



## Town of Littleton, Massachusetts

### Low Impact Design/Best Management Practices Manual

May 2007



*Final Report*



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May 2, 2007

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Subject: Final Report - Low Impact Design/Best Management Practices Manual  
"Smart Growth"/Economic Development Initiative  
Town of Littleton, Massachusetts

Dear Mr. Danos:

In accordance with our contract amendment dated May 9, 2006, Camp Dresser & McKee Inc. (CDM) is pleased to present this *Final Report – Low Impact Design / Best Management Practices Manual* (the Manual) to the Town of Littleton. The Manual has been developed as part of the Town's "Smart Growth"/Economic Development Initiative. Through this initiative, the Town is undertaking efforts that are supportive of growth, while continuing to provide protection of the environment, including water resources.

The Manual provides guidance to developers on stormwater management approaches. In order to better preserve water quality and quantity, the Town hopes to encourage developers to incorporate Low Impact Development (LID) techniques and Best Management Practices (BMPs) as part of their proposed stormwater controls.

We understand that the Manual is to be incorporated by reference into the Town's Aquifer and Water Resource District zoning bylaw. Using the method(s) outlined in the Manual, developers will be able to apply for a Special Permit to increase impervious area of a proposed development within either of the Districts. The Manual's methods have been established consistent with current Massachusetts Stormwater Policy and the Stormwater Management Standards proposed for incorporation into the Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) and Regulations for 401 Water Quality Certification (314 CMR 9.00). As these policies and regulations continue to evolve, future changes to the Manual should be considered.



Mr. Savas C. Danos  
May 2, 2007  
Page 2

CDM appreciates the opportunity to have developed this innovative approach to stormwater management at the municipal level. The Town is to be commended for undertaking the challenge of furthering economic development through "Smart Growth" measures such as LID and stormwater BMPs. Special acknowledgement also goes to the Massachusetts Executive Office of Environmental Affairs (EOEA) which provided the Town of Littleton grant funds for the development of this manual.

As necessary, CDM is available to further assist in the implementation of the *Low Impact Design / Best Management Practices Manual*. As always, please feel free to call me at (617) 452-6532 if you have any questions or require additional information.

Very truly yours,

A handwritten signature in blue ink that reads "Andrew B. Miller".

Andrew B. Miller, P.E.  
Principal Engineer  
Camp Dresser & McKee Inc.

Attachment

cc: Adam Yanulis, CDM  
Gary Mercer, CDM

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# Section 1

## Introduction

As part of the “Smart Growth”/Economic Development initiative, the Town of Littleton encourages developers to practice low-impact development (LID) techniques. LID refers to the use of a range of site design “best management practices” that attempt to preserve the site’s pre-development hydrology and water quality through stormwater controls. Best management practices, or BMPs, are usually small-scale structural and non-structural stormwater controls on a site. Littleton began using LID technologies, such as rain gardens, vegetated swales, rain barrels and a wetland park, in 2004 within Long Lake watershed. As a continuation and strengthening of these efforts and with funding from the Massachusetts Executive Office of Environmental Affairs (EOEA), Littleton’s LID/BMP Stormwater Management Manual will help guide developers in implementing these techniques, sometimes in exchange for less restrictions or limits on site development. The manual will encourage developers to employ a combination of BMPs, with a goal of preserving pre-development stormwater quality and quantity.

The goals of the program include maintaining and preserving the quality and quantity of Littleton’s public drinking water supply and contributing watersheds, and protecting the Town’s other natural resources such as quality open space and aquatic life. To that end, the Town wishes to encourage the use of LID techniques further.

### 1.1 Purpose of this Document

The purpose of this document is to outline the Town of Littleton’s stormwater objectives and to provide guidance on development of a stormwater management program. The Town of Littleton wishes to encourage incorporation of new technologies and performance-based measures related to stormwater management that allow better use of land, but do not compromise groundwater quality. Low impact development techniques can accomplish this objective in addition to promoting “Smart Growth”.

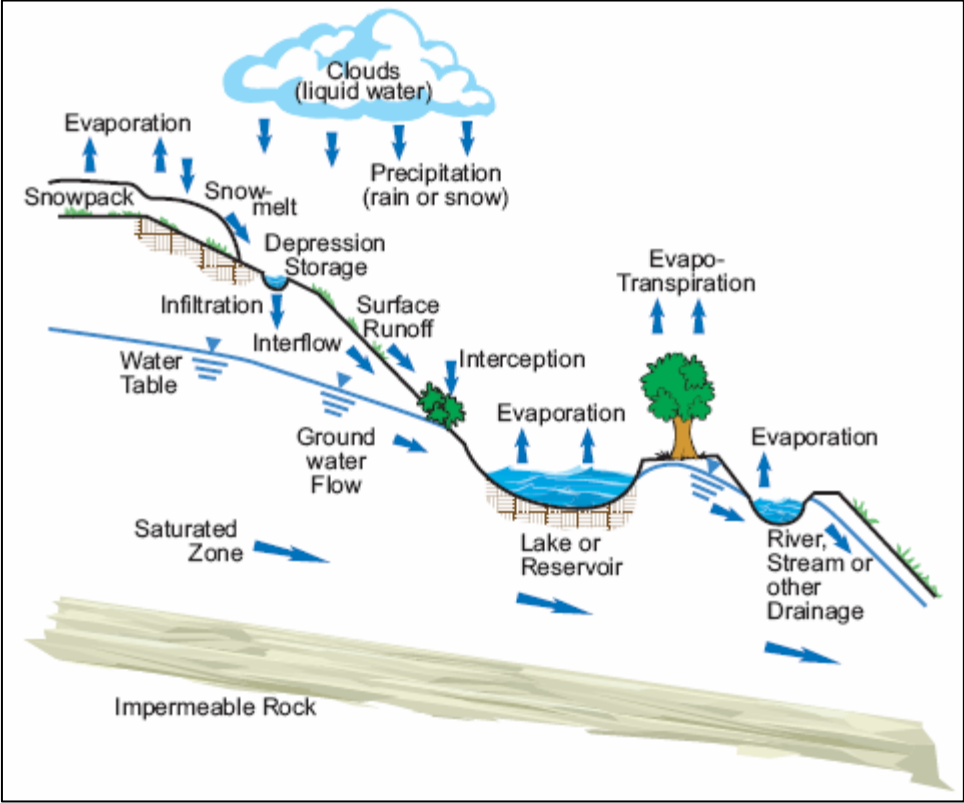
Developers will still be under the purview of the Massachusetts’ stormwater regulations and US EPA National Pollution Discharge Elimination System (NPDES) permitting where applicable, but may obtain greater flexibility in site design using Littleton’s approach. As part of the LID/BMP Stormwater Management Manual, a stormwater credit program will be established. This program is based on the use of BMPs which infiltrate more water onsite or improve the quality of the water that leaves a site. The program will encourage developers to account for both quality and quantity issues.

## 1.2 Background

Article XIV of the Town’s Zoning Bylaw establishes the Aquifer District and the Water Resource District (Figure 1) as overlay zoning districts. Within these Districts, a special permit is required for new construction if more than 20 percent of the lot or parcel will be rendered impervious [Article XIV, § 173-61 in Littleton Zoning Bylaw (Part II Chapter 173 of Town Code)]. This limit is potentially restrictive toward development. It is also recognized that different coverage limitations may be more appropriate in other areas of town, depending upon hydrologic setting (i.e., sand/gravel, glacial till). Use of LID technologies and innovative uses of existing technologies is envisioned as a way for developers to receive “credit” for using specific LID techniques, thus allowing greater use of a property (i.e., increased impervious area) when stormwater performance criteria are met. Such performance criteria are established through accepted design criteria, BMPs, and LID techniques referenced in this Stormwater Management Manual.

