T O W N O F M I L F O R D , N H
O F F I C E O F C O M M U N I T Y D E V E L O P M E N T
1 UNION SQUARE, MILFORD, NH 03055 TEL: (603)249-0620 WEB: WWW.MILFORD.NH.GOV

Date: **January 18, 2020**

To: **Planning Board**

From: **Lincoln Daley, Community Development Director**

Subject: **Amherst & Milford Bicycle / Pedestrian Connectivity Work Session**

BACKGROUND:

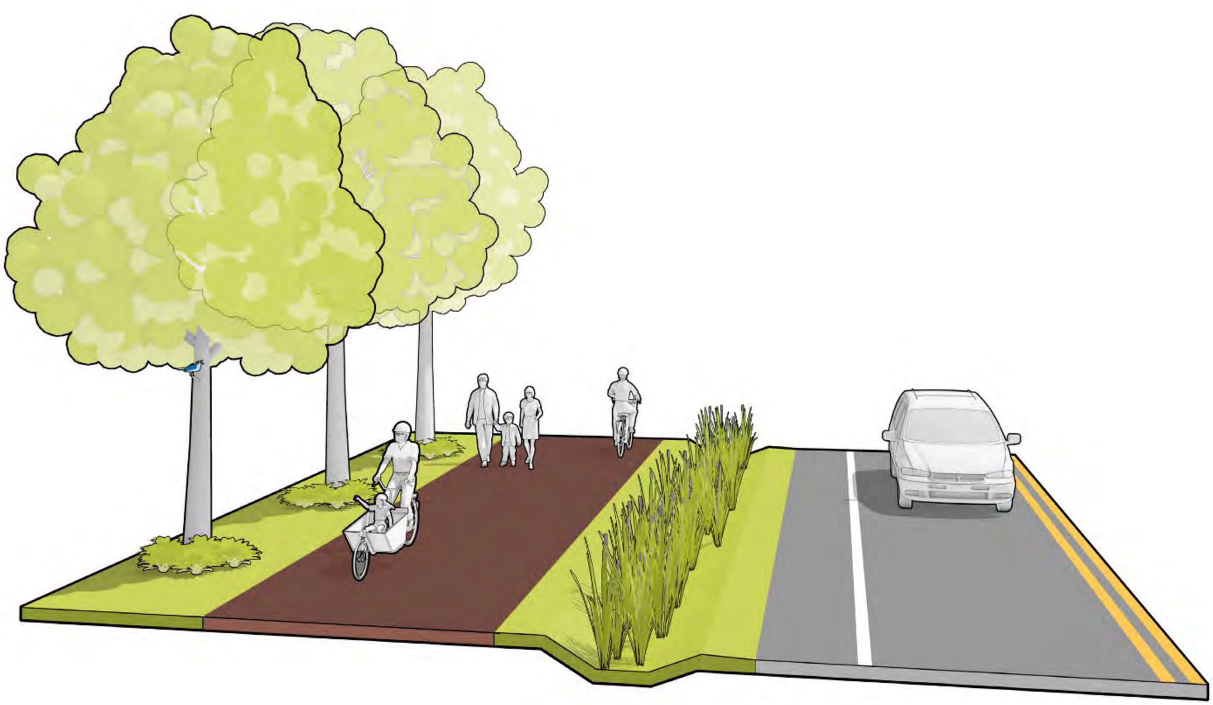
The Amherst Bicycle & Pedestrian Advisory Committee is seeking to construct a multimodal sidepath in 2020 on Amherst Street from Courthouse Road (Amherst Village) to the Milford town line. The intent of the project is to provide residents of the Town of Amherst with a safe and convenient connection for multimodal users between the Amherst Village and the Milford Oval as well as a physical and operational example of the implementation of systematic safety principles for multimodal transportation along a connecting street. The total distance of the sidepath is approximately 10,090 feet (1.9 miles) with an estimated cost of $287,500. (see attached)

The design and layout was based on Amherst's 2019 Multimodal Master Plan. The plan identified Amherst Street as primary connecting street between the two communities. The project would be completed in conjunction with the reconstruction of two segments of Amherst Street during the 2020 construction season. The terminus of the proposed sidepath will be approximately 500 feet from the Milford sidewalk associated with the recently approved Keogh Subdivision (118 Amherst Street). The section of Amherst Street in Milford has been identified as a high priority road to be reconstructed in 2020.

The purpose of the work session is to preliminarily discuss the Amherst project with the Amherst Bicycle & Pedestrian Advisory Committee, elected officials, representatives of the each community, and the NRPC to determine if there are opportunities to improve multimodal connectivity and pedestrian safety between Milford and Amherst. The discussion also presents an opportunity to revisit Milford's 2014 Pedestrian, Bicycle, Trail & Recreation Connectivity Plan (see attached) to re-evaluate/prioritize bicycle and pedestrian connectivity within the community and to our abutting municipal neighbors.

Village-to-Oval Multimodal Sidepath Project

Utilizing Systematic Safety Principles to Provide Multimodal Transportation Between the Amherst Village and the Milford Oval



Amherst Bicycle & Pedestrian Advisory Committee

Version 2.2
November 22, 2019

Contents

I. About this Project

The intent of this project is to provide residents of the Town of Amherst with a safe and convenient connection for multimodal users between the Amherst Village and the Milford Oval as well as a physical and operational example of the implementation of systematic safety principles for multimodal transportation along a connecting street.

This project could provide a showcase for the town which can demonstrate how the modification of the design of our roadways can lead to demonstrably safer transportation for all roadway users, whether by motor vehicle or otherwise.

This project proposal is different than common traffic safety suggestions as it seeks to shift the priority of road construction to consider engineering the safety of all road users into the design of the road itself.

Safety-based designs for multimodal users on roadways have been established and slowly implemented for decades in urban contexts, but there remain few rural solutions. The suggestions of this proposal are the direct result of Amherst's Multimodal Master Plan and is informed by designs from the Federal Highway Administration's 2016 Small Town and Rural Multimodal Networks guide to suggest effective methods for providing safe and comfortable transportation options for all roadway users.

What specific design considerations would this project offer?

- The utilization of **systematic safety principles** as a determination for where to separate people from motor vehicles

- The installation of **10,090 feet** of multimodal transportation facilities to connect the Amherst village to the Milford oval, including 5,775 feet of separated sidepath.

- The utilization of a **sidepath** as a separated, bidirectional, multimodal facility – a design that is especially appropriate for rural applications and is also cost-effective

- The consideration of **safer intersection designs** which reduce exposure to conflicts, reduce speeds, and allow for safe and convenient passage of multimodal users

- **Defining multimodal space** with terra cotta-colored hot-mix asphalt colorant, which lasts for the life of the pavement

- Providing an objectively safer space for multimodal users, allowing for more comfortable use of **environmentally-friendly transportation modes** (not just for recreation)

- A multimodal transportation system that does not rely on high levels of confidence, experience, or physical ability, allowing for **comfortable use by people of all ages**

II. Why Amherst Street?

The selection of Amherst Street for this project was not accidental. Based on the recommendations of Amherst's Multimodal Master plan, it is most opportune to implement multimodal road design modifications during the time of already-scheduled road construction.

By timing the construction of multimodal improvements with general road construction, it allows for the greatest possible efficiency in budget, engineering, and logistics. For example, many of the construction-related activities that are required for the installation of a sidepath are also required for general road work: a bidding process with contractors, repair/replacement of culverts, surveying, general stormwater management work, the logistics of assigning and using paving equipment, etc. By timing multimodal projects with general road construction, there is no need to duplicate many of these activities, but they may instead be done in tandem.

Figure 1

Areas of Scheduled Road Construction in 2020 colored in brown. A brown, dotted line represents possible construction, budget-allowing. Orange represents an on-road restriping configuration opportunity. Green represents existing sidewalks.

For this reason, the Bicycle and Pedestrian Advisory Committee consulted with the Department of Public Works to assess upcoming road construction efforts to select which already-scheduled efforts could be opportune multimodal efforts. In 2020, approximately 1 mile of Amherst Street is slated for significant road construction.

Amherst Street also offers a particular type of roadway the Multimodal Master Plan refers to as a "connecting street." These streets are of a particular character which is defined by higher speeds and traffic volumes, meriting a physical separation of motor vehicles from multimodal users. There are only a select few streets in the town of Amherst which offer such a roadway, allowing for this project to be a "showcase" opportunity to demonstrate a sidepath, a very specific type of multimodal treatment which is appropriate to this category of street.

Furthermore, Amherst Street is a major connector in our community. This street connects the Amherst Village with the Milford Oval, allowing for an opportunity to allow pedestrians and cyclists to safely and comfortably walk/bike from one community to another.

III. Budget

To fund this project, the Bicycle & Pedestrian Advisory committee recommends the inclusion of a single warrant article in the 2020 Amherst town ballot.

