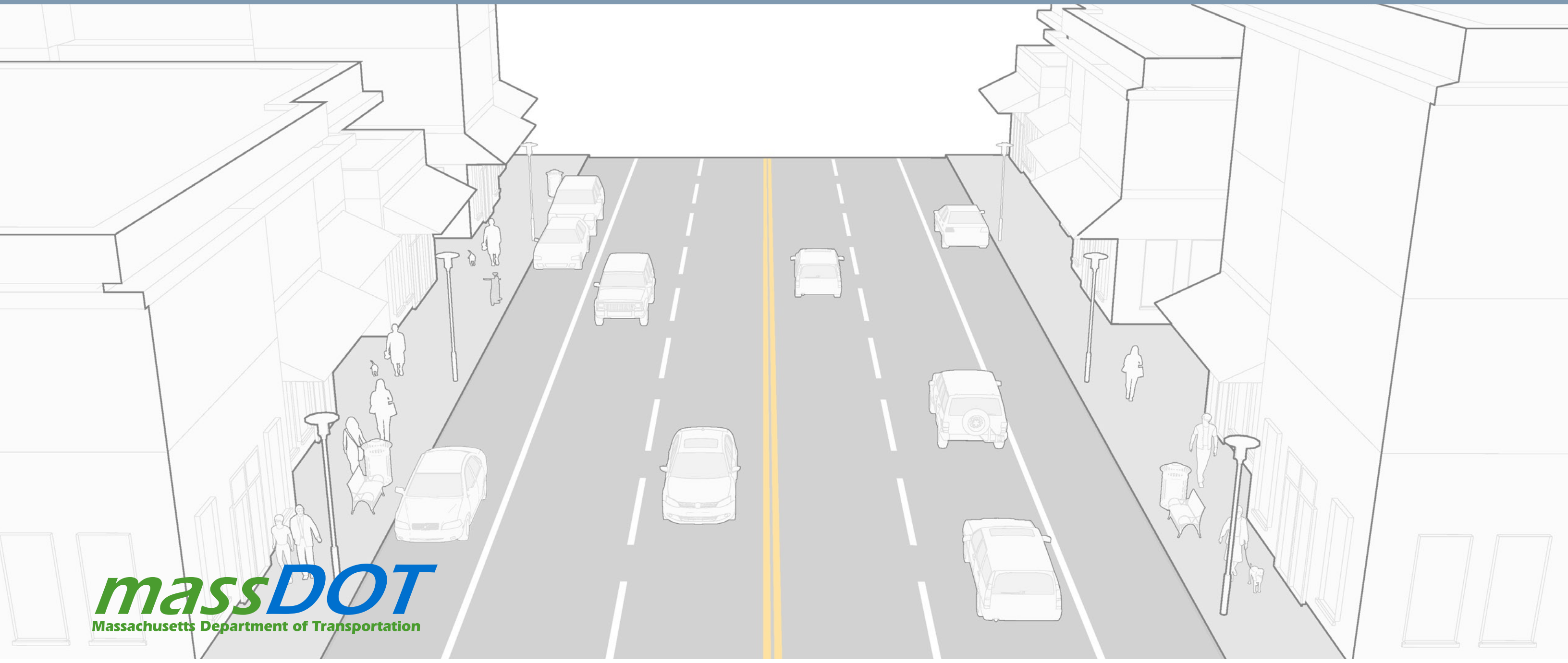


AN EVALUATION OF ROAD DIETS IN MASSACHUSETTS

Prepared by **Toole Design Group**
in association with
MassDOT and **Federal Highway Administration Every Day Counts**

DECEMBER 2017

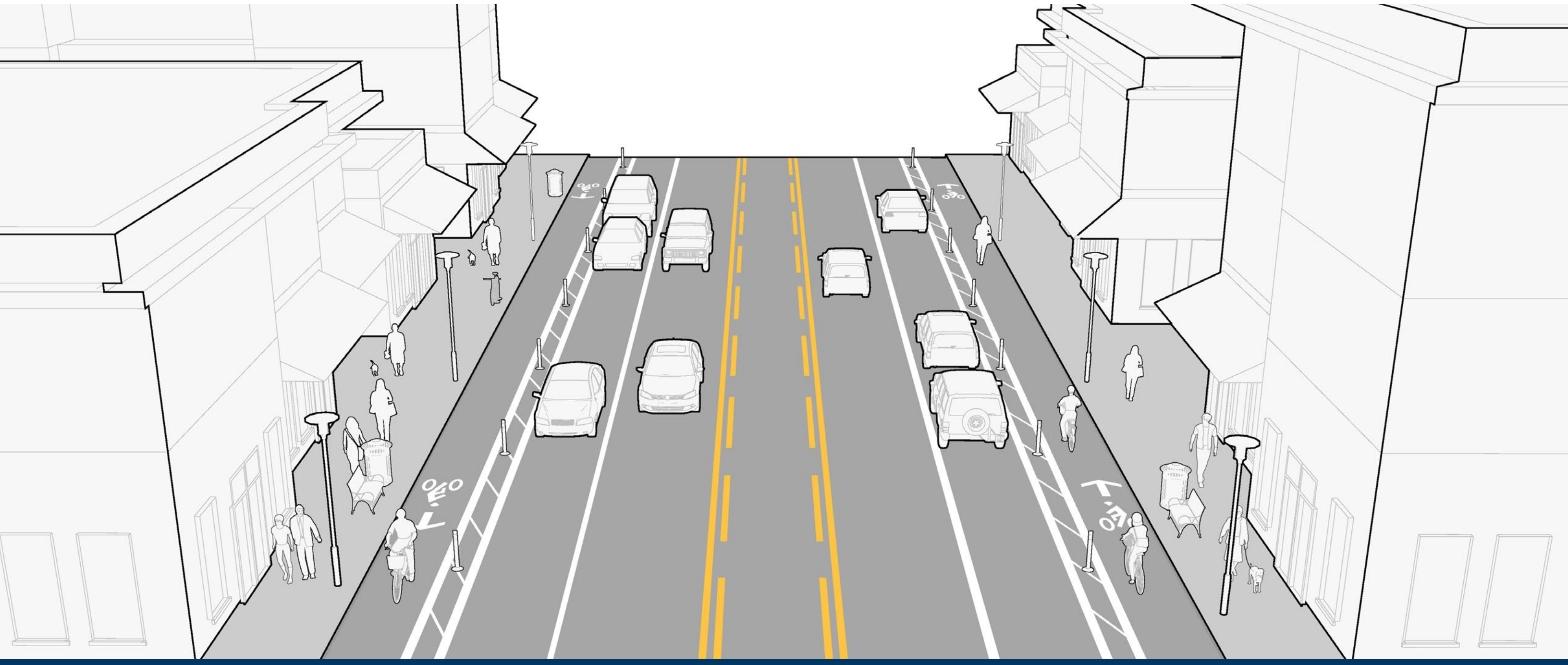


Table of Contents

List of Tables

List of Figures

Executive Summary

Toole Design Group (TDG) has prepared this Evaluation of Road Diets in Massachusetts report to present findings regarding the current national practice of road diets specific to the Commonwealth, while laying the foundation for institutionalizing road diets in Massachusetts. To create the groundwork of future road diets in Massachusetts, a national review of the current state of road diet guidelines was conducted. Additional data on corridors in Massachusetts that have previously undergone road diet conversions were collected to supplement these national best practices with local case studies. Using the information gleaned from the national and statewide reviews, additional roadways within the Commonwealth were selected as potential road diet candidates for further evaluation. These data informed the various road diet documents set forth as part of this project, providing updates to the current roadway redesign documents used within the Commonwealth, ensuring road diets are considered as a viable alternative within the state process.

Selection criteria utilized nationally for the consideration of road diets were reviewed by TDG. This research was conducted through a review of publicly available documents on various State Department of Transportation and Transportation Agency websites, literature review, materials provided by the Massachusetts Department of Transportation (MassDOT) and presentations made at the Northeast Region Road Diet Peer Exchange in June 2016. In total, 15 agencies were identified as utilizing guidelines related to road diets. All 15 agencies employ average daily traffic (ADT) as the primary site selection criterion, with the maximum thresholds ranging from 10,000 to 25,000 vehicles per day (vpd). The second most widely used criterion for road diet consideration was crash occurrence, with 11 of the 15 agencies applying this metric. In applying these criteria within the Commonwealth, crash occurrence and the associated safety enhancements with a road diet corridor redesign is set forth as the primary criterion, with volume metrics considered secondary.

The data collected for existing Massachusetts road diet case studies presented within this report were ascertained through literature provided by MassDOT, professional contacts, and surveys sent to MassDOT district offices and municipalities throughout the Commonwealth. Through feedback from this process, TDG evaluated three road diet case studies, supported further by supplemental locations to bolster the case for road diets. The three locations include Route 135 in Wellesley, Nonantum Road in Boston/ Newton/ Watertown, and Route 12 in Sterling. Both Route 135 and Nonantum Road demonstrated significant reductions in both crash occurrences and crash severity after the implementation of road diets. The 85th percentile speeds on Route 135 have also decreased by approximately 10 mph. Route 12 did not demonstrate a reduction in the number of crashes, however there was a reduction in crash severity.

TDG also analyzed Route 133 in Lowell, as it had undergone a road diet in the early 1980's. While no pre-implementation data were available, post-implementation data demonstrates Route 133 has a crash rate at about half of the state-wide average based on functional class, suggesting the road configuration is adequate. In addition to Route 133, TDG analyzed Route 9 in Spencer and Route 146A in Uxbridge. Both locations underwent lane reductions at only a single intersection, however crash data demonstrates that crash occurrences have decreased by 52% and 73%, respectively. This demonstrates that the safety benefits of road diets can be realized for projects of all sizes.

Applying this literature review and case studies, TDG created a set of criteria to identify potential road diet installation sites throughout the Commonwealth. The list of criteria had a tiered approach, with the initial screening using GIS data and the MassDOT Roadway Inventory to identify candidate roadways based on ADT and roadway cross-section. The initial screening identified 51 potential road diet corridors. The second tier of criteria included conditions such as length of corridor, number of signalized intersections, and a refined crash analysis to identify corridors exhibiting crash types for which road diets could be a mitigating solution. Based on the above conditions, the following roadways were selected for further evaluation:

- Auburn - Southbridge Street, District 3;
- Boston - Southampton Street, District 6;
- Dedham - Washington Street (Route 1A), District 6;
- Marshfield - Ocean Street, District 5;
- Milford - Medway Road (Route 109), District 3;
- Quincy - Sea Street, District 6;
- Springfield - State Street, District 2; and
- West Springfield - Westfield Street (Route 20), District 2.

While many roadways in the Commonwealth may be viable candidates for a road diet, these eight roads offer a variety of volumes, adjacent land uses, and geographic locations within Massachusetts.

The culmination of this effort is seven deliverables that could institutionalize road diets as a consideration for future implementation throughout various stages of project delivery in the Commonwealth of Massachusetts. They provide MassDOT the opportunity to evaluate projects for road diet viability at multiple stages in the project delivery process. These seven deliverables are a combination of checklists and tables, as well as updates to existing documents already integrated into the project development and delivery process. Road diet language was integrated into the Project Need Form, Project Initiation Form, Project Development & Design Guide checklist, and the Traffic and Safety Engineering 25% Design Submission Guidelines. Additionally, a new standard road diet table format was created to be inserted into Functional Design Reports to assist MassDOT reviewers by providing the necessary information to assess the viability of a road diet. To further assist MassDOT reviewers, an internal 25% design checklist and accompanying decision tree resource were also created.

Task 1 – Evaluate "Best Practices"

Methodology

The findings included herein have been ascertained from documentation made publicly available through other State Department of Transportations' and Transportation Agency websites, as well as literature provided directly to TDG by MassDOT. In addition, TDG attended the Northeast Region Road Diet Peer Exchange, led by the Federal Highway Administration (FHWA) in June 2016. Within this forum, representatives from nine states in the region shared their experience in implementing road diets, garnering instrumental information and insight into the state of the practice. In reviewing available resources, a key focus on other DOT Road Diet selection criteria, available case study data, and Crash Modification Factors (CMFs) was applied.

In addition to gathering national data on road diets, Massachusetts-specific data have been ascertained from project specific literature provided by MassDOT, as well as data collected specifically to inform this effort. In addition, MassDOT distributed a survey, created by TDG, to all municipalities in the Commonwealth to gather a comprehensive list of existing road diet corridors, roadways where the feasibility of a road diet has been studied and any potential future sites. The survey was open from January 13, 2017 until January 25, 2017. A copy of the survey and the corresponding responses from the municipalities who replied are included in the Appendix.

Selection Criteria – Transportation Agencies Nationwide

In total, 15 agencies were found to employ some type of Road Diet Guideline. Between agencies, these guidelines varied significantly in size and depth, though similarities exist. Thirteen of the 15 agencies focus primarily on 4-lane corridors and their conversion to 3-lane corridors, including one travel lane in each direction with a center two-way left-turn lane (TWLTL), while Florida DOT included 6- and 8-lane corridors and Vermont's Agency of Transportation (VTrans) considered all corridors with 3-lanes or more.