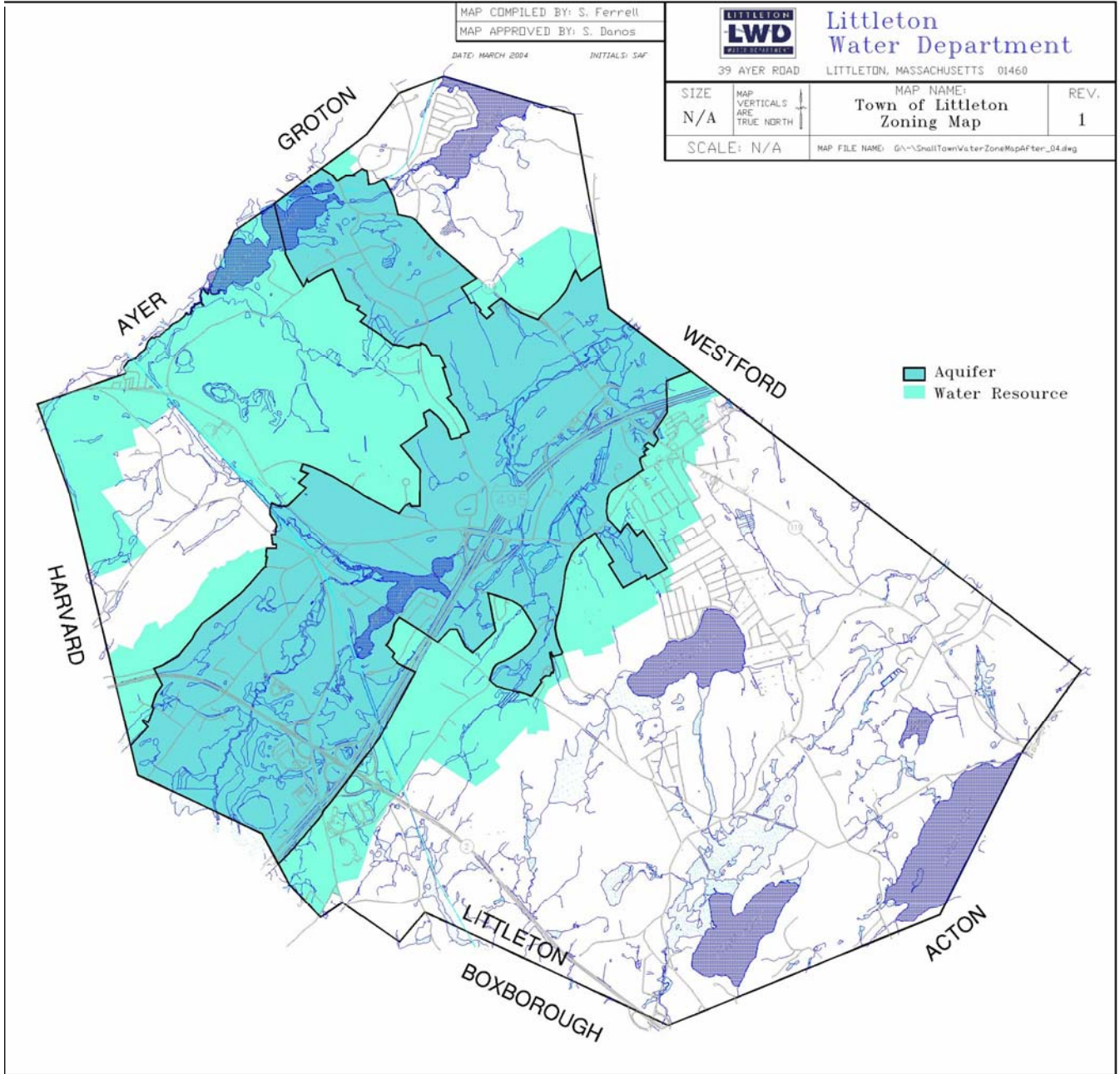
## 1.3 The Hydrologic Cycle and Infiltration

Water moves around the earth in a continual cycle of precipitation, storage, evaporation, and condensation. There is continual exchange of water between the ground (groundwater/aquifers), the earth’s surface (water bodies and biology), and the atmosphere (humidity, clouds, precipitation, etc.).



*The Hydrologic Cycle*

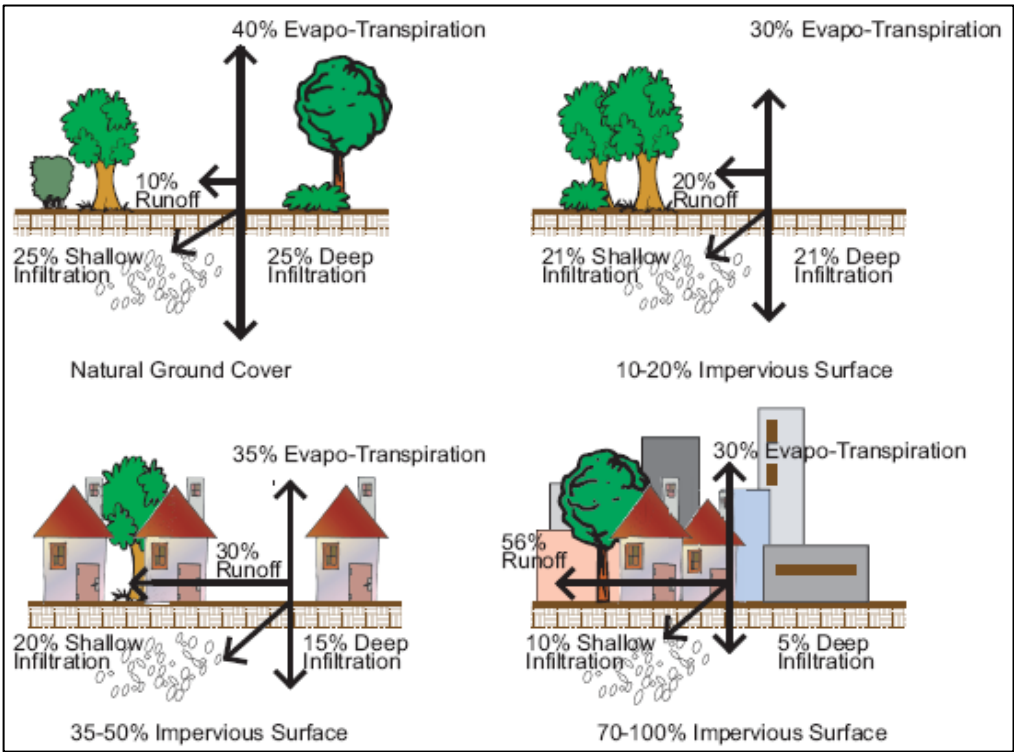
**Figure 1**  
**Town of Littleton Aquifer District and Water Resource District**



Rain falls to the ground and can enter surface water bodies directly or infiltrate into the ground. Some rainwater will flow over the land and find its way to a lake, river, stream, ocean or wetland. This water is runoff. The other portion infiltrates into the ground and may be taken up by plant life, or may seep down through soil pores as groundwater. Chemicals or particles in the infiltrating water are generally filtered out by the soil, thus usually ensuring groundwater as a clean water source. Groundwater constantly moves and flows in a groundwater aquifer. The top level of water in an aquifer is called the water table. Rainwater, some of which infiltrates into the ground, recharges aquifers and keeps water tables at a relatively constant (although often seasonally variable) level.

### 1.4 Development's Impact on Hydrology

As construction and development occur, more of the earth's surface area that used to be permeable soil through which stormwater could penetrate becomes impervious surface, such as roofs and pavement, from which stormwater runs off. As areas become more developed, a greater percentage of stormwater becomes runoff, and a lesser percentage of stormwater infiltrates into the ground; see figure. This affects stormwater in three general ways: 1) water falling on impervious surfaces no longer infiltrates into the ground, 2) stormwater moves more quickly to receiving water bodies because it is not stored in the soil, and 3) stormwater picks up pollution as it moves across trafficked surfaces.



Development and Infiltration



Infiltration is interrupted when buildings, roads, and parking areas – impervious surfaces in general – are constructed and rainwater no longer has access to the soil. The water is often then conveyed from impervious surfaces via a pipe to a river or stormwater system instead of being recharged into the groundwater system.

Development impacts the storage of stormwater because water that would normally be held in the ground now moves quickly across impermeable surfaces to a river, stream, or drainage culvert. This causes a quicker and greater influx of water to the stream or river, increasing the speed of flowing water and potentially increasing bank erosion. Drainage culverts become more expensive as they need to be designed to hold excess water capacity. Additionally, the loss of storage can contribute to flash flooding and can burden stormwater systems and treatment plants.