Article 32: Village-to-Oval Sidepath. To see if the Town will vote to appropriate the sum of $287,500 for the purpose of constructing a pedestrian/bicycle side path as part of the reconstruction of Amherst Street from Courthouse Road to the Milford town line, in accordance with the provisions of the Town of Amherst Multimodal Masterplan, as adopted 7/22/2019. This will be a non-lapsing appropriation per RSA 32:7, VI and will not lapse until the project is completed or by June 30, 2023.

This article provides for the construction of a multimodal sidepath on Amherst Street from Courthouse Road to the Milford town line. Total distance of the sidepath is approximately 10,090 feet (1.9 miles) and will connect the Amherst village to the Milford Oval.

The sidepath will be completed in conjunction with the reconstruction of two segments of Amherst Street during the 2020 construction season. At the projected cost of $28.50 per linear foot, the coordination of the two projects is estimated to save approximately $217,000 over the cost of constructing the sidepath as a stand-alone project.

The original project cost estimate of $235,000 has been revised to account for:

1. The extension of the sidepath from Boston Post Road to Courthouse Rd;
2. Provisions for crossing the Amherst Street and Boston Post Rd signalized intersection;
3. The addition of appropriate pavement marking at intersections and in areas where no construction/pavement will occur; and,
4. The addition of information and other signage for sidepath and roadway users.

For detailed information regarding the costs of the project, see the table below.

Detailed list of construction costs

Construction Element	Cost in Dollars
Construction of 5,775 feet of separated sidepath at 8 feet of with 5 feet of separation. This figure is based on pricing information provided by local paving companies and is informed by 2019-unit prices and quantities including requisite excavation, hot-mix asphalt colorant, installation of the sidepath base, tree trimming, stump removal, roadway structure adjustment, mailbox reset, etc.	255,000
Cost of delineating the “middle section” of the project where no scheduled road construction will occur – 5,315 feet of on-street “enhanced shoulder”, removal of existing pavement markings and application of new pavement markings.	12,000
Incremental cost of intersection treatments - stop bars, “shark’s teeth”, stop signs, yield signs, and/or other warning signs or devices to protect the movements on the multimodal path where it passes through intersections.	5,500
Potential costs due to the construction/layout of the path through the Amherst St-Rt-122 signalized intersection and repositioning of Amherst St over-head signal head.	2,000
Information signing at both ends of the multimodal path and major intersections (Main St and Lyndeborough Rd).	1,000
Information signing and warning signs on the route for users.	1,000
Installation of bollards or other devices to prevent unauthorized vehicle use.	6,000
Engineering review of the sidepath plans.	5,000
Total Project Cost	287,500

IV. Project Design Guidelines

The recommendations made for this project are derived from the Amherst Multimodal Plan (2019). The specific design attributes of those recommendations which are applicable to Amherst Street are provided below in greater detail.

A. Defining Multimodal Space by Color

Colored surfacing is a safety feature that communicates to road users that a portion of the roadway has been set aside for preferential or dedicated use by multimodal users and serves as a continuous reminder to drivers of the possibility of the presence of multimodal users as they merge or change lanes.

According to research, the use of colored surfaces both increases the awareness of spaces for non-motorized users, but also increases the perceived safety by multimodal users – resulting in increased use (Vera-Villarroel, et al. 2016).

In 2011, the FHWA provided interim approval for the optional use of green coloring for bike lanes. While efforts to roll out the use of green colored pavement have been successful, there are two reasons why green is not appropriate for the use as a sidepath in the context proposed in this proposal: (1) green is to be used for bike lanes, and the use of sidepaths in this proposal are to be multimodal – not exclusively for use by cyclists, and (2) bright green colors have been met with resistance with people finding its fluorescent color to be out of place in village contexts, finding colors with earthy tones to be more popular overall (Vera-Villarroel, et al. 2016).

Still seeking to utilize the benefits of colored pavement while not electing to use green paint leaves one option that achieves all goals while already being approved for use and currently in use across the state of New Hampshire: terra cotta.

FHWA Terra Cotta

Asphalt with Terra Cotta, hot-mix polymer colorant

It is the recommendation of this proposal to color all surface material of multimodal space terra cotta in its entirety, maximizing the benefits already described across the entire corridor. Utilization of coloring sporadically, such as only in intersections, fails to consistently convey delineation of multimodal facilities as a safe and comfortable space for all users.

Mitigating additional cost and recurring maintenance: use asphalt colorant, not paint

The use of paint as a surface colorant is very expensive and requires significant and recurring maintenance, especially in colder climates such as New Hampshire. Furthermore, its use modifies the properties of asphalt resulting in a surface that is more slippery and more likely to pool water. These reasons are just some of the many reasons why using paint to color multimodal space in the state of New Hampshire would be unpragmatic.

In order to provide a means of coloring multimodal space without the downsides of paint, this proposal recommends the use of hot-mix asphalt colorant to achieve this goal. Hot-mix asphalt colorant is a colored pigment that is added to asphalt in the manufacturing process. This practice is done across the country and internationally to provide asphalt coloring that (1) lasts for the lifetime of the asphalt with zero maintenance and (2) increases the durability of the asphalt itself.

Because colored asphalt pavement is fundamentally the same material as ordinary black asphalt pavement, it has the same strength, durability, and skid resistance as regular asphalt. It withstands snow plowing and sanding as well as uncolored pavement.

Asphalt pavement is almost always constructed in two or three layers. Because of the additional cost of terra cotta colorant, only the top layer, need be colored.

B. Designing Roadways According to Systematic Safety Principles

The cornerstone of this project proposal is to primarily inform the design of the roadway by systematic safety principles.

Systematic safety is a proactive approach to transportation safety that seeks to eliminate the opportunities which create high crash and injury risk by design. It posits that our traffic safety problems stem from two inherent human properties: (1) humans are vulnerable and (2) humans make mistakes, whether inadvertently or knowingly. While acknowledging these facts, systematic safety seeks to use engineering solutions to protect humans who use our transportation system by either (A) physically eliminating the possibility of a collision or else to (B) reduce the risk associated with conflicts that can still occur.

In order to understand how these considerations can be engineered into the roadway itself, one must first understand how the laws of physics dictate just how vulnerable people are.

There is a maximum safe speed for every type of conflict on the roadway.

Several studies show a predictable pattern in fatality risk. The risk of a fatal collision between a motor vehicle and a human (pedestrian, cyclist, etc.) increases slowly until impact speeds of approximately 25 mph. Above this speed, risk of fatal injury increases rapidly – the increase is between 3.5 and 5.5 times from 25 mph to 35 mph (orange line below).

For passengers in motor vehicles, side impact figures indicate even greater risk at around 40 mph (dotted-grey line below) and fatality rates increase dramatically at approximately 50 mph (red line below) for head-on collisions. These data provide general categories of roadways, each with their own design needs in order to minimize safety risks (Jurewicz, et al. 2016). This *systematic safety approach utilizes commonly accepted safety data to inform a categorization of road types and their appropriate corresponding design.*

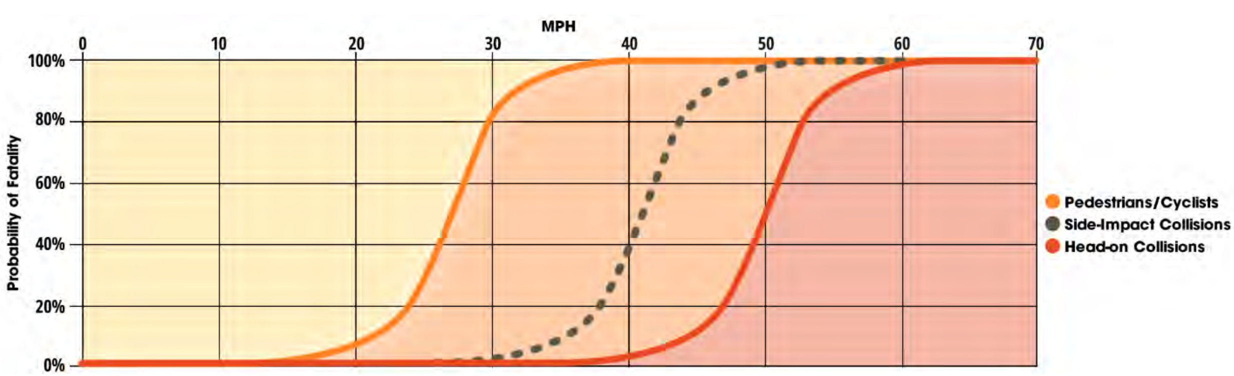


Figure 2
Wramborg's model for fatality probability vs. vehicle collision speeds (Jurewicz, et al. 2016)

By using this information and applying systematic principles, the design of our roadways should be informed by what design is most appropriate to the corresponding category above. The underlying concept is that **"roads should be designed either to separate users so that conflicts do not occur, or else to limit traffic speed based on the conflicts that will occur"** (Furth 2009)**.**

Where vulnerable road users are more commonly found and may cross the street anywhere or act in an unpredictable manner, the target speed achieved by the road design should be less than 25-30 mph (optimally, 20 mph or below), as at higher speeds the chance of surviving a collision falls rapidly. At that point, vulnerable road users should be physically separated from motor vehicles. At even higher speeds (approximately 50 mph), road design should separate vehicles from vehicles (by direction), based on the physical limitations of vehicles to absorb energy from head-on collisions without resulting in fatality.