A Selection Criteria Matrix is provided within the Appendix. The matrix demonstrates the various criteria the 15 transportation agencies studied apply in selecting an appropriate candidate corridor for road diet implementation.

Selection Criterion: Average Daily Traffic

All 15 agencies use Average Daily Traffic (ADT), in vehicles per day (vpd), as the main site selection criterion. The maximum ADT threshold ranges from 10,000 vpd to 25,000 vpd, with the majority (8) of agencies applying either 15,000 vpd or 20,000 vpd as their cap without providing for further analysis. Specific ADT thresholds, by agency, are presented within Table 1 below.

Table 1 Average Daily Traffic and Peak Hour Volume Thresholds, by Agency

Agency	Average Daily Traffic (ADT) Threshold	Peak Hour Volume Threshold*
Michigan DOT	10,000 vpd	1,000 vph
Florida DOT	15,000 vpd	-
Iowa DOT	15,000 vpd	750 vphpd
Walkable Communities	15,000 vpd	-
Ohio DOT	15,000 vpd	-
Chicago DOT	18,000 vpd	1,000 vph
Rhode Island DOT	20,000 vpd	1,200 vph
Delaware Valley Regional Planning Commission	20,000 vpd	750 vphpd
Vermont Agency of Transportation	20,000 vpd	875 vphpd
Genesee County Metropolitan Planning Commission	20,000 vpd	-
Virginia DOT	20,000 vpd	-
Kentucky Transportation Center	23,000 vpd	-
Maine DOT	25,000 vpd	-
Seattle DOT	25,000 vpd	700 vphpd
Austin Transportation Department	25,000 vpd	-
Average	**18,100 vpd**	

vpd = vehicles per day
vph = vehicles per hour
vphpd = vehicles per hour per direction
* Peak Hour Volume Threshold requires further study, while ADT Threshold translates no further consideration of a road diet.

In addition to the maximum ADT thresholds listed in Table 1, many agencies (5) utilize an ADT range to determine automatic corridor candidates for road diet implementation, versus potential corridor candidates. For example, Seattle DOT has automatically advanced road diet designs on corridors with an ADT of less than 10,000 vpd. Further, for roadways with an ADT between 10,000 vpd and 16,000 vpd, Seattle DOT considers additional criteria, such as peak hour directional volume, left-turn hourly volume, and Level of Service (LOS). Finally, for corridors with an ADT between 16,000 vpd and 25,000 vpd, the department not only considers LOS, but also the expected change in travel time with the new cross-sectional design. Of the 15 agencies, seven consider peak hour volume, either directional or bi-directional, when looking at Road Diet candidates.

Selection Criterion: Crash Data

The second most applied selection characteristic is crash occurrence with 11 of the 15 agencies studied utilizing crash history when considering corridors for road diet implementation. Within the existing guidelines, crash history has been considered both to prioritize road diet candidates (initially flagged for reasons such as number of lanes, ADT, and community nomination) and for the initial selection. Generally, crash history is documented for multiple years prior to implementation of the road diet, in many cases for use as a measure of improvement, while comparing crash rates for the candidate corridor with statewide or citywide averages. The majority of these agencies collected crash data related to vehicle-only, pedestrian and bicyclist crashes, as well as documenting type of crash and severity.

Other Selection Criteria

Additional criteria utilized by approximately one third of the agencies studied includes vehicle speed, turning movement volumes, number and spacing of intersections, presence of transit services, presence of bicyclists, and travel time or Level of Service (LOS). Elevated vehicle speeds, high left-turning volume and notable bicycle presence raised the corridor as a stronger candidate for road diet implementation. RIDOT, Iowa DOT and VTrans utilize average and 85th percentile vehicle travel speeds compared to the posted speed limit to determine if the traffic calming effects of a road diet would be beneficial to the subject corridor. Seattle uses a left-turning volume of 200 vph as a threshold to automatically approve a road diet project or consider other factors. Conversely, while the presence of transit services, mainly buses, did not disqualify a corridor, special considerations may need to be made, such as bus stop pull-outs to provide relatively uninterrupted vehicle traffic flow. In many instances, agencies were willing to trade a potential increase in travel time or degrade in LOS for the potential safety and complete street benefits of a road diet, within an acceptable limit.

A number of agencies (5) employ flowcharts or a tiered approach when determining strong sites for road diet implementation. These agencies prioritize which criteria were most important in determining candidate sites, and then apply additional criteria in order to make a final determination. For example, while VTrans prioritizes ADT, Peak Hour Volume (PHV), posted speed limit, number of travel lanes, and crash history data, there are an additional seven criteria the agency also considers in order to select a candidate corridor (as shown within the attached Selection Matrix). The Kentucky Transportation Center suggests that only traffic volumes and left-turn percentages should be prioritized, and an additional 10 criteria be considered as necessary. RIDOT prioritizes any road diet candidate that can be incorporated into pavement projects, has a history of fatalities or serious injuries (or has been targeted in the Highway Safety Improvement Program), will greatly increase bicycle or pedestrian connectivity, or has been requested by the community. RIDOT and Seattle DOT have established flowcharts for road diet candidate selection, with the latter included within the Appendix.

A consistent theme between agencies is the need for early public education and community outreach. Many use pre-construction surveys and public meetings to understand the concerns the community may have about road diets and to document their input. Follow-up surveys and post-construction meetings are also held to note any changes in perception towards road diets, with many noting an increase in favorability post-construction.

National Case Studies

To evaluate the effectiveness and experiences of road diets that have been implemented, cases studies were also reviewed. Overwhelmingly, the impact of road diets on traffic calming (vehicle speeds), crash occurrence, and injuries frequency has been positive.

Rhode Island alone has completed 30 road diets on corridors throughout the state, performing crash analyses both five years before and five years after implementation. There has been a total decrease of over 50% of all crash types and severities. Fatalities and serious injuries have been reduced by an average of five per year. RIDOT has also documented a direct correlation between road diet implementation and a reduction in the 85th percentile speed.

A study by Pawlovich et al. of 15 post-construction road diet corridors in Iowa documented a 25.2% reduction in crash frequency per mile and an 18.8% reduction in crash rate per mile, directly correlated to road diet implementation when compared to 15 nearby control corridors. An outlier to this crash reduction was documented in Winthrop, Maine where an increase in crashes was experienced. Crashes increased from 16 total crashes over a 3-year period (2007 to 2009) to 17 (2011 to 2013). While number of crashes increased slightly, crashes resulting in injury decreased from 10 crashes to 6 crashes and the total injuries reported decreased from 31 to 9, a reduction of 70%, over the same 3-year period.

The majority of case studies report improvements in areas that are difficult to quantify, including pedestrian and bicyclist experience, level of stress and network connectivity.

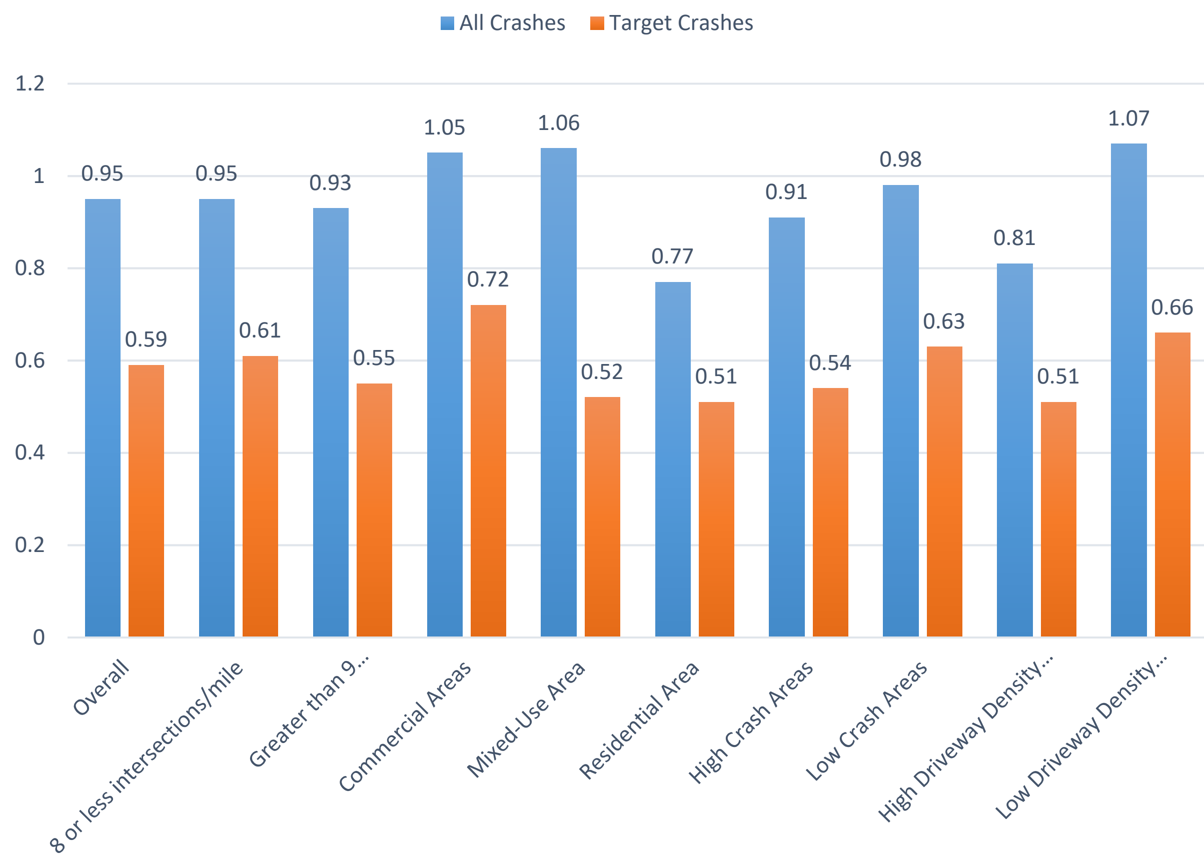
Crash Modification Factors

Five studies determined Crash Modification Factors (CMFs) associated with road diet conversions. All five studies considered the standard 4-lane to 3-lane reduction, with two studies being particularly robust. Pawlovich et al. studied 30 corridors, 15 provided road diet treatments and 15 comparison control sites. The results document a CMF of 0.748 for crash frequency per mile and 0.812 for crash rate. Lyles et al. studied 24 corridors in Michigan and calculated CMFs for a variety of corridor attributes. Figure 1 presents the CMFs within the Lyle study for various corridor attributes. The CMFs are separated into two main categories: all crash types and target crash types. Typically, road diets aim to reduce specific types of crashes, called target crash types. These crash types are sideswipes, rear-ends, and angle (left-turn) crashes, as well as those involving pedestrians and bicyclists.

A review of the information contained within Figure 1 demonstrates that all corridor attributes experience a reduction in targeted crash types with the implementation of a road diet design. Additional specific information can be interpreted from Figure 1. For example, corridors with a high number of driveways (greater than 32 per mile[1]) may experience a more significant benefit from a road diet than those with a lower number of driveways (less than 32 per mile) when considering all crash types. Another attribute that stands out is area type. Upon review of all crash types, corridors in residential areas benefit much more from road diets than those in commercial or mixed-use areas. However, when considering specifically targeted crash types, corridors in residential and mixed-use areas benefit more than those in commercial areas.

[1] Unit of measure not provided within the study, per mile assumed

Figure 1 Crash Modification Factors based on Corridor Attributes (Source: Lyles et. al.)



Massachusetts Case Studies

Through communication with MassDOT, supplemented by survey responses from state districts, and the Commonwealth municipalities, TDG has identified the following 28 corridors in Massachusetts for consideration. These sites, by municipality, are presented below in Table 2.

It should be noted that the definition of a true road diet appears to have some different interpretations based on responses received through the survey process. The Federal Highway Administration (FHWA) describes a road diet as “removing travel lanes from a roadway and utilizing the space for other users and travel modes.” Their Road Diet Informational Guide focuses on the most common road diet configuration: a 4-lane road (2-lanes in each direction) converted to a 3-lane road (1-lane in each direction and a dedicated two-way left turn lane (TWLTL)). Several locations identified by the survey were single intersections or contained lane width reductions, but had no removal of a continuous travel lane. Through this due diligence exercise of searching for existing road diet corridors within the Commonwealth, it is notable that they are not currently prevalent.

As will be realized with the three corridors TDG obtained pre- and subsequent post- data for, these roadways have similar characteristics in terms of minimal curbcuts, with left-turn movements being relatively limited to one side of the major corridor, with no presence of a center two-way left-turn lane (TWLTL). Further discussion of these corridors is presented in further detail below.

