
**Safety Improvements at Route 1, Central and Glenn Streets
Rowley, Massachusetts**

Project File No. 609392

Alternatives Analysis Memorandum

Prepared for:



**Massachusetts Department of Transportation
Highway Division**

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1. Introduction

The intersection of Route 1 (Newburyport Turnpike) with Central Street and Glen Street, in the Town of Rowley, was selected by MassDOT to be evaluated for safety and operational deficiencies. The goal of the “Safety Improvements at Route 1, Central and Glen Streets” project is to add additional traffic control to the existing two-way stop intersection for improved safety and operations. The intersection is not classified as a Highway Safety Improvement Program (HSIP) cluster; however, the crash rate is higher than district and statewide averages. In addition, one fatality occurred in June of 2018, which is not reflected in the current MassDOT HSIP classification that incorporates crash data through December 2017.

The purpose of this memo is to summarize the existing operational and safety conditions, evaluate intersection improvement alternatives, and summarize the alternatives to determine which alternative to advance to design and construction.

2. Existing Conditions

2.1 Roadway Characteristics

The project area includes the intersection of Route 1 (Newbury Turnpike) at Central Street and Glen Street, which is a 4-way, unsignalized intersection in Rowley, Massachusetts. Central Street and Glen Street are under stop control, while Route 1 is under free operation. Route 1 is classified as a major arterial that runs north/south and is under MassDOT jurisdiction. Central Street and Glen Street are urban minor arterials that run generally east to west and are under local jurisdiction. Central Street and Glen Street intersect Route 1 at an angle of 65 degrees. Route 1 has a single travel lane and a left turn lane in both directions at the intersection, with approximate lane and shoulder widths of 12 feet and 5 feet, respectively. Central Street is a single lane approach with approximate lane and shoulder widths of 12 feet and 2 feet, respectively. Glen Street is a single lane approach with approximate lane widths of 10 feet and no shoulders. There is no median or sidewalk within the project limits. Glen Street provides connections to Route 1A and I-95. Central Street provides connections to Rowley town center. Central Street and Glen Street are abutted by residences, while Route 1 is mixed-use including residential, commercial, and wooded/undeveloped parcels.

The posted speed limit on Central Street is 35 MPH near the intersection with Route 1. Posted speed limits on Route 1 in the project area are 45 MPH, which increases to 50 MPH approximately 700 feet to the south of the intersection. Speed limit signs are consistent with the speed regulations for Route 1. 85th percentile speed on Route 1 are between 50 and 55 MPH within the study area.

Sight distance constraints exist at the intersection corners, making turning movements more difficult. The northwest corner of the intersection has a raised berm that obstructs the views of Route 1 southbound traffic from Glen Street. The northeast corner has trees and brush blocking views of Route 1 southbound traffic from Central Street. The southeast corner has a retaining wall blocking views of Route 1 northbound traffic from Central Street.

Figure 1 shows a Locus map of the project area.

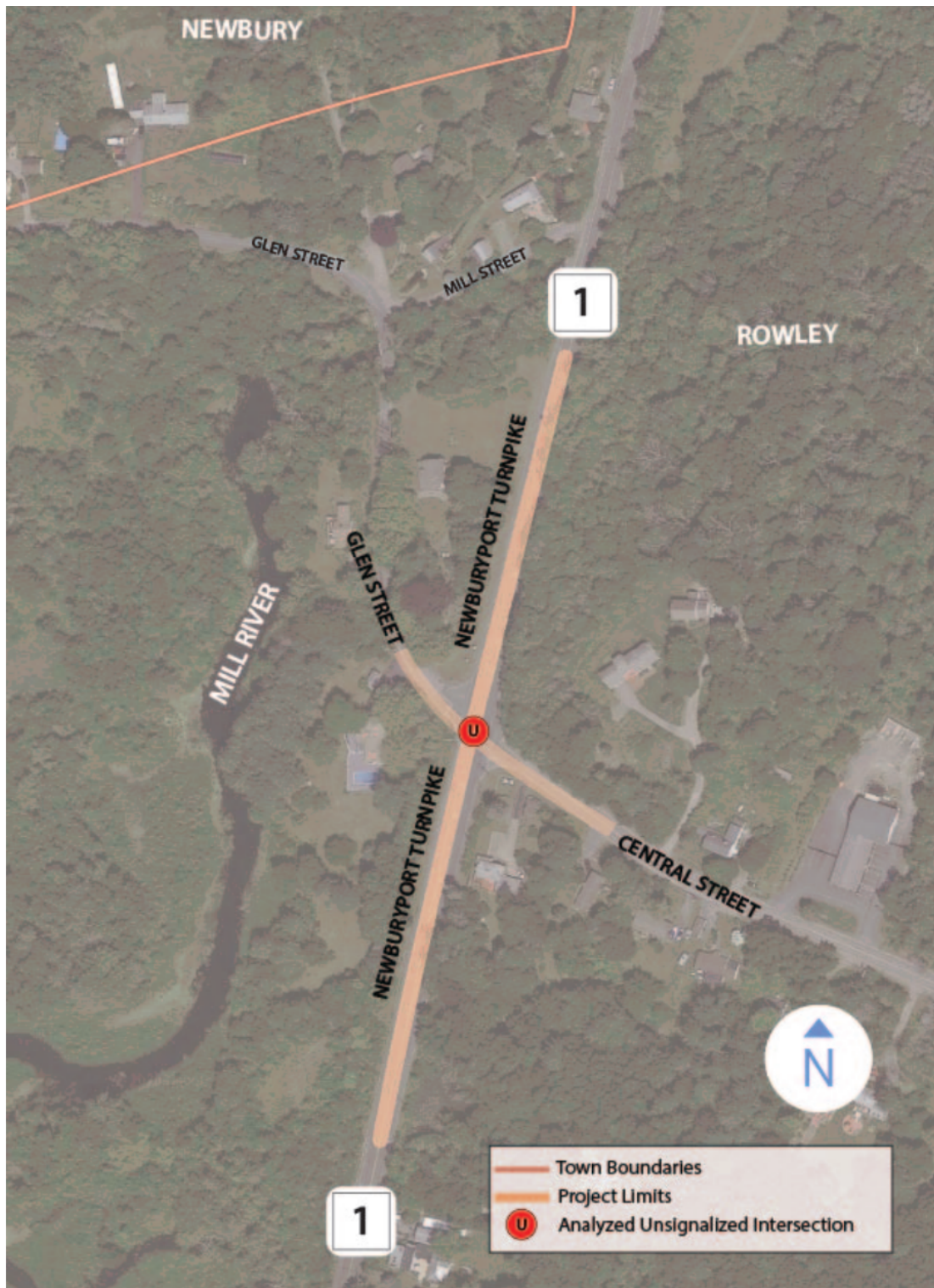


Figure 1 - Locus Map

2.2 Traffic Volumes

ATR (Automatic Traffic Recorder) counts were conducted on each of the four approaches to the intersection from Wednesday, March 11 to Saturday, March 14. Turning Movement Counts (TMCs) were conducted at the intersection of Route 1 (Newburyport Turnpike) and Central Street and Glen Street on Wednesday, March 11 from 7:00 AM to 7:00 PM.

Based on a review of historic traffic counts collected by MassDOT at a permanent count station on Route 1 in Newbury, traffic volumes in March are 10.6 percent lower than average-month conditions. Therefore, the traffic volumes were adjusted by 10.6 percent to represent Base Year (2020) conditions.

Due to the COVID-19 pandemic, traffic volumes began to decrease sometime in mid to late March. The traffic counts were reviewed with previous counts at the project intersection taken in August of 2019, and with nearby permanent count stations. It was determined that the traffic counts represent average annual traffic during normal conditions.

Table 1 summarizes the 2020 base year daily and peak-hour traffic volumes at the locations where ATR counts were taken. **Figure 2** through **Figure 4** shows the weekday hourly traffic counts throughout the day. **Figure 5** represents the 2020 weekday morning (7:30-8:30 AM) and evening (5:00-6:00 PM) peak hour turning movement volumes at the project area intersection.

Table 1 - Weekday Traffic Volume Summary (2020)

Location	ADT	AM Peak	PM Peak	K (%)
Route 1 South of Central St	8,490	600	780	9%
Northbound	4,200	210	490	12%
Southbound	4,290	390	290	9%
Route 1 North of Central St	9,650	730	860	9%
Northbound	4,810	300	500	10%
Southbound	4,840	430	360	9%
Glen Street West of Route 1	2,390	220	230	10%
Eastbound	1,200	160	75	13%
Westbound	1,180	65	160	13%
Central Street east of Route 1	4,200	400	380	10%
Eastbound	2,110	230	160	11%
Westbound	2,100	170	220	10%

