GREEN INFRASTRUCTURE TOOLKIT
For the 495/MetroWest Region

About the 495/MetroWest Partnership: Since our founding in 2003, the 495/MetroWest Partnership has been recognized as the collective voice for our economically crucial region. The Partnership, through a unique public-private collaboration with businesses municipalities and other stakeholders, is the regional leader for creating an environment that prepares for and cultivates sustainable growth. The concept(s) of green infrastructure are intriguing and parallel the broader goals of the Partnership to coordinate, educate, and advocate for solutions to regional constraints and limited natural resources. As a result the Partnership commissioned the University of Massachusetts Department of Landscape Architecture and Regional Planning (LARP) to examine the issues of green infrastructure during the 2007/2008 academic year.

About this Toolkit: This toolkit is the final product of LARP's work for the Partnership. The UMass 2008 Spring Studio would like to thank the Partnership for their support and the opportunity to work on a project with applications for addressing issues in the region. The goal was to create a toolkit that would contain useful information culled from numerous sources, which will help users understand and determine how green infrastructure could work in their community. This toolkit provides definitions, analysis and examples of how green infrastructure can and is being used in the region, and break down its different elements and techniques.

How to Use This Toolkit: This is an electronic toolkit with internal links to areas within the document and external links that lead to websites that contain pertinent information on each section. If the hyperlink is red, like this, it leads to another section of the document. If it is blue, like this, it leads to an external website. Internet access is needed to utilize the blue links.

The table of contents serves as a "site map" that describes the layout of the document, page by page. As you become familiar with the toolkit, the table of contents will allow you to jump immediately to specific sections that you have already visited. If you are a first time user, or wish to explore a new element of green infrastructure, it is probably best to start from the "home page," immediately following the FAQs, where each element of green infrastructure is listed and there are links to data in that specific area.

Each element is set up as a list of Best Management Practices (BMPs) that briefly describes each practice and then has internal links to *Advantages and Limitations, Barriers to and Incentives for Implementation* and *Economic Benefits and Incentives* associated with

each. Some BMPs fall under more than one element, such as urban forests, which could be in Water or Habitat. Any practice that performs services within multiple elements will be listed under each element in which they fit.

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Methodology

This toolkit is framed around the following 5 elements of green infrastructure: Stormwater Quantity and Quality, Habitat and Ecosystem Protection, Multi-Modal Transportation, Energy Efficiency and Conservation, and Waste Management. These element areas were selected in response to issue areas of regional and state concern and mirror elements included in other green infrastructure toolkits and programs across the nation.

For each element area we have selected a series of best management practices (BMP) that represent technologies that have already been implemented in the 495 MetroWest region and the state and those that we feel have the potential to be introduced to this area. BMPs are the structural or nonstructural measures taken to decrease damage to the natural environment caused by the built environment.

Utilizing local, state, and federal online resources we have been able to identify the advantages, limitations, barriers to and strategies for implementation, and economic benefits of each BMP. Our decision making process for the sources that would be used for this toolkit stem from the desire to use only highly regarded institutions whose data could be trusted to be accurate and up to date.

For the most part, we utilize national, state and municipality level sources. The other intention in focusing on these kinds of sites is that there is a higher expectation that the links will remain active well into the future.

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Frequently Asked Questions

What is green infrastructure?
Green infrastructure is the preservation, restoration or creation of facilities that utilize natural processes or technological innovation to recycle stormwater, conserve energy and protect habitat, in a way that encourages connectivity, supports development and is environmentally and economically sustainable.

How is it different from regular infrastructure?
The following table gives some examples of the difference between green infrastructure and conventional infrastructure:

Conventional (Gray) Infrastructure	Green Infrastructure
Uni-functional – just carry waste and water; built for cars only; electricity from fossil fuels	Multi-functional - store and treat stormwater; aesthetically pleasing; provide wildlife habitat; electricity from wind, solar; multi-modality, etc.
Manufactured materials	Manufactured and natural materials
Transports stormwater away from site	Manages stormwater on site
Concentrates stormwater and pollutants	Naturally treats and disperses stormwater and pollutants
Roads built for cars only	Roads that accommodate bicycles and pedestrians, and often, have natural elements too.
Electricity from fossil fuels	Electricity from multiple renewable energy sources
Difficult to create complementariness	Work well in tandem with and are complimentary to other types of infrastructure

How Do I implement green infrastructure?
Municipalities can introduce green infrastructure to their communities by following the Best Management Practices that are recommended by government, professional and other organizations that have studied or tested them.

- Green infrastructure Best Management Practices (BMPs) are the structural or non-structural measures that are taken to prevent or mitigate the damage to the natural environment caused by the built environment. Best Management Practices provide the most effective and efficient methods to prevent or treat pollution, save energy and save money, immediately or in the long term.

How does green infrastructure impact the environment?
Unlike conventional forms of infrastructure, which are traditionally uni-functional, made with manufactured materials, and concentrate stormwater and pollutants, green infrastructure provides numerous environmental benefits. Green infrastructure:

- Promotes cleaner water and enhances water supplies.
- Results in cleaner air.
- Leads to lower urban temperatures.
- Mitigates impacts of climate change.
- Increases energy efficiency.
- Reduces the volume of stormwater runoff and sewer overflows.
- Reduces the ecological footprint of development.
- Improves connectivity for habitat as well as for humans.

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- Helps communities grow without compromising natural resources.

Is Green Infrastructure economically viable?
While some green infrastructure applications may require more maintenance and cost more than others, all infrastructure requires routine maintenance. Often, conventional infrastructure is more expensive to replace and needs to be replaced more frequently. Although green infrastructure may not save money in the immediate short-term, it will in the long-term as maintenance fees can decrease due to the self-maintaining natural features of some BMPs.

In addition, taxable properties located adjacent to open space in urban areas often increase in value, potentially increasing tax revenues.

Is green infrastructure seen as controversial?
For the most part, green infrastructure represents ideas and values important to residents, businesses, and their employees like environmental sensitivity and sustainability. It appeals to a wide cross-section of users and does not necessarily involve or require extensive open space protection.

How easy is it to implement green infrastructure?
Green infrastructure is very flexible.

- Most BMPs can be built into both new development designs, as well as retrofitted to existing development.
- It can be built on any scale (regional, local, or site).
- It can be utilized from rural to high-density urban areas.

Features and practices will have the most benefit when used in conjunction or in close proximity to other features or natural areas. While this is best, BMPs in isolated situations are often still very worthwhile.

Is green infrastructure "green" because it's only made with natural materials?
No. Green infrastructure is an umbrella term encompassing a range of tools and techniques for creating more sustainable infrastructure systems. It incorporates many natural elements but may utilize human-made substances such as aluminum, plastic pipes, concrete, brick, etc. as well as human-made energy sources, processes, and technologies.

Is green infrastructure strictly for rural areas?
In intensively developed areas, green infrastructure might take the form mostly of retrofitting and restoring existing conventional or 'gray' infrastructure, which is the pipes, pumps and storage traditionally used to store and treat combined sewage and stormwater, and the existing roads and development strategies. In less developed areas, there is usually more opportunity for site-sensitive design and critical resource protection.

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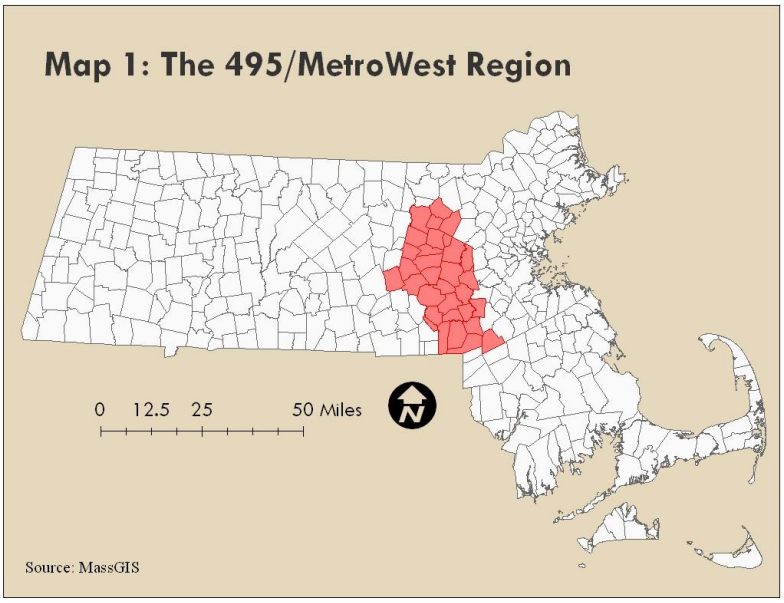
Green Infrastructure in the 495 / MetroWest Corridor

The 495/MetroWest Corridor is one of the most economically productive regions in the state of Massachusetts and will continue to experience growth over the next twenty years. Composed of 32 municipalities along Interstate 495, the 495/MetroWest Corridor supports many of Massachusetts' largest and fastest growing companies and is home to more than 500,000 residents (see Map 1).

