BOSTON REGION METROPOLITAN PLANNING ORGANIZATION

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TECHNICAL MEMORANDUM

DATE: December 21, 2017

TO: Boston Region Metropolitan Planning Organization

FROM: William S. Kuttner

RE: Weight and Height Restrictions that Impact Truck Travel

1 INTRODUCTION

This memorandum presents information about bridges in the Boston Region Metropolitan Planning Organization (MPO) area that have signs restricting the weight or height of vehicles permitted to pass over or under them. MassDOT personnel monitor these weight and height restrictions, along with a bridge's physical condition, or rating, and summarize them as inspection reports in MassDOT's internal database. However, the physical condition or rating of bridges is not the direct concern of this study.

The concern of this study is that truck restrictions cause trucks that are otherwise fully compliant with Massachusetts and Federal Highway Administration (FHWA) size guidelines to use more circuitous routes than necessary to reach their various commercial destinations. Forced circuitous truck travel increases expenses for freight carriers and customers, increases the total environmental impact for a given level of freight traffic, and increases the negative impacts on local residents and communities.

This study characterizes the severity of height and weight restrictions on trucks in the MPO region. The information developed will be used to evaluate projects considered for inclusion in two MPO planning documents: the Long-Range Transportation Plan (LRTP) and the Transportation Improvement Program (TIP). It is also possible that, at some point, MPO staff might incorporate the severity of these restrictions into its regional travel demand model.

The MPO has defined a set of six goals used for developing both the LRTP and TIP, and two of these goals relate directly to this study: capacity management/mobility and system preservation. For capacity management/mobility, projects may be awarded points if they improve the movement of trucks; which eliminating or reducing the severity of a height or weight restriction clearly achieves. For the system preservation goal, replacing a bridge that is structurally deficient or functionally obsolete also merits points. The presence of a vehicle size restriction is one aspect of a bridge being substandard, and can inform the evaluation and award of points.

This study first discusses weight restrictions and then discusses limited vertical clearances. These sections briefly present the applicable road use regulations and signage guidelines, and then describe the proposed severity metrics. Important roads in the MPO region that physically restrict trucks are listed in descending order of severity. A final section contains maps of these locations.

2 WEIGHT RESTRICTIONS

2.1 Regulations and Signage

Regulations in Massachusetts

States may set their own road use regulations, but these tend to be similar throughout the country. For the most common arrangements of truck axles, the maximum weights of loaded trucks allowed on Massachusetts roads without a special permit are:

- Two-axle single-unit trucks: 23.0 tons (46,000 pounds)
- Three axles, single or with semi-trailer: 36.5 tons (73,000 pounds)
- Four axles, single or with semi-trailer: 43.5 tons (87,000 pounds)
- Five or more axles: 49.5 tons (99,000 pounds)

Trucks weighing more than these limits may be allowed to travel in Massachusetts with an applicable permit, but such oversized vehicles are not a concern of this study. Detailed vehicle size regulations and permit applications are easily obtained on the MassDOT website.[1] The following examples provide a freight transportation context for these maximum weights:

A heavy-duty dump truck will have three axles, with the wheels doubled on the two rear axles. This ten-wheel configuration is used extensively for cargoes such as cement, home heating oil, garbage, beverages, and heavy equipment such as fire engines.

An empty dump truck may have a “curb weight” of 12 tons, which includes the truck, fuel, lubricants, and driver. A full payload of gravel may weigh 24 tons, keeping the loaded truck at less than the 36.5-ton limit. If the cargo is wet sand, the truck can be only partially filled because wet sand is heavier than gravel.

Two-axle trucks with their typical cargoes seldom approach the 23-ton maximum. Every truck has a gross vehicle weight rating (GVWR), which is the maximum fully loaded weight up to which each truck is permitted to operate. Very few two-axle trucks, if any, have GVWRs greater than 23 tons.

[1] MassDOT website http://www.massdot.state.ma.us/highway/DoingBusinessWithUs/PermitsRoadAccessPrograms/CommercialTransport.aspx.

Weight Restriction Signage

If a state or local road authority determines that a bridge should not be used by trucks loaded to the maximum allowable weight, the authority may post a weight limit sign. The design and placement of weight limit signs are described in the *Manual on Uniform Traffic Control Devices* (MUTCD).[2] The most common type of sign is shown in Figure 1 below.

FIGURE 1
Example of a Sign Restricting the Weight of Trucks

Source: GoogleEarth.

The sign depicts silhouettes of three trucks representing the three most common axle configurations: two-axle trucks, three-axle single-unit trucks, and five-axle tractor and semi-trailer combinations. Next to each silhouette is an integer informing truck drivers of the maximum total weight permitted for each axle configuration. The signs are posted at locations where trucks can choose a different route or reverse direction.

Truck operators are expected to know the total weight of their vehicle and payload. The GVWR and curb weight are affixed to the truck and the payload can be calculated when the vehicle is loaded or unloaded. Compliant trucks begin each leg of travel weighing within the limits of both the truck's GVWR and the state maximum allowed weight for the truck's configuration. If a driver encounters a bridge with a weight restriction, it should be clear whether the driver needs to find an alternate route. Upon making a delivery, the truck's total weight is re-calculated and the weight-restricted bridge may be usable by the lightened truck.

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[2] Federal Highway Administration, *Manual on Uniform Traffic Control Devices*, 2012, Section 2B.59.

2.2 The Severity of Weight Restrictions in the MPO Region

Characterizing the Severity of Weight Restrictions

The Boston Region MPO's current LRTP summarizes the region's transportation needs and devotes a section to system preservation.[3] The LRTP reports that there are a total of 2,866 bridges in the Boston MPO region, including the individual spans that comprise larger bridges or viaducts. Of these, 154 are considered structurally deficient. A bridge may be rated as structurally deficient for any of a number of reasons, and only 37 structurally deficient bridges have posted weight restrictions.

About 100 bridges in the region have posted weight restrictions. Most of these bridges are not structurally deficient but have a posted weight restriction because they were built to different design standards. This study focuses on 57 of these bridges on roads—not including parkways which prohibit trucks—that are represented in the MPO's travel demand model. These roads generally have a functional class of at least "collector." About one-third of these bridges are located on numbered routes, and these 18 locations are shown in Table 1.

For the purposes of this study, an estimate of the overall severity of a weight restriction has been calculated for each bridge. The typical weight limit sign has different weights depending on the number of axles. The relationship of these three weights depends upon the design of a bridge and the placement of its support structures. Because truck traffic contains a blend of truck sizes and axle configurations, it is helpful if the impact of a weight restriction can be expressed with a single number for comparison with other bridges.

The estimate of the overall severity of a weight restriction used here is referred to in this study as a "safe off-load per axle" and it appears in Tables 1 and 2 for each weight-restricted bridge. The safe off-load per axle is an estimate of how many tons per axle below the state maximum a truck would need to weigh in order to be permitted to cross the weight-restricted bridge; and the bridges in Table 1 are listed in descending order of this measure.

The most severely restricted bridge—Route 62 (Main Street) in Concord where it crosses the Sudbury River—can serve as an example. The safe off-load per axle for this bridge has been calculated as 8.5 tons per axle. A three-axle truck in Massachusetts can weigh 36.5 tons at most, but the bridge allows three-axle trucks to weigh only 11 tons. The difference between these two weights is 25.5

[3] Boston Region MPO, *Charting Progress to 2040: A Long-Range Transportation Plan for the Boston Region*, 2015, http://bostonmpo.org/lrtp.

TABLE 1
Posted Weight Restrictions on Numbered Routes

Town Name	Route	Street Name	Feature Crossed	Weight Limit Posting 2-Axle	3-Axle	5-Axle	Safe Off-Load per Axle
Concord	62	Main Street	Sudbury River	7	11	17	8.5
Bedford	4	Great Road	Shawsheen River	13	17	25	6.5
Revere	145	Revere Beach Pkwy.	Blue Line	14	17	24	6.5
Bedford	225	Bedford Road	Concord River	17	20	36	5.5
Topsfield	97	High Street	Ipswich River	15	21	32	5.2
Middleton	62	Maple street	Ipswich River	14	23	36	4.5
Marshfield	3A	Main Street	South River	17	23	36	4.5
Littleton	119	Great Road	Beaver Brook	17	23	36	4.5
Cambridge	2A	Massachusetts Ave.	Memorial Drive	18	23	36	4.5
Wilmington	129	Lowell Street	Interstate 93	18	23	38	4.5
Concord	2	Union Turnpike	Nashoba Brook	20	23	40	4.5
Hingham	3A	Lincoln Street	Back River	20	25	32	3.8
Waltham	US 20	Main Street	Fitchburg Line	20	25	36	3.8
Arlington	2		Lake Street	20	25	38	3.8
Hudson	85	Washington Street	Assabet River	20	25	40	3.8
Gloucester	128		Annisquam River	20	25	40	3.8
Gloucester	128		Concord Street	20	25	40	3.8
Framingham	126	School Street	Cochituate Brook	19	30	47	2.2

tons, which is 8.5 tons per axle, the amount shown in Table 1. For two-axle trucks the value would be 8 tons to get from 23 down to 7 tons, and for five-axle trucks it would be 6.5 tons to get from 49.5 down to 17 tons. Table 1 presents only the highest value of the three off-load calculations.

For all the weight-restricted bridges, the three-axle trucks require the greatest number of tons of off-load per axle, or in a few instances nearly the greatest. This circumstance results largely from the overall state weight limits described above. The maximum allowed weight of a three-axle truck is 36.5 tons, more than 12 tons per axle, and greater than the maximum weights per-axle of the other axle configurations. Starting at this higher allowed per-axle weight, crossing a weight-restricted bridge almost always requires a greater per-axle weight reduction for a three-axle truck than for other configurations.

General Observations about Freight and Weight Restrictions

It is understandable that three-axle trucks would be the most affected by weight-restricted bridges. These types of trucks are placed into service specifically to safely transport heavy loads, and efficient utilization often requires loading them to nearly the legal limit. Two-axle trucks and five-axle semi-trailer combinations often carry less-dense products and the trucks are not always full.

