Newton

STREET DESIGN GUIDE

JUNE 2018

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01

INTRODUCTION

1.1 PURPOSE OF THE GUIDE

Streets fundamentally impact the quality of life in Newton. They connect us to opportunity and one another, provide for numerous ways of moving throughout the city, and communicate our values and priorities. All of us use streets, which can lead to speeding in some places and congested conditions in others. Newton cannot build its way out of congestion with more or wider streets. It can, however, make its streets work better for everyone by attracting more people to other modes by making walking, biking, and getting to mass transit safe, comfortable, and convenient (see The Importance of Safety, Comfort, and Convenience). We can also make driving in cars safer and more predictable. Also, we can make streets better designed to slow the speed of cars, where appropriate.

Newton envisions a safe, smart, accessible, livable, and sustainable multimodal transportation system with the goal of eliminating all transportation-related fatalities and injuries. The **Newton Street Design Guide** (the Guide) translates this vision into actionable engineering and design guidance for all public and private streets within the City of Newton. Guidance is based on a "Complete Streets" approach to street design that ensures the needs of all users are met, including people walking, biking, taking transit, and driving. The City formally adopted a **Complete Streets Policy**[01] on July 15, 2016, to ensure its street network works for all modes equally and for all people regardless of age, ability, or income.

This Guide was jointly developed by Newton's Planning & Development Department and Public Works Department in coordination with representatives from the Executive Office, Office of the ADA/Section 504 Coordinator, Police Department, Fire Department, Parks & Recreation Department, Health & Human Services, and Senior Services. It is primarily intended as a resource for City planning and engineering staff, private developers, and their consultants. However, it is also a resource for decision-makers, advocacy and neighborhood groups, and Newton's residents and visitors.

THE IMPORTANCE OF SAFETY, COMFORT, AND CONVENIENCE

To make walking, biking, and transit attractive options to the greatest number of people, they must be safe, feel safe, and be convenient. Research suggests that these factors significantly influence people's decisions about how they travel, and ultimately help establish habits for routine, everyday travel.[II] For example, a family with small children may avoid walking to a nearby village center if they feel unsafe crossing busy streets. Even if walking is more convenient because the trip distance is short, real and perceived safety barriers encourage them to drive instead. Many in Newton may not have an alternative travel option and may instead be discouraged to make a trip entirely.

Newton Highlands

1.2 A FOCUS ON SAFETY

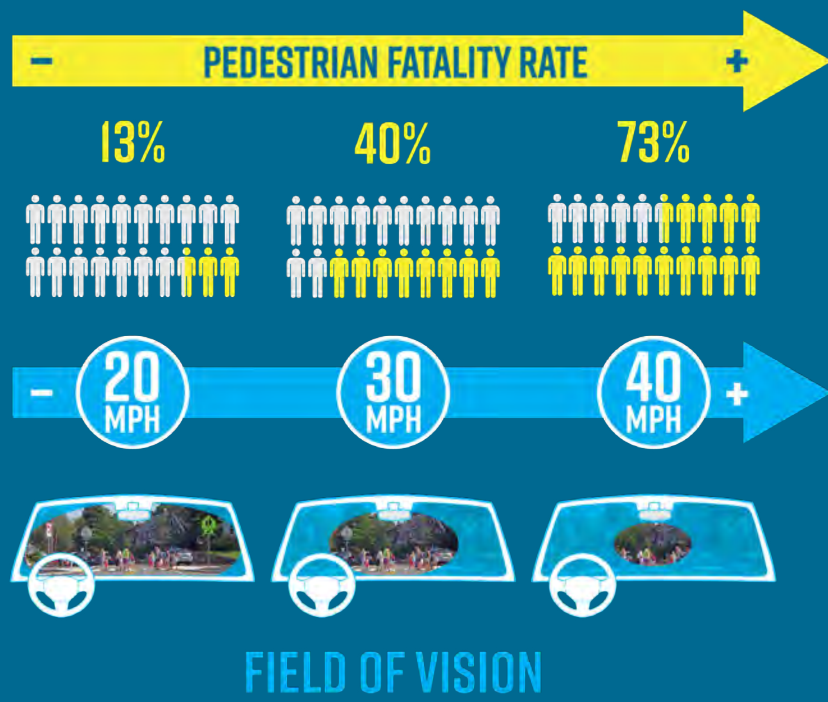
The safety of all travelers—whether by foot, mobility device, bike, bus, or automobile—is the first and highest priority for Newton's streets. Traditionally, street design in the U.S. has prioritized the mobility of motorists through the provision of shoulders, wide lanes, and large corner radii, all of which naturally encourage higher operating speeds that are incompatible with the safety and comfort of all roadway users. However, when these elements are reduced in appropriate areas, communities can realize lower motor vehicle operating speeds without reducing roadway capacity or increasing congestion, while still accommodating emergency response vehicles.[02,03] For vulnerable users, lower speeds and short crossing distances are associated with improved yielding rates[04,05] and better outcomes in the event of a crash (see **Translating Speed Limits into Design Speeds** to the right).

As Newton seeks to make walking, biking, and transit attractive and convenient options, the City will design and build its transportation infrastructure to safely and comfortably accommodate everyone. We will do this by following four guiding principles:

- **Reduce speeds at conflict points** by minimizing corner radii and implementing traffic calming elements, where appropriate.
- **Minimize exposure to conflicts** by reducing crossing distances and providing dedicated facilities for all modes, where feasible.
- **Communicate right-of-way priority** by applying consistent visual cues that reinforce desired yielding behavior.
- **Ensure adequate sight distance** by providing clear space in advance of crossings that "daylight" potential conflicts.

TRANSLATING SPEED LIMITS INTO DESIGN SPEEDS

Modest increases in vehicle speed significantly increases the likelihood that people walking or biking will be killed or severely injured in the event of a crash. In February 2017, Newton reduced the statutory speed limit on all City-controlled streets from **30 mph to 25 mph**, except where a regulatory speed limit has been established. The **Newton Street Design Guide** is translating this citywide change into lower default design speeds, enabling designers to create streets that work for everyone.



1.3 USING THIS GUIDE

The Guide provides design guidance, supporting context, and references for four broad topics: street types, sidewalks, roadways, and intersections. To quickly identify specific treatments and strategies, users should consult the index at the end of this document.

This document is intended to help guide planning, design, and decision making and does not supersede professional judgment. As such, this Guide integrates **design flexibility** to achieve outcomes that accommodate all modes, and presents minimum, maximum, and recommended criteria that vary by street type and surrounding context. A flexible design approach using engineering judgment is needed to create a multimodal street network that advances Newton's core values.

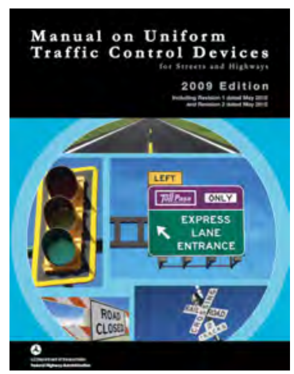
The Federal Highway Administration (FHWA) encourages designers to apply design flexibility inherent in current national standards and guidelines such as the **Manual on Uniform Traffic Control Devices for Streets and Highways**[06] (MUTCD), the American Association of State Highway and Transportation Officials' (AASHTO) **A Policy on Geometric Design of Highways and Streets**[07] (Green Book), and the Transportation Research Board's **Highway Capacity Manual**[08] (HCM). As such, this Guide incorporates multimodal design best practices from the Massachusetts Department of Transportation (MassDOT), the National Association of City Transportation Officials (NACTO), and the Institute of Transportation Engineers (ITE) as well as the latest research and evaluation findings.

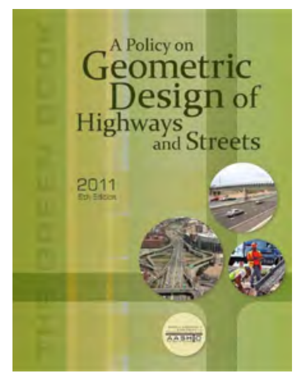
Newton owns nearly all the public streets within City limits[09] and therefore has significant discretion over design to achieve established community goals. However, in instances where MassDOT is a project proponent, is responsible for project funding (state or federal-aid projects), or owns the infrastructure, designers should consult MassDOT's latest **Project Development & Design Guide**[10] (PD&DG) and its engineering and policy directives for additional requirements.

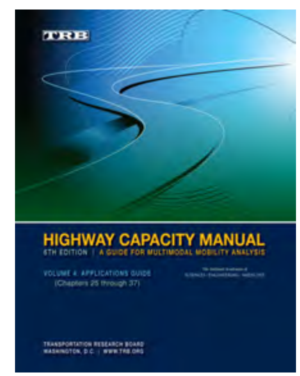
ACCESSIBILITY REQUIREMENTS

Accessible routes must be provided and comply with the U.S. Access Board's latest Americans with Disabilities Act (ADA) **Standards for Accessible Design**[12] and the Massachusetts Architectural Access Board's **Code of Massachusetts Regulations 521**[13] (521 CMR). Accessible routes must provide a continuous, clear path and meet or exceed surface, clear width, grade, cross slope, and other design requirements that are referenced throughout multiple topics in this Guide.

While not an enforceable standard, FHWA encourages communities to consult the U.S. Access Board's 2011 **Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way**[14] (PROWAG) for best practices. PROWAG provides updated dimensional requirements for elements of accessible routes that exceed existing 2010 standards.







01 http://www.newtonma.gov/civicax/filebank/documents/77240

02 http://www.pedbikeinfo.org/data/library/details.cfm?id=4348

03 https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/

04 http://docs.trb.org/prp/14-2349.pdf

05 https://trid.trb.org/view/1496968

06 https://mutcd.fhwa.dot.gov/

07 https://bookstore.transportation.org/collection_detail.aspx?ID=110

08 http://hcm.trb.org/?qr=1

09 MassDOT owns the Massachusetts Turnpike and Route 9 and the Department of Conservation & Recreation owns Hammond Pond Parkway, Nonantum Road, and Quinobequin Road. MassDOT will transfer ownership of Needham Street to the City of Newton upon completion of the Street's reconstruction.

10 http://www.massdot.state.ma.us/highway/DoingBusinessWithUs/ManualsPublicationsForms/ProjectDevelopmentDesignGuide.aspx

11 https://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=2493&context=open_access_etds

12 https://www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm

13 https://www.mass.gov/lists/521-cmr

14 https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/proposed-rights-of-way-guidelines/chapter-r3-technical-requirements

02

STREET TYPES

Newton's streets must safely facilitate the movement of people regardless of travel mode, age, ability, or income. From vibrant village centers to quiet residential areas, City streets must also serve a wide range of land use contexts and operational needs, such as transit and emergency response. These elements—the street's transportation function and its context within Newton—impact the selection of design criteria and the elements needed to create safe, comfortable, and convenient multimodal streets. Together, function and context should be considered within a flexible design approach to best allocate space and minimize conflicts in Newton's constrained rights-of-way.

Newtonville in the early 20th century

2.1 FUNCTIONAL CLASSIFICATION

As in all communities, streets in Newton are organized by functional classification, which clarifies the degree to which streets are intended to accommodate mobility or land access. The Guide assigns a target design speed and level of separation between travel modes to the traditional functional classification system of arterial, collector, and local streets (see **Figure 2.1** and **Figure 2.2**). Linking these critical design elements to functional classification ensures priorities are defined at the earliest stages of project scoping, streamlining implementation of the Guide into decisions affecting street geometry, traffic controls, and operations.

As a "railroad village" where 87 percent of structures were built before the 1960s highway era,[01] Newton's arterial and collector streets provide the most access, linking all village centers and serving abutting residences. Their alignments often intersect at non-ideal angles by today's transportation standards, creating safety challenges. Because they are the most direct routes and are served by transit, they are used by the most people. Taken together, Newton's arterial and collector streets experience the most conflicts between travel modes and, as a result, have the greatest safety issues.

In accordance with this Guide's guiding principles, design speeds should be responsive to a street's level of multimodal activity and reflect the statutory 25 mph citywide speed limit, except where a regulatory speed limit has been established. Within Newton:

- **Arterial and collector streets** will be designed to target **25 mph** operations and strive to provide safe, comfortable, and convenient facilities for all users except where a regulatory speed limit has been set.
- **Local streets** will maintain a comfortable shared operating environment with a maximum design speed of **25 mph** when traffic calmed.
- Any street where physical constraints necessitate that **people driving and biking share a travel lane**, the Guide encourages speed differentials ≤ **10 mph** between these roadway users with visual and design cues.

Figure 2.1 Newton Streets by Functional Classification

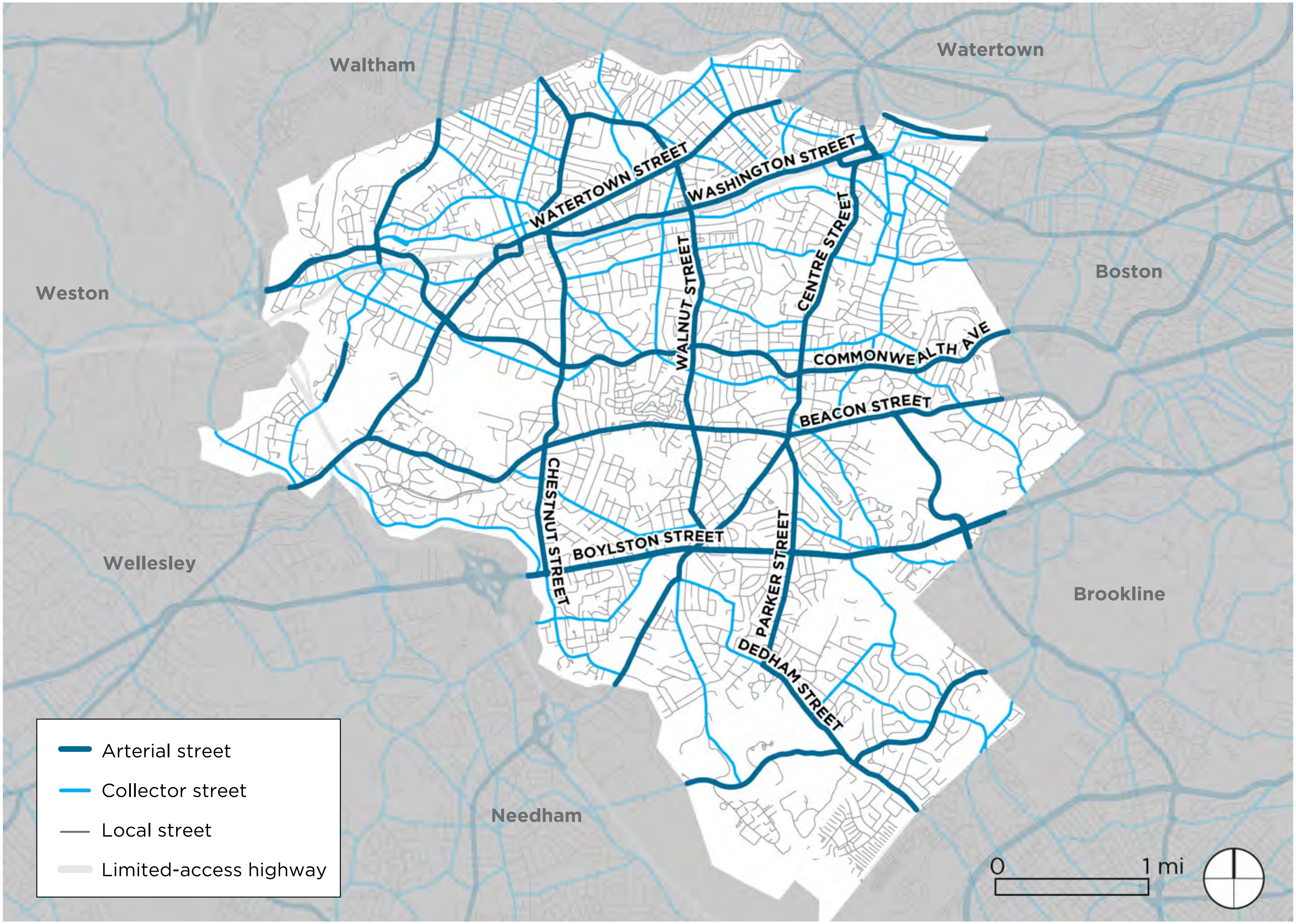


Figure 2.2 Examining Functional Classification in Newton

ARTERIAL STREETS

The traditional primary role of arterial streets is to provide mobility (i.e. few access points and high throughput). In Newton, this primary purpose is complicated by continuous residential and commercial property access. They are the most multimodal of streets and have the greatest safety need.

Walnut Street (residential)

Watertown Street (commercial)

COLLECTOR STREETS

Collector streets balance mobility and access. In Newton, the width, scale, and abutting uses of collectors vary. Like arterials, they can provide a distinct sense of place in village centers or resemble arterials in residential contexts.

Crafts Street (residential)

Lincoln Street (commercial)

LOCAL STREETS

The traditional primary role of local streets is to provide access (i.e., many access points and low throughput). In Newton, they provide similar residential property access to arterials and collectors and are usually narrower.

Walter Street (residential)

Hagen Road (residential)

2.2 CONTEXT

With target design speed and level of separation between travel modes established, designers should consult and overlay relevant contextual elements to further inform the street design process, as demonstrated in **Figure 2.3**. Overlays come in many different forms in Newton, including transportation networks and land use and development contexts. Along with functional classification, these overlays are woven into this Guide (see **Figure 2.4**).

Figure 2.3 Demonstration of Contextual Overlays in Newton

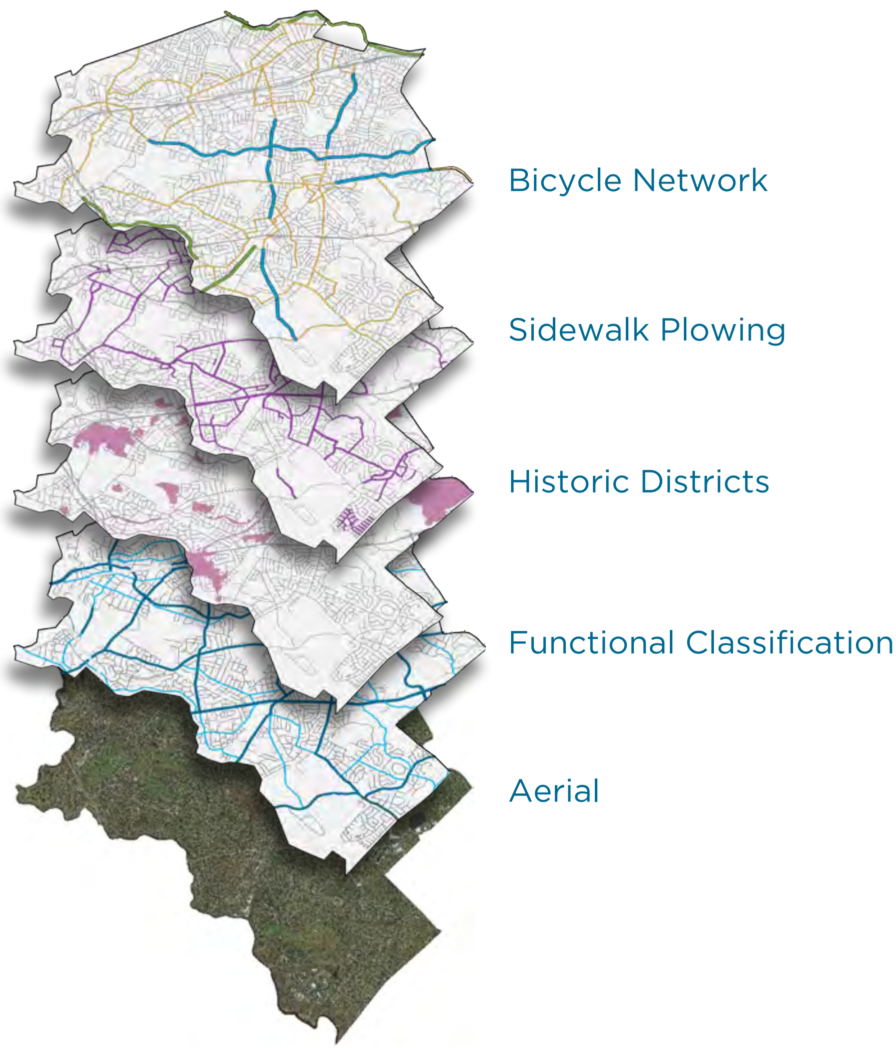


Figure 2.4 Context Informs Design Guidance

Newton's transportation and land use contexts, as well as functional classification designations, help inform the design of our streets. The diagram below illustrates where these elements influenced specific sections of this Guide.

Transportation

Newton's transportation network supports a variety of designated safety and operational needs as well as specific maintenance activities that inform the design of our streets:

- Emergency response
- Bicycle network
- Sidewalk plowing
- MBTA buses
- School buses
- Safe Routes to School

Land Use

Changes to our streets will reflect and support Newton's varied land use contexts and development patterns:

- Neighborhoods
- Village centers
- Commercial areas
- Recreation/public use
- Natural/landscape
- Historic districts

Guide Sections

Chapter 3. Sidewalks

3.1: Sidewalk Zones

3.2: Stormwater Management & Street Trees

3.3: Street Lighting

Chapter 4. Roadways

4.1 Travel Lanes & Parking

4.2 Bikeways

4.3 Traffic Calming Measures

Chapter 5. Intersections & Crossings

5.1 Conflict Points

5.2 Intersection Corners

5.3 Pedestrian Signal Timing

In addition, Newton established Priority Strategies to realize its vision of a safe, smart, accessible, livable, and sustainable transportation network. These strategies help inform individual project designs but also help define citywide priorities, guide policy development, initiate projects, and many other actions:

- **Safe Travel:** The City will reduce crashes, improve intersection safety, and re-envision major traffic corridors with the assistance of this Guide.
- **Transit and Shared Mobility:** The City will create new community transit options and partner with the MBTA to improve existing transit service. This Guide will help design safe, comfortable, and convenient first- and last-mile walking, biking, and drop-off connections to these services.
- **Active Transportation:** The City will embrace alternatives to driving and promote village and neighborhood comfort. This Guide will help make short trips to village centers, schools, and other everyday destinations active and attractive.
- **Parking Management:** The City will manage its parking to create availability. This Guide will help reduce the need to drive by balancing all travel modes.
- **Congestion Reduction:** The City will create smarter development and leverage multimodal investments made with this Guide with transportation demand management programs.
- Newton is a Garden City and **beauty and aesthetics are an integral part of the City streets.** The City will embrace the idea of making its streets attractive, considering trees, the condition of the paint, street light fixtures, etc.

A local residential street in Newton

01 http://www.newtonma.gov/civicax/filebank/documents/82700

03

SIDEWALKS

This chapter provides design guidance for sidewalk zones, streetscape elements, stormwater management, and street lighting. Additional design guidance for elements that interact with the sidewalk (e.g., curb ramps, crosswalks, bike facilities, etc.) is located in Chapter 4 (Roadways) and Chapter 5 (Intersections and Crossings).

Sidewalks are the critical accessible routes through Newton and must provide a continuous, unobstructed path that meets surface, clear width, grade, and cross slope requirements. Designers must adhere to accessibility standards outlined in the latest **ADA Standards for Accessible Design**[01] and **521 CMR**[02] and are encouraged to follow the U.S. Access Board's latest **PROWAG**.[03]

3.1 SIDEWALK ZONES

Sidewalks are organized into several zones, each with a distinct purpose. Depending on functional classification and land use context, the design of each zone may vary (see **Figure 3.1**).

- **Pedestrian zone** provides a level, stable, and slip-resistant pathway that is clear, uninterrupted, and exclusively for pedestrian travel.
- **Amenity zone** buffers pedestrians from the street, contains trees and streetscape elements, and provides snow storage in the winter. It simplifies and improves curb ramp and driveway design.
- **Frontage zone** extends from the property line and buffers pedestrians from building entrances, edges, walls, and fences, and may be used for café seating.
- The **curb** is the interface between the sidewalk and street, vertically separating these spaces and facilitating drainage.