Table 2 Road Diet (Lane Reduction) Corridor Locations in Massachusetts

Corridor	Municipality (District)	Layout/Treatment Type
Route 12 (Leominster Road)	Sterling (D3)	4- to 2-lane (no TWLTL), left-turn pockets
Nonantum Road	Boston/Newton/ Watertown (D6)	4- to 2-lane (no TWLTL), left-turn pockets
Route 135 (Central Street)	Wellesley (D6)	4- to 2-lane (no TWLTL), left-turn pockets
Route 122	Worcester (D3)	4- to 3-lane (no TWLTL), two lanes westbound, one lane eastbound
Massachusetts Avenue	Arlington (D4)	4- to 3-lane (no TWLTL), two lanes southbound, one lane northbound, added bike lanes
Greenough Boulevard	Cambridge (D6)	4- to 2-lane
Father Morissette Boulevard	Lowell (D4)	4- to 2-lane
VFW Highway (Route 110)	Lowell (D4)	4- to 2-lane
Beacon Street Westbound	Brookline (D6)	2- to 1-lane
Cupples Square	Lowell (D4)	2- to 1-lane, added parking
Route 110 (King Street)	Littleton (D3)	Single intersection
Route 9 (Main Street)	Spencer (D3)	Single intersection
Route 146A	Uxbridge (D3)	Single intersection
West Cross Road	Clarksburg (D1)	Lane width reduction
Harvard Road	Littleton (D3)	Lane width reduction
Rogers Street	Lowell (D4)	Lane width reduction, added bike lanes
Andover Street (Route 133)	Lowell (D4)	4- to 3-lane (TWLTL) – 1980's Lane width reduction - 2015
West 6th Street	Lowell (D4)	Lane width reduction
School Street	Manchester-by-the-Sea (D4)	Lane width reduction
Tremont Street/Essex Street	Melrose (D4)	Lane width reduction
Humphrey Street	Swampscott (D4)	Lane width reduction, added bike lanes
US 20 (Main Street)	Watertown (D6)	Lane width reduction, added bike lanes
Route 20	Brimfield (D2)	Under construction, 4- to 2-lane, left-turn pockets
Granite Ave	Milton (D6)	In design phase
Route 53	Weymouth (D6)	In design phase
Main Street	Worcester (D3)	In design phase
Main Street	Shrewsbury (D3)	Projected for 2017
Route 28 (Broadway)	Methuen (D4)	Studied, not recommended

The following three installation locations were chosen for further analysis based on the availability of data both before installation (pre-construction) and after (post-construction), as well as their similarities to a traditional road diet.

- Route 135 (Central Street), Wellesley (Implemented 2010);
- Nonantum Road, Boston/Newton/Watertown (Implemented late 2012); and
- Route 12 (Leominster Road), Sterling (Implemented late 2013).

Route 135 and Route 12 are under MassDOT jurisdiction, while Nonantum Road is under the Department of Conservation and Recreation (DCR) jurisdiction. Each corridor will be explained in further depth below; however, it is of note that these projects all had relatively low-density land-use surrounding the corridors with limited curbcuts, and therefore did not warrant TWLTL. Instead, left-turn pockets were implemented as needed.

In addition to these recently implemented road diet locations, a review of Andover Street (Route 133) in Lowell is included to quantify how well a traditional road diet is operating within the Commonwealth. Andover Street was converted to from a 4-lane roadway to a 3-lane roadway with a dedicated TWLTL in the early 1980's, according to discussions with City staff.

It is worthy of mention that the dataset provided herein represents a rather small sample size for the formulation of any concrete conclusions and certainly should not be construed as an indicator of the effectiveness of road diets for the Commonwealth of Massachusetts. Rather, national data studies and findings presented earlier should be looked to for further advancement of road diets in the Commonwealth.

Route 135 (Central Street), Wellesley

Overview

The corridor of Route 135 (Central Street) in Wellesley (District 6) is an urban principal arterial that underwent a lane reduction project in 2010, encompassing approximately 1.25-miles of roadway from the intersection at Weston Road to the Natick town line. This MassDOT-owned section of the corridor was restriped from a four-lane to a two-lane roadway, with left-turn lanes where appropriate at intersections and driveways.

The land uses along this segment of Route 135 are generally related to Wellesley College, whose campus encompasses much of land south of the corridor. Massachusetts Bay Transportation Agency (MBTA) Commuter Rail tracks run parallel to the corridor on the north, limiting curbcuts to the north, therefore negating the potential need for a TWLTL. There are four major intersections within this segment; Pond Road, Bacon Street, College Road, and Weston Road, with distance between them ranging from 600-feet to 2,800-feet, with the latter two under signal control.

Exhibit 1 Route 135 study limits

Prior to implementation, three years of crash data were collected and analyzed by VHB, Inc. (January 1998 to December 2000) utilizing the MassDOT Crash Portal. In addition, existing (2002) traffic conditions were studied, utilizing average daily traffic volumes (ATRs) and turning movements counts (TMCs). Two ATRs along Route 135 collected weekday daily volumes, east of Bacon Street and east of College Road. TMCs were collected for the intersection of the study road at Bacon Street and at College Road during the typical commuter peak hours (7-9AM and 4-6PM) in 2002. These crash data records and counts represent "pre-road diet" conditions as a baseline for comparison of effectiveness.

Exhibit 2 Route 135 Pre-Road Diet (2008) – 4-lanes undivided

To assess the effectiveness of the "post-road diet" implementation, crash data and count data post-construction were gathered and compared to pre-construction data. Crash data were obtained for the latest complete three-year period available from the MassDOT Crash Portal (January 2012 to December 2014) for comparison. Count data were also analyzed post-construction utilizing TMCs provided by MassDOT, conducted by VHB, Inc. and BETA Group in 2014 at the intersections of Route 135 at Bacon

Street and at College Road. To supplement these count data, TDG mimicked the pre-construction count program from 2002 in March 2017, collecting two ATRs along the corridor and weekday evening peak hour TMCs at the four major intersections along Route 135 within the study limits.

Exhibit 3 Route 135 Post-Road Diet (2016) – two-lanes along corridor with left-turn pockets

Crash Analysis

Within the project limits, the Route 135 corridor experienced a reduction in crashes over a three-year period when comparing crash data before the road diet was constructed to a three-year period post-construction. From January 1998 to December 2002 (pre-road diet), 99 crashes were reported within the project limits. From January 2012 to December 2014, 45 crashes were reported within the same project limits, representing a decrease in crash occurrence of 120%. Moreover, all intersections in the study area saw a decrease in total crashes, ranging from a decrease in crash occurrence from 23% to 100% reduction. These overall crash totals for the corridor and individual intersections are presented within Table 2. Of key importance is the crash rate associated with these intersections. While volumes along the corridor demonstrate a fluctuation along the corridor, the rate in which crashes are occurring based on million vehicles entering has also reduced dramatically, as presented in Table 3.

Table 3 Intersection Crash Summary by Year

	Route 135 (Central Street) at:					
	Pond Street	Bacon Street	College Road	'Other' campus driveways	Weston Road	**Total**
Year (Pre-Construction)						
1998	1	12	2	4	12	**31**
1999	1	8	3	1	12	**25**
2000	1	19	3	7	13	**43**
Total	**3**	**39**	**8**	**12**	**37**	**99**
MassDOT Crash Rate	**0.22**	**1.97**	**0.41**	**-**	**1.50**	
Year (Post-Construction)						
2012	0	5	0	3	5	**13**
2013	0	7	0	4	9	**20**
2014	0	4	1	2	5	**12**
Total	**0**	**16**	**1**	**9**	**19**	**45**
MassDOT Crash Rate	**0**	**0.84**	**0.06**	**-**	**0.80**	
Delta in Crash Occurrence	**-100%**	**-59%**	**-88%**	**-23%**	**-49%**	**-55%**

The severity of the reported crashes along the Route 135 corridor experienced a decrease as well, with nine fewer injuries reported over the course of the post-construction three-year period. Road diets are cited to reduce rear-end, left-turn and sideswipe crashes. The number of angle crashes, which left-turn crashes are reported as, decreased by 34 crashes over the three-year period. Rear-end crashes also decreased by 12 crashes. Sideswipe crashes increased by two crashes, however crashes with unknown collision types decreased by 13 crashes, which may account for the difference. Table 4 presents the pre- and post-construction crash data by type and severity.

Table 4 Crash Summary by Type and Severity for Route 135

	Total Crashes (% of total) Pre-Construction	Total Crashes (% of total) Post-Construction	Delta
Collision Type			
Angle	54 (55%)	20 (44%)	-34
Rear-end	25 (25%)	13 (29%)	-12
Head-on	6 (6%)	2 (4%)	-4
Sideswipe	0	2 (4%)	+2
Single Vehicle Crashes	0	7 (16%)	+7
Pedestrian/Bicycle Involved	0	0	-
Unknown	14 (14%)	1 (2%)	-13
Total	**99**	**45**	**-54**
Severity			
Property Damage Only	83 (84%)	39 (87%)	-44
Non-fatal Injury	16 (16%)	5 (11%)	-11
Fatality	0	0	-
Not Reported	0	1 (2%)	+1
Total	**99**	**45**	**-54**

Count and Speed Data Analysis

The average daily traffic (ADT) for Route 135 changed slightly throughout the corridor. At the location east of Bacon Street, ADT decreased by 10%, while at the location east of College Road, ADT increased approximately 11%. Peak Hour Volume (PHV) dropped significantly from before the road diet until when it was measured again in 2014. However, data collected in 2017 shows that the PHV as increased since 2014, therefore the overall decrease in peak volume only ranges from 12% to 33% where measured.

Table 5 Vehicular Volume Summary

	Average Daily Traffic (bi-directional, vpd)			**Weekday Evening Peak Hour Volume (bi-directional, vph)**			
Location	Pre-Construction (2002)[a]	Post-Construction (2017)[b]	**Delta (%)**	Pre-Construction (2002)[a]	Post-Construction (2014)	Post-Construction (2017)[b]	**Delta (%)**
Route 135, east of Bacon St	15,400	14,000	**-9%**	1,350	855[c]	1,015	**-25%**
Route 135, east of College Rd	12,500	14,100	**+12%**	1,040	790[d]	935	**-10%**

a Collected by VHB, Inc. in February (seasonally adjusted +2%), May and August 2002.
b Collected by TDG in March 2017.
c Collected by BETA Group in September 2014.
d Collected by VHB, Inc. in December 2014.

Pre- and post-construction speed data were collected through the ATRs. The posted speed limit on Route 135 is 45 mph, apart from traveling westbound east of College Road, where is transitions to 40 mph. The 85th percentile speeds for pre- and post-construction are shown in Table 6. Pre-construction, 85th percentile speeds at both locations in both directions were above the speed limits, ranging from 3 to 9 mph above. Post-construction, 85th percentile speeds at all locations measured were below the posted speeds limits, representing a unanimous decrease in speeds throughout the corridor. This constitutes a decrease in 85th percentile speeds from 8 to 11 mph. Off-peak 85th percentile speeds between the hours of 8 PM and 6 AM are higher than the all-day 85th percentile speeds by 0.1 mph to 4 mph.

Table 6 85th Percentile Speed Summary

	Speed (mph)			
	Speed Limit	Pre-construction Speed (2002)[a]	Post-construction Speed (2017)[b]	**Delta**
Route 135, eastbound east of Bacon St	45 mph	53 mph	42 mph	**-11 mph**
Route 135, westbound east of Bacon St	45 mph	54 mph	43 mph	**-11 mph**
Route 135, eastbound east of College Rd	45 mph	48 mph	40 mph	**-8 mph**
Route 135, westbound east of College Rd	40 mph	49 mph	39 mph	**-10 mph**

a Collected by VHB, Inc. in February and May 2002.

b Collected by TDG in March 2017.

Summary

As presented through comparison of pre- and post-construction of the road diet on approximately 1.25-miles of Route 135 in Wellesley, crash occurrence and severity have decreased dramatically. While vehicular volume levels have reduced slightly, crash rates per million vehicles entering demonstrate this reduction in crashes is not due to reduced volume. In addition, the 85th percentile speed data demonstrates that speeds have reduced by approximately 10 mph in both the eastbound westbound directions of travel along the corridor.

Nonantum Road, Boston/Newton/Watertown

Overview

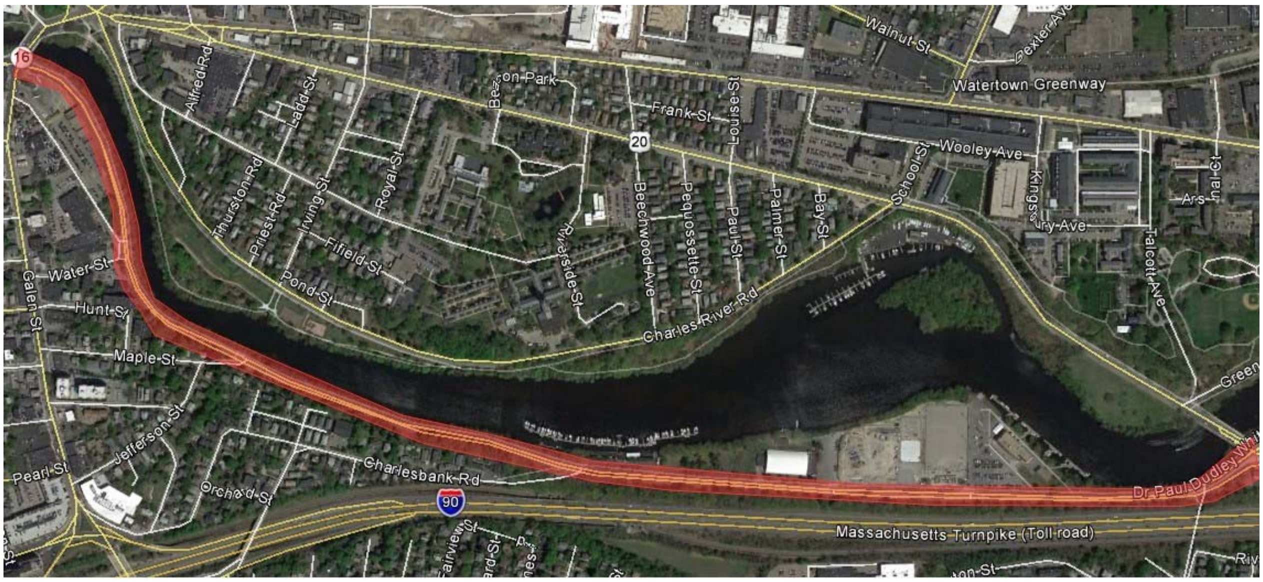
The corridor of Nonantum Road in Boston/Newton/Watertown (District 6) is an urban minor arterial that underwent a lane reduction project in 2012, comprising approximately 1.4-miles of roadway from the intersection of Galen Street in Watertown to the intersection of Brooks Street in Boston. This Department of Conservation and Recreation (DCR)-owned section of the corridor was restriped from a four-lane to a two-lane roadway, with left-turn lanes where appropriate at intersections and driveways. The project also incorporated shoulders, raised islands, flush textured medians and a shared-use path along the Charles River. The project goal was to improve safety and reduce fatal crashes, with five fatalities occurring from 2004 to 2012.