Route 62 in Concord can again serve as an example. A large three-axle dump truck would not be able to cross the Sudbury River even if it were empty. In contrast, the 7-ton limit for two-axle trucks would allow many UPS, FedEx, and small six-wheeled trucks to cross. Heavier two-axle trucks would still need to find alternative routes, depending on their load.

Three-axle and two-axle trucks often serve very different freight markets with significantly different travel patterns. For instance, heavy dump trucks, cement trucks, and trucks delivering diesel fuel often travel to and from construction sites, sometimes on specific routes defined in advance during the environmental permitting process. A preferred route for these vehicles may be unavailable because of a weight restriction, forcing use of more circuitous routes. When a construction project no longer requires heavy vehicle deliveries, any nearby weight restrictions may not be a problem for ongoing commercial activity.

Two-axle trucks often serve steady customers on regular pickup or delivery schedules. If a weight restriction prevents use of an otherwise efficient route, trucks may use a less desirable circuitous route; or if the truck operator has a fleet with different sized vehicles, a smaller vehicle may be assigned to serve customers near the weight-restricted bridge. In this freight market characterized by regular deliveries, the 10-wheeled beverage delivery truck is most affected by weight restrictions.

Planning Implications of Weight Restrictions

The motor freight industry is very adaptable. Comparatively efficient alternate routes are identified and utilized wherever all or some trucks are restricted from preferred routes. Some otherwise efficient routes are truck-restricted as a consequence of state or local policies. This is not the case with weight restrictions: If the bridge were to be rebuilt, it would accommodate all trucks that comply with the statewide weight standards.

Of the bridges cited in Table 1, the weight limits for Route 62 in Concord are outliers. The average safe off-load per axle for the bridges in Table 1 is 4.7 tons per axle. These bridges can accommodate most trucks that serve regional commerce; the greatest inconvenience would be to three-axle trucks that support construction activities.

There are an additional 39 weight-restricted bridges that are not on numbered routes, divided about evenly between arterials and collectors; these are listed in Table 2 in descending order of safe off-load per axle. The grouping of weight-restricted bridges into numbered and non-numbered routes is arbitrary. However, the weight restrictions on the bridges in Table 2 tend to be more severe, with an average safe off-load per axle of 6.1 tons. Seven of these bridges have weight restrictions that are more severe than that of Route 62 in Concord, the most severe restriction shown in Table 1.

Some of the locations in Table 2 are on important freight corridors. The first location with a 3.8-ton safe off-load per axle is Neponset Valley Parkway in Boston's Readville neighborhood. Until several years ago this was the principal access route for trucks serving the regional distribution center of the Stop and Shop supermarket chain.

The five-axle semi-trailer combination is the most important truck type serving large supermarket chains, and these trucks were loaded within Neponset Valley Parkway's 40-ton limit, while Stop and Shop operated in Readville. Stop and Shop has since moved to a larger distribution facility in Freetown, near Fall River. It is not known whether Stop and Shop has changed its truck-loading practices now that it can load trucks to the maximum 49.5 tons.

To understand fully the impact of weight restrictions, it would be necessary to have credible estimates of both the numbers of trucks that currently use these bridges as well as the numbers of trucks that would choose to use them if there were no weight restriction. These data can be developed for an individual bridge if it is possible to invest the time and resources required for detailed fieldwork and network analysis.

An alternative method would be to use a calibrated truck travel demand model, if available. General comparisons of use and impacts of weight-restricted bridges could then be estimated. These first-pass comparisons could then inform any subsequent fieldwork and network analysis. The truck modelling capabilities of the MPO's travel demand model set have advanced to the point where region-wide analysis of truck restriction impacts may be possible in the near future.

About 12 of the weight-restriction signs discussed here have been added or updated since 2007. However, bridges with weight restrictions are not necessarily deteriorating or under-maintained. Bridges were built to the standards of their time, and if they are rebuilt it will be to today's standards. If the existing bridge is properly maintained, the weight restriction could be in force for the indefinite future.

TABLE 2
Other Locations with Posted Weight Restrictions

Town Name	Street Name	Feature Crossed	Weight Limit Posting			Safe Off-Load per Axle
			2-Axle	3-Axle	5-Axle	
Wilmington	Butters Row	Lowell Line	5	5	5	10.5
Natick	Boden Lane	Worcester Line	6	6	6	10.2
Weston	Merriam Street	Fitchburg Line	6	6	6	10.2
Framingham	Beaver Street	Beaver Dam Brook	5	8	12	9.5
Maynard	Walnut Street	Assabet River	7	8	12	9.5
Framingham	Winter Street	Sudbury River	5	9	14	9.2
Boston	Granite Avenue	Neponset River	6	11	17	8.5
Ipswich	Waldingfield Road	Newburyport Line	6	12	18	8.5
Beverly	Bridge Street	Bass River	8	12	19	8.2
Natick	Marion Street	Worcester Line	10	14	20	7.5
Framingham	Winter Street	Worcester Line	12	14	18	7.5
Marblehead	Village Street	Abandoned rail line	12	14	21	7.5
Framingham	Central Street	Sudbury River	14	15	18	7.2
Framingham	Main Street	Sudbury River	15	15	15	7.2
Hopkinton	Fruit Street	Worcester Line	9	16	26	7.0
Beverly	Kernwood Avenue	Danvers River	11	16	22	6.8
Hudson	Cox Street	Assabet River	16	17	17	6.5
Somerville	Webster Avenue	Fitchburg Line	11	21	33	6.0
Hudson	Forest Avenue	Assabet River	20	20	20	5.9
Concord	Commonwealth Ave	Fort Pond Brook	13	19	27	5.8
Stow	Sudbury Road	Assabet River	14	20	32	5.5
Peabody	Endicott Street	inactive rail line	16	21	32	5.2
Lexington	Hartwell Avenue	Kiln Brook	17	21	36	5.2
Boston	West Second Street	S. Boston Bypass Rd	16	22	35	4.8
Walpole	School Street	Memorial Pond Outlet	16	23	36	4.5
Waltham	Newton Street	Fitchburg Line	17	23	34	4.5
Peabody	Warren Street	Inactive rail line	17	23	36	4.5
Needham	Central Avenue	Charles River	15	25	40	4.0
Boston	Neponset Valley Pkwy	Neponset River	17	25	40	3.8
Milford	Fisk Mill Road	Mill River	18	25	40	3.8
Boston	Forest Hills Drive	Cemetery Road	20	25	32	3.8
Wayland	Oak Street	Interstate 90	20	25	33	3.8
Waltham	Farwell Street	Charles River	20	25	36	3.8
Weymouth	Front Street	Route 3	20	25	36	3.8
Framingham	Mount Wayte Ave	CSX rail line	20	25	36	3.8
Cohasset	Atlantic Avenue	Little Harbor Inlet	20	25	40	3.8
Walpole	Coney Street	Interstate 95	20	25	40	3.8
Boston	Meridian Street	Chelsea River	20	25	40	3.8
Medford	Winthrop Street	Mystic River	20	25	40	3.8

3 LIMITED VERTICAL CLEARANCES

3.1 Regulations and Signage

Regulations in Massachusetts

In order to use Massachusetts roads without a special permit, the tallest a vehicle may be is 13 feet 6 inches. Vehicles exceeding this height may be allowed to travel in Massachusetts with an applicable permit obtained at the same MassDOT website cited above for overweight permits.

The common box-type semi-trailer, referred to in the industry as a “dry van,” is typically 53 feet long, 8 feet 6 inches wide, and 13 feet 6 inches high. Figure 2 shows a modern dry van that is equipped with aerodynamic “skirts” to both improve fuel efficiency and offer some level of protection for bicycle riders in urban environments.

FIGURE 2
Modern 53-foot Dry Van

Safe vertical clearances must exceed the maximum vehicle height to allow for vehicle bouncing, unknown protuberances, or geometric effects of any change in grade at or near the bridge, referred to in roadway design as “vertical curves.” The design guidelines for new bridges recommend that bridge structures provide at least 16 feet of vertical clearance over the entire width of the roadway.

Additional clearance is also recommended for new bridges in anticipation of future resurfacing.[4]

Vertical Clearance Signage

Requirements and recommendations for the design and placement of vertical clearance signs are described in the MUTCD[5]. The basic requirement of the MUTCD is that a sign of the style shown in Figure 3 be posted at any bridge with a clearance less than 12 inches above the state maximum vehicle height.

FIGURE 3
Type of Sign Posted on or in Advance of a Vertical Clearance Restriction

Ideally, a vertical clearance sign should indicate the actual clearance rounded down to the nearest inch. The MUTCD, however, makes some allowance for posting signs that indicate less clearance than is actually available. In certain climates, temperature change and frost action can appreciably affect the roadway surface, and the available clearance indicated may be reduced by as much as to three inches to reflect this. Additional inches can be subtracted from the clearance sign if a fresh coat of asphalt will be applied at some future point.

The application of vertical clearance signage with respect to these guidelines and tolerances is illustrated in Figure 4. The Southeast Expressway, Interstate 93, was built in the 1950s to earlier design standards, and several of the original bridges are still in use. If the vertical clearance under Dorchester Avenue were 13 feet 6.9 inches, the sign would be technically correct and any prudent driver

[4] American Association of State Highway and Transportation Officials, *A Policy of Geometric Design of Highways and Streets,* 2011.
[5] Federal Highway Administration, *Manual on Uniform Traffic Control Devices*, 2012, Section 2C.27.

would seek an alternate route rather than risk damaging a standard 13-foot 6-inch dry van with as little as a 0.9-inch bounce.

FIGURE 4
Interstate 93 under Dorchester Avenue

Source: GoogleEarth.

