University of Massachusetts
Baystate Roads Program

MassDOT Design Guide
and Complete Streets Primer

Housekeeping

- Emergency Exits
- Washroom Locations
- Halfway Break
- Informal Format – Ask Questions
- Cell Phones on Vibrate

Agenda

- General Introductions
- Introduction to Complete Streets
- MassDOT Design Guide
- Break
- Getting to Complete Streets (Complete Streets Concepts)
Project Team

- Massachusetts Department of Transportation
- Baystate Roads Program/University of Massachusetts - Amherst
- Fay, Spofford & Thorndike, LLC
- National Complete Streets Coalition

Introduction

Doug Prentiss, PE, PTOE
Transportation Engineer
Fay, Spofford & Thorndike – Burlington, MA
781-221-1207
dprentiss@fstinc.com

Introductions: Who are you?
- Your name / your organization / your job
- Have you heard of Complete Streets?
- What you hope to get out of today

Complete streets programs give more room for pedestrians, cyclists

USA TODAY

Monday, July 30, 2007

massDOT
Objectives

- Discover tools you can use to achieve Complete Streets
- Learn how the MassDOT Design Guide can help
- Understand fundamental engineering terms

Project Overview

- 3-hour Complete Streets Primers are being conducted throughout the state – encore
- Host a workshop in your community!
  Contact Cindy Schaedig: cindy@baystateroads.org

MassDOT Mission & Sustainability Commitment

Our mission is to deliver excellent customer service to the people who travel in the Commonwealth and to provide our nation's safest and most reliable transportation system in a way that strengthens our economy and quality of life.
Embedding Sustainability with GreenDOT Goals

Green DOT

1. Reduce Greenhouse Gas (GHG) Emissions
2. Promote Healthy Transportation
3. Support Smart Growth

MassDOT’s Sustainability & Livability Framework

- Requires ‘Complete Streets’, consistent with the 2006 MassDOT Design Guide on all projects

Introduction to Complete Streets

- Examples of Complete and Incomplete Streets
- Types of Complete Streets
- Benefits from Complete Streets
Incomplete Streets

We know how to build right

Anderson Bridge, Cambridge: Before
We know how to build right

Route 134, Dennis: Before

We know how to build right

Route 134, Dennis: After

Introduction to Complete Streets

- Examples of Complete and Incomplete Streets
- Types of Complete Streets
- Benefits from Complete Streets
What is a Complete Street?

A Complete Street is a facility that is safe, comfortable & convenient for travel via automobile, foot, bicycle & transit.

The many types of Complete Streets

One size doesn’t fit all.

The many types of Complete Streets

One crossing completes a Safe Route to School.
The many types of Complete Streets

Shoulder bikeways on rural roads

Busy multi-modal thoroughfares

Transit routes
The many types of Complete Streets

Suburban thoroughfares

The many types of Complete Streets

Residential streets with shoulder for bikes and sidewalks

The many types of Complete Streets

Historic Main Street
Group Exercise:
- Discuss examples of Complete Streets in your community

Introduction to Complete Streets
- Examples of Complete and Incomplete Streets
- Types of Complete Streets
- Benefits from Complete Streets

Everyone Benefits
- About one-third of Americans don’t drive:
  - 21% of Americans over 65
  - Children under 16
  - Disabled Americans
  - Those without cars

- Most Americans would rather drive less & walk more

- Transit is growing faster than population or driving
Congestion Benefits

Complete Streets are multimodal.

Trips in metro areas:
- 48% are less than 3 miles
- 28% are less than 1 mile
- 31% of trips less than 1 mile are taken by car.

These are all potential bicycle or walking trips.

