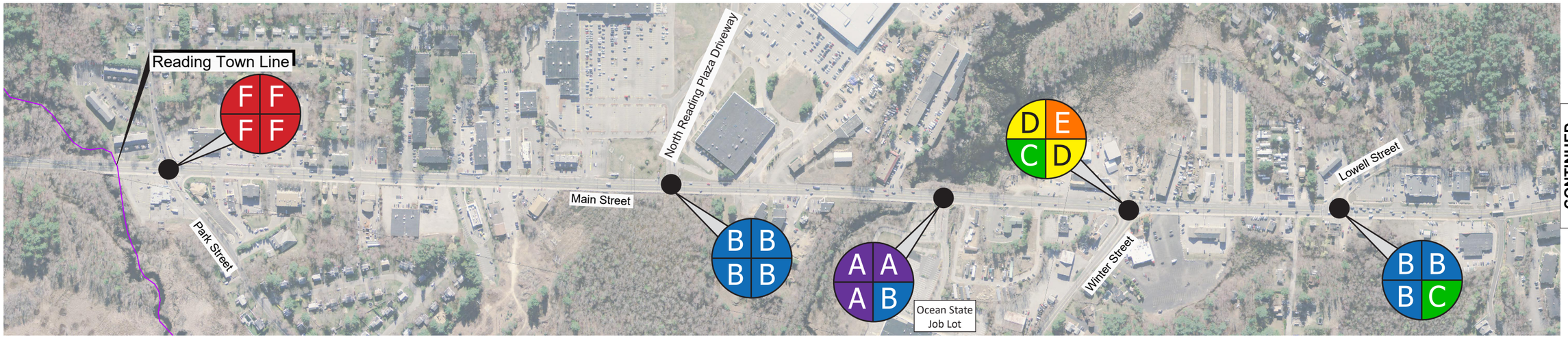
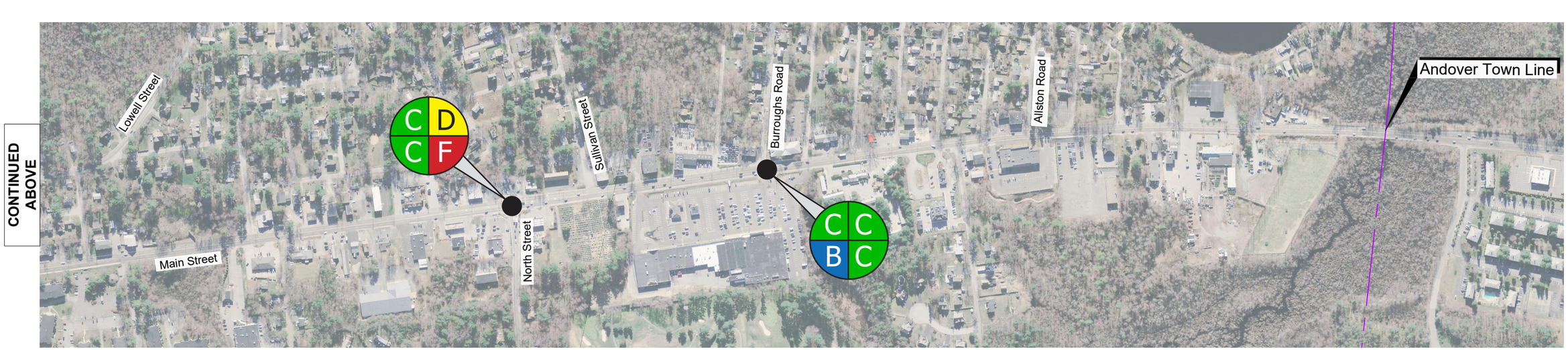
Level of Service Legend =