The actual clearance is probably between 13 feet 9 inches and 14 feet. If a second coat of asphalt has been applied, the clearance might be 13 feet 9 inches. If old asphalt has been removed and a new single layer has been applied, the clearance may be 14 feet. The many standard 13-foot 6-inch dry vans using the Southeast Expressway are able to pass beneath this underpass without incident if they are traveling the speed limit and have no protuberances. For the purposes of this study truck travel is only considered to be impacted if the vertical clearance sign indicates less than 13 feet 6 inches of clearance.

Vertical clearance signs may be placed on or near bridges, and at nearby intersections to allow vehicles to choose an alternate route. The type of sign shown in Figure 5 may be posted on the bridge structure and is especially appropriate if the bridge is a long arch and the clearance needs to be indicated for individual lanes.

FIGURE 5
Type of Sign that May be Posted on the Bridge Structure

3.2 Impact on Truck Traffic

Crashes by Large Vehicles at Low-Clearance Bridges

The MassDOT crash database contains 222 reports of trucks and buses with six or more wheels that hit a low-clearance bridge during the 13 years from 2002 to 2014. The completeness of crash reporting to MassDOT varies between law enforcement agencies and jurisdictions. Also, crash reports prepared at the crash sites often focus on the data needs of law enforcement and insurers, so some information useful to planners may be sketchy. However, taken altogether these crash reports can reveal the potential benefit of reconstructing bridges to accommodate all vehicles.

Almost all truck and bus drivers are fully cognizant of their vehicle size and find appropriate routes to their destinations. Only rarely does the operator of a large vehicle lose situational awareness and drive the vehicle on an impassable road. If the driver realizes the mistake in time, the driver could avoid a crash. If not, the truck would hit the low-clearance bridge and become one of the statistics summarized in Table 3.

The bridges in Table 3 are listed in descending order of the number of reported crashes. Only 197 crashes are listed in Table 3 because the 25 crashes that occurred on the Storrow Drive, Soldiers Field Road, and Memorial Drive parkway systems are not shown, and are not part of this study. These roads were designed as a truck-free subsystem of the regional road system and upgrading these roads to accommodate trucks is not being considered.

The first crash location listed in Table 3 is where the Franklin commuter rail line crosses over East Street in Westwood just south of Interchange 15 in Dedham, where US Route I meets I-95. The fact that 33 drivers of large vehicles either lost situational awareness, or possibly decided to “chance it,” suggests that there are a number of truck destinations reached via this route, which the inattentive drivers are trying to serve. If this overpass were to allow use by full-sized dry vans, a substantial number of trucks now precluded from this route might find it attractive. At this time, however, it is only possible to speculate about the number and routes of large vehicles that serve nearby travel markets with today’s clearance restrictions.

Vulnerable Bridges under Highways

All of the crash locations listed in Table 3 are roadways that pass under railroad alignments except for Route 1A/Dodge Street, which experienced one crash where it crosses under Route 128 in Beverly. The features of this bridge (shown in Figure 5) help illustrate several relevant clearance issues.

TABLE 3
Reported Crashes into Low-Clearance Bridges by Large Vehicles 2002-2014

Town		Street	Crossing	Number of	Signed Clearance	
Name	**Route**	**Name**	**Feature**	**Crashes**	**Feet**	**Inches**
Westwood		East Street	Franklin Line	33	10	6
Norwood		Morse Street	Inactive rail line	22	9	11
Weston		Park Road	Worcester Line	20	11	3
Concord	62	Main Street	Fitchburg Line	18	12	0
Southborough	85	River Street	Worcester Line	16	11	0
Canton		Bolivar Street	Stoughton Line	13	12	0
Malden		Medford Street	Haverhill Line/Orange Line	10	12	6
Walpole		West Street	Foxborough Branch	8	12	0
Lynn		Bennett Street	Inactive rail line	6	13	0
Holliston		Exchange Street	Holliston Rail Trail	5	8	0
Lynn		Silsbee Street	Rockport/Newburyport Line	5	11	0
Lexington		Grant Street	Minuteman Bikeway	4	11	3
Norwood		Lenox Street	inactive rail line	4	11	1
Norwood		Guild Street	Franklin Line	4	11	7
Arlington		Grove Street	Minuteman Bikeway	3	11	5
Arlington		Brattle Street	Minuteman Bikeway	3	11	6
Belmont		Concord Avenue	Fitchburg Line	3	10	3
Boston		Freeport Street	Old Colony Line/Red Line	3	12	0
Framingham		Grove Street	inactive freight line	3	11	8
Winchester		Cross Street	Lowell Line	3	10	4
Beverly		Pleasant Street	Rockport/Newburyport Line	2	12	0
Southborough		Willow Street	Active freight line	2	11	0
Beverly	1A	Dodge Street	Route 128	1	12	6
Lynn		Eastern Avenue	Rockport/Newburyport Line	1	13	0
Malden		Charles Street	Haverhill Line/Orange Line	1	13	3
Needham		Warren Street	Needham Line	1	11	0
Newton		Elliot Street	Riverside Green Line	1	13	1
Sharon		Canton Street	Providence Line	1	11	6
Walpole		Plimpton Street	Franklin Line	1	12	0

The bridge design shown in Figure 6 was widely used in the years following World War II, when express highway construction in the United States accelerated. The arch is constructed of reinforced concrete and is clad in decorative stone. Because of the age of these structures, any reconstruction might require preservation of decorative features.

The 13-foot 6-inch dry van was in widespread use at that time, and this bridge design accommodates vehicles of this size provided that they pass under the center of the arch. The clearance sign alerts drivers of trucks and buses that if they are in the right lane then their vehicle should be less than 12-feet 6-inches high. As mentioned above, posting clearance signs like the one shown in Figure 4 over each lane can reduce ambiguity about the available clearance.

Arched bridges fell out of favor as larger, rolled-steel girders became available. Also, where the goal at the time was to simply allow standard dry vans to reach their destinations, modern design guidelines recommend that at least 16 feet of clearance be available over the entire roadway, thereby increasing safety and facilitating movements by specially permitted oversized vehicles. At some point in this bridge's lifecycle, a major reconstruction would need to be considered and the various design, safety and preservation issues will need to be resolved. For the purposes of this study, however, bridges like this are not considered a barrier to truck movements.

FIGURE 6
Route 1A/Dodge Street under Route 128

Source: GoogleEarth.

Vulnerable Bridges under Railroad Alignments

Table 3 lists 28 crash locations on roads that pass under railroad alignments. Commuter trains use 19 of these overpasses, beneath which 144 of the crashes took place. The Minuteman Bikeway uses a former rail alignment, and four of its underpasses were hit a total of 15 times. There is one freight-only overpass that was hit twice, and there are four locations on inactive rail lines that were hit a total of 35 times.

As the road network expanded and evolved, it generally has adapted to the needs of large vehicles; but this process has proved far more difficult at those locations where roads and railroads meet. The bridge in Southborough that carries the Worcester Commuter Rail Line and crosses over Route 85 (Figure 7) illustrates the difficulties of resolving clearance issues at railroad overpasses. The overpass shown in Figure 7 has been hit 16 times, and is the fifth most frequent crash location cited in Table 3. Just to the left of the image in Figure 7 is a commuter rail station, built around 2000. Despite the new station and a number of ongoing improvements to the rail line itself, the vertical clearance of this overpass remains inadequate for many types of large vehicles.

In cases like this, the railroad alignment may be considered fixed. Changes to railroad alignments are implemented almost exclusively in order to improve the alignment—for example, to straighten curves or reduce grades. Raising the Worcester Line at this point would require introducing a rise in the tracks at a

FIGURE 7
Route 85/River Street under the Worcester Commuter Rail Line

Source: GoogleEarth.

point where the tracks are essentially flat; and changes to such an alignment are almost never even considered, much less implemented.

If the railroad alignment is considered fixed, then lowering the road is the only available option for increasing the vertical clearance. Lowering roads can face a number of problems, some of which may lack practical solutions. These include:

- An existing drainage system
- Introduction of vertical curves that increase clearance requirements
- Building entrances of abutters on the lowered road
- Nearby intersections

In the situation in Figure 7, the road is already rising as it approaches a signalized intersection on the far side of the underpass. If the road were lowered, the approach to the intersection would be even steeper, thus reducing overall safety of the intersection. Relocation options for under-street drainage systems also may be constrained. If lowering the roadway had been practical when several capital improvements were being undertaken in this area, then clearance might have been meaningfully increased.

Other Locations with Limited Vertical Clearance

Fortunately, there are a number of bridges with limited vertical clearance that have no record of being hit by a large vehicle since 2002. Despite the lack of crashes, these bridges may be forcing attentive large-vehicle drivers to take circuitous routes. Also, there is always the chance that their luck may run out at some point. These bridges are listed in town order in Tables 4 and 5; Table 4 cites roads that pass under another road, and Table 5 lists roads that pass beneath a rail alignment.

The clearance of the first bridge in Table 4, Kernwood Avenue, is actually limited by its own trestle structure, which allows vehicles only as high as 11 feet 9 inches. The five Route 9 bridges in Newton and Wellesley all share the classic postwar arch design similar to the bridge in Figure 5. The Route 128 bridge in Danvers also has a similar arch design but without the stone cladding.

Unlike the classic arch structures that most careful truck drivers can sneak under, most of the rail bridges in Table 5 represent absolute barriers to the modern, full-sized dry van. Casual inspection of the environs of these bridges suggests that they are not on heavily used corridors or in the midst of truck-intensive travel markets. Adams Street in Malden represents an interesting case, however, in that bridges on busier parallel streets beneath the Haverhill Line were hit multiple times, as shown in Table 3.