Water moving over paved and impermeable surfaces accumulates many pollutants associated with cars (oil, heavy metals from brake pads, etc.) and natural atmospheric deposition of elements (phosphorus, nitrogen) on its way to a receiving water body. Conversely, during infiltration, soil acts as a natural filter for groundwater, removing many of the natural elements which, in large quantities or high concentrations, can have detrimental impacts on human life and aquatic habitat.

Acknowledgement of development's impact on the hydrologic cycle and the disruption this causes to human's use of water resources has led to the water-related goals of "Smart Growth" as adopted by the Commonwealth of Massachusetts in 2000<sup>1</sup>. These goals strive to protect water resources and keep water in the basin in which it falls. Structural and non-structural LID techniques can improve water quality and ensure water storage. Techniques should be chosen to address both issues. A description of some major LID techniques follows in Section 2.

## 1.5 Special Considerations for the Town of Littleton

Among Littleton's unique attributes that relate to stormwater management are its soils, land uses, and climate.

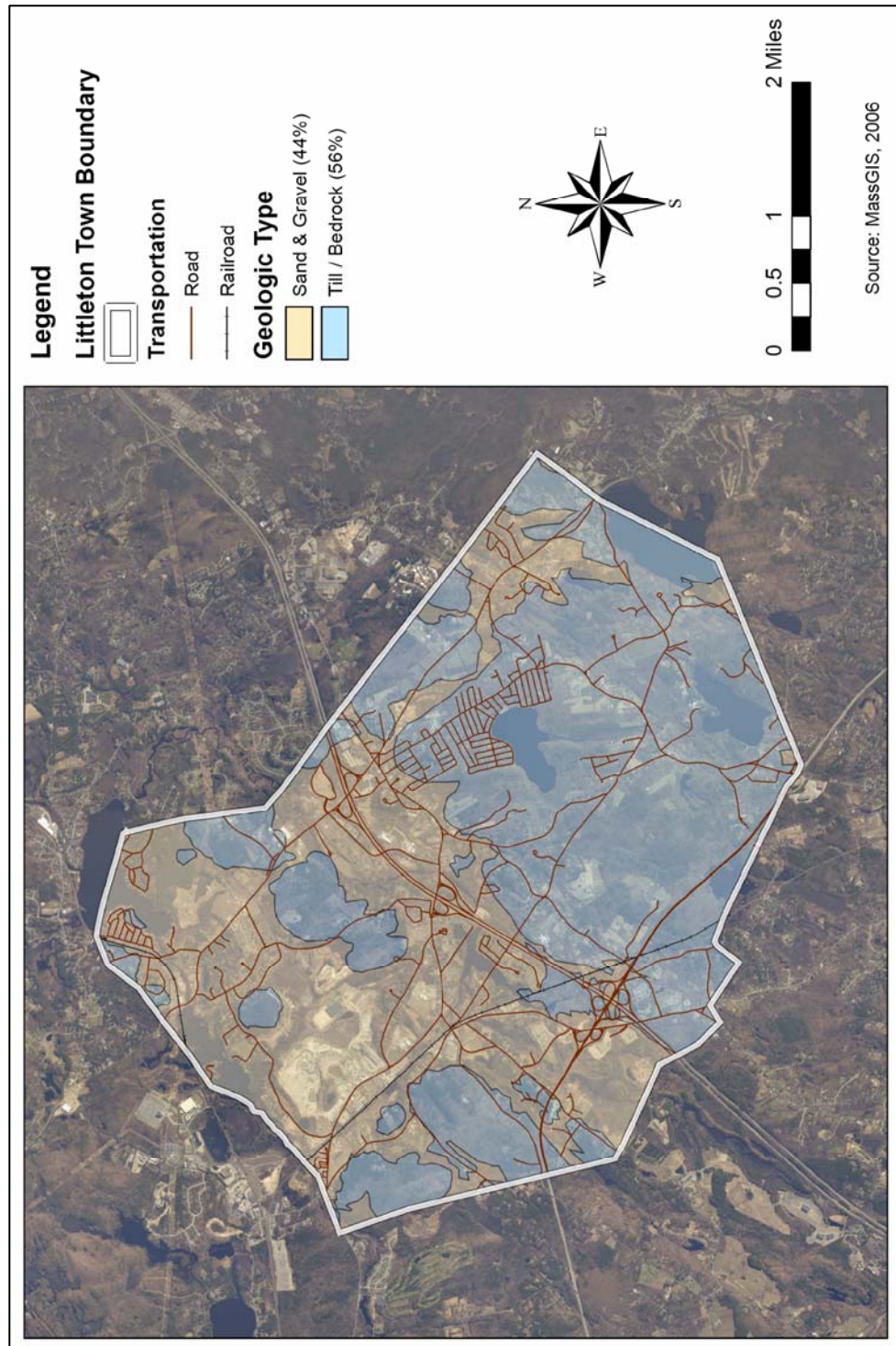
### Soils

The majority of soils in Littleton are glacial deposits which can have a range of permeability values. The two dominant surficial geologic types in Littleton are "Sand & Gravel" which covers about 44 percent of Littleton's surface area and "Till/Bedrock", which covers 56 percent (Figure 2). For Sand and Gravel the permeability is very high; for Till/Bedrock it is very low. Most BMPs are adaptable to either soil type but, in some cases, the size requirements of a BMP to infiltrate water through Till/Bedrock could become prohibitive. Site soil type should therefore be taken into consideration when selecting BMPs.

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<sup>1</sup> <http://commpres.env.state.ma.us/>

**Figure 2**  
**Surface Geologic Types in Littleton**



## Landuse

The three dominant landuses in Littleton, which account for more than 69 percent of its total area and nearly all of its developable land, are natural and open space (31 percent), residential (21 percent) and commercial/industrial (17 percent) (Figure 3). BMP selection for Littleton focuses on Residential and Commercial/Industrial landuses, as these are generally the only new types of developments that will occur here.

If only half of the current natural and open space was developed, over 7500 acres of development would be added to the Town. At the current standard, allowing for 20 percent impermeable surface with no stormwater treatment, this could translate to an additional 1,500 acres of paved surface (17 times the surface area of Long Pond (88 acres<sup>2</sup>), or 7 times the surface area of Forge Pond (212 acres<sup>3</sup>)), with an associated decrease in water quality, increase in peak flows in streams, and decrease in infiltration/recharge to ground water. By initiating this program to encourage treatment and infiltration, the Town makes clear its goals of mitigating the effects of any future development.