C. Sidepath

Streets with speeds similar to Amherst Street are characterized by their traffic speeds/volumes being higher than those of local roads, but lower than those of turnpikes. Amherst Street, with its posted speed limits varying between 35 - 40 mph (with actual speeds likely higher), falls into the middle-category of fatal-potential as depicted below in orange (see **Figure 2**). In the Amherst Multimodal Master Plan, this category is referred to as the "connecting streets" category.

While the lower limit of this category is defined by exponentially higher risk of death in a collision between a vehicle and a vulnerable road user at ≈25-30 mph, the upper limit of this category is defined by the exponentially higher risk of death in a collision between a vehicle and another vehicle at ≈50 mph.

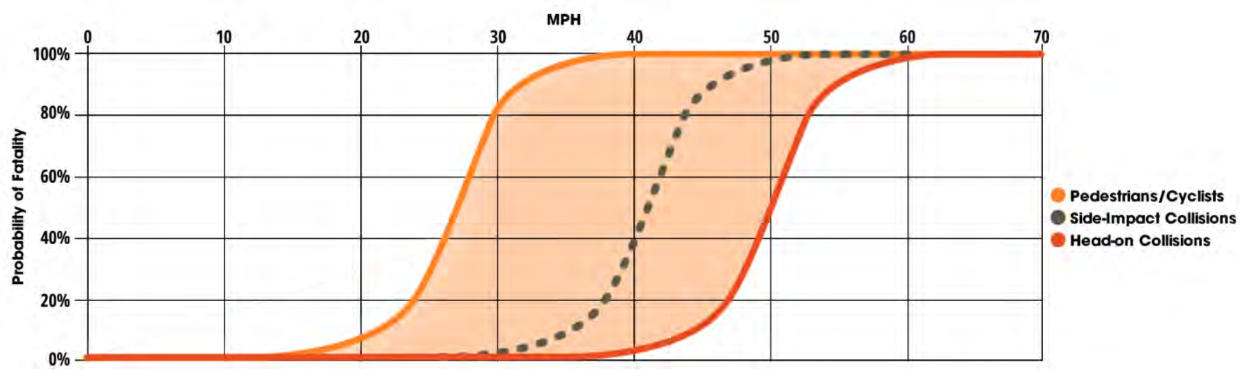


Figure 3
Wramborg's model for fatality probability vs. vehicle collision speeds, with Amherst Street's velocity category highlighted in orange (Jurewicz, et al. 2016)

For these streets, mixing of motorized traffic with vulnerable road users is no longer safe, thus segregation of vulnerable road users away from motorized traffic is the primary means of protection. Segregation on these roadways cannot be universally applied however, as intersections and crossings are an inevitable reality. As a result, physical and psychological traffic calming techniques must be employed at intersections and crossings in order to alter driver behavior in these areas.

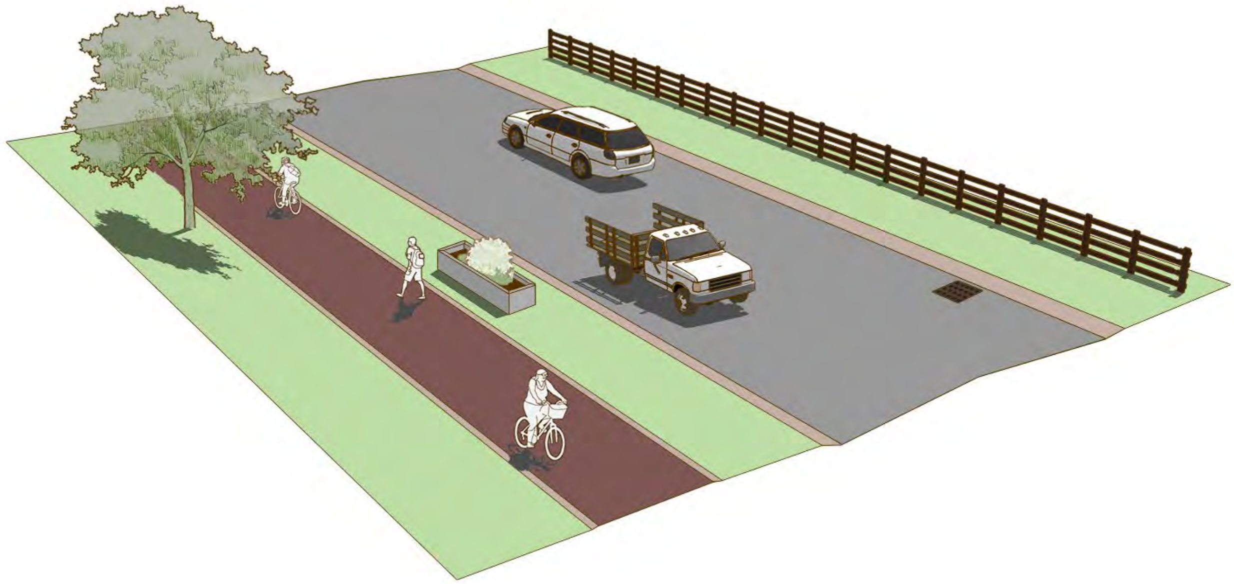
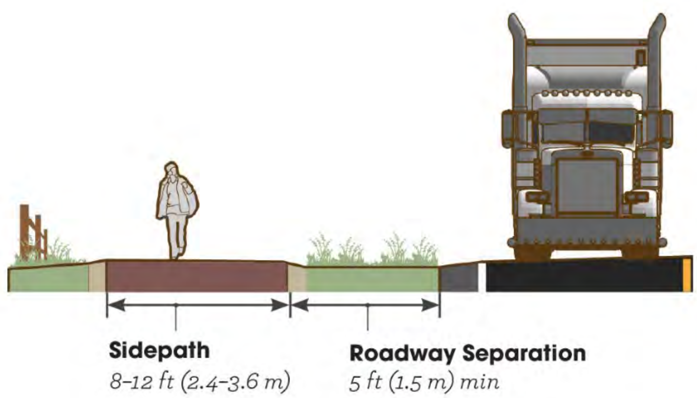


Figure 4
Sidepath (Federal Highway Administration 2016)

A sidepath is a paved, bidirectional, multiuse space beside the street. Sidepaths can offer a high-quality experience for users of all ages and abilities as compared to on-roadway facilities in heavy traffic environments, allow for reduced roadway crossing distances, and maintain rural and small-town community character.



Optimally, the sidepath is separated from the street by (at least) 5 feet of space, but this space can temporarily be narrowed by adding crashworthy, decorative obstacles or by adding a curb (See *Required Space* below).

Why not simply widen the shoulder?

The widening of shoulders alongside streets like Amherst Street might seem like a simple and inexpensive “solution” to provide some space to accommodate multimodal users, but this fails to follow systematic safety principles. While providing any space is more advantageous than not, extra space alongside fast-moving vehicular traffic would be a mediocre facility at best. Vehicular speeds on Amherst Street and other similar state highways are typically higher than 40 mph, meaning that any collision between a motor vehicle and a vulnerable road user would likely result in a fatality. For this reason, physical separation should be the only method of providing a multimodal facility.

Why not sidewalks?

Sidewalks are most appropriate in locations where, in addition to separating motor vehicles from vulnerable road users, pedestrian and bicycle traffic rates are also so high that they should be separated from each other (e.g. a sidewalk next to a bike lane). These installations are very appropriate for urban environments but are generally unnecessary in rural areas.

The population of rural areas are so low and sparse that it would be unlikely for any sort of multimodal traffic congestion to appear. Furthermore, New Hampshire's rural housing and points of interest are very sparsely distributed over a wide geographical area. This further complements the need for a *multimodal* network as opposed to a network of separate pedestrian facilities (sidewalks), as it is far more likely for users to use non-motorized wheeled modes (bicycles, roller skates, skateboards, etc.) to move across an area for transportation purposes.

The installation of conventional sidewalks alongside rural highways will always offer a mediocre facility, as state law forbids their use with wheeled vehicles, and they thus would become permanent fixtures that fail to accommodate other multimodal users (State of New Hampshire RSA 265:26 n.d.). It is the sidepath's truly multimodal characteristics that allows it to provide the most options for the most people, while still adhering to systematic safety principles.

Stormwater Management

The addition of sidepaths to a roadway presents an opportunity to introduce stormwater management strategies, including continuous treatments (e.g., linear bioretention areas, linear water quality swales, and permeable hardscape surfaces) and those that may only be implemented at spot locations. Their inclusion into the design of sidepaths is both a functional use of buffer areas and a sustainable way to enhance corridor aesthetics. Green stormwater infrastructure increases infiltration of water back into the ground, which improves water quality and reduces flooding.

Required Space

When considering modern road design and incorporating multimodal treatments in New Hampshire, a common problem arises. Our roadways are often legacies of the horse-and-carriage era with serpentine routing and narrow spaces between houses. This often poses a challenge when trying to incorporate a separate space for multimodal road users. Sidepaths will require the use of (at least) an 8' wide space offset from vehicles by a separating gap or design furniture. These key design features might lead one to quickly dismiss this design as too wide for many roadways, but this likely isn't the case.