Streetscape elements located within the amenity and frontage zones further enhance the pedestrian zone and public realm by increasing sidewalk comfort and strengthening sense of place. Designers should consider the relationship between these streetscape elements and the pedestrian zone, particularly within village centers where pedestrian volumes and frequency and diversity of streetscape elements are at their highest.

At a minimum, all streetscape elements should be set back **18"** from the face of the curb. Designers should stagger streetscape elements or consider greater setbacks when adjacent to on-street parking, where space permits, to minimize conflicts with doors. See **Figure 3.2 through Figure 3.8** for placement of typical streetscape elements within the amenity zone.

Designers must ensure that the amenity zone remains free of obstructions adjacent to designated accessible parking spaces to allow deployment of vehicle lifts and ramps. **PROWAG R309** provides detailed design guidance for accessible on-street parking spaces in narrow or wide sidewalk scenarios.

Consider the following when designing sidewalks:

- Where the right-of-way is significantly constrained, maintaining the pedestrian zone is the priority. The frontage zone should be minimized or eliminated before the amenity zone to preserve the buffer space between moving traffic and pedestrians. Where present, on-street parking, can serve as a buffer and the amenity zone may be minimized.
- On-street bike parking corrals allow convenient bike parking where there is limited sidewalk space. In the same space as one motor vehicle, a well-designed in-street corral can hold up to **12** bikes.

A shared use path (i.e., shared pedestrian and bicycle facility) may be considered in lieu of a sidewalk for streets outside of village centers where bicycle and pedestrian volumes are low enough that users can comfortably share space. See **Section 4.2** for more information on shared use paths and dedicated bikeways.

Figure 3.1 Recommended Sidewalk Zone Widths and Materials

		FRONTAGE ZONE		PEDESTRIAN ZONE[2]		AMENITY ZONE		CURB	
		WIDTH	MATERIAL	WIDTH	MATERIAL	WIDTH	MATERIAL	WIDTH	MATERIAL
FUNCTIONAL CLASSIFICATION	ARTERIAL STREET	See Land Use Context		≥ 6' (5' min.)	Saw-cut concrete[3]	≥ 6' (0' min.)	See Land Use Context	See Land Use Context	
	COLLECTOR STREET					≥ 3' (0' min.)			
	LOCAL STREET			≥ 5' (5' min.)		≥ 2' (0' min.)			
LAND USE CONTEXT	VILLAGE CENTER OR COMMERCIAL	≥ 2' (0' min.)[1]	Concrete	≥ 10' (5' min.)	See Functional Classification	≥ 6' (0' min.)	Concrete, paver	≥ 6"[4]	Granite, concrete, or asphalt berm
	NEIGHBORHOOD OR CAMPUS		Concrete or vegetated	See Functional Classification		See Functional Classification	Vegetated or country drainage		Granite, concrete, asphalt berm, or no curb (country drainage)
	RECREATION OR NATURAL/LANDSCAPE	N/A							

1 Immediately adjacent buildings, walls, or fences reduce the walking zone's usable width by 1' where the frontage zone is eliminated. Per Newton Fence Ordinance, no fence taller than 4' may be located along the front property line.
2 City ordinance requires minimum 5' pedestrian zone, which also satisfies minimum dimensions for accessible routes (federal and state levels) and Newton's sidewalk plowing operations for designated sidewalks.
3 Saw-cut concrete preferred for accessibility. Tooled joints, where employed, should be < 3/8" wide
4 Depending on reveal, wider curbs may be needed where mountable curbs are implemented alongside separated bike lanes.
5 Designers should coordinate with the four local historical commissions, where applicable, in determining curb style and material. Concrete curb only applicable to mountable curbs alongside separated bike lanes.

Figure 3.2 Recommended Minimum Offsets for Trees

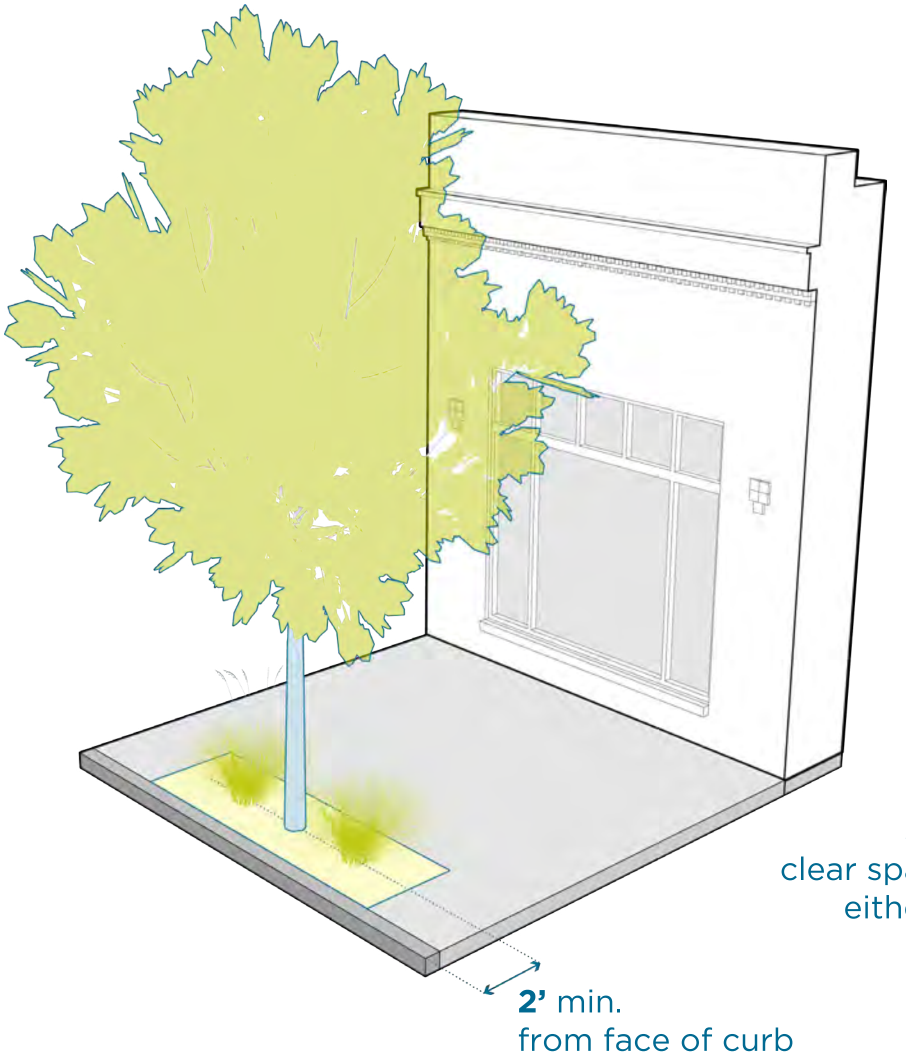


Figure 3.3 Recommended Minimum Offsets for Benches

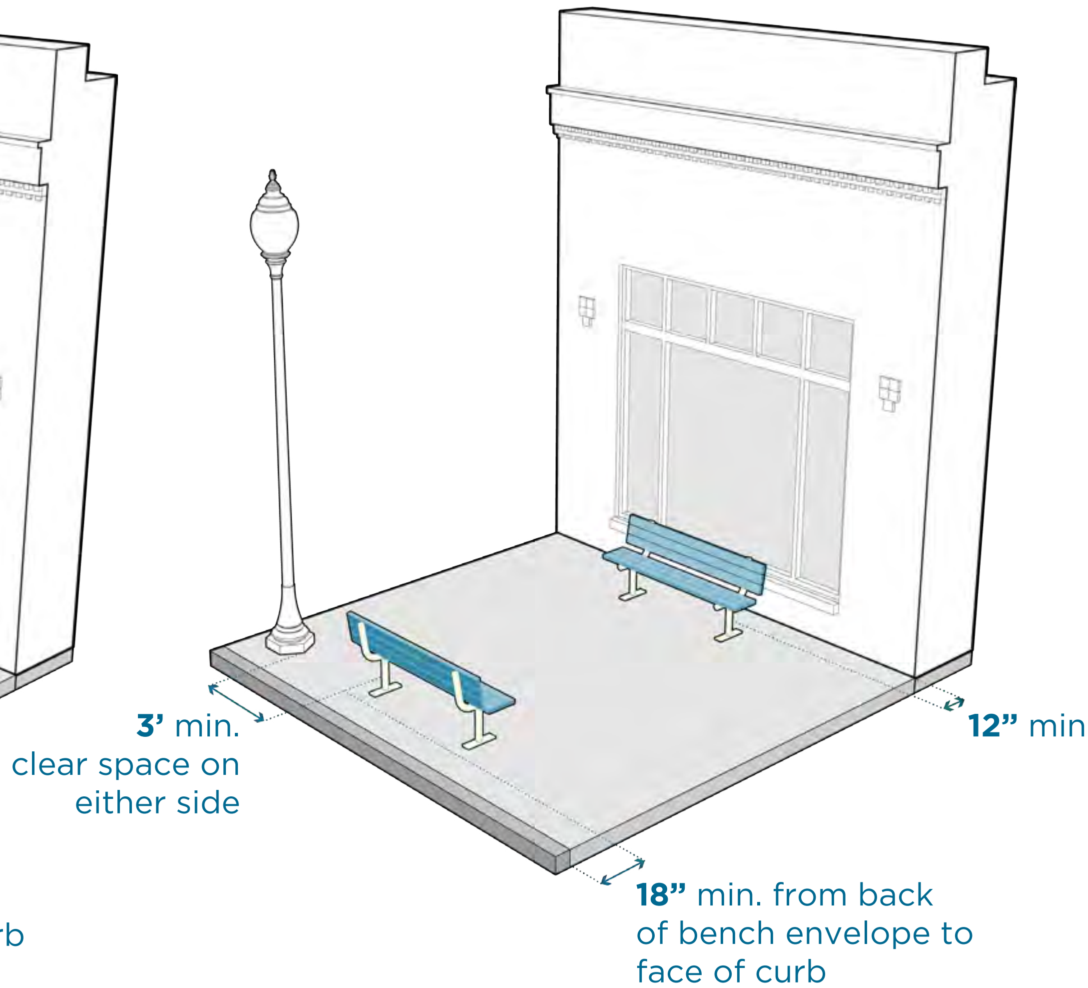


Figure 3.4 Recommended Minimum Offsets for Street Lights and Signs

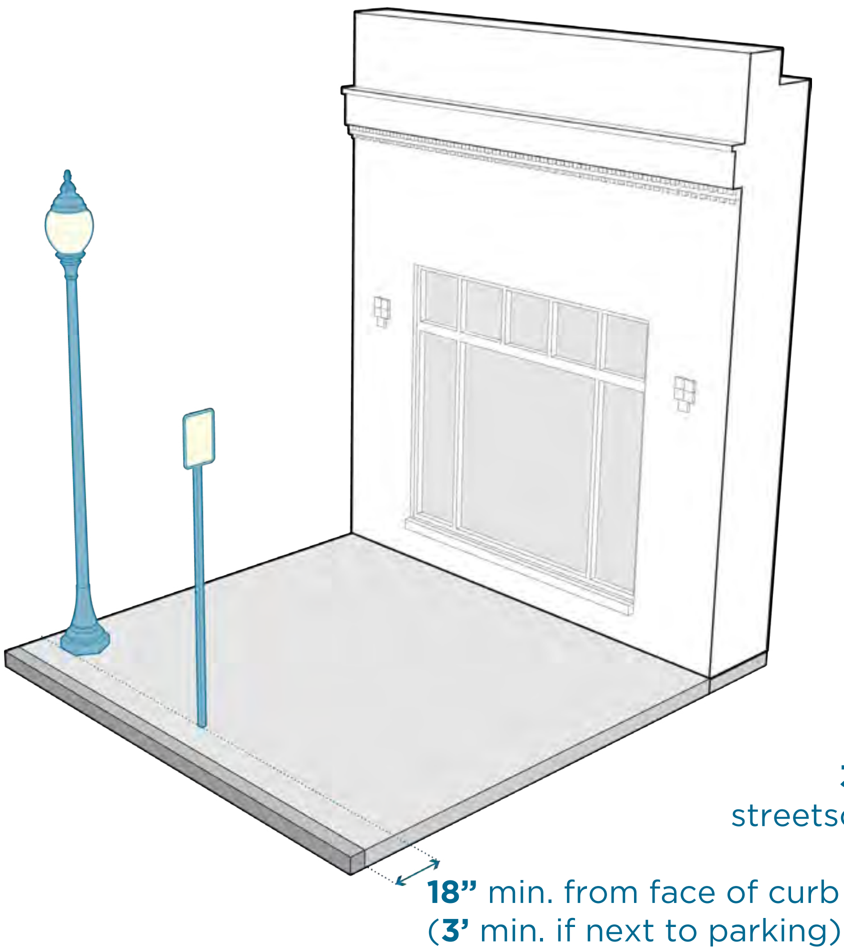


Figure 3.5 Recommended Minimum Offsets for Trash and Recycling

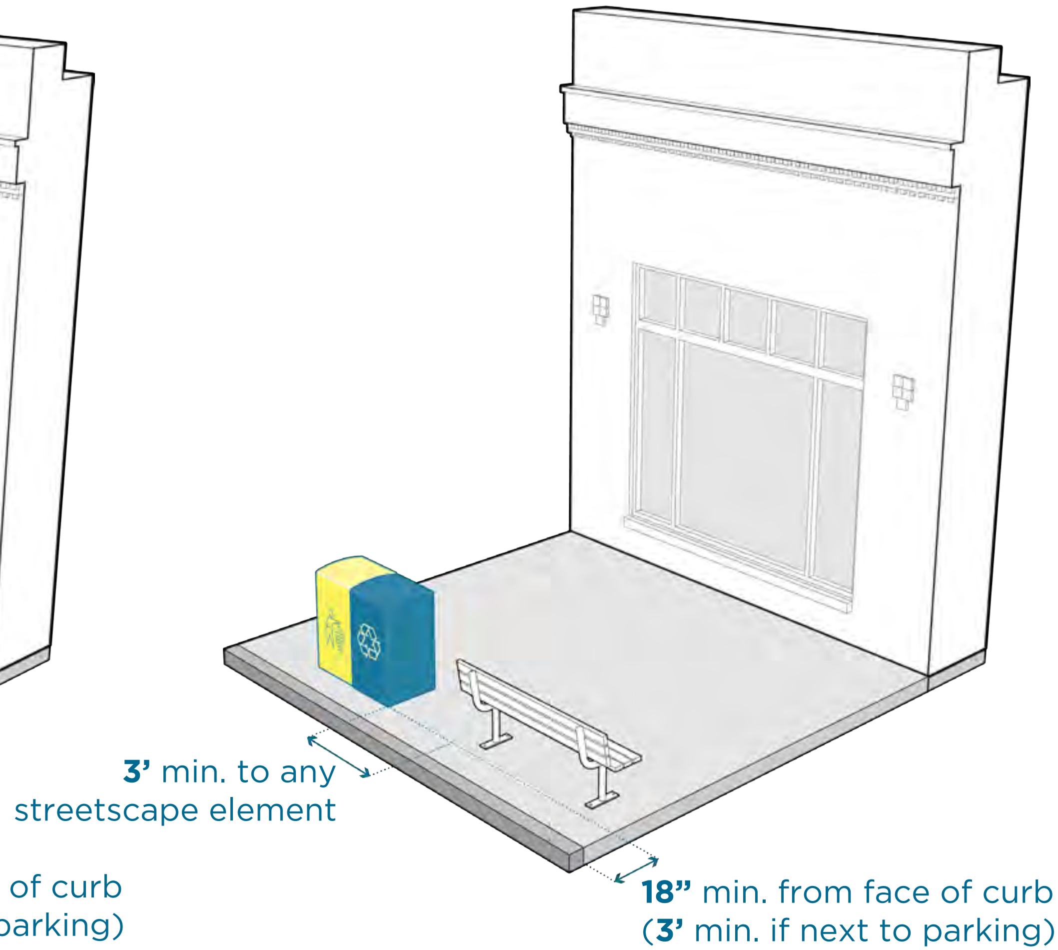


Figure 3.6 Recommended Minimum Offsets for Bus Shelters

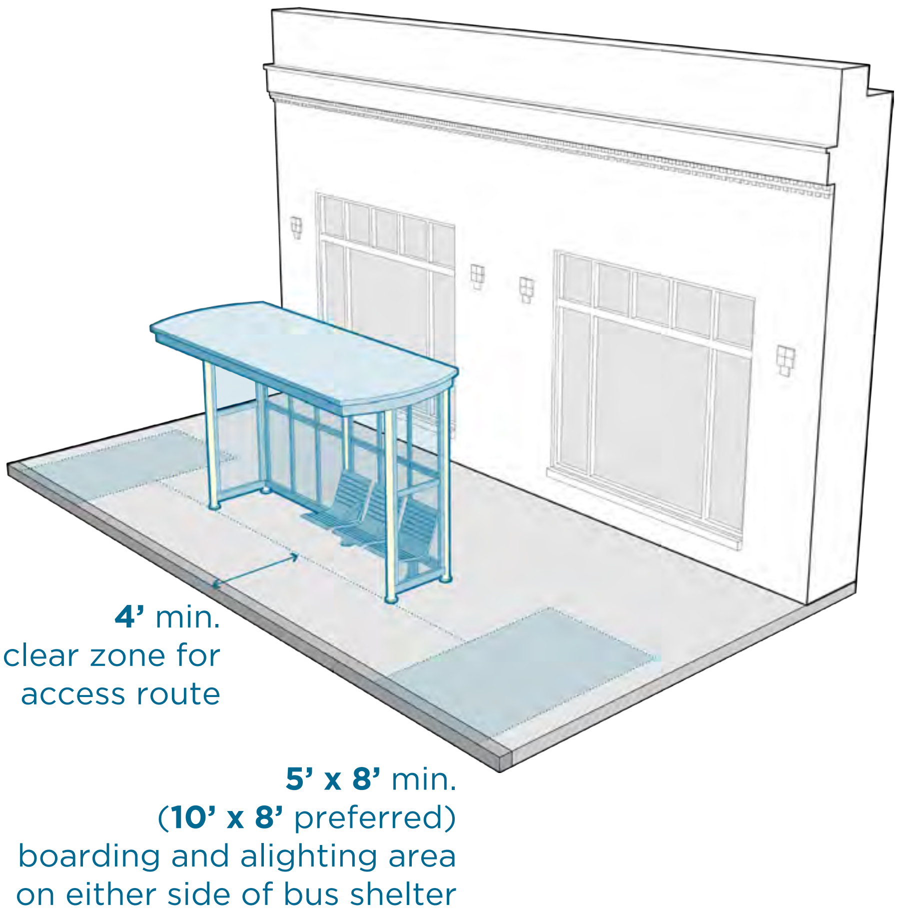


Figure 3.7 Recommended Minimum Offsets for Fire Hydrants

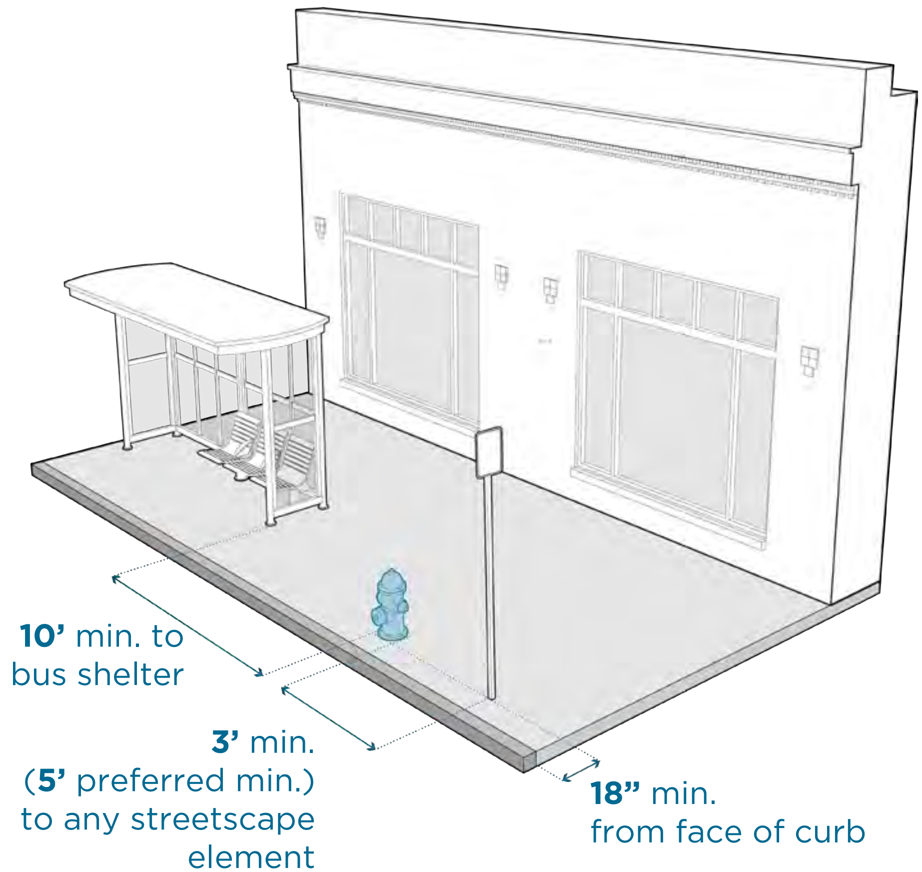
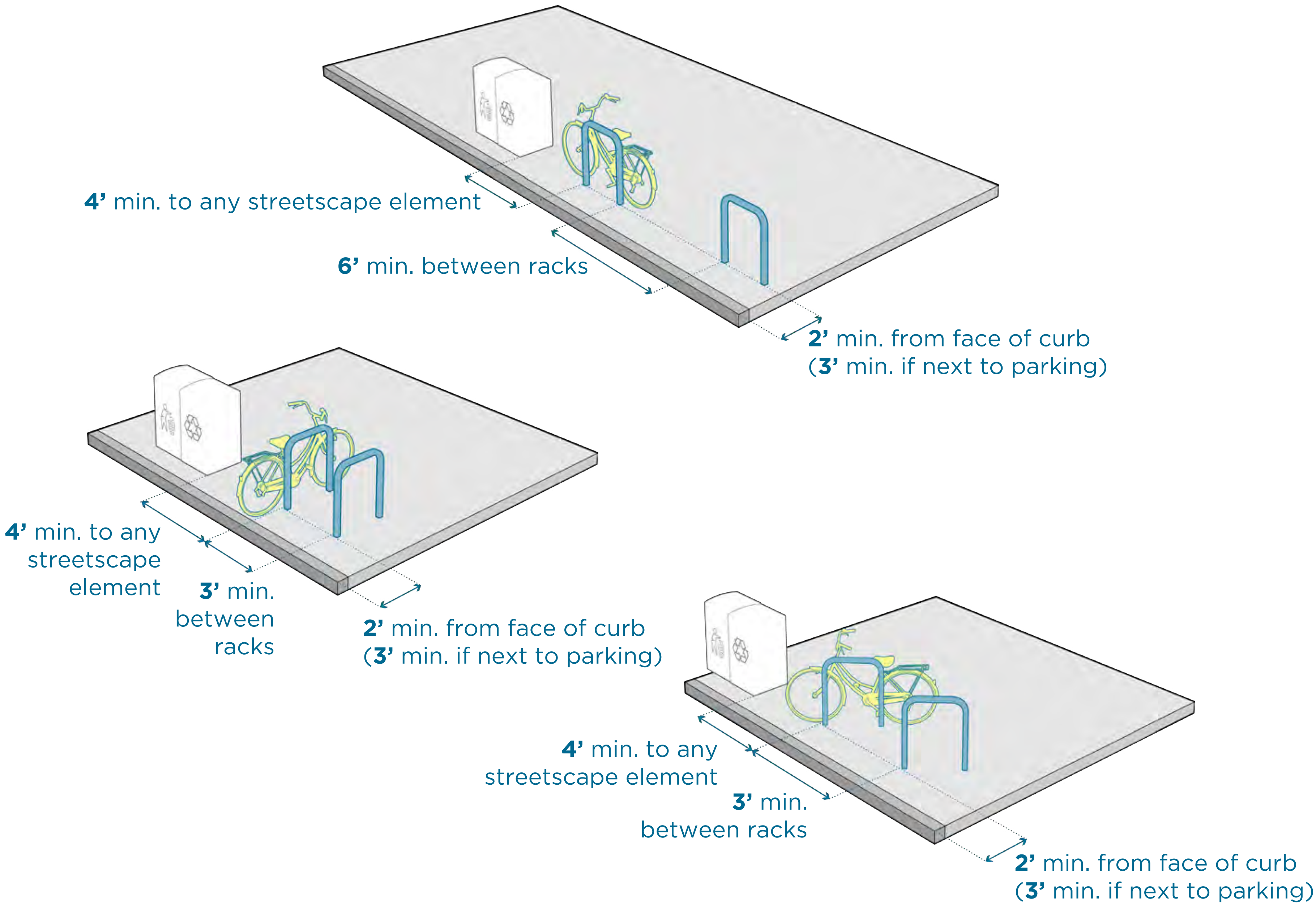


Figure 3.8 Recommended Minimum Offsets for Bike Racks



3.2 STORMWATER MANAGEMENT & STREET TREES & SHRUBS

Newton's streets provide a tremendous opportunity to employ sustainable stormwater management strategies and green infrastructure (GI) practices to improve the City's resiliency and ecological health. Impervious surfaces have disrupted natural hydrological cycles, resulting in decreased water quality, deteriorating wildlife habitat, damaging floods, excessive pressure on the municipal drainage system, and stressed wetland resource areas such as rivers, streams, ponds, and wetlands. Thoughtful street design provides an opportunity to re-establish more natural water cycles, infiltrate stormwater, filter pollutants from runoff, and provide additional benefits such as calming traffic, re-establishing native plants, and beautifying neighborhoods.