## Climate

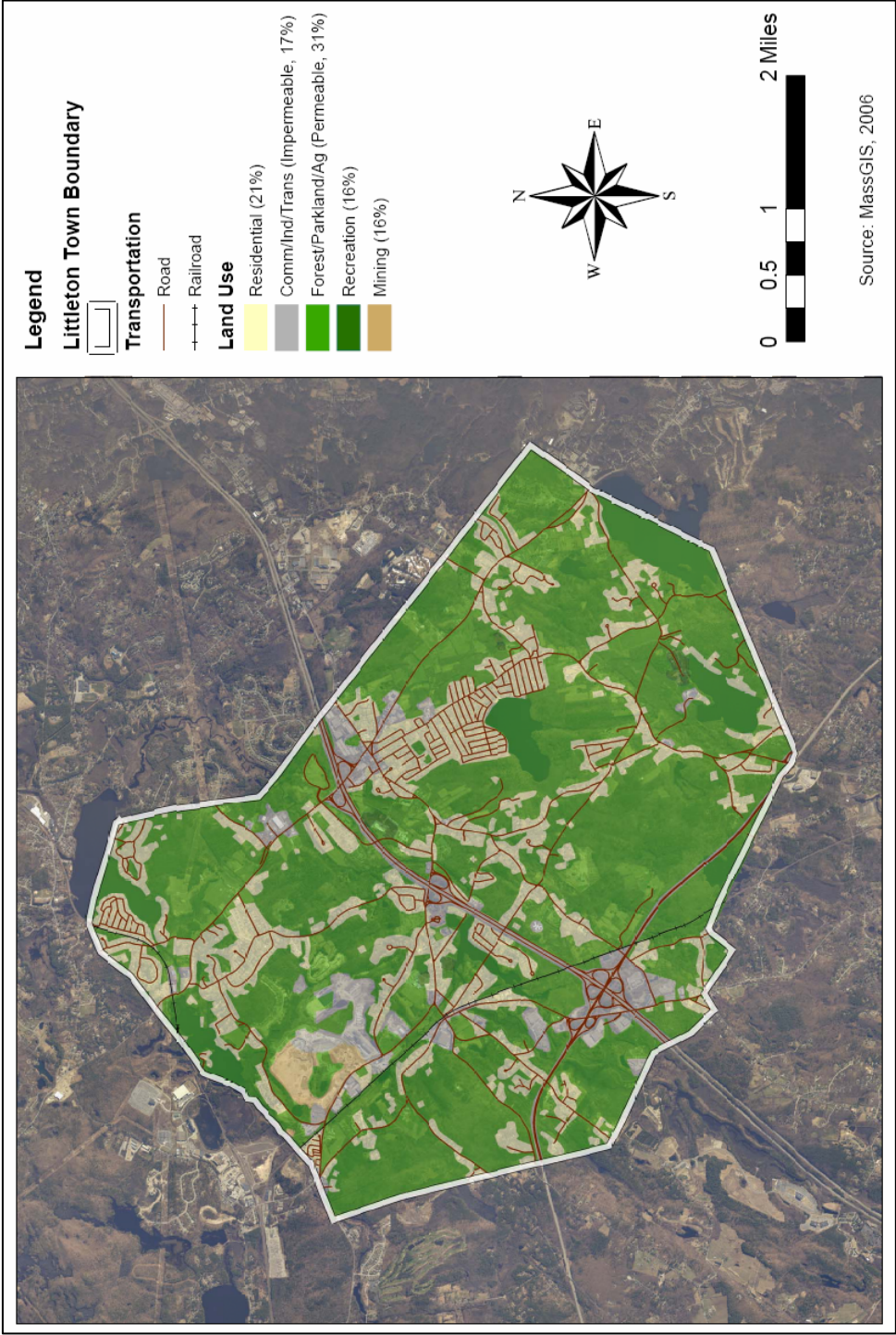
Littleton's climate, specifically its cold winters, should also be taken into account during BMP selection. For example, the plants chosen for stormwater wetlands need to be hardy enough to withstand New England winters.

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<sup>2</sup> [http://www.mas.gov/dfwele/dfw/dfw\\_pond/dfwlonlt.pdf](http://www.mas.gov/dfwele/dfw/dfw_pond/dfwlonlt.pdf)

<sup>3</sup> [http://www.mas.gov/dfwele/dfw/dfw\\_pond/dfwforg.pdf](http://www.mas.gov/dfwele/dfw/dfw_pond/dfwforg.pdf)

**Figure 3**  
**Land Uses in Littleton**



# Section 2

## Using BMPs/LID Techniques

### 2.1 Introduction

As discussed in Section 1, this program's intent is to encourage use of BMPs which infiltrate more water onsite or protect and improve the quality of the water that leaves a site, in order to protect the local drinking water supply, both in quality and quantity, as well as to preserve aquatic life and environmental health of local rivers and ponds. The program will encourage developers to account for both quality and quantity issues in stormwater discharging from a site.

This approach will afford added protection to the rivers, streams, lakes and drinking water sources within the Town of Littleton. Specifically, Littleton is situated in the Merrimack River basin. Although the northwest half of the town is in the Concord River basin, the Concord River is tributary to the Merrimack. Littleton's drinking water comes from groundwater wells in the Beaver Brook and Bennett's Brook watersheds.<sup>4</sup> Both Beaver and Bennett's Brooks drain to Stony Brook, which is a tributary of the Merrimack River. Nagog Pond, on the Acton/Littleton town line, serves as drinking water supply for the Town of Concord, Massachusetts.<sup>5</sup>

### 2.2 Goals for BMP Use

The three major goals for BMPs are to: 1) provide infiltration or groundwater recharge, 2) to provide stormwater retention and storage, and 3) to capture and treat stormwater runoff. The first two goals address issues related to water *quantity* while the third goal addresses water *quality*.

#### 2.2.1 Water Quantity

Impervious surfaces increase the amount of water that leaves a site and decrease the amount of time it takes for the water to leave the site. To address these quantity issues, a BMP may either store runoff, discharging after the peak flow of a storm has passed, or infiltrate runoff, discharging stormwater to groundwater rather than to surface water bodies. Some BMPs are designed specifically for retention and storage of stormwater, but are not necessarily suited for stormwater infiltration, such as a dry pond sited on bedrock. Some BMPs offer little storage but infiltrate particularly well, such as a sand filter or infiltration trench. As groundwater wells provide Littleton's drinking water supply, encouraging infiltration of stormwater is of great importance in protecting this resource.

As discussed in Section 1.4, during infiltration, soil acts as a natural filter for groundwater, removing many of the natural elements which can have detrimental impacts on human life and aquatic habitat. However, if polluted stormwater is continually being infiltrated in a small location, such as an infiltration trench, these pollutants may tend to build up, reducing effectiveness or even clogging BMPs.

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<sup>4</sup><http://www.lclwd.com/lwd/wtreatment.html>

<sup>5</sup>[http://www.littletonma.org/Master percent20Plan/Chap percent205.htm](http://www.littletonma.org/Master%20Plan/Chap%205.htm)

Therefore, treatment is recommended before discharge of polluted stormwater to a quantity- or infiltration-type BMP.

### 2.2.2 Water Quality

Treatment of stormwater is desirable where runoff is coming through potentially polluted pathways such as parking lots or trafficked motorways. In its most basic form, water quality is addressed by allowing for settling of sediments, and the pollutants that attach to those sediments, that become suspended in stormwater. Water treatment can also occur biologically, either by allowing plant and animal growth in pooled water (wet pond) or by selecting specific plants that absorb pollutants of interest (stormwater wetlands).

Note that regardless of the BMP selected to address quality of stormwater, 80 percent removal of Total Suspended Solids is required by the Massachusetts State Stormwater Management Policy (Standard Number Four<sup>6</sup>).

### 2.2.3 Dealing with Water Quality and Quantity Issues

Some BMPs deal with infiltration, recharge, and treatment, but the vast majority deal with one issue better than the others. Therefore, for optimal use of BMPs, the water-related issues of a site must be known. To help choose the most effective BMPs for a site, the development team should consider the following questions: <sup>7</sup>

1. What are the physical site constraints?
2. What are the opportunities to utilize comprehensive site planning to minimize the need for structural controls?
3. Are there critical areas on or adjacent to the project site?
4. Are there stormwater “hot spots” on the project site (such as previously contaminated areas, eroded areas)?
5. How can the stormwater management system be designed to meet the goals and standards for stormwater *quantity* and *quality* most effectively?
6. Are the future maintenance requirements for each BMP option acceptable? How will future maintenance be funded and implemented?
7. Is the BMP option cost-effective?

It can be useful to distinguish between water that comes from “clean” and “dirty” runoff areas on a site. In this way, all “clean” runoff (i.e., from roofs) could be directed to BMPs that do not specifically address water quality, and “dirty” runoff (i.e. from

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<sup>6</sup>Massachusetts Stormwater Management, volume 1: Stormwater Policy Handbook: <http://www.mass.gov/dep/water/laws/swmpolv1.pdf>, Page 14.

<sup>7</sup>Massachusetts Department of Environmental Protection and Coastal Zone Management. March 1997. Stormwater Management, Volume Two: Stormwater Technical Handbook.

parking lots) can be routed to BMPs that will retain some of the associated pollutants. If the entire site's water is being dealt with cumulatively, a treatment step should be used before infiltration or groundwater recharge.

BMPs should be selected to achieve a site's water quality and quantity objectives and to ensure maintenance, aesthetic, and social objectives are fully considered as well. This might mean developing a "BMP train" by stringing BMPs together and, in general, selecting a BMP to treat the water before infiltrating or storing it. For example, using swales and rain gardens upslope of what would normally be a wet pond could increase infiltration and either reduce the size of the wet pond needed, thereby easing access to the basin for maintenance, or make a dry pond feasible and eliminate standing water completely.