The land uses along this segment of Nonantum Road are generally residential along the south side and recreational along the north side, with access to athletic complexes, yacht and rowing clubs, which utilize the Charles River. Much like the MBTA Commuter Rail tracks along the north side of Route 135 in

Wellesley, the Charles River runs parallel to the corridor on the north, limiting curbcuts to the north, therefore negating the potential need for a TWLTL. Additionally, the Massachusetts Turnpike (I-90) borders Nonantum Road to the south for approximately have the length of the study corridor. This limits road and driveways to the south. The distance between intersections on Nonantum Road range from 600-feet to 3,400-feet, averaging about 1,600-feet between them.

There are six major intersections along this segment of roadway; Galen Street, Water Street, Maple Street, Charlesbank Road, Brooks Street and North Beacon Street. Galen Street, Brooks Street and North Beacon Street are signalized.

Exhibit 4 Nonantum Road study limits



Prior to implementation, two years of crash data were collected and analyzed by TDG (January 2008 to December 2009) utilizing the MassDOT Crash Portal. In addition, existing traffic conditions were studied, utilizing average daily traffic volumes (ATRs) and turning movements counts (TMCs), collected in March 2006 and March 2009. Three ATRs along Nonantum Road collected weekday daily volumes, west of Maple Street, east of Maple Street and east of Charlesbank Road. TMCs were collected for the intersection of the study road at Galen Street, Water Street, Maple Street, Brooks Street and North Beacon Street during the typical commuter peak hours (7-9AM and 4-6PM). These crash data records and counts represent "pre-road diet" conditions as a baseline for comparison of effectiveness.

Exhibit 5 Nonantum Road Pre-Road Diet (2007) – 4-lane undivided

To assess the effectiveness of the "post-road diet" implementation, crash data and count data post-construction were gathered and compared to pre-construction data. Crash data were obtained for the two-year period available post-construction, which is limited to January 2013 to December 2014, as construction for the road diet was completed in late 2012. Count data were analyzed post-construction utilizing data collected by TDG in March 2017, mimicking the pre-construction count program from 2006 and 2009, collecting three ATRs along the corridor and weekday evening peak hour TMCs at the six major intersections along Nonantum Road within the study limits.

Exhibit 6 Nonantum Road Post-Road Diet (2016) – two lanes along corridor with left-turn pockets

Crash Analysis

Within the project limits, the Nonantum Road corridor experienced a decrease in crashes over a two-year period when comparing crash data before the road diet was constructed to a two-year period post-construction. From January 2008 to December 2009 (pre-road diet), 64 crashes were reported within the project limits. From January 2013 to December 2014, 49 crashes were reported within the same project limits, representing a decrease in crash occurrence of 23% through the project limits. Individual intersections saw a decrease in crashes, apart from Brooks Street. It is notable that nearby intersection of North Beacon Street saw a decline in crashes of 83%, and is located within 200 feet of Brooks Street. Nonantum Road changes designation to North Beacon Street in the vicinity of Brooks Street, therefore it is possible this dramatic rise in crashes at Brooks Street is due to coding inaccuracies. Furthermore, the only geometric change that occurred within this segment is the westbound merge that occurs west of the Brooks Street signal. These overall crash totals for the corridor and individual intersections are presented within Table 7.

Of key importance is the crash rate associated with these intersections. The crash rate decreased at five of the six intersections along the corridor, while the crash rate increased at Brooks Street.

Table 7 Intersection Crash Summary by Year

	Nonantum Road at:							
	Galen Street	Water Street	Maple Street	Charlesbank Road	Brooks Street	North Beacon Street	Other (Driveways)	**Total**
Year (Pre-Construction)								
2008	12	6	0	8	0	2	**12**	**40**
2009	6	2	0	6	1	4	5	24
Total	**18**	**8**	**0**	**14**	**1**	**6**	**17**	**64**
MassDOT Crash Rate	**0.61**	**0.99**	**0**	**0.72**	**0.04**	**0.16**	**-**	
Year (Post-Construction)								
2013	7	1	0	5	6	0	**7**	**26**
2014	8	0	0	5	2	1	**7**	**23**
Total	**15**	**1**	**0**	**10**	**8**	**1**	**14**	**49**
MassDOT Crash Rate	**0.55**	**0.12**	**0**	**0.51**	**0.29**	**0.02**	**-**	
Delta in Crash Occurrence	**-17%**	**-88%**	**0%**	**-29%**	**+700%**	**-83%**	**-18%**	**-23%**

The severity of the reported crashes along the Nonantum Road corridor experienced a decrease as well, with eight fewer reported injuries over the course of the post-construction two-year period. Table 8 presents the pre- and post-construction crash data by type and severity. On September 27, 2013 at 2:05AM a westbound travelling vehicle on Nonantum Road went off the road, under dry pavement conditions, resulting in a single vehicle fatal collision with a tree. This crash was reported to have occurred in the vicinity of Water Street, but did not occur at the intersection. It is also worth noting that there was a pedestrian fatality in May of 2012 on Nonantum Road near Charlesbank Road at about 3:18 AM. This occurred during the construction period, and road design is not thought to have been the cause.

Road diets aim to decrease the number of rear-end, left-turn and sideswipe crashes. Post-construction, all the targeted crash types decreased by seven, one, and four crash occurrences, respectively. However, as a percent of the total number of crashes, angle crashes increased by six percent, while angle collisions, which encompass left-turns crashes, and sideswipes in the same direction decreased by four and five percent, respectively.

Table 8 Crash Summary by Type and Severity for Nonantum Road

	Total Crashes (% of total) Pre-Construction	**Total Crashes (% of total) Post-Construction**	**Delta**
Collision Type			
Angle	15 (23%)	14 (29%)	-1
Rear-end	20 (31%)	13 (27%)	-7
Head-on	2 (3%)	4 (8%)	+2
Sideswipe, same direction	8 (13%)	4 (8%)	-4
Sideswipe, opposite direction	2 (3%)	2 (4%)	0
Single Vehicle Crash	12 (19%)	11 (22%)	-1
Pedestrian/Bicyclist Involved	0	0	-
Unknown/Not Reported	5 (8%)	1 (2%)	-4
Total	**64**	**49**	**-15**
Severity			
Property Damage Only	33 (52%)	32 (65%)	-1
Possible Injury	7 (11%)	3 (6%)	-4
Non-fatal injury – non-incapacitating	16 (25%)	12 (24%)	-4
Non-fatal Injury - incapacitating	1 (2%)	1 (2%)	0
Fatality	1 (2%)	1 (2%)	0
Not Reported	6 (9%)	0	-6
Total	**64**	**49**	**-15**

Count and Speed Data Analysis

The average daily traffic (ADT) for Nonantum Road increased by 11% east of Maple Street and decreased by 2% east of Charlesbank Road. Weekday evening Peak Hour Volume (PHV) increased slightly by approximately 3% to 7%.

Table 9 Vehicular Volume Summary

	Average Daily Traffic (bi-directional, vpd)			Weekday Evening Peak Hour Volume (bi-directional, vph)		
Location	Pre-Construction (2006/2009)	Post-Construction (2017)[c]	**Delta (%)**	Pre-Construction (2006)[a]	Post-Construction (2017)[c]	**Delta (%)**
Nonantum Rd, west of Maple St.	10,100[b]	-	**-**	920	980	**+7%**
Nonantum Rd, east of Maple St.	11,800[b]	13,100	**+11%**	1,120	1,200	**+7%**
Nonantum Rd, east of Charlesbank Rd	25,100[a]	24,700	**-2%**	2,340	2,420	**+3%**

a Collected by FST in March 2006.
b Collected by FST in March 2009.
c Collected by TDG in March 2017.

While pre-construction speed data were not collected as part of the Nonantum Road reconstruction project, TDG collected post-construction speed data through the ATRs in March 2017. The posted speed along the corridor is 40 mph with observed 85th percentile speeds in the eastbound and westbound directions at 38 mph, both below the posted speed limit, post-construction.

Summary

As presented through comparison the pre- and post-construction of the road diet on approximately 1.4-miles of Nonantum Road in Boston/Newton/Watertown, crash occurrence and severity have decreased. The crash rates at five of the six intersections within the project limits also decreased, demonstrating that the decrease in crash occurrences is not due to a decrease in volume. Both vehicular volume levels and evening peak hour volume have generally increased on Nonantum Road. Finally, 85th percentile speeds are operating under the speed limit.

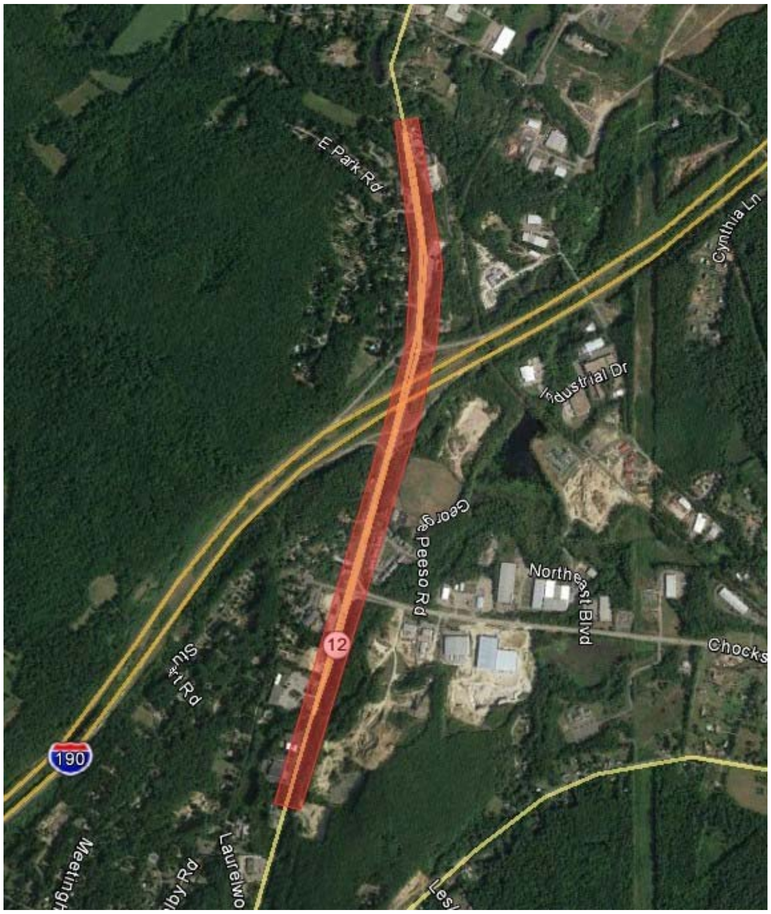
Route 12 (Leominster Road), Sterling

Overview

The corridor of Route 12 (Leominster Road) in Sterling (District 3) is an urban principal arterial that underwent a lane reduction project in 2013, comprising approximately 1.5-miles in the stretch of roadway from mile marker 34.4 ± to 35.9± encompassing most notably the Interstate 190 interchange and Chocksett Road. This MassDOT-owned section of roadway was restriped from a four-lane to a two-lane roadway, with exclusive left-turn lane pockets within the existing median at Chocksett Road, the Interstate 190 interchange, and East Park Road. The lane reduction project essentially provided for hashed pavement markings within the interior travel lane in both directions of travel along the median, with no reconstruction of the curbline.

There are three major intersections along this segment; Chocksett Road, and the ramps to with I-190 North and South. All intersections are unsignalized, under stop/yield control to Route 12. In spring 2017, construction of roundabouts at the Route 12 intersection with I-90 Southbound Ramps and Chocksett Road will begin, as recommended within the Functional Design Report (FDR) conducted by MassDOT in September 2014. In addition to the roundabouts, the construction of a shared-use path along the east side of the corridor and a sidewalk on the west side of the corridor are planned. The land surrounding this corridor is low density, with limited curbcuts. The distance between intersections range from 940-feet to 1870-feet, averaging about 1490-feet.