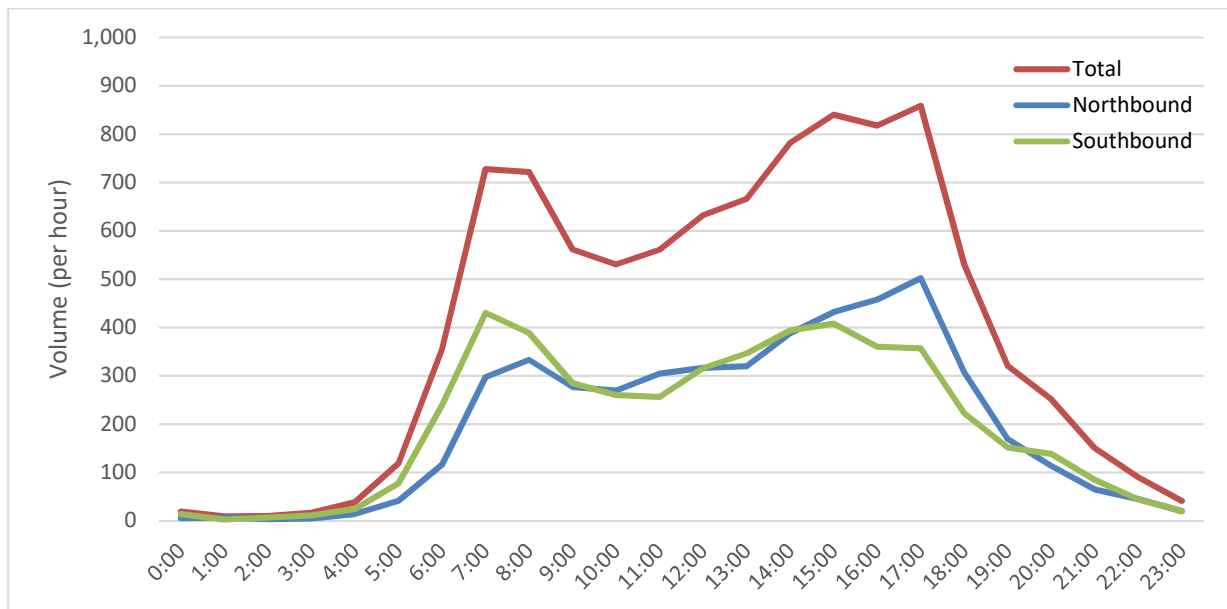


Figure 2 - Average Daily Traffic Variations - Route 1

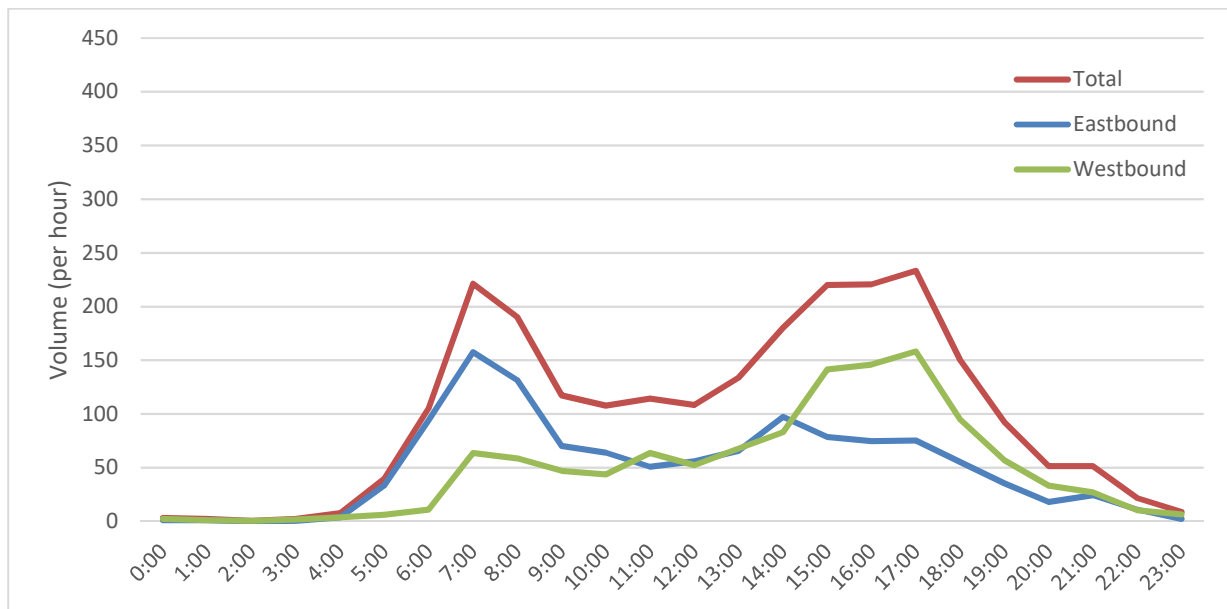


Figure 3 - Average Daily Traffic Variations - Glen Street

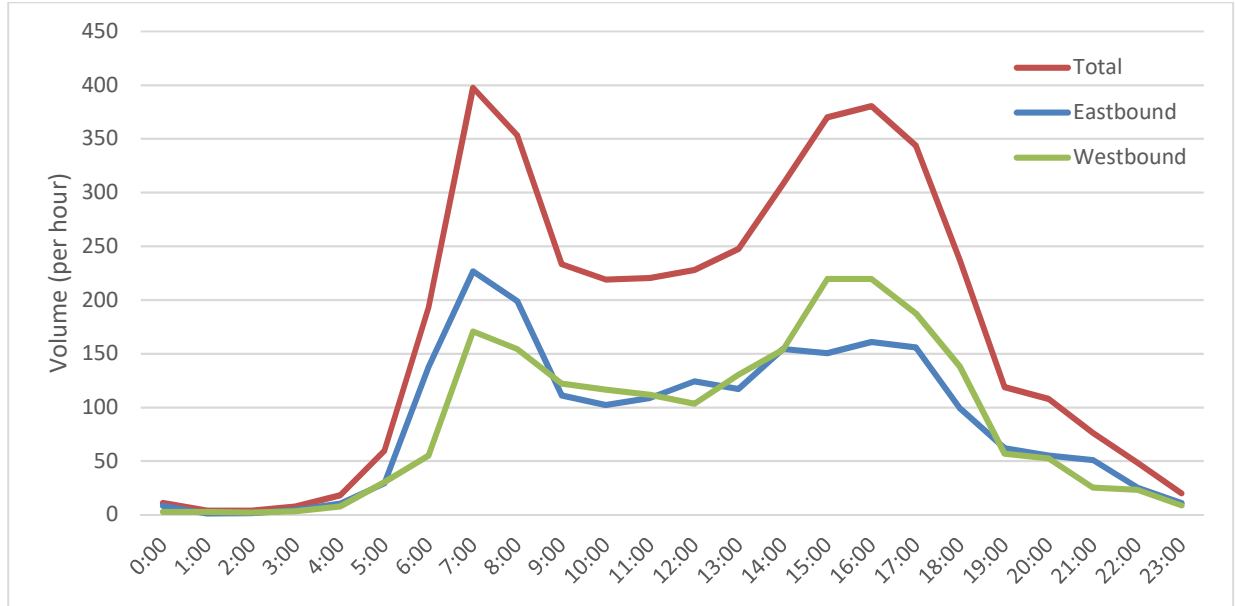


Figure 4 - Average Daily Traffic Variations - Central Street

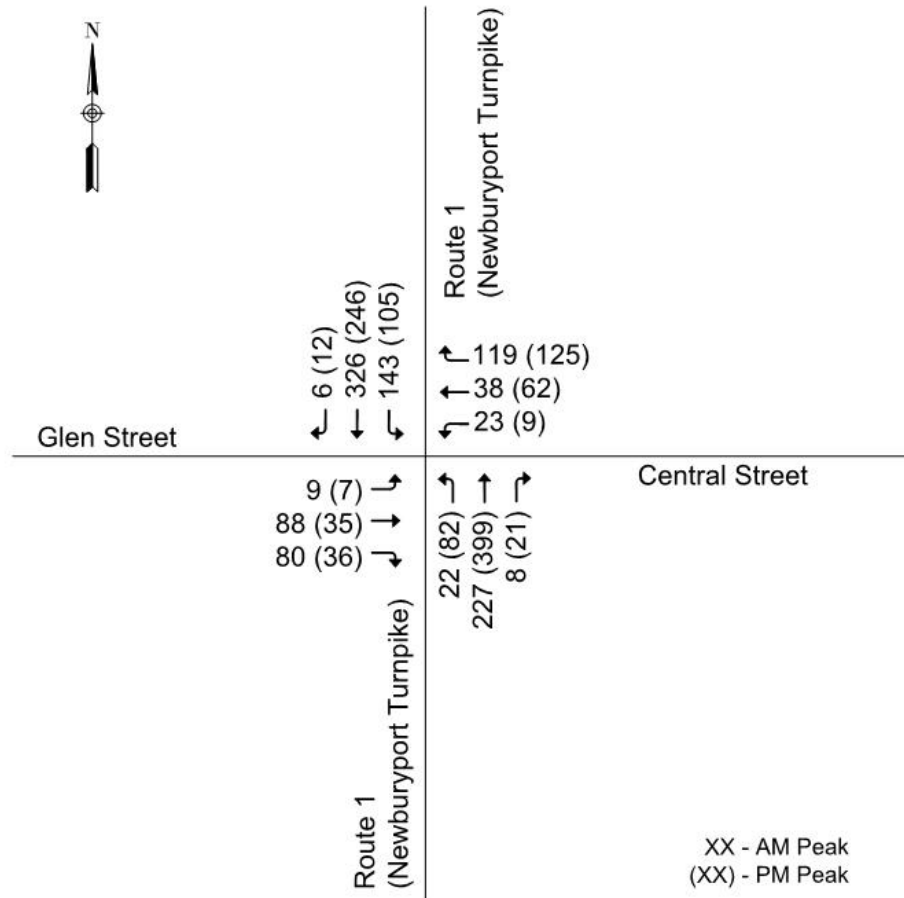


Figure 5 - Existing (2020) Peak Hour Turning Movement Volumes

2.3 Existing Analysis

Intersection capacity analysis has been performed at the intersection for the morning and evening peak hours to determine the traffic operations under existing conditions. Operational analysis was completed using Synchro 10 software, which based on the 2010 Highway Capacity Manual (HCM).

Level of Service (LOS) is defined in terms of the average total vehicle delay of all movements through an intersection and delay is measured based on multiple variables including signal phasing, signal cycle length, and traffic volumes with respect to intersection capacity. **Table 2** includes the LOS criteria as defined by Exhibit 18-4 and 19-1 of the 2010 HCM. **Table 3** provides a summary of the traffic operations under existing conditions for the morning and evening peak hours.

Table 2 - Level of Service Criteria for Intersections

LOS	Signalized Avg. Control Delay (sec/veh)	Unsignalized Avg. Control Delay (sec/veh)	Description
A	<10	<10	Free Flow
B	>10 - 20	>10 - 15	Stable Flow (slight delays)
C	>20 - 35	>15 - 25	Stable flow (acceptable delays)
D	>35 - 55	>25 - 35	Approaching unstable flow (tolerable delay, occasionally wait through more than one signal cycle before proceeding)
E	>55 - 80	>35 - 50	Unstable flow (intolerable delay)
F	>80	>50	Forced flow (jammed)

Table 3 - Existing Conditions Capacity Analysis Summary

Intersection	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)
	AM					PM				
Route 1 at Central St	C	19.1				B	12.6			
Glen St EB	F	55.4	0.82	-	170	E	35.5	0.46	-	60
Central St WB	E	44.1	0.73	-	140	E	46.5	0.76	-	148
Route 1 NB left	A	8.1	0.02	-	1	A	8.0	0.07	-	5
Route 1 NB thru/right	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Route 1 SB left	A	8.2	0.12	-	11	A	8.6	0.12	-	9
Route 1 SB thru/right	A	0.0	0.00	-	0	A	0.0	0.00	-	0

The intersection of Route 1 and Central Street and Glen Street operates at an overall LOS C in the AM peak hour and LOS B in the PM peak hour. The minor street approaches of Glen Street and Central Street experience significant delays with LOS E or F, which is typical for unsignalized approaches to a major arterial.

2.4 Signal Warrant Analysis

A traffic signal warrant analysis was performed based on the traffic volume justification criteria in Section 4C of the Manual on Uniform Traffic Control Devices (MUTCD), to determine if the installation of a traffic signal is warranted. The 2020 traffic-volume data was compared with the criteria of the following MUTCD warrants:

- Warrant 1 - Eight Hour Vehicular Volume
 - Condition A - Minimum Vehicular Volume
 - Condition B - Interruption of Continuous Traffic
- Warrant 2 - Four-Hour Vehicular Volume
- Warrant 3 - One-Hour Vehicular Volume

In accordance with the MUTCD, a traffic control signal may only be installed if at least one of the signal warrants is met. As noted in the Massachusetts Amendments to the 2009 MUTCD, dated January 2012, MassDOT views Warrant 1A and 1B as paramount when justifying a traffic control signal based on vehicular traffic flow.

Based on the existing traffic volumes, the analysis concludes that a traffic signal is warranted under the 8-hour vehicular volume Warrants 1A and 1B. The warrant analysis worksheets are provided in Appendix A.