## 2.3 Short Descriptions of BMPs Relevant to Littleton

There are many techniques that qualify as LID and are often referred to as "best management practices" (BMPs). The techniques and a short description of some of the alternatives available for use in Littleton are listed below. For additional information about a listed BMP, please follow the reference given.

Please note that this is not an exhaustive list, and that new BMPs or combinations of older techniques are continually being developed. The Town may wish to update this list in the future, and/or may wish to consider requests to install BMPs not listed here if the effectiveness of the proposed BMP can be demonstrated.

### 2.3.1 Infiltration

#### Permeable pavements

Permeable pavement surfaces replace traditional pavement, allowing parking lot stormwater to infiltrate directly and receive water quality treatment. Porous pavement can use specially formulated porous asphalt, grassed surfaces with supportive subsurface, or concrete/brick pavers with sand, crushed rock, or grass between the pavers. Porous pavement has not been used widely in New England. However, Walden Pond State Reservation in Concord, Massachusetts, has had porous pavement installed since 1977. The parking lot continues to work well without significant potholes or other problems.<sup>8</sup> (For design recommendations, see documentation from The Low Impact Development Center<sup>9</sup>. UNH Stormwater Center has also conducted research in porous pavement and offers a fact sheet on the BMP: [http://www.unh.edu/erg/cstev/fact\\_sheets/TUJ.pdf](http://www.unh.edu/erg/cstev/fact_sheets/TUJ.pdf)).

#### Pedestal sidewalks

Using porous pavers, these sidewalks can provide some stormwater storage by laying the pavers on pedestals, see figure. Water can sit between the pedestals and be

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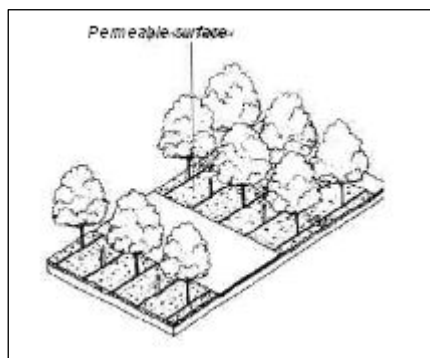
<sup>8</sup>Miller, 1997.

<sup>9</sup>[http://www.lid-stormwater.net/permeable\\_pavers/permores\\_home.htm](http://www.lid-stormwater.net/permeable_pavers/permores_home.htm) and [http://www.lid-stormwater.net/permeable\)pavers/permcomind\\_home.htm](http://www.lid-stormwater.net/permeable)pavers/permcomind_home.htm).

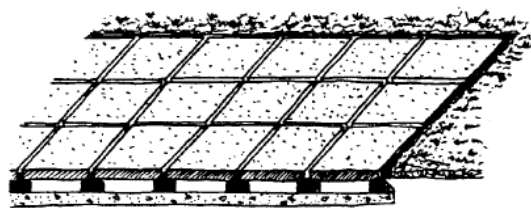
infiltrated into the ground below or evaporate through the pavement. (For design recommendations, see [Low Impact Development Center<sup>10</sup>](#)).

### Parking groves

Parking stalls are paved with permeable pavers. The stalls are delimited by trees which provide shade, aesthetic value, and some water quality improvement. (For design recommendations, see [City of Baltimore Department of Public Works BMPs<sup>11</sup>](#)).



*Parking groves with trees and permeable pavement*



*A pedestal sidewalk with modular pavers on top of pedestal supports*

### Below-Pavement Infiltration Basins

The effectiveness of any permeable pavement system can be increased with below-pavement infiltration basins. Gravel or highly-permeable material underlies the permeable surface, creating a storage area for large amounts of runoff which can then be subsequently infiltrated. (For design recommendations, see documents from [Georgia's Stormwater Manual<sup>12</sup>](#)).

### Parking Lot Planters/Buffers

Putting depressed planters/buffers between parking rows can help drain and infiltrate runoff from large parking areas. This can minimize the area that rainwater has to travel before infiltration, thus reducing the impact on water quality, and also reduces the amount of water that has to be collected from the parking area. This can reduce the size of traditional BMPs that often blight strip-mall developments with fenced-in basins that are hard to access and manage. (See design recommendations from [Low Impact Development Center<sup>13</sup>](#)).



*This parking lot buffer in Littleton captures and infiltrates stormwater runoff.*

<sup>10</sup><http://www.lid-stormwater.net/intro/homedesign.htm>

<sup>11</sup>[http://www.ci.baltimore.md.us/government/dpw/images/wUltraUrban4.pdfsearch= percent parking percent20groves percent22](http://www.ci.baltimore.md.us/government/dpw/images/wUltraUrban4.pdfsearch=percent%20parking%20percent20groves%20percent22)

<sup>12</sup> <http://www.georgiastormwater.com/vol12/3-3-4.pdf>

<sup>13</sup> [http://www.lid-stormwater.net/bioretenion/biocomind\\_home.htm](http://www.lid-stormwater.net/bioretenion/biocomind_home.htm)



## Infiltration Basin

Infiltration basins are designed to capture a specific volume of water and infiltrate it through the soil, effectively transforming a surface water flow to a groundwater flow. The soil provides some natural treatment for the runoff, potentially removing nutrients and other constituents. Infiltration basins are best applied in locations with pervious soils and low risk of groundwater contamination and can help reduce local flooding and maintain the natural hydrology of a site. However, they require careful siting and design, and require annual maintenance. (For design recommendations, see the Massachusetts Stormwater Management Handbook: Volume II, 3.F<sup>14</sup>).



*This infiltration basin collects and infiltrates runoff from the adjacent parking area.*

## Infiltration Trench

Infiltration trenches are similar to infiltration basins (above) in that they are designed to capture a specific volume of water and infiltrate it. However, instead of being a large basin, this structure is usually a long rectangular ditch filled with sand and stone. The sand/stone filter provides some treatment and storage, but this BMP should be placed in an area with high natural infiltration and a low water table. (For design recommendations, see the Massachusetts Stormwater Management Handbook: Volume II, 3.E. Ibid).

### 2.3.2 Attenuation

#### Dry swale/underdrain grassed channel

A dry swale is a shallow depression in the land surface that captures water that would otherwise run off the site. Dry swales are usually vegetated, conducting water into drainage channels and potentially aiding in groundwater recharge. A dry swale may also have a gravel layer for greater infiltration capacities beneath an amended soil layer holding vegetation in place. (For design recommendations, see Georgia's Stormwater Manual<sup>15</sup> or Virginia's Stormwater Manual<sup>16</sup>).



*This dry swale absorbs runoff from the adjacent hotel parking lot.*

<sup>14</sup> <http://www.mas.gov/dep/water/laws/swmpolv2.pdf>

<sup>15</sup> <http://www.georgiastormwater.com/vol2/3-2.pdf>

<sup>16</sup> [http://www.dcr.virginia.gov/sw/docs/swm/chapter\\_3-13.pdf](http://www.dcr.virginia.gov/sw/docs/swm/chapter_3-13.pdf)

### Wet swale

A wet swale is a shallow channel which allows retention of water, similar in design to the dry swale but more likely to remain wet for some time after a storm. A wet swale is particularly good in areas with a high water table. (For design recommendations, see references under dry swale, above).

### Above- or below-ground barrels

Barrels can be placed to collect roof stormwater from gutter end pipes or roof spouts. This water can then be used elsewhere on site for irrigation purposes or the bottom of the barrel can be constructed of a permeable material (or cut off) to allow for subsequent infiltration. There are many proprietary vendors for above-ground rain collection barrels.



*Above-ground rain barrel collects and stores water for later use.*

### Rooftop detention

Small perforated weirs around the inlet of roof drains can allow a small amount of ponding to occur on rooftops. This will delay some of the water that flows off the roof during a rainstorm and help reduce the peak runoff flows from the site. (Design recommendations available from [Georgia's Stormwater Manual](#)<sup>17</sup>).