TABLE 4
Roads under Low-Clearance Road Structures

Town Name	Street Name	Crossing Feature
Beverly	Kernwood Avenue	Bridge structure
Boston	Hallet Street	Southeast Expressway
Danvers	Route 35/High Street	Route 128
Newton	Chestnut Street	Route 9
Newton	Quinobequin Road	Route 9
Newton	Hammond Pond Parkway	Route 9
Salem	Parallel Street	Jefferson Avenue
Somerville	Dana Street	pedestrian overpass
Topsfield	Howlett Street	US 1
Wellesley	Cliff Road	Route 9
Wellesley	Weston Road	Route 9

TABLE 5
Roads under Low-Clearance Rail Alignments

Town Name	Street Name	Crossing Feature
Arlington	Forest Street	Minuteman Bikeway
Arlington	Pond Lane	Minuteman Bikeway
Beverly	Federal Street	Rockport/Newburyport Line
Boston	Hyde Park Avenue	Fairmount Line
Boston	Temple Street	Needham Line
Boston	LaGrange Street	Needham Line
Boston	Dorchester Avenue	Red Line
Boston	Conley Street	Red Line
Franklin	Acorn Place	Franklin Line
Holliston	Arch Street	Holliston Rail Trail
Malden	Adams Street	Haverhill Line/Orange Line
Medfield	Frairy Street	Active freight line
Melrose	Melrose Street	Haverhill Line
Needham	Webster Street	Needham Line
Newton	Glen Avenue	Riverside Green Line
Swampscott	Burrill Street	Rockport/Newburyport Line
Walpole	West Street	Franklin Line (mile 19.51)
Walpole	West Street	Franklin Line (mile 19.89)

4 MAPPING WEIGHT AND HEIGHT RESTRICTIONS

For the purposes of analysis, this study organized roadways with weight and height restrictions into five tables based on the type of restriction, type of road, or crash experience. This section organizes by geography all of the bridges and overpasses that are mentioned in this study, and shows their locations on nine maps that cover most of the MPO region.

Figure 8 shows the geographic extent of each of the nine maps. The boundaries that divide the 101 MPO municipalities into eight subregions are also shown in Figure 8. The subregions of weight- and height-restricted bridges are important for MPO planning because to a large extent the needs assessment of the planning process begins at the subregion level.

Each of the nine maps has its own index, with numbered locations starting at one for each map, and numbers generally arranged from west to east. If a municipality has more than one size-restricted roadway, these are numbered sequentially, and all will appear on the same map.

The location index identifies the size-restricted road by both name and route number, if applicable. In each instance, the feature being crossed is listed as well as whether the vehicle weight or height is restricted. The location icons for weight restrictions are blue discs and for height restrictions, they are red discs. If a disc is not labeled with a number, it is identified on one of the adjacent maps.

The roads shown on these maps are included in the MPO's travel demand model. Any road with a functional class of collector or higher is included, as well as local streets used by modeled bus services.

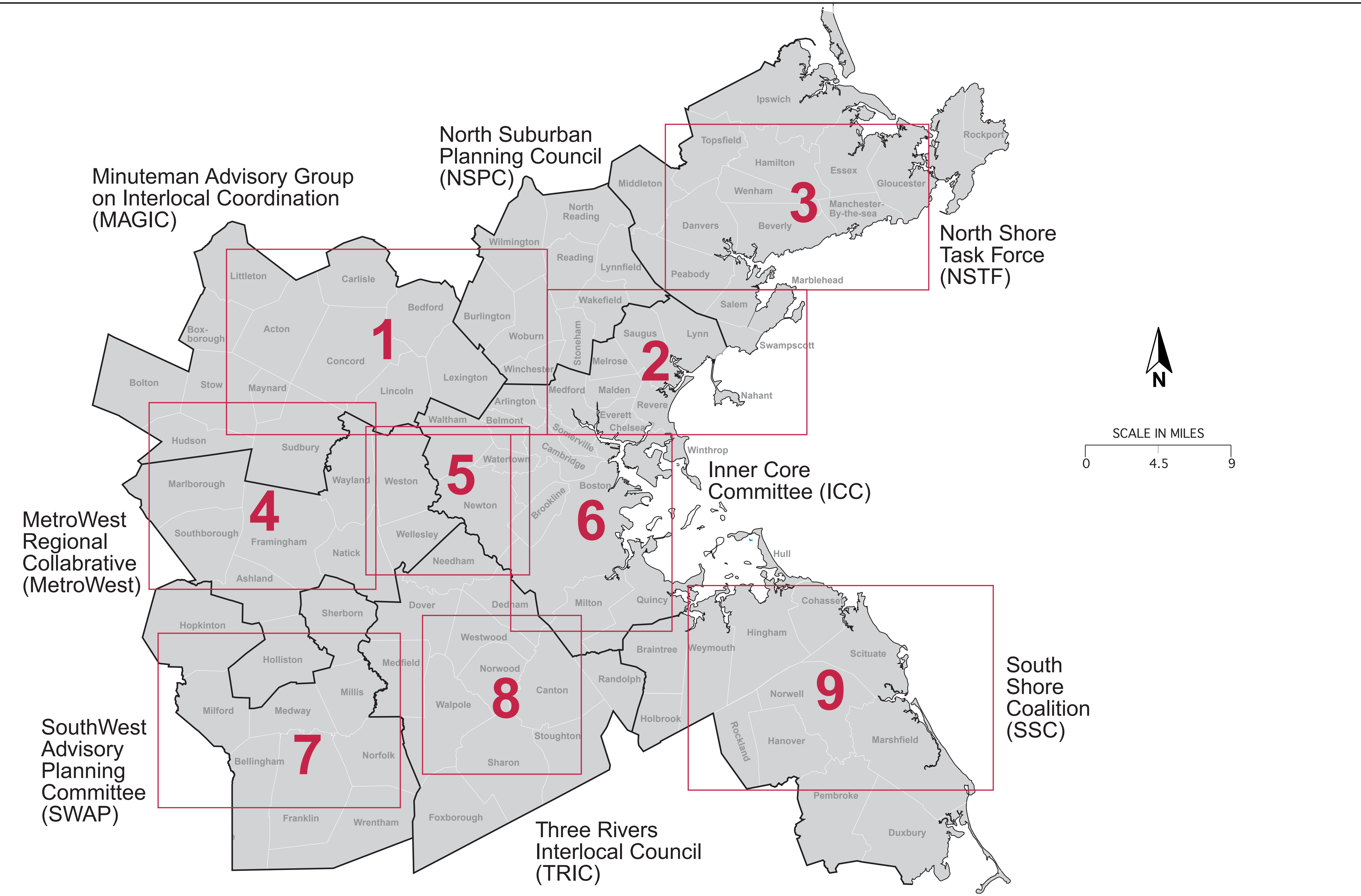
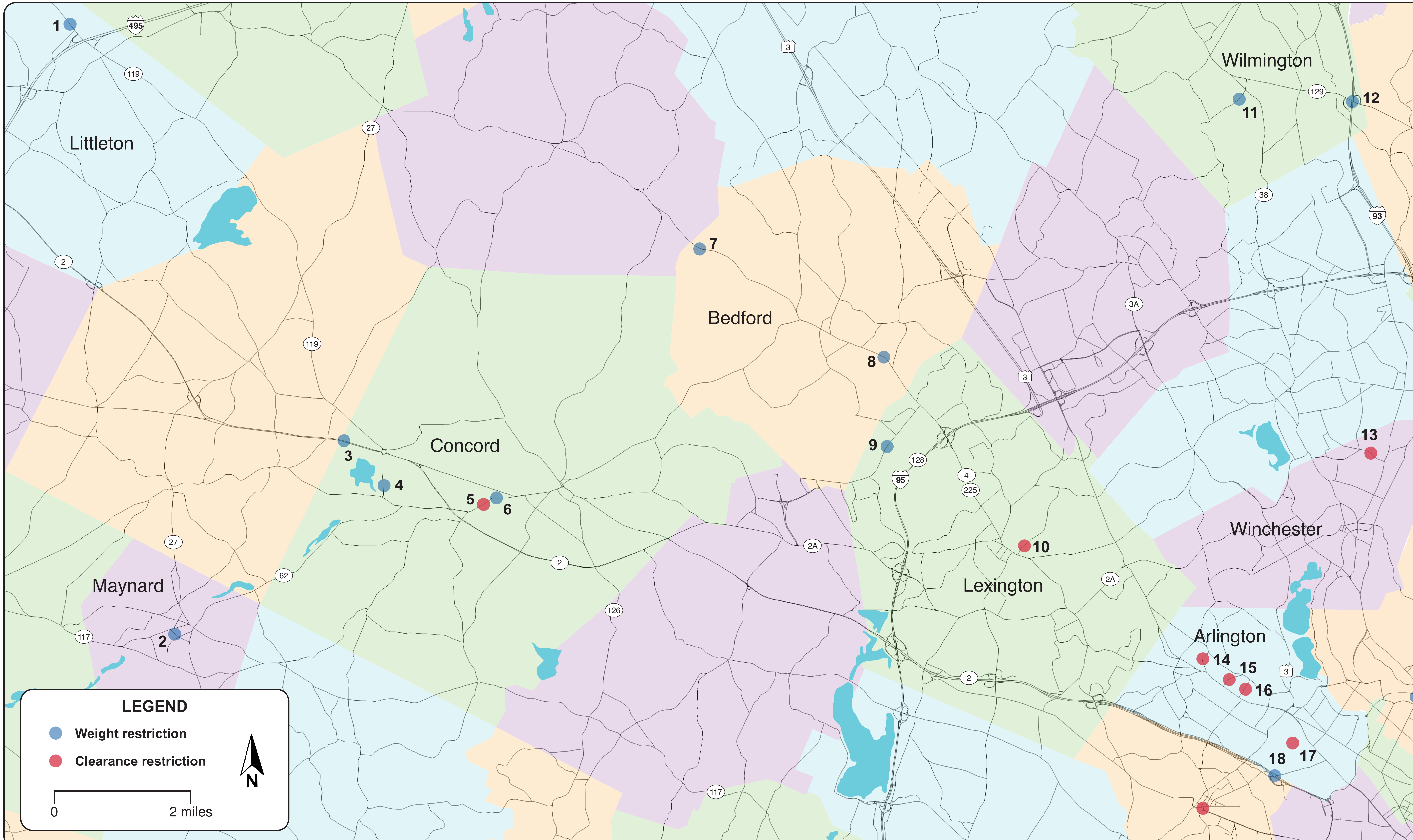