3.2.1 Stormwater Objectives

The City, as part of its federal National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer (MS4) general permit obligations, is required to reduce the discharge of pollutants and protect water quality. In addition to providing for the safety, comfort, and convenience for all users, it is critical that streets also effectively control the impacts of stormwater runoff to help meet these requirements by reducing impervious areas, disconnecting impervious areas, infiltrating stormwater, and vegetating street-scapes, new streets, intersections, and sidewalks, and existing facilities can address the following objectives:

- Reduce flood frequency, intensity, and damages;
- Protect receiving waters from pollution, erosion, flooding, and other negative impacts;
- Improve water quality;
- Improve physical and mental health;
- Utilize sustainable materials;
- Maximize life-span sustainability of the built environment;
- Improve air quality;
- Reduce urban heat island effect; and
- Create a sense of place.

These objectives demonstrate the City's vision and expectations and will serve as the basis for enhanced regulations, design requirements, and application guidance and checklists to ensure consideration of sustainable design principles to be developed in the future.

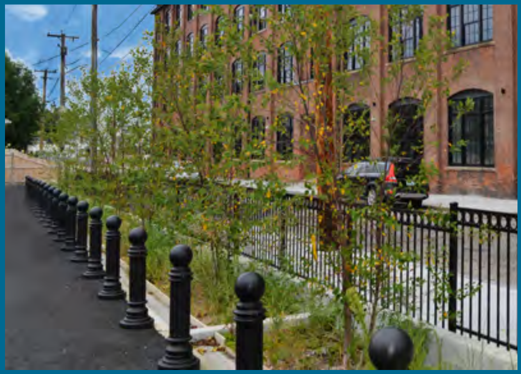
3.2.2 Promoted Best Management Practices

Green infrastructure, shade trees, shrubs, and other vegetation can help achieve the City's stormwater objectives. The green infrastructure practices listed in **Figure 3.9** are encouraged. Designers should consult **Volume 2 Chapter 2: Structural BMP Specifications of the Massachusetts Stormwater Handbook**[04] for additional information on these techniques and for other solutions. Design of BMPs is not one-size-fits-all. It is critical that BMP sizing, materials, and design are appropriately calibrated to site conditions and neighborhood context.

As established in the **Newton Tree Manual**,[05] Newton's urban forest is a multi-million-dollar asset that maintains air quality, reduces noise and soil erosion, and reduces energy consumption and stormwater runoff. Trees and shrubs can be a central component of street stormwater runoff filtration and absorption solutions and should be planted, protected, and maintained wherever feasible. Trees and shrubs can be incorporated in vegetated filter strips, bioretention areas, and as part of structural stormwater practices (e.g. tree box filters, tree trenches, structural soil). The trees and shrubs must be planted on traffic islands or on curb extensions in a way that ensures corner visibility and daylighting of an intersection.

Figure 3.9 Promoted Best Management Practices

DEPAVING & TREE PLANTING



Replacement of impervious surfaces with trees and vegetation. Trees function as stormwater management machines while also providing a multitude of other community benefits.

Potential uses:

- Street narrowing
- Intersection tightening
- Curb extensions and sidewalk amenity zones
- Bikeway buffers
- Traffic islands
- Medians
- Closure of unnecessary curb cuts

BIORETENTION & STORMWATER PLANTERS

Slightly depressed landscape areas designed to utilize soil and plants to filter runoff, and infiltrate runoff where allowable. Typically systems are designed to manage runoff from frequent, small magnitude storm events, with bypass during larger storm events. Systems can be flow-through with impermeable liners in areas of contaminated or poorly draining soils.

Potential uses:

- Parking islands
- Curb extensions and sidewalk amenity zones
- Bikeway buffers
- Traffic islands
- Medians

BIOSWALE (WET OR DRY)

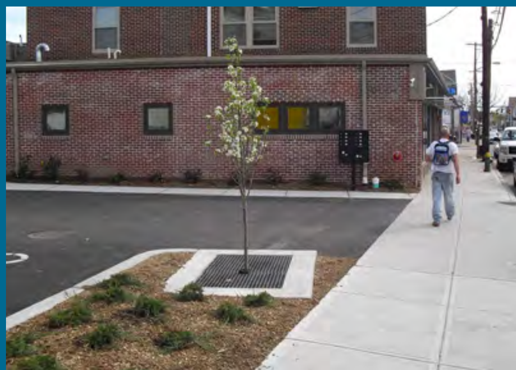
Shallow vegetated open channels that convey runoff while filtering, infiltrating, and slowing velocities.

Potential uses:

- "Country drainage" conveyance may replace curb/pipe in neighborhood land use contexts
- Narrow hard-edge conveyance systems in village/urban context
- Bicycle lane buffers

Figure 3.9 (continued) Promoted Best Management Practices

TREE FILTER/TREE TRENCH



In-ground containers or extended shared trenches for tree root volume or shrub.

Potential uses are similar to bioretention but can be a good fit for space-constrained sites:

- Parking islands
- Curb extensions and sidewalk amenity zones
- Bikeway buffers
- Traffic islands
- Medians

SAND FILTER

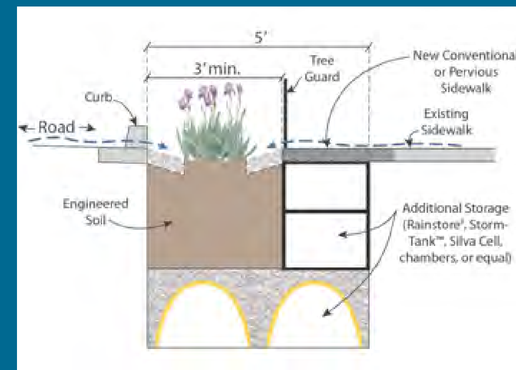
Self-contained beds of sand or peat underlaid with perforated underdrains or designed with cells and baffles. Requires vegetated cover.*

Potential uses are similar to bioretention but sometimes requires more area:

- Parking islands
- Curb extensions and sidewalk amenity zones
- Bikeway buffers
- Traffic islands
- Medians

*can be difficult to implement in areas with soil contamination requiring an im-permeable liner.

INFILTRATION STRUCTURE



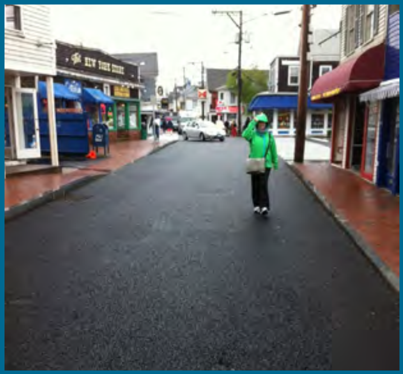
Infiltration systems (e.g., leaching catch basin, underground recharge system, infiltration trench) may include stone trenches, reservoirs, or structured void systems to provide volume for control and infiltration of runoff. Soil testing is required to determine groundwater elevation and infiltration rate to ensure drainage within 48 hours.

Potential uses:

- Catch basin replacement
- Linear stone trenches
- Underground structure (perforated pipes or proprietary systems) where space allows
- Infiltration reservoir below bioretention or permeable pavement

Figure 3.9 (continued) Promoted Best Management Practices

PERMEABLE PAVEMENT



Pavement, pavers, or other surface stabilization that contains voids allowing infiltration. Systems must be designed with proper section according to proposed use and site constraints.

Potential uses:

- Parking and driveways (avoid heavy loading areas)
- Neighborhood parking lanes and small lots
- Sidewalk amenity zones
- Bikeway surface and buffers
- Tree surrounds

Street trees and shrubs must be provided with adequate soil volume and soil design to support long-term root growth and canopy, without excessive impact to utilities or sidewalks. The following are minimum recommended soil volumes for tree roots:[06]

- Large Trees (greater than 50’ height at maturity): **1,500 cubic feet** of soil within a **27’** radius
- Medium Trees (35’–50’ height at maturity): **1,000 cubic feet**[07] of soil within a **22’** radius
- Small Trees (less than 35ft height at maturity): **600 cubic feet** of soil within a **16’** radius

Where radii for adjacent trees overlap, up to **25 percent** of required soil volume per tree may be shared.

The City should apply compaction-preventing techniques as part of tree planting, such as prevention of vehicular and pedestrian circulation on root systems and sand-based structural soils and structural cells. Structural soils are made up of greater proportions of crushed stone/sand to soil, and structural cells are plastic/fiberglass structures of columns and beams that support paving above uncompacted soil. The City should consult arborists and landscape architects to assess the feasibility of these and other options on a project-by-project basis.

3.2.3 Opportunities for Implementation of Green Infrastructure

Street stormwater management techniques include both spot solutions—for example, bioretention planters, bioretention as part of curb extension areas, and tree box filters—and continuous linear solutions such as depaving, permeable pavement, and bioswales (see **Figure 3.10**). The specific solution for any given site depends on land use context and vision, available space and infrastructure conflicts, drainage area needs, and financial feasibility for initial construction and ongoing maintenance. Design should be integrated with site use and transportation objectives to the maximum extent practicable. Costs can sometimes be mitigated through holistic integration of GI elements into planned capital street improvements.

Newton promotes the assessment and use of applicable GI and street tree practices. When considering work on streets, intersections, or sidewalks and the pedestrian realm, the following opportunities should be assessed for potential benefits and costs:

Streets and Intersections

- Replace conventional asphalt (along roadways or in intersections) with permeable pavement, reinforced turf, pavers, median or edge planters, and/or planted traffic islands. Wherever possible, design landscaped areas as depressions to accept runoff and maximize filtration and infiltration.
- Add planted curb extensions at intersections and mid-block crossings.
- Narrow roadways with expanded verges, curbless street retrofits ("country drainage"), curb extensions, and tree filters.
- Replace conventional catch basins with leaching catch basins where conditions allow.
- Increase tree and shrub planting. Note that most planted GI practices can incorporate tree planting.

Sidewalks and Pedestrian Realm

- Add stormwater planters and infiltration trenches to accept runoff for filtration and infiltration.
- Retrofit sidewalk amenity zone and other hardscape with permeable pavement.
- Protect existing trees and vegetation, and add new trees, shrubs, and other plantings.

3.2.4 Maintenance Considerations

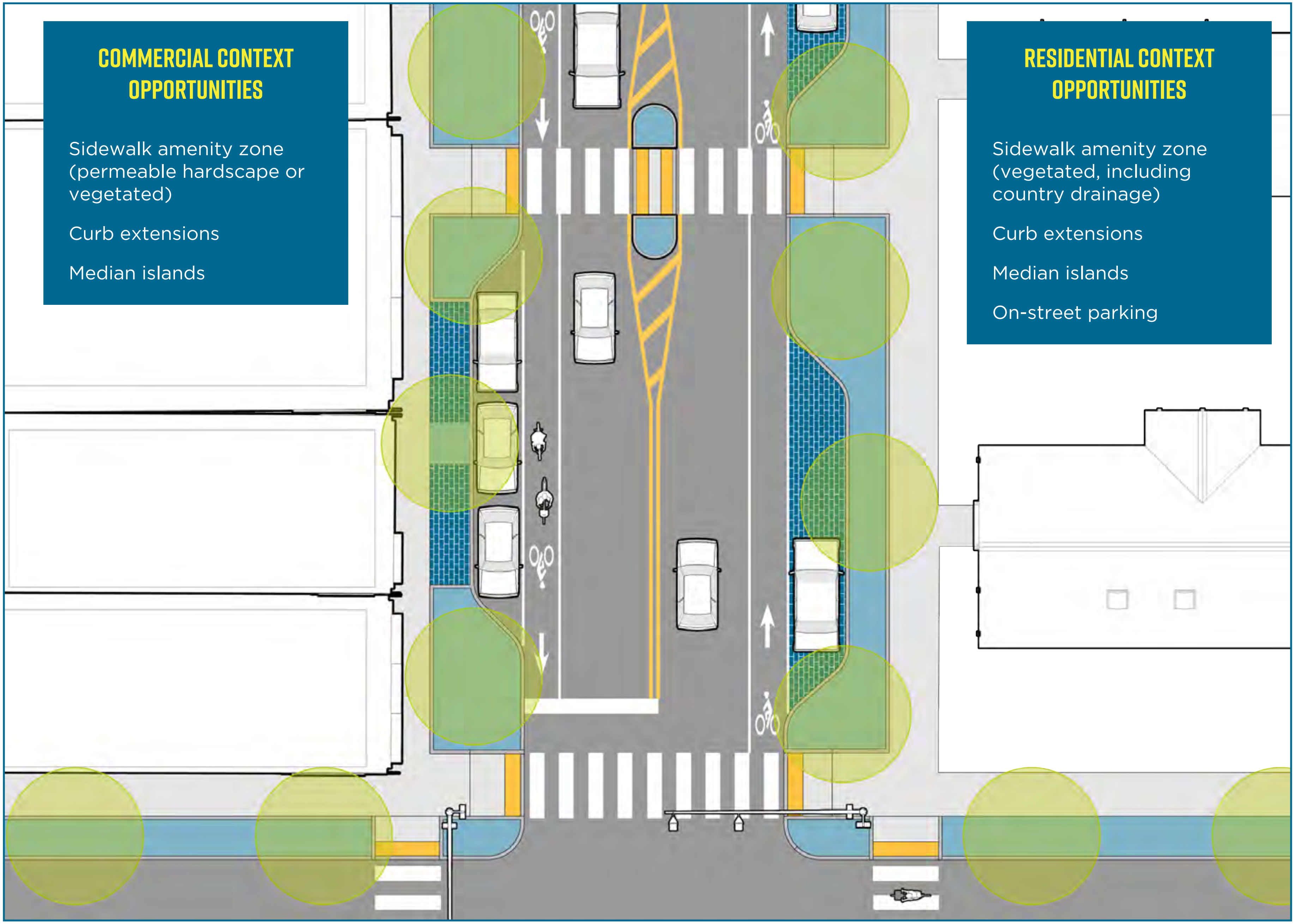
Newton's Complete Streets efforts must minimize the complexity of implementation, ease maintenance obligations, and minimize life-span costs. The effective long-term function of stormwater management BMPs increases when they are obvious, simple, and easy to maintain. Green infrastructure and tree planting practices are often simple, decentralized, multi-functional systems providing environmental and community benefit when integrated as part of the community fabric, thus are more likely to be cared for and maintained over time.

From a design perspective, pre-treatment of runoff as part of a stormwater practice is critical for ease of maintenance. Filter systems must incorporate appropriate pre-treatment elements such as forebays, sumps, stone filters, linear pre-treatment channels, or other appropriate elements to protect the main filter system and simplify the maintenance burden. Often systems within a space-constrained village center context do not allow for typical pre-treatment, and therefore require more frequent inspection and maintenance. Thus it is especially important to design for simple maintenance with minimal special training or equipment required.

All stormwater controls must be inspected and maintained regularly to prevent deficiencies in the effectiveness of the systems due to sediment build-up, damage, or deterioration. Permanent stormwater controls are to be operated and maintained appropriately in the post-construction period as well as during the construction phase of the project. Immediately after construction, all BMPs should be inspected more frequently to ensure that the system is functioning properly.

Inspection and maintenance are typically conducted twice annually (spring and fall) and after major storm events. General long-term maintenance of vegetated stormwater management practices typically falls under landscaping labor, including vegetation maintenance, correction of erosion and gullying, removal of trash and debris, weeding, fertilizing, and watering as necessary. Permeable pavement systems require alternative maintenance, including recommended minimum twice annual vacuuming and no application of sand. Often systems can function effectively with greatly reduced salt application in winter conditions, as free-draining surfaces do not provide any opportunity for ice buildup. Permeable pavement systems should be clearly designated, using signage if necessary, to ensure awareness and a commitment to alternative maintenance over time.

Figure 3.10 Example Opportunities for Implementation of Green Infrastructure



3.3 STREET LIGHTING

3.3.1 Illumination Levels

Street lighting can reduce crash frequency and improve safety by improving visibility at potential conflict points, and can also improve user comfort and personal or social safety. Guidance in this section is intended for use in street lighting and is based on Illuminating Engineering Society guidelines for roadway illumination (see **Figure 3.11**). In order to avoid unnecessary light spillover, energy usage, and environmental dis, streetlight concepts should be designed such that the average illumination levels do not exceed the recommended values. Generally, higher illumination levels are acceptable in more commercial land use contexts because of the higher vehicular and pedestrian traffic volumes. On streets surrounded by more residential contexts, recommended illumination levels are lower.

Figure 3.11 Illuminance Design Values

STREET TYPE	OFF-ROADWAY LIGHT SOURCES	ILLUMINANCE METHOD						ADDITIONAL VALUES
		AVERAGE MAINTAINED ILLUMINANCE				MINIMUM ILLUMINANCE	ILLUMINANCE UNIFORMITY RATIO	VEILING LUMINANCE RATIO
		R1	R2	R3	R4			
	LAND USE CONTEXT[1]	FC	FC	FC	FC	FC	AVG/MIN	LV(MAX)/LAVG
PRINCIPAL ARTERIAL	Village, commercial	1.1	1.6	1.6	1.4	As uniformity ratio allows	3:1	0.3:1
	Campus	0.8	1.2	1.2	1.0			
	Neighborhood	0.6	0.8	0.8	0.8			
MINOR ARTERIAL	Village, commercial	0.9	1.4	1.4	1.0		4:1	0.3:1
	Campus	0.8	1.0	1.0	0.9			
	Neighborhood	0.5	0.7	0.7	0.7			
COLLECTOR	Village, commercial	0.8	1.1	1.1	0.9		4:1	0.4:1
	Campus	0.6	0.8	0.8	0.8			
	Neighborhood	0.4	0.6	0.6	0.5			
LOCAL	Village, commercial	0.6	0.8	0.8	0.8		6:1	0.4:1
	Campus	0.5	0.7	0.7	0.6			
	Neighborhood	0.3	0.4	0.4	0.4			
ALLEY	Village, commercial	0.4	0.6	0.6	0.5		6:1	0.4:1
	Campus	0.3	0.4	0.4	0.4			
	Neighborhood	0.2	0.3	0.3	0.3			
SIDEWALK	Village, commercial	0.9	1.3	1.3	1.2		3:1	See illuminance requirements
	Campus	0.6	0.8	0.8	0.8		4:1	
	Neighborhood	0.3	0.4	0.4	0.4		6:1	
SHARED USE PATH	Any	1.4	2.0	2.0	1.8		3:1	

1 Designers should consider the International **Dark-Sky Association Model Ordinance** for lighting Recreation and Natural/Landscape land use contexts.

The illuminance levels in **Figure 3.11** are for continuous lighting along roadway and sidewalk segments. Lighting at intersections, including crosswalks and mid-block crossings, are typically lit to a value equal to the sum of the individual lighting level values of the two cross-streets. Crossings require additional consideration because the placement of luminaires can have a significant impact on the visibility of crossing pedestrians and bicyclists. In addition to ensuring that the intersection lighting meets recommended levels, streetlights should be located to front-light crosswalks, with the light source situated between the crosswalk and the motor vehicle, in the direction of motor vehicle travel. For wider intersections, it may be necessary to place light poles on all four corners of each intersection to achieve required illuminance levels. Where only two light poles are required to achieve required illuminance levels, light pole placement should generally prioritize the wider street.

Design plans for future developments should include an illuminance study to confirm that the proposed street light configuration results in AASHTO-compliant illuminance levels. Illuminance levels should also comply with the **Dark-Sky Association Model Ordinance**.[08] The study should separately present the average maintained illuminance, uniformity ratio (average/minimum illuminance), and veiling luminance for street segments, sidewalk segments, and intersections in the project area. The study should also provide specifications and photometry diagrams for luminaires used and specifications and mounting heights of poles used.

3.3.2 Luminaires & Poles

Luminaires and poles should be selected from Newton's standard family of fixtures (see **Figure 3.12** and **Figure 3.13**). It is the City's standard to use Ghisamestieri luminaire fixtures on a King Luminaire pole and Composite Material Technologies base in village centers and commercial centers. Pedestrian-scale poles may be installed as standalone post-top fixtures or as pendant lights on taller streetlights.