### Dry ponds (extended detention ponds)

Basins designed to detain stormwater for a short period of time (for example, 24 hours) to allow particles and associated pollutants to settle. These facilities do not have a large permanent pool of water and provide little dissolved pollutant removal (e.g., phosphorus, nitrates). If designed with sufficient storage, however, dry ponds can also be used to provide flood control. (For design recommendations, see the Massachusetts Stormwater Management Handbook: Volume II, 3.A<sup>18</sup> or [Georgia's Stormwater Manual](#)<sup>19</sup>).

## 2.3.3 Treatment

### Filter Strips/vegetated buffers

Vegetated surfaces designed to treat sheet flow from adjacent land. Filter strips function by slowing runoff velocities, filtering out sediment and other pollutants, and providing some infiltration into underlying soils. Another application of filter strips is to plant dense vegetation between a paved surface and a waterbody, slowing the velocity of runoff into the receiving water. (For design recommendations, see [Georgia's Stormwater Manual](#)<sup>20</sup> and EPA's guidance documents<sup>21</sup>).

<sup>17</sup> [http://www.georgiastormwater.com/vol2/3-2.pdf#search= percent22rooftop percent20detention percent22](http://www.georgiastormwater.com/vol2/3-2.pdf#search=percent22rooftoppercent20detentionpercent22)

<sup>18</sup> <http://www.mass.gov/dep/water/laws/swmpolv2.pdf>

<sup>19</sup> <http://www.georgiastormwater.com/vol2/3-4-1.pdf>

<sup>20</sup> <http://www.georgiastormwater.com/vol2/3-3-1.pdf>

<sup>21</sup> <http://www.epa.gov/nps/MMGI/Chapter7/ch7-2c.html>

## Green Roofs

Roofs can be designed to hold a thin layer of soil and support certain types of plant growth. Soil can then absorb and filter precipitation before it leaves the roof, both reducing the amount of runoff from the impervious roof surface and potentially improving the quality of the runoff before it reaches ground level. Green roofs have been very heavily studied; many examples and case studies exist. (For design recommendations, see examples from Puget Sound, WA<sup>22</sup> or LIDC<sup>23</sup>).



*Rain garden at a residence in Littleton, MA*

## Bioretention cells/Biofilters/Rain Gardens

A shallow, landscaped depression designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, the design volume of runoff is collected above the filter, and then percolates through the mulch and prepared soil mix. Stormwater exceeding the design volume bypasses the filter. Typically, the filtered runoff is collected in a perforated underdrain and returned to the storm drain system<sup>24</sup>, but it could be infiltrated as well. (See the Georgia's Stormwater Manual, Prince George's County, MD, or LIDC<sup>25</sup>).

## Tree box filters/stormwater planters

A tree box filter is similar to a small-scale cell or raingarden (see above). (Some design recommendations can be found at the Low Impact Development Center and the UNH Stormwater Center<sup>26</sup>).

## Wet ponds (retention ponds)

Wet ponds are constructed basins that have a permanent pool of water throughout the year. Similar to dry ponds, wet ponds provide detention time that allow particles to settle out of the stormwater. In addition to particle settling, wet ponds provide pollution uptake, particularly of nutrients, through biological activity in the pond. (For design recommendations, see the MA Stormwater Management Handbook: Volume II, 3.B<sup>27</sup>).



*This stormwater wetland has a healthy cattail population and treats stormwater at the McGlynn School in Medford, Massachusetts.*

<sup>22</sup> [http://www.psat.wa.gov/Publications/LID\\_studies/green\\_roofs.htm](http://www.psat.wa.gov/Publications/LID_studies/green_roofs.htm)

<sup>23</sup> [http://www.lid-stormwater.net/greenroofs/greenroofs\\_commercial.htm](http://www.lid-stormwater.net/greenroofs/greenroofs_commercial.htm)

<sup>24</sup> EPA, Menu of BMPs.

<sup>25</sup> <http://www.georgiastormwater.com/vol2/3-2-3.pdf>;

<http://www.goprincegeorgescounty.com/Government/AgencyIndex/DER/ESD/Bioretention/bioretention.asp> AND [http://www.lid-stormwater.net/bioretention/biohighres\\_home.htm](http://www.lid-stormwater.net/bioretention/biohighres_home.htm)

<sup>26</sup> [http://www.lid-stormwater.net/treebox/treeboxfilter\\_home.htm](http://www.lid-stormwater.net/treebox/treeboxfilter_home.htm) or

[http://www.unh.edu/erg/cstev/fact\\_sheets/TUK.pdf](http://www.unh.edu/erg/cstev/fact_sheets/TUK.pdf)

<sup>27</sup> <http://www.mass.gov/dep/water/laws/swmpolv2.pdf>

### Sand/organic filters

These filters are similar to bioretention filters but generally use a settling chamber to remove coarse particles, followed by a filter bed filled with sand or other filtering media to remove finer particles and other pollutants. (For design recommendations, see the MA Stormwater Management Handbook: Volume II, 3.H<sup>28</sup>).

### Stormwater wetlands

Stormwater wetlands (also called constructed wetlands) are structural practices similar to wet ponds that incorporate wetland plants into the design. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake.

Stormwater wetlands are designed specifically to treat stormwater and typically have less biodiversity than natural wetlands in terms of both plant and animal life<sup>29</sup>. (For design recommendations, see the Georgia Stormwater Manual<sup>30</sup>).

### Urban forestry



*These trees in Medford's Playstead Park provide an aesthetic and stormwater benefit as part of an Urban Forestry Program.*

Urban forestry provides numerous stormwater benefits. Urban forests filter particulate matter (pollutants, some nutrients, and sediment) and absorb water, providing both water quality and quantity benefits. Urban forestry also reduces noise levels, provides recreational benefits, and increases property values. (Sites on Urban forestry include [www.treelink.org](http://www.treelink.org) and <http://www.americanforests.org/>).

### Catch basin retrofit filters

Existing catch basins may be retrofitted with filters designed to remove trash, oil and grease, sediment, and other contaminants from the storm drain system. A number of proprietary filters exist. These products must be carefully evaluated before installation to ensure that they will not reduce flows into the storm drain and cause street flooding. (For an example of a catchbasin filter, see Connecticut's Stormwater Quality Manual<sup>31</sup>).

### Swirls and Separators

Swirls and separators are pre-designed units to separate liquid stormwater with solid contaminants, including suspended sediment, floating debris, oil and grease, and

<sup>28</sup> <http://www.mass.gov/dep/water/laws/swmpolv2.pdf>

<sup>29</sup> EPA, Menu of BMPs.

<sup>30</sup> <http://www.georgiastormwater.com/vol2/3-2-2.pdf>

<sup>31</sup> [http://dep.state.ct.us/wtr/stormwater/manual/CH11\\_CBI\\_S-9.pdf](http://dep.state.ct.us/wtr/stormwater/manual/CH11_CBI_S-9.pdf)

vegetative materials. A number of proprietary products exist. These types of units are best applied in retro-fits, where LID is not possible.

## 2.4 BMP Evaluation Criteria

A matrix of LID techniques and evaluation criteria has been developed for each technique as they relate to Littleton (Figure 4). The criteria used to develop the matrix are as follows:

### Effect on Stormwater

The major determining factor when selecting BMPs should be the effect on stormwater in relation to the stormwater goals of the site. Each BMP was evaluated for effectiveness in infiltrating stormwater, attenuating peak flows, and treating potentially dirty water on a scale of “Good”, “Possible”, or “Not effective”.

### Compatible Soil Type

As described above in Section 1, Littleton has two main types of soils: gravelly/sandy soil and glacial till/bedrock. The gravel/sand type is usually highly permeable, whereas most glacial till and bedrock are very impermeable. Each BMP is rated on its relative performance on the two soils as “Good”, “Possible”, or “Not recommended”. It should be noted that virtually any BMP can be designed for any kind of soil or permeability. The size of the BMP, however, will generally increase for less permeable soils relative to the same BMP in more permeable soils.

### Land Use

As seen in Figure 3, a majority of Littleton’s land area is forested or parkland. BMP selection however, will be limited to residential developments or commercial/industrial developments. Each BMP is rated on appropriateness for residential or commercial/industrial development as “Good”, “Moderate” or “Not Recommended.”

### Type of Construction

In most cases, integrating BMPs into a site design will be most easily accomplished for new construction or developing sites. However, some BMPs that do not take up a great deal of space or that are not too invasive can be retrofitted into existing developments. BMPs are rated on “Recommended”, “Less Feasible”, or “Not Recommended” for new or retrofit construction.