3. Safety Analysis

An RSA was held in January of 2014 to review the crashes, discuss issues and observations, and determine potential countermeasures to enhance safety for the Route 1 at Central Street and Glen Street intersection. The RSA report analyzed crash data for the time period between January 2009 and December 2012.

The major issues observed at the RSA were visibility, traffic congestion, speed, intersection geometry, and sign clutter. Recommendations from the RSA to address these issues include:

- Install a traffic signal at the intersection, if warranted. If a traffic signal is installed, it should have retroreflective backplates for overhead signal heads, and emergency preemption.
- Consider long-term profile adjustments to Route 1 north of the intersection.
- Investigate potential regrading of the hill on the northwest corner of the intersection.
- Regrade hill and/or construct retaining wall on the northwest corner of the intersection. It is assumed that right-of-way acquisition will be required.
- Investigate potential for alteration of the stone wall on the southeast corner of the intersection.
- Modify or reconstruct the stone wall on the southeast corner of the intersection.
- Reset the guide sign on the southwest corner of the intersection to the proper height and increase the setback from the roadway edge.
- Investigate the possibility of relocating utility poles along the east side of Route 1 south of Central Street.
- Consider positive offset turn lanes on Route 1.
- Consider long-term realignment of both Glen Street and Central Street at Route 1.
- Review signs and remove inappropriate, incorrect or ambiguous signage.

- Provide double stop signs with reflective sign posts on the Central Street and Glen Street approaches, and consider additional signage recommended by FHWA short-term, low cost fixes.
- Replace “Left Lane For Left Turn” sign with R3-7L “Left Lane Must Turn Left” sign, and replace existing “Caution: Turning Vehicles Ahead” sign with an additional R3-7L sign.
- Upgrade street lighting at the intersection and along Route 1.
- Replace yellow and red indications in the overhead flasher with LED indications.

Additional maintenance, enforcement, and education activities recommended in the RSA to be under the responsibility of the Town include:

- Continue to clear snow to the greatest extent practical.
- Continue to clear brush on the northeast corner of the intersection.
- Continue speed enforcement efforts.
- Implement education programs at Triton Regional High School alerting younger drivers to the need for increased awareness at the intersection.

To better understand the underlying safety issues and review more recent data, additional crash reports for the intersection were obtained from the local Rowley Police Departments for the period between January 2014 and December 2019.

The summarized crash data for the project area can be seen in **Table 4**. The crash diagrams can be found in Appendix B.

Crash rates for the intersections are determined based on the number of crashes per million vehicles entering the intersection. As shown in the table, the crash rate for Route 1 at Central Street and Glen Street is above the statewide and District 4 averages for unsignalized intersections. The crash rate calculation can be found in Appendix B.

Table 4 - Crash Summary Analysis

	Route 1 at Glen Street and Central Street
<i>Year</i>	
2014	3
2015	2
2016	4
2017	4
2018	4
2019	5
<i>Collision Type</i>	
Single Vehicle	1
Angle	16
Rear End	4
Sideswipe	1
Head On	0
Pedestrian	0
Unknown/Other	0
<i>Severity</i>	
Property Damage Only	15
Personal Injury	6
Fatality	1
Unknown	0
<i>Pavement Condition</i>	
Dry	16
Wet	5
Snow	1
Sand	0
Unknown	0
Ice	0
Total	22
Yearly Average	3.67
Crash Rate	0.82
Statewide Average	0.57
District 4 Average	0.57

At the Route 1 (Newburyport Turnpike) with Glen Street and Central Street intersection, 22 crashes were reported between January 2014 and December 2019 for an average of 3.67 crashes per year. Most of the crashes were angle type (73%), during dry roadway conditions (73%), during peak commuting hours (64%), during daylight conditions (77%), and involving property damage only (68%). Angle crashes are indicative of difficult turning movements at the intersection and poor sight lines. Additionally, vehicles queued in the Route 1 left turn lanes block sight lines of Central Street and Glen Street to the Route 1 through moving vehicles. Most crashes were during peak commuting hours of 7:00AM to 9:00AM and 4:00PM to 6:00PM, where Route 1 left-turning vehicles would be queued in the turn lanes blocking sight lines. Poor driving conditions or dark intersection do not seem to be major factors for the crashes. The crash rate (0.82) is well above district wide (0.57) and state-wide (0.57) averages for intersections.

The trends from 2014 through 2019 are consistent with the findings of the RSA, which queried crashes from 2009 through 2012. Of all the crashes reported during this time period, 94% were angle type, 82% were during dry conditions, 53% were during commuting hours and 71% were during daylight conditions.

One fatality occurred in June of 2018 due to an angle collision, which was attributed to queued left-turn traffic blocking the visibility of oncoming through vehicles. The sight distance issues at the intersections are apparent from the types and severity of crashes at this location.

4.Future Conditions

Future traffic volumes were estimated and analyzed to determine future operations and impacts of geometry and signal improvements.

Future volumes for the 2030 design year were determined by increasing the existing volumes by a growth rate consistent with historical trends and then adding traffic that will be generated by known planned developments in the area.

General Background Growth. To determine the annual growth rate for the project area, input was sought from the Merrimack Valley Planning Commission (MVPC). Based on growth rates in the region, the MVPC suggested a growth rate of 0.75% per year. However, after a review of historical traffic counts along Route 1, a growth rate of 1.0% per year over a 10-year period was used in order to be conservative.

Planned Development. Discussions with the Rowley Planning Department and MVPC on the planned developments in the area determined that one residential development is planned approximately 1.5 miles south of the intersection off of Wethersfield Street. Since the number of trips anticipated for this development is low, any increase in traffic is considered to be captured in the general background growth rate.

Figure 6 shows the No-Build (2030) traffic volumes, which include the general background growth.

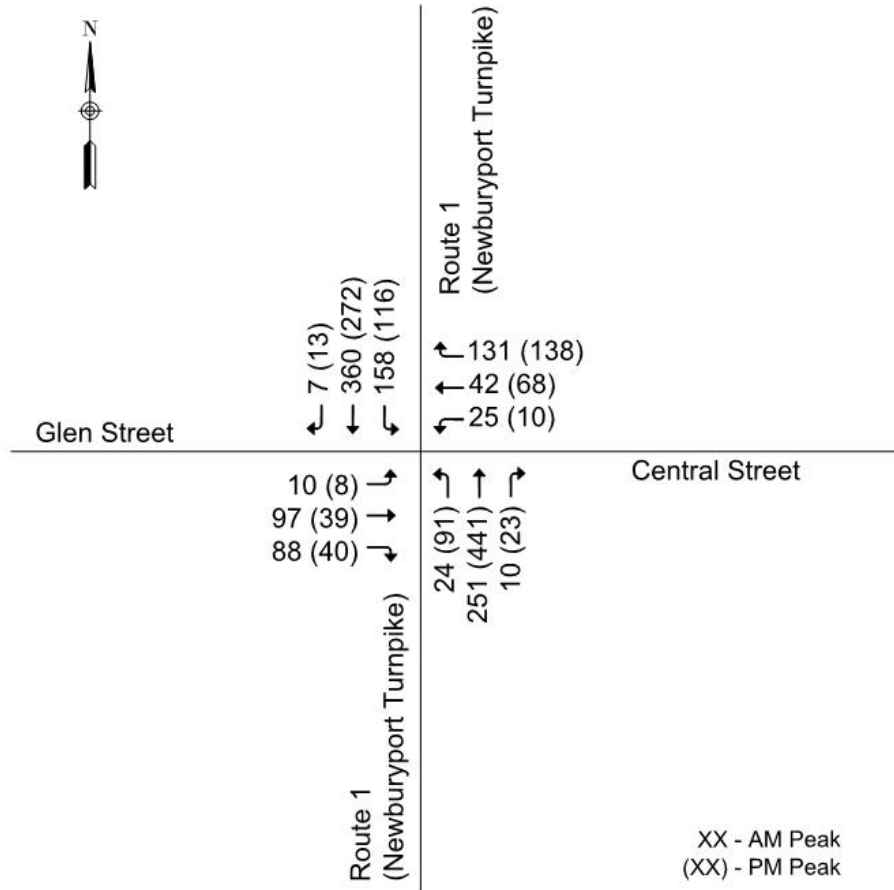


Figure 6 - No-Build (2030) Peak Hour Turning Movement Volumes

The No-Build condition analysis assumes an increase in traffic volumes based on historical growth rates with the existing roadway infrastructure.

Table 5 provides a summary of the analysis for the No-Build Conditions.

Table 5 - No-Build Conditions Capacity Analysis Summary

Intersection	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)
	AM					PM				
Route 1 at Central St	C	21.6				C	17.8			
Glen St EB	F	63.1	0.83	-	169	E	47.9	0.46	-	73
Central St WB	F	61.7	0.83	-	173	F	76.0	0.76	-	201
Route 1 NB left	A	8.1	0.02	-	2	A	8.1	0.07	-	6
Route 1 NB thru/right	A	0.0	0.00	-	0	A	0.0	0.00	-	0
Route 1 SB left	A	8.3	0.14	-	12	A	8.9	0.12	-	10
Route 1 SB thru/right	A	0.0	0.00	-	0	A	0.0	0.00	-	0

The future No-Build conditions are similar to existing conditions. The study area intersection operates at an overall LOS C or better during the AM and PM peak hour. The Central Street approach worsens from a LOS E to a LOS F in both the AM and PM peak hour.

5. Alternative Concepts

Alternative concepts for improving the safety and operations of the intersection were developed with consideration to physical roadway and Right-Of-Way (ROW) constraints. Based on discussions with MassDOT, three alternatives were developed for consideration. The concepts include:

- Alternative 1 - Signalized Intersection
- Alternative 2 - Single-lane Roundabout
- Alternative 3 - 4-way Stop Intersection

5.1 Alternative 1 - Signalized Intersection

Alternative 1 proposes to add signal control to the intersection while generally maintaining the existing pavement width, with only minor widening. The existing lane configuration would be retained, with one multi-purpose lane on the Central Street and Glen Street approaches and a left-turn lane and a through/right-turn lane on the Route 1 approaches. The left-turn lanes on Route 1 would be lengthened to accommodate the required deceleration distance so that no deceleration would be required in the through lane. The left-turn movements from Route 1 would be controlled by a protected phase, eliminating any conflict with opposing through vehicles. Dilemma zone detection and adequate clearance intervals would be added for the Route 1 approaches. Right turns on red would not be allowed from Central and Glen Streets to eliminate conflicts with the high-speed through vehicles on Route 1. Increased lighting at the intersection could be added, if needed. Dynamic “Red Signal Ahead” signs would also be included for advanced warning of the new traffic signal. A concept of this alternative is provided in Appendix C.

Table 6 includes a summary of the RSA recommendations that will be incorporated as a part of Alternative 1.