Figure 6

Weekday Morning Peak Hour
Level of Service
Main Street Intersections





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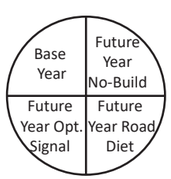
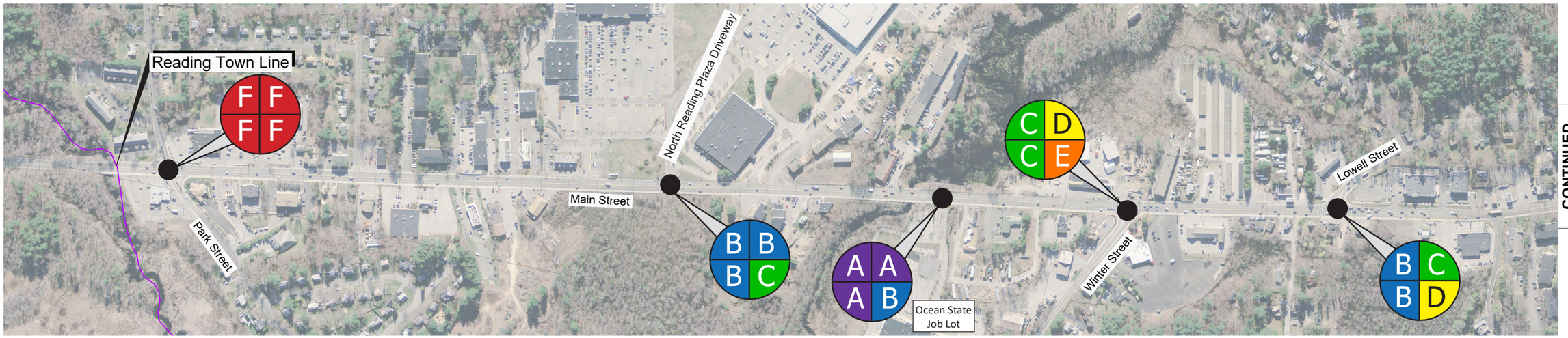
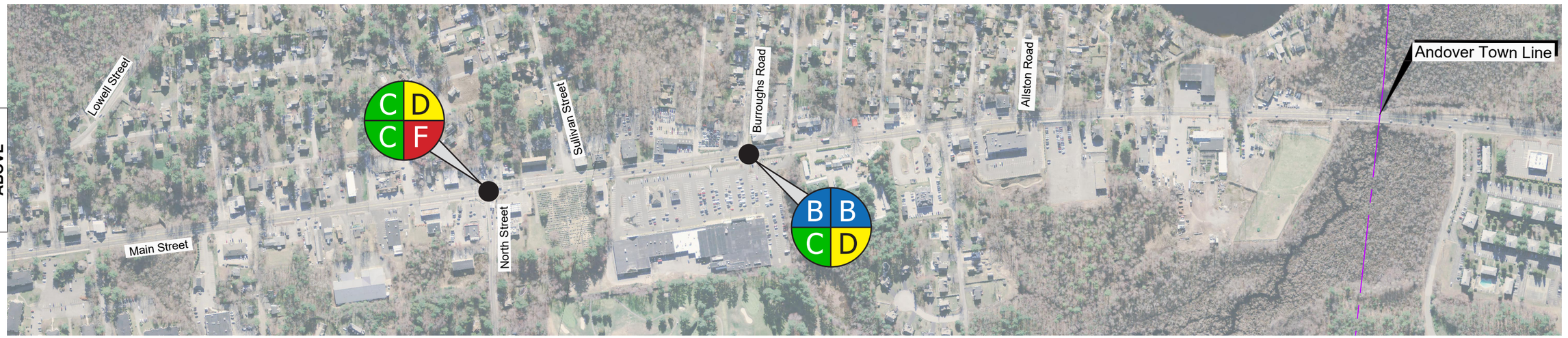


Figure 7

Weekday Evening Peak Hour
Level of Service
Main Street Intersections

North 1"=500'





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Level of Service Legend =

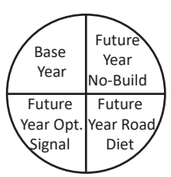

Figure 8

Saturday Midday Peak Hour
Level of Service
Main Street Intersections

IX. RECOMMENDATIONS

This Corridor Planning Study provides a vision for the transportation infrastructure needs of the Main Street (Route 28) corridor within North Reading and presents a series of improvement opportunities that would allow the corridor to operate safely and efficiently for vehicles, bicyclists, pedestrians. This chapter details the recommendations for the Main Street corridor and the implementation plan for short-term, mid-term, and long-term opportunities. As detailed in previous chapters, these opportunities were developed through several analyses, including the review of existing conditions, input from citizens / stakeholders, a comprehensive analysis of potential vehicular traffic operational and safety impacts, review of effects on right-of-way and the SHLO, and the general scope of the project's purpose and need.

The overall needs of the corridor include the replacement of aging traffic signal infrastructure, operational improvements to reduce vehicular delays and queue lengths, accommodations for persons with disabilities, and provision of multi-modal infrastructure for pedestrians and bicyclists. The final recommendations for Main Street meet those needs while adhering to the goals of both the Town and the Commonwealth. The recommendations for Main Street are divided into recommendations for the short-term, mid-term, and long-term. The corridor's full transportation system, to be comprised of multiple elements including safety enhancements, roadway capacity, and streetscapes was developed as part of the final recommendations.

SHORT-TERM RECOMMENDATIONS

The recommended short-term improvements would immediately enhance traffic operations and safety for all users, including pedestrians and bicyclists, along Main Street with a high benefit-to-cost ratio. Many of the short-term improvements should be undertaken by MassDOT as part of their general maintenance of the Main Street corridor. Alternatively, these short-term improvements could be considered and implemented as soon as resources are available from the Town's highway maintenance budget and/or Chapter 90 funding. The following summarizes the short-term improvements identified for the corridor and the key intersections.

