



To: Upper Charles Trail Committee
 Town of Hopkinton
 18 Main Street
 Hopkinton, MA 01748

Date: July 17, 2017

Memorandum

Project #: 13539.00

From: Kristin Caouette, PE

Re: Center Trail Connection
 Phase 5 Feasibility Study
 Hopkinton, MA

The purpose of this feasibility study is to identify locations where a crosswalk is feasible along SR-85 Hayden Rowe Street for the purpose of providing connectivity for a shared use path. Overall, traffic volumes and speeds were found to be uniform along the entire Study Area segment. Average daily traffic of 11,000-15,000 vehicles per day traveling at a free flow speed of 40 miles per hour suggests that installing crosswalks may be feasible but should be done with appropriate crosswalk enhancements to ensure that drivers are aware of the crosswalk with enough advanced warning to safely slow for crossing pedestrians or cyclists. Crosswalk enhancements that improve warning to drivers, calm traffic speeds, and enhance the visibility of pedestrians/cyclists are described in this study. It was observed that acceptable sight distance is achievable at locations north of College Street while College Street and all locations south of that point do not have appropriate sight distance and due to horizontal and vertical curves it is unlikely that acceptable sight distance can be achieved.

Existing Conditions

Traffic Volumes

Vehicular Traffic

Daily vehicle volumes were collected by the Town of Hopkinton at five locations along Hayden Rowe Street at various times of the year from 2013 to 2017. Table 1 summarizes the traffic volume data. Typical average daily traffic along Hayden Rowe Street is approximately 13,000 vehicles per day. Highest hourly traffic typically occurs during the morning peak hour and ranges from 1,185 vehicles per hour to 1,240 vehicles per hour. Peak evening traffic ranged from 1,010 vehicles per hour to 1,370 vehicles per hour. Traffic flow is fairly directional by time of day with morning traffic traveling toward the schools, locally, and Route 135/I-495/I-90 regionally and the reverse taking place in the evening. Overall, traffic volumes were found to be uniform along the entire segment for the data reviewed.

Table 1 Average Daily Traffic – Hayden Rowe Street (State Route 85)

Location	Daily Weekday ^a	Weekday Morning			Weekday Evening		
		Volume ^b	K-factor ^c	Dir. Dist. ^d	Volume ^b	K-factor ^c	Dir. Dist. ^d
North of Loop Road	12,540	1,185	9.4	73% NB	1,120	8.9	65% SB
South of McDermott Lane	13,780	1,240	9.0	77% NB	1,170	8.5	65% SB
North of Chamberlain St.	12,370	970	7.8	77% NB	1,170	9.5	63% SB
North of Fresh Water Farm Drive	14,770	1,230	8.3	72% NB	1,370	9.3	61% SB
North of Granite Street	11,150	1,240	11.1	78% NB	1,010	9.1	64% SB

<i>Average</i>	12,930	1,225 ^e	9.5	75% NB	1,170	9.0	64% SB
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- a Volumes expressed in vehicles per day
- b Volumes expressed in vehicles per hour
- c Ratio of peak hour traffic to daily traffic volumes
- d Directional Distribution of traffic
- e Data collected north of Chamberlain Street appears to be an outlier. This data was excluded from the average volume.

Pedestrian Traffic

One factor in evaluating the appropriateness of a crossing is unmet demand for a crossing. Available manual turning movement count data for network peak hours does not show an unmet demand for a pedestrian crossing. The purpose of this feasibility study, however, is to evaluate crossings that would be key to the connectivity of an extension of the Upper Charles River Trail. Given the existing demand on the Upper Charles River Trail, demand for a crossing would likely be realized with the trail extension.

Existing pedestrian volume data at key locations is summarized below.

Table 2 Peak Hour Pedestrian Volumes - Crossing Hayden Rowe Street

Location	Existing Crossing	Morning Peak Hour	Midday Peak Hour	Evening Peak Hour
High School driveway north	No crossing	0	1	0
Elementary School driveway	Marked crossing with Flashing signage, in roadway signage	3	5	1
McDermott Road/EMC2 Park	Marked crossing with static signage	0	n/a	0
Chamberlain Street	Marked crossing with static signage	0	n/a	n/a
Chestnut Street	Marked crossing with static signage and intersection warning beacon	0	1	0

Source: Manual Turning Movement Counts 2013 – 2016.