### Space Requirements

The amount of space that the BMP will generally need to occupy is rated as “Small”, “Medium”, or “Large”. Space considerations can be somewhat misleading, an ideal metric regarding sizing would be space required/volume treated. However, local conditions would affect a space-to-volume ratio greatly and so a definitive judgment is not possible. The general accepted size requirements are given in the matrix.

**Figure 4: Low Impact Development Matrix  
Littleton, Massachusetts**

Yes	Good	Good	Recommended	Small	Low	Good
Possible	Moderate	Moderate	Less feasible	Medium	Medium	Possible
Not effective	Not recommended	Not recommended	Not usually feasible	Large	High	n/a
n/a	n/a	n/a	n/a	n/a	n/a	

Low-Impact Development Technique	Description	Secondary effects (design feature upon which the secondary effect depends)	Effect on Stormwater			Compatible Soil Types		Land Use		Type of Construction		Space Requirements	Operation & Maintenance	Aesthetic Improvements
			Infiltration (GW Recharge)	Attenuation (Storage/Detention)	Treatment	Gravel/sand	Glacial Till or Silty /Sandy Loam	Residential	Commercial / Industrial	New	Retrofit			
<b>Infiltration</b>	<b>Primarily have qualities that promote infiltration to groundwater and groundwater recharge. May have some characteristics that provide some treatment from passage through media, or storage characteristics that attenuate peak flows from storm events.</b>													
Permeable pavements	Reduce runoff with permeable asphalt, pavers, gravel, or other surfaces													n/a
Pedestal sidewalks	Divert runoff through pedestal-supported sidewalks made with pavers over a runoff storage area													n/a
Parking groves	Permeable pavement in parking stalls which are outlined by trees							n/a						
Below-Pavement Infiltration Basins	Store runoff that percolates through permeable pavement for subsequent infiltration	Attenuation (basin capacity)												n/a
Parking lot planters/buffers	Small vegetated depressions between rows of parking, can be similar to a stormwater planter (see Treatment section)	Attenuation (basin capacity) / Treatment (plant types)						n/a						
Infiltration Basin	Basin built over permeable soils, allows for infiltration over time	Attenuation (basin capacity)												
Infiltration Trench	Rectangular trench filled with gravel or stone	Attenuation (basin capacity)												n/a
<b>Attenuation</b>	<b>Primarily have qualities that provides some storage during storm events and, therefore, attenuate the peak flow of runoff. May have some characteristics that provide treatment from passage through media, or infiltration qualities that might occur during the storage of stormwater.</b>													
Dry swale/underdrain grassed channel	More permeable layer (gravel, perforated pipe, etc.) beneath channeled soil or vegetated layer	Infiltration (soils or presence / routing of underdrain)												
Wet swale	Shallow channel which allows retention of water	Treatment (plant types and storage time)												
Above- or below-ground barrels	Collect roof storm water for subsequent reuse or infiltration	Infiltration												n/a
Rooftop detention	Small perforated weirs around the inlet of roof drains allow ponding of water and reduce peak runoff flows	Treatment (plant types and storage time)												n/a
Dry ponds (extended detention ponds)	Detain stormwater for ~24 hours to allow settling of sediment and pollutants	Infiltration (soils)												n/a
<b>Treatment</b>	<b>Primarily designed to provide treatment of stormwater. Treatment generally occurs in two forms: removal of suspended sediment (by decreasing the velocity of water and therefore its sediment-carrying capacity) or dissolved nutrient uptake (via biotic uptake). May have some characteristics that provide storage of stormwater, or infiltration qualities that might occur during the storage of stormwater.</b>													
Filter strips/vegetated buffers	Dense vegetation planted between potential source and waterbody, slows velocity of runoff	Infiltration (soils)												
Green Roofs	Soil and plants on roof, absorb and filter precipitation	Attenuation (storage capacity of the soil)												n/a
Bioretention cells/biofilters/raingardens	Conditioned planting soil bed that intercepts and filters runoff	Infiltration (soils)												
Tree box filters/stormwater planters	Small-scale cell or raingarden													
Wet ponds (retention ponds)	Retain stormwater to allow for settling and also biouptake of nutrients	Attenuation (size of pond's excess storage)												
Sand/organic filters	Runoff is directed to a shallow basin with sand/organic filter bed for filtration, sometimes has basin for pre-settling	Infiltration (soils)												
Stormwater wetlands	Constructed wetland designed to remove pollutants	Infiltration (soils)/Attenuation (capacity)												
Urban forestry	Infiltration of stormwater and filtration of particulate matter	Infiltration (soils)												
Catch basin retrofit filters	Mostly proprietary technologies that can remove trash, oil and grease, sediment, etc from existing storm drain systems							n/a	n/a					n/a
Swirls or separators	A pre-designed unit which uses to filter solid contaminates from stormwater							n/a	n/a					n/a

### **Operation and Maintenance**

Most BMPs need upkeep to remove sedimentation, check erosion, or ensure proper function. The maintenance needs for each BMP are noted as “Low”, “Medium”, or “High”.

### **Aesthetic Improvement**

Some BMPs can improve the aesthetic qualities of a site and can sometimes increase the property values as well. The potential for aesthetic improvement is rated as “Good” or “Possible”.

## **2.5 Matrix**

The matrix including all of these BMPs and evaluation criteria as described in Section 2.4 is included as Figure 4. A developer may use the matrix to select the BMPs most suited for a particular project. From the matrix, a combination of BMPs should be selected to meet quality and quantity goals as discussed further in Section 3.

Again, please note that the matrix and associated list of BMPs is not exhaustive, and other appropriate BMPs may exist.

# Section 3

## Site Design

### 3.1 Philosophy of Approach

The Town of Littleton wishes to preserve its natural resources and protect the public health by encouraging developers to view stormwater and other environmental resources as assets to be protected. Through heightened awareness of stormwater management, this program is designed to enhance the planning process for new developments by improving the quality of stormwater runoff and increasing the quantity of stormwater returned to groundwater.

### 3.2 Approach

The Town of Littleton encourages the use of BMPs and LID techniques in stormwater management, even when additional permeability is not desired on site. However, if a developer wishes to exceed the allowed percent of impervious surfaces on a site, the procedure described below must be followed to provide adequate stormwater treatment and infiltration/retention. A low impact development is one that has been planned using this procedure. The calculations and values included within the procedure are modeled based on the Massachusetts Stormwater Policy Handbook (March 1997). However, Littleton's procedure does not replace or supercede any existing regulations that may be applicable to a site. Other regulations that may be applicable to a site include the Massachusetts Stormwater Management Standards itself, which in general is applicable for larger developments and wherever the wetlands protection act has jurisdiction<sup>32</sup>, as well as the EPA NPDES regulations, Massachusetts Wetlands Protection Act, and the Title 5 Septic System code. A developer is responsible for ensuring all relevant regulations are understood and met.

In general, Littleton's procedure allows additional impervious surfaces within the proposed development, if the stormwater from the site is adequately treated and peak flows are attenuated and infiltrated. If stormwater treatment and hydrologic (infiltration and peak flow) requirements are met, the developer may proceed with planning a development with greater than the allowed percent impervious surface, while still maintaining Littleton's natural resources. The detailed approach consists of a series of steps described below.

#### **Step 1: Start Project Planning Phase with Environmental Concepts in Mind**

During preparation of site plans, the applicant should be conscious of low impact development and environmentally conscious concepts, such as minimizing imperviousness, considering infiltration and groundwater recharge, specifying local vegetation to minimize irrigation requirements, protecting stormwater from contamination to maintain quality where possible, and otherwise using innovative environmental approaches in stormwater management and community design. The

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<sup>32</sup> Stormwater Management Policy applicability table given on page 1-14 of Standards Handbook found at: <http://www.mass.gov/dep/water/laws/swmpolv1.pdf>



Town of Littleton wants to see local developers setting a standard for practical, sustainable development. In particular, the applicant is requested to minimize impervious surfaces such as roadways, driveways, parking, roofs, and sidewalks, where possible. The applicant will be required to show that all reasonable steps have been taken to reduce the amount of pervious surface on a site.