According to a 2008 report conducted by the MetroWest Economic Research Center at Framingham State College on economic and demographic indicators, the region experienced a 59% increase in employment between 1980 and 2006, with most of these jobs concentrated in the Trade, Transportation and Utilities (21%), Professional and Business Services (19%), and Manufacturing industry super-sectors (15%). Not only is the region becoming a net importer of jobs, its number of residents is also growing dramatically. Between 1990 and 2000, the region experienced a 12.1% increase in population, which is double that of the Commonwealth for this time span.



Although this significant growth in jobs and population has led to economic success for the region, it has placed considerable strain on the area's existing infrastructure and water resources. In its *Water Reuse Report (2008)*, the Metropolitan Area Planning Council (MAPC) and the 495/MetroWest Corridor Partnership projects water shortages in 2030 for fifty communities if present patterns continue, including many 495/MetroWest municipalities. The report claims that these municipalities can prevent shortages by reducing water consumption by 20% and protecting areas with significant natural resources from development.

The biggest threat to Massachusetts' biodiversity is loss of habitat: more than 40 acres of open space per day or 300 acres per week are converted into residential, commercial, or industrial lands. Massachusetts' land mass totals nearly 5.2 million acres, of which 24%

is residential, commercial, and industrial development; 29% is protected recreational land, agricultural land, wildlife habitat and open space; and 47% is remaining open space that is unprotected, including farmland, forests, and habitat areas. State programs like MassWild emphasize the importance of habitat management and protection programs for sustaining and improving biodiversity and its benefits for both residents and visitors.

The development of infrastructure in Massachusetts has been characterized by limited cooperation between municipalities within the region and limited innovation in terms of available and feasible types of infrastructure as well as system integration of infrastructure with other priorities (e.g. land use, resource management, environmental quality, and economic development).

The transition to green infrastructure can lead to large-scale monetary and resource savings, and offer significant environmental as well as public health benefits for the 32 municipalities in the 495/MetroWest Corridor. Municipalities must become more aware of existing and potential green infrastructure technologies, as well as barriers to and potential strategies for their implementation.

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The Elements of Green Infrastructure

Photo Source

Water – There are three categories of water: water supply, wastewater, and stormwater. The BMPs covered in this section deal mostly with how to mitigate changes to both the quantity and the quality of stormwater runoff, or how to prevent runoff from occurring in the first place. These strategies prevent numerous problems such as flooding, stream scouring, and the collection and concentration of pollutants. They also protect and replenish drinking water supplies. Water conservation techniques that reduce pressure on wastewater treatment plants are listed in the Energy Efficiency and Conservation section.

Photo Source

Habitat and Ecosystem Protection – This section examines BMPs that promote protecting, restoring, and managing critical ecosystem and habitat areas that contribute to biodiversity, wildlife protection, and improved water quality.

Photo Source

Multi-Modal Transportation – This section describes transportation options that include at least two modes of transport by a single operator, such as commuting by bike and rail or traveling by foot and bike. Multimodal Transportation allows one to combine the specific advantages of each mode in one voyage while encouraging a more active lifestyle.

Photo Source

Energy Efficiency and Conservation – The BMPs in this section describe solar energy systems and strategies for retrofitting or replacing conventional energy and water systems that alleviate strains on natural resources.

Photo Source

Waste Management – This section highlights methods and programs for reducing, reusing, and recycling solid waste. It focuses primarily on the diversion of organic materials like yard refuse and food scraps from the municipal waste stream.

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Water: Best Management Practices

Photo Source

GRASSY SWALES
A vegetated, open-channel area designed specifically to treat and moderate stormwater runoff.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

Photo Source

RAIN GARDENS/BIORETENTION BASINS
Shallow, landscaped depressions designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

Photo Source

GREEN PARKING
Several techniques applied in various combinations that serve to reduce total impervious cover and runoff from parking lots.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

Photo Source

GREEN ROOFS
Planted roof-tops that absorb stormwater, preventing runoff and improving the quality of any runoff that does occur. There are two main kinds of green roofs: Extensive and Intensive. A third type is a cross between the two.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

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Photo Source

VEGETATED (GRASSED) FILTER STRIPS
Vegetated surfaces that are designed to treat sheet flow stormwater runoff from adjacent surfaces. They slow velocities and filter out some sediment and other pollution. Historically used for agricultural treatment, they are being adapted for urban uses such as filtering runoff from roads and highways, parking lots and roof downspouts.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

Photo Source

POROUS PAVEMENTS
Permeable surface that replaces traditional pavement, allowing stormwater to infiltrate into the subsoil. Examples include pervious concrete and porous asphalt as well as various types of permeable pavers. There are many limitations to this BMP in cold climates, so it is low on the list of recommendations, but for more info you can visit the NPDES website or the MAPC website

Photo Source

URBAN FORESTRY
The trees and forested areas located in and around towns and cities. Trees and patches of forest absorb stormwater, provide wildlife habitat, and can provide recreational uses as well. Urban forests help break up a landscape of impervious cover, provide small but essential green spaces, and link walkways and trails.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

Photo Source

ON-LOT TREATMENT
A range of practices that manage runoff from rooftops and to a lesser extent, driveways and sidewalks. On-lot treatment does three things, alone or in combination: Infiltrates rooftop runoff; diverts runoff to a pervious area; stores runoff for later use.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

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Quick Decision Matrix

	Cost	Site Scale	Required Maintenance	Function		Implementation
	$, $$, $$$	**S/L**	**Low/Mod/High**	**Allows Infiltration**	**Pollutant Removal**	**Easy/Mod/Difficult**
Grassy Swale	$	L	Low	Yes	Yes	Easy
Bioretention/ Rain Garden	$-$$$	S	Mod-High	Yes	Yes	Moderate
Green Parking	$$$	S	Low-Mod	Yes	Maybe	Difficult
Green Roofs	$$$	S	Low-High	No	Yes	Difficult
Vegetated Filter Strip	$$	S-L	Low	Yes	Maybe	Easy
Porous Pavement	$$$	S	Moderate	Yes	Yes	Difficult
Urban Forestry	$$-$$$	S-L	Low	Yes	Yes	Mod-Diff
On-lot Treatment	$-$$	S	Low	Yes/No	Yes/No	Easy-Mod
$= Inexpensive $$=Moderately expensive $$$=Expensive						
L = Large area (> 5 acres) S = Small area (< 5 acres)						

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Grassy Swales

A vegetated, open-channel area designed specifically to treat and moderate stormwater runoff.

Advantages	Limitations
Inexpensive	Area needs to be relatively flat
Low maintenance	Treats small areas only
If properly designed, very effective for pollutant removal	If not designed properly, will have little pollutant removal
Can provide snow storage in winter	Wet swales may breed mosquitoes

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Require a fairly large amount of land	Existing drainage ditches can be modified to perform more like grassed swales	In general, cost less to implement than concrete ditches or sewers.
Lack of incentives	Implement a model stormwater bylaw and regulations	Reduce stormwater management fees
Contradictory standards between local, state, and federal regulations	Amend site plan review standards to establish landscaping requirements	Costs less than conveyance and storage structures like pipes and ponds

For more info go to the EPA NPDES website
You can also check out the MAPC Toolkit
For more info about implementation strategies check out the MAPC Low Impact Development Local Codes Checklist.

Example:
Jordan's Cove - click on Grassed Swales in the column on the left hand side
Click on Results at the top of the page to see how effective the LID techniques have been.

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Rain Gardens/Bioretention Basins

Shallow, landscaped depressions designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems.

Advantages	Limitations
Visually Pleasing	Area needs to be relatively flat
Maintenance needs decrease over time	Requires landscaping maintenance
If properly designed, very effective for pollutant removal	If not designed properly, will have little pollutant removal
Increase property value	Treats small areas only
Applicable almost anywhere in the U.S.	When used in parking lots, may reduce number of parking spots
Can provide snow storage in winter	Maintenance costs associated with use in places that typically wouldn't have gardens, like parking lots.

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Lack of incentives	Implement a model stormwater bylaw and regulations	Reduce stormwater management fees
Contradictory standards between local, state, and federal regulations	Amend site plan review standards to establish landscaping requirements for parking areas that include vegetated islands with bioretention functions.	Costs less than conveyance and storage structures like pipes and ponds
Lack of communication	Permit the locating bioretention cell in required setback areas and in buffer strips.	May lower utility costs by requiring less watering than similarly landscaped areas

To see the source from which these tables were created go to the EPA NPDES website
More information came from the MAPC Toolkit
For more info about implementation strategies check out the MAPC Low Impact Development Local Codes Checklist.
Information on the economic benefits of this BMP and Low Impact Development practices can be found in the MA Smart Growth Toolkit's Low Impact Development Module.
For specifications from the Low Impact Development Center Click Here

Examples:
Franklin, MA Stormwater Best Practices Handbook
Comprehensive Environmental Inc. has installed raingardens in a number of communities, including Franklin and Natick. Click Here to see project details.
Jordan's Cove - click on Rain Gardens in the column on the left hand side.
Click on Results at the top of the page to see how effective the LID techniques have been.

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Green Parking

Several techniques applied in various combinations that serve to reduce total impervious cover and runoff from parking lots.