Many of the state's highways will still offer adequate right of way today, but there remain several options to accommodate reductions in right of way.

By incorporating the reduction to narrowing the street's lane widths, sidepaths can be installed without a need to claim a substantial amount of space beside the street. This design can be further adapted to temporarily incorporate particularly narrow areas by adding a crashworthy barrier or curb in place of the typical 5' roadway offset (see **Figure 4** below for a visualization of this). For reference, most of Amherst Street's current roadway footprint spans 26' wide would span 30' to 34' if conventional sidewalks were added. This provides valuable context in considering the space needed for a sidepath.

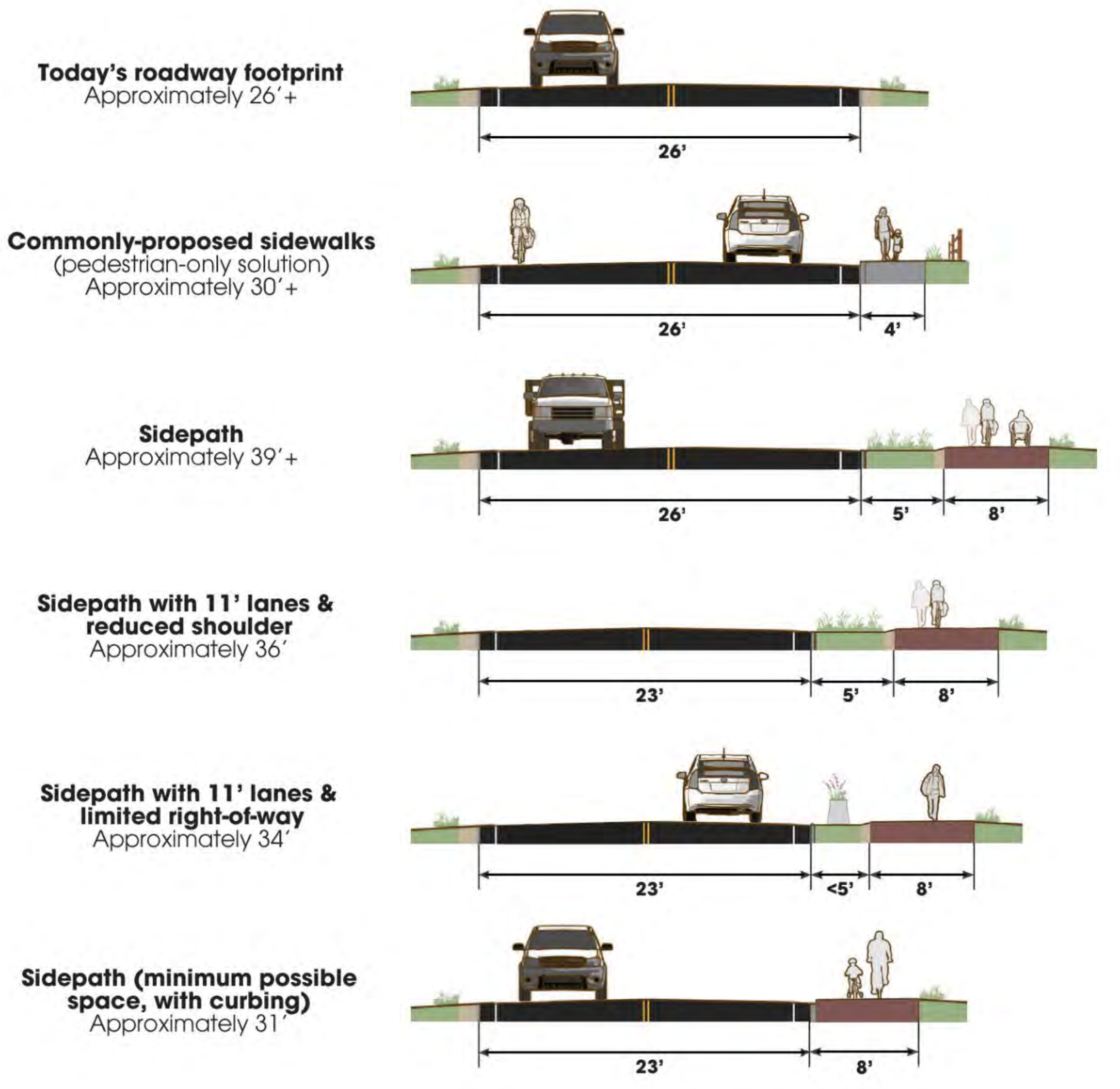


Figure 5

Comparative space required for various sidepath designs requiring minimum footprint (Federal Highway Administration 2016)

Determination of Sidepath Positioning

Because sidepaths are bidirectional, only one sidepath is required alongside vehicle space. As a result, great care should be made to determine on which side of the roadway the sidepath rests. Failure to do this will result in a more dangerous design in which the sidepath frequently crosses the vehicle space.

The following factors should be considered when selecting the sidepath's position:

- Minimizing number of intersections and other roadways
- Minimizing the number of necessary crossings
- Location of important destinations

- Connection with other multimodal facilities

It will be advantageous to keep the sidepath along one side of the roadway in its entirety if possible, but in the event that crossing is necessary, it is important to do this at a location where vehicle speeds are forced to be low by design, such as at a roundabout.

Grade Breaks/Transitions

The character of the grade of sidepaths should be like that of a road: gradual slopes that are accommodating of wheeled vehicles. The position of the sidepath should usually result in a space that is smooth and of a similar grade to that of the accompanying roadway. At some intersections and at driveways (especially if the sidepath is curbed), there may be a temptation to break the grade of the sidepath. This can result in a turbulent ride rendering the use of the sidepath to be undesirable, resulting in wheeled multi-modal users electing instead to use the roadway. It is vital to remember that the success of multimodal projects is not just based on a safe facility existing, but that it truly offers a viable, comfortable, and enjoyable alternative as well.

Figure 6
A sidepath/roadway intersection in which the sidepath's grade is maintained throughout (Wagenbuur 2011).

The priority should be to maintain an even slope of the sidepath as much as possible (especially at driveways and other interruptions) as frequent or radical changes in grade will make the space undesirable for any wheeled traffic. Sharp, frequent, or partial-width breaks in the sidepath's grade should always be avoided.

Driveways should not interrupt the sidepath

Driveways should not influence the grade of the sidepath

Driveways should not have priority over multimodal users in the sidepath, just as they would not have priority over vehicles in the roadway

The benefit of coloring multi-modal space terra cotta is best represented at these intersections, where color and grade clearly delineate sidepaths from vehicle space

Figure 7

Examples of important considerations of sidepaths at intersections with other roads and driveways (Wagenbuur 2011).

Key Sidepath Design Features

Design Attributes	
Attribute	**Description**
Roadway Category	Connecting Street
Volume	Can be used at any volume, generally reserve for higher volumes (~4200 ADT and above). Consider the function of the roadway when applying this treatment outside of standard ADT: "is this a local road or a connecting street?" Application may be appropriate if the function of the roadway does not reflect local character.
Actual Speeds	30 mph to 50 mph
Layout	Standard street with separated multimodal space
Total Roadway footprint	28+ ft wide (typically between 28-35 ft)
Self-enforcing speed mitigation	Permanent speed limitation through design (primarily lane narrowing, keep lanes as narrow as possible, strive for 11 ft lanes in most areas)
Context of emphasis	Traffic zone on the open road, public zone at intersections and in neighborhood/village areas
Signage	Limit signage to requirements, superfluous signage should be discouraged
Painted lines	May be used, though may be beneficial not to use for traffic calming within neighborhood/village contexts
Intersection treatments	Wherever sidepaths intersect with roadways, consider use of roundabout or mini-roundabout where appropriate. Alternatively, alter the character of the intersection using self-enforcing traffic calming techniques to keep actual speeds at 30 mph or below.
Traffic control devices	Optional
Desired interpretation by drivers	Some predictability, some uniformity (on the open roadway). Caution and discomfort at Intersections/Crossings.
Accessibility	Required to meet guidelines
Multimodal Space	
Attribute	**Description**
Separation	Physical Preferred minimum separation width is 6.5 ft. Minimum separation distance is 5 ft. Separation narrower than 5 ft may be accommodated with the use of a physical barrier between the sidepath and the roadway. Barrier and end treatments should be crashworthy which may introduce additional complexity if there are frequent driveways and intersections. Refer to the AASHTO Roadside Design Guide 2011 for additional information. Several separation techniques exist where space is limited, see section 3.2.1 b Required Roadway Footprint below.
Width	8-12 ft
Color	FHWA Terra Cotta. Technically "aesthetic treatment" to provide visual differentiation of the shoulder from the vehicular space (AASHTO Green Book 2011, p. 4-13).
Color application method	Recommended hot-mix asphalt colorant over conventional paint (Significant price savings, color lasts the life of the asphalt)
Treatment at crossings	Maintain physical separation of the sidepath at crossings. Consider widening separation at crossings. Where sidepaths cross street, provide multimodal crosswalks. Terra cotta background with "elephant's feet" markings (2' x 2' squares) Consider configuring crossings with raised speed table or "dustpan" style driveway geometry to create vertical deflection of turning vehicles. This physically indicates priority of path travel over turning or crossing traffic and helps reduce the risk associated with bidirectional sidepath use. Consider raised median island on the cross street to provide additional safety and speed management benefits. "Shark's Teeth" yield line at crosswalk
Vehicular Space	
Attribute	**Description**
Width	Varies
Color	None
Sight Distance	Standard
Separation by direction	No
Other Roadway Features	
Attribute	**Description**
Curbing	No preference
Storm Drain Placement	No preference
Guardrail Placement	If required, between sidepath and street
Landscaping	Trees and landscaping can maintain community character and add value to the experience of using a sidepath. They provide shade for users during hot weather and help to absorb storm water runoff. Provide a 3 ft horizontal clearance between trees and the pathway to minimize pavement cracking and heaving of the paved surface. Consult a local arborist in the selection and placement of trees. When trees are desired within the roadway separation area, consider planting small caliber trees with a maximum diameter of 4 inches to alleviate concerns about fixed objects or visual obstructions between the roadway and the pathway.