Table 6 - RSA Safety Enhancement Recommendations, Alternative 1

RSA Recommendation	Action
Install a traffic signal at the intersection, if warranted. If a traffic signal is installed, it should have retroreflective backplates for overhead signal heads, and emergency preemption.	✓
Consider long-term profile adjustments to Route 1 north of the intersection.	✗
Investigate potential regrading of the hill on the northwest corner of the intersection.	✗
Regrade hill and/or construct retaining wall on the northwest corner of the intersection. It is assumed that right-of-way acquisition will be required.	✗
Investigate potential for alteration of the stone wall on the southeast corner of the intersection.	✗
Modify or reconstruct the stone wall on the southeast corner of the intersection.	✗
Reset the guide sign on the southwest corner of the intersection to the proper height, and increase the setback from the roadway edge.	✓
Investigate the possibility of relocating utility poles along the east side of Route 1 south of Central Street.	N/A
Consider positive offset turn lanes on Route 1.	N/A
Consider long-term realignment of both Glen Street and Central Street at Route 1.	✗
Review signs and remove inappropriate, incorrect or ambiguous signage.	✓
Provide double stop signs with reflective sign posts on the Central Street and Glen Street approaches, and consider additional signage recommended by FHWA short-term, low cost fixes.	N/A
Replace "Left Lane For Left Turn" sign with R3-7L "Left Lane Must Turn Left" sign, and replace existing "Caution: Turning Vehicles Ahead" sign with an additional R3-7L sign.	✓
Upgrade street lighting at the intersection and along Route 1.	✓
Replace yellow and red indications in the overhead flasher with LED indications.	N/A
✓ = Incorporated, ✗ = Not Incorporated, N/A = Not Applicable	

It should be noted that full signal control will eliminate the need to judge gaps in Route 1 traffic for vehicles approaching from the side streets, a difficult task with existing sight distance constraints. Additional profile adjustments and sight distance improvements could be incorporated into the design once a more detailed survey is received and evaluated.

Crash Modification Factors were reviewed for installation of a traffic signal. For a high-speed major road, the installation of a traffic signal could reduce angle crashes by up to 67%, but could also increase the likelihood of rear-end crashes by 143%. Overall, crashes are anticipated

to be reduced by 5%. The addition of highway lighting at the intersection could reduce nighttime crashes by 52%.

The installation of a signal will require minimal ROW acquisitions. Based on GIS ROW lines, the northwest corner will require approximately 400 SF of fee taking. Utility poles will be able to remain in existing locations pending a more detailed design of mast arms, and drainage should need minimal adjustment.

The order of magnitude cost for these improvements is estimated at \$1.1 million. The cost estimate is included in Appendix C.

The signal improvements were analyzed for traffic operations with the program Synchro 10. The operational results are shown in **Table 7**.

Table 7 - Signalized Conditions Capacity Analysis Summary

Intersection	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)
	AM					PM				
Route 1 at Central St	B	16.3				B	18.1			
Glen St EB	B	16.3	0.50	63	137	B	16.6	0.23	29	69
Central St WB	B	16.7	0.54	65	143	B	19.4	0.59	78	157
Route 1 NB left	C	25.5	0.46	8	33	C	27.8	0.71	34	83
Route 1 NB thru/right	B	15.9	0.65	85	174	B	16.6	0.80	160	281
Route 1 SB left	C	23.0	0.77	53	126	C	28.7	0.78	44	120
Route 1 SB thru/right	B	12.8	0.65	69	208	B	12.4	0.47	87	162

Table 7 shows an overall improvement in intersection delay from No-Build conditions of approximately 5 seconds in the AM, and similar delay in the PM. Due to the introduction of the traffic signal, the delay for the Route 1 approach increased over the No-Build conditions. However, Central Street and Glen Street improve from LOS E or F in the No-Build condition to LOS B in the signal alternative. All movements operate at a LOS C or better.

5.2 Alternative 2 - Single-lane Roundabout

Alternative 2 proposes to install a single-lane roundabout at the intersection. This will require full depth construction, a retaining wall in the northeast corner and some widening along the approaches. Based on the principal arterial classification of Route 1 and a design vehicle of a WB-67, the roundabout diameter is proposed to be approximately 130 feet, with a circulating roadway width of 20 feet (2-foot right shoulder and 18-foot travel lane), and an island diameter of 94 feet with a 20-foot truck apron. The roundabout is designed for speeds of 15 to 25 MPH. The Route 1 approaches to the roundabout consist of a single lane and include successive curves, enforced by the 200-foot splitter islands, to reduce approaching speeds to 35 MPH. Flashing advanced warning signs could be added to the Route 1 approaches for increased awareness and to further reduce speeds. The Central Street and Glen Street approaches also consist of a single lane with splitter islands for proper deflection. The northwest and southeast

corners include truck aprons to accommodate SU-40 right turns from Route 1 to Central Street and to Glen Street. Vehicles larger than an SU-40 will be required to circulate the roundabout 270 degrees in order to make the southbound right-turn and northbound right-turn movements. The stone retaining wall on the southeast corner would likely need to be modified to achieve required sight distance for vehicles approaching on Central Street looking to the south. A concept of this alternative is provided in Appendix C.

Table 8 includes a summary of the RSA recommendations that will be incorporated as a part of Alternative 2.

Table 8 - RSA Safety Enhancement Recommendations, Alternative 2

RSA Recommendation	Action
Install a traffic signal at the intersection, if warranted. If a traffic signal is installed, it should have retroreflective backplates for overhead signal heads, and emergency preemption.	N/A
Consider long-term profile adjustments to Route 1 north of the intersection.	✗
Investigate potential regrading of the hill on the northwest corner of the intersection.	✗
Regrade hill and/or construct retaining wall on the northwest corner of the intersection. It is assumed that right-of-way acquisition will be required.	✗
Investigate potential for alteration of the stone wall on the southeast corner of the intersection.	✓
Modify or reconstruct the stone wall on the southeast corner of the intersection.	✓
Reset the guide sign on the southwest corner of the intersection to the proper height, and increase the setback from the roadway edge.	✓
Investigate the possibility of relocating utility poles along the east side of Route 1 south of Central Street.	N/A
Consider positive offset turn lanes on Route 1.	N/A
Consider long-term realignment of both Glen Street and Central Street at Route 1.	N/A
Review signs and remove inappropriate, incorrect or ambiguous signage.	✓
Provide double stop signs with reflective sign posts on the Central Street and Glen Street approaches, and consider additional signage recommended by FHWA short-term, low cost fixes.	N/A
Replace "Left Lane For Left Turn" sign with R3-7L "Left Lane Must Turn Left" sign, and replace existing "Caution: Turning Vehicles Ahead" sign with an additional R3-7L sign.	✓
Upgrade street lighting at the intersection and along Route 1.	✓
Replace yellow and red indications in the overhead flasher with LED indications.	N/A
✓ = Incorporated, ✗ = Not Incorporated, N/A = Not Applicable	

It should be noted the roundabout will eliminate most sight distance issues. Additional profile adjustments and sight distance improvements could be incorporated into the design once a more detailed survey is received and evaluated.

Crash Modification Factors were reviewed for installation of a modern roundabout. Converting a minor street stop-controlled intersection to a roundabout could reduce crashes by up to 39% and reduce serious and minor injuries by up to 81%. Roundabouts force the driver to slow and yield to traffic before entering the roundabout, resulting in fewer crashes with injuries.

The installation of a roundabout will require ROW acquisitions. Based on GIS ROW lines, a total of 5,400 SF of fee takings would be required from four different residential parcels. At least six utility poles will need to be relocated, and new drainage structures and pipes would be needed to properly drain the roundabout and approaches.

The order of magnitude cost for these improvements is estimated at \$2.4 million. The cost estimate is included in Appendix C.

The roundabout improvements were analyzed for traffic operations with the program SIDRA. The operational results are shown in **Table 9**.

Table 9 - Roundabout Conditions Capacity Analysis Summary

Intersection	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)
	AM					PM				
Route 1 at Central St	B	10.5				B	11.6			
Glen St EB	B	11.5	0.36	-	37	A	6.3	0.13	-	12
Central St WB	A	8.3	0.29	-	29	B	11.3	0.38	-	41
Route 1 NB	A	9.2	0.39	-	43	B	14.0	0.65	-	127
Route 1 SB	B	11.6	0.58	-	98	A	9.6	0.47	-	12

Table 9 shows an overall improvement in intersection delay from No-Build conditions of approximately 11 seconds in the AM, and 6 seconds in the PM. Due to the introduction of the roundabout control, there is an increase in delay for the Route 1 approaches over the No-Build conditions. However, Central Street and Glen Street improve from LOS E or F in the No-Build condition to LOS B or A in the roundabout alternative. All movements operate at a LOS B or better.

5.3 Alternative 3 - 4-Way Stop Intersection

Alternative 3 proposes to add stop signs to the Route 1 approaches, making the intersection a 4-way stop intersection. The existing left-turn lanes on the Route 1 approaches would be eliminated, making all four approaches single lanes with the reduction in lanes and the existing pavement widths could be maintained. This alternative would require milling and overlay to the start of the left-turn lanes on Route 1 (approximately 450 feet from the intersection), additional stop and advanced warning signs and new pavement markings. Advanced warning signs with

flashing LED lights for the stop signs would be required since a stop sign controlled intersection is not expected by drivers. The existing flashing beacon would be retained, and new red LED flashing lights would be installed for all approaches.

With a roadway speed of 50 mph, stopping sight distance requirements for vehicles traveling on Route 1 is 495 feet. Intersection sight distance requirements for vehicles stopped on the side streets is 610 feet looking left and 530 feet looking right. Stopping sight distance is most likely met, pending a more detailed review of vertical roadway curves with the use of survey. Intersection sight distance is most likely met in this alternative since side street stopping position would be moved closer to Route 1 center line due to removing the left turn lanes on Route 1.

Realigning the Central Street and Glen Street approaches was considered for better sight lines. However, due to ROW constraints, the rocky hill in the northeast corner of the intersection, and minimum roadway curve requirements, realigning the approaches was not incorporated into this alternative.

The intersection volumes meet the suggested minimum volumes for all-way stop control set forth by the MUTCD. However, the MUTCD suggests that traffic volumes on all approaches should be approximately equal. Traffic volumes on the minor approaches of Central Street and Glen Street are approximately only one-third of the major approaches of Route 1.

Table 10 includes a summary of the RSA recommendations that will be incorporated in Alternative 3.

Table 10 - RSA Safety Enhancement Recommendations, Alternative 3

RSA Recommendation	Action
Install a traffic signal at the intersection, if warranted. If a traffic signal is installed, it should have retroreflective backplates for overhead signal heads, and emergency preemption.	N/A
Consider long-term profile adjustments to Route 1 north of the intersection.	✗
Investigate potential regrading of the hill on the northwest corner of the intersection.	✗
Regrade hill and/or construct retaining wall on the northwest corner of the intersection. It is assumed that right-of-way acquisition will be required.	✗
Investigate potential for alteration of the stone wall on the southeast corner of the intersection.	✗
Modify or reconstruct the stone wall on the southeast corner of the intersection.	✗
Reset the guide sign on the southwest corner of the intersection to the proper height, and increase the setback from the roadway edge.	✓
Investigate the possibility of relocating utility poles along the east side of Route 1 south of Central Street.	✗
Consider positive offset turn lanes on Route 1.	N/A
Consider long-term realignment of both Glen Street and Central Street at Route 1.	✗
Review signs and remove inappropriate, incorrect or ambiguous signage.	✓
Provide double stop signs with reflective sign posts on the Central Street and Glen Street approaches, and consider additional signage recommended by FHWA short-term, low cost fixes.	✓
Replace "Left Lane For Left Turn" sign with R3-7L "Left Lane Must Turn Left" sign, and replace existing "Caution: Turning Vehicles Ahead" sign with an additional R3-7L sign.	✓
Upgrade street lighting at the intersection and along Route 1.	✗
Replace yellow and red indications in the overhead flasher with LED indications.	✓
✓ = Incorporated, ✗ = Not Incorporated, N/A = Not Applicable	

It should be noted the additional stop signs will not eliminate the existing sight distance issues. Although profile adjustments and sight distance improvements could be incorporated into the design once a more detailed survey is received and evaluated, the cost for these improvements would not be consistent with the low-cost improvements of adding stop signs.