Safety Benefits

- Sidewalks reduce pedestrian crashes 66% (FHWA)
- Shoulders reduce pedestrian crashes 71% (IDOT)
- Medians reduce crashes 40% (NCHRP)
- Road diets reduce crashes 16 – 49% (ITE)
- Countdown signals reduce crashes 25% (FHWA)

Transit Benefits

- Connect transit to work, to shops, to schools, to homes through appropriate planning and design for transit users.
Equity Benefits

- Low and moderate income families spend a higher percentage of income on transportation (Roughly 30% vs. 20% for all families)
- Complete Streets give everybody more control over their expenses, replacing car travel with options like walking, riding bikes, and taking public transportation

Benefits for People with Disabilities

- 20% of Americans have a disability that limits their daily activities (physical, visual, and hearing impairments)
- Complete Streets feature curb cuts, high visibility crosswalks, and other designs for travelers with disabilities
- Complete Streets reduce isolation and dependence

Benefits for Older Adults

- By 2030, nearly 1/5 of Americans will be 65 or older.
- About 1/3 of all non-drivers over the age of 65 would like to get out more often.
- Complete streets policies help create streets that support older drivers and pedestrians through better design.
- Complete streets help older Americans stay active and involved in their communities.
Benefits for Children

- Streets that provide dedicated space for bicycling and walking help kids be physically active and gain independence.
- More than 1/3 of our nation's children are overweight or obese.
- Limited physical activity contributes to the obesity epidemic among children.

Health Benefits

- Obesity is lower in places where people use bicycles, public transportation, and walk.

Health Benefits

- States with the lowest levels of biking and walking have, on average, the highest rates of obesity, diabetes, and high blood pressure.
Health Benefits for MA

Massachusetts spent over $1.8 B/year on medical costs related to obesity (1998 – 2000)

- 13.3% of MA children are obese and 16.9% are overweight
- Childhood obesity rates are as high as 27% in some communities
- 58.6% of MA adults are overweight or obese
- Over the last 15 years, obesity rate has increased more than 90%

Health Benefits

- The Centers for Disease Control and Prevention identified adoption of Complete Streets policies as a recommended strategy to prevent obesity.

Physical Activity Benefits

- Residents are more likely to walk in a neighborhood with sidewalks
- Cities with more bike lanes have higher levels of bicycle commuting
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MassDOT Design Guide

Project Development & Design Guide

- Award Winning in Numerous Categories:
  - Transportation
  - Environmental
  - Public Works
  - Historic Preservation
  - Planning
  - Context Sensitivity
  - Highway Design

MassDOT Design Guide

- Recognized by organizations spanning disciplines:
  - Institute of Transportation Engineers
  - Federal Highway Administration
  - American Public Works Association
  - Federal Transit Administration
  - American Planning Association
  - American Association of State Highway and Transportation Officials
  - National Complete Streets Coalition
Project Development & Design Guide

- Three key objectives:
  - Multimodal consideration
  - Context sensitive design
  - Clear project development process

Design Guide applies when:
- MassDOT is the project proponent
- MassDOT is responsible for project funding (state or federal-aid projects)
- MassDOT controls the infrastructure (projects on state highway)

Also appropriate for use:
- Chapter 90 funded projects
- Any locally funded project
- Subdivision developments

Project Development Process

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<th>Process</th>
<th>Outcomes</th>
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<td>Step 1</td>
<td>Procurement Planning and Selection</td>
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<td>Step 2</td>
<td>Right-of-Way Design and Analysis</td>
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<td>Step 3</td>
<td>Environmental Design (ESP) Project</td>
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<td>Step 4</td>
<td>Procurement</td>
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<td>Step 5</td>
<td>Project Delivery</td>
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<td>Step 6</td>
<td>Construction Administration</td>
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<td>Step 7</td>
<td>Project Closeout</td>
</tr>
</tbody>
</table>

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Project Review Checklists

Public Outreach Approach

Perceived Barriers to Complete Streets

- Engineering standards
- Slower speeds will reduce mobility and increase costs for all vehicles
- Required to design roads to handle the peak traffic levels 20 years in the future at C LOS
- Limited right-of-way
Do we have to widen roads to fit everything?

Once your street is improved, the curb will be right here.

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There's room; it needs to be rethought.

Proposed design – from the outside in.

Add up desirable elements, fit in ROW; result: sidewalks, bike lanes, travel lanes.
Proposed design – from the outside → in

Approaches to cross-section formulation are presented from right-of-way edge to edge, rather than the more traditional method from center line out. Design Guide, p. 3.3

Add up desirable elements, fit in ROW; result: sidewalk, bike lanes, travel lanes

Group Exercise:

» What are the challenges of implementing Complete Streets in your community?