Exhibit 7 Route 12 study limits



Prior to implementation, three years of crash data were collected and analyzed by TDG (January 2012 to December 2014) utilizing the MassDOT Crash Portal. In addition, existing traffic conditions were studied, utilizing turning movements counts (TMCs), collected in April 2013. TMCs were collected for the intersection of the study road at both the I-90 ramps and Chocksett Road during abridged typical commuter peak hours (7-8AM and 5-6PM). Pre-construction ADT data from 2012 were obtained from the MassDOT Roadway Inventory database along Route 12 for establishment of a baseline condition. These crash data records and counts represent “pre-road diet” conditions as a baseline for comparison of effectiveness.

Exhibit 8 Route 12 Pre-Road Diet (2011) – 4-lanes divided

To assess the effectiveness of the "post-road diet" implementation, crash data and count data post-construction were gathered and compared to pre-construction data. Crash data were obtained from the Sterling Police Department for the latest three-year period available post-construction, January 2014 to December 2016. Count data were analyzed post-construction utilizing data collected by TDG in March 2017, mimicking the pre-construction count program from 2013, including an ATR directly north of Chocksett Road and weekday evening peak hour TMCs at the three major intersections along Route 12 within the study limits.

Exhibit 9 Route 12 Post-Road Diet (2017) – 2-lanes divided along corridor with left-turn pockets

Crash Analysis

Within the project limits, the Route 12 corridor experienced an increase in crashes over a three-year period when comparing crash data before the road diet was constructed to a three-year period post-construction. However, this increase was limited to one intersection, the unsignalized intersection of Chocksett Road at Route 12. From January 2010 to December 2012 (pre-road diet), 69 crashes were reported within the project limits. Crashes from the Sterling Police Department from January 2014 to

December 2016, demonstrate that 88 crashes were reported within the same project limits, representing an increase in crash occurrence of 28% when comparing to pre-construction. Although the total number of crashes for the corridor increased from pre-construction to post-construction of the lane reduction markings, the severity of these crashes notably decreased.

While the intersection at Chocksett Road experienced an increase of 81% in crash occurrence, the I-190 ramps experienced a decrease in crashes of 37%. Crashes not located at these intersections also decreased post-construction by 44%. These overall crash totals for the corridor and individual intersections are presented within Table 10.

Of key importance is the crash rate associated with these intersections. The rate in which crashes are occurring based on million vehicles entering has also increased dramatically for the intersection with Chocksett Road, while decreasing at the I-190 ramps and along the corridor, as presented in Table 10. The Chocksett Road intersection is still over both the District 3 and statewide average crash rates. The crash rate at the I-190 ramps were calculated together as the pre-construction data did not consistently distinguish between northbound and southbound ramps. The crash rate remained unchanged at the I-190 ramps with the lane reduction.

Table 10 Intersection Crash Summary by Year

	Route 12 (Leominster Road) at:			
	Chocksett Road	I-190 Ramps	Other	**Total**
Year (Pre-Construction)				
2010	8	3	7	**18**
2011	13	12	9	**34**
2012	11	4	2	**17**
Total	**32**	**19**	**18**	**69**
MassDOT Crash Rate	**2.54**	**0.78***	-	
Year (Post-Construction)				
2014	16	8	1	**25**
2015	19	3	5	**27**
2016	23	9	4	**36**
Total	**58**	**20**	**10**	**88**
MassDOT Crash Rate	**3.28**	**0.78***	**-**	
Delta in Crash Occurrence	**+81%**	**+5%**	**-44%**	**+28%**

*Crash Rate calculated as one intersection due to pre-construction data not distinguishing NB and SB ramps

Although the total number of crashes for the corridor increased from pre-construction to post-construction of the lane reduction markings, the severity of these crashes notably decreased. Specifically, pre-construction there were two fatalities along this segment of corridor, reduced to zero fatalities in the three years of data post-construction. Additionally, the number of incapacitating injuries decreased from an average of one per year pre-construction, to one occurrence in a total of three years, post-construction.

In 2010, one crash involved a pedestrian that occurred in front of Barbers Crossing North Restaurant that resulted in no reported injuries. There were no crashes involving pedestrians or bicyclists post-construction. The number of angle and sideswipe crashes decreased post-construction by seven and four crashes, respectively.

The number of rear-end crashes increased by 16 crashes post-construction. Many of these rear-end crashes occurred on Chocksett Road when attempting to execute a right-turn, towards the I-190 interchange, utilizing the slip-lane onto Route 12. Given the wide radius of this maneuver, drivers seeking a gap in northbound flow along Route 12 are required to look essentially back 180-degrees. This plausibly causes rear-end crashes when additional vehicles in the queue are also looking back roll forward or accelerate before checking that the vehicle in front had already merged. Construction of two roundabouts at these intersections is slated to begin in March of 2017 to decrease crash occurrences. It is unclear if the restriping was done as an interim project before the roundabouts, or if the road diet will be used in tandem. Table 11 presents the pre- and post-construction crash data by type and severity.

Table 11 Crash Summary by Type and Severity for Route 12

	Total Crashes (% of total) Pre-Construction	**Total Crashes (% of total) Post-Construction**	**Delta**
Collision Type			
Angle	25 (36%)	18 (20%)	-7
Rear-end	29 (42%)	45 (51%)	+16
Sideswipe	5 (7%)	1 (1%)	-4
Single Vehicle Crash	5 (7%)	6 (7%)	-
Head-on	2 (3%)	0 (0%)	-2
Pedestrian/Bicyclist Involved	1 (1%)	0	-
Other	3 (4%)	0 (0%)	-3
Unknown	1 (1%)	18 (20%)	+17
Total	**69**	**88**	**+19**
Severity			
Property Damage Only	48 (70%)	64 (73%)	+16
Possible Injury	1 (1%)	7 (8%)	+6
Non-incapacitating Injury	12 (17%)	10 (11%)	-2
Incapacitating Injury	3 (4%)	1 (1%)	-2
Fatality	2 (3%)	0 (0%)	-2
Not Reported/Unknown	2 (3%)	6 (7%)	+4
Total	**69**	**88**	**+19**

Count and Speed Data Analysis

The average daily traffic (ADT) on Route 12 increased slightly by 7%, while weekday evening Peak Hour Volume (PHV) decreased slightly by approximately 2% to 8%.

Table 12 Vehicular Volume Summary

Location	Average Daily Traffic (bi-directional, vpd)			Weekday Evening Peak Hour Volume (bi-directional, vph)		
	Pre-Construction (2013)[a]	Post-Construction (2017)[b]	**Delta (%)**	Pre-Construction (2013)[c]	Post-Construction (2017)[b]	**Delta (%)**
Route 12, north of Chocksett Rd	8,500	9,100	**+7%**	-	-	**-**
Route 12 at Chocksett Rd	-	-	**-**	660	615	**-8%**
Route 12 at I-190 NB Ramps	-	-	**-**	775	760	**-2%**
Route 12 at I-190 NB Ramps	-	-	**-**	585	575	**-2%**

a Source MassDOT Roadway Inventory database, 2012.
b Collected by TDG in March 2017.
c Collected by MassDOT in April 2013.

While pre-construction speed data were not collected as part of the Route 12 reconstruction project, TDG collected post-construction speed data through the ATR in March 2017. The posted speed along the corridor is 55 mph with observed 85th percentile speeds in the northbound direction at 53 mph and in the southbound direction at 51 mph, both below the posted speed limit, post-construction.

Summary

As presented through comparison the pre- and post-construction of the road diet on approximately 1.5-miles of Route 12 in Sterling, while crash occurrence has increased, the severity has decreased, with more construction to follow. While vehicular daily volumes have increased slightly, peak hour volumes have decreased marginally.

Route 133 (Andover Street), Lowell

Overview

The urban principal arterial of Route 133 (Andover Street) in Lowell (District 4) was converted from a 4-lane to a 3-lane road with a dedicated TWLTL in the early 1980's for a stretch of 1.4-miles. This segment of corridor is under City of Lowell jurisdiction, with the conversion spanning from Nesmith Road (Route 38) to the Tewksbury town line. There are three major intersections, over 20 minor intersections, and residential driveways as well. The distance between the intersections span 300-feet, on average. The surrounding land use is relatively dense residential. Notably this stretch of roadway includes no signalized intersections.

Pre-implementation data was not available due to the date of installation; however, TDG spoke to the City and confirmed the conversion. TDG obtained crash data from MassDOT for the years 2012 to 2014. ADT data was obtained for 2012 from MassDOT Roadway Inventory database files.

Exhibit 10 Route 133 (Andover Street) study limits

Exhibit 11 Route 133 Post-Road Diet (2013) – 2-lanes with center TWLTL

Crash and Count Analysis

The crash rate for Route 133 is 1.65 crashes per million vehicles entering. While we do not have pre-implementation count data for comparison, this crash rate falls well below the statewide average crash rate for urban principal arterials of 3.33 crashes per million vehicles entering. The ADT in 2015 was recorded at 19,400 vpd, which is below the maximum ADT typically recommended for a road diet. Since the road has been in this configuration for more than three decades, it can be assumed that the number of lanes is adequate for the traffic volume. Table 13 presents a summary of crashes and count data (post-construction) for Route 133 in Lowell.

Table 13 Crash Rate and Traffic Volume for Route 133

	Total Crashes	Crash Rate	MassDOT Crash Rate	ADT
2012	13	-	-	17,400
2013	16	-	-	17,600
2014	18	-	-	18,500
Total	**47**	**1.65**	**3.33**	

During the most recent three-year period (January 2012 to December 2014), 47 crashes were reported on Route 133. Road diets typically reduce rear-end, left-turn and sideswipe crashes. On Route 133, the percent of sideswipe crashes is minor; however, left-turn crashes are captured as angle crashes which makeup the highest percentage of crashes. There were no head-on collisions reported during these years. On June 6, 2014, there was a crash involving a bicyclist at the intersection of Andover Street and Rivercliff Road. The driver was turning left; however, it is unclear as to which road the driver was traveling on and which road they were turning to. The bicyclist possibly sustained non-fatal injuries.

Table 14 Crash Type and Severity for Route 133

	Total (% of total)
Collision Type	
Angle	17 (36%)
Rear-end	17 (36%)
Sideswipe	2 (4%)
Single Vehicle	6 (13%)
Pedestrian/Bicyclist Involved	1 (2%)
Not Reported	3 (6%)
Unknown	1 (2%)
TOTAL	47
Severity	
Property Damage Only	24 (51%)
Possible Injury	12 (26%)
Non-incapacitating Injury	2 (4%)
Incapacitating Injury	1 (2%)
Fatality	1 (2%)
Not Reported/Unknown	7 (15%)
TOTAL	47

Of the 47 crashes that occurred during the study period, two (4%) resulted in fatal or serious injury. The fatal crash occurred on December 18, 2013, when a resident was backing into their driveway on Andover Street and was struck broadside. The fatal injury occurred to the driver travelling straight along Andover Street. Over half of the crashes resulted in no injuries, whereas 26% of crashes resulted in only possible injuries.

Intersection Road Diets

Road diets are typically implemented over corridors encompassing many intersections. However, the safety benefits of road diets can also be realized at the intersection level. Route 9 in Spencer underwent a lane reduction in the eastbound direction at the intersection of Route 49. Route 146A in Uxbridge also underwent a lane reduction in both directions at the intersection of Chocolog Road, as well as added a left-turn only lane in the northbound direction. From a five-year period before the road diets were implemented (2002 to 2006) to the most recent five-year period (2010 to 2014), these intersections saw a decrease in crash occurrences of 30 (52%) and eight (73%), respectively. The number of crashes resulting in injury have decreased for both intersections, with the Uxbridge location not recording a single injury-causing crash since the road diet was implemented in 2007. At both locations, the number of angle and rear-end type crashes has decreased dramatically, with Spencer location seeing a decrease in rear-end crashes of 28 occurrences, or 76%. The crash severity and crash types for both locations are listed in Tables 15 and 16.