Maintenance Discussions with MassDOT

Some improvement opportunities identified can be completed within the general maintenance jurisdiction of Main Street by MassDOT. This includes those improvements listed under Opportunity 2A pertaining to general maintenance of Main Street such as pavement restoration, pavement marking reapplication, inventorying and updating traffic signage, and stormwater infrastructure cleaning. The Town could compile a detailed outline of the short-term improvement measures from specific locations along the corridor and submit the request for maintenance to the MassDOT District 4 office.

Opportunity 2B - Traffic Signal Optimization and Retrofit Improvements

Improvements to the traffic signal equipment, which may include minimal traffic signal timing and/or coordination maintenance level optimization, are normally exempt from the need to prepare and submit a Design Justification Workbook or meeting certain Federal Highway Administration (FHWA) controlling criteria requirements. The traffic signal optimization and retrofit improvements are a good candidate to explore municipal level funding to provide focused improvements at each of the seven (7) signalized intersections. Additional modest upgrades to the traffic signal infrastructure such as implementation of video detection, may also be beneficial to add to Opportunity 2B as part of a MassDOT Permit to Access State Highway.

Permit to Access State Highway Level Improvements

Utilizing the MassDOT Permit to Access State Highway process, opportunities identified in Chapter VII – "Identification of Corridor Opportunities" can be implemented through a MassDOT design review outside of the state/federal funding process. Since the permit process does not use state or federal funding sources, municipal funding sources such as the Town's highway maintenance budget and Chapter 90 funding may be utilized. Specifically, many of the items outlined in Opportunity 2B and Opportunity 3A related to the retrofit or reconstruction of the seven (7) key signalized intersections along the corridor could be completed as part of a Permit to Access State Highway design process. Road Safety Audits would need to be prepared for any high crash location prior to undertaking a Permit to Access State Highway design process.

Road Safety Audits (RSA)

Any infrastructure improvements, except for general maintenance, along SHLO at a location that is defined as HSIP-eligible will require the completion of an RSA prior to submission of the project's 25% Design. Based on the published MassDOT IMPACT database, the intersection of Main Street / Winter Street is designated as a 2017-2019 HSIP Crash Cluster (current year of eligibility). The crash data also indicates that the intersections of Main Street / Park Street and Main Street / North Street may in fact be HSIP-eligible in the current year of eligibility based on the data presented in the MassDOT IMPACT database. Further evaluation of individual crash reports for each of these intersections will be needed to determine if the HSIP-eligibility thresholds are met and whether an RSA may need to be conducted in advance of any design project along the corridor.

MID-TERM RECOMMENDATIONS

The recommended mid-term improvements would further enhance traffic operations and safety for all users, including pedestrians and bicyclists, along Main Street. Based on the level of funding that may be necessary to complete mid-term improvements, these potential projects should be undertaken in coordination with MassDOT as part of the State Transportation Improvement Program (STIP or TIP). As part of the TIP program, any traffic signal reconstruction project will require full pedestrian and bicycle infrastructure through the project limits. The following summarizes the mid-term improvements identified for the corridor and the several key intersections.

Opportunity 3A - Traffic Signal Reconstruction Improvements

Retrofitting the existing traffic signal infrastructure at one or more of the traffic signal locations along Main Street can be completed under the MassDOT Permit to Access State Highway design process. However, the level of capital cost that would be associated with a full traffic signal reconstruction may be too high to be undertaken by the Town of North Reading directly and may be more appropriate for placement within the State TIP program. The high crash nature of multiple intersections along the corridor also opens the opportunity for the Town and State to utilize HSIP funding as part of the TIP program.

Should the Town choose to use utilize state or federal funding sources due to the higher capital costs of traffic signal infrastructure, the scope of work along Main Street may need to be limited to traffic signal infrastructure only. As part of the TIP program, any project traffic signal reconstruction project that seeks to go beyond a limited traffic signal scope of work (or "isolated intersection improvement") will be subject to preparation of a Design Justification Workbook and/or meeting certain FHWA controlling criteria requirements. This includes providing both pedestrian and bicycle infrastructure on each side of Main Street and the intersecting side streets through the project limits. The Town should evaluate the level of improvements that may be necessary beyond traffic signal infrastructure should the mid-term goal be to not construct full pedestrian and bicycle infrastructure throughout the corridor at the time of application.

HSIP Funding

With the designation of an HSIP-eligible intersection, HSIP funding through the FHWA can be sought to assist in the reconstruction of infrastructure in the name of improving safety for all users at each intersection or along a select portion of roadway within the bounds of the HSIP-eligible area. HSIP funding is allocated under MassDOT's direction through adherence to HSIP Guidelines Committee. Similar to the Permit to Access State Highway design process, Road Safety Audits will need to be completed at any HSIP-eligible location to receive HSIP funding through the TIP.

