

Kids Are Commuters Too!

Assessing the Mode Shift Potential of Walk to School Programs



Final Report

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Metropolitan Area Planning Council



and

WalkBoston



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EXECUTIVE SUMMARY

Thousands of schools across the country have initiatives that encourage students and their parents to choose walking, biking, and other non-auto modes for commutes to and from school. Commonly falling under the rubric of Safe Routes to School (SRTS), these programs generally seek to achieve a variety of objectives: health benefits of active transportation for students, air quality improvements, and reduced congestion. There is growing interest in the potential for SRTS programs to reduce auto vehicle miles travelled (VMTs) and associated Greenhouse Gas Emissions (GHGs). A commonly-cited statistic¹ suggests that auto school commutes account for 10% - 14% of all vehicles on the road during morning peak periods. This figure suggests that getting more kids to walk or bike to school might also measurably reduce emissions, and it raises the question of where investments in walk to school programs might yield the greatest reduction in auto commutes and associated VMT. This report presents a new framework and analysis for considering these questions in the context of Metro Boston.

The walk-to-school literature is rich with data on mode choice, parent and student attitudes, the impact of walk to school programs, and recently, the potential GHG benefits of SRTS program. Previous research demonstrates that travel distance has the single greatest effect on student travel mode. Meanwhile, travel distance is a function of two variables: the geographic distribution of students and schools, and the availability of safe pedestrian infrastructure connecting the two. In other words, only students with a reasonably short and safe route to school have commutes that may be amenable to SRTS interventions. However, few SRTS studies use detailed mapping to estimate the potential collective VMT impact of walk to school programs, and spatial data is rarely collected or used to design, implement, or evaluate SRTS programs. Parent surveys commonly ask parents to report a nearby intersection and to estimate the distance to school, yet the location information is rarely geocoded; self-reported distances are notoriously unreliable; and the responses are rarely correlated with sidewalk availability data. A new analytic approach that overcomes these deficiencies can help pinpoint the “target audience” for walk to school programs: students who could walk or bike to school but who are currently being driven. Finding and mapping this target audience is critical to effective programs, infrastructure, and investments.

This report describes a new spatial framework for assessing district- and school-level walkability; new methods for collecting student commute data; and a formula for estimating the GHG footprint of student auto commutes and the reductions that might be achieved by successful SRTS programs. Collectively, these comprise the outline of a rapid assessment tool that could be used to prioritize, tailor, and measure the effectiveness of SRTS investments. Our analysis also provides new insights into vehicle availability, spatial factors, and “trip chaining” considerations that influence student travel patterns. These findings may support a more comprehensive approach to school commutes, one that draws strategies from the practice of transportation demand management to promote more sustainable transportation choices for all students.

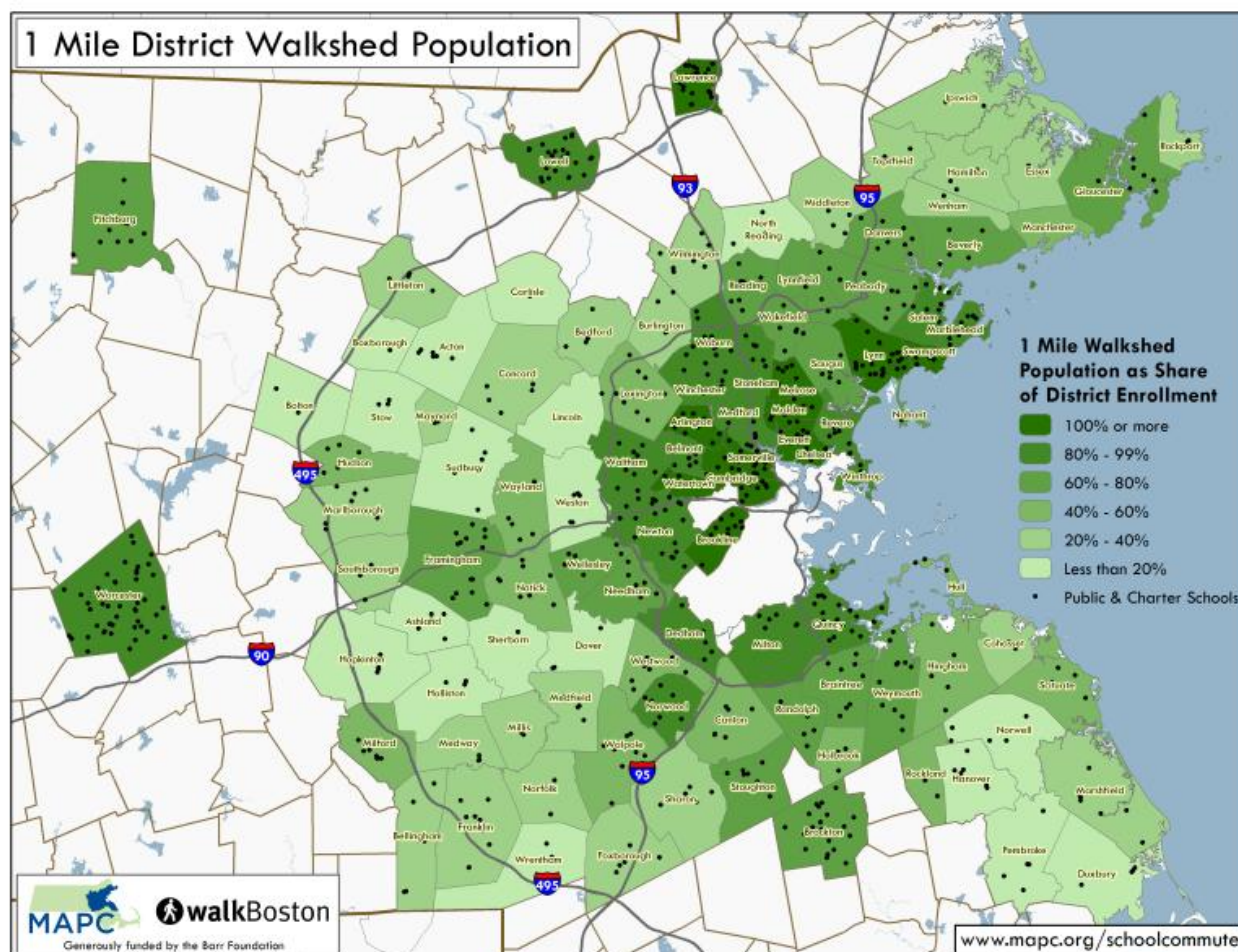
With the support of the Barr Foundation, WalkBoston and MAPC began an initiative to better understand the nexus between school commutes, SRTS programs, and GHG reduction. In particular, this research sought to answer the following questions: How many students in the region live within a safe walking distance of their school? How many students within walking distance of a given school are currently being driven? What would be the GHG impacts of shifting these auto commutes to walking or biking? To answer these questions, WalkBoston and MAPC conducted the following analysis:

- applied a new method of spatial analysis to over 800 schools in Eastern Massachusetts and defined “walksheds” of various distances based on mapped sidewalk infrastructure;
- evaluated land use and demographics to assess walkability potential across districts;
- surveyed over 4,500 students in 23 schools to better understand existing travel patterns;
- identified six schools with the greatest potential for greenhouse gas emissions reduction through increased walk & bike mode share; and
- developed new methods and tools for replicating this analysis across Metro Boston and the U.S.

¹ Noreen C McDonald et al., “U.S. School Travel, 2009 an Assessment of Trends,” *American Journal of Preventive Medicine* 41, no. 2 (August 2011): 146–151.

REGIONAL FINDINGS


79% of the school-age children in the study area live within a mile of at least one school. However, school proximity varies widely. In a dozen high-density cities and towns, more than 99% of school-age residents live within a one mile walk of at least one school, and in many cases they are within walking distance of three or more schools. In lower density suburban communities with more dispersed residential growth and less sidewalk connectivity, far fewer children could walk to school even if they wanted to. In ten of the region's lowest density communities, fewer than 10% of school-age children live within a one mile walk of any school.

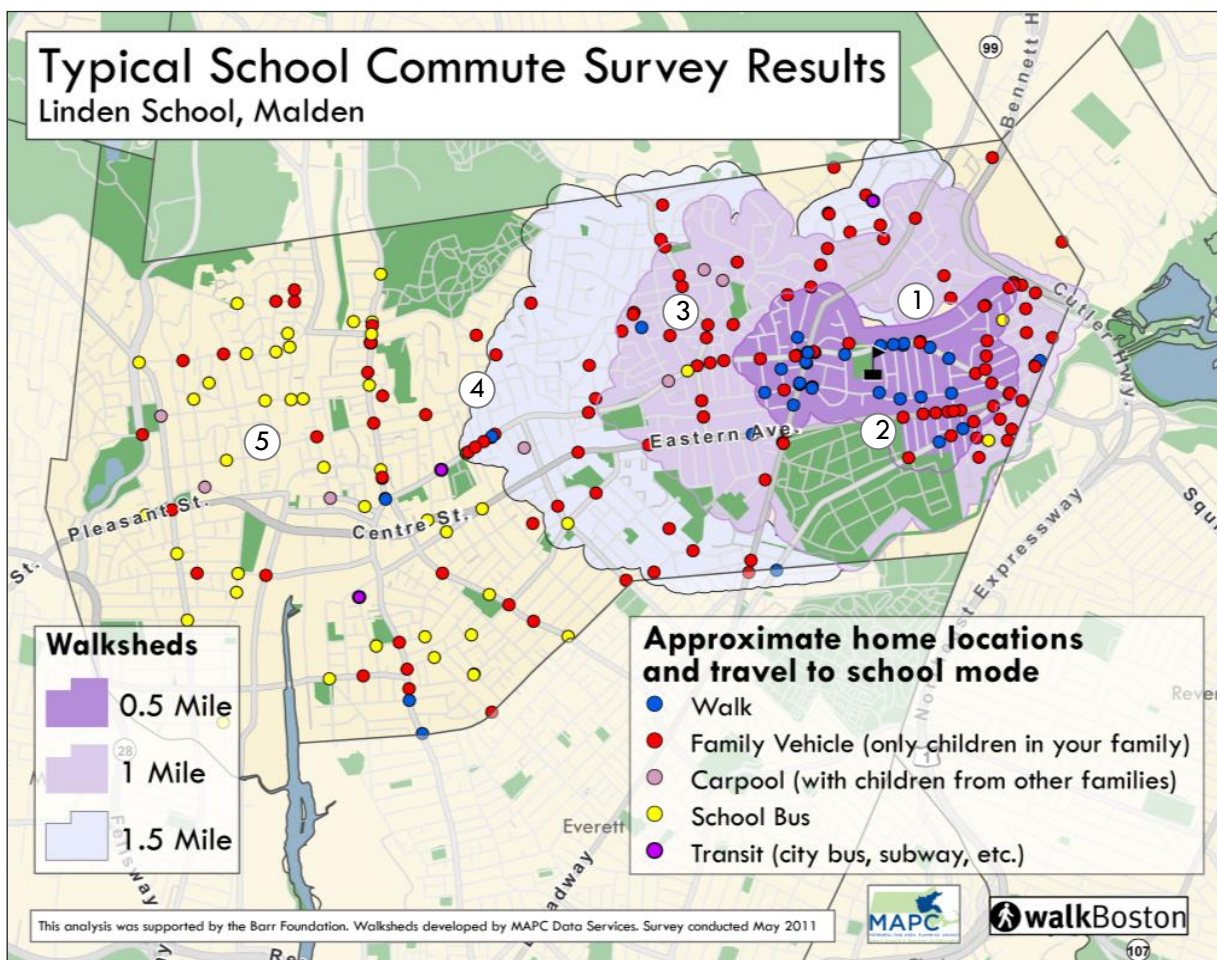


Most districts use proximity as one factor among many when assigning students to schools. Of 28 school districts surveyed, most have zone-based assignment policies. However, most of these *also* have parental choice policies or magnet schools that result in a hybrid neighborhood/district-wide assignment pattern. Only four of the surveyed districts do not take proximity into account when assigning students to schools.

ILLUSTRATIVE SURVEY RESULTS

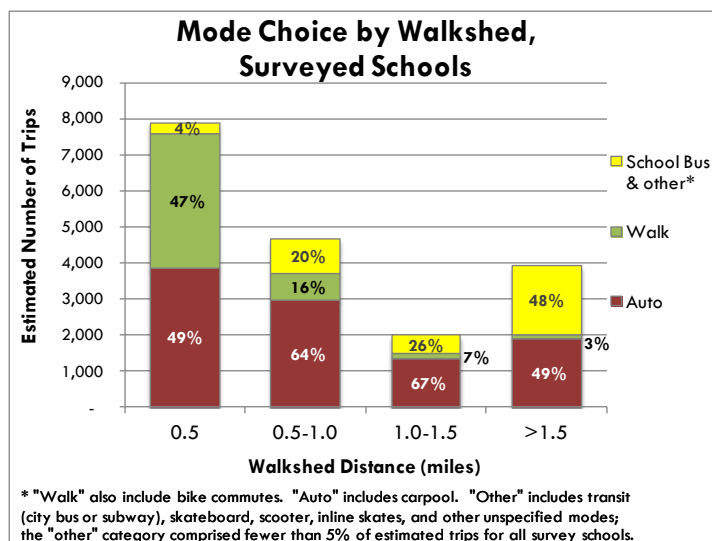
The map below—from a K-8 school with district-wide enrollment eligibility—illustrates many of the patterns observed in the survey results.

- ① Surrounding the surveyed school  are *walksheds* which demarcate the areas accessible within a given walking distance. Three quarters of walking students live within the 0.5 mile walkshed.
- ② At every school surveyed there are dozens if not hundreds of *proximate auto commuters*—students living within walking distance, but currently being driven to school. These are the primary targets for SRTS programs. Often these potential walkers are found in clusters that suggest barriers to walking or biking. Given the right infrastructure improvements and outreach strategies, these clusters may also represent the best potential for mode shift.
- ③ Past a half mile from school, walk share drops off dramatically and auto commutes, especially in the 0.5 – 1.0 mile walkshed, represent a secondary market for walk to school programs.
- ④ The most auto-dependent commutes are often found at 1.5 miles and just beyond—a distant walk for most students, but not distant enough to be eligible for free school bus service.
- ⑤ School bus commutes are more prevalent beyond two miles, where the key to GHG emission reductions may be mode shift from auto to bus—not something traditionally addressed by SRTS programs.



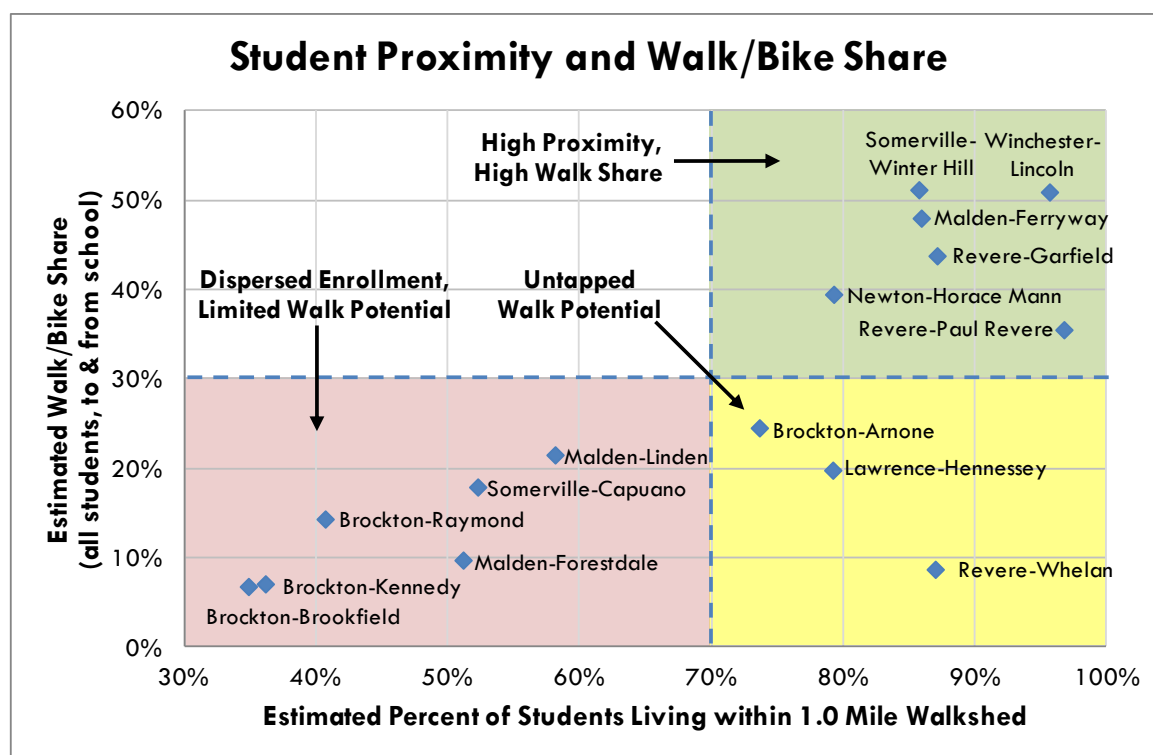
STUDENT PROXIMITY AND MODE CHOICE

54% of students living in the one mile walkshed of a surveyed school are currently being driven to school. Walking and biking account for an estimated 26% of school commute trips to the surveyed schools, and 36% of commutes for students living within one mile of their school. Students are more likely to travel by auto in the morning than in the afternoon, when walk and bus shares are higher.

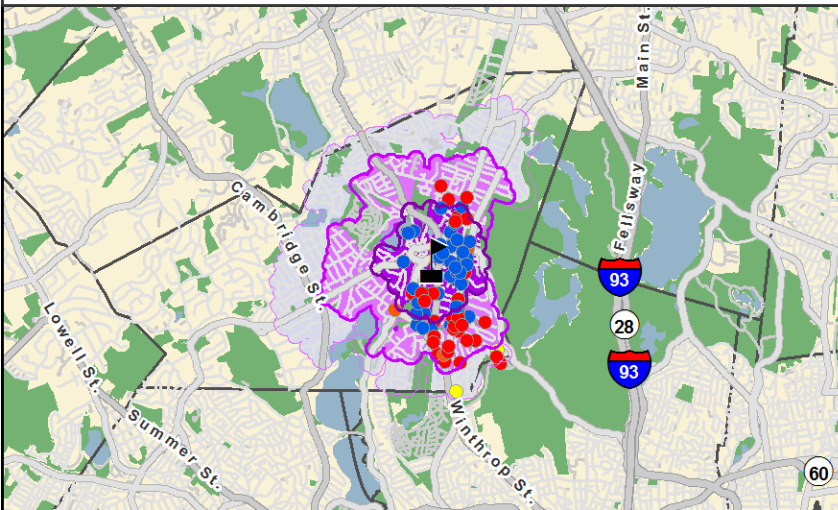


High student proximity is a prerequisite to having a high walk/bike share, but not a guarantee.

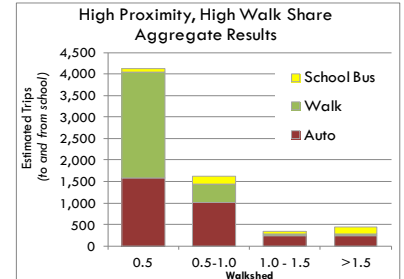
Comparison of the schoolwide walk/bike share to student proximity identified three general categories of schools which differ in their walk to school and mode shift potential. In the *High Proximity, High Walk Share* schools, more than 75% of students live within a mile of school and walk rates exceed 30%. The *Untapped Walk Potential* schools have similar student proximity but much lower walk rates, suggesting the possibility of substantial mode shift (10 – 20%) through SRTS programs. The *Dispersed Enrollment, Limited Walk Potential* schools are those where fewer than 60% of students live within a mile of school; as a result, the schoolwide walk rates never exceed 21%. These three types of schools are mapped and described on the following page.



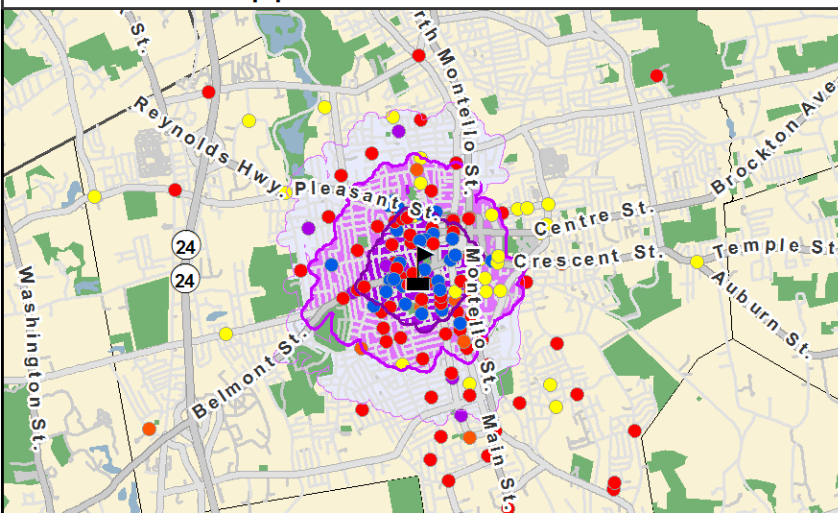
High Proximity, High Walk Share



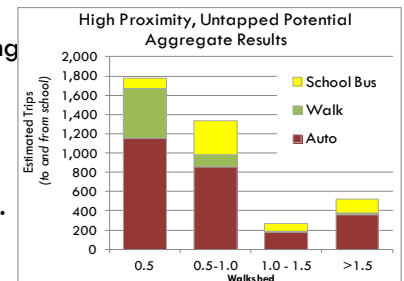
High proximity, high walk share schools are those where more than three quarters of students live within one mile walking distance of their school and at least one third of students walk or bike to school. At the illustrative school to the left, 96% of students live within a mile of school and more than 50% of students commute by walking or biking. At schools such as this, the mode shift potential of SRTS programs is somewhat limited because fewer than half of the proximate students are being driven.