Figure 3.12 Recommended Luminaires and Poles

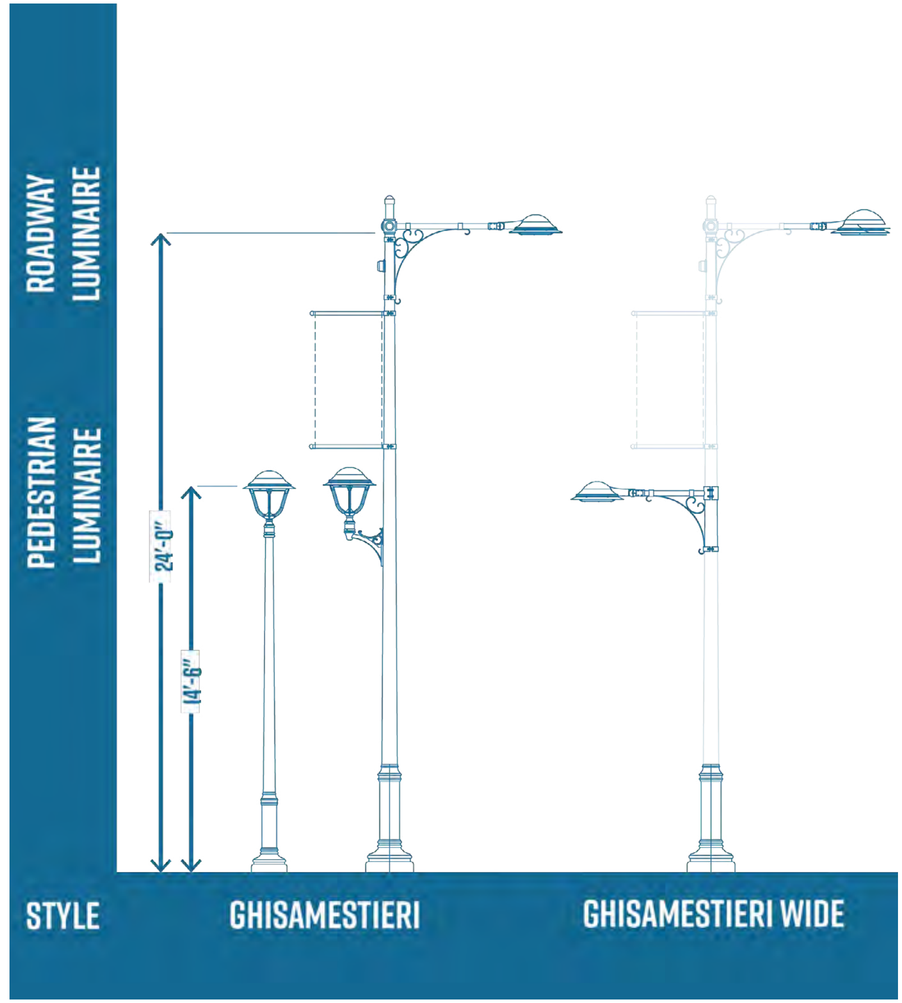
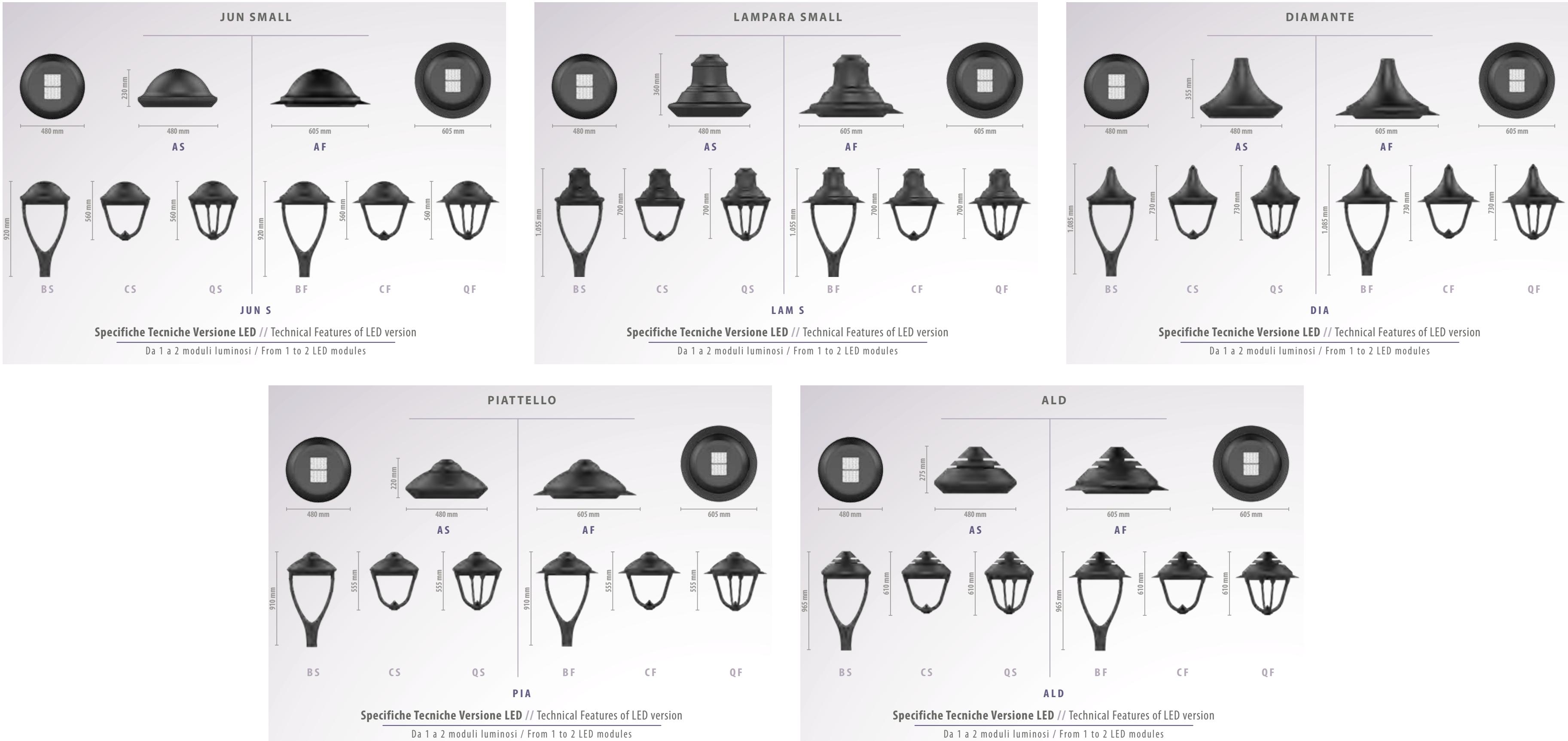


Figure 3.13 Ghisamestieri Luminaires Options



The City standard is to utilize LED luminaires, as the City has been fully LED since 2014. In residential areas, LED fixtures should have a color temperature within **2500K–3000K**. Higher color temperatures may be considered for LED fixtures in areas with commercial or industrial uses on a case-by-case basis. Understanding that LED technology continues to improve, when replacements take place, the City will re-evaluate the light color and distribution pattern that best suits the location.

Figure 3.14 illustrates horizontal lighting distribution patterns. Generally, fixtures with type III or IV directional distribution should be used along roadways and intersections (including crosswalks) to minimize light spillover onto adjacent properties. Type II luminaires may be used on paths primarily intended for pedestrians or cyclists, or on narrow roads. Designers should choose lighting fixtures with a full or partial vertical cut-off.

The placement of new streetlights should be sensitive to the location of existing buildings and utilities. New poles should be placed on property lines between buildings and should not be placed directly in front of buildings or windows. Designers should ensure that there is at least **3'** (**4'** minimum preferred) of clear sidewalk space adjacent to all poles, as poles should not encroach on ADA accessible pathways. All street lighting cables should be placed in conduits—direct burial is not permitted. Poles and conduit should have adequate horizontal and vertical clearance from underground utilities, stormwater features, and existing trees.

Figure 3.14 Recommended LED Distribution Types

Designers should ensure that once fully-grown, planted trees will not block streetlights. Also, designers should generally avoid running conduit under or through stormwater infiltration areas.

Recommended pole heights and luminaire mounting heights vary by location: **24'** along roadways and intersections and **14'6"** for supplemental pedestrian-scale lighting or along shared use paths (see **Figure 3.14**). Taller poles will cast light over a larger area, and will generally result in more uniform lighting. Shorter poles will need to be spaced closer together to achieve desired illumination levels and uniformity. Designers should look for opportunities to mount luminaires on existing utility poles or traffic signals to reduce cost and maintenance.

Light poles should be spaced evenly, and may be placed on the same side of the street or alternate every other pole. Spacing should be determined by illuminance levels, trees, and utility conflicts. Generally, taller poles will be spaced less frequently because they cast a wider effective area. Designers should consider providing additional lighting near high pedestrian areas such as schools, parks, village centers, and transit stations, or in areas where personal safety is a concern.

Consider the following when designing street lighting:

- Minimize light trespass onto adjacent properties. Generally, light spillover should be limited to **0.25 fc** at the property line. Many jurisdictions require **0 fc** at the property line, but this may be difficult to achieve in an urban environment.
- Dimmable lighting, motion sensors, and/or timer control can be installed to provide lighting only when people are present or during certain times of the day. Photocells may be installed on controller cabinets to shut off lights during daylight hours.

01 https://www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm

02 https://www.mass.gov/lists/521-cmr

03 https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/proposed-rights-of-way-guidelines/chapter-r3-technical-requirements

04 https://www.mass.gov/files/documents/2016/08/qi/v2c2.pdf

05 http://www.newtonma.gov/civicax/filebank/documents/37258

06 2014 District of Columbia, Department of Transportation, Green Infrastructure Standards

07 1,000 cubic feet of soil is a popular recommendation for medium and larger size trees between numerous municipalities according to DeepRoot, a company that maintains an online viewer of soil volume recommendations by city/state.

08 http://www.darksky.org/wp-content/uploads/bsk-pdf-manager/16_MLO_FINAL_JUNE2011.PDF

04

ROADWAYS

This chapter summarizes design guidance for roadways, which must safely, comfortably, and conveniently accommodate taking transit, biking, and driving. Design guidance for sidewalks is provided in Chapter 3 while intersections and crossings guidance is found in Chapter 5.

Roadway guidance covers travel lane and parking widths; bikeway types and applications; and speed reduction through horizontal and vertical traffic calming treatments.

4.1 TRAVEL LANES & PARKING

Street space in Newton is physically constrained by buildings, mature trees, existing curb lines, and narrow rights-of-way. However, many of the City's arterial and collector streets exhibit wide lanes that exceed contemporary standards.

To better balance the allocation of public right-of-way from a Complete Streets perspective, designers will seek opportunities to minimize travel lane, shoulder, and on-street parking widths. Narrower lanes help discourage higher motor vehicle operating speeds and improve safety for all users without reducing roadway capacity or increasing congestion. MassDOT notes that lane widths narrower than **11'** discourage higher operating speeds, reduce pedestrian crossing distances, and create space for other uses, such as sidewalks and bikeways.[01] As of 2015, FHWA no longer considers lane and shoulder width as controlling criteria for streets with less than **50 mph** design speeds, allowing for increased flexibility to implement narrower lanes.[02]

On low-volume local streets, narrow street widths and unmarked lanes are recommended to reinforce low design speeds and create a comfortable shared environment, particularly along bicycle boulevards (see **Section 4.2**). These conditions create "yield streets," which require motorists in opposing vehicles to carefully pass by using a portion of a parking lane. A yield street should have relatively frequent driveway spacing or up to approximately **50 percent** on-street parking utilization. Yield streets must provide sufficient usable width for occasional emergency vehicle or moving truck access. Many local streets in Newton already operate as yield streets.

Consider the following when designing travel lanes and shoulders:

- Travel lane and shoulder widths should be minimized to provide the space to accommodate all roadway users, reduce total impervious surface area, and support the City's established safety goals, including the citywide adoption of a **25 mph** statutory speed limit, except where a regulatory speed limit has been established
- Centerlines are required on streets with ≥ **6,000** vehicles per day and ≥ **20'** traveled way, per the MUTCD.
- Visually narrow travel lanes with pavement markings or contrasting materials in retrofit situations where excess pavement cannot be reduced.
- Local streets should be designed for low-speed, shared operations. See **Section 4.3** for traffic calming treatments.
- Sidewalk amenity zones and bikeway buffers accommodate traditional shoulder functions of drainage, snow storage, and lateral support of pavement.
- Fire truck outriggers are used to support ladder deployment and require a minimum **18'** clear area when in use. Where the travel way is narrower than 18', outriggers can be deployed between parked cars or onto another stabilized area such as a curb extension or sidewalk.

Consider the following when designing on-street parking:

- Restrict on-street parking at least **20'** in advance pedestrian crossings to provide adequate sight distance of pedestrians and bicyclists in accordance with the latest MUTCD and/or City Ordinance.
- Refer to **PROWAG R309**[03] for accessible parking guidance.
- On-street parking can be integrated into the design of separated bike lanes.
- Where angled parking is considered, back-in parking is preferable to front-in parking to increase motorist visibility when exiting a parking spot. When situated at a 45-degree angle, parking stalls should be striped to a **9'** width and **15'–19'** depth.

Figure 4.1 Recommended Travel and Parking Lane Widths

FUNCTIONAL CLASSIFICATION	SIDEWALK	BIKEWAY	PARKING LANE		TRAVEL LANE	
			RECOMMENDED	MAXIMUM	RECOMMENDED	MAXIMUM
ARTERIAL STREET	See **Section 3.1**	See **Section 4.2**	7'–8' [2]	9'	10'–11' [3]	12'
COLLECTOR STREET			7'–8' [2]	9'	10'	11'
LOCAL STREET[1]			Unmarked	Unmarked	Varies by parking[4]	10'

1 Striping for travel lanes or parking is not recommended for local streets.
2 8' recommended when adjacent to 10' travel lane or for any designated commercial loading zones.
3 Where MassDOT is a project proponent, a Design Exception Report is required with arterial lane widths < 11', arterial or collector shoulder widths < 4', or local shoulder widths < 2'.
4 26'–28' total curb-to-curb width for a two-way yield street with parking on both sides, or 20' curb-to-curb width with parking on one side.

4.2 BIKEWAYS

4.2.1 Bikeway Design

Figure 4.2 through **Figure 4.7** introduce bikeway design considerations including recommended widths. Designers should refer to the following resources for detailed design guidance on bikeways as well as intersection treatments:

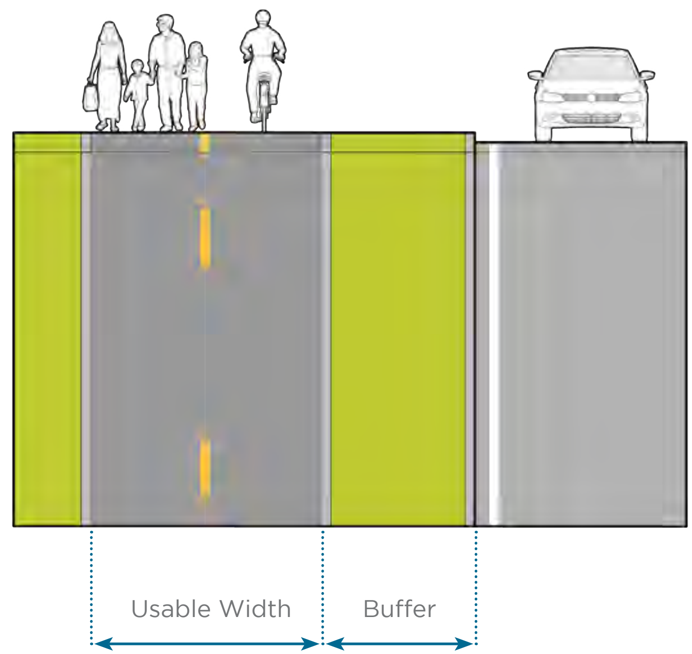
- **AASHTO Guide for the Development of Bicycle Facilities**
- **MassDOT Separated Bike Lane Planning & Design Guide**
- **NACTO Urban Bikeway Design Guide**

Where provided, designers should strive to provide continuous facilities through intersections to maintain safety and comfort where most conflicts occur. At a minimum, designers should provide bicycle crossings (see **Section 5.1.3**) and should consider supplemental intersection treatments such as bike boxes, two-stage turn queue boxes, and protected intersections. Additional geometric and signal strategies at intersections should be considered to reduce motor vehicle speeds and reduce bicyclist exposure at intersections (see **Chapter 5**).

Shared lane markings should only be implemented along with traffic calming treatments on local streets (i.e. bike boulevard). Along physically constrained arterial or collector streets where dedicated bikeways are not feasible, designers should consider lane or road diets or other traffic calming treatments to reduce operating speeds and encourage speed differentials ≤ **10 mph** between people driving and biking (see **Section 4.3**).

Figure 4.2 Shared Use Path

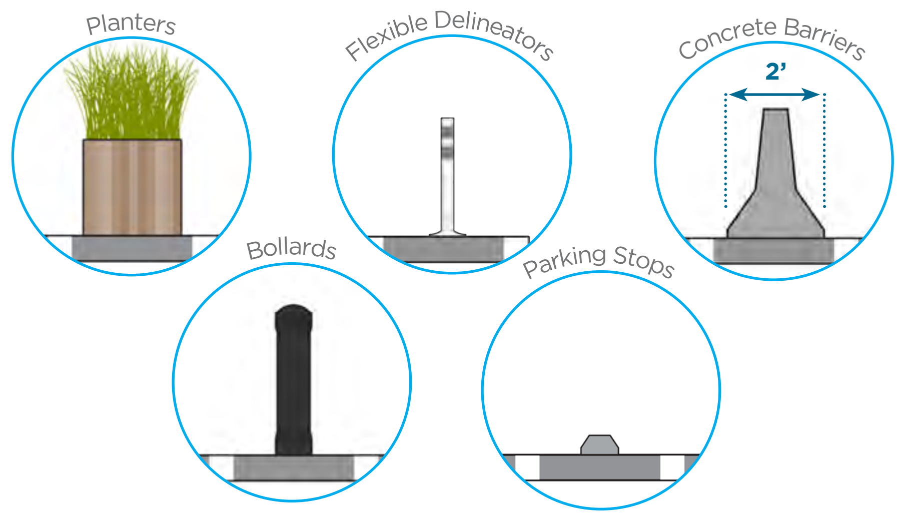
Shared use paths are physically separated from traffic and permit two-way operations for use by all non-motorized users. Shared use paths may be located along and parallel to a street or through parks, abandoned railroads, or other independent rights-of-way. Shared use paths are important links in accessible routes and must be designed to meet accessibility requirements concerning width, grade, cross slope, surfaces, etc. They are recommended only in locations with low pedestrian demand to minimize conflicts. Where implemented, they should be accompanied by signage to instruct bicyclists to yield to pedestrians and etiquette education, including possible audible indication. In some instances, the number of conflicts between bicyclists and pedestrians can diminish the utility of a shared use path. In these cases, designers should utilize the **Shared Use Path Level of Service Calculator**[04] to help guide decisions on when to separate people walking and biking.

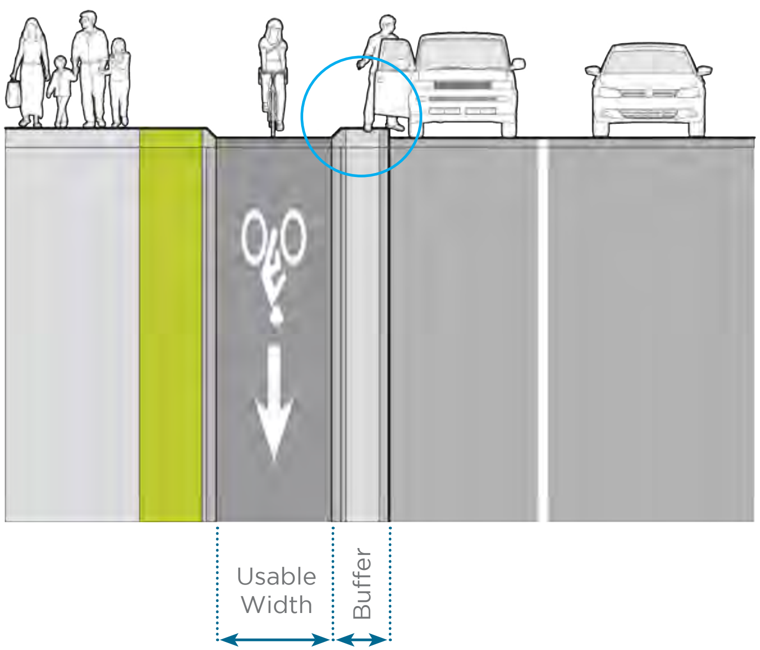


	Usable Width	Buffer
Rec.	11’	≥ 3’
Min.	8’	2’
Max.	N/A	16.5’

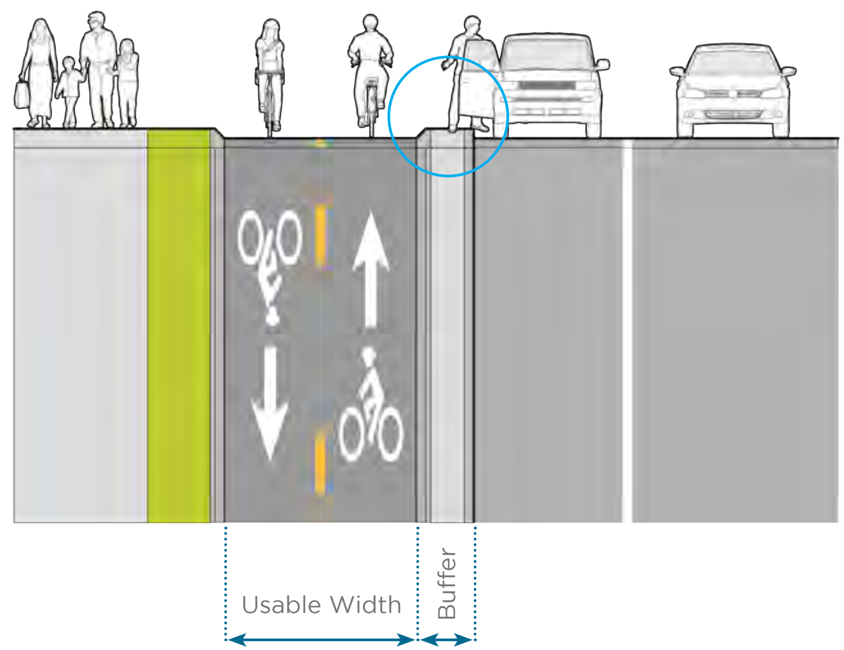
Figure 4.3 One-way or Two-way Separated Bike Lane and Vertical Elements Options for the Buffer

Separated bike lanes are physically separated from automobile traffic with vertical and horizontal elements and designated for exclusive use by bicycles. They may be designed for one- or two-way operation and may be constructed at street or sidewalk level, or at an intermediate level. Separated bike lanes are buffered from adjacent travel or parking lanes with a raised median (see below) or vertical elements (see options to the right). A sidewalk amenity zone with trees or other streetscape elements adjacent to the bike lane is recommended to prevent encroachment (see **Section 3.1**). In constrained corridors, a vertical curb between the bike lane and sidewalk is recommended where an amenity zone is infeasible. Designers should refer to the **MassDOT Separated Bike Lane Planning & Design Guide** for detailed guidance, including connectivity considerations, curb design, and suggested maintenance practices for year-round use.





	Usable Width	Buffer
Rec.	6.5'	≥ 3'
Min.	5'	2'
Max.	8'	16.5'



	Usable Width	Buffer
Rec.	10'	≥ 3'
Min.	8'	2'
Max.	11'	16.5'

Figure 4.5 Raised Bike Lane

Raised bike lanes are physically separated from traffic with a vertical curb but lack the dedicated buffer space provided in separated bike lanes. They are exclusively designed for one-way operation and may be constructed at sidewalk level or at an intermediate level between the street and sidewalk. Because they lack a buffer, raised bike lanes should not be implemented adjacent to on-street parking. A sidewalk amenity zone with trees or other streetscape elements adjacent to the bike lane is recommended to prevent encroachment (see **Section 3.1**). In constrained corridors, a vertical curb between the bike lane and sidewalk is recommended where an amenity zone is infeasible. A separated bike lane is recommended where a combined usable width and buffer width is ≥ **7'** to prevent vehicular encroachment.

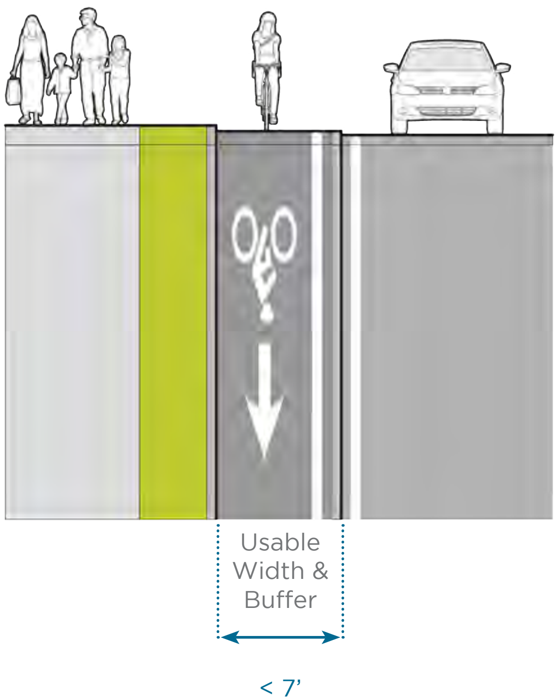


Figure 4.4 Buffered Bike Lane

A buffered bike lane is an on-street bikeway separated from an adjacent travel lane or on-street parking lane by a striped buffer area. This buffer may be placed on either side of the bike lane but is preferred against high turnover parking, where present, to reduce dooring risks to bicyclists. Buffered bike lanes are recommended on streets with low curbside activity or congestion pressure. A separated bike lane is recommended where a combined usable width and buffer width is ≥ **7'** to prevent vehicular encroachment.