Crash Modification Factors were reviewed for installation of stop signs on the major road. Converting a minor street stop-controlled intersection to an all-way stop controlled intersection would reduce all crashes by 68%, reduce serious and minor injuries by 70%, reduce angle crashes by 75% and reduce rear end crashes by 18%.

The installation of stop signs will not require ROW acquisition. Utility poles will be able to remain in existing locations, and drainage should need minimal adjustment.

The order of magnitude cost for these improvements is estimated at \$350,000, which includes milling and overlay of the intersection.

The stop sign improvements were analyzed for traffic operations with the program Synchro. The operational results are shown in **Table 11**.

Table 11 - 4-Way Stop Conditions Capacity Analysis Summary

Intersection	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)	LOS	Delay (sec)	v/c Ratio	50% Queue (feet)	95% Queue (feet)
	AM					PM				
Route 1 at Central St	E	37.9				E	38.8			
Glen St EB	C	15.4	0.42	-	53	B	12.5	0.20	-	18
Central St WB	C	15.2	0.42	-	53	C	15.3	0.45	-	56
Route 1 NB	C	18.8	0.58	-	93	F	60.6	0.99	-	373
Route 1 SB	F	65.2	0.99	-	375	D	26.9	0.76	-	170

Table 11 shows an overall increase in intersection delay from No-Build conditions of approximately 16 seconds in the AM, and 21 seconds in the PM. The stop sign alternative reduces the Central Street and Glen Street delay, but increases the delay on the Route 1 approaches. Central Street and Glen Street improve from LOS E or F in the No-Build condition to LOS B or C in the roundabout alternative. The Route 1 approaches worsen from LOS A in the No-Build condition to LOS F southbound in the AM and northbound in the PM.

6. Environmental Impacts

An existing environmental conditions analysis was conducted to assist in the evaluation of project alternatives and to facilitate early coordination with the appropriate regulatory agencies. Results from a preliminary desktop investigation of existing environmental constraints and permitting implications to be considered are provided below:

6.1 Existing Conditions

Wetland Resource Areas

The Mill River flows northeast along Route 1 and under Glen and Mill Streets just west of the subject intersection. The river is dammed by the Jewel Mill Dam just west of Glen Street and splits into two distinct channels to accommodate the historic Jewel Mill north of Mill Street before converging again north of the mill. The segment of the Mill River adjacent to the intersection is identified as a Category 5 Impaired Waterbody ("Water requiring a TMDL") on

the *Massachusetts Year 2016 Integrated List of Waters*, and is classified as an Outstanding Resource Water (ORW) downstream (north) of the Jewel Mill Dam due to its association with the Great Marsh Area of Critical Environmental Concern (ACEC).

According to data from MassGIS, the Mill River comes within 15 feet of the existing right-of-way (ROW) near the Route 1/Mill Street intersection. The ORW boundary, as well as the FEMA Regulatory Floodway (Zone AE), 100-year floodplain (Zone AE), and 500-year floodplain (Zone X) boundaries intersect the ROW in this area. The base flood elevation (BFE) in this area is 10-12 feet. Southwest of the intersection, the Mill River and its associated FEMA 100-year floodplain come within approximately 30 feet of the ROW.

Several Massachusetts Department of Environmental Protection (DEP) vegetated wetlands border Mill River south of the intersection, including several wetlands that directly abuts the ROW east of Route 1. One potential vernal pool was identified approximately 400 feet west of the ROW along the Mill River. All identified wetland resources are depicted on Figure 1.

Hazardous Materials

There are no superfund sites, Activity and Use Limitations (AULs), or DEP regulated release sites near the project area. The closest closed release site is located approximately 0.5 miles south of the subject intersection along Route 1.

Open Space

The William Ford Wildlife Management Area (WMA) owned by the Department of Fish and Game (DFG), abuts the highway ROW northeast of the subject intersection. The Glen Mills Conservation Restriction (CR) owned by Philip E. and Sharon T. McGowan borders the south side of Glen Street, west of Mill River. All MassGIS mapped open space areas are depicted in Figure 1.

State and Federally Protected Endangered Species

According to MassGIS, there are no mapped Natural Heritage and Endangered Species Program (NHESP) Estimated Habitat of Rare Wildlife or Priority Habitat of Rare Species polygons within the project area. The closest NHESP mapped habitat polygon is located approximately 0.75 miles north of the intersection within the Great Marsh ACEC.

The United States Fish and Wildlife Service (USFWS) Information for Planning and Consultation (IPaC) tool identified the Northern long-eared bat (*Myotis septentrionalis*) as a federally listed species that may be impacted by the proposed project. However, there is no identified critical habitat for the Northern long-eared bat within the project area.

Massachusetts Coastal Zone

According to MassGIS, the northeastern quadrant of the intersection is located within the designated Massachusetts Coastal Zone boundary. The limits of the designated Coastal Zone boundary are depicted in **Figure 7**.

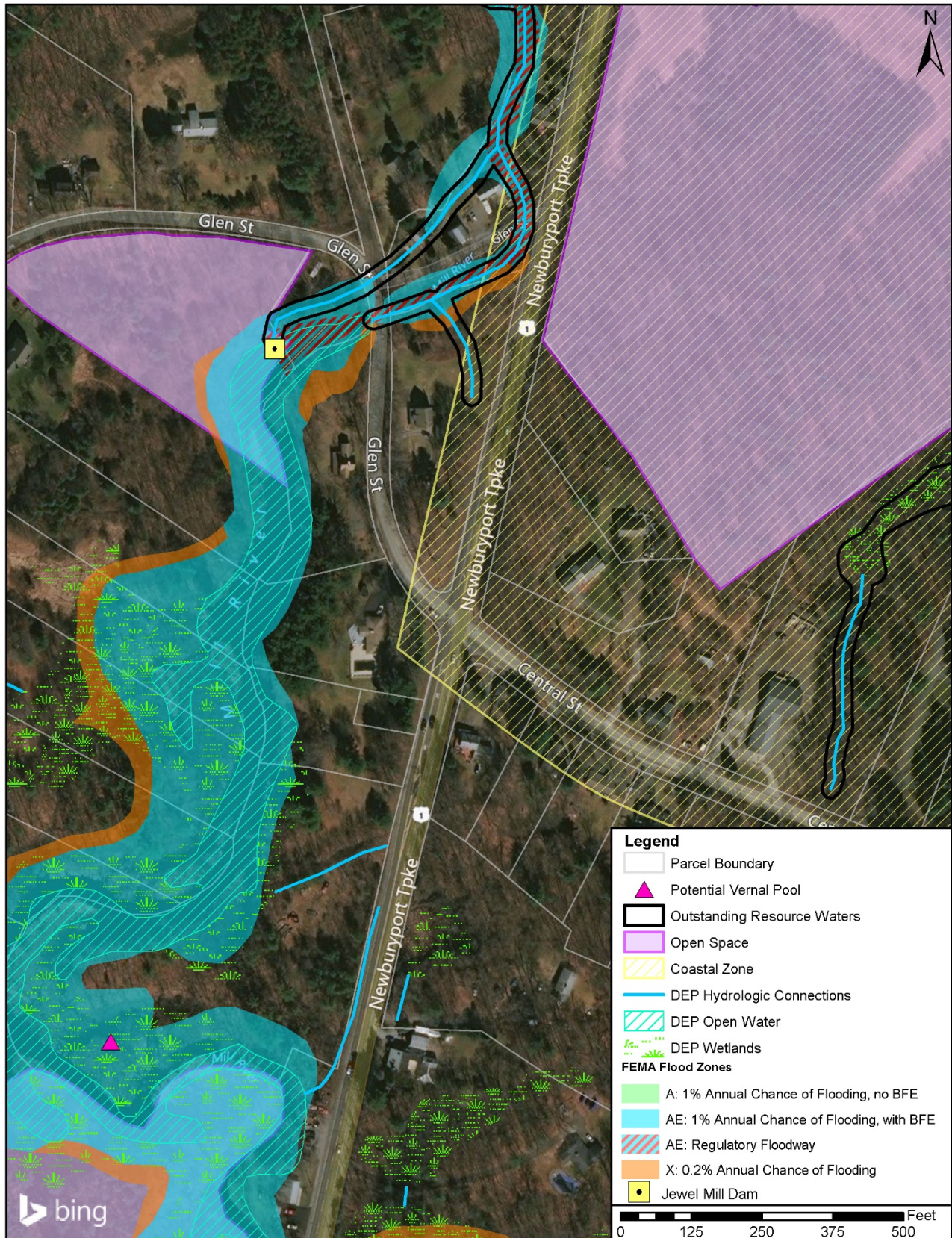


Figure 7 - Environmental Constraints Map

Historic Resources

According to the Massachusetts Historical Commission's MACRIS database, there are no National Register listed properties, districts, or sites within or adjacent to the project area. However, the Glen Mill Historic District (ROW.B), designated as a Local Historic District (LHD) by the Massachusetts Historical Commission (MHC) and outlined in green in **Figure 8** below, is located on the western side of Route 1 and along Glen Street. This area includes the following LHD buildings and structures:

- Joseph N. Pearson-Dummer House (ROW.38)
- Captain John Pearson House (ROW.39)
- Glen Mills Stone Bridge/Old Stone Arch Bridge (ROW.904)
- Mill River Dam (ROW.905)
- Glen Mills Cereal Company Boarding House (ROW.40)
- Glen Mills Grist Mill - Jewel Mill (ROW.56)
- First Fulling Mill Marker (ROW.909)

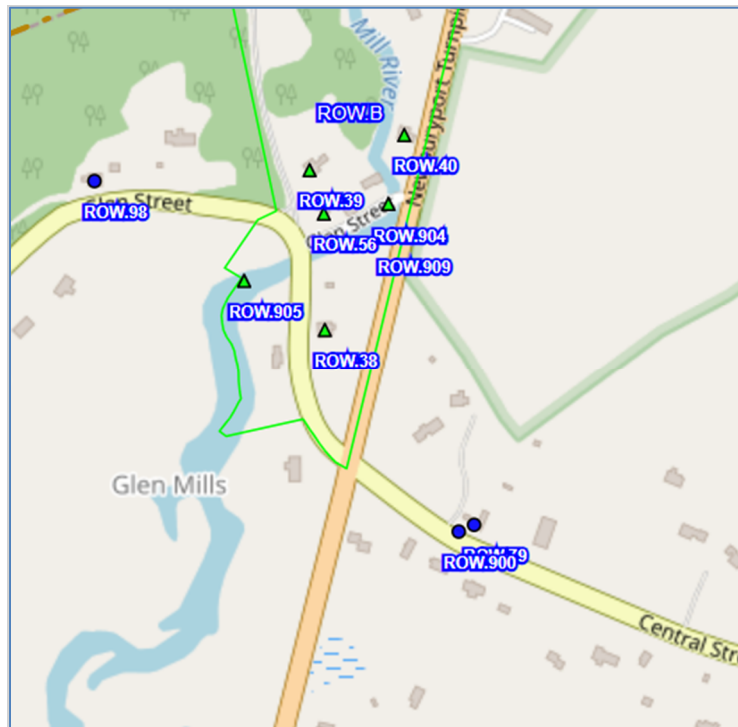


Figure 8 - Local Historic District Map

Other Resources

According to MassGIS, there are no Areas of Critical Environmental Concern, certified vernal pools, Wild & Scenic Rivers, USACE Special Aquatic Sites (salt marsh, tidal flats, vegetated shallows, etc.), or Essential Fish Habitat within the project area.