Table 15 Crash Severity and Select Crash Types for Route 9

	Route 9 at Route 49:					
	Crashes	Injury Crashes	PDO Crashes	Angle	Rear-end	Sideswipe
Year (Pre-Construction)						
2002	17	3	14	4	13	0
2003	4	1	3	1	3	0
2004	15	0	15	3	8	1
2005	16	5	11	6	9	0
2006	6	0	6	1	4	0
Total	**58**	**9 (16%)**	**49 (85%)**	**15 (26%)**	**37 (64%)**	**1 (2%)**
Year (Post-Construction)						
2010	5	1	4	0	2	2
2011	10	2	8	4	3	0
2012	6	1	4	1	2	1
2013	3	0	3	1	1	0
2014	4	0	4	1	1	1
Total	**28**	**4 (14%)**	**23 (82%)**	**7 (25%)**	**9 (32%)**	**4 (14%)**
Delta in Crash Occurrence	**-52%**	**-56%**	**-53%**	**-53%**	**-76%**	**+300%**

Table 16 Crash Severity and Select Crash Types for Route 146A

	Route 146A at Chocolog Road:					
	Crashes	Injury Crashes	PDO Crashes	Angle	Rear-end	Sideswipe
Year (Pre-Construction)						
2002	1	1	0	0	0	0
2003	0	0	0	0	0	0
2004	2	0	2	1	0	0
2005	2	0	2	1	1	0
2006	6	1	5	3	2	0
Total	**11**	**2 (18%)**	**9 (82%)**	**5 (46%)**	**3 (27%)**	**0**
Year (Post-Construction)						
2010	3	0	3	0	1	1
2011	0	0	0	0	0	0
2012	0	0	0	0	0	0
2013	0	0	0	0	0	0
2014	0	0	0	0	0	0
Total	**3**	**0**	**3 (100%)**	**0**	**1 (33%)**	**1 (33%)**
Delta in Crash Occurrence	**-73%**	**-100%**	**-67%**	**-100%**	**-67%**	**-**

Rhode Island Case Studies

As the number of locations where traditional road diets have been installed in Massachusetts is limited, TDG reached out to Rhode Island Department of Transportation (RIDOT), where experience is more prevalent, to supplement these data review efforts. Rhode Island has implemented over 20 road diets throughout the state. These corridors reflect the more traditional road diet of a 4- to 3-lane conversion with a TWLTL. TDG obtained pre- and post-construction crash data for five road diet sites, as well as ADT from the year 2000 for reference. As part of their guidelines, RIDOT does not consider roadways for a road diet if the ADT is greater than 20,000 vpd. Data obtained by TDG include the following corridors:

- Turnpike Avenue, Portsmouth, RI (4,800 vpd)
- Route 138 (East Main Road), Portsmouth, RI (9,950 vpd)
- Route 2 (South County Trail), South Road, RI (9,800 vpd)
- Route 44 (Putnam Pike), Smithfield, RI (14,600 vpd)
- US Route 6A (Hartford Avenue), Johnston, RI (16,600 vpd)

The ADT's on these corridors range from 4,800 to 16,600 vpd in 2000. All the road diets studied in RI were implemented between 2009 and 2012. Overall, the number of crashes on these corridors decreased from 7.1 crashes per month to 4.1 crashes per month, representing an average reduction of approximately 42%. Only one location (Turnpike Avenue) saw an increase in crashes of 0.4 crashes per month. In the post-construction study period, none of the study locations experienced a fatal or serious injury as a result of a vehicle crash. Before construction, there were 0.2 serious injuries per month during the study period.

All collision types experienced a decrease in crashes per month after the road diets were constructed, however angle crashes saw the greatest decrease of 1.4 crashes per month. Rear-end crashes decreased by 0.5 crashes per month, whereas sideswipe crashes decreased 0.4 crashes per month.

Municipality Input and Experience

TDG communicated with consultants, state and local officials at multiple levels regarding their experience with road diets. In Massachusetts, most of the road diets studied were implemented as a traffic calming and safety measure, not necessarily to add bike lanes or sidewalks. Where roadway modifications were implemented, they were often done so without the collection or analysis of pre-construction data. These roadways were chosen for modifications mainly due to community input/concerns regarding elevated speeds and planned repaving schedules.

Public and municipal feedback of the implemented road diets listed within Table 1 have generally been positive. TDG spoke with a Town of Wellesley staff member regarding the Route 135 restriping, with the following feedback. The goal of implementing a road diet on Route 135 was to improve safety and address concerns over speed. The narrowness of the lanes, combined with the number of lanes and speed along the corridor, prompted the restriping. With a single, slightly wider, lane in each direction, the Town felt Route 135 would be safer.

During the Federal Highway Administration (FHWA) New England Peer Exchange, the design team for Nonantum Road presented their experiences on the post-construction. According to the team, the road diet has received “rave reviews”, stating that while vehicle queue lengths are longer, the travel time along the corridor has remained comparable to pre-construction.

TDG spoke with a Project Engineer at MassDOT regarding the Route 12 in Sterling restriping and proposed roundabouts. During a public meeting for the roundabouts, the Police Chief claimed that the restriping (road diet) significantly reduced the severity of crashes, though not the number of occurrences. To our knowledge, there has been no negative public feedback from the restriping.

An exception to the positive public feedback is Father Morissette Boulevard in Lowell. Father Morissette Boulevard processes approximately 9,000 vehicles per day and was restriped in August of 2013 from a 4-lane divided roadway to 2-lane divided roadway with bike lanes and on-street parking where roadway width permitted. The road diet was implemented to expand the bicycle network and add parking spaces for the University of Massachusetts’ Lowell campus. Parking kiosks were also added to increase parking revenue for the City. Father Morissette Boulevard may be reverted to a 4-lane road after complaints of traffic congestion and concerns over improper use of the bicycle lanes by vehicles causing crashes. Revenue from the parking kiosks was also lower than the City had projected. According to a staff member in the City of Lowell, the bike lanes are used infrequently except by the occasional vehicle and the traffic signals are close together. In addition, it was stated that speeds are not a concern. TDG travelled this roadway via vehicle during a site visit and noted the westbound bike lane switches from the right side of the road to the left (along the median) mid-intersection, which could account for the low number of cyclists on Father Morissette Boulevard, as this does not present a low-stress facility. This bike lane also forces cyclists to merge with vehicles potentially travelling at high speeds when it ends on the left side of the travel lanes at its terminus.

For all other roadways mentioned previously, most concerns before implementation were over the potential cost of the roadway treatment and traffic impacts. However, once implemented, these concerns generally dissipated.

Lessons Learned

Utilizing the various case studies that have been identified, supported by input from other DOTs at the FHWA-led Northeast Region Road Diet Peer Exchange, TDG has distilled the “Lessons Learned” through the implementation of road diets. The following is a summary of these lessons learned, with a detailed breakdown provided within the Appendix.

- CAREFULLY SELECT CORRIDORS FOR ROAD DIETS
    - In addition to selection criteria, coordinate with other corridor improvements, such as resurfacing or a reconstruction project to reduce cost. Road diet striping on new pavement is less confusing for drivers.
    - If there is opposition, consider a trial period before a planned resurfacing project to allow users to warm up to the idea.
- USE APPROPRIATE SIGNAGE
    - Use barrels/VMS signs before and after implementation to notify users.
    - Create new wayfinding signs when appropriate.
- COMMUNITY INVOLVEMENT IS KEY
- EDUCATE THE PUBLIC EARLY
    - Consider developing a pre-construction public survey to gather data and feedback. Be sure to follow up with a post-construction survey.
- LET DATA DRIVE THE CONVERSATION
    - Identify project goals, performance measures and expectations. Gather data to support them.
- DON’T FORGET THE DETAILS
    - Be cognizant of storm water grates and manholes in new bicycle lanes.
    - Improve sidewalks, ramps, and landscaping on any medians.
    - Update traffic signal equipment, as necessary, with new configuration.

Task 2 – Select Installation Sites

Methodology

Task 2 involved identifying potential road diet installation sites throughout the Commonwealth based on a set criteria, defined through this process. These criteria were created utilizing the research previously completed under the scope of Task 1 and through consult with MassDOT.

Potential road diet candidates were selected by first utilizing the MassDOT Roadway Inventory database via GIS to create a list comprised of roadways in the Commonwealth with the following characteristics:

- 4-lane, undivided roadway;
- Estimated Average Daily Traffic (ADT) less than 20,000 vehicles per day (vpd); and
- Roadway intersected with a HSIP crash cluster, pedestrian crash, or bicyclist crash.

Once this preliminary list was populated, TDG then verified lane geometry to ensure the accuracy of these data and establish limits on the corridor. The resulting list of 51 corridors is presented in Table 17, below. Additional details on the candidates can be found in the Appendix.

Table 17 Initial list of Road Diet Candidates

Street Name	Municipality	Street Name	Municipality
Washington Street (Route 1)	Attleboro	Main Street (Route 28)	Reading
Pleasant Street	Attleboro	Highland Avenue (Route 107)	Salem
Southbridge Street	Auburn	Taunton Avenue (Route 44)	Seekonk
Spring Street	Boston	Grand Army of The Republic Highway (Route 6)	Somerset
Southampton Street	Boston	Dwight Street	Springfield
Belmont Street (Route 123)	Brockton	State Street	Springfield
North Montello Street	Brockton	Maple Street	Springfield
Washington Street (Route 1A)	Dedham	Page Boulevard	Springfield
Bedford Street	East Bridgewater	Berkshire Avenue	Springfield
Huttleston Avenue (Route 6)	Fairhaven	Cooley Street	Springfield
Derby Street	Hingham	Boston Road	Springfield
Winthrop Avenue	Lawrence	Main Street	Stoneham
North Main Street	Leominster	Grand Army of The Republic Highway (Route 6)	Swansea
Arcand Drive	Lowell	Middlesex Road	Tyngsborough
Market Street	Lynn	Lexington Street	Waltham
Commercial Street	Malden	Arsenal Street	Watertown
Medford Street	Malden	Galen Street	Watertown
Us 6 (Wareham Rd/Mill Street)	Marion	Westfield Street (Route 20)	West Springfield
Ocean Street	Marshfield	Franklin Street (Route 20)	Westfield
Medway Road (Route 109)	Milford	Elm Street	Westfield
Reedsdale Road	Milton	Washington Street (Route 1a)	Westwood
Washington Street	Newton	Main Street	Wilmington
East Washington Street	North Attleborough	Park Avenue	Worcester
Route 28	North Reading	Main Street	Worcester
Cranberry Highway/Old King's Highway (Route 6a)	Orleans	Chandler Street (Route 122a)	Worcester
Sea Street	Quincy		

Based on the initial list of candidates, additional criteria were introduced to further refine the candidate list. Additional criteria included the following:

- Length of the corridor;
- Density of signals;
- Density of curbcuts;
- Adjacent land use;
- Number of bicycle and pedestrian crashes;
- Bicycle and/or pedestrian fatalities, if any;
- Percent of crashes being angle, sideswipe, or rear-ends (types typically mitigated by road diets);
- Severity of crashes; and
- Connections to existing bicycle facilities.

The following final candidate list represents a variety of corridors characteristics within the Commonwealth in terms of length, adjacent land use, signal density, and traffic volume.

Table 18 Final Road Diet Candidate List

Street Name	Municipality	From	To	Estimated ADT (vpd)[1]
Southbridge Street	Auburn	Oxford Street	Auburn Street	17,379
Southampton Street	Boston	Massachusetts Avenue	Dorchester Avenue	18,218
Washington Street (Route 1A)	Dedham	Gay Street	Court Street	8,160
Ocean Street	Marshfield	Moraine Street	Main Street	18,035
Medway Road (Route 109)	Milford	East Main Street	Beaver Street	N/A
Sea Street	Quincy	Southern Artery	Peterson Road	13,938
State Street	Springfield	Catharine Street	Boston Road	10,157
Westfield Street (Route 20)	West Springfield	Old Westfield Road	Kings Highway	10,869

[1] MassDOT Road Inventory GIS Layer, 2012

Crash History

Crash data for all study areas were obtained from the MassDOT crash portal for the most recent complete five-year period available (2011 through 2014). Table 19 summarizes crash statistics for the final candidate list. Additional crash data are included in the Appendix.

Table 19 Crash Statistics for Final Candidate List

Corridor	Total Crashes	Fatal crashes	% road diet mitigated crashes*	% of crashes resulting in an injury	% of crashes involving a cyclist or pedestrian	% of crashes not at signalized intersections
Southbridge St., Auburn	268	0	84%	17%	0%	85%
Southampton St., Boston	77	1	60%	49%	21%	40%
Washington St., Dedham	84	0	80%	32%	0%	85%
Ocean St., Marshfield	102	0	82%	26%	5%	91%
Medway Rd., Milford	412	0	82%	19%	2%	83%
Sea St., Quincy	254	1	72%	27%	4%	83%
State St., Springfield	420	2	79%	47%	9%	82%
Westfield St., West Springfield	215	3	75%	33%	2%	99%

*This includes angle, rear-end, and sideswipe crashes

Count Data

Existing 2017 traffic volumes within the study areas were obtained with 24-hour Automatic Traffic Recorder (ATR) counts and peak hour manual turning movement counts (TMCs) in July and September of 2017. Existing vehicular, pedestrian and bicycle volumes were obtained through TMCs, performed at key intersection along the eight candidate corridors. Count data were collected during the weekday morning period (7:00AM-9:00AM), and weekday evening (4:00PM-6:00PM) typical peak hour periods. These data were collected to inform design decisions, specifically related to the feasibility of implementing a road diet on each of the selected corridors. Raw count data are provided within the Appendix.

Table 20 summarizes the 2017 daily and peak-hour traffic volumes at the ATR installation locations.