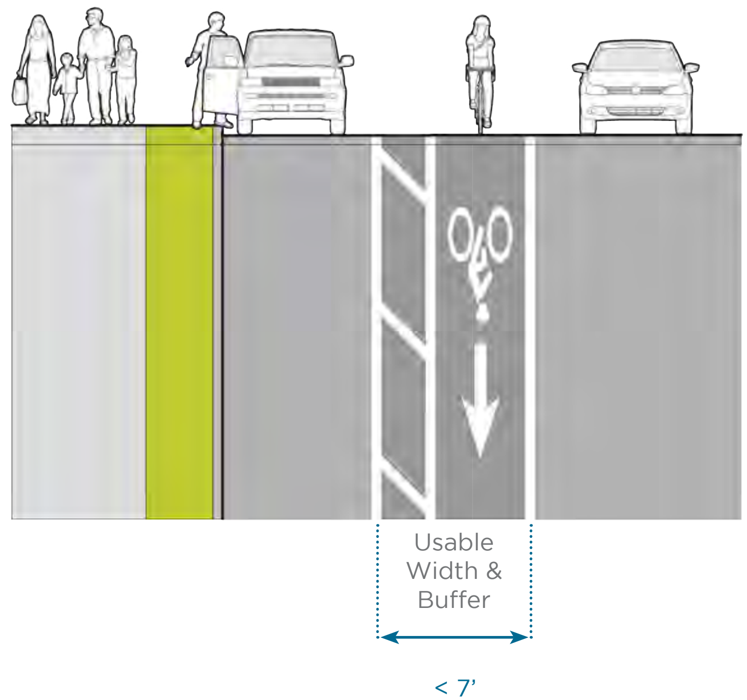
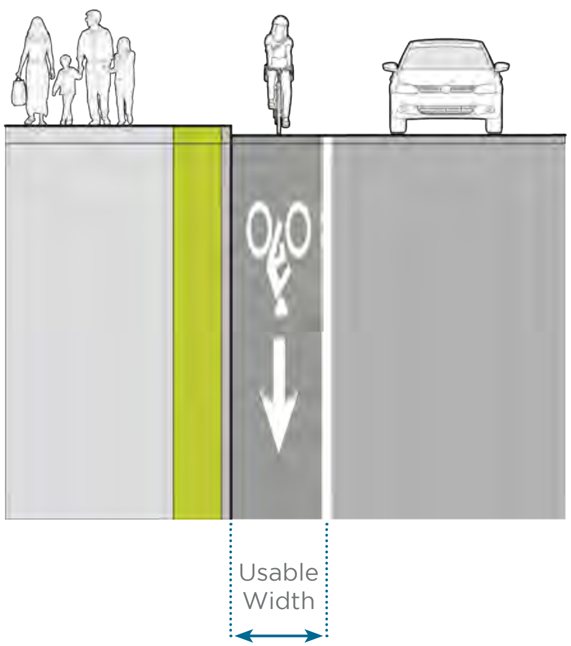


Figure 4.6 Conventional Bike Lane

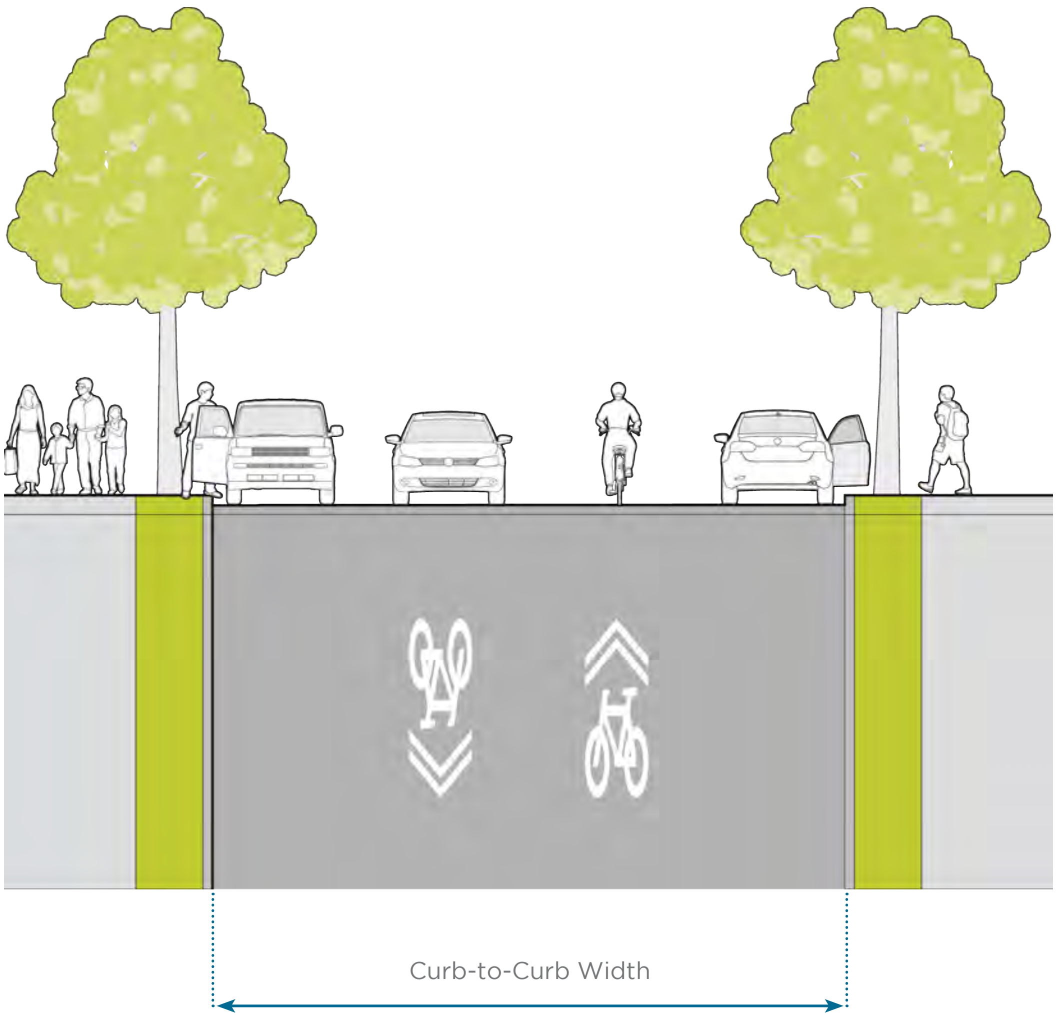
A conventional bike lane is an on-street bikeway delineated from an adjacent travel lane or on-street parking lane with pavement markings. Conventional bike lanes are recommended on streets with low curbside activity or congestion pressure. In addition, bike lanes **> 6'** may be interpreted as on-street parking lanes and see frequent encroachment. Designers should consider separated bike lanes where available width is ≥ **7'**. For projects where MassDOT is a project proponent, a Design Exception Report is required when the usable width of a bike lane is **< 5'**.



Rec.	5'–6'
Min.	4'
Max.	6'

Figure 4.7 Bike Boulevard

Bike boulevards are low-volume, low-speed streets—typically local streets—that have been designed to prioritize bicycle travel with signs, pavement markings, traffic calming measures (see **Section 4.3**), and, at major crossings, enhanced crossing treatments.



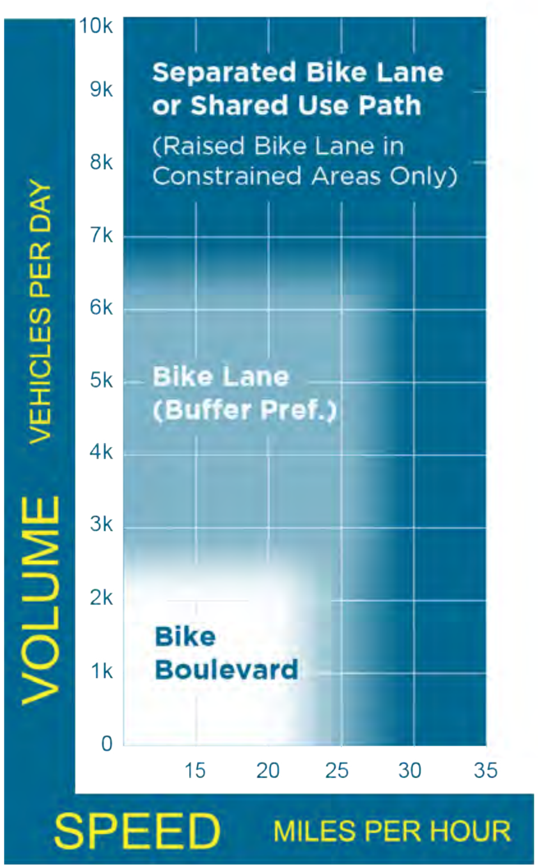
	Two Parking Lanes	One Parking Lane
Rec.	26'–28'	20'

4.2.2 Bikeway Selection

The planning, design, and implementation of dedicated bikeways—including on and off-street facilities—as part of a connected network will play a critical role in attracting people to everyday bicycle travel for work, shopping, and social visits. Some people are willing to bike in mixed traffic but most will not consider biking a viable transportation option unless they can make their entire trip along a "low-stress" route that is safe, comfortable, and convenient (see **Chapter 2** of the MassDOT Separated Bike Lane Planning & Design Guide for further information on low-stress principles). For most people, a low-stress route for biking means low motor vehicle volumes and speeds or separation from traffic when volumes and speeds are high. **Figure 4.8** provides designers with a framework to select low-stress bikeways that can attract riders of all ages and abilities. Used in the appropriate context, all bikeways in this Guide have the potential to provide low-stress conditions.

Biking in Newton

Figure 4.8 Selecting a Low-Stress Bikeway



1 This figure assumes operating speeds are similar to posted speeds. If they differ, designers should use operating speed rather than posted speed.
2 Separated bike lanes or shared use paths recommended on any street with two or more travel lanes per direction.

4.3 TRAFFIC CALMING MEASURES

Traffic calming helps manage motor vehicle operating speeds by introducing changes to a roadway's cross section (horizontal deflection), changes in pavement elevation (vertical deflection), reductions in roadway width, or a combination of these techniques. By managing speeds and reinforcing target design speeds, traffic calming increases the comfort of a shared operating environment, improves yielding at crossings, and enhances the quality of life along the street. Horizontal measures are visualized in **Figure 4.9** through **Figure 4.13**, vertical measures are shown in **Figure 4.14** through **Figure 4.17**, and width reduction measures summarized in **Figure 4.18**.

Consider the following when designing traffic calming measures:

- Design speed should target posted speed. Designing higher than the posted speed encourages faster driving and should be avoided.
- Travel times in urban environments depend on more than prevailing speeds, most notably intersection and traffic signal operations. Traffic calming helps maintain safe speeds between intersections, which may not impact overall travel time.
- While not specifically traffic calming measures, maintaining a sense of enclosure with street furnishings, trees, and walking and biking facilities provides a traffic calming effect.
- Stormwater management and impervious surface reduction may be ancillary benefits of traffic calming measures (see **Section 3.2**).

4.3.1 Vertical Deflection

Many nearby communities have successfully implemented traffic calming measures with vertical deflection on local, collector, and arterial streets, including Boston, Brookline, Cambridge, Dover, Milton, Quincy, Somerville, and Watertown. Vertical deflection is designed to be traversed at operating speeds between **20–25 mph**. Over the years, vertical deflection slopes and profiles have been refined and simplified to better realize target speeds, ease construction, reduce wear and tear on vehicles, and meet emergency response needs. To achieve these desired results, designers should use:

- A full reveal height (typically **6"**)
- A **flat profile** for all approach ramps (i.e., linear slope); other profiles are difficult to construct, which may result in improper installation that causes wear and tear
- **6'** approach ramp lengths except for raised driveway crossings where narrower ramps are encouraged
- ≤ **10'** approach ramp lengths when located on a "framework street" that serves a primary emergency response function (see **Section 4.3.2**). Assume an additional **2 seconds** to emergency response time per raised measure.

Designers should evaluate potential drainage impacts of any vertical traffic calming technique that spans the full curb-to-curb width of the street.

4.3.2 Implementation Framework

Horizontal and vertical traffic calming measures may be applied to arterial, collector, and local streets. The context for their application varies, however, so it is helpful to plan, design, and implement traffic calming by categorizing streets into **"framework"** and **"non-framework"** streets. Framework streets are arterial and collector streets that connect village centers, serve a primary emergency response function, and serve heavy vehicles such as buses and trucks. Non-framework streets are all other streets, typically low-volume local streets that serve a residential land use context.

Horizontal traffic calming measures are appropriate on any framework and non-framework street, as they do not generally impact emergency response times.

Vertical traffic calming measures, however, may adversely impact emergency response times if placed with excessive frequency. Therefore, vertical traffic calming measures on framework streets should be limited to school crossing, transit station access points, and other destination-specific crossings where increased yielding behavior is needed. Designers should assume an additional **2 seconds** to emergency response time per raised measure.

For non-framework streets, vertical traffic calming measures should be planned, designed, and implemented with a **zone-based approach**. Zone boundaries are typically defined by framework streets and the zones themselves are comprised entirely of local streets. By considering an entire area at the same time, the zone-based approach to vertical traffic calming anticipates and avoids the "transfer effect" of pushing speeding issues to nearby streets that have not received vertical traffic calming. Vertical measures may be placed more frequently within zones because emergency responders typically do not travel through non-framework streets. Designers should consider up to **8–12** vertical measures between framework streets as a general rule of thumb.

4.3.3 Data Collection & Evaluation

Traffic calming is most effective when its results are monitored over time and those results influence future approaches. Planning, design, and prioritization of traffic calming measures should be informed by a data-driven process that addresses both known safety concerns (i.e., crashes, speeds, etc.) and perceived safety concerns (i.e., near-misses, resident opinions, etc.). This Guide recommends the City collect before-and-after speed, volume, travel mode, crash, and public opinion data and continue to evaluate the success of traffic calming strategies and inform future designs. Where feasible, consider implementing traffic calming with low-cost, interim materials to test designs. Using the results, these measures may be tweaked and re-tested or advanced to full construction.

Figure 4.9 Lateral Shift

A lateral shift causes travel lanes to shift in one direction, typically by flipping on-street parking to the other side of the street.

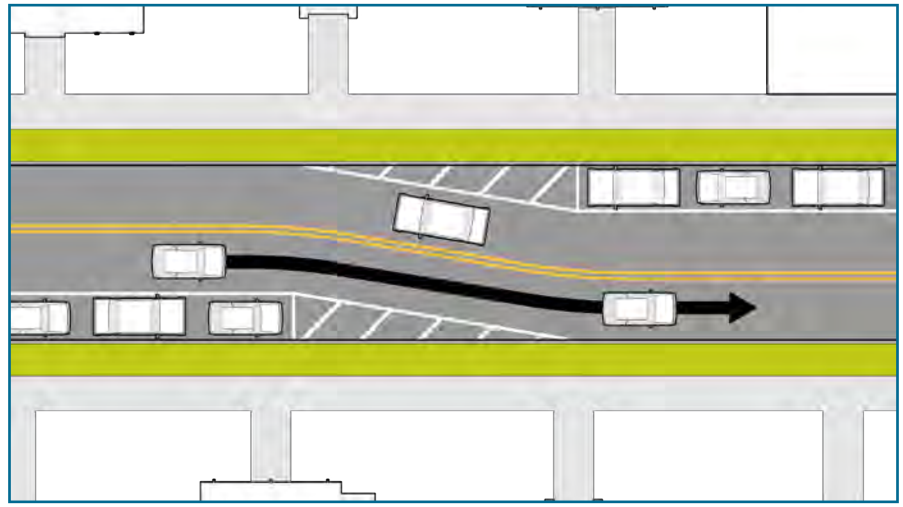


Figure 4.10 Chicane

A chicane is a series of alternating curves or lane shifts resulting from strategic placement of curb extensions or islands.

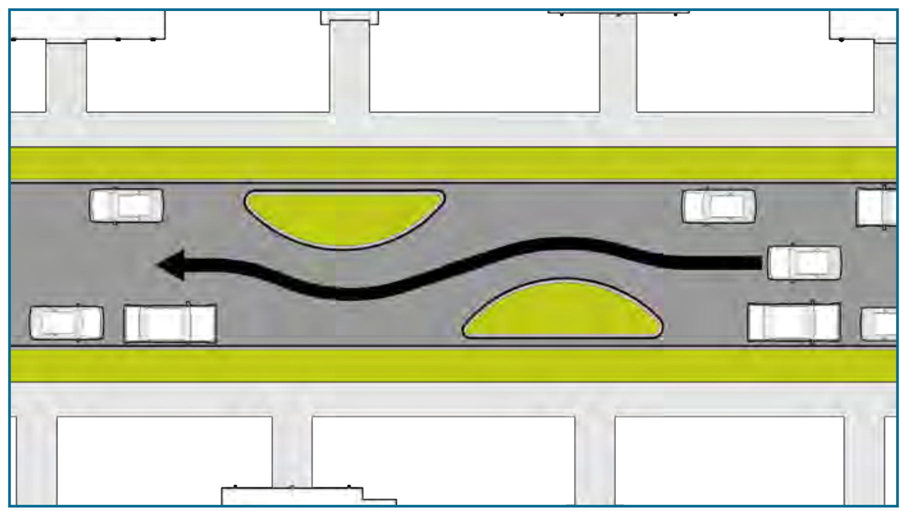


Figure 4.11 Intersection Realignment

A realignment reconfigures intersection geometry with perpendicular angles and reclaims excess pavement.

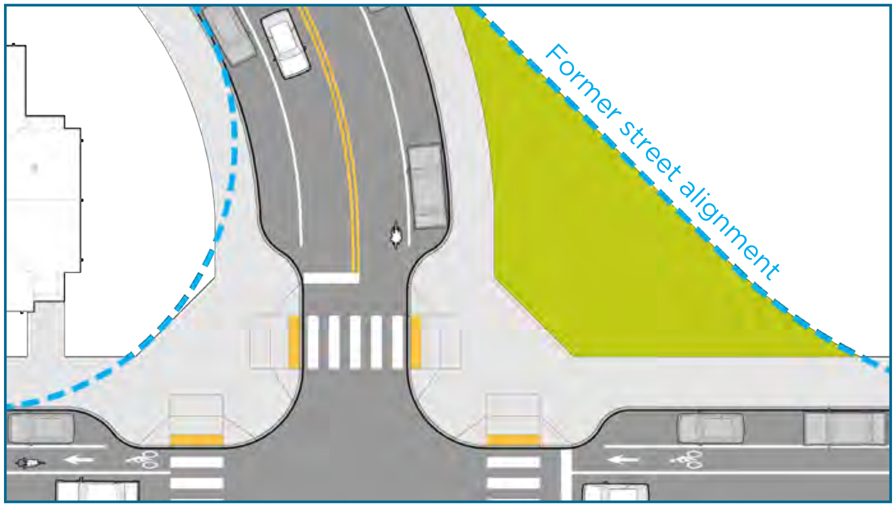


Figure 4.12 Neighborhood Traffic Circle

A neighborhood traffic circle is a raised island within an unsignalized intersection.

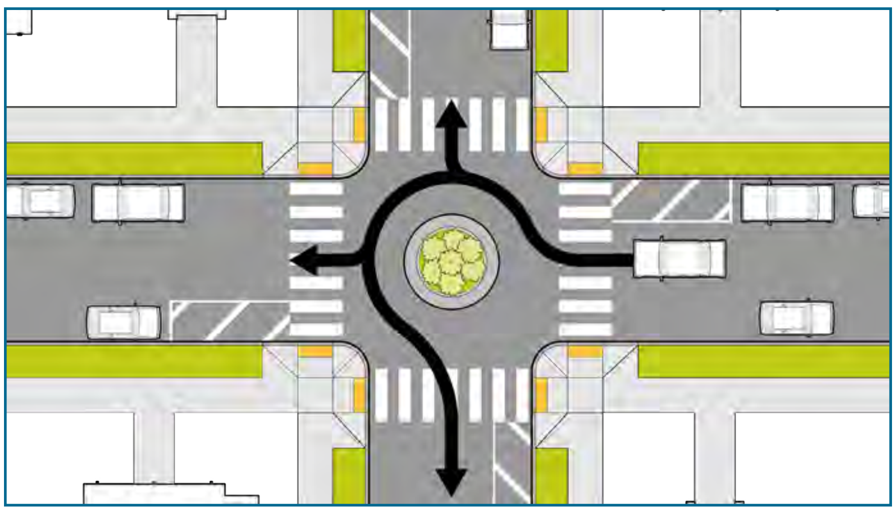


Figure 4.13 Roundabout

A roundabout requires all motor vehicles to follow a counterclockwise path. It is a **Proven Safety Countermeasure**.[05]

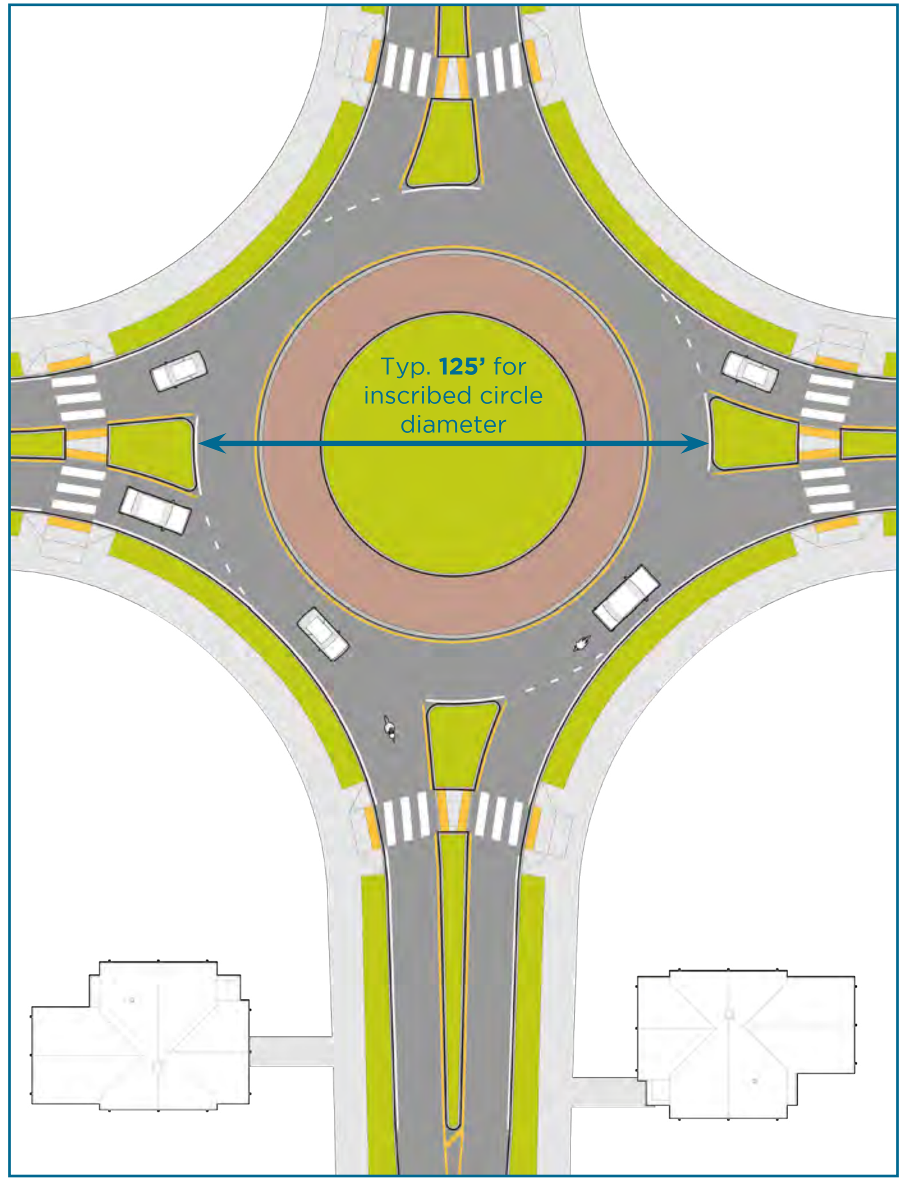


Figure 4.14 Speed Table

A speed table is a raised area with a ≥ **10'** flat top placed across the full width of the street (see **Section 4.3.1** for ramp details).