6.2 Alternatives Analysis and Regulatory Considerations

Wetland Resource Areas

According to MassGIS data, all project alternatives will impact the 200-foot Riverfront Area and 100-foot wetland buffer of state-regulated wetland resource areas. As the 200-foot Riverfront Area and 100-foot buffer zone to Bordering Vegetated Wetlands (BVW) are subject to protection under the Massachusetts Wetlands Protection Act, all project alternatives will require the filing of a Notice of Intent (NOI) with the Town of Rowley Conservation Commission.

Based on preliminary MassGIS wetlands mapping, Alternative 1 also has the potential to impact Bordering Vegetated Wetlands (BVW) within close proximity of the existing ROW along Route 1. This is due to lengthening the left-turn lanes on Route 1 to accommodate deceleration distance and storage distance. Lane length could be reduced to avoid impacts to BVW without deteriorating traffic operations. Erosion and sedimentation controls are required to be installed and maintained where activities are proposed within 100-feet of wetland resources areas. These controls will provide a limit of work barrier, while preventing silt and sediments from migrating into or towards wetland resource areas downgradient of Route 1. All erosion control measures shall be in place prior to the commencement of any land disturbance work and shall remain intact until all disturbed areas have been stabilized.

It is assumed that no work associated with any of the project alternatives will impact the Mill River or its associated bank or 100-year base flood elevations.

Stormwater Management

The proposed project is classified as a redevelopment project and is therefore required to meet stormwater management standards to the maximum extent practicable, while improving upon existing conditions.

Open Space

The William Ford WMA parcel immediately abuts the existing ROW near the northern terminus of the Alternative 1 project limits. Impacts to the WMA are not anticipated, as work associated with Alternative 1 is proposed entirely within the existing ROW. None of the other alternatives will impact this identified open space parcel.

Endangered Species

As there is no identified critical habitat for the Northern long-eared bat within the project area, adverse impacts to this species are not anticipated as a result of any of the project alternatives.

Massachusetts Coastal Zone

It is not anticipated that any of the project alternatives will impact Waters of the U.S. or trigger any of the Massachusetts Environmental Policy Act (MEPA) review thresholds under 301 CMR 11.03. Accordingly, all project alternatives are deemed compliant with policies of the Massachusetts coastal program and will not require federal consistency review by the Massachusetts Office of Coastal Zone Management (CZM).

Historic Resources

None of the project alternatives will impact any properties, districts, or sites that are listed or eligible for listing on the National Register of Historic Places. Due to the allocation of federal funds toward construction, the project requires review by MassDOT's Cultural Resources Unit pursuant to Section 106 of the National Historic Preservation Act of 1966, as amended.

Funding Obligations

Due to the allocation of federal funds toward construction, the project requires review in accordance with the National Environmental Policy Act (NEPA). NEPA review requires federal agencies to use all practicable means and measures to minimize damage to the environment by studying alternatives to the proposed project prior to undertaking any federal action (including issuance of permits or funding). Based on preliminary review of baseline conditions and potential environmental impacts associated with each of the alternatives, it is anticipated that this project will qualify as a Categorical Exclusion in accordance with the provisions of NEPA.

7. Summary

The need for improved traffic control at the intersection of Route 1 (Newburyport Turnpike) and Central Street and Glen Street is evident by the higher than average crash rate, and the severity of crashes at the intersection. Delay for the minor street approaches is high, which could be contributing to driver **frustration** and **erratic behavior**. Sight distance restrictions and high speeds on Route 1 also contribute to difficult turning movements at the intersection. **Table 12** shows a comparison of the RSA enhancements that are able to be incorporated for each of the alternatives.

Table 12 - Comparison of RSA Safety Enhancement Recommendations

RSA Recommendation	Alt. 1	Alt. 2	Alt. 3
Install a traffic signal at the intersection, if warranted. If a traffic signal is installed, it should have retroreflective backplates for overhead signal heads, and emergency preemption.	✓	N/A	N/A
Consider long-term profile adjustments to Route 1 north of the intersection.	✗	✗	✗
Investigate potential regrading of the hill on the northwest corner of the intersection.	✗	✗	✗
Regrade hill and/or construct retaining wall on the northwest corner of the intersection. It is assumed that right-of-way acquisition will be required.	✗	✗	✗
Investigate potential for alteration of the stone wall on the southeast corner of the intersection.	✗	✓	✗
Modify or reconstruct the stone wall on the southeast corner of the intersection.	✗	✓	✗
Reset the guide sign on the southwest corner of the intersection to the proper height, and increase the setback from the roadway edge.	✓	✓	✓
Investigate the possibility of relocating utility poles along the east side of Route 1 south of Central Street.	N/A	N/A	✗
Consider positive offset turn lanes on Route 1.	N/A	N/A	N/A
Consider long-term realignment of both Glen Street and Central Street at Route 1.	✗	N/A	✗
Review signs and remove inappropriate, incorrect or ambiguous signage.	✓	✓	✓
Provide double stop signs with reflective sign posts on the Central Street and Glen Street approaches, and consider additional signage recommended by FHWA short-term, low cost fixes.	N/A	N/A	✓
Replace "Left Lane For Left Turn" sign with R3-7L "Left Lane Must Turn Left" sign, and replace existing "Caution: Turning Vehicles Ahead" sign with an additional R3-7L sign.	✓	✓	✓
Upgrade street lighting at the intersection and along Route 1.	✓	✓	✗
Replace yellow and red indications in the overhead flasher with LED indications.	N/A	N/A	✓
✓ = Incorporated ✗ = Not Incorporated N/A = Not Applicable			

Alternative 1 proposes the installation of a traffic signal. The order of magnitude cost for these improvements is estimated at \$1.1 million. Advantages of traffic signal control include:

- Decreased delay for minor street approaches and the intersection overall
- Increased safety for turning and through movements by removing some conflicting movements and removing the need to judge gaps on Route 1
 - Decreased possibility of crashes by 5%
 - Decreased possibility of angle crashes by 67%
- Minimal ROW taking needed
- Minimal full depth construction needed
- Minimal utility impacts

Disadvantages of traffic signal control include:

- Increased delay for major street approaches
- Increased possibility of rear-end crashes by 143%
- Similar sight distance issues to existing conditions if no modifications to sight restrictions are made
- High maintenance cost
- Cost for construction, although less than the roundabout alternative

Alternative 2 proposes the installation of a single lane roundabout. The order of magnitude cost for these improvements is estimated at \$2.4 million. Advantages of a roundabout include:

- Decreased delay for all approaches and the intersection overall
- Increased safety for turning and through movements by removing some conflicting movements, removing the need to judge gaps on Route 1 and reducing speeds at the intersection. Roundabouts have been shown to dramatically reduce crash severity due to the lower operating speeds
 - Decreased possibility of crashes by 39%
 - Decreased possibility of crashes involving serious or minor injuries by 81%
- Lower maintenance cost than traffic signals
- Improved sight distance

Disadvantages of roundabout control include:

- Significant ROW taking needed
- Significant full depth construction needed
- Significant utility impacts
- Unexpected intersection control type for Route 1 in this area
- Cost for construction

Alternative 3 proposes the installation of stop signs on Route 1 for an all-way stop sign intersection. The order of magnitude cost for these improvements is estimated at \$350,000. Advantages of an all-way stop intersection include:

- Decreased delay for minor street approaches

- Increased safety for turning and through movements by removing conflicting movements, removing the need to judge gaps on Route 1 and reducing speeds at the intersection. Slower operating speeds will reduce crash severity.
 - Decreased possibility of crashes by 68%
 - Decreased possibility of serious and minor injury crashes by 70%
 - Decreased possibility of angle crashes by 75%
 - Decreased possibility of rear-end crashes by 18%
- Improved sight distance
- Minimal ROW taking needed
- Minimal full depth construction needed
- Minimal utility impacts
- Minimal construction cost
- Minimal maintenance cost

Disadvantages of all-way stop control include:

- Increased delay for major street approaches and the intersection overall
 - Route 1 southbound will operate at LOS F in the AM
 - Route 1 northbound will operate at LOS F in the PM
- Unexpected intersection control type for Route 1 in this area
- According to MUTCD suggestions, all-way stop control at this intersection is not recommended based on the imbalance of traffic volumes on the major street versus the minor street.