Speed Study

Speed data were collected using pneumatic tubes over a period of 24 or 48 hours on a typical weekday. Pneumatic tubes will record the speed of every vehicle passing by that point over the given period. The 85th percentile speed is a speed at or below which 85 percent of the observed traffic on the roadway travel, and is used as a typical measure of prevailing speed in the traffic engineering profession.

Free flow speeds on Hayden Rowe Street were generally highest in the southern segments and lowest in the northern segments. In the northbound direction free flow speeds range from 36 mph to 46 mph. In the southbound direction they range from 35 mph to 43 mph.

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Table 3 Speed Study - State Route 85 Hayden Rowe Street

Location	Speed Observations	Notes
North of Loop Road	Posted speed limit: 20 mph ^a	<i>Exceeds posted speed limit by greater than 10 mph.</i>
Northbound	85 th percentile speed: 36 mph	
Southbound	85 th percentile speed: 35 mph	
North of Hilltop Road	Posted speed limit: 40 mph	<i>Speed observations approximate to the posted speed limit.</i>
Northbound	85 th percentile speed: 40 mph	
Southbound	85 th percentile speed: 41 mph	
North of Chamberlain Street	Posted speed limit: 40 mph	<i>Speed observations approximate to the posted speed limit.</i>
Northbound	85 th percentile speed: 38 mph	
Southbound	85 th percentile speed: 39 mph	
South of Chamberlain Street	Posted speed limit: 40 mph	<i>Speed observations approximate to the posted speed limit.</i>
Northbound	85 th percentile speed: 38 mph	
Southbound	85 th percentile speed: 41 mph	
North of Granite Street	Posted speed limit: 40 mph	<i>Exceeds posted speed limit by less than 5 mph.</i>
Northbound	85 th percentile speed: 43 mph	
Southbound	85 th percentile speed: 43 mph	
South of Granite Street ^b	Posted speed limit: 40 mph	<i>Exceeds posted speed limit by approximately 5 mph.</i>
Northbound	85 th percentile speed: 46 mph	
Southbound	85 th percentile speed: 43 mph	

Note:

- a Speed limit traveling southbound south of Grove Street is posted as 20 mph while in the northbound direction it is posted as 20 mph "when flashing".
- b Speed study south of Granite Street is based on observations using a radar speed gun during the off-peak period. Slightly higher speeds were recorded during this period, as all vehicles are traveling at free flow speeds.

Crosswalk Evaluation

There is no singular guidance document for the installation of a midblock crosswalk. As an alternative, a number of key resources that continue to build upon one another have been consulted to provide a comprehensive series of considerations that should be made in order to validate the suitability of an uncontrolled crosswalk. The following criteria should be considered.

- **Sight distance:** Appropriate sight distance is available for vehicles and pedestrians based on AASHTO sight distance calculations or other comparable methods.
- **Vehicle Speed:** Vehicle operating speeds do not exceed 40 miles per hour.
- **Vehicle volume:** Vehicular average daily traffic does not exceed 15,000 vehicles and is not projected to exceed that threshold.

- › In the case that the average daily traffic does exceed 15,000 vehicles a marked crosswalk may still be considered if operating speeds are below 30 miles per hour
- › If there are four or more travel lanes and vehicular average daily traffic exceeds 12,000 vehicles or is projected to exceed 12,000 vehicles then a raised median should be provided.
- **Crosswalk Density:** Location is at least 300 feet from the nearest marked crossing location
- **Demand:**
 - › Typically pedestrian volume of 20 pedestrians (or 15 elderly/children) during the peak hour or 60 pedestrians during a four hour peak period. However, some resources recommend a threshold of 100 pedestrians during a four hour peak period.
 - › Presence of nearby attractions or generators for pedestrians should also be considered for installation of a crosswalk.
- **FHWA Recommendation:** The Federal Highway Administration has published a report of recommended guidelines for installing uncontrolled crosswalks. Given the vehicle speed, number of vehicle travel lanes, and vehicle volumes, this report will make one of three recommendations. Table 4 summarizes the recommendations. Recommendations concerning two lanes roads are bolded to highlight values applicable to this corridor.
 - › C – Candidate Site for marked crosswalk
 - › P – Possible increase in pedestrian crash risk may occur
 - › N – Marked crosswalks alone are insufficient
- **Safety:** A qualitative assessment of the projected positive and negative impacts to safety for all roadway users.
- **Recommended Crosswalk Enhancements:** Crosswalk enhancements are intended to enhance safety for pedestrians and bicyclists at locations that have some type of deficiency.