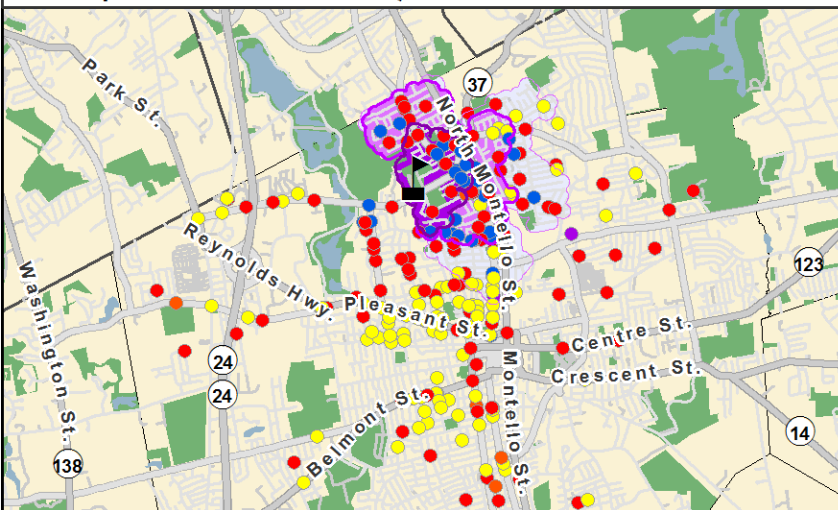
Untapped Walk to School Potential



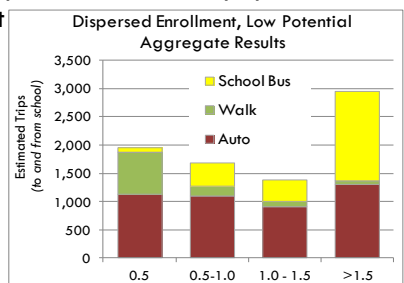
Untapped walk to school potential exists at schools where three quarters of students live within one mile walking distance, but fewer than a quarter walk to school. Even within a half mile, only 29% of students commute by walking or biking, on average. These schools represent the best potential for mode shift as a result of SRTS programs, since there given the large number of proximate auto commuters. Shifting these trips to walking or biking could have major effects on school-wide mode share.



Dispersed Enrollment, Limited Walk Potential



At schools with **dispersed enrollment and limited walk potential**, most students live beyond a mile from school. As a result, the potential walk mode share is very limited, and walk to school programs will be relevant to a minority of students. Infrastructure improvements to expand the reach of the walkshed may have some effect on the size of the proximate student population, but efforts to shift distant commutes from car to bus might be more effective at reducing GHG emissions.



Walksheds

- 0.5 Mile
- 1 Mile
- 1.5 Mile

All maps at same scale

Approx. home locations and travel to school mode

- Walk
- Family Vehicle (only children in one family)
- Carpool (with children from other families)
- School Bus
- Transit (MBTA bus, subway, etc.)

- School
- Lakes and Ponds
- Open Space

0 0.25 0.5 1 Miles



GREENHOUSE GAS EMISSIONS AND MODE SHIFT POTENTIAL

Commuting to school by car is responsible for a measurable share of the average family's total greenhouse gas emissions. Auto commute trips to and from the 15 schools generate an estimated 1,645 metric tons of GHG annually, an average of 329 kg per auto commuter. Depending on the municipality in which this is located, these average commutes would constitute 2% to 8% of an average household's annual emissions².

More than one-eighth of auto emissions at the surveyed schools result from auto commutes that could be shifted to walking or biking. In the surveyed schools, we estimate that 1,900 auto commute trips—21% of the total commutes—are made by students living within the 0.5-mile walkshed. Another 16% of all commutes are auto trips of between 0.5 and 1.0 miles. Auto commutes from within the 0.5 mile walkshed generate approximately 237,000 kg of GHG emissions annually (14% of the total) and the 0.5 – 1.0 mile auto commutes generate 400,000 kg annually (24% of the total) Based on their proximity and current mode choice, these proximate auto commuters constitute the prime target audience for walk-to-school programs.

Student commutes are intertwined with parent work commutes. The prevalence of “trip chaining” complicates the GHG picture for school commutes and the potential for mode shift more generally. Of the target audience described above, 68% are dropped off by a parent on their way to work or another destination. The barriers to achieving mode shift among these students are greater than for students in a dedicated auto commute trip; and the marginal emissions benefit is small if the parent commutes to work by auto anyway. However, many of those students travel home by a different means, suggesting that there are opportunities to substitute the auto commute for another mode, preferably one with a lower carbon footprint.

² It should be noted that these are survey results from a sample of schools considered to have a relatively high walk-to-school potential, by virtue of nearby school-age population and school assignment policies, so should not be considered representative of mode choice or GHG footprint of auto commutes regionwide.


NEXT STEPS

A half-dozen of the surveyed schools demonstrate the best potential for shifting school commutes from auto to walking or biking. Six of the surveyed schools, in four districts³, represent the best potential for reducing GHG emissions through walk to school programs. For these schools, the students in the 0.5 mile walkshed commuting via *dedicated* auto trips (not en route to work) comprise 4.8% of estimated auto GHG for all 15 schools surveyed. If *half* of these students could be shifted to walking, biking, it might reduce emissions by 39,000 kg per year, approximately 2.5% of all auto commute-related GHG emissions. If a quarter of the dedicated auto trips for students living in the 0.5 – 1.0 mile walkshed were also shifted to walking or biking, the total GHG reductions amount to over 67,500 kg which comprises 4% of estimated auto emissions from the surveyed schools.

New tools are available to help schools, districts, and state agencies plan and implement SRTS programs. New survey tools and practices can help schools and districts gather student data necessary to assess SRTS GHG potential at relatively low cost. A new six-question survey implemented by MAPC and WalkBoston achieved a 51% response rate across 8,400 students in 13 schools and 6 districts where it was administered using both paper and on-line formats and accompanied by monetary incentives from a local foundation to a school-based organization⁴. MAPC was able to map the approximate home location of 91% of survey responses, providing a novel and highly detailed picture of mode choice relative to school proximity. The resulting maps can also serve as a resource to local communities as they seek to prioritize programs and infrastructure investments.

MySchoolCommute.org

AboutEnglishEspañolPortuguésFrançaiseKreyòl ayisyen tiếng Việt 中文 اسم اللغة



We'd like to learn how students get to and from school in order to help plan safe and healthy walking options for students.

This 3-minute parent survey was developed by the [Metropolitan Area Planning Council \(MAPC\)](#), the regional planning agency for Metro Boston, and [WalkBoston](#), a nonprofit organization, as an innovative and simple web tool that schools can use to learn about student mode choice. Funding for this project was provided by the [Barr Foundation](#).

The survey tool is available for 101 school districts in the MAPC region, in addition to Lowell, Fitchburg. For a complete list of districts and schools for which the survey tool is available please see below. If your school or district would like to participate or if you'd like additional information please click here for more information or contact MAPC.

Please select your school district:

Scroll or start typing your district name

Acton

Please select your school:

Scroll or start typing your school name

Select an Option

Open School Survey Form

MAPC is publishing the dataset of survey responses—complete with location, mode, and other attributes—for use by other researchers who wish to analyze in more detail the environmental factors that influence mode share. MAPC is also publishing the open source software code used for the online survey tool, so that other regions and programmers may adopt or add functionality to that tool.

³ These are: Arnone (Brockton), Ferryway (Malden), Forestdale (Malden), Horace Mann (Newton), Garfield (Revere), and Whelan (Revere).

⁴ This response rate excludes Somerville, where the survey was distributed district-wide using only the on-line tool. Only two Somerville Schools are included in the final analysis.

POLICY CONSIDERATIONS AND STRATEGIC DIRECTIONS

WalkBoston and MAPC undertook this research project to develop tools that would enable SRTS practitioners to target their efforts to places where the programs can yield the greatest benefits. Over the past decade the Safe Routes to School (SRTS) movement has grown from a set of small local projects to a federally funded program in all 50 states. The benefits of SRTS programs to children's physical activity, improvements in safety, and increased community engagement have already been substantial. However, public resources for SRTS resources are constrained; and there is a growing need to target those resources effectively using place-based policies and investments.

In order to focus the next generation of trip-based SRTS programs on school districts where the programs can yield the most substantial benefits for both students and the environment, it is important to identify those places where there is the greatest potential for success, defined as the best potential for mode shift from auto to walking or biking.

The research undertaken by MAPC and WalkBoston focused on developing effective tools for identifying districts with the following characteristics:

- A substantial proportion of students living with a safe walking route of less than one-mile to nearby schools;
- A substantial number of students being driven short distances by their parents; and
- A substantial proportion of low-income students who are at risk for being overweight or obese.

With these tools in hand, and an understanding of the importance of implementing programs in places where they can be most effective, the stage is set to design and implement SRTS programs that are targeted to those locations where they can have the greatest health, air quality and community benefits.

The next steps are to

1. Further develop and implement regional analysis and rapid assessment tools; and to
2. Develop state and local policies that incorporate the resulting data into program investment priorities.
3. To achieve substantial GHG emissions from school commutes, policy makers may need a slightly different set of tools and programs.

At many schools—whether as a result of land use patterns or school assignment policies—the target audience for walk to school programs comprises a minority of the student body or generates a minority of GHG emissions. In these schools, achieving air quality improvements, congestion relief, and emission reductions may require greater utilization of carpools and school buses, strategies that are not core elements of the conventional SRTS approach. This suggests a need to incorporate SRTS programs into a more comprehensive transportation demand management framework that considers pricing, parking, incentives, school siting, and land use policies as strategies and tools to promote more sustainable school commutes among all students.

INTRODUCTION

The walk-to-school literature is rich with data on mode choice, parent and student attitudes, and the impact of walk to school programs. Recent research has begun to address the potential GHG benefits of SRTS program. However, little empirical research has been published using spatial analysis to estimate the potential impact of walk to school programs and the GHG emissions savings that might result. School proximity and infrastructure are dominant forces in determining whether students even have the opportunity to walk or bike to school and some researchers have modeled the impact of these and other factors. In practice, spatial data is rarely collected or used to design, implement, or evaluate SRTS programs⁵. Parent surveys commonly ask parents to report a nearby intersection and to estimate the distance to school, yet the location information is rarely geocoded, self-reported distances are notoriously unreliable, and the responses are rarely correlated with sidewalk availability data. Detailed spatial analysis is needed to quantify the target audience for walk to school programs: students who could walk to school but are currently being driven. Evaluation of mode choice by distance is necessary to estimate the VMT and GHG impacts of existing school commutes, in particular those that *might* be shifted to non-auto modes.

METHODOLOGY

Walkshed Analysis

Few walk-to-school research studies include a mapping component to determine what residential areas are actually pedestrian-accessible to a given school based on sidewalk availability and on-road distance. Those studies that do seek to estimate student population within walking distance commonly use a fixed radius from the school location (1/2 mile or 1 mile) to define the area within walking distance. However, such an approach ignores the constraints that sidewalk infrastructure (or lack thereof) places on school walkability, and the fact that the shortest on-road distance to school may be considerably longer than the straight-line distance. To our knowledge, only a limited number of studies have sought to define school walk areas based on sidewalk infrastructure and on-road distance.

In order to overcome these challenges, we developed a new methodology for defining school walksheds based on mapped sidewalk infrastructure, other pedestrian routes (such as school grounds), and network analysis, and applied this methodology to 804 schools in Eastern Massachusetts. The districts analyzed include the entire MAPC region (with the exception of Boston⁶), as well as five major urban school districts outside of MAPC: Brockton, Fitchburg, Lawrence, Lowell, and Worcester.

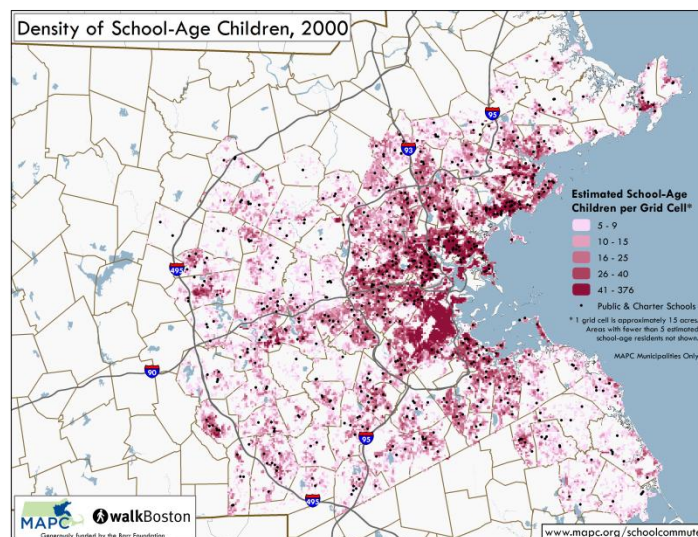
MAPC mapped a pedestrian network for the study area, representing the potential walking routes that a student might use to walk to school. The pedestrian network is comprised of three components: roadways with sidewalks on one or both sides, low-volume residential roadways (<1,000 vehicles per day), and school grounds. MAPC then delineated *walksheds* for each target school by calculating the shortest distance to the school for each roadway segment and then buffering the road network by 100 meters to include adjacent residential areas. Figure A.1 (Appendix A) shows the 1.0 mile walk network and walkshed for two schools, demonstrating how land use patterns, roadway connectivity, and sidewalk availability influence walking access to school. The walksheds from all schools within a municipality were merged to create *district walksheds*—those areas within a city or town that are within 0.5, 1.0, or 1.5 mile walking distance of any school⁷.

⁵ We consider parent-reported distance from school to be qualitative, given the poor reliability of subject-reported distances (Sally Macintyre, Laura Macdonald, and Anne Ellaway, "Lack of Agreement Between Measured and Self-reported Distance from Public Green Parks in Glasgow, Scotland," *The International Journal of Behavioral Nutrition and Physical Activity* 5 (2008): 26; Frank Witlox, "Evaluating the Reliability of Reported Distance Data in Urban Travel Behaviour Analysis," *Journal of Transport Geography* 15, no. 3 (May 2007): 172–183.) and the lack of detail on available sidewalk infrastructure.

⁶ Boston Public Schools was excluded due to the complexity of the district assignment policies and the near-universal proximity to at least one school.

⁷ Due to their spatial complexity, we were not able to analyze regional school districts. We use the term "district" to summarize all schools within a given municipality, and recognize that this approach excludes children who travel into or out of a municipality to attend a regional school.

The number of residents age 5 – 17 within each walkshed was estimated based on U.S. Census data. These estimates were prorated based on the range of grades at the target school⁸ and scaled based on district enrollment. This is the *walkshed population*. For each school, the walkshed population within each walkshed was compared to school enrollment as a relative measure of walk-to-school potential. For each municipality, the district walkshed population was compared to total district enrollment as a relative measure of district walkability.



District screening & selection

Following the walkshed analysis, MAPC implemented a two-step screening process to identify target schools for the survey. The objective of the screening process was to identify districts and schools with characteristics and conditions thought to be conducive to a successful, high-impact walk to school programs specifically targeted to reducing GHG emissions. These characteristics include: districts with multiple schools with large walkshed populations; high district walkshed population relative to district enrollment; participation in existing SRTS or MA Department of Public Health Mass in Motion programs; and districts with a large low-income population. Maps of these factors are included in Appendix C. The screening process also relied on WalkBoston's extensive practical experience implementing SRTS programs in a number and variety of Metro Boston school districts.

MAPC contacted 28 selected districts to collect data on school assignment and transportation policies. Few districts could readily provide responses to the full range of questions, and calls were often made to multiple staff members to gather individual pieces of information.

Respondents were asked to characterize district policies for school assignment, and whether there was a map of assignment zones. MAPC classified assignment policies into three broad categories:

- Neighborhood-based zones (most students attend closest schools)
- Neighborhood-based zones with district-wide magnet schools or option to attend a different zone
- Assignment not based on geographic zones

District maps were received from a limited number of districts, and generally in a hard-copy, PDF, or online formats that cannot be directly imported into a GIS program. Few districts could provide detailed information on assignment statistics (e.g., percent of students attending outside of their zone.)

Districts were also asked to characterize the transportation services provided and whether there was recent data on student mode choice. The responses demonstrated the great complexities and many idiosyncrasies of school district transportation policies, with regard to eligibility areas, eligibility by grade, fees, and discounts. As a result, MAPC and WalkBoston chose not to classify or categorize these policies for analytical purposes, though screening notes were consulted when choosing potential survey schools.

Once the district screening was complete, WalkBoston and MAPC reviewed the results to identify districts with conditions thought to be conducive to walk-to-school programs (e.g., neighborhood-based assignment,

⁸ There are 14 possible grades from pre-K to grade 12, and school age children are assumed to be evenly distributed across grades. For example, a Pre-K through 5th grade school (7 of possible 14 grades) with 1,000 students in the 1 mile walkshed was estimated to have a walkshed population of 500.

limited transportation within 1 mile of school) and schools in those districts with high walk-to-school potential (e.g., large 0.5 mile walkshed population.) Districts with no zone-based assignment and those with a large number of magnet schools were assumed to have less potential for successful SRTS programs. Qualitative factors such as previous participation in a walk-to-school program or the expressed support of school administrators were also considered. Based on WalkBoston's successful experiences with elementary students, the review focused on elementary schools.

Based on this analysis, 54 schools were contacted and invited to sponsor a parent survey. To encourage participation, WalkBoston offered cash incentives to schools (\$250 for 50% participation rate; and \$400 for a 75% participation rate), with the money made available to the school administration or local PTA or parent council, depending on local preference. MAPC offered to provide paper copies of surveys for each student in English and one alternate language; and provided online surveys for every school in seven languages.

Thirteen individual schools accepted the invitation to participate in the survey, in both paper and electronic form⁹. In addition, the Somerville Public School district offered to make schools aware of the offer and to include the URL of the online survey in an electronic newsletter distributed to parents. Paper surveys were not provided to any school in Somerville.

Survey research, tools & implementation

MAPC and WalkBoston considered a range of survey methodologies for collecting data about mode choice in the selected districts, including visual surveys, classroom tallies, and standard paper surveys. However, few collected the right combination of data points or promised easy data collection and processing. After reviewing a range of survey methods and tools, MAPC and WalkBoston developed a new parent survey tool to collect the following information about each student:

- Grade
- Home location (nearest intersection)
- Mode to school (most days)
- Mode from school (most days)
- If auto commute, whether the driver continued on to work or another destination (a "chained trip")
- Vehicle availability (number of vehicles, number of drivers)

The survey tool was reviewed by staff from MassRIDES (state SRTS program administrators), SRTS consultants, and elementary school parents for comment. Once finalized, the survey was translated into seven languages common in the districts selected for surveying: Spanish, Portuguese, French, Haitian Creole, Vietnamese, Chinese, and Arabic. Hard copies of the survey were distributed to each school, with the English survey on one side of each page, and one alternate language for each school on reverse, chosen in consultation with school administrators and their practices communicating with parents. Each survey also included a note in multiple languages directing parents to the website for translations.

The online version of the survey, posted at www.myschoolcommute.org, allowed parents to identify their home location using either a mapping tool (place the marker at a location near your house) or by providing the names of streets at a nearby intersection. Translations in six alternate languages could be accessed by clicking the language name at the top of the page. A screenshot of the online tool is included in Appendix C.

Once the survey had been drafted, it was piloted at the Brookfield and Kennedy elementary schools in Brockton where WalkBoston was already involved in SRTS programs. Results from these pilot surveys were reviewed to identify apparent problems with the survey results. The survey achieved response rates of 41% and 61%, and the vast majority of surveys were determined to be "complete" (grade, cross streets, and mode to/from school filled in.) School administrators reported that the survey was easy to implement and indicated that the participation incentive was a very compelling motivation for parents.

⁹ With the exception of the Lincoln School in Winchester, where the survey was conducted online only.

Twelve individual public schools, with a combined attendance of 8,400 students, administered the survey in both paper and on-line versions, and one school chose to administer only the on-line survey. These schools generated 4,300 completed surveys, a response rate of 51%. All but one school had response rate of more than 30%. Ten schools received incentives for a response rate at or near 50%; two achieved a response rate of 75% and received the \$400 incentive. A table with response rate by school and format is included in Appendix A.

In Somerville, the survey was administered district-wide and online only, but with limited outreach to individual school administrators and parent organizations regarding the survey and incentives. With inconsistent school-level outreach and promotion, only 190 Somerville students returned surveys, a response rate of just 4%. Only the two schools with response rates over 10% were included in the analysis¹⁰. With the addition of the two Somerville schools to the 13 schools from other districts, the total number of “surveyed schools” was 15, with a combined response rate of 48%. Overall, 554 surveys were submitted using the online tool, 12% of the total. 91% of surveys could be geocoded to a point location and assigned to a walkshed. Analysis of results from the online tool suggests good validity of the map tool as an instrument for collecting geographic information. The home location of survey respondents using the mapping tool was within 200 meters of the reported intersection for 74% of surveys that provided both pieces of information.

Analysis and estimation

A multi-step process was used to estimate enrollment and mode choice based on survey results. The distribution of survey responses across walksheds was assumed to be representative of the total school enrollment, and mode choice (including trip chaining) for surveys within a walkshed was assumed to be representative of other students in that walkshed. These ratios were applied to the reported 2010 – 2011 enrollment to estimate trips by mode and walkshed.

MAPC estimated VMT and GHG emissions for each student auto commuter based on walkshed and mode (family vehicle versus carpool.) We also differentiated between *dedicated* trips (parent returns home after the school commute), versus *en route* trips, in which the parent continued on to work or another destination. The VMT for dedicated auto commutes is based on the round trip distance from home to school. For en

Paul Revere School

Important School Travel Survey

Dear Parent or Guardian,

Paul Revere School would like to learn how students get to and from school.

This information will be used to plan safe and healthy walking options for students.

The survey will take less than 3 minutes to complete.

Please complete one survey for each child at Paul Revere School by **Friday, May 20.**

Your school earns money when you complete this survey! If surveys are completed for 203 students, WalkBoston (a nonprofit group) will donate \$250 to the school. If surveys are completed for 304 students, WalkBoston will donate \$400!

You can also fill out the survey online at myschoolcommute.org/revere

Please complete EITHER the online survey or this form – NOT BOTH!

Al dorso encontrará una traducción de la encuesta al español.

Português: Se for necessário, por favor peça que lhe traduzam este questionário ou visite myschoolcommute.org/revere para responder a uma versão online em português.