Appendices

Appendix A - Signal Warrant Calculation

Appendix B - Crash Diagram and Crash Rate Calculation

Appendix C - Concept Design Plans and Cost Estimates

Appendix A

Signal Warrant Calculation

Traffic Control Signal Warrant Analyses

(Based on MUTCD-2009 Edition)

Intersection:	Route 1 at Glen St/Central St				
Pop. <10,000? (Y/N)	Y	Count Date:	3/11/2020	Analysis Date:	04/09/20
Speed (in mph):	50 mph	Analysis Year:	2020	Analyst:	CTW
Is Major?*		Adjustment Factor:	1	Raw counts	
(Y/N)		#Lanes*			
	(one way)				
EB	N	1	Major Lanes:	1	Enter the higher number of lanes for the major street approach
WB	N	1	Minor Lanes:	1	Enter the number of lanes for the minor street approach you want to analyze
NB	Y	1			
SB	Y	1			

*Note: If intersection is a "T" intersection, leave cells blank for the non-existent approach

Time	EB LT	EB TH	EB RT	WB LT	WB TH	WB RT	NB LT	NB TH	NB RT	SB LT	SB TH	SB RT
6:00	0	49	46	10	6	41	6	85	7	76	154	2
7:00	2	82	81	21	35	118	25	178	7	132	292	7
8:00	14	67	50	19	32	97	23	227	8	111	282	4
9:00	6	30	43	19	23	81	18	197	14	75	228	1
10:00	4	23	34	22	18	74	21	196	17	66	186	7
11:00	8	17	30	18	28	72	22	241	22	61	168	7
12:00	3	25	29	10	22	74	17	243	22	76	244	3
13:00	1	33	20	14	32	77	23	240	17	70	278	6
14:00	1	34	58	13	33	104	48	279	21	94	312	7
15:00	10	24	42	15	73	131	53	298	18	112	293	2
16:00	8	35	35	22	71	131	71	312	27	111	271	7
17:00	7	35	36	9	62	125	82	399	21	105	246	12
18:00	6	25	36	9	52	85	48	233	11	83	164	10

Time	Σ EB	Σ WB	Σ NB	Σ SB	Σ Major	Σ Minor	Σ Max Minor	W1 A	W1 B	W1combo	W2	W3
6:00	95	56	97	232	330	152	95	N	N	N	N	N
7:00	165	175	210	430	640	340	175	Y	Y	Y	Y	Y
8:00	132	148	258	397	655	280	148	Y	Y	Y	Y	N
9:00	79	123	229	304	533	201	123	Y	Y	N	Y	N
10:00	62	114	233	259	492	176	114	Y	N	N	N	N
11:00	54	117	285	236	521	171	117	Y	N	N	N	N
12:00	58	106	282	324	606	164	106	Y	Y	N	Y	N
13:00	54	124	280	353	633	178	124	Y	Y	Y	Y	N
14:00	93	150	347	413	760	243	150	Y	Y	Y	Y	Y
15:00	76	219	368	407	775	295	219	Y	Y	Y	Y	Y
16:00	79	223	409	388	797	302	223	Y	Y	Y	Y	Y
17:00	79	196	502	363	865	274	196	Y	Y	Y	Y	Y
18:00	67	146	292	257	549	213	146	Y	Y	N	Y	N
								12 of 8	10 of 8	7 of 8	10 of 4	5 of 1

Warrant Analyses

Warrant 1: Condition A Minimum Vehicular Volume Warrant is Met
Warrant 1: Condition B Interruption of Continuous Traffic Warrant is Met
Warrant 1: Combination of Warrants 1A and 1B is Not Met
Warrant 2: Four-Hour Warrant is Met
Warrant 3: One-Hour Warrant is Met

Appendix B

Crash Diagram and Crash Rate Calculation

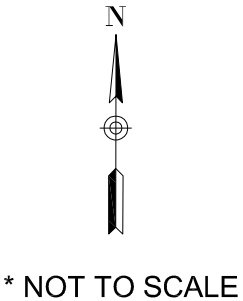


ROWLEY, MA
ROUTE 1 (NEWBURYPORT TURNPIKE) AT GLEN STREET AND
CENTRAL STREET
REGION: MERRIMACK VALLEY PLANNING COMMISSION

COLLISION DIAGRAM

TIME PERIOD ANALYZED: JANUARY 2014 - DECEMBER 2019
SOURCE OF CRASH REPORTS: MassDOT
DATE PREPARED: APRIL 14, 2019
PREPARED BY: NJE

SYMBOLS	MANNER OF CRASH	SEVERITY
Moving Vehicle	Rear End	Injury
Backing Vehicle	Head On	Fatal
Non-Involved Vehicle	Angle	Night Time Crash
Pedestrian	Turning Movement	
Bicycle	Sideswipe	
Animal	Out of Control	
Parked Vehicle		
Fixed Object		



Crash Data Summary Table
Route 1 (Newburyport Turnpike) at Glen Street and Central Street, Rowley MA
January 2014 - December 2019

Crash Diagram Ref #	Crash Date	Crash Day	Time of Day	Manner of Collision	Injury Status	Light Condition	Weather Condition	Road Surface	Driver Contributing Code	Comments
1	02/13/14	Thursday	3:02 PM	Rear-end	No Injury	Daylight	Snow	Snow	Inattention	Operator #1 slowed down and stopped at the intersection and Vehicle #2 backed into and struck the rear portion of Vehicle #1. Operator #2 stated that while plowing snow and clearing the intersection, he unknowingly backed into Vehicle #1. A witness stated that Operator #2 caused the collision by backing into Vehicle #1.
2	05/05/14	Monday	7:40 AM	Angle	No Injury	Daylight	Clear	Dry	Failed to yield right of way	Operator #2 said he was traveling on Glen Street and had stopped at the intersection of Route 1 or Newburyport Turnpike and was attempting to cross the intersection and continue onto Central Street. Operator #2 could not see Vehicle #1 traveling northbound on Newburyport Turnpike and in doing so travelled directly in the path of Vehicle #1 causing the accident.
3	12/19/14	Friday	5:09 PM	Angle	No Injury	Dark - Lighted Roadway	Clear	Dry	Inattention	Vehicle #1 was driving southbound approaching Glen St. on Route 1 and said he was passing a truck on the right which was stopped in the center lane waiting to make a left turn onto Central Street. Vehicle #2 was stopped on Central Street waiting for a break in traffic then proceeded to cross Route 1 to Glen Street when her vehicle was struck in the right rear quarter by Vehicle #1 as she entered Glen Street. Operator #1 said because of a stopped truck she never saw Vehicle #2 crossing Route 1. Operator #2 stated that she was crossing Route 1 onto Glen Street when she was struck by Vehicle #2 who was traveling southbound on Route 1.
4	10/25/15	Sunday	2:08 PM	Single Vehicle Crash	No Injury	Daylight	Clear	Wet	No Improper Driving	Vehicle was traveling south on Route 1 Newburyport Turnpike at Glen Street when a deer ran out and struck the vehicle along the right side causing damage to both doors and the side mirrors were destroyed along with a cracked windshield and dent on the motorvehicle roof. The deer ran across to the woods on Central Street side of Route 1 after the collision.
5	12/18/15	Friday	2:53 PM	Angle	Non-incapitating	Daylight	Cloudy	Dry	Failed to yield right of way	This collision was caused by the failure of Operator #1 to use caution and due regard while crossing the Newbury Turnpike and Central Street intersection. Operator #1 stated he was traveling straight across Glen Street and he did not see Vehicle #2. Operator #2 stated she was traveling northbound when Vehicle #1 pulled into her path. Operator #3 stated that she saw Vehicle #1 edging out into traffic and then suddenly pulled out into the intersection and into the path of Vehicle #2.
6	02/04/16	Thursday	4:28 PM	Angle	No Injury	Dusk	Cloudy	Dry	Failed to yield right of way	Vehicle #1 was traveling northbound on the Newburyport Turnpike and was struck by Vehicle #2 as it passed through the intersection of the Newburyport Turnpike at Central and Glenn Streets. Operator #2 was attempting to turn left onto Central Street from the left turn lane of the Newburyport Turnpike. Operator #2 misjudged the distance and/or speed of Vehicle #1.
7	03/15/16	Tuesday	5:02 PM	Angle	No Injury	Dusk	Cloudy, Rain	Wet	Failed to yield right of way	Vehicle #2 was traveling southbound on Route 1 when Vehicle #1 T-boned him as he was passing the intersection of Central Street and Route 1. Operator #2 also stated he was traveling 45 m.ph. Operator #1 stated she proceeded through the intersection towards Glen Street and did not see Vehicle #2 in time and struck the side of the Vehicle #1. Vehicle #2 had the right of way on Route 1 combined with the damaged areas on each vehicle.
8	09/22/16	Thursday	5:24 PM	Rear-end	Non-incapitating	Daylight	Clear	Dry	Inattention	Operator #2 was facing westbound on Central Street at the Route 1 intersection. Operator #2 was struck from behind by Vehicle #1 and pushed into the intersection of Central Street and Route 1. Operator #1 indicated that he thought Vehicle #2 was moving and subsequently struck the rear of Vehicle #2 with the front bumper of Vehicle #1.
9	12/28/16	Wednesday	3:45 PM	Angle	No Injury	Daylight	Cloudy	Dry	Failed to yield right of way	Operator #1 was traveling northbound on Central Street when she observed Vehicle #2 traveling westbound cross the intersection. Vehicle #1 stated that Operator #2 was on the phone and then went into the intersection. Vehicle #1 stated she was unable to stop and struck Vehicle #2. Operator #2 stated she stopped aat a stop sign at Central Street westbound and saw Vehicle #1 in the left turn lane northbound. Operator #2 stated that Operator #1 waved her hand at the intersection so she proceeded and then struck Vehicle #1.
10	07/21/17	Friday	6:17 PM	Angle	No Injury	Daylight	Clear	Dry	Failed to yield right of way	Vehicle #1 was traveling south on the Newburyport Turnpike and attempted to make a left hand turn onto Central Street. Vehicle #1 failed to yield for the oncoming traffic. Vehicle #1 was struck by Vehicle #2 on the passenger side rear door and sent across the northbound travel lane causing it to strike Vehicle #3 which was stopped in traffic and preparing to make a right turn onto the Newburyport Turnpike.
11	09/17/17	Sunday	3:35 PM	Angle	Incapacitating	Daylight	Rain	Wet	Failed to yield right of way	Vehicle #1 was traveling south on the Newburyport Turnpike. As Vehicle #1 passed through the intersection of the Newburyport Turnpike and Glen Street it was struck on its left rear saddle bag by Vehicle #2. Vehicle #2 was attempting to cross the Newbuport Turnpike from Central Street an stated that he did not see vehicle #1. After being struck, Vehicle #1 ran off the road to the right and began to tumble throwing Operator #1 out of his vehicle. Operator #1 tumbled and was thrown approximately 90 feet before hitting a sign post. Operator #1 sustained serious injury and was tranported tby EMS to Beverly Hospital.
12	11/01/17	Wednesday	5:24 PM	Angle	Possible	Dusk	Clear	Dry	Failed to yield right of way	Vehicle #1 was traveling northbound when Vehicle #3 made a right hand turn from Central Street onto the Newburyport Turnpike failing to grant the right of way to Vehicle #1. Vehicle #1 struck Vehicle #3 and then veered to the left striking Vehicle #2 which was waiting to make a left onto Central Street from the Turnpike.
13	12/15/17	Friday	7:32 PM	Angle	Possible	Dark - Lighted Roadway	Clear	Dry	Stop Sign Violation	Operator #2 stated he was driving northbound on Route 1, when Vehicle #1 cut across Route 1 from Central Street to Glen Street. Operator #2 stated he locked up his brakes and tried to stop. Operator #2 stated that Vehicle #1 spun around and struck the front bumper of Vehicle #3 with the front bumper of Vehicle #1 . Operator #1 failed to stop at the stop sign on Central Street going towards Route 1.
14	06/15/18	Friday	8:19 AM	Angle	Fatal Injury	Daylight	Rain	Wet	Disregarded traffic signs, signals, and road markings	Vehicle #1 was traveling southbound on Route 1. Operator #1 stated that there was a dumptruck waiting to make a left turn onto Central Street from Route 1 southbound. Vehicle #1 indicated that Vehicle #2 pulled out from Central Street, across the Route 1 intersection going towards Glen Street. Vehicle #1 pulled out in front of the southbound stopped traffic waiting to turn left and was struck by the dumptruck.
15	08/10/18	Friday	5:04 PM	Rear-end	No Injury	Daylight	Clear	Dry	Inattention	The accident happened westbound on Central Street. Operator #2 fully admitted to being inattentive approaching the intersection where she was unable to come to a full stop before striking the rear of Vehicle #1, which was stopped at the blinking red traffic light waiting to take a right turn onto the Newburyport Turnpike.
16	08/14/18	Tuesday	4:27 PM	Angle	No Injury	Daylight	Cloudy	Wet	Failed to yield right of way	Vehicle #1 was traveling northbound on Newburyport Turnpike when Vehicle #2 was attempting to cross the Turnpike, from Central Street to Glen Street. Vehicle #2 collided with Vehicle #1 during that attempt.
17	08/25/18	Saturday	1:16 PM	Angle	Non-incapitating	Daylight	Clear	Dry	Visibility Obstructed	Operator #1 stated he was trying to cross Route 1 from Glen Street to Central Street at a stop sign. The northbound traffic was clear and when he saw a southbound truck turn right, he thought he was clear to cross Route 1. When he observed Vehicle #2, a motorcycle, proceeded southbound within the southbound lane it was too late to stop and he was already obstructing the lane. Operator #2 stated he was traveling southbound when the SUV type vehicle in front of thim turned right on Glen St. Vehicle #1 pulled into his lane of travel causing him to vrake hard but he was unable to avoid a collision.