D. Signage for Sidepaths

The MUTCD offers an array of signage that is relevant for sidepaths and other "multi-use paths", this signage should not be confused with those for sidewalks or bike lanes.

MUTCD W11-15
for sidepaths/multi-use paths

MUTCD W11-1
for bike paths

MUTCD W11-2
for pedestrian crosswalks

Modified MUTCD R10-15
optionally used at crossings

MUTCD W7-5 for steep grade on sidepaths

Optional "Trail Courtesy" Sign

E. Intersection Considerations

Operational and safety concerns exist where sidepaths cross driveways and intersections. Crossings should be designed to promote awareness and visibility of conflict points and facilitate proper yielding of motorists to multimodal users.

Collision risk increases as the speed and volume of the parallel roadway increase. The AASHTO Bike Guide 2012 lists a variety of design strategies for enhancing sidepath crossings including:

- Reduce the frequency of driveways
- Design intersections to reduce driver speeds and heighten awareness of path users
- Encourage low speeds on pathway approaches
- Maintain visibility for all users
- Provide clear assignment of right-of-way with signs and markings and elevation change.

Maintain physical separation of the sidepath through the crossing. Sidepath separation distance should widen to allow space for 1 vehicle between the primary roadway and the side street. Separation distance could vary from 6.5 ft –16.5 ft. Separation distance may vary in response to available right of way and visibility constraints.

Use small roadway corner radii to enforce slow turning speeds of 20 mph or less.

The roadway and path approaches to an intersection should always provide enough stopping sight distance to obey the established traffic control and execute a stop before entering the intersection (AASHTO Bike Guide 2012).

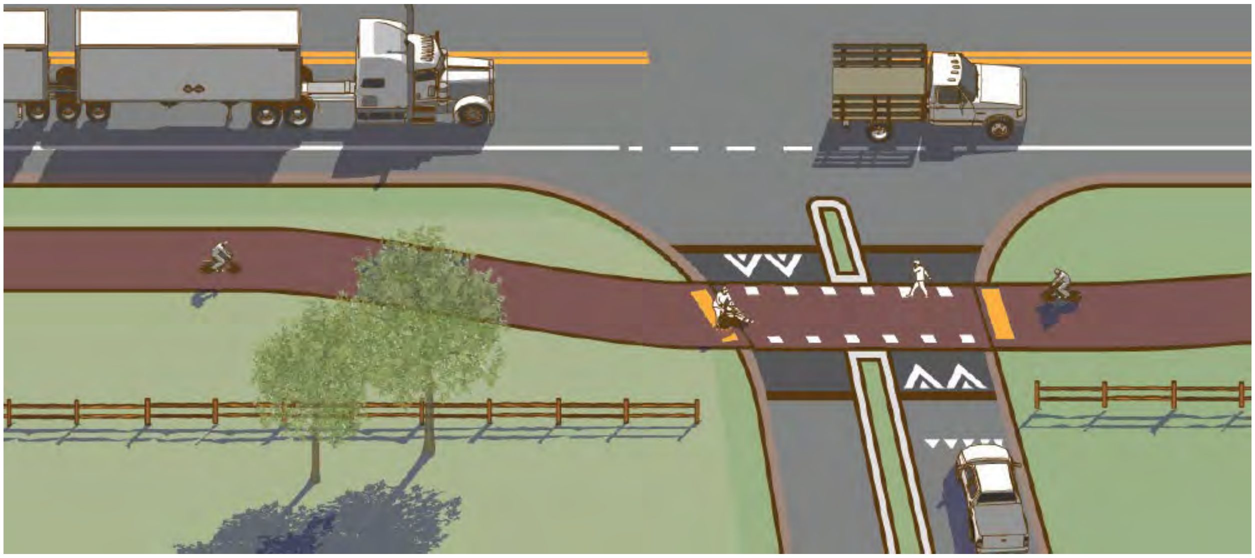


Figure 8
Depiction of a sidepath with a raised "dustpan" crossing

Configure crossings with raised speed table or "dustpan" style driveway geometry to create vertical deflection of turning vehicles. This physically indicates priority of path travel over turning or crossing traffic and helps reduce the risk associated with bidirectional sidepath use.

Painted Markings at Crossings

Use "elephant feet" markings to indicate the through crossing along the pathway. At low-volume residential driveways, crosswalk markings may be omitted. Use "shark's teeth" yield line markings in advance of the crossing to discourage encroachment into the crosswalk area.

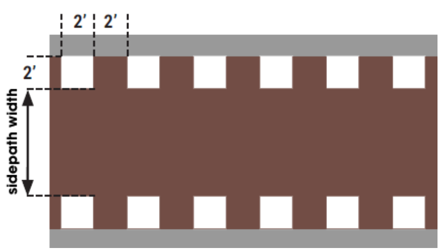


Figure 9
"Elephant feet" crosswalk for sidepath crossings

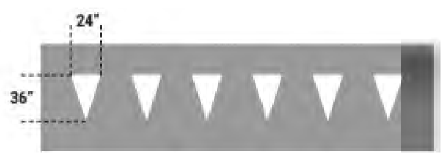


Figure 10
"Shark's teeth" yield line markings for motor vehicles

Figure 11
"Shark's teeth" yield line markings on a sidepath

Give the sidepath the same priority as the parallel roadway at all crossings. Attempts to require path users to yield or stop at each cross-street or driveway promote noncompliance and confusion and are demonstrably ineffective. Geometric design in these cases should promote a high degree of yielding to path users through geometric design.

Visual obstructions should be low to provide unobstructed sight of the crossing from the major street. Both motorists and path users should have a clear and unobstructed view of each other at intersections and driveways.

V. Project Details

While the Bicycle and Pedestrian Advisory Committee does not offer a prescription for every attribute and application of this project, some specific recommendations and considerations are offered.

A. Sidepath Location and Design

In seeking the minimization of the number of side street crossings and seeking to minimize the ADT of the side streets that must be crossed, it is recommended that the sidepath be placed on the Southern and Eastern side of Amherst Street

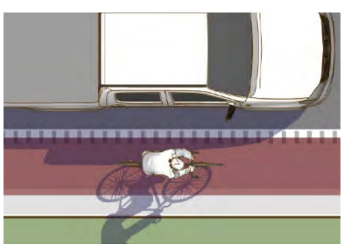
As roadway footprint and right of way vary, it is recommended that the separation between the roadway and the sidepath expand and contract to accommodate these variations – not the width of the sidepath. This will lead to a more predictable and comfortable experience for users of the sidepath, especially cyclists.

The project is divided into 3 distinct areas, described below from North to South:

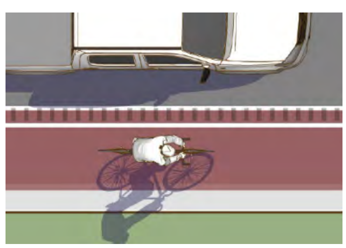
1. **Courthouse Road to Miles Road**
   The portion of Amherst Street between Miles Road and Courthouse Road is scheduled for road construction in 2020. This section of roadway offers a 4,725' opportunity for the installation of a separated sidepath facility. At the beginning and end of this segment, multimodal users can be deposited back on the existing roadway at the existing asphalt shoulder.

2. **Miles Road to Border Street**
   Where road construction is not scheduled to take place, an on-road solution is offered to provide multimodal users with 4,315' of space using paint. Coupled with the narrowing of lanes to no more than 11' in each direction, sufficient space should be available on the existing roadway to accommodate this design. Though this design is not intended to be the optimal, permanent, systematically safe design that a sidepath offers, this design does provide continuity across an area where road construction is not currently scheduled.