Français: Si nécessaire, veuillez faire traduire ce questionnaire sur papier, ou visitez myschoolcommute.org/revere pour répondre à une version en ligne en français.

Tiếng Việt: Nếu cần, hãy cho dịch bản khảo sát y kiến bằng giấy này hoặc vào thăm trang mạng myschoolcommute.org/revere để hoàn tất bản khảo sát trực tuyến bằng tiếng Việt.

如果您需要，請翻譯本紙張調查問卷，或登錄 myschoolcommute.org/revere，填寫中文網上版本。

1. What grade is your child in? K 1 2 3 4 5 6 7 8

1a. On what day of the month was your child born?

2. What street do you live on?

Name of your street:

Name of nearest cross-street: (nearest intersection)

3. How does your child get TO school on most days? (choose one)

☐ School Bus ☐ Carpool (with children from other families) ☐ Other (skateboard, scooter, inline skates, etc.)

☐ Bike ☐ Walk

☐ Family Vehicle (only children in your family) ☐ Transit (city bus, subway, etc.)

3a: If you selected "family vehicle" or "carpool" for travel to school, do you usually drop off your child on your way to work or another destination?

☐ Yes ☐ No ☐ Not applicable

4. How does your child get home FROM school on most days? (choose one)

☐ School Bus ☐ Carpool (with children from other families) ☐ Other (skateboard, scooter, inline skates, etc.)

☐ Bike ☐ Walk

☐ Family Vehicle (only children in your family) ☐ Transit (city bus, subway, etc.)

4a: If you selected "family vehicle" or "carpool" for travel home from school, do you usually pick up your child on your way from work or another location?

☐ Yes ☐ No ☐ Not applicable

5. How many vehicles do you have in your household?

6. How many people in your household have a driver's license?

That's all! Thank You! RP-a

¹⁰ Despite the low response rate in Somerville, exclusive use of the online tool can generate respectable response rates; the Lincoln School in Winchester achieved a response rate of 38% using the online tool, and 35% of students at the Horace Mann school in Newton used the online tool, contributing to their 50% response rate. These results suggest that the low response rates in Somerville may be attributable to limited communication and publicity associated with the district-level survey, not the survey method that was used.

route trips, we estimated the additional increment of VMT that might be attributed to the school commute¹¹. GHG estimates were based on the estimated VMT and included assumptions and adjustments for average fuel efficiency, carpools, cold starts, annual temperature changes, and GHG emissions other than CO2.

MAPC also received partial results from approximately 900 parent surveys conducted by MassRIDES partner schools, geocoded the reported home location, and estimated total mode choice and GHG.

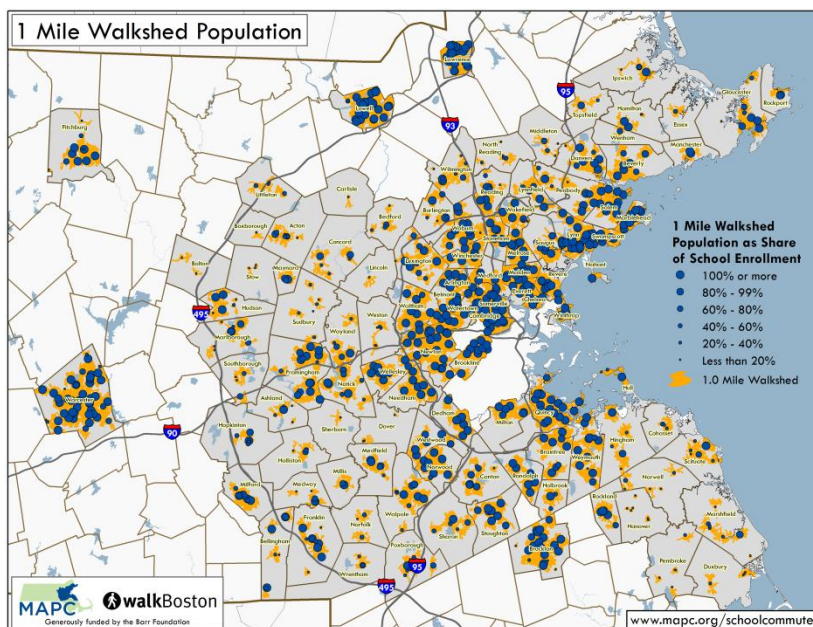
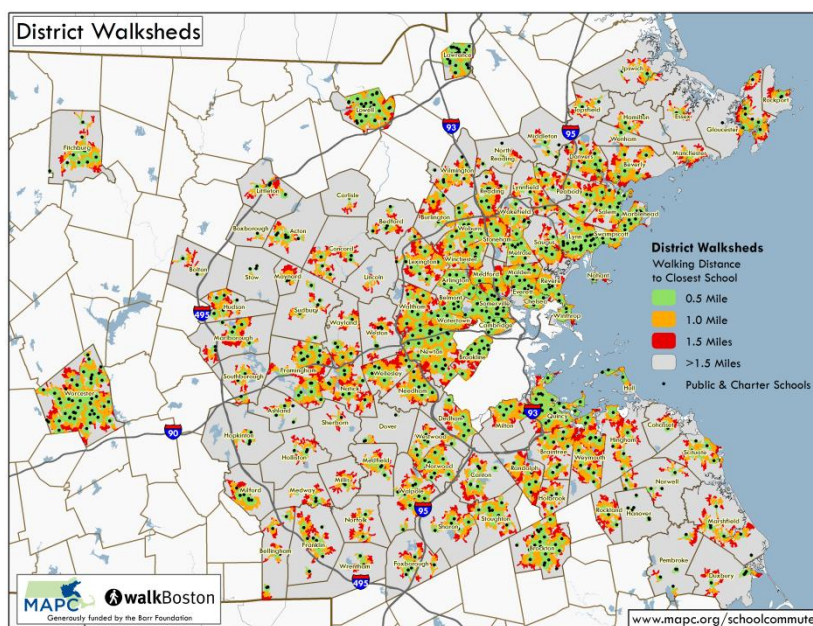
RESULTS

Walkshed Population

The extent of school walksheds, the population within those walksheds, and the resulting likelihood that a child lives within walking distance of a school that he or she can attend varies widely across the region. The map of District Walksheds demonstrates the extensive coverage of walksheds in most urban municipalities and many of the region's higher density suburbs. The less extensive walkshed coverage that exists in most suburban municipalities is a product of three factors: a low density of schools, irregular roadway networks, and inconsistent sidewalk coverage.

At the school level, the number of potential students living nearby varies considerably. In more than one-third of study area schools, the 1 mile walkshed population exceeds enrollment. This includes districts in nearly every in the study area and dozens of Maturing Suburbs as well. Not every child attends the closest school, of course, and some young residents may live in multiple walksheds, but high density areas represent the potential for finding the walk to school “target audience”: students who are living within walking or biking distance from school but who are currently being driven in a private auto.

Meanwhile, there are 240 schools where the 1 mile walkshed population is less than 25% of school enrollment. This is to be expected in the region's low-density Developing Suburbs, but it can also be observed in some Maturing Suburbs and Regional Urban Centers with schools located in remote areas distant from local population centers or isolated by lack of sidewalk infrastructure. In schools



¹¹ These estimates assume that the parent school trip may represent a large dedicated round trip

with a small walkshed population, even a successful walk-to-school program will have limited impact because such a large portion of the school's students live beyond a walkable distance.¹² These "low-accessibility" schools, most of which are elementary and middle schools, comprise 30% of study area schools and more than 37% of total enrollment. The vast majority are elementary and middle schools. There are many high schools with enrollment of more than 1,000 students with 1 mile walkshed population of less than 10%.

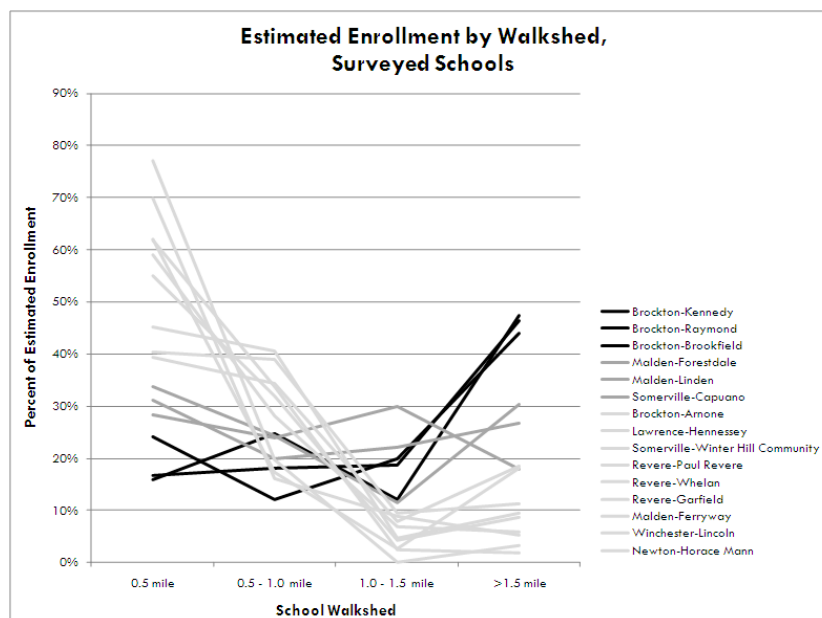
Proximity to School

In the 15 survey schools, we estimate that 44% of students live within 0.5 mile of their school, and 67% live within 1.0 mile. As shown in the graph of estimated enrollment by walkshed, the surveyed schools fall into three general categories:

- Nine schools that have students clustered within the 0.5 mile and 1.0 mile walksheds, with much smaller shares in the 1.5 mile walkshed and beyond. These are the schools with the greatest potential for walk to school programs because most students live near school.
- Three schools where enrollment is dispersed evenly, with 10 – 30% in each walkshed.
- Three schools where most students live further than a mile from school, and more than 40% of students live beyond 1.5 miles from school. Because of the small share of students within walking distance, these schools have the lowest potential for walk to school programs, relative to enrollment.

School assignment policies and school location factor into the observed trends. Both Brockton and Malden have zone-based assignment with an option to attend a different zone. The three Brockton schools with the largest share of students beyond 1.5 miles are located on the periphery of the city's high-density residential neighborhoods, where the walkshed is constrained due to undeveloped land and a circuitous street network. There are fewer estimated children in the 0.5 mile walkshed than there are enrolled in the school.

Contrast this with the Arnone school, which is located very

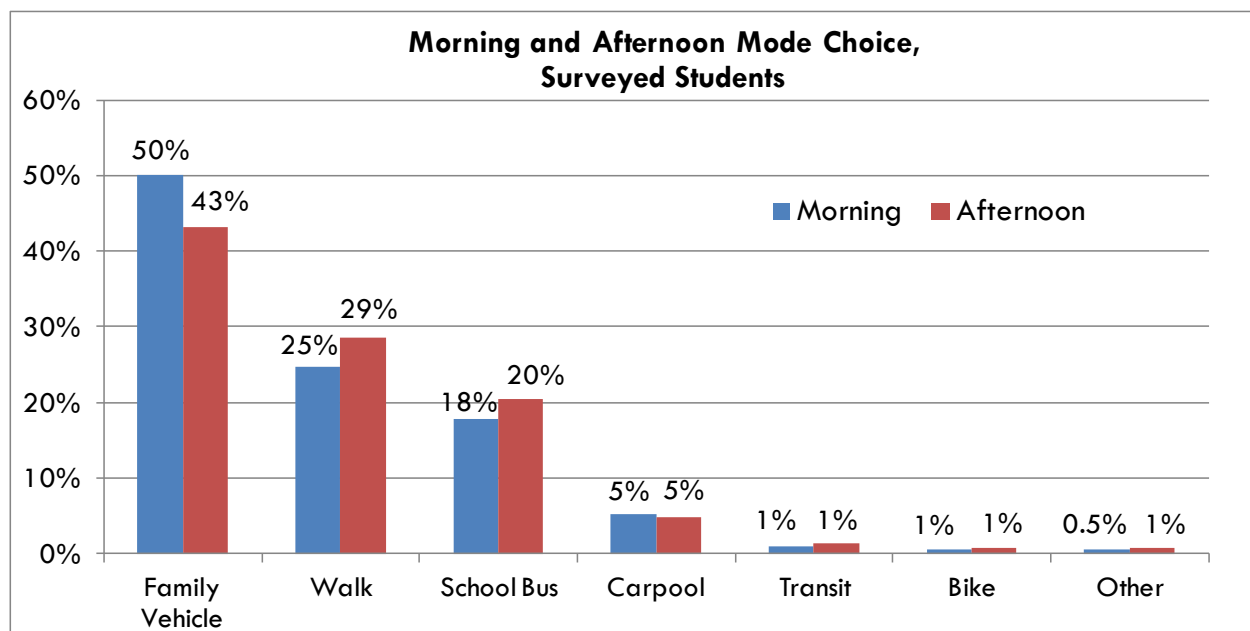


close to the downtown in a high-density residential area with a highly connected street network, with a 0.5 mile walkshed population twice as high as enrollment. All four of these Brockton schools are subject to the same assignment policies, yet have very different patterns of enrollment. Differences in school attractiveness notwithstanding, the Arnone has a greater chance of attracting students from nearby because the proximate school age population is so much higher. Similar patterns can be observed in Malden, where the Forestdale and Linden schools are located at the edge of the city and in an area with poor sidewalk connectivity, respectively. Meanwhile, the Ferryway school is located within a mile of downtown in an area with a highly interconnected sidewalk network.

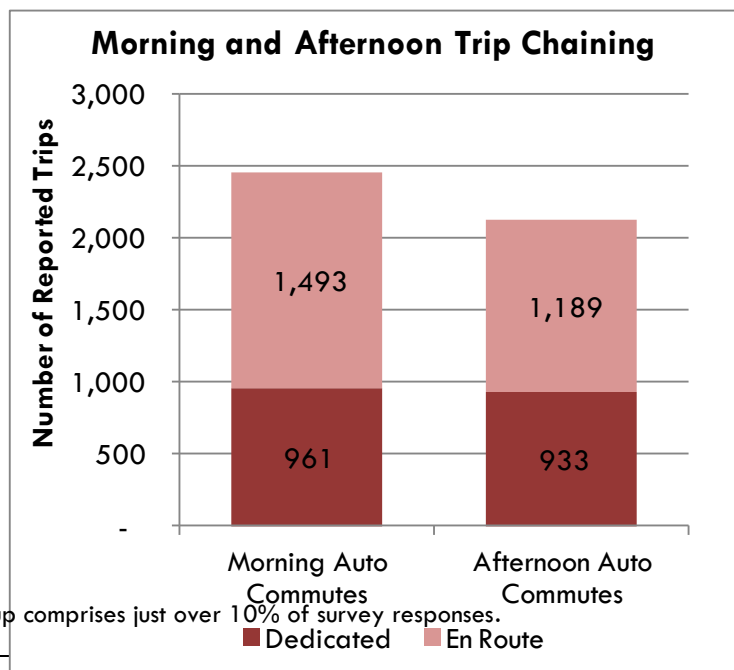
Mode choice

¹² This assessment does not account for increases in the walkshed population that might be created by infrastructure improvements, such as gaps in the sidewalk network. An analysis of walkshed population assuming that all non-highway road segments have sidewalks would indicate whether an apparently small walkshed population is due to poor sidewalk connectivity to nearby residents, or simply lack of such residents.

Auto, walking, and school bus were the dominant modes of travel reported. Of the 9,028 reported trips to and from school reported by students, 51% were made by car (46% family vehicle, 5% carpool.) 27% of trips were made by walking, and 19% by school bus. All other modes each constitute less than 1% of reported trips. The data also show differences in mode choice for the morning and afternoon trips. Family vehicle trips are more common in the morning than in the afternoon (50% versus 43%.) Conversely, walking and school bus trips are more common in the afternoon. Additional charts in Appendix A shows that mode choice patterns vary by age as well. Older students are less likely to travel by car, and more likely to walk, though bus share does not vary appreciably with age. However, the divergence between morning and afternoon mode choice is much more pronounced for older students. Afternoon walk share is 2% higher than morning commutes for Pre-K through 3rd graders, 5% higher for 4th & 5th graders, and 12% higher for 6th – 8th graders¹³. In fact, afternoon walk share is higher than morning auto share for these oldest students, suggesting that the preference for morning auto trips is not driven by distance or inaccessibility, but by convenience, time, or trip chaining.



Trip chaining has a strong influence on the divergence of morning and afternoon mode choice. In the morning, approximately 60% of auto trips (family vehicle and carpool) are made by parents who continue on to work or another destination. There are about 15% fewer reported auto trips in the afternoon, but this difference appears to be the result of fewer parents picking up their children on the way home from work. The number of dedicated auto trips is practically identical for the morning and afternoon commutes, but the number of en route trips is about 20% less in the afternoon. The prevalence of



¹³ Though it should be noted that this oldest group comprises just over 10% of survey responses.

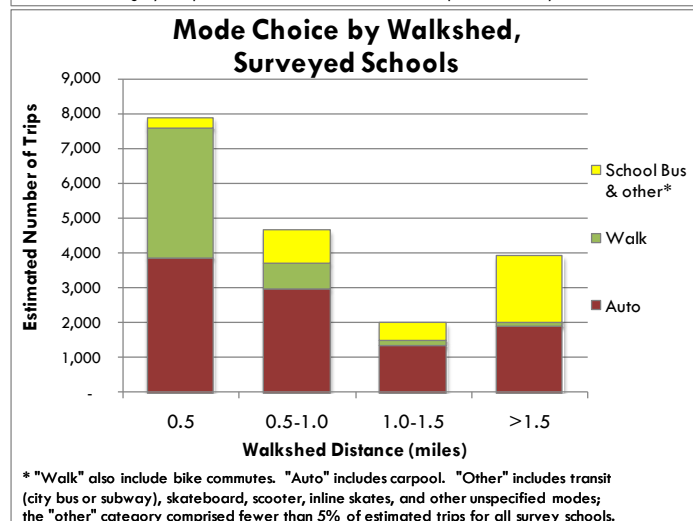
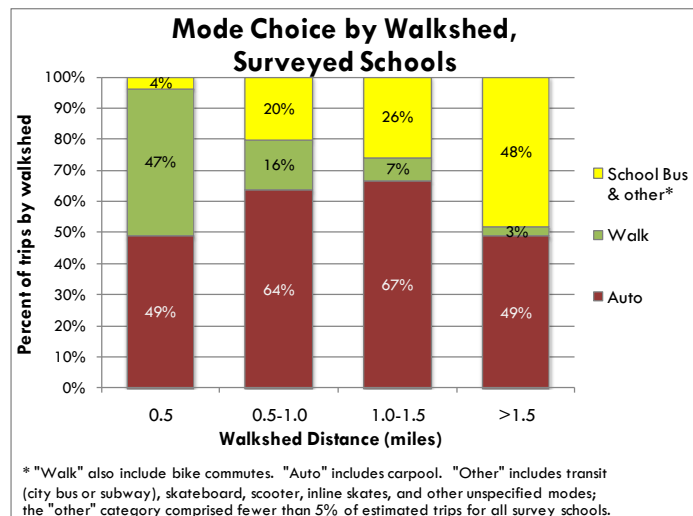
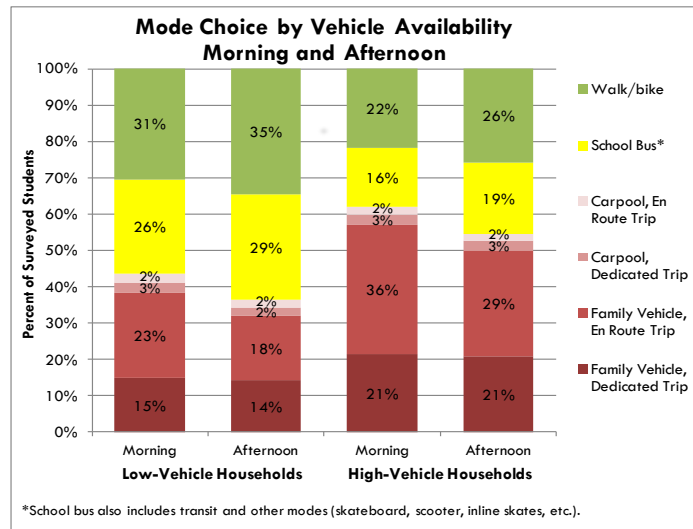
trip chaining does not vary appreciably by walkshed.

Vehicle availability also influences mode choice. One third of the survey responses indicated that there were more licensed drivers than vehicles in the household (24%), or that there were no licensed drivers (9%). In both the morning and the afternoon, students from these households with low vehicle availability are more likely to walk or take the school bus. Both low- and high-vehicle availability households use autos for the afternoon commute less often than the morning commute, and in both cases the differences are a result of fewer auto trips en route from work or another destination.