Opportunity 3C - Pedestrian Connectivity Improvements

MassDOT is currently operating a project that looks at minor upgrades or minor new construction of pedestrian and bicycle accommodations across the state. The project, which provides for state/federal funding, is listed as MassDOT Project File No. 609524 – "Pedestrian and Bicycle Improvements at Various Locations." The purpose of the project is to complete lower-level infrastructure improvements within SHLO that assist a community with deficiencies in the pedestrian, bicycle, and public transportation network. As each project has limited scope, certain FHWA controlling criteria are not subject to be completed within the limit of work based on the project's designation.

TEC recommends that the Town coordinate with the MassDOT District 4 office on the planning for this project and the potential to use the limited scope to complete the gaps in the Main Street sidewalk network identified in Opportunity 3C. This will allow for the sidewalk network throughout the North Reading portion of Route 28 to be completed utilizing state/federal funding, where municipal funding could be utilized elsewhere on the corridor. Although the timeframe of this MassDOT project as currently situated is limited, any extension of the project's

timeframe or reconstitution of the project under a new MassDOT contract could be employed by the Town.

LONG-TERM RECOMMENDATIONS

The recommended long-term improvements are desirable to provide enhanced traffic operations and safety for all users, including pedestrians and bicyclists, along the Main Street corridor. The long-term improvement opportunities identified for recommendation can be completed through direct coordination with MassDOT as part of the state TIP. Any access management improvements would require coordination with the abutters along Main Street.

Combination: Opportunity 3A - Traffic Signal Reconstruction Improvements and Opportunity 3C - Pedestrian Connectivity Improvements

Alternative to completing the traffic signal reconstruction on a single-intersection basis, a full corridor length project seeking state TIP funding could be considered. The length of Main Street in North Reading and the number of signals would likely require the TIP funding be requested in phases, such as Lowell Road to the Andover Town Line and Winter Street to the Reading Town Line. A full corridor project seeking state TIP funding would be tied to completion of pedestrian and bicycle accommodations required by MassDOT's Healthy Transportation Policy along both sides of Main Street, including a buffered 10-foot shared use path or side path in each direction of travel. Maintaining the existing vehicular cross-section while providing the required space for both pedestrian and bicycle accommodations would result in a full cross-section of 75-feet in width, requiring 4-5 feet of right-of-way beyond the limits of the existing 66-foot SHLO and force the modification and acquisition to portions of private commercial and residential properties along the Main Street corridor. The timeline for design, permitting and construction of this level of corridor project is years longer than for isolated intersection reconstruction.

Opportunity 3D – Access Management Improvements

To address overall safety and congestion along the corridor, thoughtful consideration should be given to an Access Management Plan between the Town of North Reading and MassDOT. Both sides of the corridor from Town Line to Town Line consist of a substantial number of curb-cuts to area businesses and residences. Although residential driveways are more difficult to combine or reduce, an opportunity exists to review the number and location of curb-cuts to the commercial and industrial land uses along Main Street.

Modifications to driveways which directly access MassDOT's SHLO will require a Permit to Access State Highway. The Town should coordinate with MassDOT on these permit modifications and/or repairs. MassDOT has a standard process for commercial, mixed-use, and residential driveway permits that can be classified in several ways. Coordination with MassDOT and the District 4 office on the permit classification will be key as the intent of such work is to improve access management along the corridor for 'existing' uses with potential circulation and parking changes on-site but without other major site plan and building alterations.

Opportunity 3E – Road Diet and Bicycle Cross-Section Improvements

The capacity and queue analysis conducted along Main Street under the 2032 Future Year Condition with a Road Diet indicate that the operations and potential queueing resulting from the

road diet cross-section would be negatively impacted. While the Road Diet Pilot project appears to be a sufficient improvement in the Town of Reading, the nature of Route 28 within Reading as opposed to the commercial nature and zoning along Main Street in North Reading does not provide for a direct comparison of the expected future operations. Main Street within North Reading provides multiple direct connections from Interstate 93 to points east that cross Main Street. Although the Town of Reading provides one such connection (Route 129), this connection occurs within Reading Center, which is not subject to the Road Diet Pilot that was completed. Three Interstate 93 connector roadways; including Park Street, Lowell / Winter Street, North Street result in side-street traffic with elevated traffic volumes in North Reading as compared to similar side-streets in Reading.

Based on the level of traffic operation impact to multiple intersections and specific turning movements at the intersections along the corridor, TEC does not provide an affirmative recommendation to complete road diet improvements along the Main Street corridor. The limited 66-foot SHLO and the need to maintain multiple lanes for vehicular traffic in each direction to facilitate operations inhibits the ability to provide sufficient pedestrian and bicycle accommodations in both directions of travel along Main Street without substantial right-of-way acquisition and impacts to adjacent property parking and circulation.