Advantages	Limitations
Reduce stormwater runoff	Numerous regulatory barriers
Reduce heat island effect	Greater maintenance needs than conventional parking surfaces
Can reduce pollutant levels in area waterways	May reduce number of parking spots
Visually pleasing (compared to tarmac)	May increase construction costs

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Regulations that promote peak parking ratios	Minimizing the dimensions of parking lot spaces and setting maximums for the number of parking lots created	Reduce stormwater management fees
Minimum stall widths that more than accommodate SUVs	Changing the width regulations	Costs less to build a smaller lot
Lack of incentives	Encouraging shared parking	Costs less to share a lot
	Encourage structured (above or below ground) parking	Novelty that may attract customers
Pressure on developers to ensure sufficient customer parking	Education about alternatives and incentives to reduce parking area	

Other BMPs such as permeable paving and raingardens/bioretention basins can be a part of green parking design.
For more info go to the EPA NPDES website
For more info about implementation strategies check out the MAPC Low Impact Development Local Codes Checklist.

Example:
The Orange Bowl Stadium in Miami, FL
The German Embassy in Washington DC
A Unitarian Church in Hillsboro, OR

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Green Roofs

Planted roof-tops that absorb stormwater, preventing runoff and improving the quality of any runoff that does occur.

Advantages	Limitations
Visually pleasing	More expensive than conventional roofs
Maintenance needs decrease over time	Needs some ongoing maintenance
Increased acoustic and thermal insulation	Load capacity of existing structures must be taken into account
Last longer than conventional roofs	Prevents rainwater from returning to the water table
Eliminate the toxic components associated with standard roofing materials	
Curb urban heat island effects	
Absorb air pollution, collect airborne particulates and store carbon	
Provide habitat for insects and birds	

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Higher up-front costs	Cost-benefit analyses that show savings over time	Costs recouped by energy savings and roof longevity
Misperception that green roof is more likely to leak	Information on roof soundness	
Lack of incentives	Implement a model stormwater bylaw and regulations	Can Reduce stormwater management fees

For more info go to the EPA NPDES website. You can also check out the MAPC Toolkit
For specifications from the Low Impact Development Center Click Here
Check out the International Green Roof Association
For more info about implementation strategies check out the MAPC Low Impact Development Local Codes Checklist.

Examples: For numerous examples in MA and elsewhere greenroofs.com has an extensive list.

Types of Green Roofs

Intensive	Extensive	Semi-intensive
> 6 inches of growing medium	≤ 6 inches of growing medium	Having at least 25% of the roof in one category, 75% in the other
High maintenance	Low maintenance	Medium maintenance
Designed for public access	No public access	Designed for public access
35-100 lbs/sq.ft.	13-30 lbs/sq.ft.	25-40 lbs/sq.ft.
Most expensive	Least expensive	Medium expensive
Regular irrigation	No irrigation (except initially)	Periodic irrigation

Extensive

Photo Source

Intensive

Photo Source

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Vegetated (Grassed) Filter Strips

Vegetated surfaces that are designed to treat sheet flow stormwater runoff from adjacent surfaces.

Advantages	Limitations
Low maintenance	Area needs to be relatively flat
Inexpensive	Consume a large amount of space
Can provide snow storage in winter	Not proven as reliable pollutant removal practice
	Not suitable in ultra-urban areas

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Expense	If area was going to be grassed and maintained anyway, environmental benefits could outweigh added costs	Land used for filter strip may have been seeded anyway, so the only additional costs are for design and berms
Lack of incentives	Implement a model stormwater bylaw and regulations	Can Reduce stormwater management fees

For more info go to the EPA NPDES website
You can also check out the MAPC Toolkit
For more info about implementation strategies check out the MAPC Low Impact Development Local Codes Checklist.

Examples:
Drumlin Farm Wildlife Sanctuary, Lincoln, MA

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STORMWATER BMP SITE ASSESSMENT GUIDE

	Grassy Swale	Bioretention/ Rain Garden	Green Parking	Green Roofs	Porous Pavement	Vegetated Filter Strip
Flat (ideal slope 1%-2%)	√	O	√	√	-	√
Shallow Slopes (≈5%)	√	√	√	√	-	√
Steep Slopes	X	X	-	O	-	X
Highly Impermeable Soils	X	√	-	-	X	X
Treat < 5 acre area	√	√	-	-	-	-
Treat > 5 acre area	X	X	-	-	-	-
Above Water Table	√	√	√	-	-	√
Below Water Table	O	X	X	-	-	X
Applicable for New Development	√	√	√	√	√	√
Applicable for Existing Development	√	√	O	√	√	O
Applicable in Ultra-Urban Areas	X	√	√	√	√	X
Applicable for Highly Contaminated Runoff	X	O	-	X	-	X
Cold Water (Trout) Streams	√	√	-	-	√	√

*Based on EPA NPDES website

Table Key:
√ = Yes
O = Yes, but only in some applications, or with modifications
X = No
- = Not Applicable

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Urban Forestry

The trees and forested areas located in and around towns and cities

Advantages	Limitations
Visually pleasing	Can inhibit development
Low maintenance	Consume a large amount of space
Reduce heat island effect	Requires some forestry expertise
Reduce noise levels	May harbor insects and pests

Barriers to Implementation	Strategies for Implementation	Economic Benefits
High land values and development pressure in urban areas	Tree preservation ordinances and conservation easements	Property value increases
		Preserving trees during construction can cut down on clearing and grading and erosion control costs

For more info go to the EPA NPDES website
You can also check out the Minnesota's Urban Forestry BMP Manual

American Forests, a non-profit forest preservation organization, offers services to municipalities to help them preserve forested areas. They offer a tool to quantify existing "green infrastructure" (defined by American Forests as areas covered with trees, shrubs, and grass that allows water to soak into soil which naturally filters pollutants) via satellite imagery. To find out more about the organization Click Here
To find out more about their assessment software, CITYgreen Click Here

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On-Lot Treatment

A range of practices that manage runoff from rooftops and to a lesser extent, driveways and sidewalks.

Types of On-Lot Treatment

Practices that infiltrate rooftop runoff	Practices that divert runoff to a pervious area	Practices that store runoff for later use
Dry Well	Downspout Disconnection	Rain Barrel
Soakage Trench	Rain barrel overflow pipe	Cistern
French Drain		

Advantages	Limitations
Inexpensive – downspout disconnections, rain barrels, soakage trenches	Moderate to somewhat expensive – Dry wells, cisterns (the more digging, the more expensive)
Flexible – can be used from rural to ultra-urban sites and any size lot as long as there is some landscaping.	The smaller the lot, or larger the percentage of impervious surface, the fewer applications will be possible
Can be DIY (do it yourself) project - downspout disconnections, rain barrels, soakage trenches	Requires routine maintenance
Stored water can be used for irrigation	Have to have a need for stored water in order for it to be useful
Promote groundwater recharge (unless captured water is used for toilet flushing or some other application that is not landscaping)	Risk for mosquito breeding in storage tanks

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Lot size, amount of landscaping in relation to size of roof or impervious surface managed		If used for irrigation will lower water bill
Conflict with building codes	Change code to allow use	
Lack of incentives	Implement a model stormwater bylaw and regulations	Can Reduce stormwater management fees

For more info go to the: EPA NPDES website
You can also check out the MAPC Toolkit
For specifications from the Low Impact Development Center Click Here

Examples:
Drumlin Farm Wildlife Sanctuary, Lincoln, MA
For a do-it-yourself guide to making a rain barrel click here

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Habitat & Ecosystem Protection: Best Management Practices

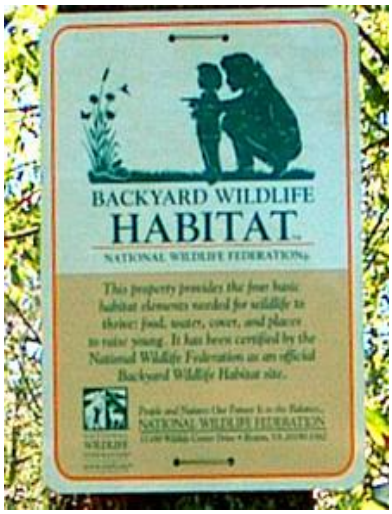

Photo Source

BACKYARD HABITAT
A portion of property developed for attractive and productive wildlife habitat. Backyard habitats must provide sources for food and water, places for cover and to raise young, and incorporate sustainable gardening practices. Nesting boxes, feeders, and watering sites can be added to improve the habitat.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

Photo Source

GREENBELT
Protected areas of undeveloped, wild, or agricultural land surrounding or neighboring urban areas.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

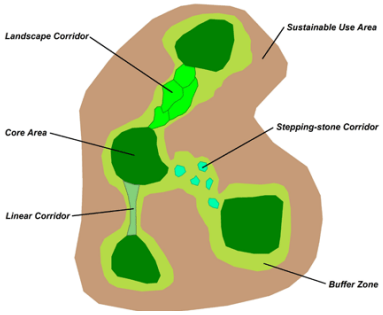

Photo Source

HABITAT CORRIDOR
A linear habitat that connects two or more larger areas of core habitat. This space is used to create wildlife habitat and support wildlife movement. It relies on a matrix of existing but discontinuous natural areas to realize its full potential.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

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Photo Source

WETLAND / RIPARIAN BUFFER
A protected area of naturally vegetated land located adjacent to a lake, stream, or wetland that serves to protect these water resources from neighboring land uses and adverse actions, which include agriculture, urban development, and industrial uses, taking place in upland areas.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

Photo Source

URBAN WILD
The remains of a natural ecosystem located in a largely developed, highly urban area. This is often an intact ecosystem that can offer valuable ecological services like filtering, storing, and slowing stormwater run-off, benefiting air quality, and countering the warming effect of urban development.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

Photo Source

URBAN FORESTRY
Urban forests are the trees and forested areas located in and around towns and cities. Trees and patches of forest absorb stormwater, provide wildlife habitat, and can provide recreational uses as well. Urban forests help break up a landscape of impervious cover, provide small but essential green spaces, and link walkways and trails.