Table 20 Traffic Volume Summary

Location/Time Period	Daily Volume (vpd) [a]	Peak Hour Volume (vph) [b]	K Factor (%) [c]	Directional Distribution [d]
Southbridge Street				
South of Water Street, Auburn:	19,108			
Weekday AM Peak Hour	--	1,348	7.1%	62% SB
Weekday PM Peak Hour	--	1,429	7.5%	61% SB
Southampton Street				
Between I-93 Ramps, Boston:	23,334			
Weekday AM Peak Hour	--	1,703	7.3%	56% WB
Weekday PM Peak Hour	--	1,419	6.1%	53% WB
Washington Street				
South of Fay Road, Dedham:	22,235			
Weekday AM Peak Hour	--	1,987	8.9%	81% NB
Weekday PM Peak Hour	--	2,102	9.5%	65% SB
Ocean St				
West of Mariners Hill Drive, Marshfield:	35,702			
Weekday AM Peak Hour	--	2,515	7.0%	52% WB
Weekday PM Peak Hour	--	2,784	7.8%	59% EB
Medway Road				
West of Messina Street, Milford:	15,941			
Weekday AM Peak Hour	--	1,279	8.0%	73% WB
Weekday PM Peak Hour	--	1,249	7.8%	58% WB
Sea Street				
East of Palmer Street, Quincy:	20,994			
Weekday AM Peak Hour	--	1,646	7.8%	67% WB
Weekday PM Peak Hour	--	1,496	7.1%	62% EB
State Street				
East of Berlin Street, Springfield:	15,528			
Weekday AM Peak Hour	--	1,000	6.4%	58% WB
Weekday PM Peak Hour	--	1,237	8.0%	51% WB
Westfield Street				
Between Thompson St and Belmont Ave, West Springfield:	28,056			
Weekday AM Peak Hour	--	2,235	8.0%	65% EB
Weekday PM Peak Hour	--	2,276	8.1%	55% WB

a 2017 Average traffic volumes in vehicles per day.
b Vehicles per hour.
c Percentage of daily traffic occurring during the peak hour.
d SB = southbound, NB = northbound, WB = westbound, EB = eastbound

As a case study for this application, TDG analyzed the crash data and volume data collected for the final roadway candidates. Of the eight final candidates, three had a measured ADT below 20,000 vpd. These roadways were Southbridge Street in Auburn, Medway Road in Milford, and State Street in Springfield. Medway Road (Route 109) in Milford was used as a case study for a road diet as it had the highest crash rate of all corridors (16.66 crashes/mev) and one of the highest percent of crashes occurring on the roadway that could potentially be mitigated by a road diet. A brief analysis was conducted to determine the feasibility of a lane reduction. The analysis concluded that from an operations stand point, a road diet would have minimal effects on vehicular delay and level of service. The full analysis is included in the Appendix.

Challenges and Limitations

To establish a list of the primary potential candidates for a road diet within the Commonwealth, TDG utilized the Road Inventory database. The principal criterion employed include any 4-lane, undivided roadway with an ADT under 20,000 vpd. As mentioned in Task 1, a literature review was performed to ascertain the best practices regarding road diets nationwide. Of the 15 agencies found to employ criteria for road diets, all employ ADT as a benchmark. The top 12 candidates for a road diet, based on the data within the GIS database were selected to obtain 24-hour ATR volume data, to vet the feasibility of a road diet. The volume data obtained in the field, however, varies significantly from volume presented within the database.

Accurate volume data is essential to execute a systematic approach within MassDOT for the implementation of road diets. Table 21 below presents ADT represented within the Road Inventory database for the 12 select roadways, in direct comparison to the ADT volume collected as part of this effort in 2017.

Table 21 ADT Discrepancies

Roadway	Location	Road Inventory ADT	Measured ADT	% Difference	Date Collected
Southbridge St, Auburn	South of Water St	4,356	19,108	+338%	June 2017
Southampton St, Boston	Between I-93 ramps	20,052	23,334	+16.4%	September 2017
Washington St, Dedham	South of Fay Rd	8,160	22,235	+172%	September 2017
Ocean St, Marshfield	West of Mariners Hill Dr	18,035	35,702	+98%	June 2017
Medway Rd, Milford	West of Messina St	27,579	15,941	-42.2%	September 2017
Merrill Rd, Pittsfield	North of Gifford St	21,197	22,996	+8.5%	June 2017
Sea St, Quincy	East of Curlew Rd	13,938	20,994	+50.6%	May 2015
Main St, Reading	South of Nelson Ave	17,635	15,133	-14.2%	June 2017
Main St, Reading	South of Summer Ave	12,790	19,774	+54.6%	June 2017
Berkshire Ave, Springfield	South of Robert Dyer Circle	14,216	12,706	-10.6%	September 2017
State St, Springfield	East of Berlin St	19,789	15,528	-21.5%	September 2017
Westfield St, West Springfield	Between Thompson St and Belmont Ave	11,300	28,056	+148%	October 2017

As can be seen, there were numerous discrepancies identified between the data ascertained as part of this effort and the data within the MassDOT Road Inventory file. The largest discrepancy was on Southbridge Street in Auburn where the measured ADT was 338% greater than the ADT listed in the Road Inventory database, followed by Washington Street in Dedham where the measured ADT was 172% greater than the ADT listed in the Road Inventory. While the majority (eight out of 12 roadways) of roadways had an actual volume higher than the Road Inventory, there were four roadways where the ADT was less than the Road Inventory. This may cause potential road diet candidates to be overlooked due to incorrect ADT that exceeds the volume criterion threshold. For example, Medway Road (Route 109) in Milford carries an ADT of over 27,000 vpd in the Road Inventory, which is above the typical road diet feasibility threshold of 20,000 vpd. However, the measured ADT of just under 16,000 vpd is well within the feasible range to perform a road diet.

Upon investigation, the data integrity of the MassDOT Road Inventory, as it relates to ADT does not support utilizing this database to conduct a statewide screening for road diet candidates. It is suggested that other means be explored to provide statewide ADT estimations or the data integrity of the MassDOT Road Inventory database file may need to be addressed, before any further systemic screening for road diet candidates advances, with ADT as a criterion. Though, an evaluation of road diet candidates utilizing the safety metrics set forth within Task 3 provides a path forward, regardless of ADT as a foundation for the onset.

Task 3 – Establish MassDOT Road Diet Design Criteria

Methodology

Task 3 lays the foundation for institutionalizing road diets as a design alternative for all suitable roadway redesign projects within the Commonwealth. This incorporation into the existing project delivery process provides a mechanism by which to evaluate the feasibility of a road diet for all projects prior to design. This task produced a total of seven deliverables, either stand-alone evaluations or updates to existing MassDOT project documents. The pathway deliverables are as follows:

- Project Need Form (PNF) – Update;
- Project Initiation Form (PIF) – Update;
- Project Development & Design Guide Checklist (PDDG) – Update;
- Traffic and Safety Engineering 25% Design Submission Guidelines – Update;
- Functional Design Report (FDR) Road Diet Table;
- MassDOT Internal Road Diet Review Checklist; and
- MassDOT Internal Road Diet Review Decision Tree.

The development of these documents, and associated language, could institutionalize the road diet practice through every facet of project delivery in MassDOT. These associated documents are available in the Task 3 Appendix of this report. The following provides a description of the various mechanisms provided to support the instituting of road diets in Massachusetts.

Project Need Form/Project Initiation Form

Before projects progress into design, they are first evaluated by the Executive Office of Transportation's Project Review Committee (PRC) for statewide priorities and then by the Metropolitan Planning Organization (MPO) for programming of funding. These committees utilize information about projects obtained through the PNF and PIF. Project Proponents complete and submit each form to their MassDOT District Office and MPO for initial review. As the PNF is the first document to be completed in this process, the addition of language on road diets is imperative to allow Project Proponents ample time to discuss a road diet as a viable redesign option. Recommended language about road diets is incorporated into the Safety Section (Part III, Section C) of the PNF and PIF, as shown below and in context within the Task 3 Appendix.

Figure 2 Project Need Form Road Diet Language Excerpt

4. **Road Diet**: Identify if the project roadway has four (4) lanes or more, is not divided by a raised median for the majority of the corridor, and has an average daily traffic (ADT) volume of 20,000 vehicles per day or less. Please note that a road diet should be considered as a design alternative if these conditions are met, and the project length is more than a half mile. A road diet may still be considered when the above conditions are not met, with community support.

Figure 3 Project Initiation Form Road Diet Language Excerpt

4. **Road Diet**: If the project is a candidate for a road diet, describe any improvements that are expected to improve the general safety for motor vehicles, pedestrians, bicyclists, and other roadway users. Please provide any analysis that has been completed.

Project Development & Design Guide checklist

The PDDG checklist is a workbook that provides MassDOT reviewers the opportunity to evaluate a proposed design at multiple stages in the process consistently with other projects. The purpose of the

25% Traffic Engineering Review is to evaluate the proposed design and Functional Design Report relative to current design standards, operation impacts, safety impacts, and other potential community concerns associated with the proposed design. Recommended language about road diets is incorporated into the Safety Section (Section C) of the PDDG workbook, as shown below and in context within the Task 3 Appendix.

Figure 4 Project Development & Design Guide Checklist Road Diet Language Excerpt

	Yes	No	N/A	C. Safety Analysis
21	☐	☐	☐	Was a road diet design alternative considered?
			Comment:	______________________________

Traffic and Safety Engineering 25% Design Submission Guidelines

The Traffic and Safety Engineering 25% Design Submission Guidelines are available to assist Project Proponents in developing an FDR for their project design. By inserting road diet design criteria in this guide, Project Proponents will be provided the framework to evaluate the feasibility of a road diet before submitting design alternatives. Recommended language about road diets is incorporated into the Safety Section (Section C) of the Traffic and Safety Engineering 25% Design Submission Guidelines, as shown below and within the Task 3 Appendix.

Figure 5 Traffic and Safety Engineering 25% Design Submission Guidelines Road Diet Language Excerpt

6. *Road Diet* – A road diet should be considered, when feasible, to address safety issues and to accommodate all roadway users. When a road diet is proposed for a project, review the latest edition of the Federal Highway Administration's publication, Road Diet Information Guide. Design criteria are explained in depth with detailed explanations of the benefits and hindrances of fewer motor vehicle through lanes. If conditions a, b, and c below are met, please include document "FDR ROAD DIET TABLE" in the accompanying FDR.

   a. *Number of Through Lanes* – The most common type of road diet has four (4) through lanes, two (2) in each direction of travel, before lanes are repurposed; However, road diets have been performed on a variety of additional cross sections.

   b. *Average Daily Traffic* – Road diets are typically feasible when the Average Daily Traffic (ADT) is less than 20,000 vehicles per day when considering a four-lane cross section.

   c. *Raised Median* – A traditional road diet involves a roadway not divided by a raised median to easily accommodate two-way left turn lanes (TWLTL). Roadways that otherwise fit the criteria, but are divided, may still be considered.

Functional Design Report Road Diet Table

The FDR road diet table is intended to be inserted into the FDR to assist Project Proponents in gathering necessary data to inform the decision on where or not a road diet is a viable option. Laying out the information in the table will also assist MassDOT in locating the necessary information to review the alternatives for road diet consideration.

Figure 6 Functional Design Report Road Diet Table

Topic	Description	Yes	No	N/A	Comment
Safety					
Overall Crashes/ Crash Rate	Is the corridor crash rate greater than the average crash rate for its functional classification? Note the number of crashes reported along the corridor within the latest five-year period available. *Note: Road diets have been shown to reduce overall crashes by 19 to 47 percent.*				
Injury Occurrence	Is the injury occurrence on the corridor greater than 35% of the total crashes? *Note: Road diets can reduce the severity of crashes by lowering speeds.*				
Rear-end Crashes	Have rear-end crashes occurred on this corridor in the past five years? *Note: Road diets can reduce the number of rear-end crashes with left-turning vehicles by removing stopped or slowing vehicles from the through lanes.*				
Sideswipe Crashes	Have sideswipe crashes occurred on this corridor in the past five years? *Note: Road diets can reduce the number of sideswipe crashes by eliminating the friction associated with changing lanes.*				
Angle Crashes	Have angle crashes occurred on this corridor in the past five years? *Note: Road diets can reduce the number of left-turn crashes by eliminating the negative offset between opposing left-turning vehicles and increasing available sight distance.*				
Pedestrian Crashes	Have pedestrian crashes occurred on this corridor within the past five years? Note the number of pedestrian crashes. *Note: Pedestrian crashes can be reduced with a road diet as pedestrian conflict points are reduced.*				
Bicyclist Crashes	Have bicyclist crashes occurred on this corridor within the past five years? Note the number of bicyclist crashes. *Note: Bicyclist crashes can be reduced with a road diet if bicycle lanes are provided to separate bicyclists from traffic.*				

Vehicular Metrics					
Average Daily Traffic	Is the ADT of the corridor under 20,000 vpd? *Note: Road diets are most viable on roadways with an ADT under 20,000 vehicles per day (vpd).*				
Vehicle Speed	Is speed an issue on the corridor, defined by the average recorded speed being greater than the posted speed limit? *Note: Road diets have been shown to calm traffic, and reduce speeds.*				
Roadway Characteristics					
Number of Through Lanes	Does the corridor have 4 or more through lanes? *Note: Road diets are typically performed on roadways with 4 or more through lanes.*				
Raised Medians	Is the corridor currently divided by a raised median? *Note: Road diets that incorporate a two-way left turn lane are traditionally implemented on roadways not divided by a raised median.*				
Access Control	Does the corridor have an average signal spacing of 1/4 mile or more? *Note: Roadways with signal spacing of a 1/4 mile or more perform well with a road diet.*				
Access Control	Are the left-turn volumes on the corridor greater than 5%, but less than 35% of the total volume? *Note: The number of left-turning vehicles play a role in the success of a road diet.*				

The above table was completed for the Medway Road (Route 109) case study, serving as an example of a completed table. It is included in the Task 3 Appendix.