Figure 8
Map Extents Superimposed
on MPO Subregions

Map 1 Location Index

Municipality	Map Label	Size-restricted Roadways Route	Street Name	Type of Restriction	Feature Crossed
Littleton	1	119	Great Road	Weight	Beaver Brook
Maynard	2		Walnut Street	Weight	Assabet River
Concord	3	2	Union Turnpike	Weight	Nashoba Brook
Concord	4		Commonwealth Avenue	Weight	Fort Pond Brook
Concord	5	62	Main Street	Clearance	Fitchburg Line
Concord	6	62	Main Street	Weight	Sudbury River
Bedford	7	225	Bedford Road	Weight	Concord River
Bedford	8	4	Great Road	Weight	Shawsheen River
Lexington	9		Hartwell Avenue	Weight	Kiln Brook
Lexington	10		Grant Street	Clearance	Minuteman Bikeway
Wilmington	11		Butters Row	Weight	Lowell Line
Wilmington	12	129	Lowell Street	Weight	Interstate 93
Winchester	13		Cross Street	Clearance	Lowell Line
Arlington	14		Forest Street	Clearance	Minuteman Bikeway
Arlington	15		Brattle Street	Clearance	Minuteman Bikeway
Arlington	16		Grove Street	Clearance	Minuteman Bikeway
Arlington	17		Pond Lane	Clearance	Minuteman Bikeway
Arlington	18	2		Weight	Lake Street

Dots on the map without numbers are identified on an adjacent map.


Wilmington
Littleton
Bedford
Concord
Lexington
Winchester
Maynard
Arlington
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
LEGEND
Weight restriction
Clearance restriction
N
0
2 miles

Map 1

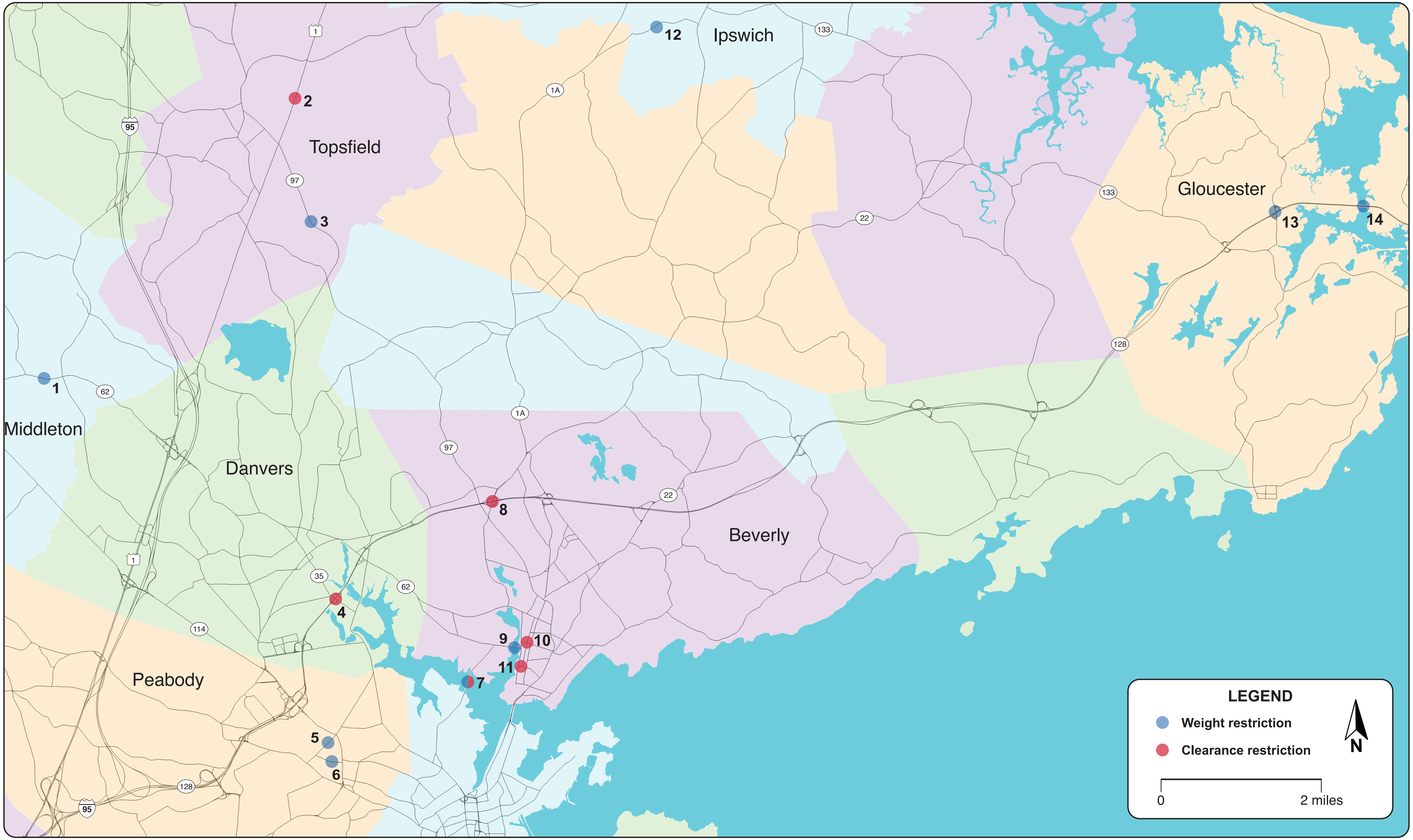
Map 2 Location Index

Municipality	Map Label	Size-restricted Roadways Route	Street Name	Type of Restriction	Feature Crossed
Medford	1		Winthrop Street	Weight	Mystic River
Melrose	2		Melrose Street	Clearance	Haverhill Line
Malden	3		Charles Street	Clearance	Haverhill Line/Orange Line
Malden	4		Adams Street	Clearance	Haverhill Line/Orange Line
Malden	5		Medford Street	Clearance	Haverhill Line/Orange Line
Revere	6	145	Revere Beach Parkway	Weight	Blue Line
Lynn	7		Bennett Street	Clearance	inactive freight line
Lynn	8		Silsbee Street	Clearance	Rockport/Newburyport Line
Lynn	9		Eastern Avenue	Clearance	Rockport/Newburyport Line
Swampscott	10		Burrill Street	Clearance	Rockport/Newburyport Line
Salem	11		Parallel Street	Clearance	Jefferson Avenue
Marblehead	12		Village Street	Weight	abandoned rail line


Marblehead
Salem
Lynn
Swampscott
Melrose
Medford
Malden
Revere
1
2
3
4
5
6
7
8
9
10
11
12
95
93
28
129
1
99
107
1A
60
16
LEGEND
Weight restriction
Clearance restriction
N
0
2 miles

Map 3 Location Index

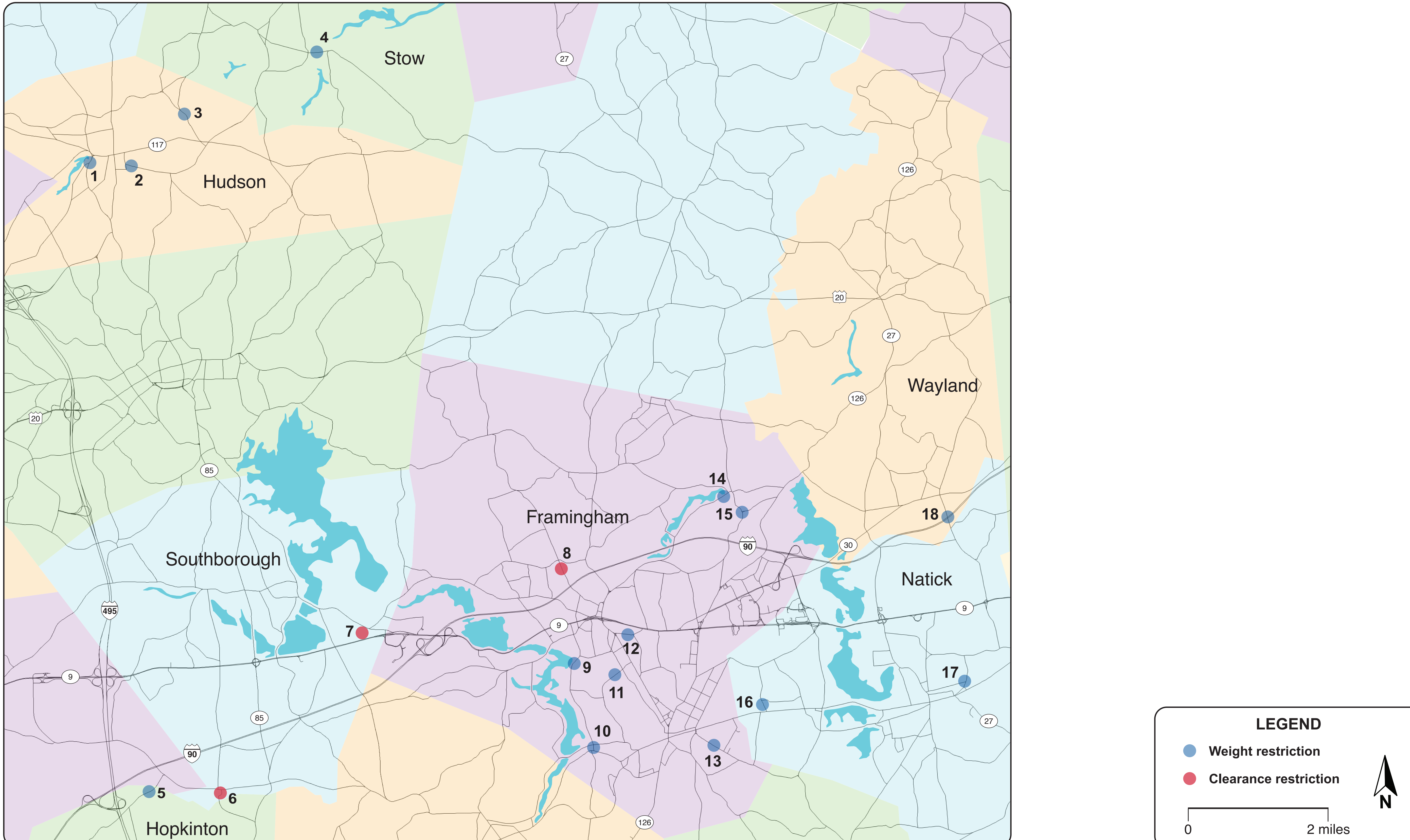
Municipality	Map Label	Size-restricted Roadways Route	Street Name	Type of Restriction	Feature Crossed
Middleton	1	62	Maple street	Weight	Ipswich River
Topsfield	2		Howlett Street	Clearance	US 1
Topsfield	3	97	High Street	Weight	Ipswich River
Danvers	4	35	High Street	Clearance	Route 128
Peabody	5		Endicott Street	Weight	inactive rail line
Peabody	6		Warren Street	Weight	inactive rail line
Beverly	7		Kernwood Avenue	Clearance	bridge truss structure
Beverly	7		Kernwood Avenue	Weight	Danvers River
Beverly	8	1A	Dodge Street	Clearance	Route 128
Beverly	9		Bridge Street	Weight	Bass River
Beverly	10		Federal Street	Clearance	Rockport/Newburyport Line
Beverly	11		Pleasant Street	Clearance	Rockport/Newburyport Line
Ipswich	12		Waldingfield Road	Weight	Newburyport Line
Gloucester	13	128		Weight	Concord Street
Gloucester	14	128		Weight	Annisquam River