Complete Streets Concepts

» Roadway Type as Part of Context
» Design Speed Selection
» Mobility Considerations
» Lane Widths
» Road Diets
» Intersection Curb Radii
» On-Street Bike Lanes
» Pedestrian Facilities
Complete Streets Concepts

- Roadway Type as Part of Context
- Design Speed Selection
- Mobility Considerations
- Lane Widths
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- On-Street Bike Lanes
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Three elements of context:
- Area Type
- Roadway Type
- Access Control

Area Type:
- Rural
Design Guide/Context

Area Type:
- Rural
- Suburban

Design Guide/Context

Area Type:
- Rural
- Suburban
- Urban

Design Guide/Context

Roadway Type:
- Freeways
- Major arterials
- Minor arterials
- Major collectors
- Minor collectors
- Local roads
Should Street Width be Based Solely on Roadway Type?

Roadway type doesn't adequately describe the street's role in a community.

These 3 streets are "arterial," yet look, feel and perform very differently.

Cross-section based on context

Urban Arterial

Cross-section based on context

Suburban Arterial
Cross-section based on context

A context-sensitive design should begin with analysis of the contextual elements, such as environmental and community resources, of the area through which the roadway passes. Reference: p.3-2

Design Guide/Context

- Most highway design guides use typical sections
- Typical sections can lead to inadequate user accommodation or superfluous width
- MassDOT Design Guide use "descriptive cases" rather than "typical sections"
- Descriptive cases are based on context

Case 1

Separate accommodation for all users
Case 2

Partial sharing for bicyclists and motor vehicles

Case 2

- Appropriate for:
  - Areas where width necessary for Case 1 is not available
  - Areas with low motor vehicle speeds and low to moderate motor vehicle volumes
Case 3

Shared bicycle/motor vehicle accommodation

Appropriate for:
- Densely developed areas where right-of-way is constrained
- Residential/local streets where speeds and traffic volumes are low

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Case 4

Shared bicycle/pedestrian accommodation

• Appropriate for:
  • Rural or sparsely developed areas
  • Areas with infrequent pedestrian and bicycle use
Case 5

Shared accommodation for all users

Appropriate for:
- Areas where user demands and motor vehicle speeds are very low
- Areas where severe constraints limit the feasibility of providing separate accommodation
Design for street types

- Design criteria:
  - Physical configuration
  - Surrounding context
- Dimensions for:
  - Sidewalk environment
  - Street
  - Intersections
- **Target speed** (desirable operating speed)

Why Speed Matters

High speeds lead to greater chance of serious injury & death

- Doubling the speed from 20 mph to 40 mph reduces the survivability from 85% to just 15%

Child dart-out: speed is a factor!
First scenario: Speed 25 mph

100' = distance covered in 2.5 sec. perception/reaction time

Driver applies brakes

150'

100'

First scenario: Speed 25 mph

Driver applies brakes

50' stopping distance (wet pavement)

150'

100'

First scenario: Speed 25 mph

Result: Nothing happens beyond one scared child, driver & parent!
Second scenario: Speed 38 mph

140' = distance covered in 2.5 sec. perception/reaction time

Driver applies brakes

140' 150'

In the last 10' car slows to 30 MPH
First scenario: no crash

Second scenario: Crash speed 38 MPH

Pedestrian chances of death if hit by a single vehicle

Design Guide/Speed

- Appropriate target speed should consider:
  - The context of the roadway including area type, roadway type, and access control
  - The volume, mix, and safety of facility users
  - The anticipated driver characteristics and familiarity with the route
Design Speed Ranges (MPH)

When high speeds are selected, the designer should also include design elements to maintain the safety of pedestrians and bicyclists, as described in Section 3.6.7.

Benefit/Cost Analysis

- Reducing speed from 45 mph to 30 mph
  - For a 5-mile trip, a 3.33-minute delay
  - Assume 50,000 ADT and $20/hr driver cost
  - $12.154 million in loss to economy, right?
  - Wrong!
  - Delay for each person is still 3.33 minutes
  - Less time than their daily stop for Starbucks

- Community benefit
  - Slower operating speeds
  - Safer and more comfortable pedestrian crossings
Group Exercise:

- How fast would you like people to drive on different roads in your community?