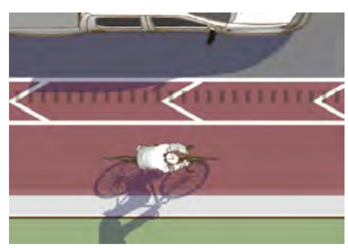
   Three designs are proposed by the FHWA "Small Town and Rural Design Guide" below, each offering a different buffer. Coloring the multimodal space with paint is an expensive proposition and is optional. The images below are from the FHWA and depict a colored multimodal space. Of these designs, the right-most is likely the most appropriate solution. "Self-Watering planters" may also be placed in the buffer space as a crashworthy physical barrier. Rumble strips are also optional within buffer space, so long as it does not impinge on the lane of traffic or into the pathway.



A wide 8" white line.



A narrow buffer space–two normal 4" solid white lines separated by an 18" or greater space.

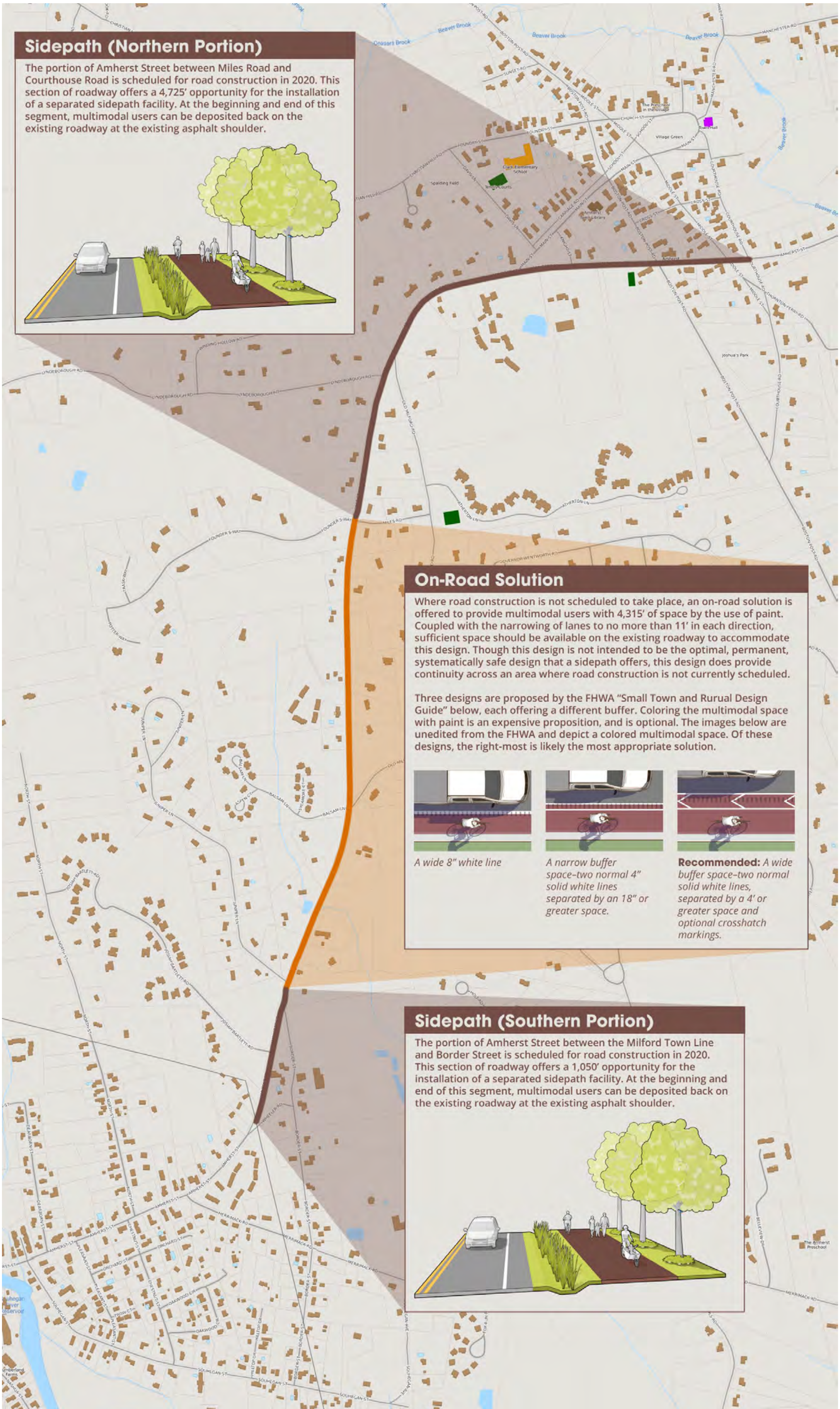


Recommended: A wide buffer space–two normal solid white lines, separated by a 4' or greater space and crosshatch markings.

3. **Border Street to the Milford Town Line**
   The portion of Amherst Street between the Milford Town Line and Border Street is scheduled for road construction in 2020. This section of roadway offers a 1,050’ opportunity for the installation of a separated sidepath facility. At the beginning and end of this segment, multimodal users can be deposited back on the existing roadway at the existing asphalt shoulder.

A map depicting many of these recommendations can be found below.

B. Map


Sidepath (Northern Portion)
The portion of Amherst Street between Miles Road and Courthouse Road is scheduled for road construction in 2020. This section of roadway offers a 4,725' opportunity for the installation of a separated sidepath facility. At the beginning and end of this segment, multimodal users can be deposited back on the existing roadway at the existing asphalt shoulder.
On-Road Solution
Where road construction is not scheduled to take place, an on-road solution is offered to provide multimodal users with 4,315' of space by the use of paint. Coupled with the narrowing of lanes to no more than 11' in each direction, sufficient space should be available on the existing roadway to accommodate this design. Though this design is not intended to be the optimal, permanent, systematically safe design that a sidepath offers, this design does provide continuity across an area where road construction is not currently scheduled.
Three designs are proposed by the FHWA "Small Town and Rural Design Guide" below, each offering a different buffer. Coloring the multimodal space with paint is an expensive proposition, and is optional. The images below are unedited from the FHWA and depict a colored multimodal space. Of these designs, the right-most is likely the most appropriate solution.
A wide 8" white line
A narrow buffer space–two normal 4" solid white lines separated by an 18" or greater space.
Recommended: A wide buffer space–two normal solid white lines, separated by a 4' or greater space and optional crosshatch markings.
Sidepath (Southern Portion)
The portion of Amherst Street between the Milford Town Line and Border Street is scheduled for road construction in 2020. This section of roadway offers a 1,050' opportunity for the installation of a separated sidepath facility. At the beginning and end of this segment, multimodal users can be deposited back on the existing roadway at the existing asphalt shoulder.

C. Specific Intersections

Major intersection improvements such as restructuring are not currently incorporated in budgeting for this project, though optimal solutions are included for consideration. Several intersection modifications, such as the inclusion of crosswalks and signage, are minor in nature and are incorporated into the scope of this project's budget. Other, more major intersection reconstructions are outside of the scope of this project as proposed and would be reliant on the Department of Public Works' existing budget scheduled road construction and improvements. It is also likely that some of these improvements will present a cost savings opportunity for the existing project's scope by the reduction of asphalt in some areas.

Amherst Street at Border Street

Fork-style intersections offer many challenges for multimodal users, especially on sidepaths. As they are currently laid out, sight distance is extremely poor forcing drivers to look reverse when approaching the intersection. By restructuring the intersection, the crossings can be designed to promote awareness of conflict points and facilitate proper yielding of motorists to bicyclists and pedestrians. A vital component to this design is to allow enough space for one vehicle to sit between the sidepath and the stop sign, so that drivers do not block the sidepath when waiting for a gap in traffic. See graphical depictions below.

Figure 12
Amherst Street at Border Street Today

Figure 13
Graphical depiction of a restructured intersection at Amherst Street and Border Street. A transition from sidepath to on-road treatment can also be found at the top of this picture.

Amherst Street at Old Milford Road (North)

Intersections between Amherst Street and Old Milford Road offer similar challenges that can be found at Amherst Street with Border Street. Similar recommendations can be found depicted below.

Figure 14
Amherst Street at Border Street Today

Figure 15
Graphical depiction of a restructured intersection at Amherst Street and Old Milford Road

Amherst Street at Main Street

The intersection of Amherst Street and Main Street offers a unique opportunity for intersection modification. Fork-style intersections fail to provide a systematically safe environment for both motorists and multimodal users, as they do not have any psychological or physical traffic calming properties, offer no protection for multimodal users, allow for high-speed passage of motor vehicles through the intersection, and have very poor visibility for some of the intersection's approaches.

This intersection in particular could be improved by changing the design to a small, single-lane roundabout. By modifying the design of this intersection to be a roundabout, several benefits could be provided:

- The geometric design of roundabouts offer physical traffic calming properties which force motorists to reduce speeds to 20 mph
- Modern roundabout design keeps multimodal users separated from motor vehicles in the intersection, allowing the maximum possible protection
- A roundabout in this location would be an excellent location for a gateway treatment, helping to define the future Village Special Roadway District. Gateway treatments are vital to defining the space within a special roadway district from the space outside the district
- Roundabouts allow for priority to be conveniently given to multimodal users, encouraging motor vehicles to be "a guest of the space" as opposed to requiring multimodal users to "apply for permission to cross the road"
- Roundabouts reduce significantly reduce the number of possible conflict points in an intersection, and nearly eliminates the possibility of injury or fatal crashes

Roundabouts have been installed in New Hampshire within areas that have similar space constraints and offer similar benefits. A state-managed roundabout in Goffstown has a diameter of exactly 97' feet, which could fit in this intersection with modest expansion of the footprint. The Federal Highway Administration provides requirements for sight distance, speeds, and grade of a roundabout's approaches.