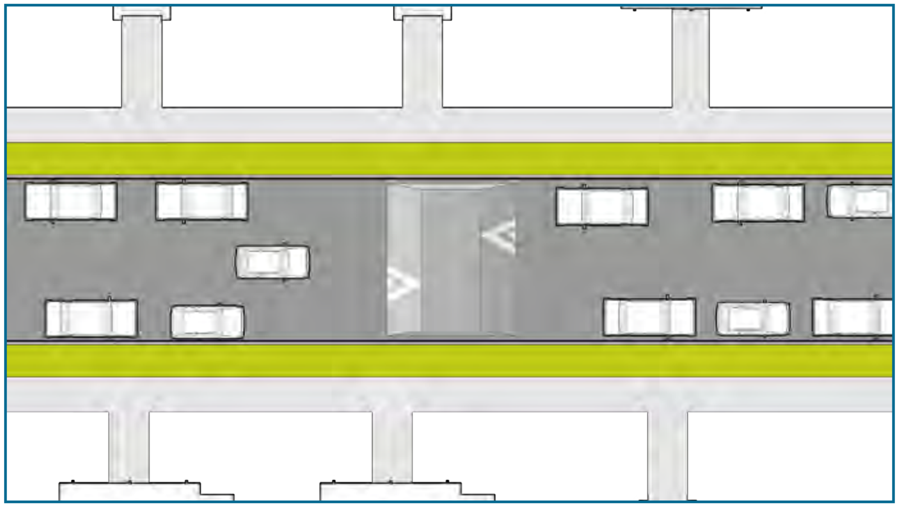


Figure 4.15 Speed Cushion

A speed cushion is a speed table with wheel cutouts designed to accommodate large vehicles (see **Section 4.3.1** for ramp details).

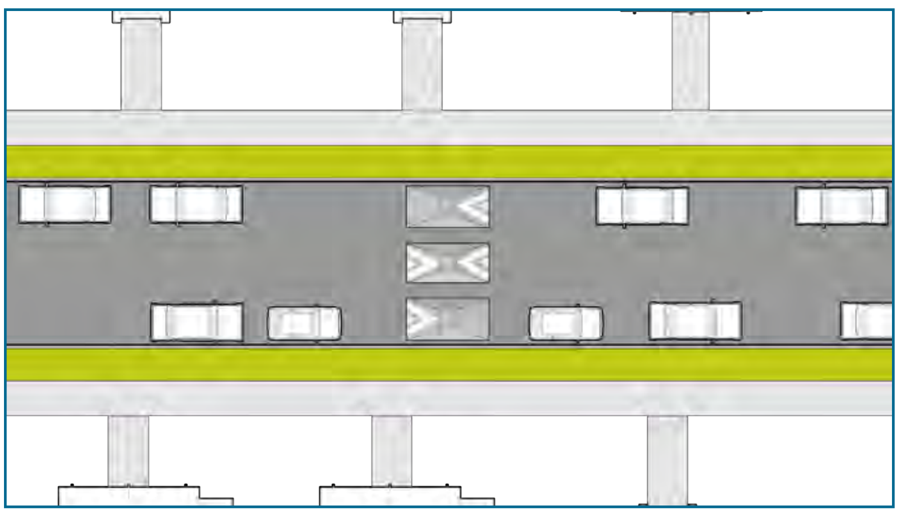


Figure 4.16 Raised Crossing

A raised crossing elevates a crosswalk to sidewalk level with ≥ **10'** flat top (see **Section 4.3.1** for ramp details).

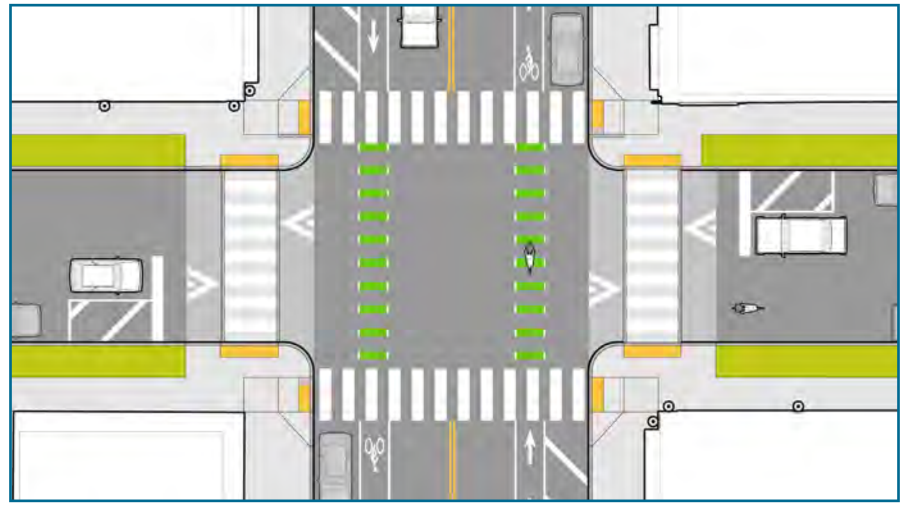


Figure 4.17 Raised Intersection

A raised intersection elevates the entire intersection footprint to sidewalk level (see **Section 4.3.1** for details).

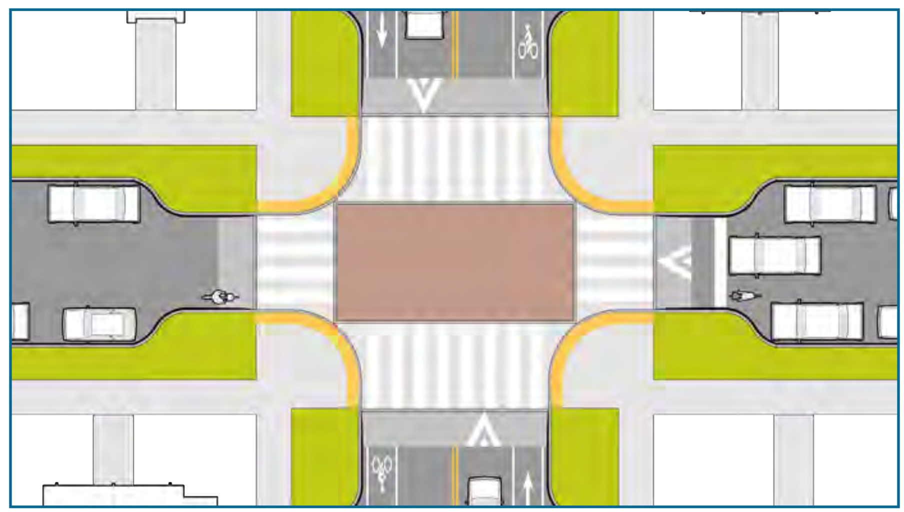


Figure 4.18 Width Reduction Measures

Width reduction measures may include on-street parking, curb extensions, crossing islands, or a combination of these measures. Where appropriate, designers should consider a road diet, which is a **Proven Safety Countermeasure**[06] (see FHWA's **Road Diet Informational Guide**[07] for road diet considerations, feasibility determination, and design guidance).

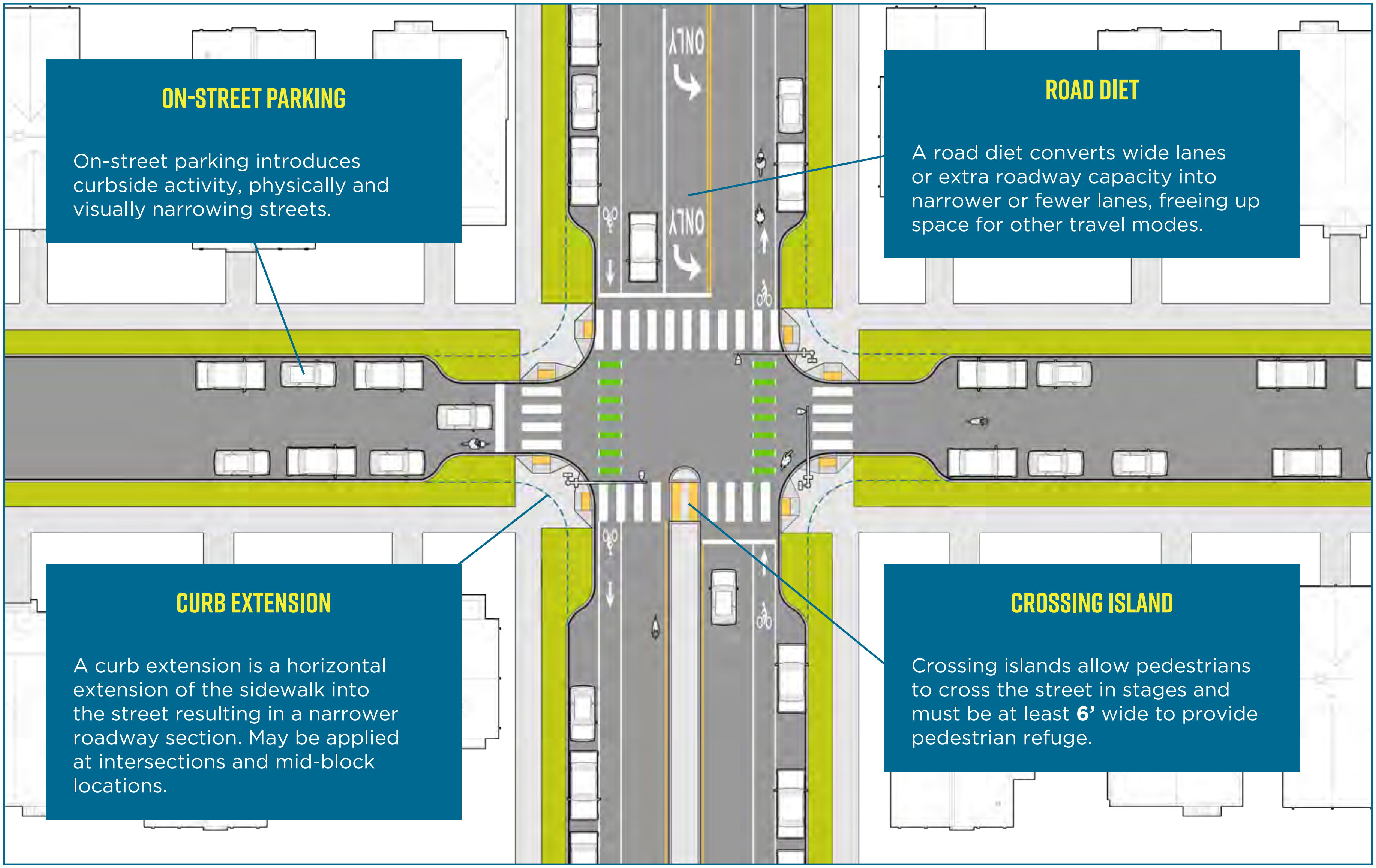


Figure 4.19 Traffic Calming Measures Toolbox

MEASURE	NON-FRAMEWORK STREET	FRAMEWORK STREET		NOTES
	LOCAL STREET	COLLECTOR STREET	ARTERIAL STREET	
HORIZONTAL DEFLECTION				
LATERAL SHIFT	Suitable	Suitable	May be suitable	
CHICANE	Suitable	Suitable	Not suitable	Avoid along streets with bus, freight, or emergency response activity unless traffic volumes are very low and large vehicles can straddle the centerline
INTERSECTION REALIGNMENT	Suitable	Suitable	May be suitable	
NEIGHBORHOOD TRAFFIC CIRCLE	Suitable	May be suitable	Not suitable	Provide corner daylighting when parked cars are present to facilitate turns by design vehicles
ROUNDABOUT	May be suitable	May be suitable	Suitable	Use passenger car for small or mini-roundabout design vehicle; mountable center islands or aprons are recommended for other design vehicles
VERTICAL DEFLECTION				
SPEED TABLE	Suitable	Suitable	May be suitable	See **Section 4.3.1** for vertical deflection design guidance
RAISED CROSSING	Suitable	Suitable	May be suitable	
RAISED INTERSECTIONS	Suitable	Suitable	May be suitable	
WIDTH REDUCTION				
CURB EXTENSION	Suitable	Suitable	Suitable	Recommended for use with on-street parking only. Incorporate daylighting and gateway elements for additional visibility. Ensure any reconfiguration of drainage or utilities does not preclude implementation of future bikeway.
CROSSING ISLAND	Suitable	Suitable	Suitable	
ON-STREET PARKING	Suitable	Suitable	Suitable	
ROAD DIET	Suitable	Suitable	Suitable	

01 http://www.massdot.state.ma.us/highway/DoingBusinessWithUs/ManualsPublicationsForms/ProjectDevelopmentDesignGuide.aspx

02 https://www.fhwa.dot.gov/design/standards/160505.cfm

03 https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/proposed-rights-of-way-guidelines/chapter-r3-technical-requirements

04 https://www.fhwa.dot.gov/publications/research/safety/pedbike/05138/

05 https://safety.fhwa.dot.gov/provencountermeasures/roundabouts/

06 https://safety.fhwa.dot.gov/provencountermeasures/road_diets/

07 https://safety.fhwa.dot.gov/road_diets/guidance/info_guide/

05

INTERSECTIONS & CROSSINGS

This chapter provides design guidance to mitigate conflicts and encourage safe speeds at intersections and crossings, and to ensure crossings are accessible and visible. Additional guidance related to sidewalks and roadways are found in Chapters 3 and 4, respectively.

Accessible routes must be maintained through intersections via dedicated crossings, curb ramps, and signal strategies, which are discussed in this chapter. Designers must adhere to accessibility standards outlined in the latest **ADA Standards for Accessible Design**[01] and **521 CMR**[02] and are encouraged to follow the U.S. Access Board's latest **PROWAG**.[03]

5.1 CONFLICT POINTS

Newton's intersections should clearly establish right-of-way priority using visual cues that communicate expected yielding behavior. They should also provide adequate sight distance between people walking, biking, and driving to give sufficient time to identify and react to potential conflicts. This section provides guidance regarding pedestrian and bicycle crossing templates, crossing spacing and placement, approach clear spaces for visibility, and additional considerations

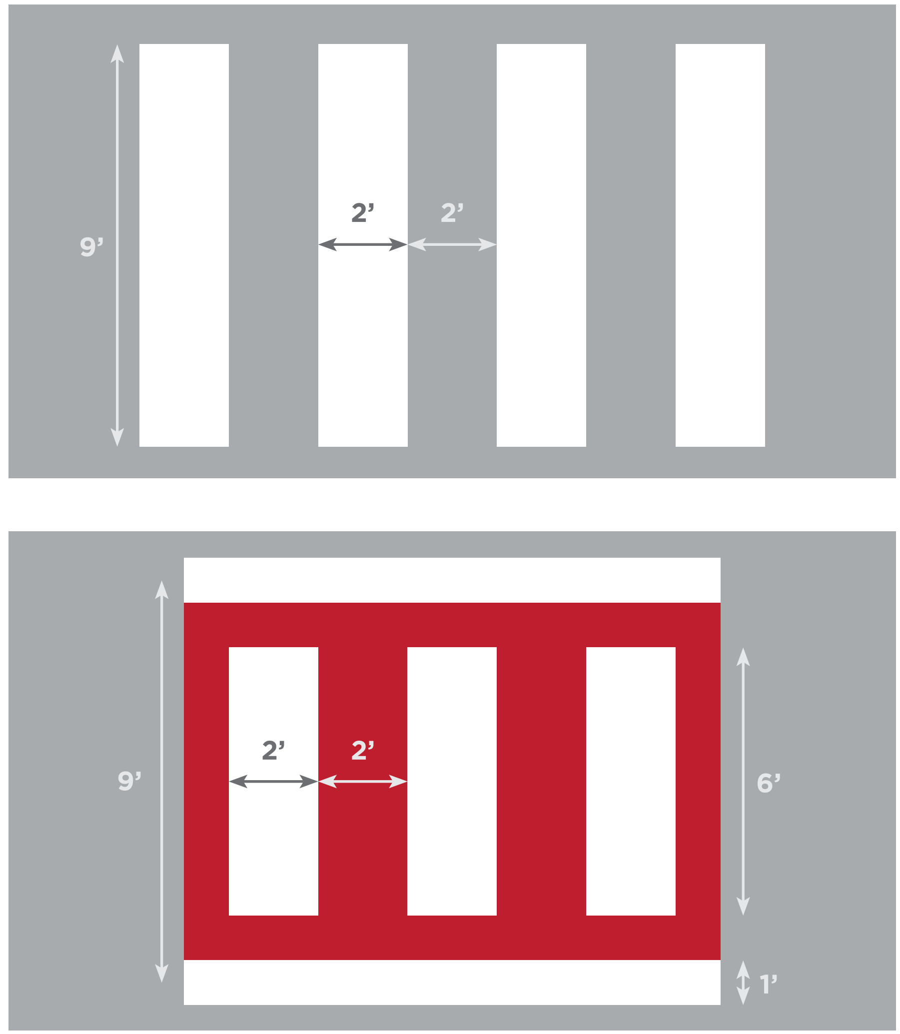
5.1.1 Crosswalk Design

All marked pedestrian crossings should include continental crosswalk striping, which have been shown to be highly visible and may provide up to **48 percent** pedestrian crash reduction.[04] Crossings should also provide regulatory signage for turning and side street/driveway traffic and must provide ADA-compliant curb ramps or blended transitions connecting to accessible routes. In well-lit village centers, high-visibility crosswalks may be enhanced with red paint (see **Figure 5.1**).

At signalized intersections, provide a stop bar in advance of the crossing and consider signal timing guidance outlined in **Section 5.3**. Recessed stop bars should be considered based on design vehicle turning envelope (see **Section 5.2.1**). At mid-block crossings, provide yield lines and regulatory sign R1-5 in advance of the crossing.

Designers should restrict on-street parking, where present, at least **20'** in advance of crossing to provide adequate sight distance (i.e. "daylighting").[05] Parking restrictions should be supplemented with signage, and may be supplemented with pavement markings and vertical elements such as flexible delineators (i.e., flexposts) or planters.

Figure 5.1 Standard (top) and Village Center (bottom) Crosswalk Design



Designers should consider enhanced pedestrian crossing treatments to address challenging crossing locations, for example at uncontrolled mid-block locations, along multi-lane streets, or at known crash clusters (see **Figure 5.2**).

Crossing islands allow pedestrians to cross the street in stages and must be at least **6'** wide to provide pedestrian refuge. They are a Proven Safety Countermeasure with up to **56 percent** pedestrian crash reduction.[06] Crossing islands can be located in the median or implemented as part of a separated bike lane (see **Figure 4.3**).

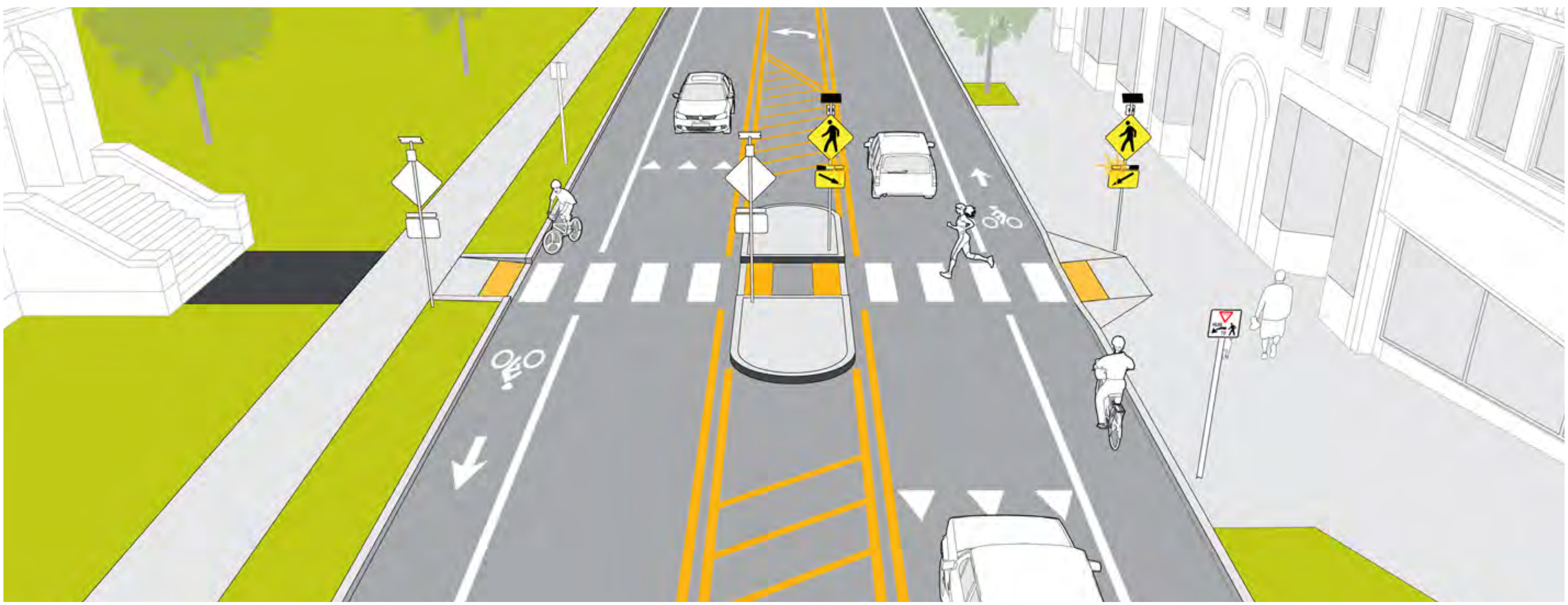
Raised crossings or intersections effectively control motor vehicle operating speeds, which encourages yielding (see **Section 5.2.3**). Raised crossings may reduce fatal and injury crashes by up to **36 percent**.[07]

Pedestrian hybrid beacons require motorists to stop when activated. They are a Proven Safety Countermeasure with up to **69 percent** pedestrian crash reduction.[08] Designers should perform a warrant study as outlined in the Enhanced Crossing Treatments section of FHWA's **Achieving Multimodal Networks** to determine applicability.

Rectangular rapid-flashing beacons (RRFB) help alert of pedestrians where motorists do not expect crossings and may reduce pedestrian crashes up to **47 percent**.[09] On multi-lane streets, RRFBs are most effective when paired with a crossing island to provide refuge. All RRFBs must be accessible (see **Section 5.3.4**).

Road diets remove one or more travel lanes to provide space for other facilities or amenities, narrow pedestrian crossings, and remove the multiple-threat risk associated with four-lane streets. They are a Proven Safety Countermeasure with up to **47 percent** crash reduction.[10] Designers should refer to FHWA's **Road Diet Informational Guide**[11] for road diet considerations, feasibility determination, and design guidance.

Figure 5.2 Enhanced Pedestrian Crossing Treatments



Consider the following when designing pedestrian crossings:

- Wider crosswalks may be provided in areas of high pedestrian activity, to better connect offset T intersections, or where increased visibility is desired.
- Irregular intersection geometry may necessitate additional strategies to provide sufficient visibility at pedestrian crossings. May not be feasible to add crosswalks to all legs of certain intersections in the near-term because they would require corner reconstruction for curb ramps.

5.1.2 Crosswalk Placement

Unmarked crossings are typically located on local streets with lower motor vehicle speeds and volumes. Where appropriate, marked crossings should be considered to increase the safety, accessibility, and convenience of the pedestrian network. In Newton, marked pedestrian crossings should be considered in the following instances:

- Across arterial and collector streets at a reasonable spacing to be convenient and accommodate desire lines[12]
- Across all intersecting side streets of arterial and collector streets
- Within village center and commercial land use contexts
- At bus stops
- Mid-block at major generators and destinations for walking trips, in particular schools, senior centers, playgrounds, and places of worship
- Along designated Safe Routes to School walking routes

Designers may mark only one crosswalk at minor T intersections with low pedestrian volumes. Designers should ensure that all pedestrian crossings are accessible, even if unmarked. See **Section 5.2.2** for curb ramp placement considerations.