Ipswich
Topsfield
Gloucester
Middleton
Danvers
Beverly
Peabody
1
2
3
4
5
6
7
8
9
10
11
12
13
14
LEGEND
Weight restriction
Clearance restriction
N
0
2 miles

Map 4 Location Index

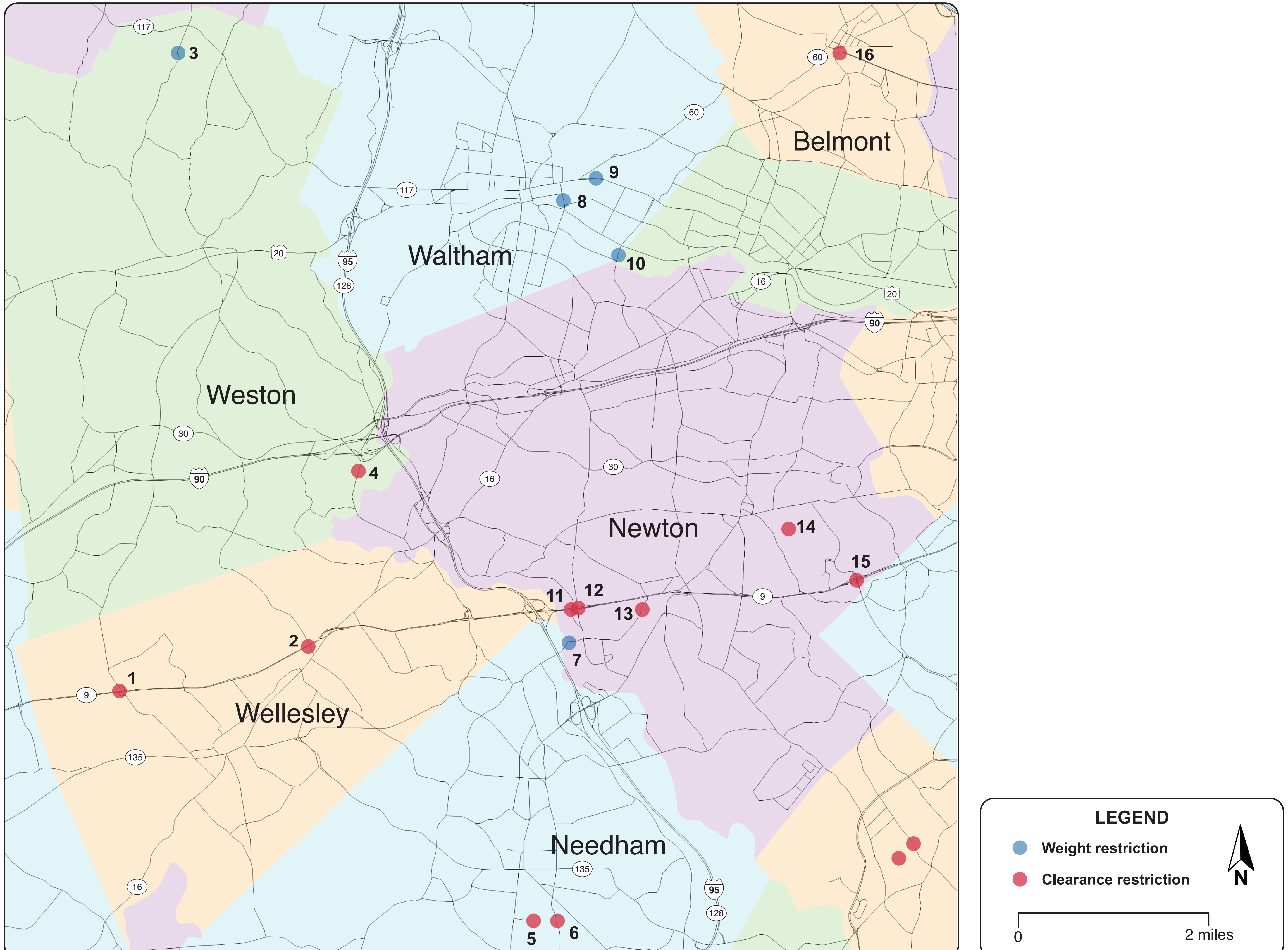
Municipality	Map Label	Size-restricted Roadways Route	Street Name	Type of Restriction	Feature Crossed
Hudson	1	85	Washington Street	Weight	Assabet River
Hudson	2		Forest Avenue	Weight	Assabet River
Hudson	3		Cox Street	Weight	Assabet River
Stow	4		Sudbury Road	Weight	Assabet River
Hopkinton	5		Fruit Street	Weight	Worcester Line
Southborough	6	85	River Street	Clearance	Worcester Line
Southborough	7		Willow Street	Clearance	CSX freight line
Framingham	8		Grove Street	Clearance	inactive freight line
Framingham	9		Winter Street	Weight	Sudbury River
Framingham	10		Winter Street	Weight	Worcester Line
Framingham	11		Mount Wayte Avenue	Weight	CSX rail line
Framingham	12		Main Street	Weight	Sudbury River
Framingham	13		Beaver Street	Weight	Beaver Dam Brook
Framingham	14		Central Street	Weight	Sudbury River
Framingham	15	126	School Street	Weight	Cochituate Brook
Natick	16		Marion Street	Weight	Worcester Line
Natick	17		Boden Lane	Weight	Worcester Line
Wayland	18		Oak Street	Weight	Interstate 90


Stow
Hudson
Framingham
Southborough
Wayland
Natick
Hopkinton
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
LEGEND
Weight restriction
Clearance restriction
0
2 miles
N

Map 5 Location Index

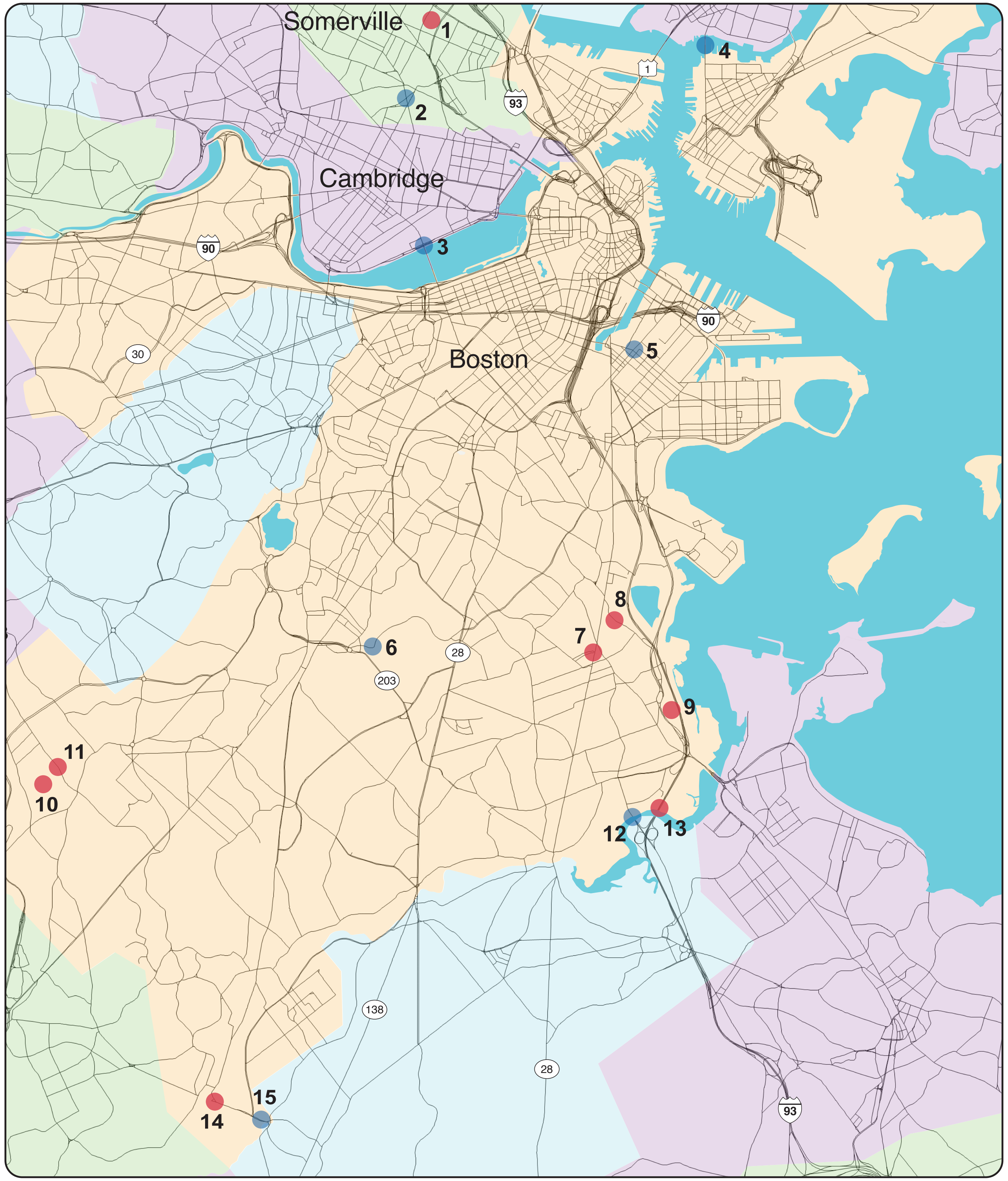
Municipality	Map Label	Size-restricted Roadways Route	Street Name	Type of Restriction	Feature Crossed
Wellesley	1		Cliff Road	Clearance	Route 9
Wellesley	2		Weston Road	Clearance	Route 9
Weston	3		Merriam Street	Weight	Fitchburg Line
Weston	4		Park Road	Clearance	Worcester Line
Needham	5		Warren Street	Clearance	Needham Line
Needham	6		Webster Street	Clearance	Needham Line
Needham	7		Central Avenue	Weight	Charles River
Waltham	8		Newton Street	Weight	Fitchburg Line
Waltham	9	US 20	Main Street	Weight	Fitchburg Line
Waltham	10		Farwell Street	Weight	Charles River
Newton	11		Quinobequin Road	Clearance	Route 9
Newton	12		Chestnut Street	Clearance	Route 9
Newton	13		Elliot Street	Clearance	Riverside Green Line
Newton	14		Glen Avenue	Clearance	Riverside Green Line
Newton	15		Hammond Pond Parkway	Clearance	Route 9
Belmont	16		Concord Avenue	Clearance	Fitchburg Line