Complete Streets Concepts

- Roadway Type as Part of Context
- Design (Target) Speed Selection
- Mobility Considerations
- Lane Widths
- Road Diets
- Intersection Curb Radii
- On-Street Bike Lanes
- Pedestrian Facilities

Redefining Mobility

- Typical experience:
  - 45 mph speed
  - 2 min wait at signal
Redefining Mobility

- Viable alternative:
  - Time signals for 30 mph uninterrupted flow

Complete Streets changes mobility for all users

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Roadway Capacity Analysis

- Roadway design based on peak hour (or half hour) traffic for design year (typically 20 years hence)

<table>
<thead>
<tr>
<th>Signalized Intersection</th>
<th>Level of Service (LOS) Intervals</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay Per Vehicle (sec)</td>
<td>LOS</td>
<td>Description</td>
</tr>
<tr>
<td>5 or less</td>
<td>A</td>
<td>Free flow</td>
</tr>
<tr>
<td>6 and 20</td>
<td>B</td>
<td>Minor delays</td>
</tr>
<tr>
<td>21 and 63</td>
<td>C</td>
<td>Occasional delays</td>
</tr>
<tr>
<td>64 and 55</td>
<td>D</td>
<td>Typical urban flow</td>
</tr>
<tr>
<td>56 and 80</td>
<td>E</td>
<td>Practical capacity</td>
</tr>
<tr>
<td>80 or more</td>
<td>F</td>
<td>Stop-and-go</td>
</tr>
</tbody>
</table>


Designing urban roadways to LOS D or lower is usually the most cost-effective.
To evaluate future conditions, first establish a baseline using existing conditions data.

Forecasts should include estimates of pedestrian and bicycle activity, taking into account latent demand.

Although the typical process for forecasting traffic volumes assumes that traffic will increase over time, in some situations traffic volumes may decline or remain relatively constant.
Level of Service - Service Measures

<table>
<thead>
<tr>
<th>System Element</th>
<th>Mode</th>
<th>Model Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Street</td>
<td>Automobile</td>
<td>Weighted avg. of segment LOS scores</td>
</tr>
<tr>
<td>Facility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedestrian</td>
<td></td>
<td>Street segment and intersection LOS, mid-block crossing difficulty</td>
</tr>
<tr>
<td>Bicycle</td>
<td></td>
<td>Street segment and intersection LOS, driver vs. conflict</td>
</tr>
<tr>
<td>Transit</td>
<td></td>
<td>Weighted avg. of segment LOS scores</td>
</tr>
<tr>
<td>Urban Street</td>
<td>Automobile</td>
<td>Stops per mile, left-turn lane presence</td>
</tr>
<tr>
<td>Segment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedestrian</td>
<td></td>
<td>Sidewalk width, separation from vehicles, traffic vol. and speed</td>
</tr>
<tr>
<td>Bicycle</td>
<td></td>
<td>Separation from vehicles, pavement quality, traffic vol. and speed</td>
</tr>
<tr>
<td>Transit</td>
<td></td>
<td>Service frequency, speed, pedestrian LOS</td>
</tr>
<tr>
<td>Signalized</td>
<td>Pedestrian</td>
<td>Delay, exposure to turning vehicles, crossing distance</td>
</tr>
<tr>
<td>Intersection</td>
<td>Bicycle</td>
<td>Separation from vehicles, crossing distance</td>
</tr>
</tbody>
</table>

Source: Highway Capacity Manual, 2010

Design Guide/Level of Service

» Level of Service:
  » Desired LOS is determined through consensus of the affected community and the facility owner
  » Evaluate LOS of each user group and test alternatives to meet goals of the project.