To see the Advantages and Limitations, Barriers to and Strategies for Implementation, and Economic Benefits and Incentives associated with this BMP click here

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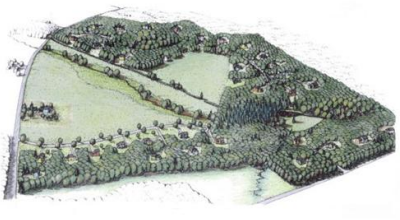

Photo Source

OPEN SPACE RESIDENTIAL DESIGN

Design techniques that concentrate dwelling units in one portion of the site while providing for open space and natural area conservation elsewhere. By reducing impervious surfaces OSD reduces stormwater runoff and increases runoff treatment via natural percolation.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

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Backyard Habitat

A portion of property developed for attractive and productive wildlife habitat.

Advantages	Limitations
Restores habitat and piece of ecosystem disturbed by development	Requires planning in advance
Numerous habitats can be provided on one site	Setting out food may attract unwanted animals
Can be visually appealing	
Can improve air, water, soil quality	
Size of yard or space does not matter	

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Property may have an existing conservation easement* on it	Conservation easements can be set up to preserve habitat	Can receive tax benefits from conservation easements
Laws and regulations can limit what one does on their property	Ordinances and bylaws can be used to create conservation areas that protect against disturbance click here for model wetland bylaws or to see what bylaws exist in your community	

*Conservation easement is a permanent, legal restriction that is recorded on the deed and filed with the county or town clerk that ensures the current and future property owners abide by conservation restrictions. For more information on conservation easements visit the Nature Conservancy's website

For more information visit the National Wildlife Federation Backyard Habitat Program

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Greenbelt

Protected areas of undeveloped, wild, or agricultural land surrounding or neighboring urban areas.

The objectives of a greenbelt are to:

- protect natural or semi-natural environments;
- improve air quality within urban areas;
- ensure that urban dwellers have access to countryside, with consequent educational and recreational opportunities; and
- protect the unique character of rural communities which might otherwise be absorbed by expanding suburbs.

Advantages	Limitations
Provides recreational opportunities and has potential for linking and expanding trail systems	Can be eroded by urban-rural fringe land uses
Protects and connects natural areas and wildlife habitat	Development can jump over greenbelts creating satellite towns
Can curtail sprawl development	High land prices can prevent farmers from buying land within greenbelt
Offer protection for agricultural and natural land	

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Potential buffer and liability issues between housing, agriculture, and wildlife uses	Best to have vegetated buffers, rural characteristics and non-intrusive lighting on adjacent roads; and, minimum of buildings on Greenbelt lands adjacent to the edge.	Potential for expanded agricultural-related business opportunities (e.g. pick your own farms, community supported agriculture)
Purchasing open space lands and easements can be costly		Aesthetic agricultural and natural landscapes with recreational opportunities can raise property values and add value to surrounding urban areas

For more information on greenbelt planning visit Canada's National Capital Commission's GreenBelt Master Plan. Although this is a source from outside the United States, it is a helpful guide on greenbelts for planners and resource managers.

Example: The Capital Area Greenbelt is a 20-mile long green belt around urbanized parts of Harrisburg, Pennsylvania that links city neighborhoods, parks, and open spaces. The green belt offers recreational opportunities like hiking, biking, birding, walking, running, and cross country skiing for area residents and visitors.

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Habitat Corridor

Any natural or manmade wildlife strip that connects two core habitats. Size can vary from a large wooded strips that connect a larger woodland to as simple as a line of shrubs along a sidewalk. Water corridors are called riparian ribbons and usually come in the form of rivers and streams.

Another common type of habitat corridor is a wildlife crossings, which are structural passageways built either above or beneath roadways that are designed to decrease wildlife mortality and increase animals ability to overcome habitat fragmentation by guiding safe passage over roads.

Advantages	Limitations
Creates green space in urban setting	
Provides opportunity for movement of animal populations	Some species react more positively to corridors than others
Offers wildlife habitat protection and food sources	Effectiveness depends on size, width, composition, and location of corridor
Can be used for recreational opportunities	Human use can compromise efficacy of structures
Can be used as boundary for property lines or barriers of landscape elements	Without a buffer it can be affected by urban land uses and development
Can be made cleaner and safer than urban sidewalks	
Helps increase biodiversity	Lack of data exists about effectiveness
Can be aesthetically pleasing	

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Can be costly to implement	Carefully planning in advance; important to link open space in developments	Can increase value of nearby house sites
Public support is needed for connecting two areas of green space	Monitoring programs should be created to ensure long term effectiveness	Reduce potential expenses of streambank stabilization and clean up costs of river and streams
	Can use conservation design to protect or restore significant natural elements of land before building lots	Can reduce risk of building on poor soils for development

For more information visit Washington University's website on Habitat Corridors
For more information on wildlife crossings visit The Wildlife Crossing Toolkit
For information on Habitat Conservation Planning visit the United State's Department of Fish and Wildlife Service's Habitat Conservation Planning Handbook

Example: For an example of how to implement wildlife crossings in Massachusetts review the Walden Woods Project, a study put forth by the MAPC, UMass Amherst Center for Economic Development, and the Federal Highway Administration.

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Wetland / Riparian Buffer

A protected area of naturally vegetated land located adjacent to a lake, stream, or wetland that serves to protect these water resources from neighboring land uses and adverse actions, which include agriculture, urban development, and industrial uses, taking place in upland areas.

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Many towns lack sufficient information to implement effective bylaws	To review Mass's wetland policies click here	Can reduce risk of building on poor soils for development; Potentially reducing costs associated with flood damage

Advantages	Limitations
Preserves habitat for terrestrial riparian wildlife	Effectiveness of buffer depends upon its width
Improves habitat for aquatic species	Existing regulations do not offer adequate protection for many species
Protects water quality	Wetland buffer is not a protected water resource area in MA: MA Wetland Protection Act only regulates activities in buffer zone that affect protected wetland area not upland areas.
Controls erosion	
Stores floodwaters and can reduce flood damage	
Improves aesthetic appearance of stream corridors	
Provides recreational and educational opportunities	

For more information about wetland and riparian buffers visit the following resources:
Planners Guide to Wetland Buffers for Local Governments
UMass Department of Natural Resource Conservation: Wetland Buffer Zones and Beyond
Mass DEP Wetlands Program
Mass DEP Wetland Permit Forms

Examples:
North Andover enforced Section 3A, a section of the town by-law that regulates all activities in the buffer zone and requires a Notice of Intent (NOI) to be filed with the conservation commission for projects within the buffer zone. Some towns in Massachusetts have extended protection further and completely protect the 100ft buffer from building. The town of Blackstone's wetland protection bylaw requires a NOI for any work within the regulated buffer and a 100ft. setback from a wetland edge for any building.

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Urban Wild

The remains of a natural ecosystem located in a largely developed, highly urban area.

Advantages	Limitations
Often home to native vegetation and animal life	Vulnerable to development if not protected
Contribute to biodiversity	
Perform a range of ecosystem functions	Smaller urban wilds enhance ecosystem function less
Can provide passive recreation and educational opportunities	
Provide space for refuge and tranquility; psychological benefits	

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Formal protection can be difficult and complex to achieve	Conservation restrictions can be used to keep land tenure systems in place while protecting	Can increase value of nearby house sites
Ownership of land can be complex with multiple owners	Public/private partnerships have been successful at acquiring and monitoring land	
	Click here to view information on how to transfer land for conservation	Transfer of Development Rights can conserve land without using public funds

For more information visit Boston's Urban Wilds Initiative or the Rappaport Institute of Greater Boston's Urban Wild website.

Also, look out for James L. Ortiz' *Urban Wild: A Manual for the Development, Implementation, and Operation of Nature Centers on School Campuses.*

Example:
The Boston Natural Areas Network (BNAN) is 646 acres of urban wilds that are protected and publicly accessible. BNAN has established linear corridors or "greenways" of protected open spaces, including parks and urban wilds. Proposed greenways include the "Charles-to-Charles" greenway from Charlesgate in downtown Boston to Jamaica Pond and beyond. Click here to visit the BNAN website.

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Open Space Residential Design

Design techniques that concentrate dwelling units in one portion of the site while providing for open space and natural area conservation elsewhere.