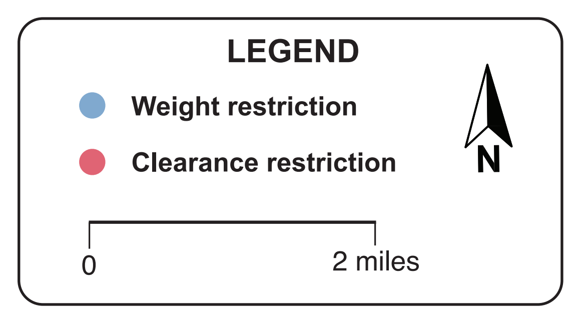
Dots on the map without numbers are identified on an adjacent map.


Belmont
Waltham
Weston
Newton
Wellesley
Needham
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
LEGEND
Weight restriction
Clearance restriction
N
0
2 miles

Map 6 Location Index

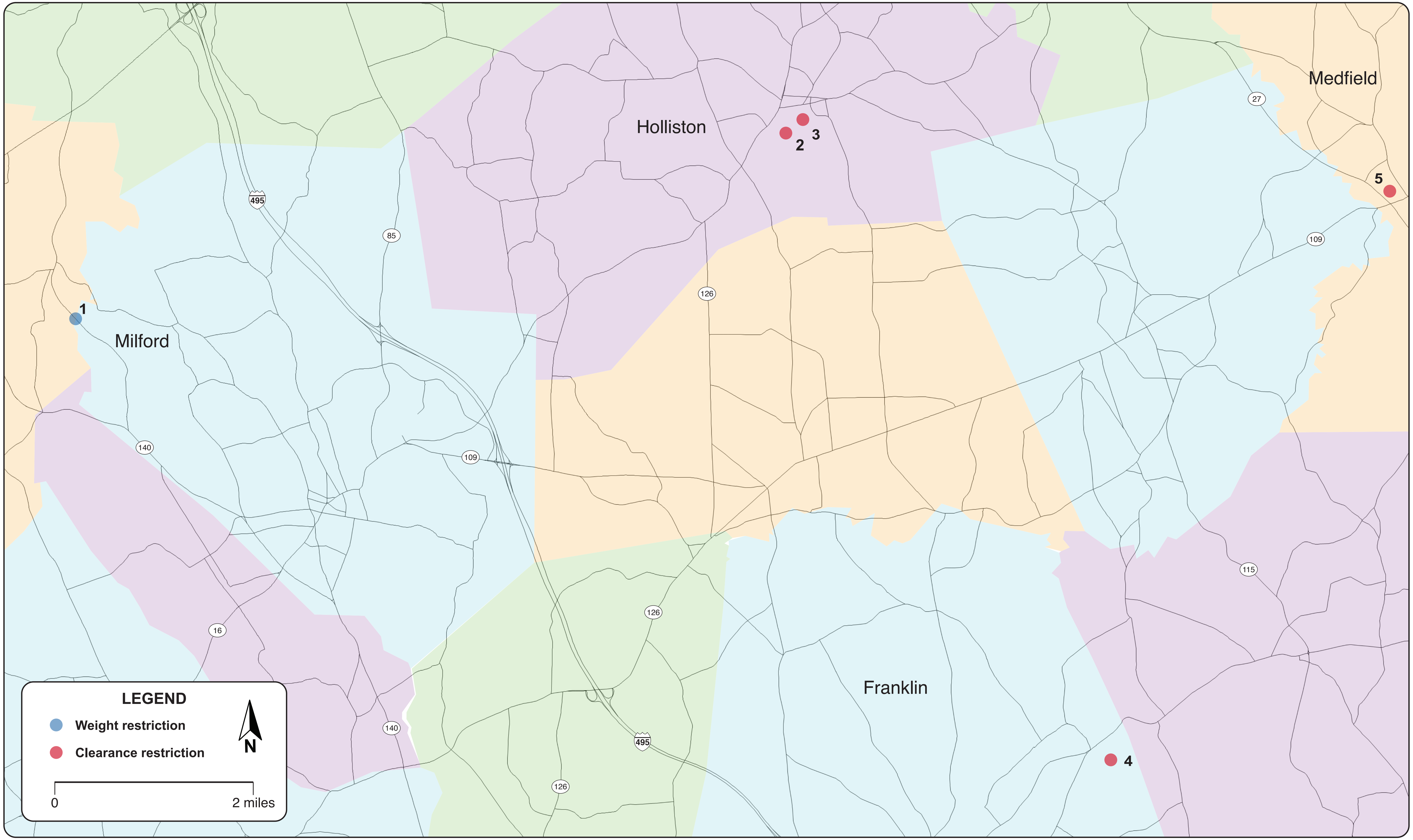
Municipality	Map Label	Size-restricted Roadways Route	Street Name	Type of Restriction	Feature Crossed
Somerville	1		Dana Street	Clearance	pedestrian overpass
Somerville	2		Webster Avenue	Weight	Fitchburg Line
Cambridge	3	2A	Massachusetts Avenue	Weight	Memorial Drive
Boston	4		Meridian Street	Weight	Chelsea River
Boston	5		West Second Street	Weight	South Boston Bypass Road
Boston	6		Forest Hills Drive	Weight	Cemetery Road
Boston	7		Dorchester Avenue	Clearance	Red Line
Boston	8		Freeport Street	Clearance	Old Colony Line/Red Line
Boston	9		Conley Street	Clearance	Old Colony Line/Red Line
Boston	10		Temple Street	Clearance	Needham Line
Boston	11		LaGrange Street	Clearance	Needham Line
Boston	12		Granite Avenue	Weight	Neponset River
Boston	13		Hallet Street	Clearance	Southeast Expressway
Boston	14		Hyde Park Avenue	Clearance	Fairmount Line
Boston	15		Neponset Valley Parkway	Weight	Neponset River


Somerville
Cambridge
Boston
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
93
1
90
90
30
28
203
138
28
93


LEGEND
Weight restriction
Clearance restriction
N
0
2 miles

Map 7 Location Index

Municipality	Map Label	Size-restricted Roadways Route	Street Name	Type of Restriction	Feature Crossed
Milford	1		Fiske Mill Road	Weight	Mill River
Holliston	2		Arch Street	Clearance	Holiston Rail Trail
Holliston	3		Exchange Street	Clearance	Holliston Rail Trail
Franklin	4		Acorn Place	Clearance	Franklin Line
Medfield	5		Frairy Street	Clearance	active freight line