Design Guide/Level of Service

» Level of Service:
  » In most instances, the designer should not propose a design that provides a level-of-service improvement for one user group at the expense of another.
Complete Streets Concepts

- Roadway Type as Part of Context
- Design (Target) Speed Selection
- Mobility Considerations
- Lane Widths
  - Road Diets
  - Intersection Curb Radii Road Diets
  - On-Street Bike Lanes
  - Pedestrian Facilities

Design Guide/Lane Width

- Travel lane width is selected through consideration of:
  - Roadway context
  - Approach to multimodal accommodation
  - Dimension of vehicles
  - Speeds
  - Other traffic flow characteristics

Design Guide/Lane Width

- Travel lane widths range 10 to 12 feet
- 11 to 12-foot lanes are selected where:
  - Design speeds ≥ 45 mph
  - Average Daily Traffic ≥ 2,000
  - Truck/bus volumes > 30/hour
Design Guide/Lane Width

- Lanes wider than 12 feet are used in:
  - Some cases where shoulders are not provided (e.g., rural villages, suburban villages and town centers, or urban areas)
  - Areas with high driveway density

If more than 12 feet is available, it is often preferable to stripe a shoulder.

Design Guide/Lane Width

- Lanes narrower than 11 feet:
  - Appropriate for lower speed, lower volume roads that primarily provide access
  - May be striped to allow a shoulder that provides separation for bicyclists and pedestrians
  - Minimize right-of-way requirements
  - Minimize impact to the built and natural environment
Design Guide/Lane Width

- Lanes narrower than 11 feet:
  - MyC
  - Pw
  - M
  - My
  - M
  - M
  - M
  - M

- Flexibility is permitted to encourage independent designs tailored to particular situations.

Group Exercise:
- Do you know how wide your roads are? Your lanes and shoulders?
- Do you think that certain widths are better than others? Why?

Complete Streets Concepts
- Roadway Type as Part of Context
- Design (Target) Speed Selection
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How to Make Room: Road Diets

Convert 4-Lane Road to 3-Lane including Center Turn Lane
→ 18 - 49% crash reduction (ITE)

Crash Reduction

Rear end

Crash Reduction

Side swipe
Road Diets can handle roughly 20,000 daily vehicles.

Reclaiming road space creates room for pedestrian islands.
Road Diet

Reclaiming road space creates room for pedestrian islands

Which road improves mobility for all users?
Which road carries more traffic?

Road Diet

Reclaiming road space creates room for pedestrian islands

Road Diet
Road Diet

- Which road produces higher speeds?
  - 4-lane: faster driver can pass others
  - 2-lane: slower driver sets speed
- Which road produces a higher crash rate?

Group Exercise:

- Do you have any candidates for road diets in your community?

Complete Streets Concepts

- Roadway Type as Part of Context
- Design (Target) Speed Selection
- Mobility Considerations
- Lane Widths
- Road Diets
- Intersection Curb Radii
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Effect of large radius on drivers

They drive fast, ignoring pedestrians

Large corner radii:
- Allow high-speed turns by cars
- Less likely to yield
- Injury severity is higher at higher speeds

Tighten Corner Curb Radii

Large corner radii:
- Increase crossing distance
- Longer crosswalk means more pedestrian signal time, reducing roadway capacity for vehicles
Corner "Pork Chop" Islands

Benefits:
- Separate conflicts & decision points
- Reduce crossing distance
- Improve signal timing
- Reduce ped crashes (29%)

Curb Bulb-outs

- Reduce crossing distance
- Improve sight distance and sight lines
- Prevent encroachment by parked cars
- Create space for curb ramps and landings

Design Guide/Curb Radius

- Simple curb radius (preferred):
  - Controls motor vehicle speeds
  - Minimizes crossing distance
- Compound curves:
  - Used where encroachment by large vehicles must be avoided
- Turning roadways (separate right turn lane):
  - Employs channelizing islands
  - Used where high speed turns are desired
Design Guide/Curb Radius

- Simple curb radius (preferred):
  - The pavement corner radius is a key factor in the multimodal performance of the intersection.

- Curb (Intermediate): Used where high speed turns are desired.