Advantages	Limitations
Protects unique or fragile habitats	Open space must be connected to provide maximum ecosystem benefits
Sets aside open space based on resource values, not by formula	Not always supported by community
Opportunity to link wildlife habitats	Limits opportunity for development and potential economic gain
Reduces isolation and sprawl; goal is to save land not stop development	
Reverses typical subdivision planning process by designating open space first and drawing lot lines last	
Reduces stormwater runoff and promotes aquifer recharge	

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Requires flexibility and support of community	Can be used to further goals of open space and community development plans	Can reduce infrastructure and maintenance costs
Conflict among community boards and existing regulations	Can be combined with 40 B, as an alternative to comprehensive permit	Streamlines plan review process; reduces time and costs
Existing zoning does not always encourage open space protection	Click here to access a model OSRD bylaw	Decreases site development costs by designing with the terrain
	Bylaw might call for a modest density bonus, mix of housing types and help from consultants with plan review	Reduces demand to acquire new public parkland
		Adds valuable amenities that can enhance marketing and sale and resale prices of real estate

For more information on OSRD visit the Massachusetts Smart Growth / Smart Energy Toolkit's OSRD section

Example: Olde North Mill in the town of Hopkinton, MA implemented an Open Space and Landscape Preservation Development. For more information on this case click here

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Multi-Modality Best Management Practices

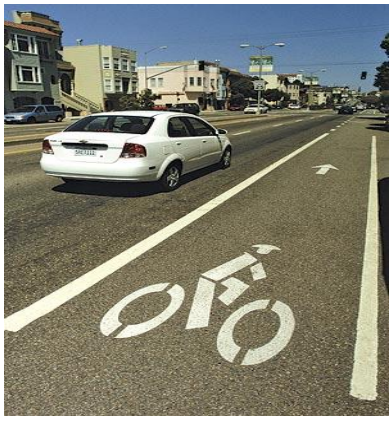

Photo Source

BIKE LANE
A striped and signed space exclusively for the use of bicyclists and is typically 4 or 5 feet wide.

To see the Advantages and Limitations, Barriers to and Strategies for Implementation, and Economic Benefits and Incentives associated with this BMP click here

Photo Source

TRAFFIC CALMING
The application of traffic engineering and other physical measures designed to control traffic speeds and encourage driving behavior appropriate to the environment.

To see the Advantages and Limitations, Barriers to and Strategies for Implementation, and Economic Benefits and Incentives associated with this BMP click here

Photo Source

SIDEWALKS
Can be separated from the curb by a planting strip that is just several feet of grass between the sidewalk and the street.

To see the Advantages and Limitations, Barriers to and Strategies for Implementation, and Economic Benefits and Incentives associated with this BMP click here

RECREATIONAL OPPORTUNITIES
Active or passive activities for entertainment or amusement. Examples of recreation are but not limited to; parks, playgrounds, and trails.

To see the Advantages and Limitations, Barriers to and Strategies for Implementation, and Economic Benefits and Incentives associated with this BMP click here

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Bike Lanes

A striped and signed space exclusively for the use of bicyclists and is typically 4 or 5 feet wide.

Advantages	Limitations
Reduced traffic congestion	Increased impervious surface
Increased health and fitness	Requires maintenance
Increased safety for bicyclists	High motorist turn volume can reduce effectiveness
Improved highway capacity	Drivers assume bicyclists must only ride in the bike lane
Increased pavement life	Encourages wrong-way cycling
Increased motorist and bicyclist safety	
Serves as a traffic calming tool	
Provides a buffer zone for motorists	
Increases visibility of bicyclists	

Barriers to Implementation	Incentives for Implementation	Economic Benefits
On street parking decreases bike lane safety and effectiveness.	Vehicle Trip Reduction Ordinance	Inexpensive to install
	Bicyclist's Bill of Rights and Responsibilities (H. 1411)	Increased levels of tourism
	Technical Assistance	Increased employment from bicycle facilities
		Attraction of skilled work force
		Creates a healthier work force
		Reduced commuting costs

For information on where bike lanes are located in Metro West Click Here
For a listing of bike path projects funded by the Massachusetts Highway Department Click Here

Examples:
The Massachusetts Area Planning Council has developed a Regional Bicycle Plan.
The Massachusetts Bicycle Coalition offers commute by bicycle workshops.
The Federal Highway Administration offers design guidance on accommodating bicycle travel.

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Traffic Calming

The application of traffic engineering and other physical measures designed to control traffic speeds and encourage driving behavior appropriate to the environment.

Advantages	Limitations
Increased pedestrian Safety	Construction and development costs are potentially expensive
Increased visibility	Increased driver commuting time
Increased road Safety	Spillover of traffic onto other roads
Vehicle speed reduced	Potential delays on emergency and service vehicles
Better conditions for children and elderly	Driver frustration
Increased non-motorized travel	Can be hazardous for drivers and bicyclists if not designed and maintained properly
Decreased noise volume	Opposing drivers arriving simultaneously can create confrontation
Decreased air pollution	Reduced sight distances if landscaping is not low and trimmed
Increased neighborhood interaction and crime prevention	
Decreased crash severities	

Barriers to Implementation	Incentives for Implementation	Economic Benefits
Must have public support	Reduced crime	Crash cost savings
Potentially dangerous conditions for bicycles	Equitable balance among transportation modes	Increased property values
Potentially dangerous	Decreased auto dependency	Decreased fuel consumption
Crash liability issues	Encourages alternative modes of transportation	Increased economic activity
Levels of success change with traffic volumes	Supports higher-density and mixed use	
May affect response times for emergency vehicles	Reduces traffic impacts on neighborhoods	

For more information on the advantages and disadvantages of this BMP visit The Federal Highway Administration website.
Information on economic benefits can be found at walkable streets.
Other links to check out are included below:
Victoria Policy Transit Institute's Roadway Design to Reduce Traffic Speeds & Volumes
Traffic Calming Toolbox

Examples: Franklin, MA, like a number of area communities, is planning for the redevelopment of its town center to make it more pedestrian and retail friendly. The use of streetscape improvements, traffic calming, and connections with transportation systems are all included in the vision. For more information on the Franklin, MA downtown concepts for the future Click here.

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Sidewalks

Can be separated from the curb by a planting strip that is just several feet of grass between the sidewalk and the street.

Advantages	Limitations
Increased Pedestrian Safety	Increased impervious surface
Serves as a traffic calming tool	Potentially expensive to install
Provides an alternative mode of transportation	Not always necessary in less dense areas
Serves as a way to link the community	Requires Maintenance
Increased pedestrian comfort	
Provides a place to absorb runoff	
Serves as a place to dump snow in the winter	
Protects a falling pedestrian	

Barriers to Implementation	Incentives for Implementation	Economic Benefits
High speed limits	Decreased dependence on automobile usage	Increased property values
Homeowners are held responsible for sidewalk maintenance	Technical assistance	Attracts more skilled work force
	Sidewalk snow and ice removal required by homeowners	Healthier work force
	Programs that encourage an active lifestyle	Increased walkability in commercial and residential districts raises retail sales
		Reduced commuting costs

For more information on design guidelines for sidewalks Click Here.
For information on walkable catchments Click Here.

Examples:
The Pioneer Valley Planning Commission created a Model Sidewalk Bylaw.
MAPC has recently begun the update to the Regional Pedestrian Plan.
The Federal Highway Administration offers design guidance for integrating walking into transportation infrastructure.

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Recreational Opportunities

Active or passive activities for entertainment or amusement. Examples of recreation include but are not limited to; parks, playgrounds, and trails.

Advantages	Limitations
Provides active living spaces	Increased usage of open space can decrease environmental integrity.
Increased property values that are located in vicinity	Potential loss of privacy by property owners in vicinity
Increased social bonds	Potential loss of property
Helps to better develop youth	
Increased volunteerism	
Promotes Social Inclusion	
Reduces crime and vandalism	
For more information on the benefits of recreational opportunities visit the Danvers, MA Recreation website click here	

Barriers to Implementation	Incentives for Implementation	Economic Benefits
Apprehension amongst property owners	Subdivision Regulations	Tourism
	Technical Assistance	Increased retail sales
		Increased property value

For information on different types of recreational opportunities visit the Congress for New Urbanism's Highways to Boulevards Initiative.

Example: A group of citizens are working to establish a 12.5-mile bike and pedestrian path on a long-abandoned railroad right-of-way paralleling the Assabet River through Hudson, Stow, and Maynard, with connections to Marlborough and the MBTA commuter rail station in South Acton. In 1998, all five communities started to acquire land for the trail.

Six miles of the trail in Marlborough and Hudson are completed while work is continuing in Maynard, Acton, and Stow. For more information on the Assabet River Rail Trail Click here.

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Energy Efficiency and Conservation

Photo Source

SOLAR (PHOTOVOLTAIC) PANELS – Generate electricity without using any fossil fuels.

To see the Advantages and Limitations, Barriers to and Strategies for Implementation, and Economic Benefits associated with this BMP click here

Photo Source

ENERGY STAR SYSTEMS – Provide an energy-saving alternative to conventional appliances and heating/cooling systems.

To see the Advantages and Limitations, Barriers to and Strategies for Implementation, and Economic Benefits and Incentives associated with this BMP click here

Photo Source

SOLAR HOT WATER – Can eliminate the need for conventional hot water heaters.

To see the Advantages and Limitations, Barriers to and Strategies for Implementation, and Economic Benefits and Incentives associated with this BMP click here

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Photo Source

SUPER-INSULATED HOME DESIGN – Use better windows and doors, high-efficiency HVAC equipment, more insulation, and better air sealing.