BOSTON REGION MPO

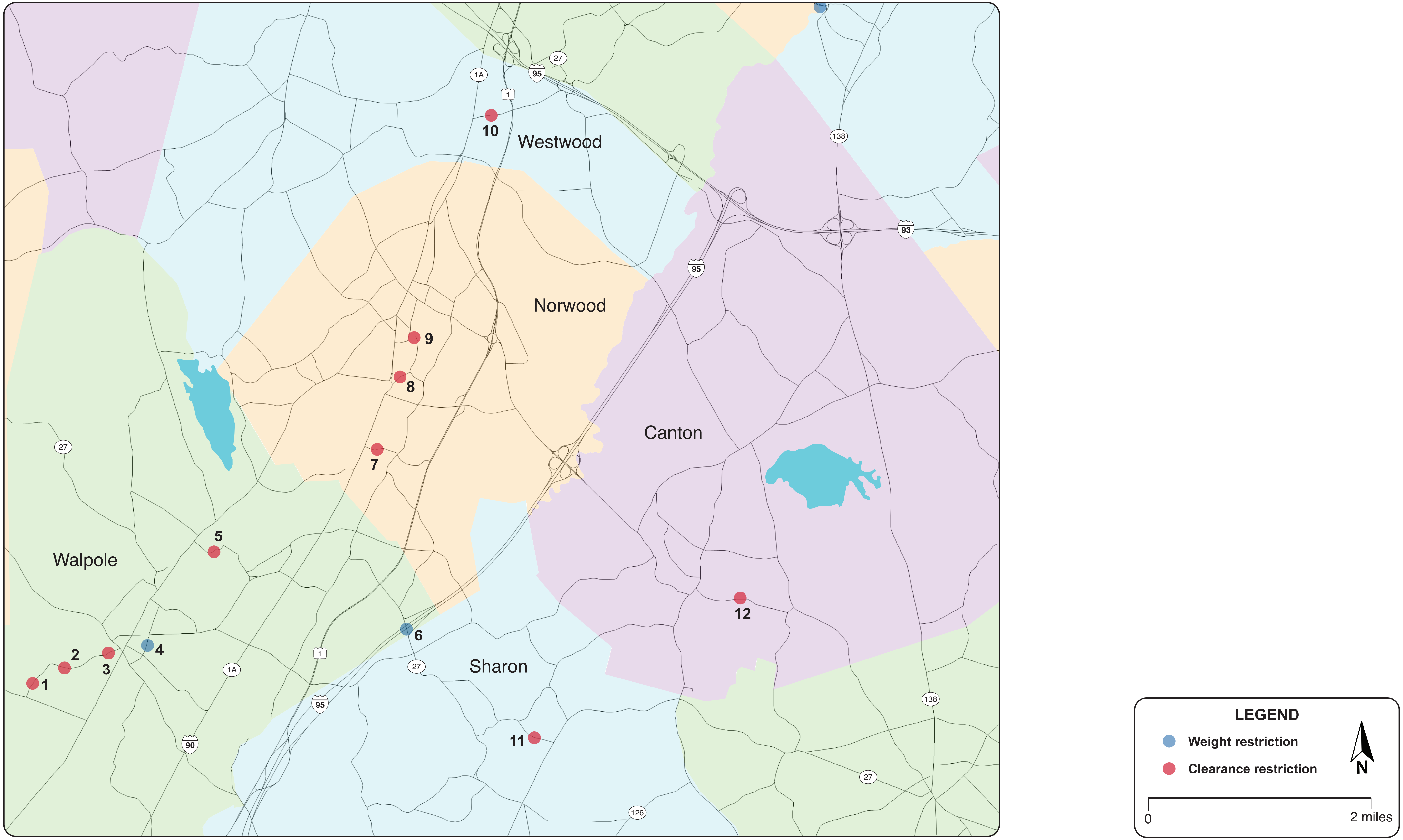
Map 7

Freight Planning Support
FFY 2017

Map 8 Location Index

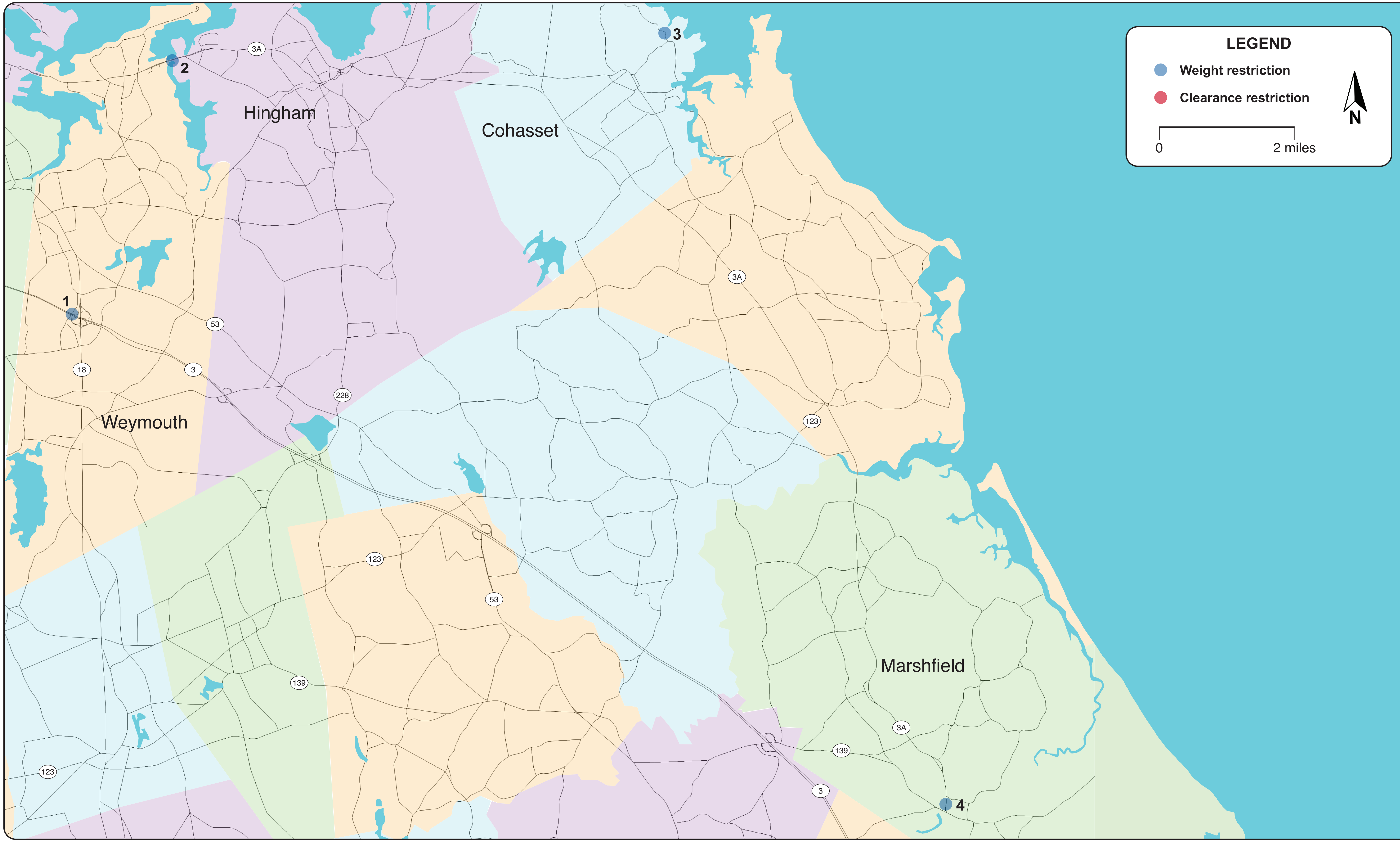
Municipality	Map Label	Size-restricted Roadways Route	Street Name	Type of Restriction	Feature Crossed
Walpole	1		West Street	Clearance	Franklin Line mile 19.89
Walpole	2		West Street	Clearance	Franklin Line mile 19.51
Walpole	3		West Street	Clearance	Foxborough branch
Walpole	4		School Street	Weight	Memorial Pond outlet
Walpole	5		Plimpton Street	Clearance	Franklin Line
Walpole	6		Coney Street	Weight	Interstate 95
Norwood	7		Morse Street	Clearance	inactive freight line
Norwood	8		Lenox Street	Clearance	inactive freight line
Norwood	9		Guild Street	Clearance	Franklin Line
Westwood	10		East Street	Clearance	Franklin Line
Sharon	11		Canton Street	Clearance	Providence Line
Canton	12		Bolivar Street	Clearance	Stoughton Line

Dots on the map without numbers are identified on an adjacent map.


Westwood
Norwood
Canton
Walpole
Sharon
10
9
8
7
5
6
4
3
2
1
11
12
1A
27
95
1
138
93
90
126
LEGEND
Weight restriction
Clearance restriction
N
0
2 miles

Map 9 Location Index

Municipality	Map Label	Size-restricted Roadways Route	Size-restricted Roadways Street Name	Type of Restriction	Feature Crossed
Weymouth	1		Front Street	Weight	Route 3
Hingham	2	3A	Lincoln Street	Weight	Back River
Cohasset	3		Atlantic Avenue	Weight	Little Harbor inlet
Marshfield	4	3A	Main Street	Weight	South River


LEGEND
Weight restriction
Clearance restriction
0
2 miles
N
Hingham
Cohasset
Weymouth
Marshfield
1
2
3
4
3A
53
18
3
228
123
139

5 CONCLUSIONS

The various parts of the MPO's regional roadway network were built at different times and to different standards. Even with adequate ongoing maintenance, not all bridges allow use by trucks at the Massachusetts maximum permitted vehicle weights or the maximum permitted vehicle heights. The motor freight industry is very adaptable, and alternate routes are identified as necessary to allow truckers to serve their customers.

The need to use alternate routes to bypass weight and height restrictions adds costs to truck movements, which by necessity are passed on to the freight customer. A goal of this study was to identify specific locations in the roadway network that might force trucks to use more circuitous routes. These locations are summarized in Tables 1 and 2 for weight restrictions and Tables 3, 4, and 5 for limited vertical clearance.

A second goal of this study was to consider the severity of these restrictions and get a sense of how motor carriers are affected and how they adapt. In terms of weight restrictions, it appears that most trucks can use almost the entire roadway system unimpeded. The industry most dependent on moving very heavy loads, hence most impacted by weight restrictions, is the construction industry. Specific weight limitations may impact heavy vehicles for the duration of a project, after which work shifts to a different construction site with different access routes.

The significance of limited vertical clearance is quite different. Even a lightly loaded 13-foot 6-inch dry van will be precluded from using a route if it can't fit under the bridge. The clearance barriers in the system are well marked and widely known. The vast majority of truck drivers find an appropriate route, and the ones who hit a bridge create a record of where improved clearances might possibly help the motor freight industry. Unfortunately, many bridges with limited clearance are located under railroad overpasses whose alignment is generally fixed; and often, the problems related to lowering the road under a railroad-carrying bridge are insurmountable.

Taken altogether, we hope that the data gathered and insights gleaned from this study will inform development and evaluation of the MPO's TIP and LRTP. Aspects of this work may also be incorporated into the truck component of the MPO's travel demand models.

WSK/wsk