Crash Data Summary Table
Route 1 (Newburyport Turnpike) at Glen Street and Central Street, Rowley MA
January 2014 - December 2019

Crash Diagram Ref #	Crash Date	Crash Day	Time of Day	Manner of Collision	Injury Status	Light Condition	Weather Condition	Road Surface	Driver Contributing Code	Comments
18	03/13/19	Wednesday	4:07 PM	Sideswipe, angle direction	No Injury	Daylight	Clear	Dry	Unknown	A witness stated that Vehicle #1 entered the intersection without stopping causing a sideswipe collision with Vehicle #2. Operator #2 stated while traveling northbound he saw Vehicle #1 approach the intersection and it appeared the vehicle was going to slow down but then the vehicle sped up as he approached Central Street causing a collision between the two vehicles.
19	05/22/19	Wednesday	7:27 AM	Angle	No Injury	Daylight	Clear	Dry	Failed to yield right of way	Vehicle #1 was traveling southbound on Newburyport Turnpike and Vehicle #2 was traveling westbound crossing Newburyport Turnpike from Central Street to Glen Street. Vehicle #1 stated that there was a large truck stopped in the left turn lane waiting to turn left onto Central street from Newburyport Turnpike. Vehicle #2 stated that she proceeded into the intersection after stopping at the stop sign at Central Street and Newburyport Turnpike in an attempt to proceed through the intersection to Glen Street. Vehicle #1 continued traveling south in the travel lane and struck the left front fender and tire of Vehicle #2. Vehicle #1 stated that he did not see the car enter the intersection due to the truck blocking his view and proceeded at the speed limit past the truck remaining in the straight travel lane south because he had the right of way through the interesection.
20	06/24/19	Monday	4:57 PM	Rear-end	No Injury	Daylight	Clear	Dry	Unknown	While at a stop sign waiting to turn right onto Newburyport Turnpike northbound, Vehicle #1 was struck in the rear by Vehicle #2. While on the scene, he observed minor damage to the front end of Vehicle #2, and also minor damage to the rear end of Vehicle #1.
21	10/09/19	Wednesday	7:26 AM	Sideswipe, same direction	No Injury	Daylight	Clear	Dry	Failure to keep proper lane or running off road	Operator #1 stated that Vehicle #2 was pulled up to the intersection and was appearing to go straight threw with no indication of making a turn. He then stated that he pulled up beside Vehicle #2 also turned southbound last minute causing a collision between the two vehicles. The operator of Vehicle #2 confirmed the same stating he couldn't see Vehicle #1 beside him.
22	11/15/19	Friday	8:45 AM	Sideswipe, same direction	No Injury	Daylight	Clear	Dry	Unknown	Operator #1 stated he was traveling southbound and didn't see Vehicle #2 in the intersection until the last minute causing him to collide with the rear bumper. The operator of Vehicle #2 stated she came to a complete stop and looked in either direction and procdeede through the intersection as she believed she had enough time. Vehicle #1 struck the rear passenger side of Vehicle #2 with its drivers side front bumper causing minor damage to both vehicles. An ambulance arrived but both operators refused treament. Both vehicles left on their own power.

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Rowley COUNT DATE : 3/12/2020

DISTRICT : 4 UNSIGNALIZED : ☒ X SIGNALIZED : ☐

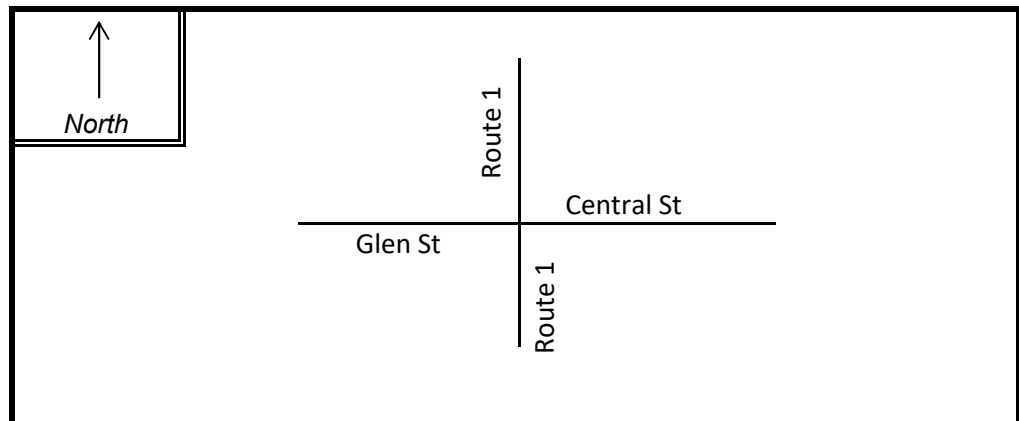
~ INTERSECTION DATA ~

MAJOR STREET : Route 1 (Newburyport Turnpike)

MINOR STREET(S) : Central Street

Glen Street

INTERSECTION
DIAGRAM



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :	Rte 1 NB	Rte. 1 SB	Central St.	Glen St.		
PEAK HOURLY VOLUMES (PM) :	487	357	75	187		1,107

" K " FACTOR :

0.090

INTERSECTION ADT (V) = TOTAL DAILY
APPROACH VOLUME :

12,295

TOTAL # OF CRASHES :

22

OF YEARS
:

6

AVERAGE # OF CRASHES
PER YEAR (A) :

3.67

CRASH RATE CALCULATION :

0.82

$$\text{RATE} = \frac{(A * 1,000,000)}{(V * 365)}$$

Comments : Average weekday ATR volumes used.

Project Title & Date: Newburyport Turnpike (Route 1) at Central Street and Glen Street, 4/20/2020

Appendix C

Concept Design Plans and Cost Estimates



ALTERNATIVE 1 - SIGNALIZED INTERSECTION



HNTB For ROWLEY — SIGNALIZED CONCEPT		Job Number 609392
	Made by DTM	Sheet Number 2 OF 2
	Checked by CW	

MA:60920 MassDOT MSA\Assignment\41 Rowley Rte 1\609392 CAD Design\Project Drawing Data\DWG\References\REF\HD\60920_HD_Concept_Signalized.dwg 4/17/2020 3:30 PM

<div><div>HNTB</div><div>The HNTB Companies Engineers Architects Planners</div></div>	Made	DTM	Date	4/13/2020	Job Number	6009329	
	Checked	JH	Date	4/13/2020			
For	Route 1 at Central Street Intersection Improvements		Backchk'd	JH	Date	4/17/2020	Sheet No.

ALTERNATIVE 1 - SIGNALIZED INTERSECTION

Item Description	Qty	Unit	Unit Cost	Subtotal
Traffic Signal	1	LS	\$ 200,000	\$ 200,000
Dynamic Stop Ahead Signs	2	LS	\$ 30,000	\$ 60,000
Pavement Micromilling and Overlay	11,300	SY	\$ 30	\$ 339,000
Granite Edging, Type SB	600	LF	\$ 45	\$ 27,000
Truck Apron	150	SY	\$ 105	\$ 15,750
Hot Mix Asphalt Berm	750	SY	\$ 13	\$ 9,750
Full Depth Widening	920	SY	\$ 85	\$ 78,200
Guardrail	1	LS	\$ 30,000	\$ 30,000
hard cost subtotal				\$ 759,700
Signing & marking	2%			\$ 16,000
Temporary Traffic Control	2%			\$ 16,000
Mobilization	3%			\$ 23,000
Subtotal				\$ 814,700
<u>Contingency items</u>				
Utility Relocation Costs			5%	\$ 40,735
Construction Contingency			10%	\$ 81,470
Design Contingency-Roadway Construction			15%	\$ 122,205
Traffic Police			4.5%	\$ 36,662
Right of Way Costs			5%	\$ 40,735
TOTAL COST				\$ 1,137,000



SCALE: 1" = 60'

ALTERNATIVE 2 - SINGLE-LANE ROUNDABOUT

HNTB	Job Number	
	609392	
	Sheet Number	
For ROWLEY - ROUNDABOUT CONCEPT	Made by DTM	1 OF 2
	Checked by JH	

<div><div>HNTB</div><div>The HNTB Companies Engineers Architects Planners</div></div>	Made	DTM	Date	3/18/2020	Job Number	609392	
	Checked	JH	Date	4/13/2020			
For	Route 1 at Central Street Intersection Improvements		Backchk'd	JH	Date	4/17/2020	Sheet No.

ALTERNATIVE 2 - SINGLE-LANE ROUNDABOUT

Item Description	Qty	Unit	Unit Cost	Subtotal
Retaining Wall	1,200	SF	\$ 260	\$ 312,000
Old Pavement Excavation	5,384	SY	\$ 20	\$ 107,689
Full Depth Construction	5,644	SY	\$ 85	\$ 479,721
Cement Concrete Pavement (Splitter Islands)	567	SY	\$ 65	\$ 36,869
Granite Edging, Type SB	3,571	LF	\$ 45	\$ 160,695
Truck Apron	517	SY	\$ 105	\$ 54,238
Clearing and Grubbing	0.15	A	\$ 30,000	\$ 4,500
Lighting	1	LS	\$ 55,000	\$ 55,000
Relocate Wall Southeast Quadrant	1	LS	\$ 140,000	\$ 140,000
hard cost subtotal				\$ 1,350,713
Signing & marking	2%			\$ 28,000
Drainage and BMP	8%			\$ 109,000
Temporary Traffic Control	5%			\$ 68,000
Mobilization	3%			\$ 41,000
Subtotal				\$ 1,596,713
<u>Contingency items</u>				
Utility Relocation Costs	6%		\$	95,803
Construction Contingency	10%		\$	159,671
Design Contingency-Roadway Construction	25%		\$	399,178
Traffic Police	4.5%		\$	71,852
Right of Way Costs	5%		\$	79,836
TOTAL COST				\$ 2,404,000