Internal Review Checklist and Decision Tree

The 25% Review Checklist is intended to assist MassDOT in reviewing 25% Design submissions. It demonstrates whether a road diet should be considered as an alternative based on prescribed volume and/or safety metrics. The Decision Tree (similar to a flowchart) presents the same information as the Checklist, only in a more visual format. The Decision Tree directs reviewers to the safety analyses metrics first. If the safety analyses do not prompt a road diet being considered within the FDR, the reviewer is then directed to the various volume-based analyses to determine if the subject roadway may be a viable candidate for a road diet. The Decision Tree is formatted as such to prioritize safety at the forefront of roadway redesign.

Figure 7 Road Diet Internal 25% Review Checklist

Road Diet Checklist

Massachusetts Department of Transportation

This checklist should be completed for all 25% Design reviews for applicable roadway projects. A road diet, for the purpose of this checklist, is defined as reducing the number of vehicle travel lanes on a roadway by one or more.

*Completed by:*______________________________

1. Project Description

Roadway/Route: ______________________________

Begin Mile Marker: ____________________ End Mile Marker: ____________________

Project Length (feet): ________________ Number of Lanes: ______________

Average Daily Traffic (ADT): ____________

2. Initial Screening

☐ Yes ☐No I. Undivided: Majority of the project roadway segment is not divided by raised median.

☐ Yes ☐No II. Vehicle Travel Lanes: Majority of the roadway segment is four lanes or more.

If Yes for both of the two above conditions, proceed to Section 3.

If No for either of the two above conditions, a road diet does not need to be considered and the completion of this checklist is not necessary.

3. Safety Analysis (most recent 5-year period):

If the roadway project limits are longer than ½ mile, evaluate in ½ mile increments.

☐ Yes ☐No I. Segment crash rate is greater than the average crash rate for it's functional classification.

☐ Yes ☐No II. Injury occurrence on the segment is greater than 35% of total crashes.

☐ Yes ☐No III. Crash types that are mitigated by road diets (rear-end, sideswipe, and angle crashes) make up approximately 50% or more of crashes on the roadway.

☐ Yes ☐No IV. A pedestrian or bicyclist was involved in a crash along the corridor segment (unsignalized intersection or midblock location).

If Yes for any of the above conditions, a road diet should be considered as a design alternative in the Functional Design Report.

If No for all the above conditions, proceed to Section 4.

4. Volume Metrics:

If the roadway has an ADT of less than 10,000 vpd, a road diet should be considered as a design alternative in the Functional Design Report.

If the roadway has an ADT of less than 20,000 vpd, but more than 10,000 vpd, a road diet should be considered as a design alternative with additional conditions (proceed to Section 4a below).

Road Diet Checklist

If the roadway has an ADT of greater than 20,000 vpd, a road diet does not need to be considered and the completion of this checklist is not necessary.

4a. Vehicular Traffic Metrics:

☐ Yes ☐ No I. Peak Hour Volume (PHV): PHV is less than 1,500 vehicles per hour per direction (vphpd).
☐ Yes ☐ No II. Average Daily Traffic (ADT): ADT is less than 15,000 vpd, but more than 10,000 vpd.

If Yes for the two above conditions, a road diet should be considered as a design alternative in the Functional Design Report.

If No for either of the two above conditions, a road diet should be considered as a design alternative with additional conditions (proceed to Section 4b below).

4b. Additional Vehicular Metrics:

☐ Yes ☐ No I. Left-Turn Volume: Percent of left-turning vehicles is between 5% and 35% of all volume.
☐ Yes ☐ No II. Signal Density: Average distance between signalized intersections if greater than ¼-mile.

If Yes for the two above conditions, a road diet should be considered as a design alternative in the Functional Design Report.

If No for either of the two above conditions, a road diet a road diet does not need to be considered.

Design Elements: The following elements should be considered upon the design of a road diet. For additional information, please reference the FHWA 2014 Road Diet Informational Guide.

- Access Management
- Pedestrian Safety (review Pedestrian Master Plan)
- Bicycle Safety (review Bicycle Master Plan)
- Curbside Management (applicable to bus routes/commercial districts)

Provide justification for why a road diet was or was not considered as a design alternative in the Functional Design Report:

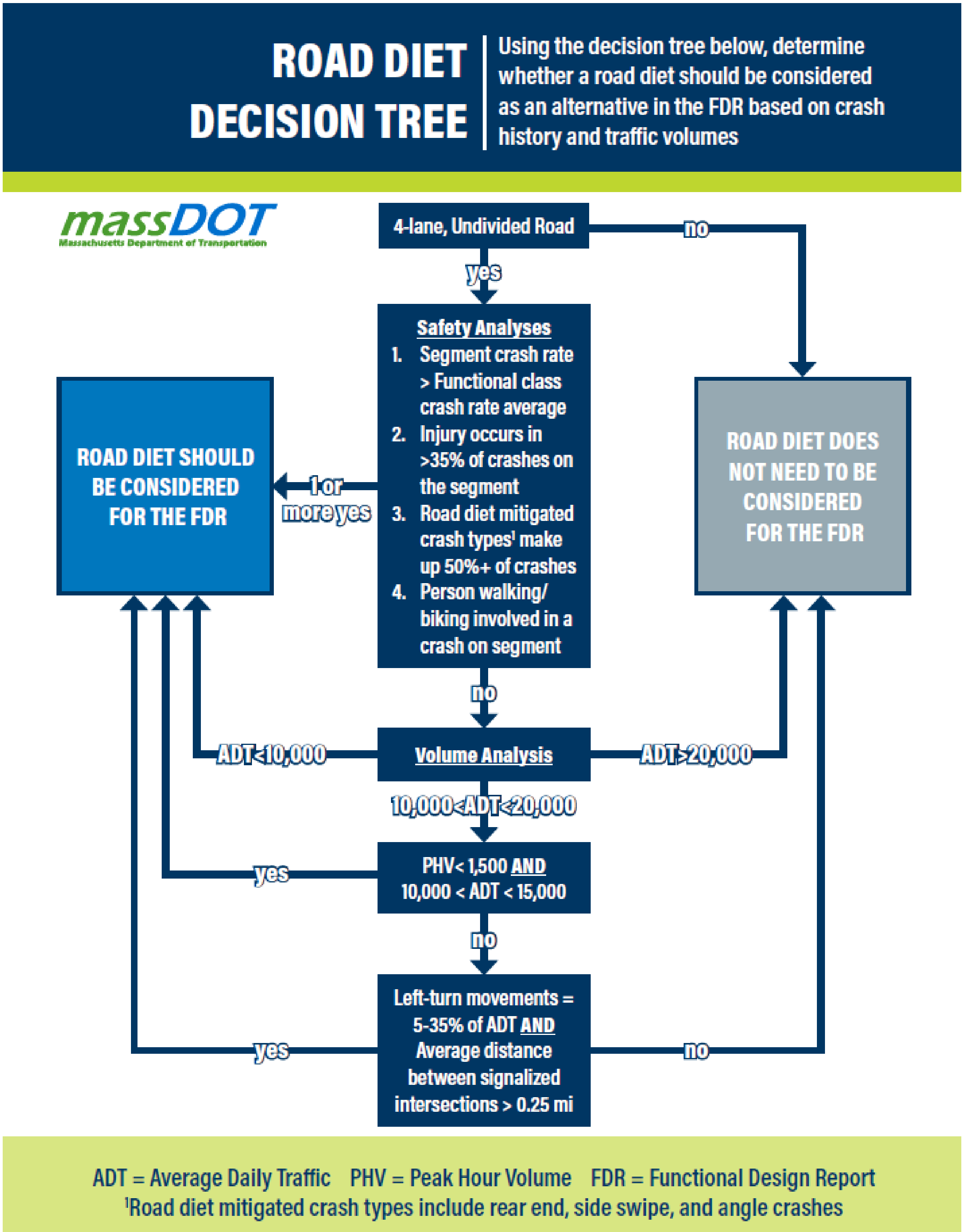
____

____

____

____

Figure 8 Road Diet Internal 25% Review Decision Tree



Task 4 – Municipality Outreach, Training and/or Collaboration

Methodology

The final component of this effort is the provision of training materials to facilitate municipal outreach throughout the state. TDG is preparing training materials as a means to communicate the information ascertained within the previous tasks of this effort. These materials will focus specifically on the benefits of road diets, highlighting the updates in the project delivery process through MassDOT, and the associated design elements to consider.

A series of two presentations, and the agenda for an associated training course, will be provided. The content and level of detail within these materials will be tailored to facilitate an approximately half day training course and will include two presentation slide decks, a training agenda highlighting topics addressed during the course, and supplemental handouts to support the course.

The Executive Summary presentation (approximately 20 minutes), provides an overview of road diets, including the definition of a road diet, the benefits, and the potential trade-offs, and two examples of road diets performed in Massachusetts. This presentation is included as a PDF in the Task 4 Appendix.

The second presentation, accompanying training materials, and course agenda, will provide extensive detail (spanning approximately 90 minutes) that will be intended for incorporation into a half day training seminar, such as through Baystate Roads program. This long-form presentation will include information on how to screen potential candidates and what analyses should be performed before making the conversion. This expanded version also includes guidance on the new tools developed in Task 3 of this project. These course materials will be furnished following this submission, and through continued collaboration with MassDOT.

Conclusion

Road diets are proven to reduce the frequency and severity of crashes and lower vehicular speeds, while providing a safer, more multi-modal corridor for all roadway users. While road diets in Massachusetts have yet to be implemented as common practice, the few that have been completed demonstrate positive results upon pre- and post- construction evaluation. With the tools set forth in this report, the practice of assessing roadways for characteristics befitting of a successful roadway project may be institutionalized through the various pathways to project development within the Commonwealth. This initiative ensures the opportunity for the inclusion of road diets as a design alternative early in the project development process.

Nationally, the primary selection criterion applied for evaluating the viability of a road diet is average daily traffic volume (ADT) along a subject corridor, with all 15 agencies utilizing this metric. These agencies utilize a maximum threshold of ADT ranging from 10,000 to 25,000 vehicles per day (vpd). The second most widely used criterion for road diet consideration is crash occurrence, with 11 of the 15 agencies applying this metric. In applying these criteria within the Commonwealth, crash occurrence and the associated safety enhancements with a road diet corridor redesign is set forth as the primary criterion, with volume metrics considered secondary. This prioritization of safety over capacity is evident within the tools set forth in Task 3 of this report, establishing MassDOT Road Diet Design Criteria for the Commonwealth. If the primary safety analyses do not prompt a road diet being considered, the guidelines then direct Project Proponents and MassDOT reviewers to the secondary volume-based analyses to determine if the subject roadway may be a viable candidate for a road diet. The culmination of this effort is the ability to institutionalize road diets as a consideration for future implementation throughout various stages of project delivery in the Commonwealth of Massachusetts.

Going forward, it is suggested that other means be explored to provide statewide ADT estimations or the data integrity of the MassDOT Road Inventory database file may need to be addressed, before any further systemic screening for road diet candidates advances, with ADT as a criterion. However, an evaluation of road diet candidates utilizing the safety metrics set forth within Task 3 provides a path forward, regardless of ADT, as a foundation for the onset. Lastly, the importance of analyzing a subject corridor, with records of before and after vehicle speeds, crash occurrence, and travel times, should be stressed, regardless of which metric suggests a road diet.

Next steps include training municipal staff, as well as engineering staff within MassDOT, on the tools and guidance provided within the scope of this project, in addition to providing design elements for consideration once the guidance has been brought to bear and a road diet is deemed a viable alternative. An executive summary presentation (included within the Task 4 Appendix) summarizing the findings of this effort may be utilized as a training mechanism in support of road diets throughout Massachusetts. In addition, a detailed presentation (approximately 90 minutes) that may be incorporated into a half day training seminar, such as through Baystate Roads program, will be furnished, following this submission. This long-form presentation will include information on how to screen potential candidates and what analyses should be performed before making the conversion. This expanded version also includes guidance on the new tools developed in Task 3 of this project.

Appendices

Task 1 – Evaluate "Best Practices"

Selection Criteria Matrix
Compilation of DOT "Lessons Learned"
Seattle DOT Flowchart
References
Crash Rate Worksheets
Crash Data
Traffic Counts
Survey Questions and Responses
MassDOT District Responses
RIDOT Data

Task 2 – Select Installation Sites

Crash Data
Traffic Counts
Additional Candidate Information
Select Crash-based Rankings

Task 3 – Establish MassDOT Road Diet Design Criteria

Project Need Form (PNF) – Update
Project Initiation Form (PIF) - Update
Project Development & Design Guide Checklist (PDDG) - Update
Traffic and Safety Engineering 25% Design Submission Guidelines - Update
Functional Design Report (FDR) Road Diet Table
Internal Review Checklist
Internal Review Decision Tree
Medway Road Case Study

Task 4 – Provide Municipality Outreach, Training and/or Collaboration

Executive Summary Road Diet Training Presentation