Table 4 Recommendations for Installing Marked Crosswalks and Other Needed Pedestrian Improvements at Uncontrolled Locations

Roadway Type	Vehicle ADT ≤9,000			Vehicle ADT >9,000 to 12,000			Vehicle ADT >12,000 to 15,000			Vehicle ADT >15,000		
	Speed Limit (miles per hour)											
	30	35	40	30	35	40	30	35	40	30	35	40
Two lanes	C	C	P	C	C	P	C	C	N	C	P	N
Three lanes	C	C	P	C	P	P	P	P	N	P	N	N
Multilane (four or more) with raised median	C	C	P	C	P	N	P	P	N	N	N	N
Multilane (four or more) without raised median	C	P	N	P	P	N	N	N	N	N	N	N

Source: Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations: Final Report and Recommended Guidelines. US Department of Transportation – Federal Highway Administration. Report No. FHWA-HRT-01-100, August 2005. Table 11.

Note: Source document should be referenced for detailed definitions of factors considered and recommendations provided.

Table 5 Crosswalk Evaluation – Loop Road

Criteria	Threshold	Observed	Finding
<i>Sight Distance</i>	Meets AASHTO recommendations based on travel speeds and roadway grade	Clear sight lines in both directions, no obstructions noted.	No obstructions on existing sight lines.
<i>Vehicle Volume</i>	Average Daily Traffic does not exceed 15,000 vpd. If volumes exceed 15,000 vpd then operating speeds must be below 30 miles per hour	Ranges from approximately 11,000 to 15,000 vpd	ADT is approaching the threshold of 15,000 vehicles per day.
<i>Vehicle Speed</i>	Does not exceed 40 mph	20 mph posted speed limit 35 mph operating speed	Operating and Posted speeds do not exceed 40 mph. Operating speeds exceed the posted speed limit.
<i>Roadway Geometry</i>	Raised median recommended if daily vehicle volumes exceed 12,000 vpd	One travel lane in each direction, no raised median.	A raised median is recommended to reduce crossing distance, provide refuge, and facilitate ability for pedestrians to find gaps.
<i>Crosswalk Density</i>	Minimum distance to a marked crossing, 300 feet	Approximately 600 feet (uncontrolled crossing, EMC2 Park/McDermott Lane)	Exceeds 300 feet.
<i>Pedestrian Demand</i>	Minimum of 20 pedestrians during peak hour or 60 pedestrians over a peak four hour period	5-10 pedestrians per hour existing demand. Extension of the Upper Charles River Trail could generate needed demand.	Demand is feasible with trail extension.
<i>FHWA Recommendation</i>	Based on roadway geometry and traffic operating speed.	ADT volumes less than 15,000 vehicles per day at speeds of 40 mph	C – Site is a candidate for a marked crossing.
<i>Recommended Crosswalk Enhancements</i>	Crash history should be considered when evaluating any crosswalk to help further identify existing deficiencies. Existing crosswalk enhancements including pedestrian activated flashers, pedestrian warning signage, and in-street pedestrian signage are all desirable safety enhancements. Measures such as enforcement and traffic calming should be considered to address speeds exceeding the posted limit. Other potential crosswalk enhancements that could be considered at this location are continental style crosswalk striping, a raised median for refuge, and bump-outs to improve pedestrian visibility and sight lines.		