To see the Advantages and Limitations, Barriers to and Strategies for Implementation, and Economic Benefits and Incentives associated with this BMP click here

PASSIVE SOLAR SYSTEMS - Take advantage of climatic conditions, especially the sun, for heating in the winter and cooling in the summer.

To see the Advantages and Limitations, Barriers to and Strategies for Implementation, and Economic Benefits and Incentives associated with this BMP click here

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Solar (Photovoltaic) Panels

Generate electricity without using any fossil fuels.

Advantages	Limitations
Use no fossil fuels	Can't supply all electricity for high-demand facilities
Grid-connection allows for sale to and purchase from the grid	Requires silicon which is an expensive commodity (dye-sensitized panels are cheaper)
Provides power during grid shortages	
Can be added on to existing construction	

Barriers to Implementation	Strategies for Implementation	Economic Benefits
PV roofs require building permits (p71) from local building and electric inspectors	Fast Track Permitting (MA Dept. of Environmental Protection)	No electricity costs
Solar access can be blocked by the orientation or height of other buildings or landscaping	Communities may pass laws to preserve solar access (p70), in accordance with MA general laws	Systems pay for themselves in 5-10 years
Abutters may complain about visual effect or perceived impact on property values	Contact abutters before filing for permits	
Must follow interconnection standards if connecting to the grid	No fees for the interconnection approval process and applications must be processed within 15 days	
	State rebates, grants/loans for communities, businesses, and non-profits, and tax incentives available. Federal tax incentives available	

For free help in marketing surplus power, visit the Mass Energy Consumers Alliance
To use state rebate calculators click here and scroll to the bottom of the page
For a complete list of federal incentives click here
For information on purchasing renewable energy and energy conservation products click here

Examples

Public construction: Boston plans to install about $1 million worth of panels on municipal buildings, including Brighton High School, The Strand Theatre, Tobin Community Center, and the West Roxbury Branch Library click here. That is on top of Boston's $2 million Green Affordable Housing Program that has added solar to the roofs of six city developments. Also, the Massachusetts Water Resources Authority plans to install solar panels at the Deer Island Wastewater Treatment Plant click here. For another example visit Charlemont Sewer District goes solar.

Commercial construction: 433 kilowatts of cells at Staples office supply store in Killingly click here. The output of the solar-power system is equivalent to the power used by 36

homes. The solar array is calculated to reduce carbon emissions from Staples' warehouse by 195 tons a year.

State and local incentives- In December 2007, Governor Patrick launched a $68 million program, known as Commonwealth Solar, to increase the number of solar electric panels on Massachusetts homes, businesses, and schools by 600% over the next four years. Through easy-to-use mail-in rebates, the state will fund residential projects of up to 5,000 watts and commercial projects of at least 100,000 watts, with a maximum commercial rebate of $1 million per system. $16 million of these funds are earmarked for incorporating solar technologies into public construction projects. With the state rebates, homeowners and businesses could save enough on their electric bills to pay off the net cost of solar panels within five to eight years, then reap thousands of dollars in savings after that. The plan also includes special incentives for buying solar panels made by Massachusetts companies, such as Evergreen Solar in Marlborough. In addition, Boston mayor Menino wants to increase capacity within the city to 25 mw by 2015 click here. Dubbed Solar Boston, the program will also map neighborhoods to identify south-facing rooftops ideal for photovoltaic panels.

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Energy Star Systems

Provide an alternative to conventional appliances and heating/cooling systems.

Advantages	Limitations
Energy-saving replacements for conventional appliances and heating/cooling systems, visit on the web	Systems still use non-renewable energy
Also reduce water use, click here for information on industrial water conservation	
HVAC and refrigeration systems minimize or eliminate the emission of compounds that contribute to ozone depletion and global warming	
Very effective in combination with other energy saving methods (see lighting and plug load methods for businesses, and click here to use the Building Upgrade Calculator for Office Buildings)	

Barriers to Implementation	Strategies for Implementation	Economic Benefits
	Energy Rated Mortgages increase the borrowing power of buyers of energy-efficient homes.	Save money
	Federal tax incentives and grants available. Utility company rebates and loans available	

For more information on environmental performance and economic competitiveness for Massachusetts businesses click here, or here for info on developing an Energy Management Strategy
For information on Energy Star certification for new homes click here
For a list of existing certified buildings in Massachusetts click here
Follow this link for a complete list of federal incentives
For more information on incentives provided by utility companies and other sponsors click here
To learn about other ways you can conserve energy click here
For more information on lawn and landscape water conservation click here

Examples

The Mansfield Municipal Electric Department has implemented its own Energy Star Appliance Rebate Program.
A demonstration home in Hadley, MA with solar photovoltaic electric generation and solar thermal hot water heating is also equipped with Energy Star appliances. Built with the help of Western Massachusetts Electric Company in 2004, the home is also super-insulated. Click here for more info.

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Solar Hot Water

Can eliminate the need for conventional hot water heaters.

Advantages	Limitations
Can meet the bulk of hot water requirements	Moderately more expensive than conventional hot water heaters
Storage tank can provide hot water on cloudy days	
Can be designed to meet 15-25% of regular heating needs also	

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Solar access can be blocked by the orientation or height of other buildings or landscaping	Communities may pass laws to preserve solar access, in accordance with MA general laws	A typical solar water heating system costs $3,000 but can save $150-350 per year (12 year payback period)
Expertise required for improvement/replacement	Many electric utilities and gas companies offer free home energy audits	
	State rebates and tax incentives are available Federal tax incentives are available. Utility company rebates and loans are available	

For more Advantages and Limitations go to the U.S. DOE website
To use state rebate calculators click here and scroll to the bottom of the page
For more information on picking out a solar water heater click here
To use state rebate calculators click here and scroll to the bottom of the page
Follow these links for complete lists of federal incentives and utility company incentives
For more information on incentives provided by utility companies and other sponsors click here

Examples

Commercial Construction: Announced in April 2008, Fenway Park will install enough solar panels to heat 1/3 of the hot water needed for the park, reducing annual carbon dioxide emissions by roughly 18 tons click here.

Municipal Construction: Worcester's new North High School will incorporate solar hot-water collectors, as well as photovoltaics. The solar system for the school could be as large as 4,000 square feet. North High School is likely to receive a grant to aid in the construction.

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Super-insulated Home Design

Use better windows and doors, high-efficiency HVAC equipment, more insulation, and better air sealing.

Advantages	Limitations
Conserves energy	Difficult to retrofit a house
Can be built on any building lot, facing any direction	House must be of certain size to meet super-insulated specifications for ventilation

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Requires careful education, communication, coordination, and supervision of subcontractors	Workers can utilized a variety of methods according to experience and skill level	Increases new construction costs by 5-7%, but saves 75% on annual energy costs for heating and cooling compared to a standard home
	Energy Rated Mortgages increase the borrowing power of buyers of energy-efficient homes.	
	Federal grants and some federal tax incentives available Utility company rebates and loans available	

For more information on superinsulated houses click here
To learn about other ways you can conserve energy click here
Follow this link for a complete list of federal incentives

Example

A recently constructed Colonial style house in Stow features super-insulated exterior walls click here and scroll down). Garnering a free LEED for homes pilot silver certification (the first given in Massachusetts), the house was built without a large budget or much expertise. It also features day lighting, Heat Recovery Ventilation, and Radiant Floor Heating.

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Passive Solar Systems

Take advantage of climatic conditions, especially the sun, for heating in the winter and cooling in the summer.

Advantages	Limitations
Provide heating (thermal mass), lighting, and ventilation completely without fossil fuels	Requires South-facing exposure
	Don't produce as much energy as active systems with greatly-enhanced heat transfer and transport

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Requires permit from local building inspector	Fast Track Permitting (MA Dept. of Environmental Protection)	Doesn't take energy to produce like photovoltaics
Abutters may complain about window orientation or other unconventional design elements	Contact abutters before filing for permits	Lower maintenance costs than photovoltaics
	Energy Rated Mortgages increase the borrowing power of buyers of energy-efficient homes.	
	State tax incentives available.	

For information on passive solar home design click here

Example

The MA Audubon Education Center in Natick, was designed for passive solar when it was converted from a barn click here and scroll down. In 2004, the Audubon Society installed solar panels from Evergreen Solar, headquartered in Marlborough, MA, further reducing electricity consumption. The building also incorporates natural daylighting and ventilation.

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Waste: Best Management Practices

Photo Source

COMMUNITY COMPOSTING PROGRAMS
A method for accelerating the natural decomposition of organic materials like plant and food wastes into a rich soil-like amendment. Composting programs can occur at many different scales including: backyard, municipal, commercial, and agricultural.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

Photo Source

FOOD WASTE RECYCLING
The managed composting of residual food waste from food preparation and consumption at homes, restaurants, commercial businesses and institutions.

To see the advantages and limitations, barriers to and strategies for implementation, and economic benefits associated with this BMP click here

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Community Composting

A method for accelerating the natural decomposition of organic materials like plant and food wastes into a rich soil-like amendment.