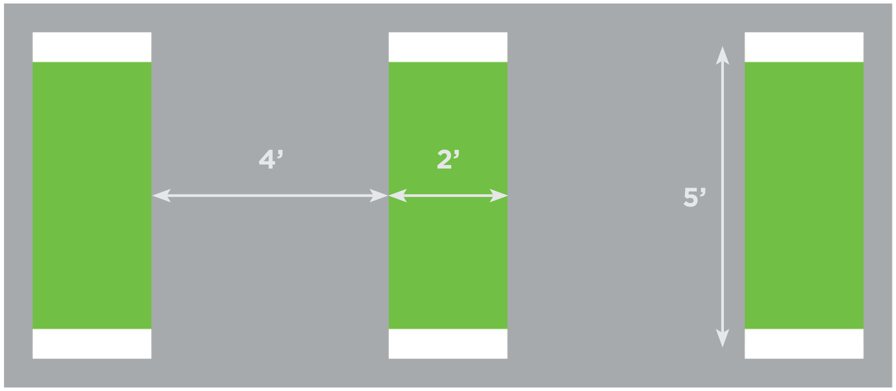
5.1.3 Bicycle Crossing Design

Bicycle crossings guide bicyclists through intersections, indicate areas of conflict, and encourage motorist yielding. Designers should consider bicycle crossings through all intersections and commercial driveways with dedicated bikeways and across motor vehicle merge areas. At a minimum, bicycle crossings should be the full width of the bikeway and bound by white dotted lines that align with parallel crosswalks, where available. Supplemental dashed green colored pavement is recommended in locations with permissive motor vehicle conflicts to further highlight areas of conflict (see **Figure 5.3**).

Consider the following when designing bicycle crossings:

- Supplemental intersection treatments, for example bike boxes, two-stage turn queue boxes, and protected intersections, help bicyclist safely navigate intersections. See detailed design guidance in the latest **MassDOT Separated Bike Lane Planning & Design Guide**[13] and **AASHTO Guide for the Development of Bicycle Facilities.**[14]
- On-street parking, where present, should be restricted at least **20'** in advance of crossing to provide adequate sight distance (i.e. "daylighting").[15] Consider greater distances for higher vehicular turning speeds, as outlined in **Section 4.2.5** of MassDOT's Separated Bike Lane Planning & Design Guide.[16]

Figure 5.3 Standard Bicycle Crossing Design



5.2 INTERSECTION CORNERS

Newton's intersections should reinforce safe speeds to reduce the likelihood of severe or fatal crashes, particularly for vulnerable users such as pedestrians and bicyclists. This section summarizes geometric strategies to reinforce these desired turning speeds.

5.2.1 Corner Radius

Designers should strive to provide the smallest appropriate corner radius based on an understanding of design vehicle, target turning speeds, acceptable encroachment, and effective pavement width. In addition to discouraging higher turning speeds, smaller corner radii are preferred in order to better align curb ramps with pedestrians' intended paths of travel (see **Section 5.2.2**).

The design vehicle is a frequent user of the street that helps determine the general layout of intersection corner. Newton uses the following default design vehicles as a starting point, each of which has a different turning radius based on their wheelbase:

- DL-23 (**15'** wheelbase) for local streets
- SU-30 (**20'** wheelbase) for collector streets
- WB-50 (**50'** wheelbase) for arterial streets

Designers have discretion when selecting a design vehicle and may find that local conditions warrant a different vehicle:

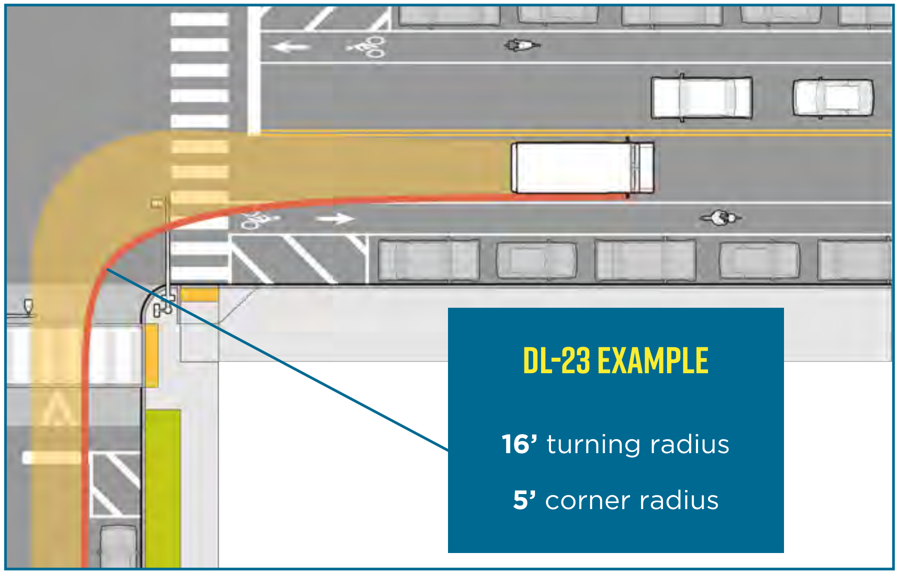
- SU-30 for arterial streets where truck traffic is low
- CITY-BUS (**25'** wheelbase) along transit bus routes
- S-BUS-36 (**21'** wheelbase) on school bus routes

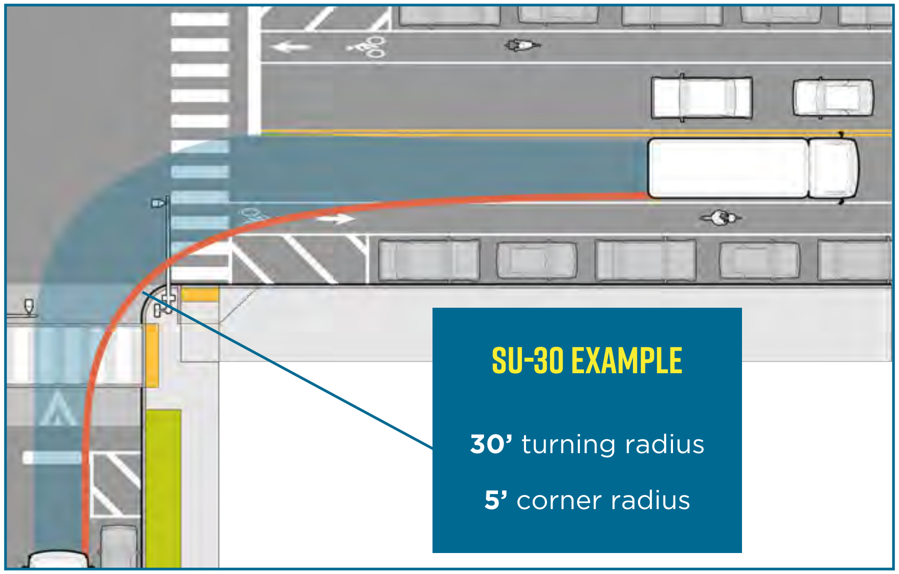
Designers should always analyze impacts to all users and select the smallest appropriate design vehicle to support safe and comfortable multimodal facilities while still accommodating motor vehicle turns. Achieving the smallest appropriate corner radius will require additional strategies:

- Assume **10 mph** turning speeds (**15 mph** maximum) for passenger cars and **5 mph** "crawl" turning speeds[17] for design vehicles.
- Compare the corner radius to the vehicle's effective turning radius on streets with wide lanes, bikeways, shoulders, or on-street parking (see **Figure 5.4**).
- Assume an acceptable level of encroachment for the design vehicle based on scenarios outlined in **Figure 5.5**.
- Recess the stop line of the receiving street beyond the minimum required **4'** from the crosswalk.[18] Ensure that any encroachment does not conflict with overlapping phases at signalized intersections.

Design vehicle negotiating an intersection corner

Figure 5.4 Corner vs. Turning Radius Examples





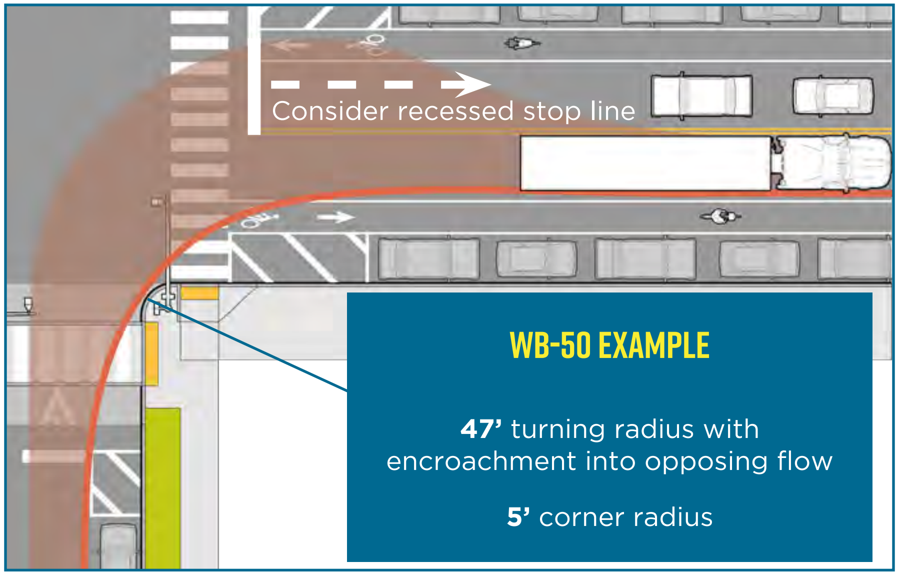


Figure 5.5 Encroachment Scenarios

FULL USE OF INTERSECTION FOOTPRINT

- Fire truck at any intersection
- Design vehicle from local to local

FULL APPROACH IN SAME DIRECTION, DEPART IN OPPOSING FLOW

- Design vehicle from local to arterial or collector
- Design vehicle from collector or arterial to local

FULL APPROACH AND DEPARTURE WIDTH IN SAME DIRECTION

- Design vehicle at arterial to arterial signalized intersections
- Design vehicle from collector to arterial or collector
- Design vehicle from arterial to collector
- Passenger car from local to local or collector (no passenger car encroachment in all other intersections)

While each intersection is unique and requires analysis when designing corner radius and curb ramp placement, designers should strive to provide corner radii less than **20’** for intersections with local streets and less than **30’** for all other intersections. Where right-turning movements are prohibited, consider a corner radius less than **5’**.

Where resulting corner radius must exceed **20’**, designers should consider geometric techniques to slow speeds, for example raised crossings (see **Section 5.2.3**) or mountable truck aprons. Mountable truck aprons should be a maximum of **3”** to accommodate lowboy trailers. This height is sufficient to facilitate design vehicle off-tracking while discouraging higher turning speeds for automobiles. Designers should place signal equipment and bicycle and pedestrian elements (e.g., detectable warning surfaces, bicycle stop bars, etc.) behind the mountable area to discourage refuge.

Motor vehicle turning alongside a mountable truck apron

5.2.2 Curb Ramp Placement

By facilitating connectivity between sidewalks and crossings—marked or unmarked—curb ramps are essential links of accessible routes. Historically, curb ramps have been placed at the apex of intersection corners, which directs pedestrians into the intersection and away from the crosswalk. Designers should strive to provide two curb ramps per corner, each aligning with desired paths of travel to minimize out-of-direction routing (see **Figure 5.6**). Pedestrians must be directed into the intended crosswalk via a **4' by 4'** accessible clear space at the base of the ramp, which must be outside of the parallel travel lane (see **PROWAG R304.5.5**[19] for detail).

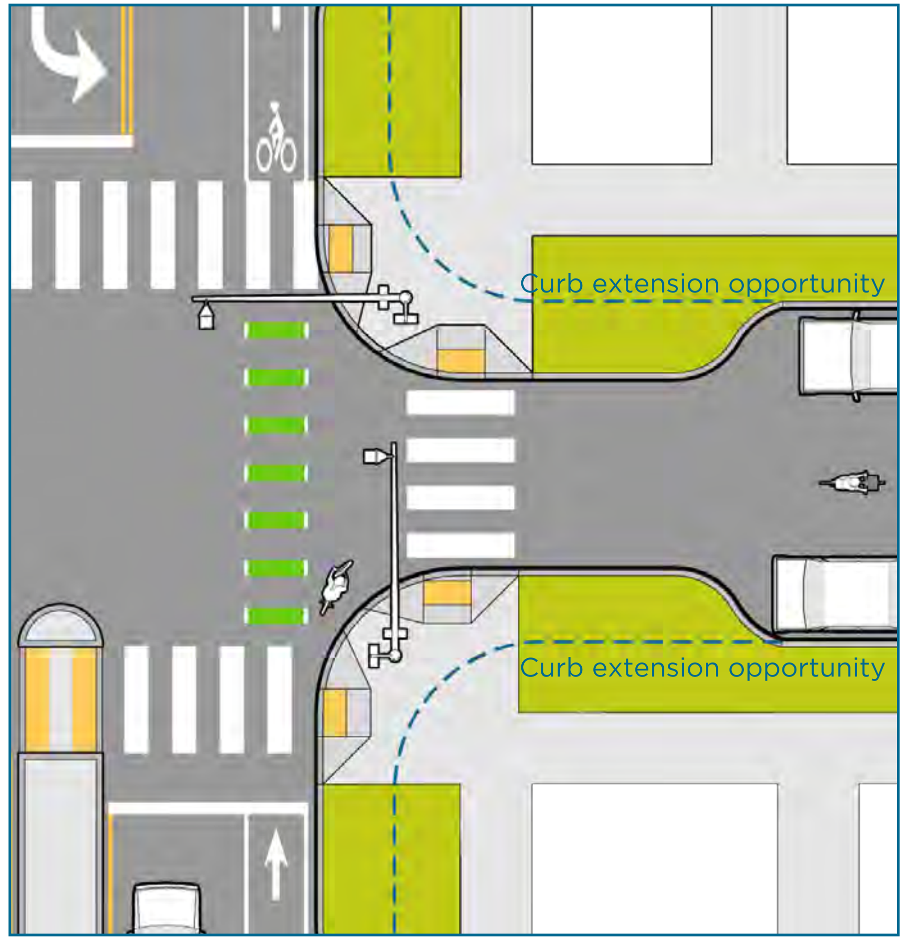
To achieve this, designers should provide the smallest appropriate corner radius (see **Section 5.2.1**) and:

- Locate perpendicular/parallel curb ramp as close to the intersection as possible, or
- Raise the crossing to eliminate the need for curb ramps or minimize their size (see **Section 5.2.3**). Raised crossings are especially useful to provide an accessible environment in constrained locations and to minimize water ponding.

Consider the following when designing curb ramps:

- Ramp placement may be affected by the location and placement of streetscape elements and utilities, including catch basins.
- Curb extensions can create additional sidewalk space and simplify alignment and design of curb ramps. Designers should refer to the latest Bicycle Master Plan for Newton to ensure that curb ramp placement does not preclude the implementation of all-age-and-ability bikeways.

Figure 5.6 Recommended Curb Ramp Placement



5.2.3 Raised Crossings

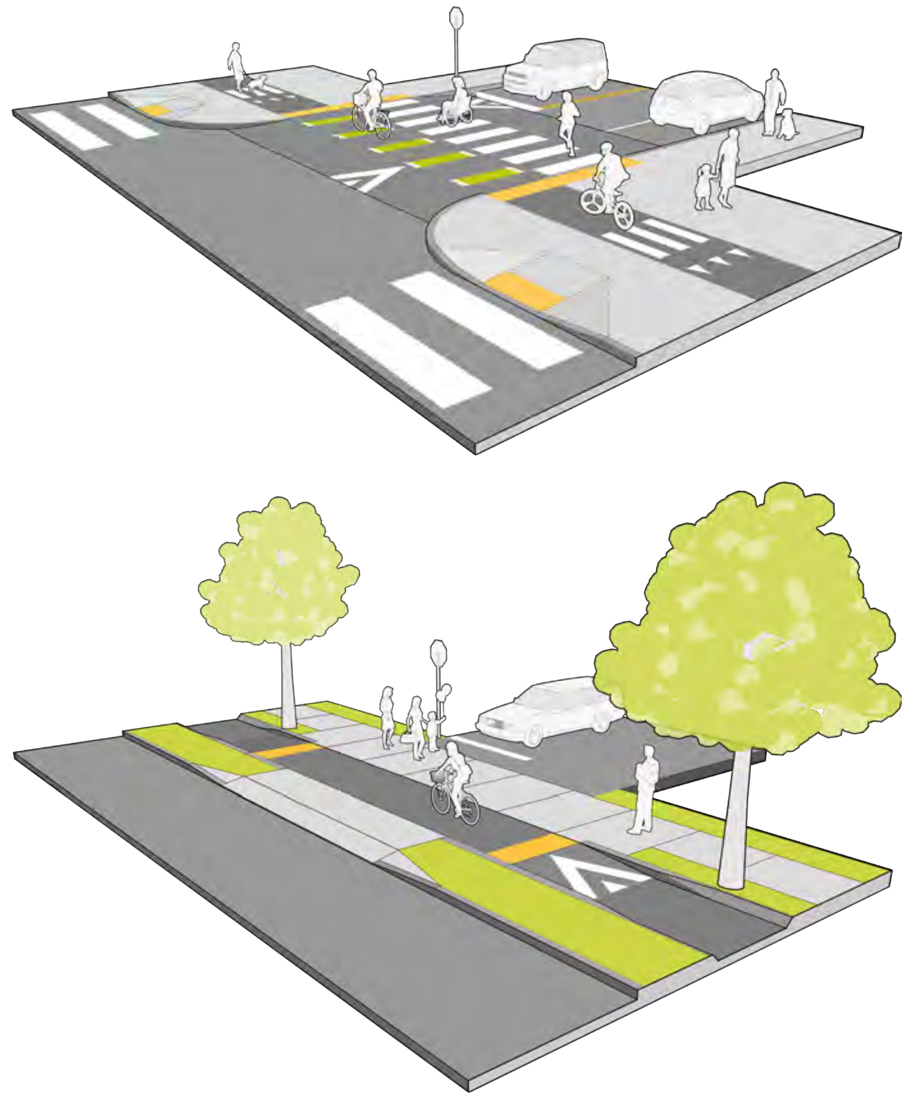
A raised crossing is the application of a speed table at a designated pedestrian or bicycle crossing (see **Figure 5.7**). As a traffic calming device, raised crossings effectively control motor vehicle operating speeds and are designed to achieve **20–25 mph** target speeds. Raised crossings may apply in any location where motorists yield to pedestrians or bicyclists or where a flush walking or biking surface is desired (for example to simplify the accessibility of pedestrian crossings in constrained locations). Designers should consider raised crossings at:

- Collector or local side street crossings along arterial streets
- Driveway and alley crossings
- Channelized right-turn lane crossings
- Roundabout crossings
- Crossings where corner radius exceeds **20'** (see **Section 5.2.1**)

Consider the following when designing raised crossings:

- Motor vehicle approach ramp slope and profile design should follow guidance established in **Section 4.3.1**.
- Raised pedestrian crossings require special consideration to maintain an accessible environment. Designers should refer to the latest ADA and MAAB requirements for blended transitions to ensure that blind or low-vision pedestrians can safely cross.
- Extend the surface of the walking zone or bikeway through the raised crossing to communicate right-of-way priority.

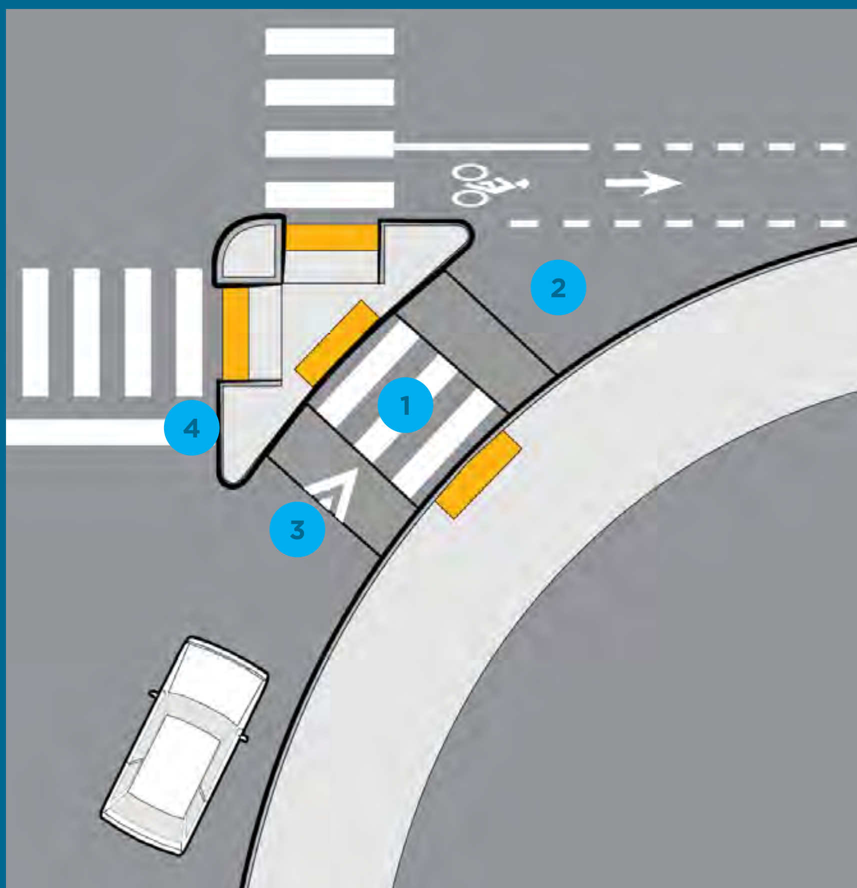
Figure 5.7 Raised Crossings at Side Streets (top) and Driveways (bottom)



5.2.4 Channelized Right-turn Lanes

Channelized right-turn lanes (i.e., slip lanes) are primarily designed to increase vehicular capacity of intersections by enabling higher turning speeds and reduced stopping frequency. They can also enable turning movements at skewed intersections and facilitate large design vehicles. While their safety impacts relative to pedestrian crashes are not well documented,[20] higher motor vehicle speeds generally reduce motorist yielding rates[21] and result in worse health outcomes for pedestrians in the event of a crash. Channelized right-turn lanes require through-bicyclists and right-turning motorists to negotiate space in advance of the intersection, reducing the safety and comfort of the bicycling environment.[22] However, several Newton intersections include channelized right-turn lanes today. **Figure 5.8** highlights short-term strategies to slow motor vehicle turning speeds and encourage yielding, and longer-term options to redesign and reconstruct intersection corners with channelized right-turn lanes.

Figure 5.8 Channelized Right-turn Lane Strategies



Short-term Strategies

1. Align crosswalk with the lane at a **90-degree** angle to reduce pedestrian crossing distances and maximize pedestrian visibility.
2. Offset the crosswalk at least one car length from the street to allow for one vehicle to queue before merging with cross street traffic.
3. Raise the crosswalk to the sidewalk level to slow vehicles moving through the slip lane.
4. Install a STOP,* YIELD,* or traffic signal to minimize conflicts with people in the crosswalk (*only applicable when the channelized turn lane is not controlled by a traffic signal). Use NO TURN ON RED with signalized right turn lanes.

Reconstruction Options

- Modify corner radius to a maximum of **40’** and minimize turn lane width to ≤ **12’** based on turning analysis, and modify traffic island to ensure slip lane merges with the intersecting street at a **55–70-degree** angle to maximize sight lines.
- Remove the channelized right-turn lane and replace with a **90-degree** turn.

5.3 PEDESTRIAN SIGNAL TIMING

Traffic signals control intersection operations for all users. Vulnerable users, such as people walking and biking, are most vulnerable at intersections because they cross paths with motor vehicles. Designers should strive to minimize exposure to intersection conflicts while also minimizing delay, as delays exceeding **30 seconds** increase pedestrian risk-taking behavior and likelihood of crossing against the signal.