Table 6 Crosswalk Evaluation – EMC2 Park and McDermott Lane

Criteria	Threshold	Observed	Finding
<i>Sight Distance</i>	Meets AASHTO recommendations based on travel speeds and roadway grade	Clear sight lines in both directions, no obstructions noted.	No obstructions on existing sight lines.
<i>Vehicle Volume</i>	Average Daily Traffic does not exceed 15,000 vpd. If volumes exceed 15,000 vpd then operating speeds must be below 30 miles per hour	Ranges from approximately 11,000 to 15,000 vpd	ADT is approaching the threshold of 15,000 vehicles per day.
<i>Vehicle Speed</i>	Does not exceed 40 mph	40 mph posted speed limit 40 mph operating speed	Posted limit and operating speed approximately 40 mph.
<i>Roadway Geometry</i>	Raised median recommended if daily vehicle volumes exceed 12,000 vpd	One travel lane in each direction, no raised median.	A raised median is recommended to reduce crossing distance, provide refuge, and facilitate ability for pedestrians to find gaps.
<i>Crosswalk Density</i>	Minimum distance to a marked crossing, 300 feet	Approximately 600 feet (uncontrolled crossing, elementary school)	Exceeds 300 feet.
<i>Pedestrian Demand</i>	Minimum of 20 pedestrians during peak hour or 60 pedestrians over a peak four hour period	Less than 5 pedestrians per hour existing demand. Extension of the Upper Charles River Trail could generate needed demand.	Demand is feasible with trail extension.
<i>FHWA Recommendation</i>	Based on roadway geometry and traffic operating speed.	ADT volumes less than 15,000 vehicles per day at speeds of 40 mph	N – Marked crosswalk alone is not sufficient
<i>Recommended Crosswalk Enhancements</i>	Crash history should be considered when evaluating any crosswalk to help further identify existing deficiencies. Potential crosswalk enhancements to consider at this location include in-street pedestrian signage, continental style crosswalk pavement markings, a raised median for refuge, ADA compliant infrastructure for mobility, rectangular rapid flashing beacons, bump-outs to improve pedestrian visibility and sight lines. Given the proximity of the 20 mph travel zone and the entrance to EMC2 Park, feasibility of moving the beginning of the reduced speed zone should be investigated.		

Figure 1 Loop Road – Sight Lines



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Figure 2 EMC2 Park/McDermott Lane – Sight Lines



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Table 7 Crosswalk Evaluation – Water Fresh Farm

Criteria	Threshold	Observed	Finding
<i>Sight Distance</i>	Meets AASHTO recommendations based on travel speeds and roadway grade	Clear sight lines in both directions, no obstructions noted.	Sufficient sight distance is likely achievable in the vicinity of Water Fresh Farm.
<i>Vehicle Volume</i>	Average Daily Traffic does not exceed 15,000 vpd. If volumes exceed 15,000 vpd then operating speeds must be below 30 miles per hour	Ranges from approximately 11,000 to 15,000 vpd	ADT is approaching the threshold of 15,000 vehicles per day.
<i>Vehicle Speed</i>	Does not exceed 40 mph	40 mph posted speed limit 40 mph operating speed	Posted limit and operating speed approximately 40 mph.
<i>Roadway Geometry</i>	Raised median recommended if daily vehicle volumes exceed 12,000 vpd	One travel lane in each direction, no raised median.	A raised median is recommended to reduce crossing distance, provide pedestrian refuge, and facilitate ability for pedestrians to find gaps.
<i>Crosswalk Density</i>	Minimum distance to a marked crossing, 300 feet	Approximately 700 feet (uncontrolled crossing, Chamberlain Street)	Exceeds 300 feet.
<i>Pedestrian Demand</i>	Minimum of 20 pedestrians during peak hour or 60 pedestrians over a peak four hour period	No existing demand. Extension of the Upper Charles River Trail could generate needed demand.	Demand is feasible with trail extension.
<i>FHWA Recommendation</i>	Based on roadway geometry and traffic operating speed.	ADT volumes less than 15,000 vehicles per day at speeds of 40 mph	N – Marked crosswalk alone is not sufficient
<i>Recommended Crosswalk Enhancements</i>	Crash history should be considered when evaluating any crosswalk to help further identify existing deficiencies. The 40 mph speed limit prohibits a marked crossing alone from being an appropriate implementation of a crosswalk Potential crosswalk enhancements to consider at this location include in-street pedestrian signage, continental style crosswalk pavement markings, a raised median for refuge, rectangular rapid flashing beacons, bump-outs to improve pedestrian visibility and sight lines.		