Advantages	Limitations
Saves landfill space and diverts organic material from waste stream	Larger compost operations are difficult and more costly to manage
Helps suppress some plant diseases	Facilities need to be routinely monitored to prevent against strong odors and fires
Reduces or eliminates the need for chemicals and fertilizers	Community opposition
Helps stabilize soil pH	Quality of end product may vary
Remove solids, oil, grease, and heavy metals from stormwater runoff	
Can be used for reforestation, wetlands restoration, and habitat revitalization efforts by amending contaminated or compacted soils	
Promotes cleaner air	

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Permitting can be complicated and complex	To see the laws and regulations for composting in Massachusetts click here	Saves money on waste disposal
Siting of facilities can be difficult		Provides savings on chemicals and fertilizers and soil remediation
Funding is a challenge	Government agencies could play a larger role by increasing purchases and promotion of compost products.	Provides cost savings of at least 50% over conventional soil, water, and air pollution remediation technologies, where applicable
		End product can be sold back to community

For more information visit EPA's Composting page or the Mass DEP Composting page
For more information about reducing waste and recycling visit the EPA's Waste Wise website

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Food Waste Recycling Programs

The managed composting of residual food waste from food preparation and consumption at homes, restaurants, commercial businesses and institutions.

Advantages	Limitations
Diverts materials from the landfill or municipal solid waste stream	Difficult to separate and collect waste
Produces a usable end product that is good for the environment	Materials are often contaminated with inorganic waste like plastic and metals
Reduces air pollution	Involves coordination, time, and funding
Promotes need for recycling	Composting of food waste requires monitoring and maintenance

Barriers to Implementation	Strategies for Implementation	Economic Benefits
Permitting can be complicated	Review Mass laws and regulations by clicking here	Saves money by reducing disposal fees for businesses (food waste is often heavier than most solid waste)
Siting of compost facility can be difficult	Click here to access a checklist for compost facility operators	
Coordination of different parties involved can be difficult		

For more information visit Massachusetts' Waste Cap
Click here for a list of organic food waste haulers in Eastern Massachusetts
For more information visit the Mass DEP Food Waste Recycling page

Also, check out the Center for Environmental Technology's Handbook on School and Restuarant Food Waste Recycling Programs

Example: Review EPA's list of case studies by clicking here

Back to Waste Management BMPs
Back to Elements
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Toolkit Sources

Water

GRASSY SWALES

Model Stormwater Bylaw and Regulations (appears in a number of BMPS)- http://www.mass.gov/envir/smart_growth_toolkit/bylaws/LID-Bylaw-reg.pdf

EPA NPDES website, grassy swales - http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=75

MAPC Toolkit, grassy swales - http://www.mapc.org/regional_planning/LID/swales.html

MAPC Low Impact Development Local Codes Checklist (appears in a number of BMPS)- http://www.eot.state.ma.us/smartgrowth/07toolkit/LID/regional_planning/LID/LID_codes.html

Jordan's Cove - http://www.jordancove.uconn.edu/jordan_cove/tour.html

RAINGARDENS/BIORETENTION BASINS

EPA NPDES website, raingardens/bioretention - http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=72

MAPC Toolkit, bioretention - http://www.mapc.org/regional_planning/LID/bioretention.html

Low Impact Development Center, bioretention – http://www.lid-stormwater.net/site_map.htm#Bioretention

Comprehensive Environmental Inc., raingarden examples - http://www.ceiengineers.com/LID/natickma.htm

GREEN PARKING

EPA NPDES website, green parking - http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=89

The Orange Bowl Stadium – http://64.207.55.2/project_profile/browserecord.php?-lay=Form View&action=browse&-recid=10

The German Embassy – http://64.207.55.2/project_profile/browserecord.php?-lay=Form View&-action=browse&-recid=1

A Unitarian Church - http://www.uuworld.org/news/articles/57741.shtml

GREEN ROOFS

EPA NPDES website, green roofs - http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=114

MAPC Toolkit, green roofs - http://www.mapc.org/regional_planning/LID/green_roofs.html

Low Impact Development Center, green roofs – http://www.lid-stormwater.net/site_map.htm#Green_Roofs

International Green Roof Association - http://www.igra-world.com/

Green roof examples - http://www.greenroofs.com/projects/

VEGETATED (GRASSED) FILTER STRIP

EPA NPDES website, vegetated filter strip – http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=76

MAPC Toolkit, vegetated filter strip - http://www.mapc.org/regional_planning/LID/grass_strip_filters.html

Drumlin Farm Wildlife Sanctuary - http://www.mass.gov/envir/smart_growth_toolkit/pages/CS-lid-lincoln.html

URBAN FORESTRY

EPA NPDES website, urban forestry - http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=84

Minnesota's Urban Forestry BMP Manual - http://www.dnr.state.mn.us/forestry/urban/bmps.html

American Forests - http://www.americanforests.org/productsandpubs/citygreen/

CITYgreen software from American Forests - http://www.americanforests.org/productsandpubs/citygreen/

ON-LOT TREATMENT

EPA NPDES website, on-lot treatment - http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=81

MAPC Toolkit, on-lot treatment - http://www.mapc.org/regional_planning/LID/cisterns_barrels.html

Low Impact Development Center, Rain Barrels and Cisterns - http://www.lid-stormwater.net/site_map.htm#Rain_Barrels

Do-it-Yourself Rain Barrel Guide - http://www.swfwmd.state.fl.us/publications/files/rain_barrels_guide.pdf

The New England Rain Barrel Company - http://www.nerainbarrel.com/

Habitat and Ecosystem Protection

BACKYARD HABITAT

Massachusetts Association of Conservation Commissions: Bylaws, Regulations, and Policies
http://www.maccweb.org/resources_bylaws.html

Nature Conservancy: Conservation Easements
http://www.nature.org/aboutus/howwework/conservationmethods/privatelands/conservationeasements/

National Wildlife Federation: Wildlife Habitat
http://www.nwf.org/backyard/

Greenbelt
Greenbelt Master Plan Summary: The National Capital Commission
http://www.canadascapital.gc.ca/data/2/rec_docs/199_GbeltMPlanSumm_e.pdf

Captial Area Greenbelt Association
http://www.caga.org/about/about.html

HABITAT CORRIDOR

University of Washington: Habitat Corridor Study
http://depts.washington.edu/open2100/pdf/2_OpenSpaceTypes/Open_Space_Types/habitat_corridors.pdf

Wildlife Crossings Toolkit
http://www.wildlifecrossings.info/beta2.htm

US Fish and Wildlife Service: Habitat Conservation Planning Handbook
http://www.fws.gov/Endangered/hcp/hcpbook.html

Walden Passage Feasibility Study (Dec 2007): Metropolitan Area Planning Council, Federal Highway Administration, University of Massachusetts Amherst Center for Economic Development
http://www.umass.edu/waldenpassage/Final%20Report/Walden%20Passage%20Final%20Report.pdf

WETLAND / RIPARIAN BUFFER

Mass General Laws Ch. 131
http://www.mass.gov/legis/laws/mgl/131-40.htm
Massachusetts Department of Environmental Protection Wetland Policies
http://www.mass.gov/dep/water/laws/policies.htm#wetlpol

Environmental Law Institute's Planners Guide for Local Governments
http://www.elistore.org/reports_detail.asp?ID=11272

University of Massachusetts Extension: Buffers and Beyond
http://www.umass.edu/nrec/pdf_files/final_project.pdf

Massachusetts Department of Environmental Protection Wetlands Program
http://www.mass.gov/dep/water/resources/wetlands.htm

Massachusetts Department of Environmental Protection Wetlands Permits
http://www.mass.gov/dep/water/approvals/wwforms.htm#wetlands

URBAN WILD

Mass Smart Growth / Smart Energy Toolkit: Transfer of Development Rights
http://www.mass.gov/envir/smart_growth_toolkit/pages/mod-tdr.html

City of Boston's Urban Wilds Program
http://www.cityofboston.gov/parks/urbanwilds/

Rappaport Institute for Greater Boston's Urban Wild's Program
http://ksgaccman.harvard.edu/hotc/DisplayIssue.asp?id=140

Boston Natural Areas Network
http://www.bostonnatural.org/index.htm

OPEN SPACE RESIDENTIAL DESIGN

Mass Smart Growth / Smart Energy Toolkit: OSRD Model Bylaw
http://www.mass.gov/envir/smart_growth_toolkit/pages/SG-bylaws-osrd.html

Mass Smart Growth / Smart Energy Toolkit: OSRD Hopkinton Case Study
http://www.mass.gov/envir/smart_growth_toolkit/pages/CS-osrd-hopkinton.html

Mass Smart Growth / Smart Energy Toolkit: OSRD Module
http://www.mass.gov/envir/smart_growth_toolkit/pages/mod-osrd.html

Multimodal Transportation

BIKE LANES

Department of Cambridge Community Development:
http://www.ci.cambridge.ma.us/CDD/et/bike/bike_lanes.html#implanes

Massachusetts Bicycle Coalition
http://www.massbike.org/bikelaw/
http://www.massbike.org/
http://www.massbike.org/projects/commuterclass.htm

Massachusetts Highway Department: Executive Office of Transportation
http://www.mhd.state.ma.us/default.asp?pgid=content/bikepaths03&sid=about

MAPC Regional Bike Plan
http://www.mapc.org/transportation/trans_alternatives/Bike_plan_PDFs/Bike_Plan_FINAL_version_3-14-07.pdf