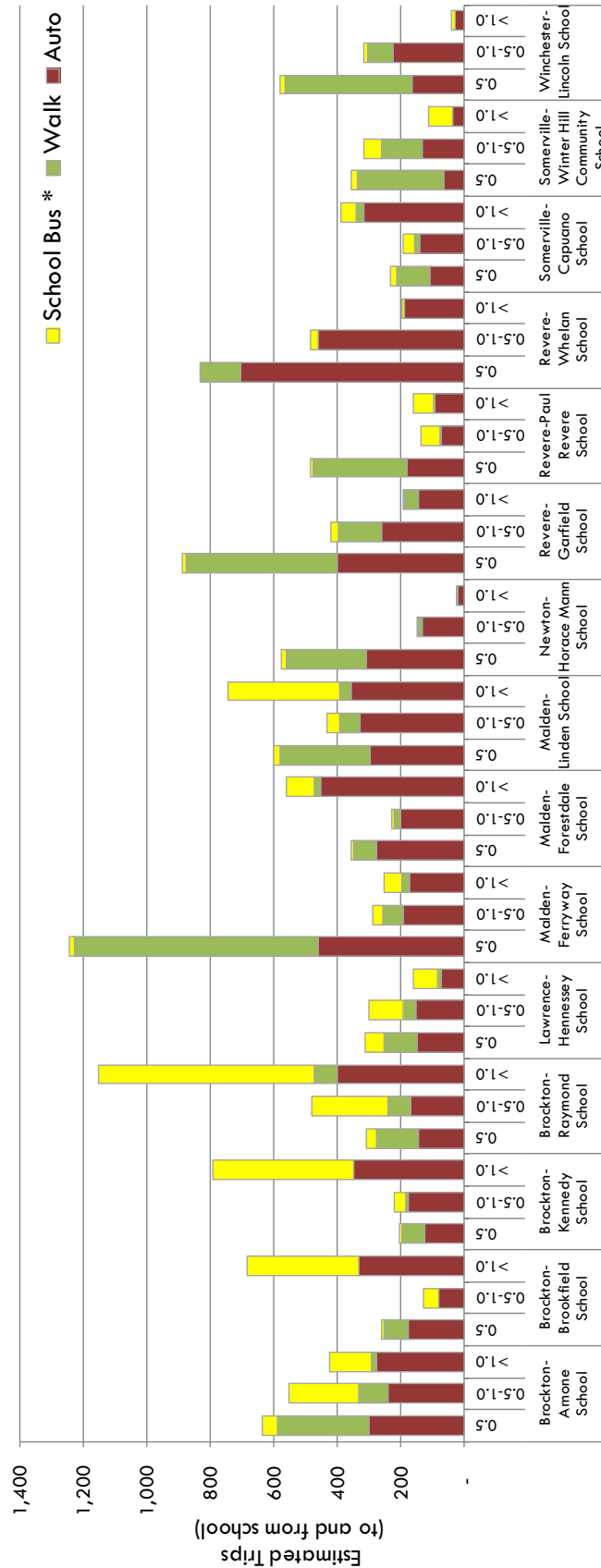
Estimated Trips by Walkshed

Based on the survey results and reported enrollment, MAPC estimated the total number of students living in each walkshed and their mode choice, in order to estimate the total number of trips, associated auto VMT, and resulting GHG, as well as the potential impact of walk to school programs.

Not surprisingly, mode choice varies considerably by walking distance to school. Walk trips comprise 47% of estimated school commutes within the 0.5 mile walkshed, but just 16% of commutes for students living between 0.5 and 1.0 miles. The share of auto commutes peaks between 1.0 and 1.5 miles, beyond the walking distance of most students but close enough that most districts limit the availability of school bus transportation or charge fees for it. These figures show that there are nearly 4,000 auto trips (to or from school) made from within the 0.5 mile walkshed and nearly 3,000 from 0.5 – 1.0 miles.



Total Trips To & From School, by Mode & Walkshed



* School bus share includes transit (city bus or subway), skateboards, scooter, inline skates, and other, which together comprise less than 5% of total trips.

GHG Estimates

This GHG estimation found that auto commutes in the 15 survey schools generate 822 metric tons of CO₂ equivalents each year. The majority of emissions (61%) are generated by students living beyond the 1.0 mile walkshed. Only 14% of emissions are generated by auto commuters living within 0.5 miles, because the trips are so short.

	< = 0.5 mile		0.5- 1.0 mile		>1.0 mile		Total
School	kg	% of total	kg	% of total	kg	% of total	kg
Brockton-Arnone School	18,900	16%	28,000	23%	72,500	61%	119,400
Brockton-Brookfield School	11,500	7%	11,100	7%	138,800	86%	161,400
Brockton-Kennedy School	6,900	5%	21,500	15%	112,500	80%	140,900
Brockton-Raymond School	9,300	6%	21,200	13%	132,800	81%	163,300
Lawrence-Hennessey School	8,400	19%	18,100	41%	18,200	41%	44,700
Malden-Ferryway School	27,300	29%	26,100	27%	41,700	44%	95,000
Malden-Forestdale School	19,800	12%	25,300	15%	126,000	74%	171,000
Malden-Linden School	18,800	10%	48,000	26%	115,500	63%	182,300
Newton-Horace Mann School	18,900	52%	13,600	38%	3,500	10%	36,000
Revere-Garfield School	28,400	27%	35,100	33%	42,900	40%	106,400
Revere-Paul Revere School	10,300	18%	9,700	17%	35,800	64%	55,800
Revere-Whelan School	39,200	23%	74,700	44%	56,800	33%	170,700
Somerville-Capuano School	5,000	4%	21,700	18%	93,900	78%	120,600
Somerville-Winter Hill Community School	4,100	18%	12,800	57%	5,600	25%	22,400
Winchester-Lincoln School	10,700	19%	33,500	60%	11,500	21%	55,600
Grand Total	237,400	14%	400,400	24%	1,007,800	61%	1,645,600

Commuting to school by car is responsible for a measurable share of the average family's total greenhouse gas emissions. Auto commute trips to and from the 15 schools generate an estimated 1,645 metric tons of GHG annually, an average of 329 kg per auto commuter. Depending on the municipality in which this is located, these average commutes would constitute 2% to 8% of an average household's annual emissions¹⁴.

Estimated Emissions and Cost of Auto School Commuting, by Surveyed District				
Municipality	Annual GHG Emissions (kg) per Student Auto Commuter*	Annual Fuel Cost per Student Auto Commuter**	Annual Auto GHG per Household (kgs)	Avg. Student Commutes as a Share of Avg. Household GHG
Brockton	425	\$152	7,196	5.9%
Lawrence	240	\$86	5,611	4.3%
Malden	329	\$113	5,374	6.1%
Newton	157	\$59	7,485	2.1%
Revere	267	\$95	5,572	4.8%
Somerville	369	\$120	4,505	8.2%
Winchester	266	\$95	8,352	3.2%
Source: MassGIS analysis of MA RMV vehicle inspection records, 2005-07; MAPC analysis; MAPC survey, 2011. * Surveyed Schools only, **Assuming Avg. gas price of \$3.70/gal (fuel gauge report)				

¹⁴ It should be noted that these are survey results from a sample of schools considered to have a relatively high walk-to-school potential, by virtue of nearby school-age population and school assignment policies, so should not be considered representative of mode choice or GHG footprint of auto commutes regionwide.

Based on these results, we identified six schools where SRTS programs might have the greatest relative impact on GHG emissions: Brockton Arnone, Malden Ferryway, Malden Forestdale, Newton Horace Mann, Revere Garfield, and Revere Whelan. For these schools, the students in the 0.5 mile walkshed commuting via *dedicated* auto trips (not en route to work) comprise 4.8% of estimated auto GHG for all 15 schools surveyed. If *half* of these students could be shifted to walking, biking, it might reduce emissions by 39,000 kg per year, approximately 2.5% of all auto commute-related GHG emissions for the surveyed schools. If a quarter of the dedicated auto trips for students living in the 0.5 – 1.0 mile walkshed were also shifted to walking or biking, the total GHG reductions amount to over 67,500 kg, or 4% of estimated auto emissions.

Of course, shifting auto trips to walking or biking is only one way to reduce GHG emissions. At schools where the majority of emissions result from students beyond one mile, policies to promote bus usage instead of autos may be an effective strategy to reduce emissions. However, greater bus usage may cost more and may have offsetting emissions impacts.

Challenges

Our effort also identified a variety of resource and information barriers to better assessment of SRTS potential and application of spatially-informed programs. To begin, many schools may not consider SRTS assessments and programs a high priority, given the many other challenges they face. MAPC and WalkBoston experienced significant challenges in getting schools to participate in the survey; we invited 54 schools to participate in the survey and received commitments from just 13 schools and one district.

The complexity of school assignment in Metro Boston is also a considerable challenge to gauging SRTS potential. There are no available standardized datasets regarding school assignment zone boundaries; schools have difficulty estimating the number of students who attend out of zone; and transportation policies vary widely and are rarely documented. As a result, simply assessing the number of students who live within walking distance requires a survey.

DISCUSSION

This analysis demonstrates the substantial variability that exists with regard to school walkability and mode choice, both across regions and within individual districts. At some schools, more than 90% of students live within walking distance, while in others the figure may be less than 5%. Yet despite the profound importance of *location* in school commute mode options, spatial analysis of walk to school potential is rarely incorporated into policy decisions or program planning, due to lack of information as well as the tools necessary to utilize that information. Student addresses collected by school districts are often restricted, rarely geo-located, and provide no information about travel to school mode. School and parent groups generally have only anecdotal and experiential information about walkability. Student commute survey methods either do not collect spatial information or, when they do, such information is rarely utilized. Finally, analysis of school walkability is rarely conducted at the regional or state scales where it can be used to inform more effective allocation of SRTS program resources.

As a result, districts and schools cannot assess the existing walk/bike mode share or set reasonable goals for improvement. District and school level programs have difficulty locating their target audience or assessing what infrastructure improvements or programs would be most effective. State agencies do not have the information needed to prioritize investments based on the potential impact in terms of students affected or auto trips averted.

This research provides a framework for more robust consideration of spatial factors in SRTS activities in Metro Boston and across the U.S. The regional analysis demonstrates that there are many schools and districts where SRTS programs will have a minimal impact on school commute mode choice due to dispersed land use patterns; most school-age children live beyond walking distance of any school and so will be largely unaffected by SRTS programs. While these students may have the most significant transportation and GHG emission impacts in the region, the potential for shifting to non-motorized modes is slim. Meanwhile, there are many urban and near-suburban districts where schools are surrounded by a dense population of school-age children and those children live within walking distance of multiple schools. Even

acknowledging complex assignment policies, it is in these districts where SRTS programs will reach their largest audience and where the walking/biking students have the potential to comprise a substantial share of the student body. Our survey results indicate that walk/bike mode shares of more than 30% exist only where at least 70% of the student body lives within the one mile walkshed. While safety or social equity may be important concerns, state investments in SRTS programs should be prioritized for schools and districts with high student proximity if they are to maximize impact on mode choice.

The survey result maps in Appendix B tell complex and detailed stories about school commutes at each of the participating schools, and these stories may help to inform local program design. Clusters of students who walk or bike may serve as the nucleus for a walking school bus program; and areas where most students are driven short distances may indicate infrastructure deficiencies that could be remedied. The results of the survey also provide information about how many students are walking to school in comparison to those who could be walking; and the walkshed enrollment estimates from the survey can provide a benchmark against which to establish goals for walking and biking. Taken together, the online survey tool and supporting analysis provide the framework for a rapid assessment tool that schools can use to evaluate current travel patterns and estimate the potential for improvement. The product of such a tool would be the walkshed maps with survey responses, estimates of mode choice by walkshed, and estimated GHG emissions. The most efficient method for implementing such a tool would be a web-only survey that largely eliminates the need for manual data and geocoding. Concerns about inequitable internet access or capacity could be addressed by having laptops or ipads for data collection at school events or parent-teacher conferences. Additional investments in the website could create the functionality for school/district users to initiate a survey, collect responses, generate reports, and download raw data. In the meantime, analysis of data and report generation is likely to require 10 - 15 hours of MAPC staff time per survey instance.

The survey results also demonstrate the significant and challenging connection between school commute and parent commute mode choice. For more than 60% of students who are driven to school, their parent or driver continues on to work or another destination. For these students, shifting school commutes to parent-accompanied walking or biking may place a burden on morning routines; and it may have negligible impacts on traffic or GHG emissions if the parent drives to work anyway. On the other hand, data was not collected that would allow an assessment of whether journey-to-school choices or journey-to-work choices are underlying the trip chain, and it could be that shifting the journey-to-school would shift parent trips to other modes. There are 20% fewer chained auto trips during the afternoon commute as compared to the morning, indicating that many students who are dropped off on the way to work could get to school by another mode.

This research demonstrates the complex spatial, infrastructure, and household travel demand factors that influence school commute mode choice. Our particular interest in GHG emissions and sustainability also suggests the need for strategies broader than the conventional SRTS focus on safety and attitudinal barriers to active modes of transportation. A more comprehensive transportation demand management approach that also incorporates bus usage and carpooling is needed to achieve the substantial benefits of mode shift among students who live beyond a reasonable walking distance. This research has outlined a new set of analytical tools to help understand school commutes; and our findings suggest that the success of SRTS programs will benefit from greater integration with transportation demand management programs, transportation planning, and land use planning.

APPENDIX A - FIGURES

Figure A1: Walk Network Examples

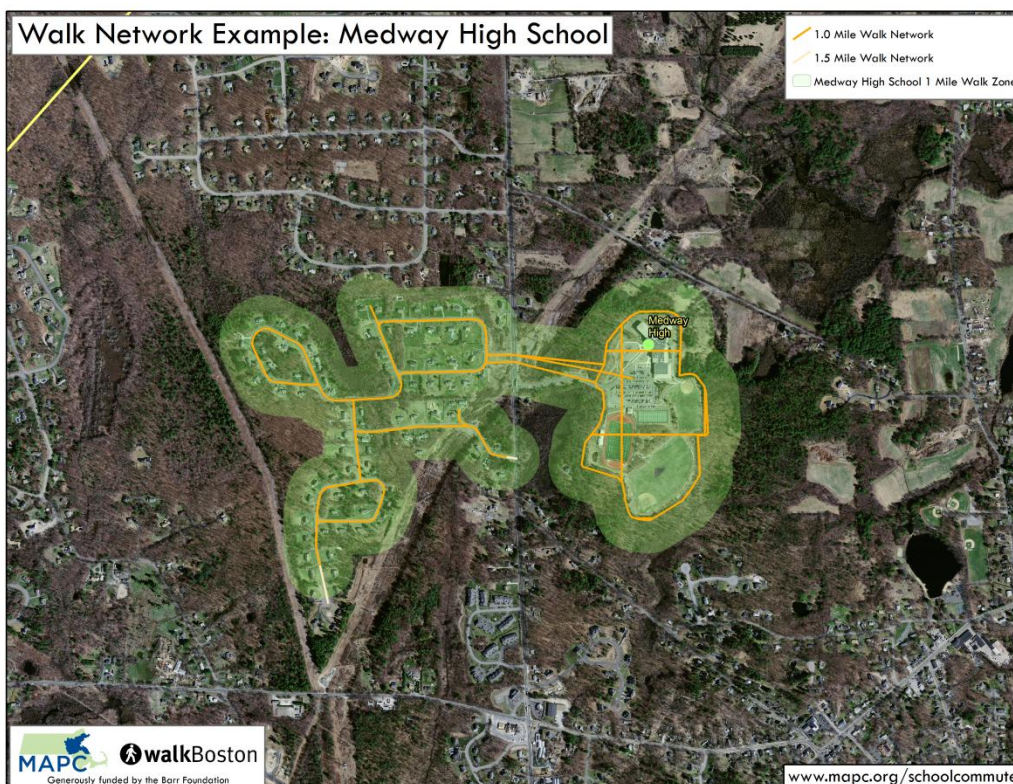
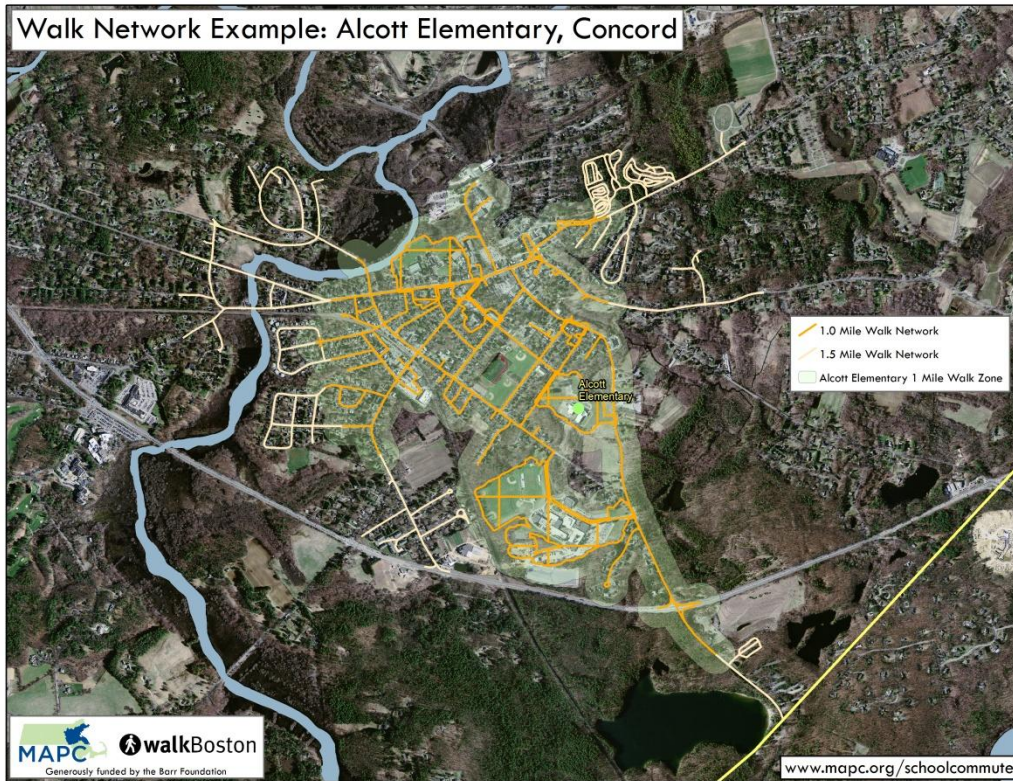


Table A1: Survey Response Rate by School and Format

School	Enrollment 2010 - 11	Number of Surveys Returned	Response Rate	Percent online survey
Brockton-Arnone School	807	244	30%	3%
Brockton-Brookfield School	536	219	41%	0%
Brockton-Kennedy School	608	373	61%	0%
Brockton-Raymond School	971	681	70%	0%
Lawrence-Hennessey School	388	299	77%	0%
Malden-Ferryway School	892	577	65%	1%
Malden-Forestdale School	572	232	41%	24%
Malden-Linden School	888	474	53%	1%
Newton-Horace Mann School	374	188	50%	70%
Revere-Garfield School	751	413	55%	1%
Revere-Paul Revere School	389	374	96%	1%
Revere-Whelan School	757	74	10%	58%
Somerville-Capitano School	406	73	18%	100%
Somerville-Winter Hill Community School	392	49	13%	100%
Winchester-Lincoln School	469	176	38%	100%
Total	9,200	4,446	48%	12%