Table 8 Crosswalk Evaluation – Existing crossing at Chestnut Street

Criteria	Threshold	Observed	Finding
<i>Sight Distance</i>	Meets AASHTO recommendations based on travel speeds and roadway grade	No observed sight distance impact at the existing crossing. Sight lines continue to remain clear moving north of the intersection. Moving south, horizontal curve begins to limit sight distance.	Sight lines at the intersection are clear and remain clear north of the intersection (easement 180/182 Hayden Rowe Street).
<i>Vehicle Volume</i>	Average Daily Traffic does not exceed 15,000 vpd. If volumes exceed 15,000 vpd then operating speeds must be below 30 miles per hour	Ranges from approximately 11,000 to 15,000 vpd	ADT is approaching the threshold of 15,000 vehicles per day.
<i>Vehicle Speed</i>	Does not exceed 40 mph	40 mph posted speed limit 43 mph operating speed	Posted limit and operating speed approximately 40 mph.
<i>Roadway Geometry</i>	Raised median recommended if daily vehicle volumes exceed 12,000 vpd	One travel lane in each direction, no raised median.	A raised median is recommended to reduce crossing distance, provide pedestrian refuge, and facilitate ability for pedestrians to find gaps.
<i>Crosswalk Density</i>	Minimum distance to a marked crossing, 300 feet	Approximately 400 feet (uncontrolled, Teresa Road)	Exceeds 300 feet.
<i>Pedestrian Demand</i>	Minimum of 20 pedestrians during peak hour or 60 pedestrians over a peak four hour period	Less than 5 pedestrians per hour existing demand. Extension of the Upper Charles River Trail could generate needed demand.	Demand is feasible with trail extension.
<i>FHWA Recommendation</i>	Based on roadway geometry and traffic operating speed.	ADT volumes less than 15,000 vehicles per day at speeds of 43 mph	N – Marked crosswalk alone is not sufficient
<i>Recommended Crosswalk Enhancements</i>	Crash history should be considered when evaluating any crosswalk to help further identify existing deficiencies. The 40 mph speed limit prohibits a marked crossing alone from being an appropriate implementation of a crosswalk Potential crosswalk enhancements to consider at this location include in-street pedestrian signage, continental style crosswalk pavement markings, a raised median for refuge, rectangular rapid flashing beacons, bump-outs to improve pedestrian visibility and sight lines. Should a traffic signal be warranted, signalization would be an appropriate enhancement as well.		

Figure 3 Water Fresh Farms – Sight Lines



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Figure 4 Chestnut Street – Sight Lines



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Table 9 Crosswalk Evaluation – College Street