Figure 16
Amherst Street at Main Street Today

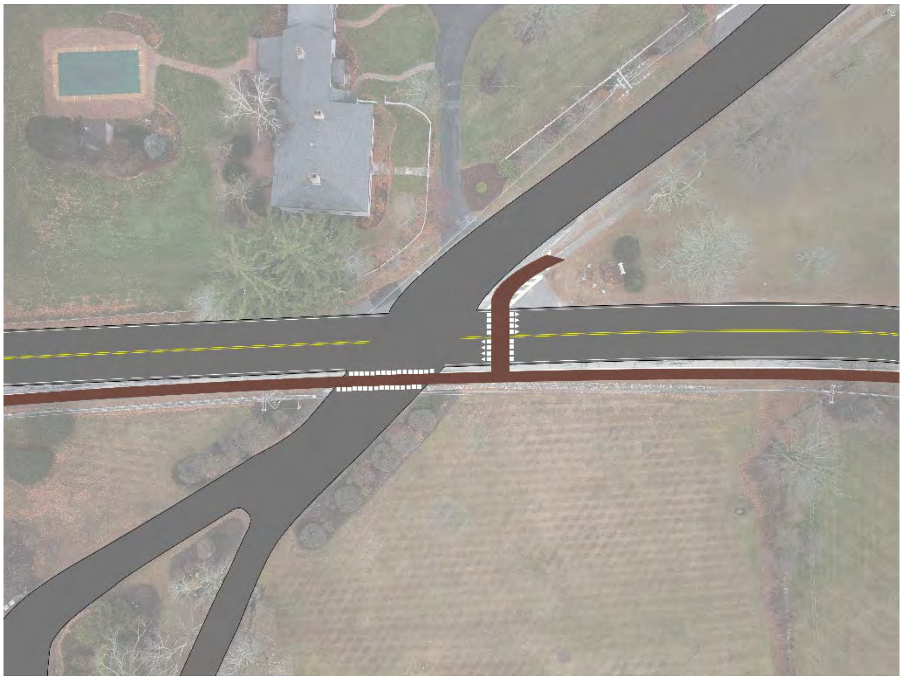


Figure 17
Graphical depiction of the installation of a sidepath alongside Amherst Street at Main Street with no intersection improvements

Figure 18

Overlay of a 97' diameter modern roundabout which offers systematically safe intersection for all users, doubling as a gateway treatment to calm traffic in the Amherst Village Special Roadway District. This intersection treatment *<u>is not incorporated into any budget at this time</u>.*

VI. References

Amherst Bicycle & Pedestrian Advisory Committee. 2019. "Amherst Multimodal Master Plan." Amherst, New Hampshire.

Federal Highway Administration. 2016. "Small Town and Rural Multimodal Networks." FHWA-HEP-17-024, Washington.

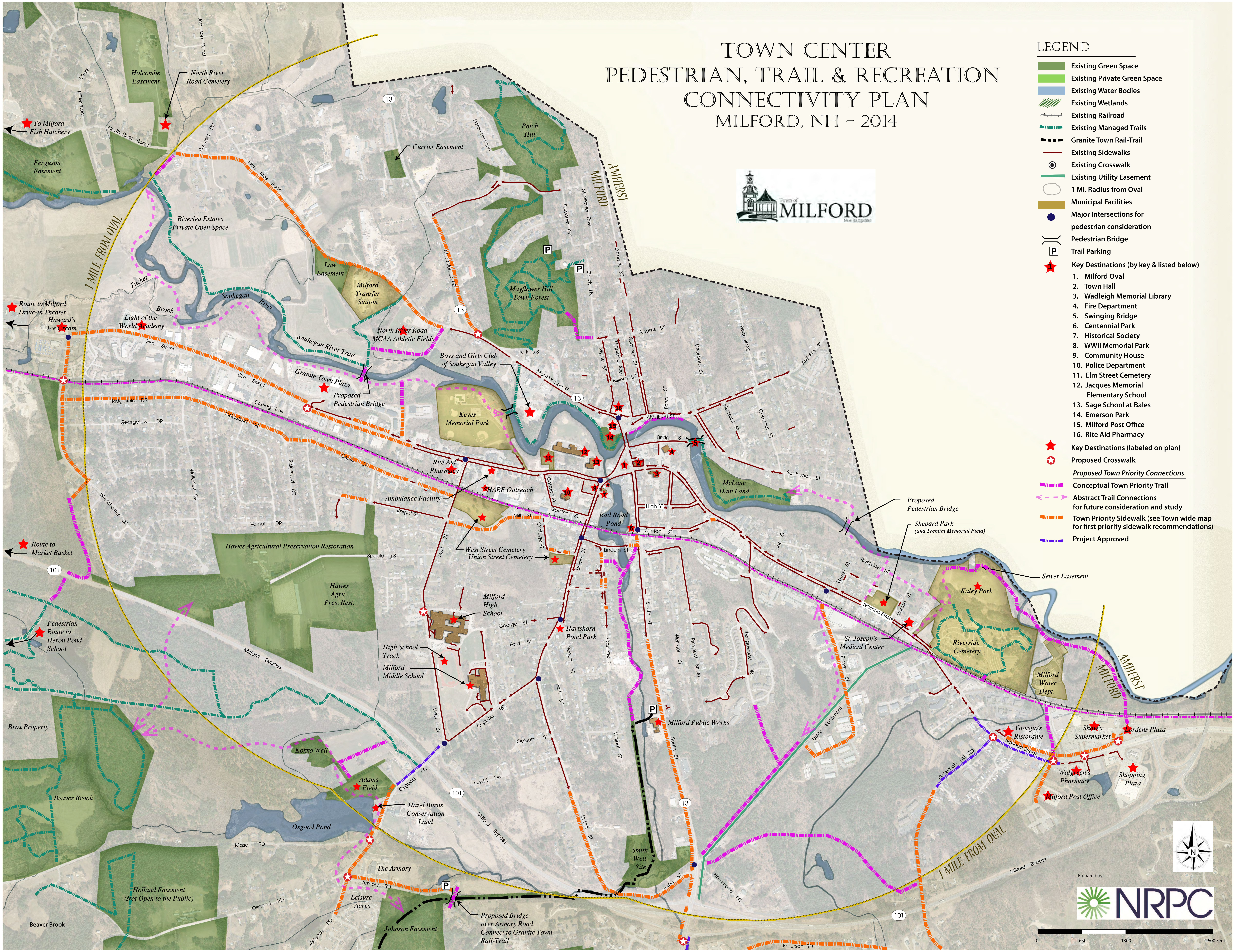
Furth, Peter G. 2009. *Bicycle Priority Lanes: A Proposal for Marking Shared Lanes.* Northeastern University.