Figure A2: Reported mode by grade clusters, PreK – 3rd

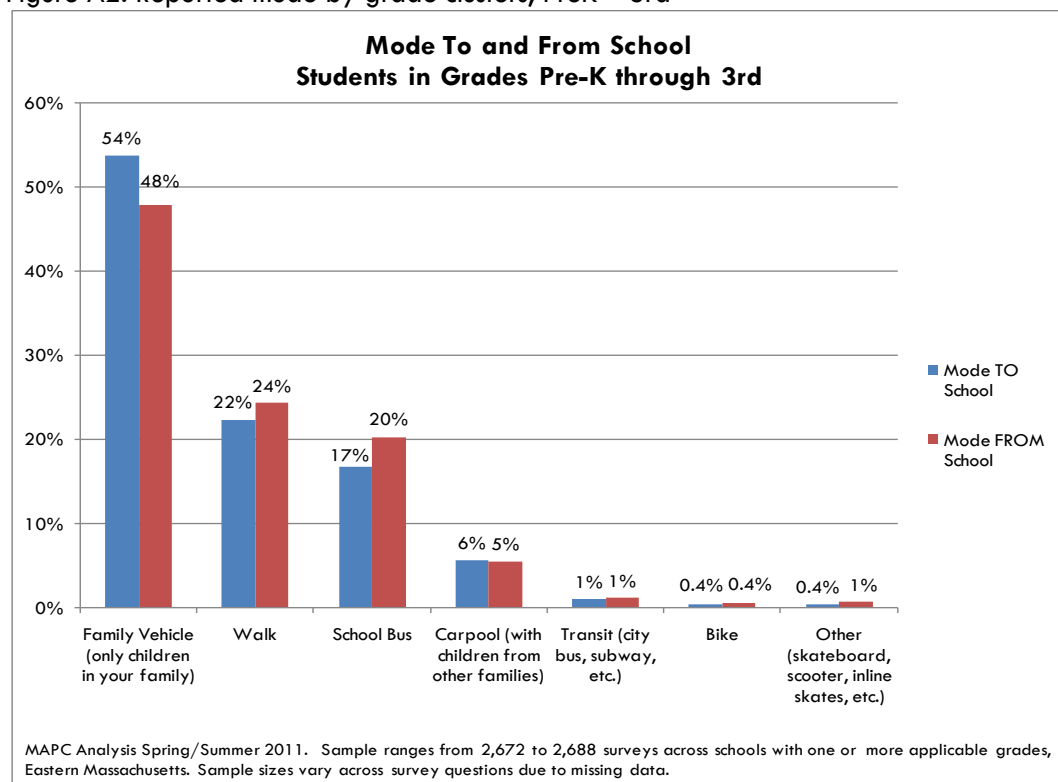


Figure A3: Reported mode by grade clusters, 4th & 5th

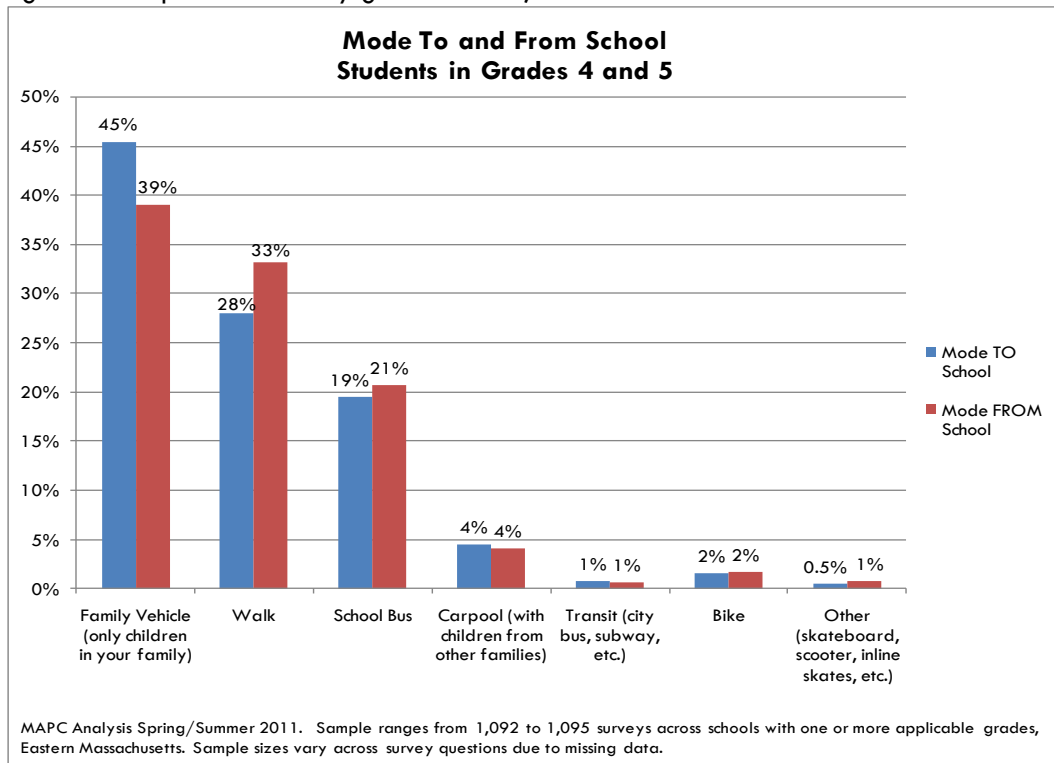
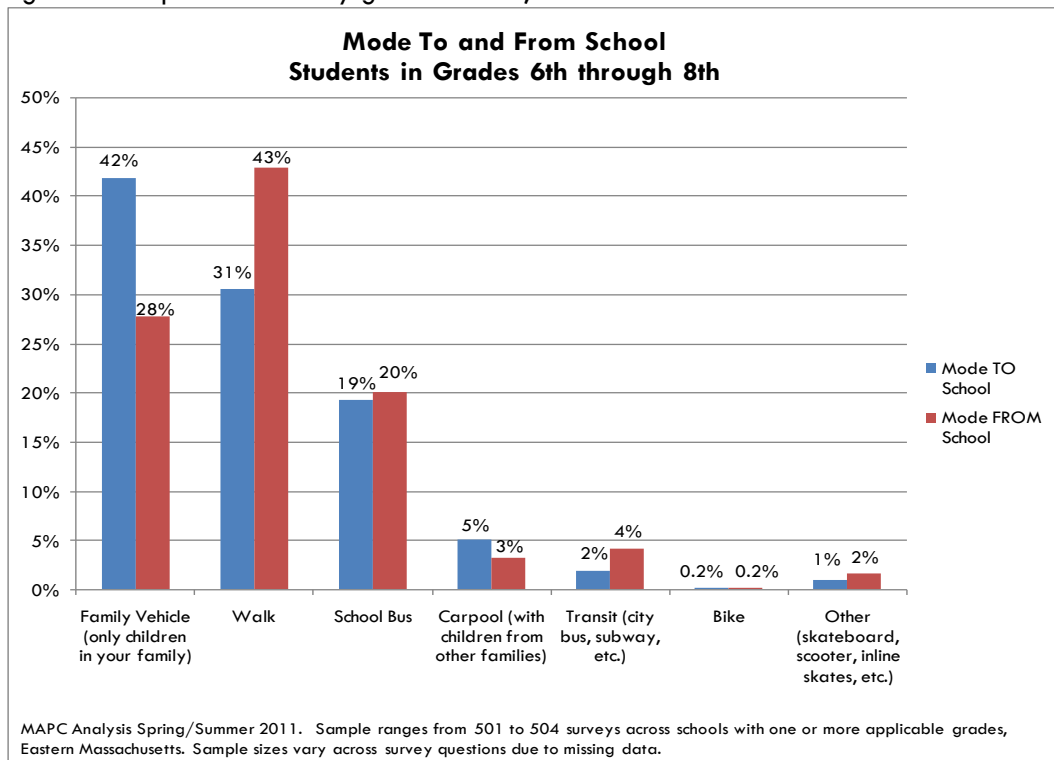


Figure A4: Reported mode by grade clusters, 6th – 8th

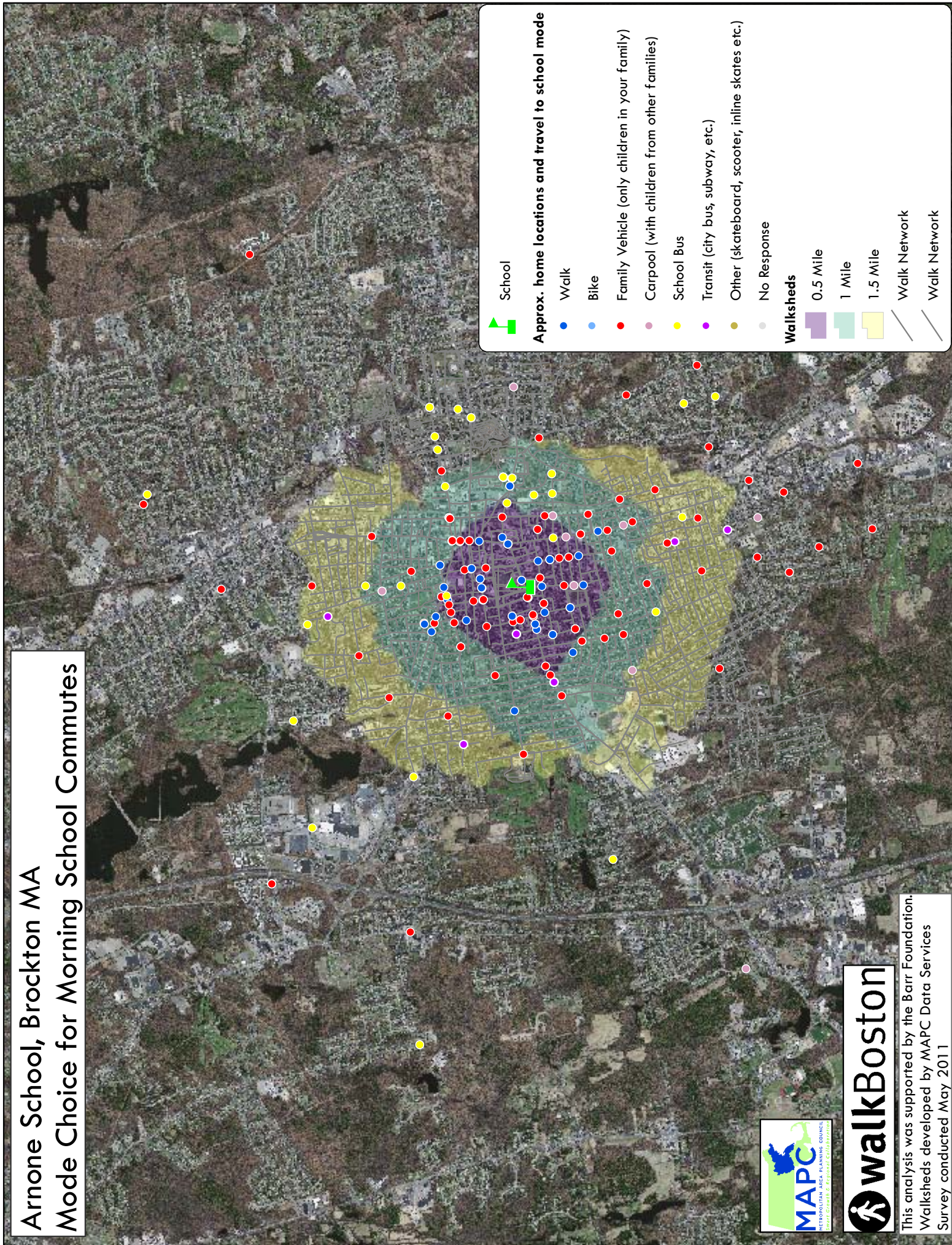


Trip Chaining Survey Results, by school; auto and carpool trips only						
School	Morning Commute			Afternoon Commute		
	Dedicated Auto Trips	En Route Auto Trips	Percent En Route	Dedicated Auto Trips	En Route Auto Trips	Percent En Route
Brockton-Arnone School	52	88	63%	43	68	61%
Brockton-Brookfield School	60	75	56%	60	55	48%
Brockton-Kennedy School	72	147	67%	92	104	53%
Brockton-Raymond School	124	170	58%	86	153	64%
Lawrence-Hennessey School	58	100	63%	55	76	58%
Malden-Ferryway School	106	217	67%	86	134	61%
Malden-Forestdale School	72	120	63%	78	101	56%
Malden-Linden School	135	140	51%	120	127	51%
Newton-Horace Mann School	22	84	79%	41	82	67%
Revere-Garfield School	114	107	48%	111	105	49%
Revere-Paul Revere School	70	103	60%	56	90	62%
Revere-Whelan School	26	39	60%	29	37	56%
Somerville-Capitano School	16	33	67%	25	21	46%
Somerville-Winter Hill Community School	6	19	76%	4	5	56%
Winchester-Lincoln School	28	51	65%	47	31	40%
All Survey Responses	961	1,493	61%	933	1,189	56%

APPENDIX B: MAPS OF SURVEY RESPONSES


Brockton - Arnone School
Brockton - Brookfield School
Brockton - Kennedy School
Brockton - Raymond School
Lawrence - Hennessey School
Malden - Ferryway School
Malden - Forestdale School
Malden - Linden School
Newton - Horace Mann School
Revere - Garfield School
Revere - Paul Revere School
Revere - Whelan School
Somerville - Capuano School
Somerville - Winter Hill Community School
Winchester - Lincoln School

Arnone School, Brockton MA Mode Choice for Morning School Commutes





This analysis was supported by the Barr Foundation.
 Walksheds developed by MAPC Data Services
 Survey conducted May 2011


Brookfield School, Brockton MA Mode Choice for Morning School Commutes



School


Approx. home locations and travel to school mode



Walk



Bike



Family Vehicle (only children in your family)


Carpool (with children from other families)



School Bus



Transit (city bus, subway, etc.)



Other (skateboard, scooter, inline skates etc.)



No Response

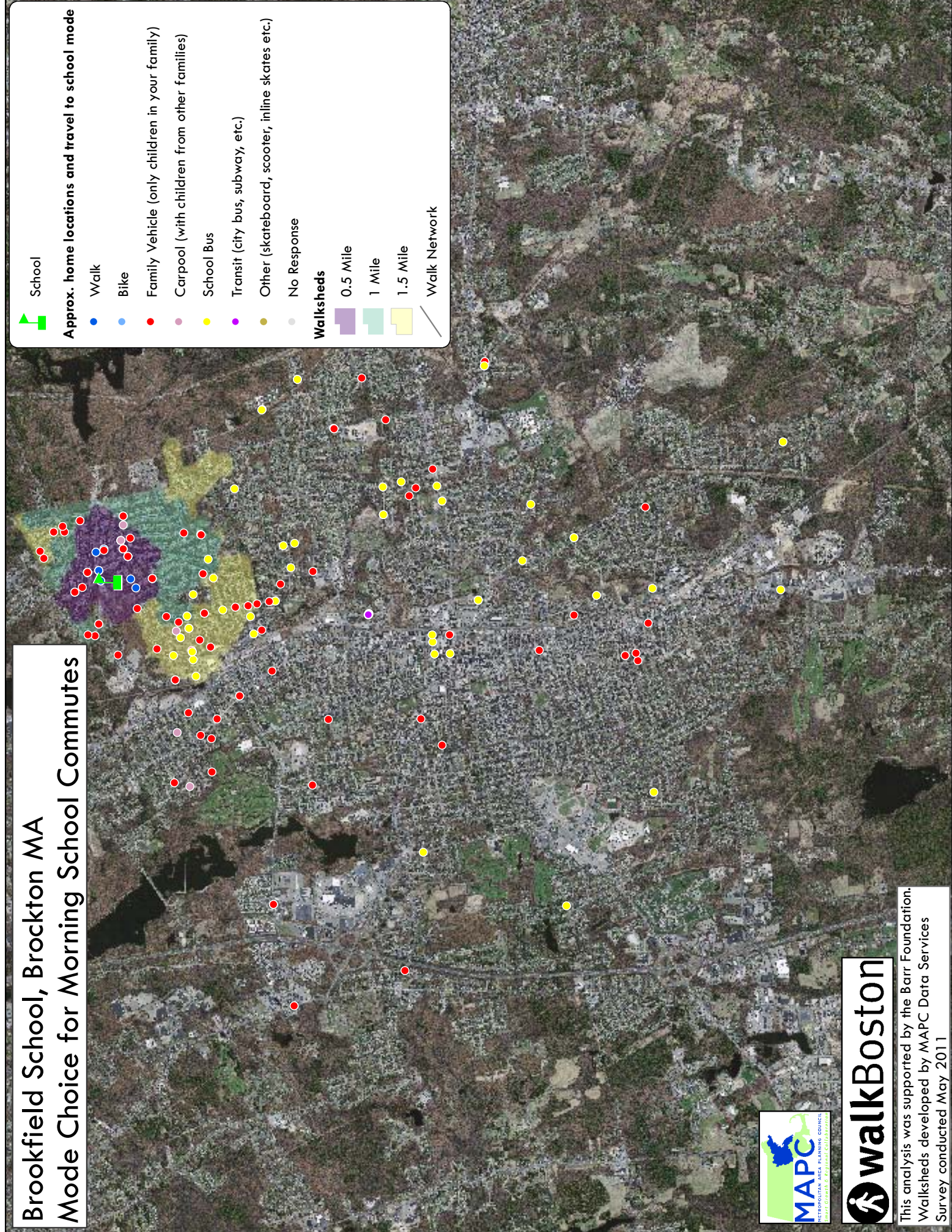
Walksheds


0.5 Mile


1 Mile


1.5 Mile

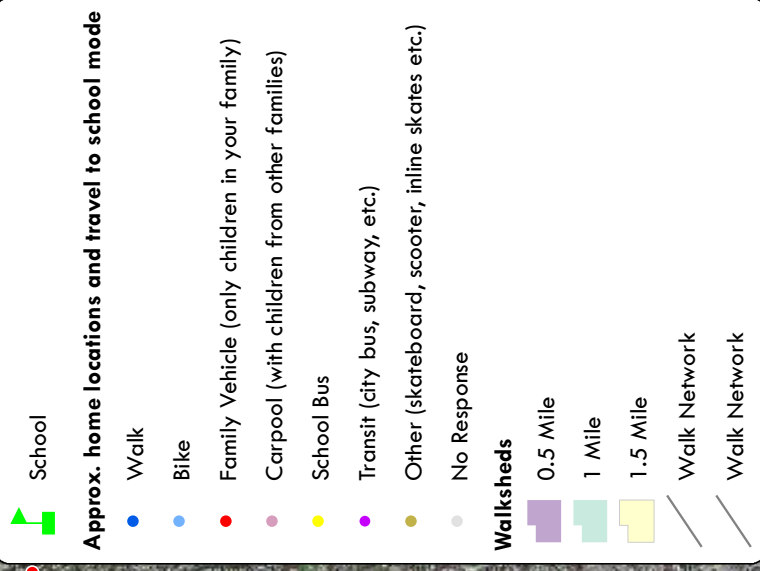

Walk Network



This analysis was supported by the Barr Foundation.
 Walksheds developed by MAPC Data Services
 Survey conducted May 2011

Kennedy School, Brockton MA

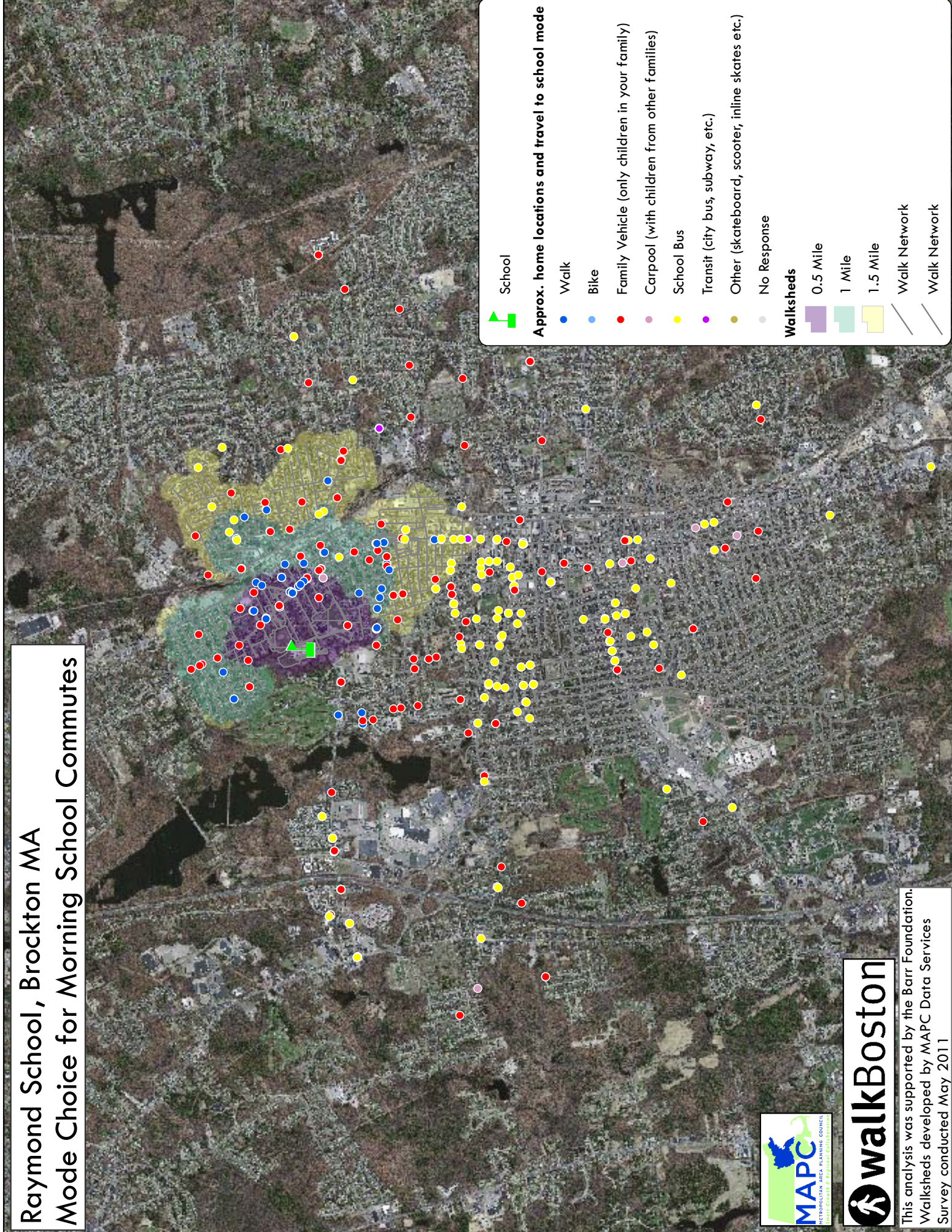
Mode Choice for Morning School Commutes



This analysis was supported by the Barr Foundation.
 Walksheds developed by MAPC Data Services
 Survey conducted May 2011