Criteria	Threshold	Observed	Finding
<i>Sight Distance</i>	Meets AASHTO recommendations based on travel speeds and roadway grade	Vertical curve limits sight lines, sufficient sight distance cannot be achieved traveling NB or looking left.	Sufficient sight distance cannot be achieved at this location.
<i>Vehicle Volume</i>	Average Daily Traffic does not exceed 15,000 vpd. If volumes exceed 15,000 vehicles per day then operating speeds must be below 30 miles per hour	Ranges from approximately 11,000 to 15,000 vpd	ADT is approaching the threshold of 15,000 vehicles per day.
<i>Vehicle Speed</i>	Does not exceed 40 mph	30 mph posted speed limit 43-46 mph operating speed	Posted limit does not exceed 40 mph, however, operating speed does exceed 40 mph.
<i>Roadway Geometry</i>	Raised median recommended if daily vehicle volumes exceed 12,000 vpd	One travel lane in each direction, no raised median.	A raised median is recommended to reduce crossing distance, provide pedestrian refuge, and facilitate ability for pedestrians to find gaps.
<i>Crosswalk Density</i>	Minimum distance to a marked crossing, 300 feet	Approximately 4,000 feet (uncontrolled crossing, Chestnut Street)	Exceeds 300 feet
<i>Pedestrian Demand</i>	Minimum of 20 pedestrians during peak hour or 60 pedestrians over a peak four hour period	No existing demand. Extension of the Upper Charles River Trail could generate needed demand.	Demand is feasible with trail extension.
<i>FHWA Recommendation</i>	Based on roadway geometry and traffic operating speed.	ADT volumes less than 15,000 vehicles per day at speeds of 43-46 mph	N – Marked crosswalk alone is not sufficient
<i>Recommended Crosswalk Enhancements</i>	Due to the limited sight distance caused by the horizontal and vertical curves in the roadway alignment this location is not a desirable location for an uncontrolled crossing. A signalized crossing such as a hybrid pedestrian beacon (often referred to as a HAWK) would be an appropriate signalized crossing if warranted.		

Figure 5 College Street – Sight Lines



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Bridge Crossing

Text

Cost Estimate

Table 10 provides and estimated order of magnitude costs for various crosswalk enhancements described.

Table 10 Crosswalk Enhancement Costs

Crosswalk Enhancement	Cost	Notes
<i>Continental Style crosswalk (1- crosswalk)</i>		
<i>In-street Warning Signage (1- two-sided sign)</i>		
<i>Advanced Warning Signage (1-pair of signs)</i>		
<i>Bump-outs (2-curb extensions)</i>		
<i>Advanced Yield Line marking (2 lanes)</i>		
<i>Raised Crossing (1- crosswalk)</i>		
<i>Raised Median (1-median island)</i>		
<i>Rectangular Rapid Flashing Beacon – push button actuated (1 pair)</i>	\$15,000 - \$30,000	Cost varies depending on power source
<i>Overhead Warning Beacon (1-two-way beacon)</i>	\$40,000 - \$60,000	Cost varies depending on mast arm size
<i>Hybrid Pedestrian Beacon – HAWK (1 HAWK system)</i>	\$60,000 - \$80,000	Cost varies depending on mast arm size

Findings

- All crosswalks should be striped in the Continental Style to improve visibility to drivers.
- Advanced warning signage should always be included as part of crosswalk installation. Existing signage, where observed, agrees with the current standards.

- Given the posted speed limit of 40 mph, FHWA Guidance does not find that an uncontrolled crossing alone is appropriate. Traffic calming measures should be considered at any potential crossing location. Lower travel speeds would be a safety benefit, however, the operational impacts during peak travel periods should also be considered.
 - › Narrow lane width
 - › Bump-outs
 - › Raised crossing
 - › Raised median
 - › Raised median with a Z-crossing to encourage pedestrians to observe oncoming vehicle traffic.
- Generally speaking, appropriate sight lines can be achieved for potential crossing locations north of College Street. Locations south of College Street (including the intersection with College Street) have significant sight distance constraints due to horizontal and vertical curve limitations in the roadway alignment.
 - › Along the entire corridor minor obstructions in the public right-of-way such as vegetation, utility poles, mail boxes, and political signage risk limiting sight lines.
- In locations where sight lines could be obstructed enhancements that improve visibility of the crossing should be considered.
 - › Bump-outs and raised medians can reduce pedestrian crossing distance. Raised medians have the additional benefit of allowing pedestrians to make a two-stage crossing. Narrower travel lanes can be implemented to help provide the necessary pavement width for such improvements.
 - › Supplemental warning signage including in-street pedestrian warning signs can be used to draw attention to a crossing. Similarly, advanced yield line markings can draw attention to a crossing.
 - › In locations with greater sight distance impacts overhead flashing beacons or rectangular rapid flashing beacons could be considered. Such systems could use active (push button) or passive (sensors) detection.
 - › In locations that do not have sufficient sight lines a controlled crossing may be necessary, such as a hybrid pedestrian beacon (HAWK).