5.3.1 Pedestrian Phasing Schemes

Pedestrian phasing at signalized intersections will fall into one of three general categories: concurrent or exclusive pedestrian phasing, or a hybrid of the two:

- **Concurrent pedestrian phasing** allows pedestrians and vehicles to proceed along the same approach within the same phase (see **Figure 5.9**). Concurrent phasing can reduce overall delay at an intersection, which improves signal compliance. Because turning motorists and bicyclists must yield to crossing pedestrians, designers should, at a minimum, implement a leading pedestrian interval (LPI) with concurrent phasing (see **Section 5.3.2**).
- **Exclusive pedestrian phasing** holds all vehicle traffic while allowing pedestrians to proceed in all directions (see **Figure 5.10**). It may increase intersection delay because it is a separate phase in the overall signal cycle. Exclusive phasing should be considered in locations where concentrations of vulnerable users are likely to be present (e.g., parks, playgrounds, senior citizen housing and centers, hospitals or other medical facilities, schools, daycare facilities, etc.) or with at least **250** motor vehicle right turns per hour along any approach.
- A hybrid pedestrian phasing scheme may be appropriate, for example concurrent phasing with some approaches coupled with an exclusive phase to protected pedestrians against a specific high-volume turn, multi-lane crossing, or skewed geometry.

Figure 5.9 Concurrent Pedestrian Phasing

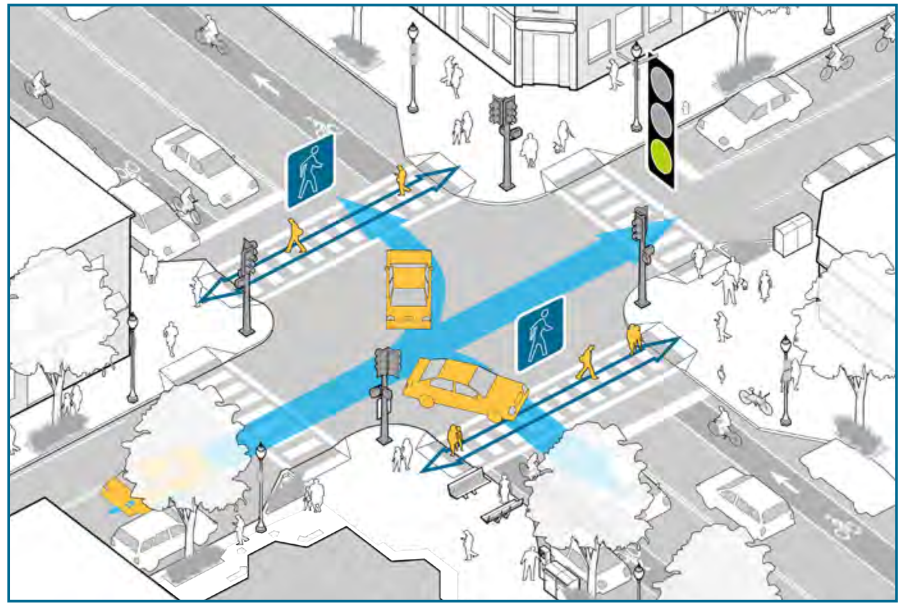
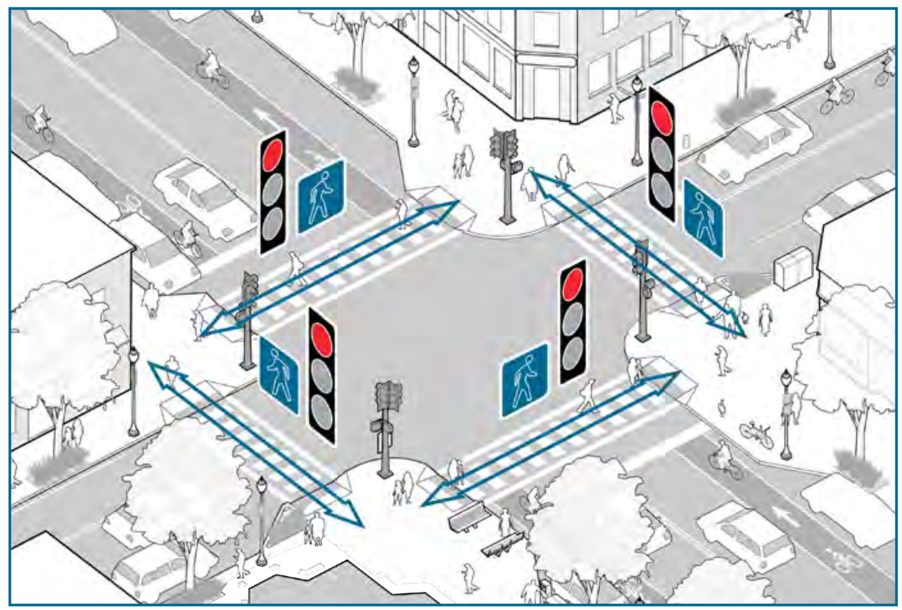


Figure 5.10 Exclusive Pedestrian Phasing



Designers should consider supplemental signal strategies (see **Section 5.3.2**) and the following during the design of pedestrian phasing schemes:

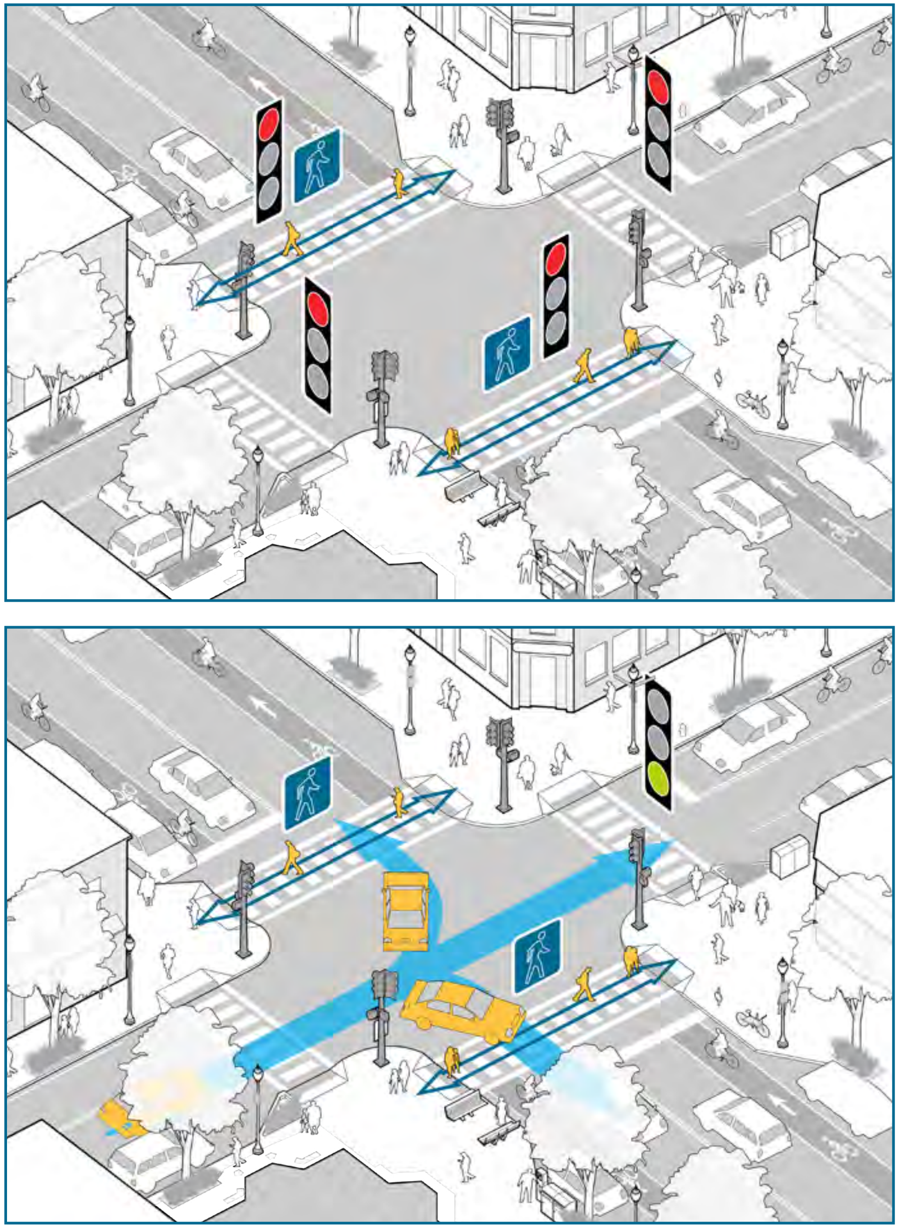
- Shorter cycles lead to shorter delays.
- During off-peak hours, cycle lengths shorter than peak hour cycle lengths should be considered.
- Pedestrian recall, or automatic pedestrian phase, may be appropriate where there are higher concentrations of pedestrians, for example, within village centers and commercial areas as well as within a 10-minute walk of transit stations and stops (see p. 45 and 47 of the **Newton Draft Pattern Book**[23]).
- Pedestrians should be able to cross both sides of a median-divided street during a single walk phase. A pushbutton must still be provided within a median that serves as a pedestrian refuge.
- Perform an educational and enforcement campaign, including signs posted at the intersection, when transitioning from exclusive to concurrent phasing.
- Continue to explore new technologies to optimize signal timing and make crossings more convenient, for example passive pedestrian detection.

5.3.2 Supplemental Signal Strategies

Supplemental signal strategies should be considered to strengthen the safety of the intersection by minimizing conflicts and reinforce desired yielding behavior where conflicts occur.

Leading pedestrian intervals help mitigate the right- and left-turn conflicts associated with concurrent phasing and have shown up to **60 percent**[24] pedestrian-vehicle crash reduction. LPIs give pedestrians a "head start" with no conflicts by temporarily holding motor vehicle movements (see **Figure 5.11**). LPI duration should be at least **3 seconds** and timed to allow pedestrians to cross at least one lane of traffic. Designers should implement LPIs when switching from exclusive to concurrent phasing (see **Section 5.3.1**).

Figure 5.11 Leading Pedestrian Interval Phasing



NO TURN ON RED (NTOR) restrictions help keep crosswalks clear of conflicts and have been shown to contribute to fewer crashes.[25] Designers should consider such restrictions in conjunction with LPIs and exclusive pedestrian phasing to reduce crashes and promote intersection predictability. NTOR should also be considered at intersections with bikeways as outlined in **Section 6.3.3** of MassDOT's Separated Bike Lane Planning & Design Guide.[26]

Flashing yellow arrow (FYA) signal indication allows permissive motor vehicle turning maneuvers while indicating caution to motorists to be alert for people walking and biking (see **Figure 5.12**). Designers should consider FYAs for permissive left- or right-turn conflicts, as clarified in FHWA's **Interim Approval IA-17**,[27] and consider alongside LPIs, as **piloted**[28] by NYC Department of Transportation (i.e. "Split LPI").

Bicycle signals provide separate traffic control for bicyclists. Designers should consider bicycle signals to promote user compliance, provide leading bike intervals, as part of contra-flow bikeways, help direct cyclists through complex intersections, or when continuing a bikeway alongside an exclusive right-turn lane. FHWA currently prohibits the use of bike signal faces with conflicting vehicle movements and for leading bicycle intervals; however, designers may use a standard signal face with BICYCLE SIGNAL sign (R10-10b) in these situations (see **Figure 5.13**). Designers should refer to **Chapter 6** of the MassDOT Separated Bike Lane Planning & Design Guide for greater detail on bicycle signal design and phasing.

Figure 5.12 Flashing Yellow Arrow Options

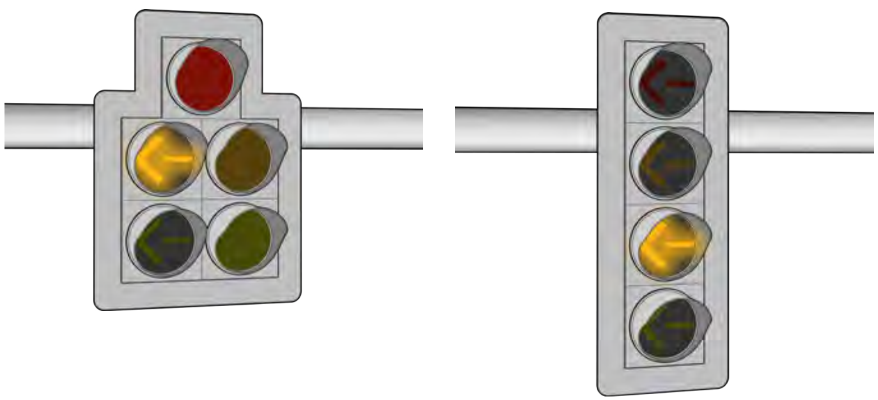
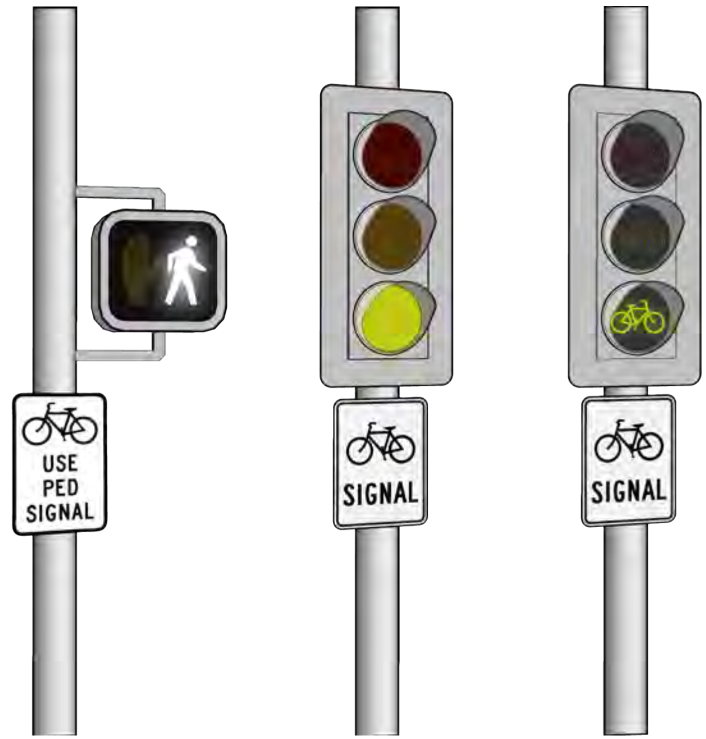


Figure 5.13 Bicycle Signal Options



5.3.3 Protected Turning Phases

Turning vehicles present safety challenges for pedestrians and bicyclists at intersections, as motorists are primarily scanning for gaps in oncoming traffic and not the presence of people walking or biking.[29] Protected turning phases—where turning motor vehicles are held and through-motorists move concurrently with pedestrians and bicyclists—improve overall intersection safety by eliminating the need for motorists to scan for gaps in traffic. Designers should consider such phasing to protect crosswalks or bicycle crossings under the following conditions:

- **Protected left-turn phases** should be considered with at least **100** motor vehicle turns per hour across one lane or in any location with turns across at least two lanes. Where provided, lagging left-turn phases are preferred over leading phases because they are associated with lower vehicle-pedestrian crash risk and lower intersection collision rates.[30] Designers should be aware that lagging-lefts can introduce "yellow trap" conditions on two-way streets unless opposing left-turn movements are protected-only at the same time. FYA signal indication may help alleviate "yellow trap" conditions in other situations (see **Section 4.3.1.3** of FHWA's Signal Timing Manual - Second Edition).[31]
- **Protected right-turn phases** should be considered with at least **250** motor vehicle turns per hour. Designers should consider other factors such as intersection geometry, presence of traffic calming, operational speeds, and visibility among all users when evaluating.
- At locations with inadequate sight distance. It is imperative that intersections provide adequate sight distance between motorists and vulnerable users.
- At locations with unique or complex geometry, such as skewed or offset intersections, where turning speeds may be higher or motorists have a complex travel path through in the intersection.

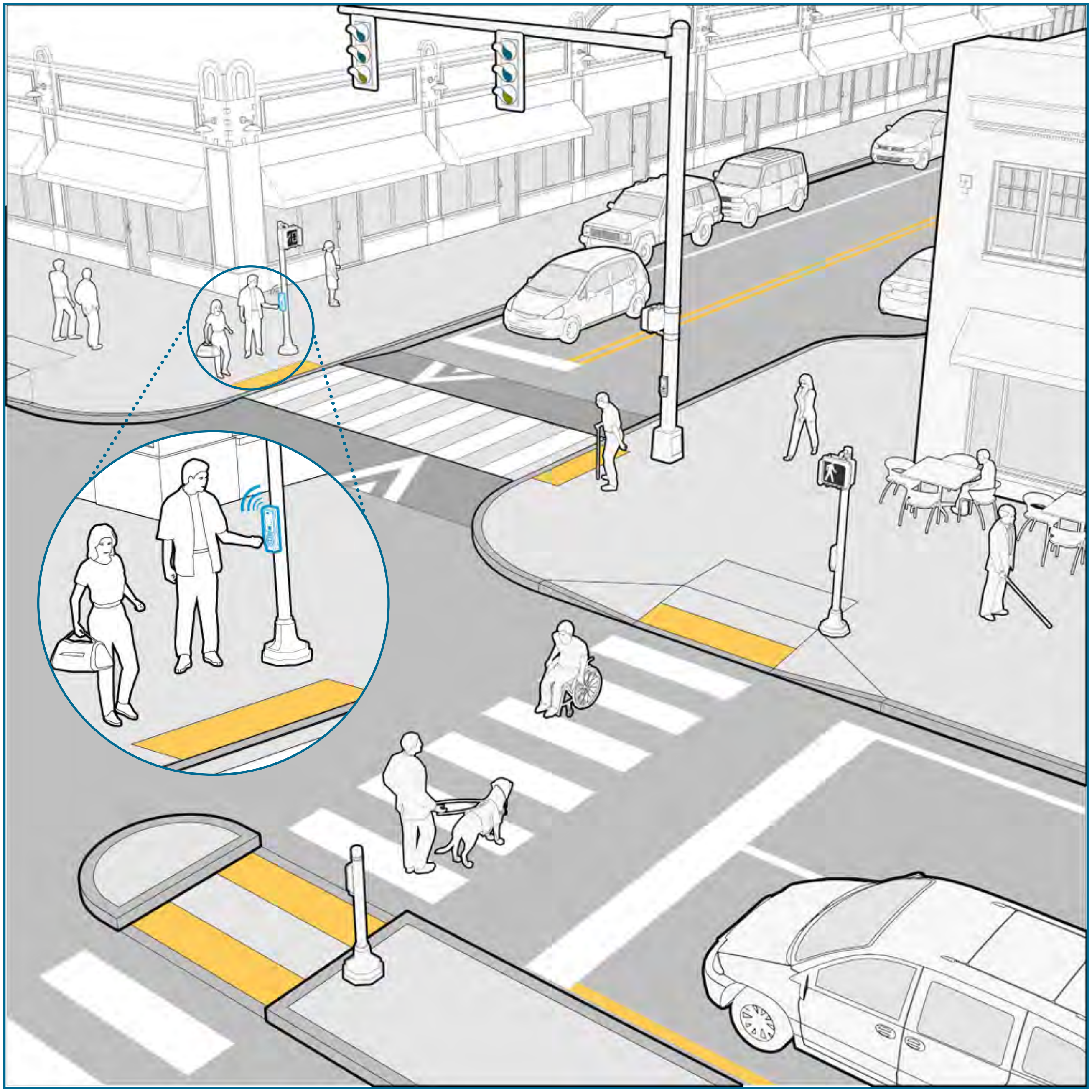
Protected phases are recommended to have dedicated turn lanes and/or split phasing. As a result, it may not be practical or desirable to provide protected phasing in constrained areas or where introduction of a turn lane precludes the implementation of safe and comfortable walking and biking facilities. In such instances, designers should consider geometric strategies to slow motor vehicle turns, for example raised crossings, narrow median islands, or "hardening" the centerline with flexible delineators.

5.3.4 Accessible Pedestrian Signals

At signalized intersections, designers should ensure that accessible pedestrian signals (APS) provide a non-visual method of communicating pushbutton locations and crossing directions for people who are blind or have low-vision. Designers should refer to the latest **MUTCD 4E**[32] and **PROWAG R209**[33] for additional detail.

Methods include audible tones and vibrotactile surfaces. For example, the use of different audible tones for north-south and east-west crossings and enabling far-side beaconing tones with an extended press of the pushbutton. In addition, designers should consider walking speeds slower than **3.5 feet per second** to help ensure pedestrian clearance times account for the elderly, children, and people with disabilities.

Figure 5.14 Accessible Pedestrian Signals



01 https://www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm

02 https://www.mass.gov/lists/521-cmr

03 https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/proposed-rights-of-way-guidelines/chapter-r3-technical-requirements

04 http://docs.trb.org/prp/12-3237.pdf

05 Up to 33% crash reduction (Lombard Street Vision Zero Safety Project. San Francisco Vision Zero. 2015. https://www.sfmta.com/sites/default/files/projects/2015/Lombard%20Street%20Safety%20Project%20Plans_Updated.pdf)

06 https://safety.fhwa.dot.gov/provencountermeasures/ped_medians/

07 https://safety.fhwa.dot.gov/ped_bike/tools_solve/ped_tctpepc/

08 https://safety.fhwa.dot.gov/provencountermeasures/ped_hybrid_beacon/

09 http://www.cmfclearinghouse.org/detail.cfm?facid=2922

10 https://safety.fhwa.dot.gov/provencountermeasures/road_diets/

11 https://safety.fhwa.dot.gov/road_diets/guidance/info_guide/

12 NACTO notes that pedestrians may not seek the nearest crosswalk when doing so requires out-of-direction travel that exceeds 3 minutes. Out-of-direction travel includes walking to the crosswalk, waiting for a crossing opportunity, and then walking back to the intended route. Maximum crosswalk spacing of 500’ satisfies this recommendation, though, in practice, opportunities for crosswalks are highly dependent upon street network density and configuration.

13 https://www.mass.gov/lists/separated-bike-lane-planning-design-guide

14 https://bookstore.transportation.org/item_details.aspx?ID=1943

15 Up to 33% crash reduction (Lombard Street Vision Zero Safety Project. San Francisco Vision Zero. 2015. https://www.sfmta.com/sites/default/files/projects/2015/Lombard%20Street%20Safety%20Project%20Plans_Updated.pdf)

16 https://www.mass.gov/lists/separated-bike-lane-planning-design-guide

17 https://nacto.org/publication/urban-street-design-guide/design-controls/design-vehicle/

18 https://nacto.org/publication/transit-street-design-guide/intersections/transit-route-turns/recessed-stop-line/

19 https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/proposed-rights-of-way-guidelines/chapter-r3-technical-requirements

20 https://www.nap.edu/catalog/22238/design-guidance-for-channelized-right-turn-lanes

21 http://docs.trb.org/prp/14-2349.pdf

22 https://www.mass.gov/lists/separated-bike-lane-planning-design-guide

23 http://www.newtonma.gov/civicax/filebank/documents/82700

24 https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/traffic-signals/leading-pedestrian-interval/

25 69% crash increase after turn restrictions removed. http://www.cmfclearinghouse.org/detail.cfm?facid=4579

26 https://www.massdot.state.ma.us/Portals/8/docs/SBLG/Chapter6_Signals.pdf

27 https://mutcd.fhwa.dot.gov/resources/interim_approval/ia17/index.htm

28 http://docs.trb.org/prp/17-05455.pdf

29 https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/fhwahep16055.pdf

30 https://repository.library.northeastern.edu/files/neu:849/fulltext.pdf

31 http://www.trb.org/OperationsTrafficManagement/Blurbs/173121.aspx

32 https://mutcd.fhwa.dot.gov/htm/2009/part4/part4e.htm

33 https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/proposed-rights-of-way-guidelines/chapter-r2-scoping-requirements