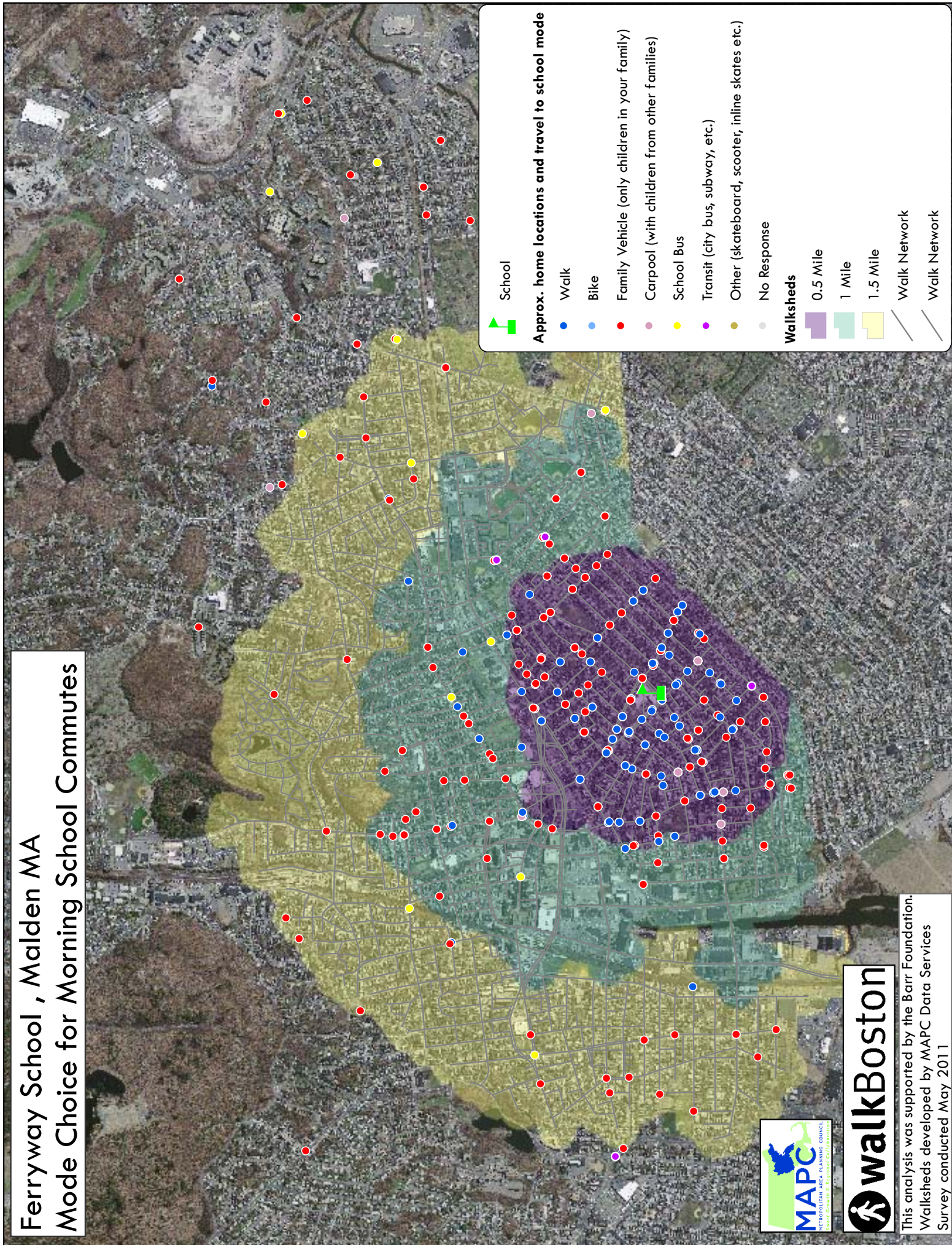
Raymond School, Brockton MA

Mode Choice for Morning School Commutes



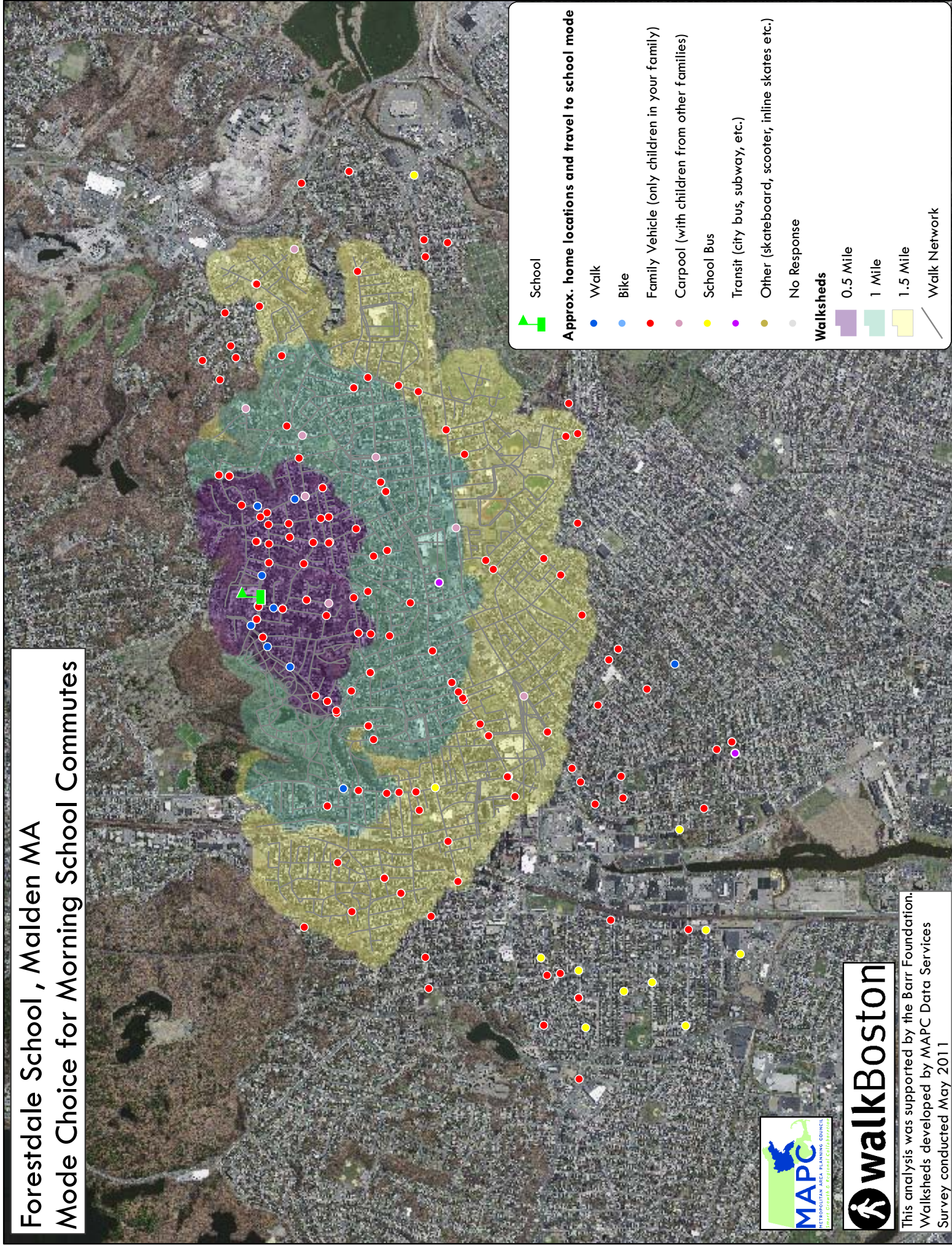
This analysis was supported by the Barr Foundation.
Walksheds developed by MAPC Data Services
Survey conducted May 2011

Ferryway School , Malden MA Mode Choice for Morning School Commutes



This analysis was supported by the Barr Foundation.
Walksheds developed by MAPC Data Services
Survey conducted May 2011

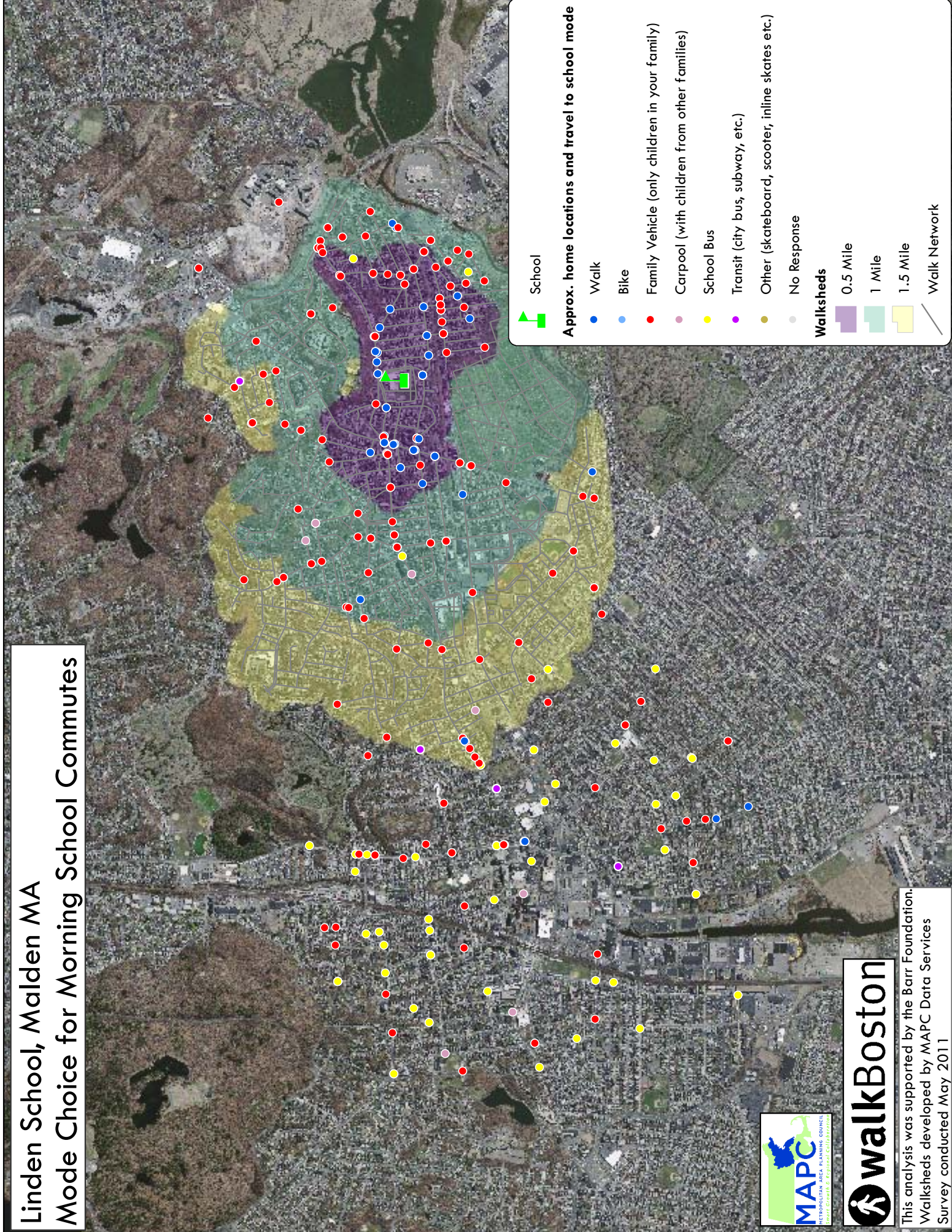
Forestdale School , Malden MA Mode Choice for Morning School Commutes



This analysis was supported by the Barr Foundation.
 Walksheds developed by MAPC Data Services
 Survey conducted May 2011

Linden School, Malden MA

Mode Choice for Morning School Commutes



School

Approx. home locations and travel to school mode

Walk

Bike

Family Vehicle (only children in your family)

Carpool (with children from other families)

School Bus

Transit (city bus, subway, etc.)

Other (skateboard, scooter, inline skates etc.)

No Response

Walksheds

0.5 Mile

1 Mile

1.5 Mile

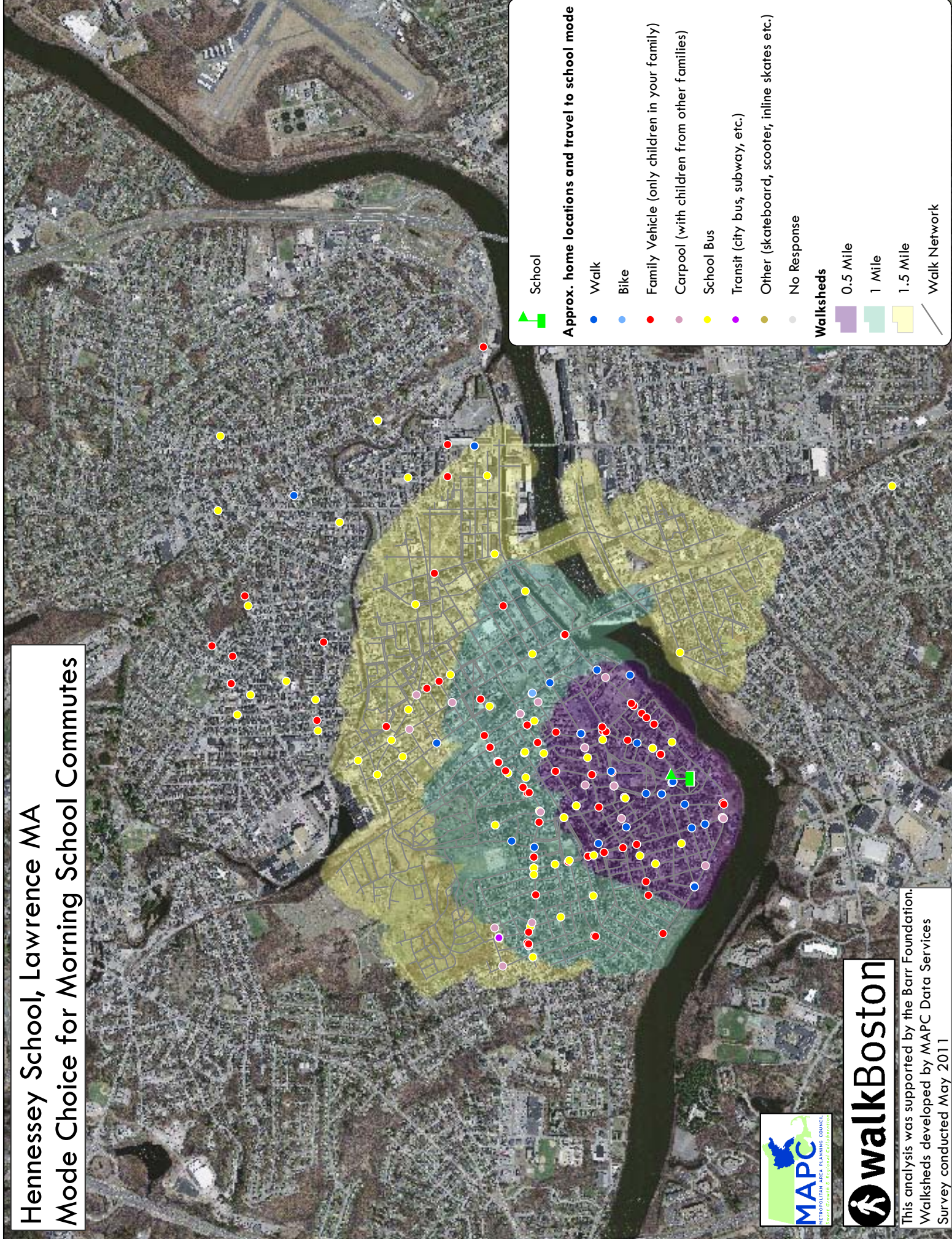
Walk Network



This analysis was supported by the Barr Foundation.
 Walksheds developed by MAPC Data Services
 Survey conducted May 2011

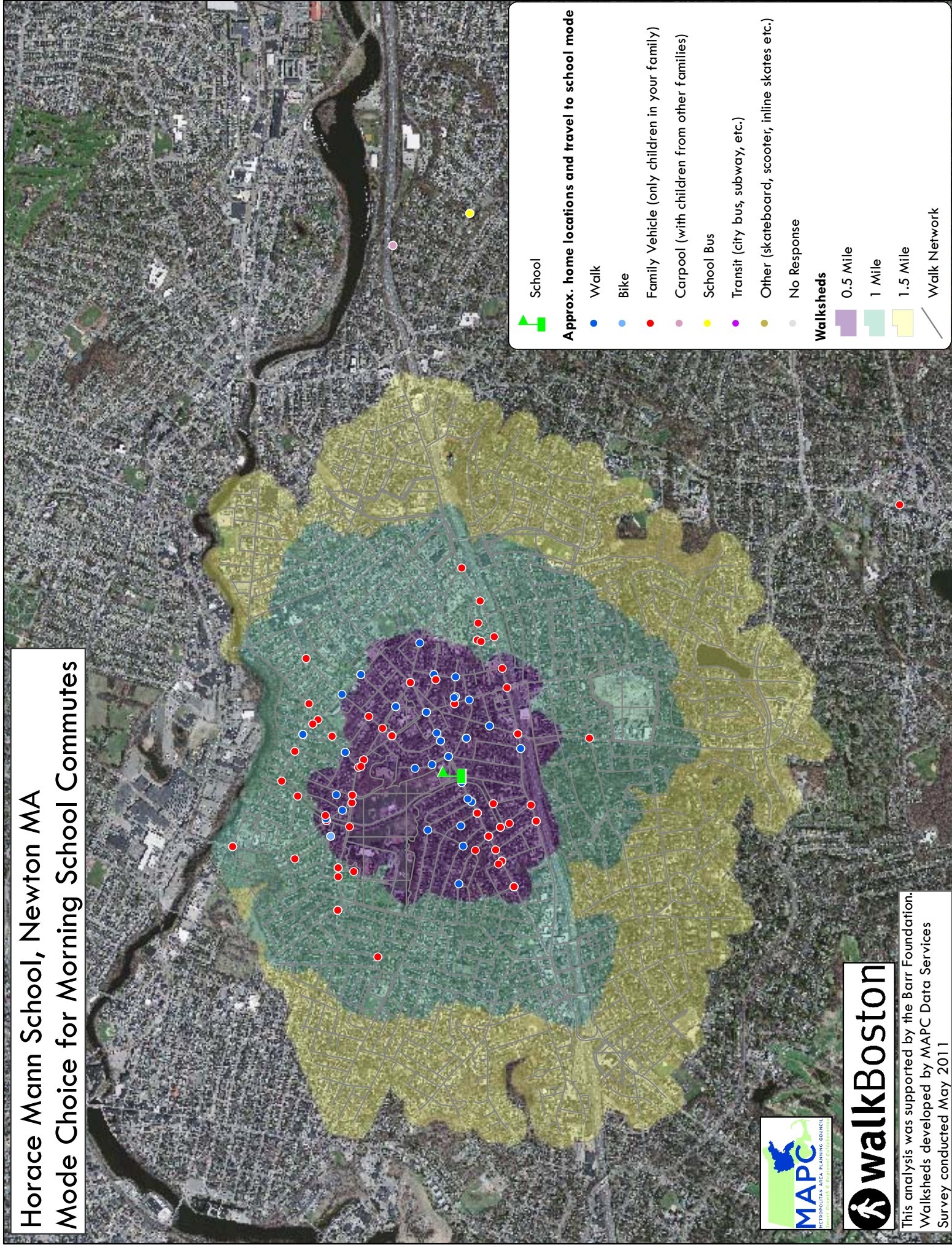
Hennessey School, Lawrence MA

Mode Choice for Morning School Commutes



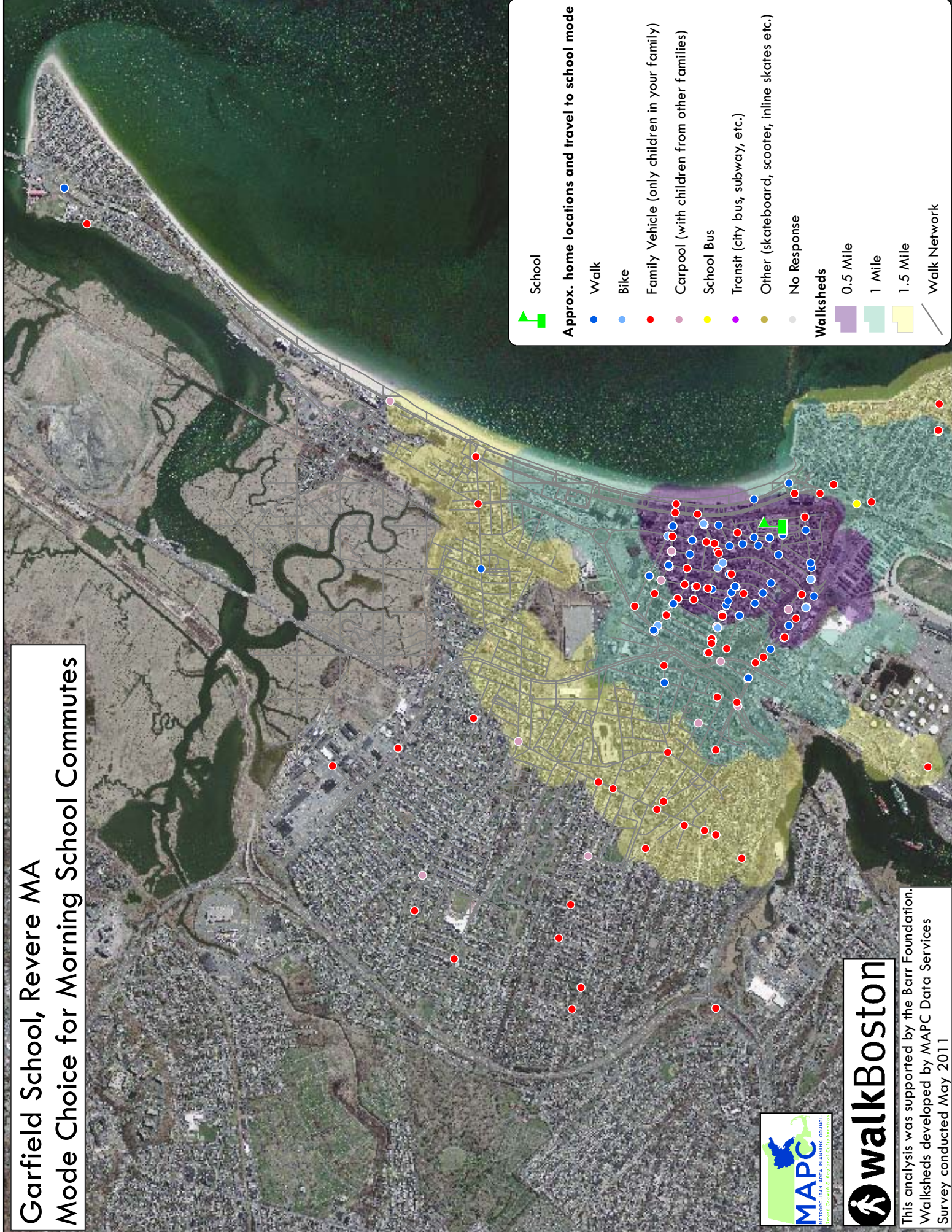
This analysis was supported by the Barr Foundation.
Walksheds developed by MAPC Data Services
Survey conducted May 2011

Horace Mann School, Newton MA Mode Choice for Morning School Commutes



This analysis was supported by the Barr Foundation.
 Walksheds developed by MAPC Data Services
 Survey conducted May 2011

Garfield School, Revere MA Mode Choice for Morning School Commutes



School

Approx. home locations and travel to school mode

Walk

Bike

Family Vehicle (only children in your family)

Carpool (with children from other families)

School Bus

Transit (city bus, subway, etc.)

Other (skateboard, scooter, inline skates etc.)