Complete Streets Concepts

- Roadway Type as Part of Context
- Design (Target) Speed Selection
- Mobility Considerations
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- On-Street Bike Lanes
- Pedestrian Facilities

Retrofitting for Bike Lanes

- Bicycle Lanes
  - OK to reduce travel lane
  - Before:
  - After:
Retrofitting for Bike Lanes

- Reduce travel lane widths
- Reconfigure parking
- Reduce number of travel lanes

Typical "Road Diet"

Retrofitting for Bike Lanes

- Option when:
  - Current lane 23 feet wide with parking
  - Vehicle speeds 30 mph
- How to implement:
  - Reduce width of travel and parking lanes

Relative Danger Index of Facilities

- On major streets without bike lanes: 1.28
- On minor streets without bike lanes: 1.04*
- On streets with bike lanes: 0.5
- On shared use paths: 0.67
- On sidewalks: 5.32

(* = shared roadway)

1.00 = median

Reference: William Mortz, L.W., "Accident Rates for Various Bicycle Facilities" - based on 2374 cases, 4.4 million miles
Group Exercise:

- What are the challenges of accommodating all users within the available roadway cross section?

Complete Streets Concepts

- Roadway Type as Part of Context
- Design (Target) Speed Selection
- Mobility Considerations
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Pedestrian Signals

- 50% of pedestrians in the U.S. do not understand the "Flashing Don't Walk" really means it's OK to continue walking.

So we put signs like this to "correct" the problem.
Countdown Signals

- Pedestrian countdown signal tells pedestrians how much crossing time is left.
- Reduces all crashes by 25%

Pedestrian Signal Timing

- Pedestrian walking speed revised in 2009 MUTCD from 4.0 feet per second (fps) to 3.5 fps
- Recognizes many users need more time to cross the street

Design Guide/Pedestrian Signals

- The WALK indication should be concurrent with parallel traffic
- Signal timing should accommodate the average walking speed of the type of pedestrian using signal
- Pedestrians should be given the longest possible walk time, while balancing vehicular flow and pedestrian delay
Pedestrians and Transit

Every bus stop is a pedestrian crossing

Design Guide/Bus Stops

- Bus stops and pedestrian routes should be considered together
- Midblock bus stops can create crossing difficulties for pedestrians unless a midblock crosswalk is also provided

Rectangular Rapid Flash Beacon

- Beacon in yellow, rectangular, and has a rapid "stutter" flash
- Beacon located between the warning sign and the arrow plaque
- Must be pedestrian activated (pushbutton or passive)
- Studies indicate motorist yielding rates increased from 18.2% to 81.2% for 2 beacons and to 87.6% for 4 beacons (TRB)
- Interim approval from FHWA in July 2008 & MassDOT in 2012
Group Exercise:

» Provide examples of streets that are "incomplete" and should be fixed.
Have we achieved today's objectives?

» Discover tools you can use to achieve Complete Streets

» Learn how the MassDOT Design Guide can help

» Understand fundamental engineering terms

---

**District Contacts**

**Pedestrian/Bicycle Coordinators**

**District 1 – Lenox**
- Keith Blond
- T: 413.637.5742
- E: keith.blond@state.ma.us

**District 2 – Northampton**
- Mary Ann Mandell
- T: 413.582.0528
- E: mary.mandell@state.ma.us

**District 3 – Wilbraham**
- Richard Harfield
- T: 508.529.3664
- E: richard.harfield@state.ma.us

**District 4 – Arlington**
- Mary Sulvan
- T: 781.641.8346
- E: mary.sulvan@state.ma.us

**District 5 – Taunton**
- Tim Kochan
- T: 508.884.4254
- E: timothy.kochan@state.ma.us

**District 6 – Boston**
- Steve Cleen
- T: 617.566.6160
- E: steven.cleen@state.ma.us
District Contacts

Project Need Form and Project Initiation Form assistance:

District 1 - Leicester
Mark Moore, Project Development Engineer
T: 413 837.5720
E: mark.moore@state.ma.us

District 2 - Northampton
Richard Masse, Project Development Engineer
T: 413.582.0629
E: richard.masse@state.ma.us

District 3 - Worcester
Arthur Foss, Project Development Engineer
T: 508.254.3707
E: arthur.foss@state.ma.us

District 4 - Arlington
Frank Susznrski, Project Development Engineer
T: 781.641.5474
E: frank.suszynski@state.ma.us

District 5 - Taunton
Pamela Hazen, Project Development Engineer
T: 608.884.4026
E: pamela.hazen@state.ma.us

District 6 - Boston
Peter Cavicchi, Project Development Engineer
T: 617.368.6151
E: steve.cavicchi@state.ma.us

Thank you!