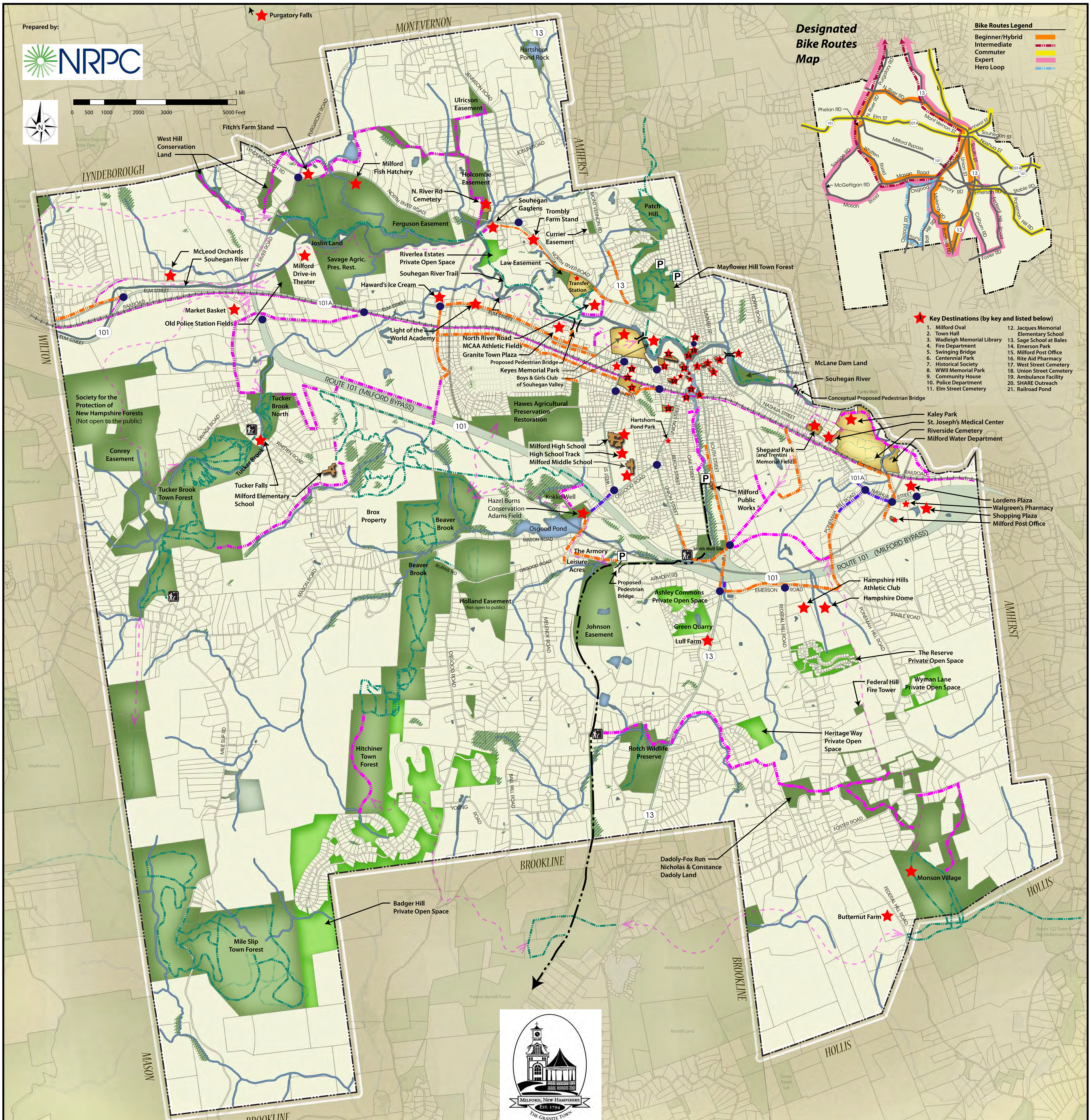
Jurewicz, Chris, Amir Sobhani, Jeremy Woolley, Jeffrey K. Dutschke, and Bruce Corben. 2016. "Exploration of Vehicle Impact Speed – Injury Severity Relationships for Application in Safer Road Design." *Transportation Research Procedia* 4247-4256.

State of New Hampshire RSA 265:26. n.d. "Overtaking and Passing, Highway Markings, Right of Way." *Title XXI.*

Vera-Villarroel, Pablo, Daniela Contreras, Sebastián Lillo, Christian Beyle, Ariel Segovia, Natalia Rojo, Sandra Moreno, and Francisco Oyarzo. 2016. "Perception of Safety and Liking Associated to the Colour Intervention of Bike Lanes: Contribution from the Behavioural Sciences to Urban Design and Wellbeing." *PLoS One* 11.

Wagenbuur, Mark. 2011. *But we have driveways.* August 18. https://bicycledutch.wordpress.com/2011/08/18/but-we-have-driveways/.


TOWN CENTER
PEDESTRIAN, TRAIL & RECREATION
CONNECTIVITY PLAN
MILFORD, NH - 2014
Town of MILFORD New Hampshire
LEGEND
Existing Green Space
Existing Private Green Space
Existing Water Bodies
Existing Wetlands
Existing Railroad
Existing Managed Trails
Granite Town Rail-Trail
Existing Sidewalks
Existing Crosswalk
Existing Utility Easement
1 Mi. Radius from Oval
Municipal Facilities
Major Intersections for pedestrian consideration
Pedestrian Bridge
Trail Parking
Key Destinations (by key & listed below)
1. Milford Oval
2. Town Hall
3. Wadleigh Memorial Library
4. Fire Department
5. Swinging Bridge
6. Centennial Park
7. Historical Society
8. WWII Memorial Park
9. Community House
10. Police Department
11. Elm Street Cemetery
12. Jacques Memorial Elementary School
13. Sage School at Bales
14. Emerson Park
15. Milford Post Office
16. Rite Aid Pharmacy
Key Destinations (labeled on plan)
Proposed Crosswalk
Proposed Town Priority Connections
Conceptual Town Priority Trail
Abstract Trail Connections for future consideration and study
Town Priority Sidewalk (see Town wide map for first priority sidewalk recommendations)
Project Approved
Holcombe Easement
North River Road Cemetery
To Milford Fish Hatchery
Ferguson Easement
Riverlea Estates Private Open Space
1 MILE FROM OVAL
Currier Easement
Patch Hill
Law Easement
Milford Transfer Station
Mayflower Hill Town Forest
Route to Milford Drive-in Theater
Haward's Ice Cream
Light of the World Academy
Souhegan River
Souhegan River Trail
North River Road MCAA Athletic Fields
Boys and Girls Club of Souhegan Valley
Granite Town Plaza
Proposed Pedestrian Bridge
Keyes Memorial Park
Rite Aid Pharmacy
SHARE Outreach
Ambulance Facility
McLane Dam Land
Rail Road Pond
Proposed Pedestrian Bridge
Shepard Park (and Trentini Memorial Field)
West Street Cemetery
Union Street Cemetery
Route to Market Basket
Hawes Agricultural Preservation Restoration
Hawes Agric. Pres. Rest.
Sewer Easement
Kaley Park
Milford High School
Hartshorn Pond Park
St. Joseph's Medical Center
Riverside Cemetery
Pedestrian Route to Heron Pond School
High School Track
Milford Middle School
Milford Water Dept.
Milford Public Works
Brox Property
Giorgio's Ristorante
Shaw's Supermarket
Lordens Plaza
Kokko Well
Walgreen's Pharmacy
Shopping Plaza
Adams Field
Hazel Burns Conservation Land
Milford Post Office
Beaver Brook
Osgood Pond
Smith Well Site
The Armory
Holland Easement (Not Open to the Public)
Leisure Acres
Proposed Bridge over Armory Road. Connect to Granite Town Rail-Trail
Johnson Easement
1 MILE FROM OVAL
AMHERST
MILFORD
Prepared by:
NRPC
0 650 1300 2600 Feet



Pedestrian, Bicycle, Trail & Recreation Connectivity Plan

Milford, NH - 2014

Town Wide Pedestrian, Bicycle, Trail and Recreation Goals

1. Implementation of new sidewalks, trails, marked pavement routes, bike trails, and marked/signalized crosswalks to facilitate:
- Walking, running, biking, and other opportunities for exercise
- Safe pedestrian routes of travel to town-wide destinations and within neighborhoods
- Town-wide connections for those without access to transportation
2. Ongoing improvement and maintenance of existing sidewalks, trails, and marked routes
3. Implement new sidewalks in locations where there are gaps in existing sidewalks
4. Ongoing improvement and maintenance of roadways for the safety of bicyclists
5. Implementation of pedestrian bridges to facilitate town-wide trail connections
6. Ongoing improvement of parks and implementation of new parks/pocket parks, active/passive recreation areas, playgrounds and/or facilities that connect to the town-wide plan.
7. Implementation of new signage to clearly identify access to public trails and parking
8. Provide connections from new developments to the town-wide plan
9. Include innovative design in development proposals to enhance neighborhoods and increase safety with elements such as lighted paths and trails, tree coverage over impervious areas, end of bike route facilities, benches, picnic tables, etc.

LEGEND

- Existing Green Space
- Existing Private Green Space
- Existing Water Bodies (ponds, river, brooks, etc.)
- Existing Wetlands
- Existing Railroad
- Existing Managed Trails
- Granite Town Rail-Trail
- 1 Mi. Radius from Oval
- Municipal Facilities
- Pedestrian Bridge
- Existing Trail Parking
- Proposed Parking/Bike Racks at Trail Heads
- Major Intersections for Pedestrian Consideration
- Key Destinations (See Town Center Map for a more detailed list of Key Destinations)

Proposed Town Priority Connections

- Conceptual Town Priority Trail
- Abstract Trail Connections for future consideration & study
- Town Priority Sidewalk
- Project Approved

Pedestrian, Bicycle, Trail and Recreation Action Priorities

Existing Sidewalk/Roadway Improvements

1. Roadway: Mason Road, North River Road, Armory Road, Emerson Road, and South Street
2. Sidewalks: Nashua ST, Clinton ST, South ST, West ST, Bridge ST, Wilton RD, and McLane Dam
3. Improve roadways in areas designated as bike routes (see Designated Bike Route Map above)

Proposed Town Priority Sidewalks/Crosswalks

1. Complete Nashua Street Sidewalks and Crosswalks (see Town Center Map)
2. South Street, Nashua Street, and Union Street with access to Rail-Trail
3. Wilton Road

Proposed Town Priority Trails

1. Extend Rail Trail from Milford Public Works to Oak Street and Town Center
2. Provide connections from existing trails near Milford Elementary School
3. Provide connections w/in 1-Mile Radius of Town Center to Key Destinations (see map above)
4. Provide trail connections (see map above) to facilitate a town-wide network of walkable and bikeable routes.