No Response

Walksheds

0.5 Mile

1 Mile

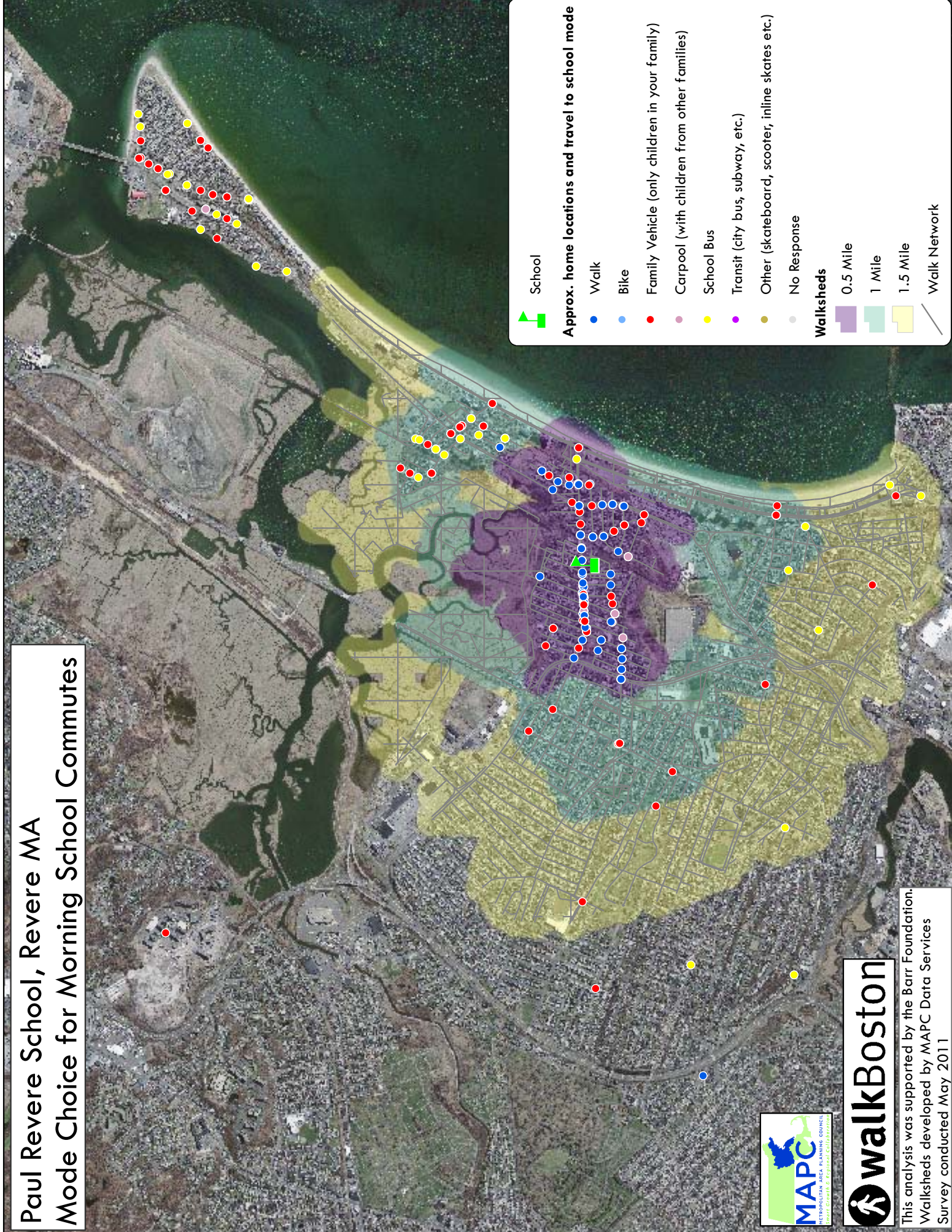
1.5 Mile

Walk Network



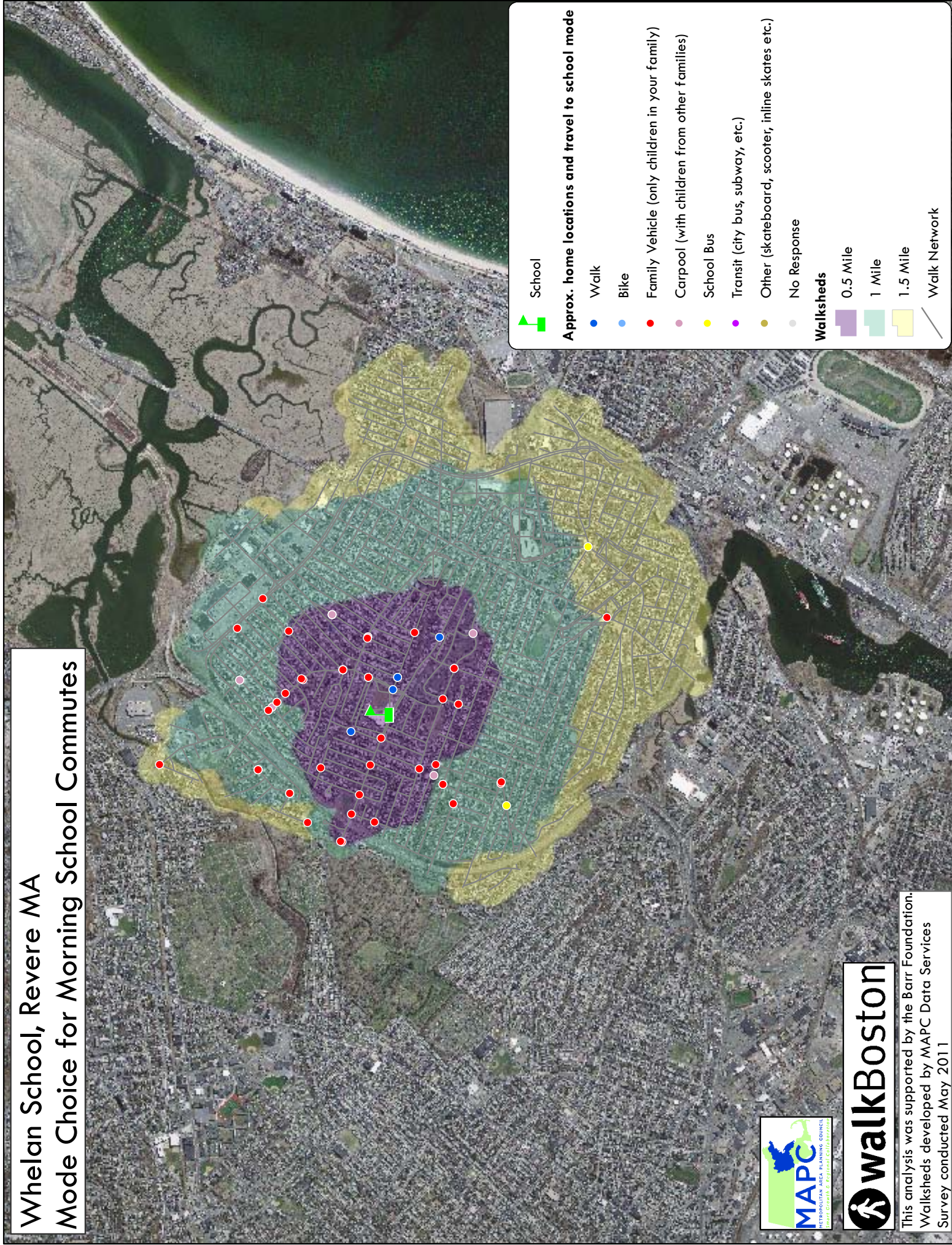
This analysis was supported by the Barr Foundation.
Walksheds developed by MAPC Data Services
Survey conducted May 2011

Paul Revere School, Revere MA Mode Choice for Morning School Commutes



This analysis was supported by the Barr Foundation.
Walksheds developed by MAPC Data Services
Survey conducted May 2011

Whelan School, Revere MA Mode Choice for Morning School Commutes



School

Approx. home locations and travel to school mode

- Walk
- Bike
- Family Vehicle (only children in your family)
- Carpool (with children from other families)
- School Bus
- Transit (city bus, subway, etc.)
- Other (skateboard, scooter, inline skates etc.)
- No Response

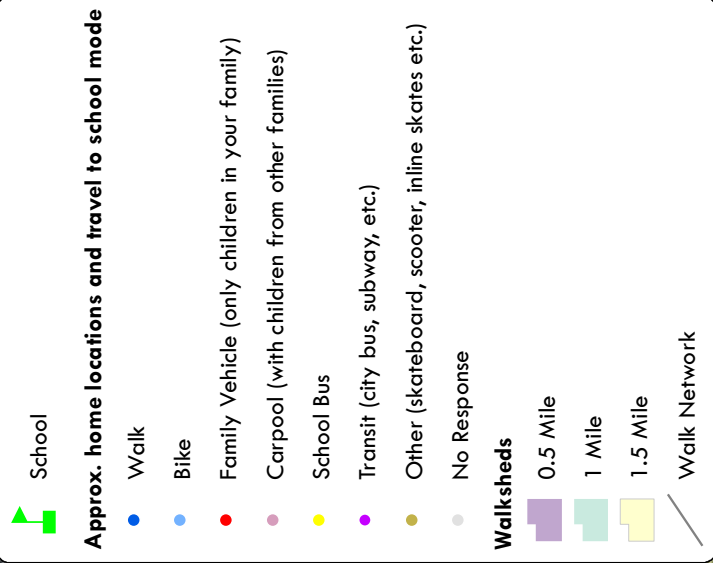
Walksheds

- 0.5 Mile
- 1 Mile
- 1.5 Mile
- Walk Network



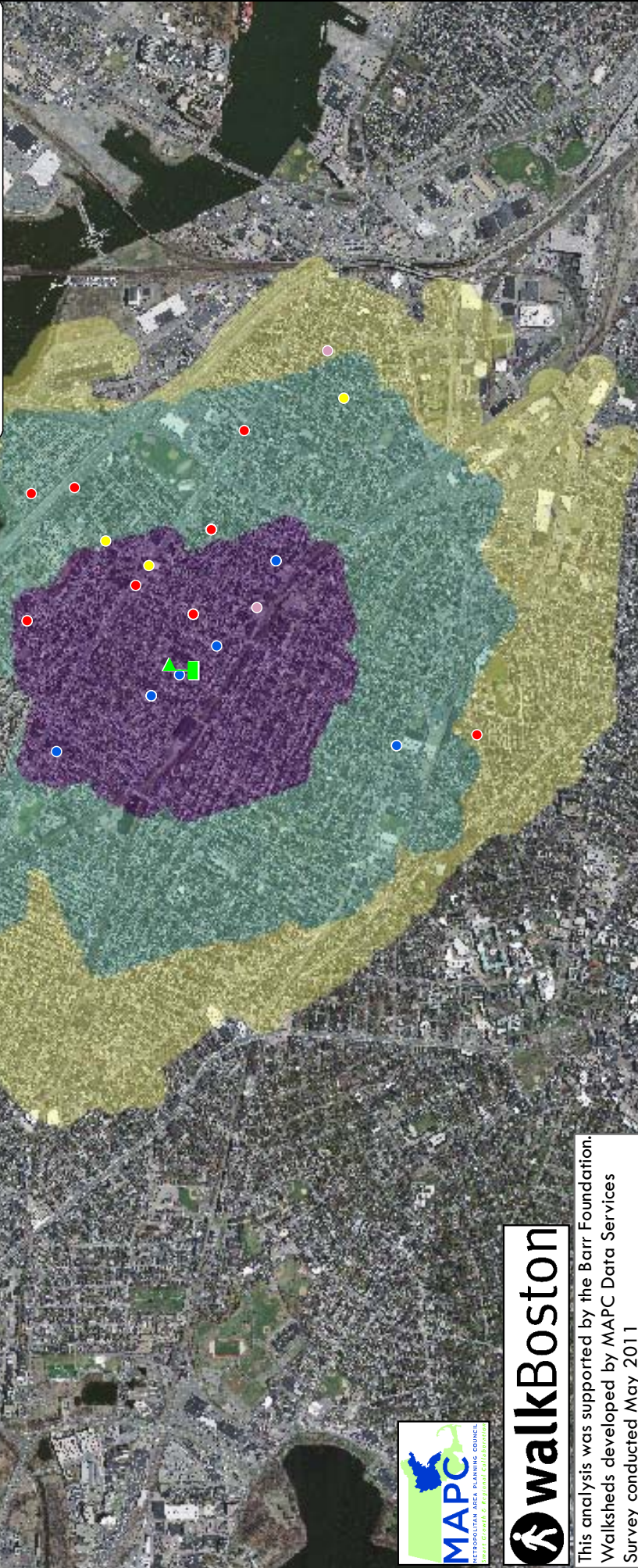
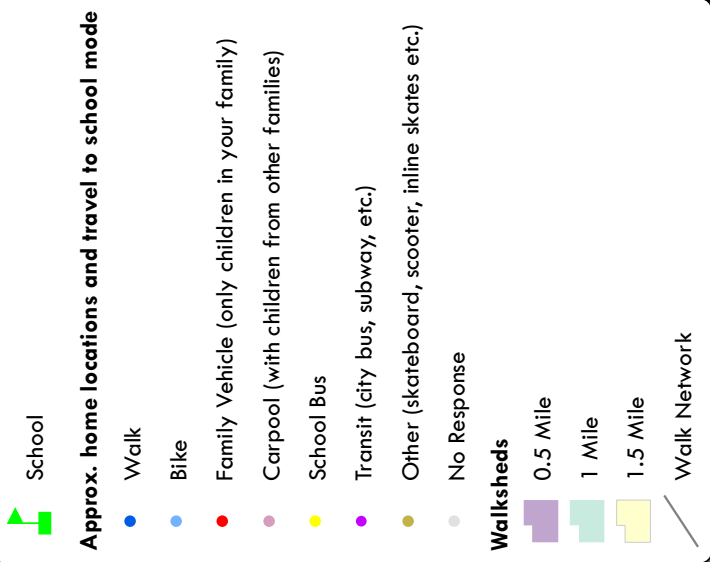
This analysis was supported by the Barr Foundation.
Walksheds developed by MAPC Data Services
Survey conducted May 2011

Capuano School, Somerville MA Mode Choice for Morning School Commutes



This analysis was supported by the Barr Foundation.
 Walksheds developed by MAPC Data Services
 Survey conducted May 2011

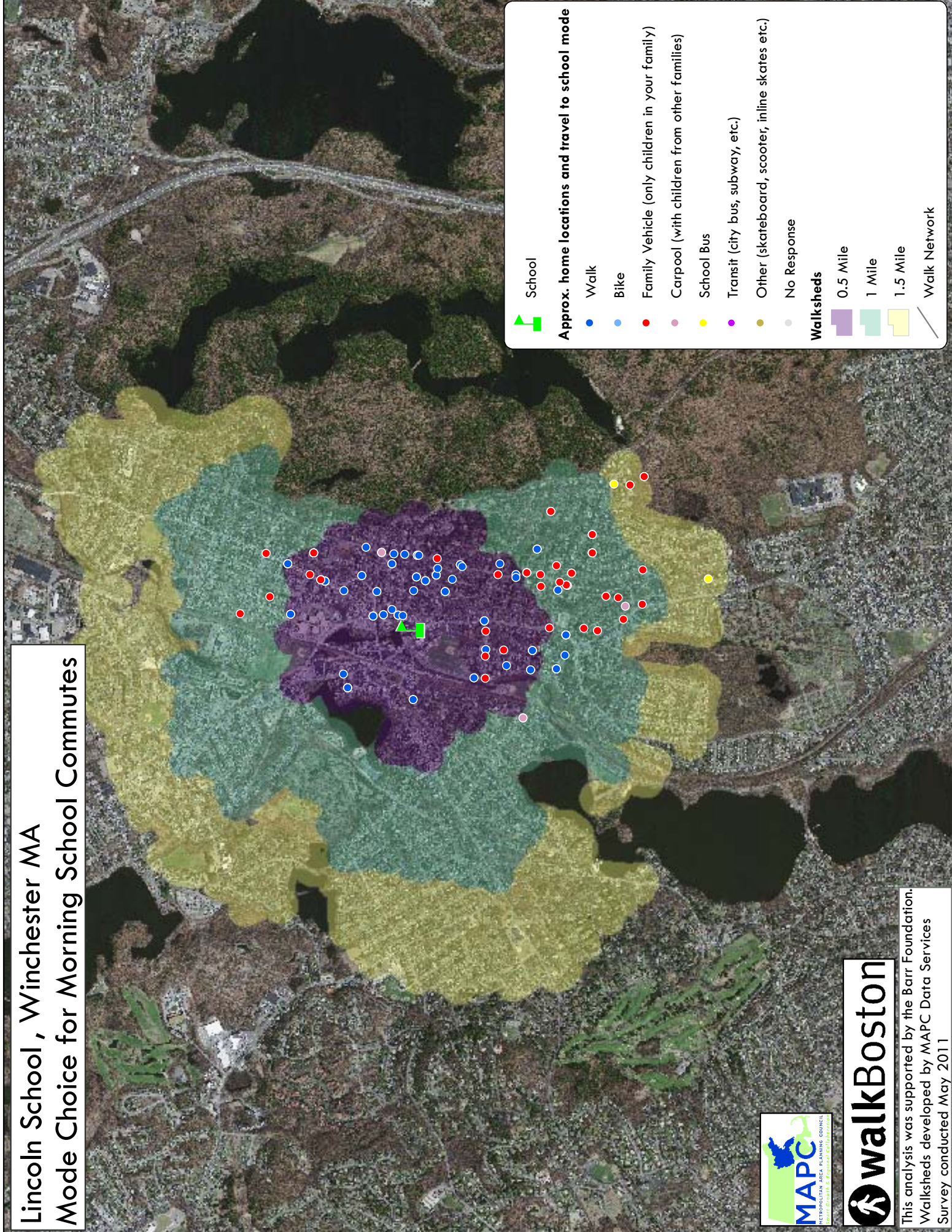
Winter Hill Community School, Somerville MA Mode Choice for Morning School Commutes



This analysis was supported by the Barr Foundation.
 Walksheds developed by MAPC Data Services
 Survey conducted May 2011

Lincoln School , Winchester MA

Mode Choice for Morning School Commutes



School

Approx. home locations and travel to school mode

Walk

Bike

Family Vehicle (only children in your family)

Carpool (with children from other families)

School Bus

Transit (city bus, subway, etc.)

Other (skateboard, scooter, inline skates etc.)

No Response

Walksheds

0.5 Mile

1 Mile

1.5 Mile

Walk Network



This analysis was supported by the Barr Foundation.
 Walksheds developed by MAPC Data Services
 Survey conducted May 2011

APPENDIX C: TECHNICAL NOTES

School Locations, Pedestrian Network and Walksheds

The location of each public school in the study area was mapped using the “Schools” layer published by MassGIS. Locations were confirmed by MAPC staff and adjusted as necessary to reflect the current location of the school building. The 799 schools have a combined enrollment of 438,000. Each school point has a unique ID that can be linked to school-level enrollment, achievement, and demographic data available from MassDOE. District-level data are from the 2010 – 2011 school year. To simplify the analysis, regional school districts were not mapped; schools are analyzed within their host municipality and school-level statistics are summed to the municipal level. Different schools within a regional school district might be summarized in different municipalities.

The pedestrian network used for the walkshed includes three components: roadways with sidewalks on one or both sides, low-volume roadways, and school grounds. Roadways with sidewalks were identified based on the MassDOT roadway inventory published by MassGIS as the “Roads” layer. Any roadway segment with a sidewalk on either or both sides of the road] was included in the walk network. While the accuracy of this data has not been verified, and although the sidewalk data has not been updated since 2004 (if not longer), this remains the most accurate and comprehensive dataset of sidewalks. In addition to roadways with mapped sidewalks, the walking network also includes very low-volume roadways, such as small subdivision roadways or park roadways, where it is possible that children might be able to walk safely within the paved width without the presence of a sidewalk. MAPC selected certain road segments with a MassDOT-estimated ADT (average daily traffic) of less than 1,000 vehicles per day; as well as other minor roadways and included these road segments in the walking network.

The analysis also recognizes that the most direct route for students walking to school may not be via the main roadway into the school—there may be multiple points of entry into the school grounds that students may reasonably use. In order to account for this, MAPC identified school grounds by selecting “urban public” land uses from the 2005 MassGIS land use layer that intersect the point location of a public school. These land uses were merged with a statewide 250m vector grid to create a grid network that approximates a pathway students might use to traverse the school grounds. Finally, the school grounds network was buffered by 25 meters to intersect with nearby streets.

To create a regionwide “walk network,” the roadway segments and other lines created as described above were merged into a single layer and analyzed using ESRI Network Analyst Extension running in ArcGIS 10.0. The network was split at municipal boundaries so that walksheds are contained within individual cities and towns. The “Service Area” function was used to define all walk network segments that were within 0.5, 1, and 1.5 miles of each school. These segments were buffered by 50 meters to create a “walkshed” for each of these three distances. This walkshed analysis was conducted for all 804 schools in the study.

Walkshed Population

In order to estimate the school-age population living near each school, MAPC used a 250-meter vector grid layer, created by MassGIS, that includes estimated year 2000 population for each grid cell, based on block-level counts allocated by land use. Each grid cell is also assigned to a U.S. Census 2000 block group¹⁵. The school-age population (5 – 17) as a share of the total block group population was applied to the estimated population for each grid cell to generate estimated school-age population per grid cell.

These values were summed for each grid cell that was partly or completely contained within each walkshed. The estimates for grid cells partly contained within a walkshed were prorated based on the fractional area of the grid cell within the walkshed. Finally, the estimated school-age population was prorated by the number of grades at the school relative to the total number of school-attending years (14,

¹⁵ Census 2000 data was used because the analysis was conducted in December 2010, before Census 2010 block counts were available for Massachusetts.

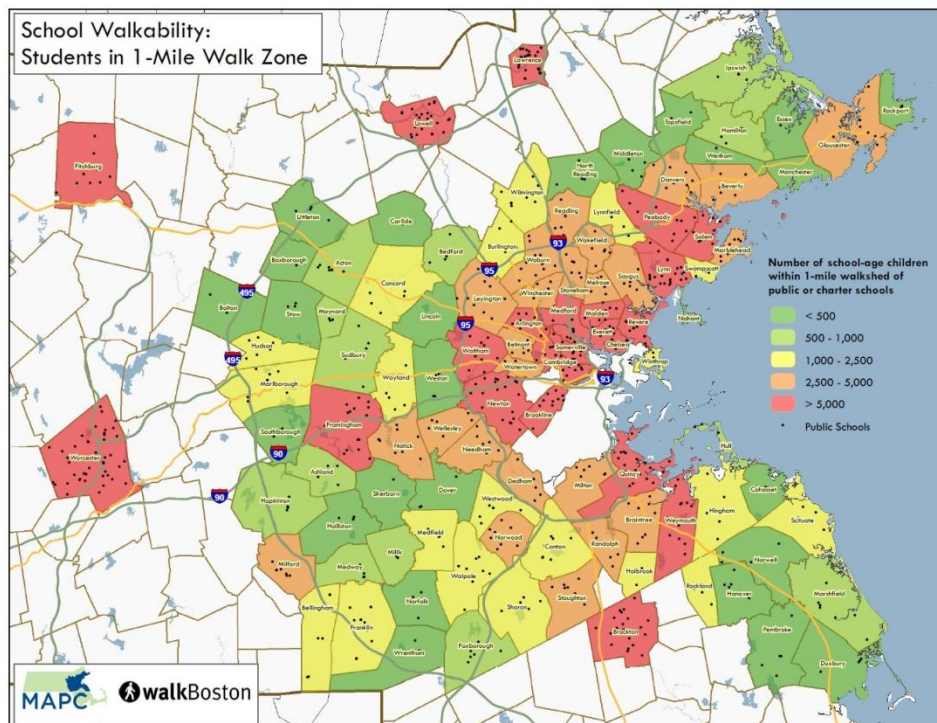
including Pre-K.)¹⁶ This estimate is termed the “walkshed population”¹⁷ and can be calculated for individual schools and at the municipal level. Where walksheds for different schools overlap, school-age children are counted toward the walkshed population of both schools.