United States Department of Transportation: Federal Highway Administration
http://www.fhwa.dot.gov/environment/bikeped/design.htm

TRAFFIC CALMING

Walkablke Streets: Dom Nozzi, Executive Director
http://www.walkablestreets.com/diet.htm

Victoria Transport Policy Institute
http://www.vtpi.org/tdm/tdm4.htm

Project for Public Spaces: New York, NY
http://www.pps.org/info/placemakingtools/casesforplaces/livememtraffic

Town of Franklin Massachusetts
http://franklinma.virtualtownhall.net/Pages/FranklinMA_Planning/current

SIDEWALKS

United States Department of Transportation: Federal Highway Administration
http://www.fhwa.dot.gov/environment/sidewalks/chap4a.htm

Congress for the New Urbanism
http://www.cnu.org/sites/files/CNU_Ped_Sheds.pdf
http://www.cnu.org/node/609

Pioneer Valley Planning Commission
http://209.85.215.104/search?q=cache:wvefikLFjg0J:www.pvpc.org/val_vision/html/toolbox/Part%2520III%2520Strategies/Model%2520Bylaws/Model%2520Sidewalk%2520Regulations.rtf+model+sidewalk+bylaw&hl=en&ct=clnk&cd=1&gl=us

RECREATIONAL OPPORTUNITIES

Canadian Council on Social Development
http://www.ccsd.ca/subsites/inclusion/bp/pd.htm

Town of Danvers
http://www.danversrec.com/benefits.htm

Walk Boston Organization

http://www.walkboston.org/work/legis.htm

Massachusetts Bicycle Coalition
http://tdc-www.harvard.edu/mink/bike/bikeways/indexm.htm

Energy Efficiency and Conservation

MA Dept. of Environmental Protection
http://www.mass.gov/dep/energy.htm#commonwealth

U.S. DOE Energy Efficiency and Renewable Energy
http://www.eere.energy.gov/consumer/

U.S. Green Building Council
http://www.usgbc.org/DisplayPage.aspx?CategoryID=19

MA Technology Collaborative, Green Building
http://www.masstech.org/cleanenergy/greenbuilding/greenbuildMA.htm

SOLAR (PHOTOVOLTAIC) PANELS

Dye-Sensitized Solar Cell Data Center
http://solarcellsinfo.com/dyecell/

MA Div. of Energy Resources Renewable Energy Guidebook
http://www.mass.gov/Eoca/docs/doer/pub_info/guidebook.pdf

MA Dept. of Environmental Protection, Fast Track permitting
http://www.mass.gov/dep/service/fasttrack.htm

Database of State Incentives for Renewables and Efficiency, MA Solar Access
http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=MA02R&state=MA&CurrentPageID=1&RE=1&EE=1

MA Technology Collaborative, solar
http://www.masstech.org/solar/

MA Technology Collaborative, rebates
http://www.masstech.org/renewableenergy/index.html

Database of State Incentives for Renewables and Efficiency, MA
http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=MA&RE=1&EE=1

Energy Star, Tax Incentives
http://www.energystar.gov/index.cfm?c=products.pr_tax_credits

MA Energy Consumers Alliance
http://www.massenergy.com/Solar.REC.Sale.html

Database of State Incentives for Renewables and Efficiency, U.S.
http://www.dsireusa.org/library/includes/genericfederal.cfm?CurrentPageID=1&state=us&ee=1&re=1

U.S. Conference of Mayors
http://www.usmayors.org/climateprotection/documents/2007presentations/gb/hunt.pdf

MA Water Resources Authority
http://www.mwra.state.ma.us/03sewer/html/renewableenergydi.htm

Renewable Energy News and Information
http://www.renewableenergyworld.com/rea/news/story?id=37056

SunEdison, Inc.
http://www.sunedison.com/images/press/011607-stapleskillingly.pdf

ENERGY STAR SYSTEMS

U.S. DOE & EPA Energy Star
http://www.energystar.gov/

MA EOEA Office of Technical Assistance, water conservation
http://www.mass.gov/envir/ota/publications/pdf/water_conservation_fact_sheet.pdf

MA EOEA Office of Technical Assistance, energy conservation
http://www.mass.gov/envir/ota/publications/pdf/energy_conserv_buildings_final.pdf

Energy Star, calculator
http://www.energystar.gov/index.cfm?c=comm_real_estate.building_upgrade_value_calculator

Energy Star, mortgages

http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.energy_efficient_mortgage

Database of State Incentives for Renewables and Efficiency, U.S.
http://www.dsireusa.org/library/includes/genericfederal.cfm?CurrentPageID=1&state=us&ee=1&re=1

Energy Star, grants
http://www1.eere.energy.gov/financing/

Database of State Incentives for Renewables and Efficiency, MA
http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=MA&RE=1&EE=1

MA EOEA Office of Technical Assistance
http://www.mass.gov/envir/ota/

MA EOEA Office of Technical Assistance, Energy Management Strategy
http://www.mass.gov/envir/ota/publications/pdf/energy_efficiency_final.pdf

Energy Star, new home certification
http://www.energystar.gov/index.cfm?c=new_homes.hm_index

Energy Star, MA certified buildings
http://www.energystar.gov/index.cfm?c=reps.pt_reps

MA Dept. of Environmental Protection, Energy Conservation Tips
http://www.mass.gov/dep/energy.htm#you

Mansfield Municipal Electric Department Rebate Program
http://www.mansfieldelectric.com/rebateBrochure/billingForm.html

Energy Star, national case studies
http://www.eere.energy.gov/buildings/building_america/pdfs/41085.pdf

SOLAR HOT WATER

MA Div. of Energy Resources Renewable Energy Guidebook
http://www.mass.gov/Eoca/docs/doer/pub_info/guidebook.pdf

Database of State Incentives for Renewables and Efficiency, MA Solar Access

http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=MA02R&state=MA&CurrentPageID=1&RE=1&EE=1

MA Technology Collaborative, solar
http://www.masstech.org/solar/

Database of State Incentives for Renewables and Efficiency, MA
http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=MA&RE=1&EE=1

Energy Star, Tax Incentives
http://www.energystar.gov/index.cfm?c=products.pr_tax_credits

Energy Star, solar hot water
http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=12850

Northeast Sustainable Energy Association, solar hot water
http://www.nesea.org/buildings/info/choosing.html

Boston Globe, Fenway Park
http://www.boston.com/news/local/articles/2008/04/10/fenway_park_ready_for_green_power/

SUPER-INSULATED HOME DESIGN

Energy Star, mortgages
http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.energy_efficient_mortgage

Energy Star, grants
http://www1.eere.energy.gov/financing/

Database of State Incentives for Renewables and Efficiency, U.S.
http://www.dsireusa.org/library/includes/genericfederal.cfm?CurrentPageID=1&state=us&ee=1&re=1

Database of State Incentives for Renewables and Efficiency, MA
http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=MA&RE=1&EE=1

Northeast Sustainable Energy Association, Super-insulation
http://www.nesea.org/publications/NESun/super_houses.html

Northeast Sustainable Energy Association, Stow house
http://www.nesea.org/buildings/openhouse/listings.php?action=Search&region=MA%20Middlesex%20County&feature=&submit=Search&page=1

PASSIVE SOLAR SYSTEMS

U.S. DOE Energy Efficiency and Renewable Energy, daylighting
http://www1.eere.energy.gov/solar/solar_lighting.html

MA Dept. of Environmental Protection, Fast Track permitting
http://www.mass.gov/dep/service/fasttrack.htm

Energy Star, mortgages
http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.energy_efficient_mortgage

Database of State Incentives for Renewables and Efficiency, MA
http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=MA&RE=1&EE=1

Build it Solar, passive solar home design
http://www.builditsolar.com/Projects/SolarHomes/PasSolEnergyBk/PSEbook.htm

Northeast Sustainable Energy Association, Natick Audubon
http://www.nesea.org/buildings/openhouse/listings.php?action=Search&region=MA+Eastern&submit=Search

Evergreen Solar, Inc.
http://www.evergreensolar.com/app/en/home/

Waste Management

COMMUNITY COMPOSTING PROGRAM

Environmental Protection Agencies: Composting Laws
http://www.epa.gov/epaoswer/non-hw/composting/laws.htm

Environmental Protection Agencies: Composting
http://www.epa.gov/epaoswer/non-hw/composting/index.htm

Mass Department of Environmental Protection: Compost Webpage

http://www.mass.gov/dep/recycle/reduce/composti.htm

EPA Waste Wise Program
http://www.epa.gov/epaoswer/non-hw/reduce/wstewise/index.htm

FOODWASTE RECYCLING PROGRAM

Mass Department of Environmental Protection: Composting Regulation
http://www.mass.gov/dep/recycle/reduce/composti.htm#regulatory

Center for Environmental Technology: Compost Facility Operator Checklist
http://cetonline.org/Publications/Operational%20Checklist.pdf

WasteCap Massachusett: List of Organic Food Waste Haulers
http://www.wastecap.org/wastecap/commodities/organics/organics.htm

Center for Environmental Technology: Municipal Toolkit for Schools and Restaurants
http://cetonline.org/Publications/res-schools-online.pdf

Environmental Protection Agency Organic Recycling Success Stories
http://www.epa.gov/epaoswer/non-hw/organics/fd-study.htm