The *municipal-level* analysis indicated that, in most cities and towns, the school-age population exceeds enrollment. This may be due to declining enrollment since the 2000 Census on which the analysis is based; large numbers of students at private schools, using METCO, or attending a regional school outside of the municipality. In about a quarter of the municipalities, school-age population is less than enrollment, indicating either rapid growth in enrollment or the presence of one or more regional schools that is drawing students from other municipalities.

District Screening and Selection

The district screening sought to collect data on school assignment and transportation policies for districts that exhibited the highest potential based on the walkshed analysis. The following criteria were used to select districts for screening:

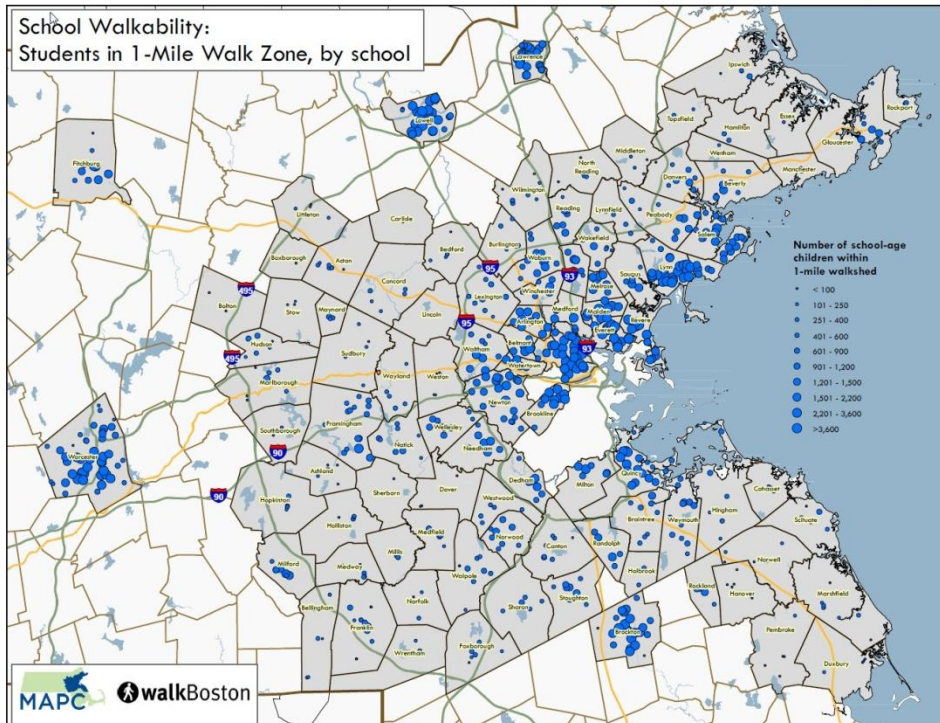
- Larger districts (14 districts with more than 10 schools; 16 districts with more than 5,000 students)



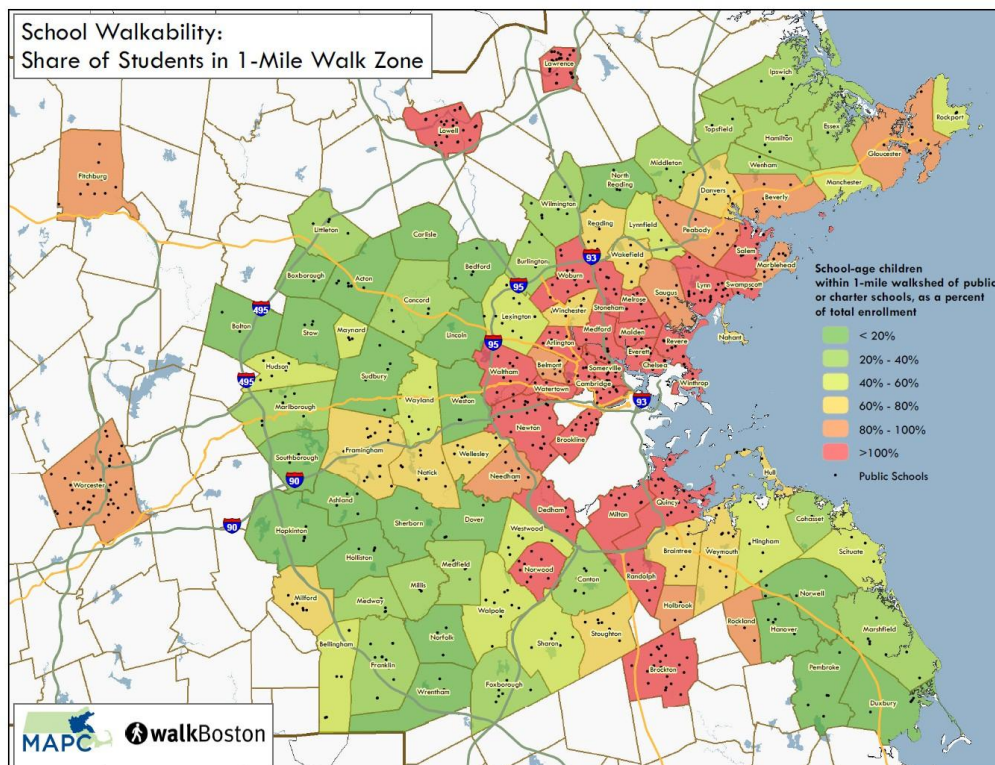
¹⁶ For example, a Pre-K through 5th grade school with 1,000 students in the 1 mile walkshed was estimated to have 500 school-age residents who might *potentially* attend that school, with the remainder in grades 6 through 12.

¹⁷ The term can be used to specify the population within a specific walkshed (e.g., 0.5 miles) or as a general term to describe all such walksheds..

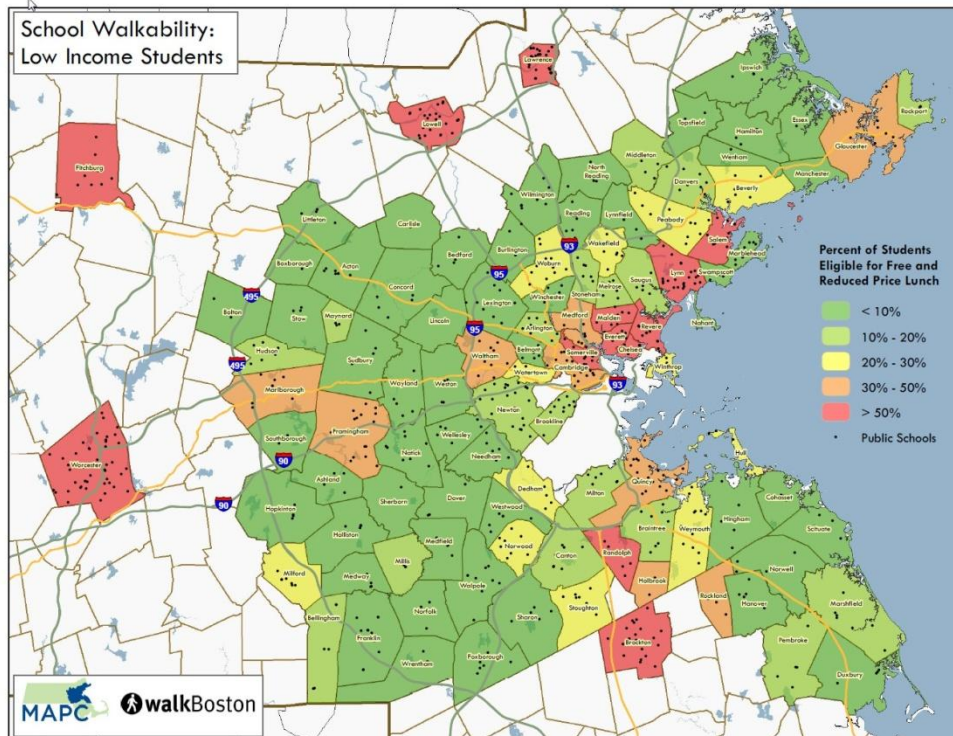
- Districts with multiple schools with large nearby walkshed populations (most have > 5 schools with 0.5 mile walkshed population >500.)



- Districts where the majority of school-age children live within a mile of any school (Municipal 1 mile walkshed population > 75% of enrollment).



- Districts in municipalities that are DPH Mass in Motion communities, and MassRIDES SRTS partner districts.
- Districts with a substantial low-income population (12 districts with >50% low-income students)¹⁸



All districts we contacted provide bus service to eligible students. All are required by M.G.L. Ch. 71, Sec. 68 to provide free bus service to students living beyond 2 miles; but within that limit, each district has a unique set of rules regarding eligibility and cost. Eligibility may be based on distance to school, grade, and special needs. Eight districts were confirmed to have a fee system, which generally charged upwards of \$200 per year for students ineligible for free school transportation. Most districts also offer free or discounted transportation to low-income students, additional siblings, or one-way trips.

The screening was conducted via phone and internet research. MAPC staff reviewed district websites to gather resources and contact information, then called the appropriate contact in each district. While most districts could easily generalize their assignment policies, a minority had statistics on what share of students were attending a school outside of their district. Data was collected from 28 districts. MAPC also asked district representatives what languages other than English were used for district communications to parents.

We assume that neighborhood-based zones are most conducive to walk-to school programs, with the highest likelihood that a public school student attends the school closest to his or her home. District-wide schools or school choice programs may reduce that likelihood, depending on how many students are participating and where the schools are. Assignment policies not based on geographic zones (such as those based on achieving racial or economic integration) may have mixed effects on student proximity to school. While not tested using the data we collected, we speculated that restrictive eligibility rules and broad-based fees might discourage bus utilization. Whether these policies would encourage more auto commutes or walking to school was not immediately apparent.

Survey Design and Implementation

¹⁸ Student overweight and obesity rates, where available, were also reviewed when selecting districts; the screened districts exhibit a range of obesity rates.

Key observations about existing survey methods and tools were:

- Visual surveys were determined to be not feasible because they do not collect data on home location.
- Classroom tallies presented challenges to collecting home location data: the “show of hands” method does not provide home location; younger students may not know this information; social bias may affect the accuracy of the results; and it seems reasonable that parents—not students—should decide whether to provide their home location to a survey.
- Existing parent survey instruments collect home location and mode, but not trip chaining; they also include a large number of behavioral and attitudinal questions that result in a longer survey and potentially lower response rates. The most common survey (National Center for SRTS) is available only on one language other than English.
- None of the available on-line tools utilized a mapping tool to submit responses

Six versions of the English language survey were created, with a different order of the multiple choice list for mode to/from school. This was to allow analysis of bias that might be created by the order in which choices are listed. In each of the six alternatives, the order of choices was the same for both to/from, with “other” being last in each case.

MAPC provided paper copies of the survey for every student at participating schools and also provided the URL to the online survey that could be distributed via newsletters, email, listservs, or other methods. Schools were generally given a two-week window to administer the survey, with paper surveys delivered on a Monday and picked up the Friday of the following week. Surveys were administered between May 9 and May 27, 2011.

As described above, the online survey tool allowed parents to locate their place of residence using an interactive map tool (“drag and drop the yellow home-marker to an intersection on your street, near your home”) or they could enter the name of their street and a nearby cross street into a text box. Overall, 56% of parents using the web tool indicated their home location using the map tool. Of those, 73% also entered the name of their street and cross street (n=225). This duplicative information provided an opportunity to test the validity of the interactive map survey instrument versus conventional modes of asking for home location. The histogram on the following page shows the distance between the point placed using the map tool and the geocoded home location based on the reported street and cross street. More than 54% of map tool responses were within 100 meters of the reported nearest intersection, and 74% were within 200 meters. Given an on-road walk distance intervals of 0.5 miles (805 meters), these small discrepancies are likely to have little impact on the analysis. These results suggest that an interactive web tool may provide a valid alternative to conventional methods of asking parents for street names, though the subset of parents who entered home address using both methods may not be representative of all respondents.

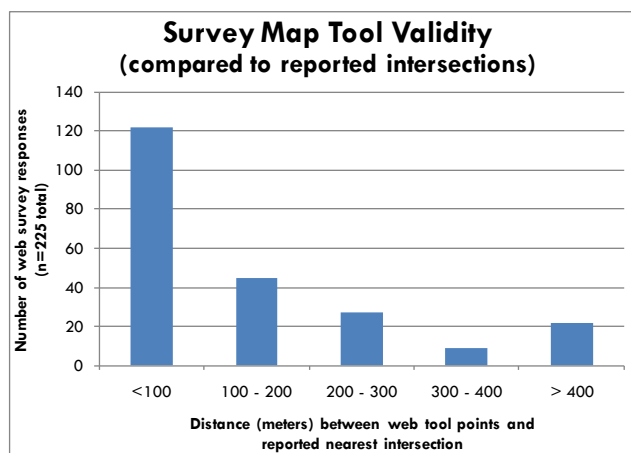
The screenshot shows the 'Ferryway School Important School Travel Survey' form. At the top, there are language options: English, Spanish, Portuguese, French, Haitian Creole, Vietnamese, Chinese, Arabic. The form is addressed to 'Dear Parent or Guardian,' and explains that the survey is to learn how students get to and from school to plan safe walking options. It states the survey takes less than 2 minutes and is due by Friday, May 27. A note mentions that the school earns money for completing the survey, with WalkBoston donating \$250 to the school if 444 surveys are completed. Below this, there is a section for 'What street do you live on?' with a map of the Malden area and a yellow home-marker. Below the map, there are text boxes for 'Name of your street' and 'Name of nearest cross-street (nearest intersection)'. There are also dropdown menus for 'What grade is your child in?', 'On what day of the month was your child born?', 'How does your child get TO school on most days?', and 'How does your child get home FROM school on most days?'. At the bottom, there are checkboxes for 'Add another child at this school', 'How many vehicles do you have in your household?', and 'How many people in your household have a driver's license?'. A 'Submit Survey' button is at the bottom right. The footer includes a copyright notice for 2011.

Data Entry and Analysis

Data entry was conducted by MAPC using a custom data entry form in Microsoft Access. Errors in coding street names were minimized by constraining the list of available street names to the streets in the NAVTEQ road database that would be used for geocoding. Specifically, only streets listed in the municipality where the school was located could be chosen from the drop-down list. If the reported street did not exist in the NAVTEQ database, data entry staff could enter the response in a text box. A screen-shot of the data entry form is shown to the right. Data entry took approximately 75 hours for 3,900 surveys.

Paper survey responses were geocoded based on the reported streets. However, 40% of paper surveys did not geocode initially, due to missing cross streets or reported streets that did not intersect. Approximately 40 hours were spent analyzing those that did not match and assigning a cross street or address. In addition to the time spent in manual data entry, this demonstrates the labor-intensive nature of processing paper surveys. Appendix D includes notes and guidance for editing street names. Eventually, the geocoding process achieved a 91% match rate overall, including web surveys.

The geocoded survey responses were spatially joined to the walkshed areas and each survey was assigned a walkshed (0.5, 1.0, 1.5, beyond) using the NEAR function in ArcGIS. For survey points beyond 1.5 miles, the straight-line distance to the edge of the 1.5 mile walkshed was also calculated.



GHG Estimation Methodology as per EPA and USDOT guidelines

Green house gas (GHG) estimates were derived from the survey analysis, EPA and USDOT standards (<http://www.epa.gov/oms/climate/420f05004.htm>), and certain assumptions. In order to derive annual estimates, travel behavior during the survey period (May 2011) was assumed to be representative of average behavior over the course of the school year. Separate estimates were derived for 'to' and 'from' school travel patterns which were then added and scaled as per the sample size to represent total annual GHG emission for each school.

1. Distance calculations were approximated based on survey responses. To estimate average distance, walkshed distances are discounted. For trips exclusively to school, the distance is doubled to account for the trip back home.

Walkshed Distance	Estimated Travel Distance (miles)
0.5	0.33
1.0	0.75
1.5	1.25
>1.5	1.25+ (nearest straight line distance X 1.25)

In order to account correctly for drop-off and pick-ups en route to work/ errand, only the extra travel for school is estimated by assuming four equally probable trip patterns to the final

destination. These are: the trip continuing orthogonally in either direction, straight ahead, or back via home. In case of trip in direction of home, the round trip to school is the extra drive, while in case of orthogonal trip onward, the extra miles is the difference b/w the triangle hypotenuse length and the sum of other two sides. The extra miles for different walkshed distances are:

Walkshed Distance	Drop off extra travel (miles)
0.5	0.26
1.0	0.595
1.5	0.99
>1.5	Difference b/w sum of orthogonal sides and hypotenuse

2. In order to account for a carpool, a factor for vehicle occupancy was assumed. For family vehicle with single student, the factor is 1, whereas for a carpool the factor is 0.5 assuming carpool size of 2 students.
3. Vehicle Miles Traveled (VMT) estimated for each survey response as a product of vehicle factor (2) and estimated distance (1).
4. Before using EPA GHG estimation methodology, cold-start emissions were accounted for. This was done because EPA estimates are for annual VMT. In order to account for region specific cold-start estimates, there are a certain set of factors by the EPA that need to be applied. Average monthly temperatures from Sept- June were collected and the annual school year average temperature was estimated at 47F.
5. Fuel efficiency as per EPA standard is 23.9mpg for passenger cars and 17.4 for trucks. USDOT gives estimated vehicle mix as 63.4% passenger cars, and 36.6% trucks. To estimate with-in city/ local roads travel, fuel efficiency was reduced to- Passenger cars= 21 mpg, trucks 17 mpg. (Gallons consumed= $VMT / ((21.0 \times 0.634) + (17.0 \times 0.366))$). To account for cold-start and temperature variations, gas consumption was factored up by 1.8 for average temperature of 47F. (See [ColdStart.xls](#) for further details.)
6. Estimate of CO₂ emissions derived as per fuel consumption. EPA estimates 8.8 kg or 19.4 pounds of CO₂ per gallon of gasoline (40 CFR 600.113-78)
 $CO_2 \text{ emission (kg)} = 8.8 \times \text{Gallons consumed}$
7. Other GHG estimation: Other gases like CH₄, N₂O, HFCs account for 5-6% of total GHG emissions, with CO₂ forming 94-95% of the total. To account for these gases, CO₂ emission estimate is divided by a factor of 5/95 or 19.
 $\text{Other GHG Emission (kg or tons)} = CO_2 \text{ emission (kg or tons)} / 19$
8. Cold start additive estimated for other GHG gases (not CO₂) were analyzed, and found to be approximately 0.035 kg for 47F temperature. These numbers were derived from latest available information regarding average vehicle age, and EPA estimates. (See [ColdStart.xls](#) for further details.)
9. Total GHG estimated by adding CO₂ emissions (7) and other GHG emissions (8). Annual GHG estimated derived by assuming 180 school days.
10. To account for trip distribution and travel patterns as observed, GHG emission factors per trip were calculated by mode and walkshed . For trips originating beyond the 1.5 mile walkshed boundary, GHG emission factor were estimated for each school. This is done to scale trips and GHG emissions as per observations, to avoid error in aggregated estimation.

11. Assuming uniform distribution of samples over 5% response rate, total GHG emissions for each school were estimated by factoring up the GHG estimate by (100/ sample %)

Municipal Level GHG Estimation

To roughly estimate school trip share of average household GHG emissions, annual household VMT data from MA RMV were compared with municipal level aggregate school trips. It should be noted that the MA RMV numbers are for 2005-07, and Census 2000 household numbers were used.

The methodology to estimate annual household GHG emissions is slightly different than that followed for school-trip emissions, mainly in terms of vehicle fuel efficiency and cold-start emissions. This is because the EPA methodology applies to annual VMT, and cold-start factors cannot be applied to annual estimates.

1. Gasoline consumption estimates as per EPA standards. (Gallons consumed= $VMT / ((23.9 * 0.634) + (17.4 * 0.366))$). CO2 per gallon gasoline (8.8 kg/ gallon) as per EPA standard used to calculate Annual CO2 per HH.
2. Other GHG Gases estimated at 5% of total emissions (EPA). Total GHG emission calculated as (CO2 emission X (100/95))

APPENDIX D: STREET ASSIGNMENT METHODOLOGY

The table below summarizing our approach to assigning streets to records where the data were missing or the two given streets did not intersect. Hard copy surveys were entered into our survey database in Access and the street fields were coded using NavTech streets, a pre-populated list of actual street names. Web surveys were downloaded into an Access Database and similar to the hard copy surveys, street names manually entered by survey respondents were updated to match the streets in the NavTech list so they could be geocoded. Web surveys may have also had point data associated with them (X and Y coordinates) which were generated as a result of survey respondents moving the geographical marker on the map to an intersection near their home.

For future surveys, we would limit survey administration to the web-based version due to the burden of manually inputting hard copy data. We would also include a pre-populated list of NavTech streets on the website to minimize the possibility of misspelled or non-existent street names manually entered. In addition, we would be more explicit in asking for streets that intersect (as opposed to streets that are nearby or parallel) because there was some confusion over the term “cross streets.”

Scenario	Solution
One NavTech street and one street written/typed in manually	Use Google maps to verify that the written street intersects with the given NavTech street and populate the new street field using the NavTech list
Two NavTech streets that did not geocode (did not intersect)	Use Google maps to update the cross street field (assume “your street” is correct) by selecting the next best option (see below for guidance)
Web survey street names that were manually entered	Use Google maps to verify that the streets intersect and populate the new “your street” and “cross street” fields using the NavTech street list

We also developed more specific guidelines when necessary. Please see below.

Rules for connecting two known streets with no true intersection

- If *your street* is shorter than the distance from the recorded *cross street*, negate *cross street* and geocode to the midpoint of *your street*
- If *your street* and *cross street* run parallel for a substantial distance, find a midpoint perpendicular street on *your street*
- If *your street* is only connected to one street (which is not the specified *cross street*) make that street the new *cross street*
- If the listed *cross street* turns into a street that intersects *your street* then use the street name that that it turns into as the new *cross street*
- If specified *cross street* is a substantial distance from *your street* and there is another street with a similar name that intersects *your street*, use the similar named street and as the *cross street* (e.g. Oakland Rd vs Oakland St)