## Step 2: Determine Stormwater Management Requirements

These calculations will be used in the subsequent steps.

**(2a) Total Impervious Surface:** The applicant should calculate the total area of impervious surfaces on the proposed site layout. This includes the sum of areas such as roadways, driveways, parking, roofs, walkways, sidewalks, patios, and similar surfaces. Note that the total area of porous pavement surfaces should be included in this value.

**(2b) Percent of Impervious Surface:** The applicant should calculate the percentage of impervious surfaces on the site:

$$\% \text{ Impervious} = (\text{total area of imperviousness from Step 2a}) / (\text{total area of site})$$

If the percentage is less than allowed percent imperviousness, the Town encourages completion of steps 2c, and 3 through 5. However, if the percentage is greater than the allowed percent, the Town requires that these steps be completed.

**(2c) Infiltration Volume:** Impervious surfaces reduce infiltration, as described in Sections 1.3 and 1.4. To mitigate for this, infiltration BMPs, such as listed in Section 2, can be employed.

The applicant should determine the soil hydrologic group (or groups) underlying the site.<sup>33</sup> Using the values in the table below, the applicant should calculate the volume of infiltration reduced due to the proposed impervious surfaces as follows.

$$\text{Infiltration Volume} = (\text{Inches of recharge from table}) * (\text{Total impervious surface, 2a})$$

<i>Soil Hydrologic Group</i>	<i>Inches of Recharge per Storm<sup>34</sup></i>
A	0.60
B	0.35
C	0.25
D	0.10

<sup>33</sup>This data is available from the NRCS or the Middlesex Conservation District, <http://www.middlesexconservation.org/>

<sup>34</sup>The infiltration guidance is from the MA draft Stormwater Standards Page 7. <http://www.mass.gov/dep/service/regulations/newregs.htm#stormwater>

**Example 2c-1:**

Conservation district maps show that a ten acre site is underlain 40 percent by Soil Hydrologic Group A and 60 percent by Soil Hydrologic Group B. The pre-development recharge is calculated as:

$$0.4 * 10 \text{ acres} * (0.6 \text{ inches}) \text{ for group A} + 0.6 * 10 \text{ acres} (0.35 \text{ inches}) \text{ for group B}$$

$$4.5 \text{ inch-acre} * [43,560\text{ft}^2/\text{acre}] * [1\text{ft}^2/12\text{inches}]$$

$$\text{Pre-Development Infiltration} = 16,335 \text{ ft}^3$$

A developer wishes to construct a large shopping center on this parcel. Although he has worked diligently to reduce the amount of pavement, the sum of all impervious surfaces, including roof area, parking lot, access roads, loading docks, etc., totals approximately 40 percent of the site. This proposed impervious area will cover all of the group A soils on site. The post-development recharge is then calculated as:

$$\begin{array}{lll} 0 * 10 \text{ acres} * (0.6 \text{ inches}) & + 0.6 * 10 \text{ acres} * (0.35 \text{ inches}) & + 0.4 * 10 \text{ acres} * (0 \text{ inches}) \\ \text{For group A} & \text{For group B} & \text{For impervious surfaces} \end{array}$$

$$2.1 \text{ inch-acre} * [43,560\text{ft}^2/\text{acre}] * [1\text{ft}^2/12\text{inches}]$$

$$\text{Post-Development Infiltration, without BMPs} = 7,623 \text{ ft}^3$$

The difference between the pre-development and post-development recharge (16,335 - 7,623 ft<sup>3</sup>) is 8,712 ft<sup>3</sup>. This is the volume of water, per storm, that the developer should plan to infiltrate on site. Step 4 discusses BMP selection for infiltration.

$$\text{BMPs needed to infiltrate } 8,712 \text{ ft}^3$$

**Example 2c-2**

Planning for the same parcel of land, the developer now proposes a development with 40 percent impervious, with all of this proposed impervious over the soil group B. The post-development recharge is then calculated as:

$$\begin{array}{lll} 0.4 * 10 \text{ acres} * (0.6 \text{ inches}) & + 0.2 * 10 \text{ acres} * (0.35 \text{ inches}) & + 0.4 * 10 \text{ acres} * (0 \text{ inches}) \\ \text{For group A} & \text{For group B} & \text{For impervious surfaces} \end{array}$$

$$3.1 \text{ inch-acre} * [43,560\text{ft}^2/\text{acre}] * [1\text{ft}^2/12\text{inches}]$$

$$\text{Post-Development Infiltration, without BMPs} = 11,253 \text{ ft}^3$$

The pre-development infiltration is the same as example 2c-1. The difference between the pre-development and post-development recharge (16,335 - 11,253 ft<sup>3</sup>) is 5,082 ft<sup>3</sup>. This is the volume of water, per storm, that the developer should plan to infiltrate on site. Note that simply by considering where on-site to place the impervious surfaces,

i.e. over the tighter soil, the developer reduces the required infiltration volume substantially over Example 2c-1. Step 4 discusses BMP selection for infiltration.

BMPs needed to infiltrate 5,082 ft<sup>3</sup>

**Example 2c-3, Porous Pavement**

Section 4 further discusses selection of BMPs. By way of example, porous pavement, one example of a Best Management Practice that might be used for infiltration, is discussed here. Most porous pavement designs allow sufficient recharge through the surface such that the area of the porous pavement may not only be removed from the calculation of total impervious surface, but also the area may be considered to infiltrate runoff from adjacent impervious surfaces. For example, the porous pavement discussed in the UNH Stormwater Center design treats 4 inches of runoff<sup>35</sup>, well above the requirements for all soil groups. If runoff from adjacent impervious surfaces is directed to the porous pavement, undesirable ponding may occur during rainfall events, potentially impeding use of the surface. Porous pavement is generally not recommended for very high volume roads. Design manuals should be consulted for calculations and recommendations on use restrictions.

**(2d) Treatment Volume:** The applicant should calculate the volume of stormwater runoff from the impervious surface for a storm of 0.5-inch depth.<sup>36</sup> In some cases the volume to be treated may be less than this value as some surfaces can be deemed “clean” and may not require treatment. This is discussed in more detail in Step 3.

**Example 2d-1**

A developer proposes 50 percent impervious surface on a 10-acre site. BMPs should be sized to treat a volume of water equal to:

$$0.5 * (10 \text{ acres}) * 0.5 \text{ inches}$$

$$2.5 \text{ inch-acres} * [43,560\text{ft}^2/\text{acre}] * [1\text{ft}^2/12\text{inches}]$$

BMPs needed to treat 9,075 ft<sup>3</sup>

The treatment volume does not rely on soil types or pre-development conditions. Only the impervious surface area is required to calculate the treatment volume. Selection of BMPs for treatment is discussed in Step 3.

**Example 2d-2 Porous Pavement**

If porous pavement is proposed for use on a site, the applicant should also include the volume of runoff expected from the porous pavement. However, most porous pavement designs will not produce any runoff for a 0.5 inch rainstorm. The porous pavement design described by the UNH Stormwater Center can treat 4 inches of

<sup>35</sup>[http://www.unh.edu/erg/cstev/fact\\_sheets/TUJ.pdf](http://www.unh.edu/erg/cstev/fact_sheets/TUJ.pdf)

<sup>36</sup> MA Stormwater Policy requires 0.5 inches of treatment for all areas under jurisdiction of the policy, and 1.0 inches of treatment for areas that discharge to “critical areas”. As the MA Stormwater Policy remains in effect where applicable, the 0.5 inches of treatment is adopted for Littleton’s Policy.

rainfall. So this porous pavement could be subtracted from the impervious area. For example, the developer from Example 2d-1 decides to install 120 ft<sup>2</sup> of porous pavement in place of a proposed impervious walkway. The replaced 120 ft<sup>2</sup> of impervious surface contributed 5.0 ft<sup>3</sup> (120 ft<sup>2</sup> \* 0.5 inch) of runoff to be treated. This volume no longer will need to be treated and can therefore be subtracted from the overall treatment volume.

BMPs needed to treat 9,070 ft<sup>3</sup>

### **Step 3: Select and Size Treatment BMPs.**

Discharge of clean stormwater is a priority. Therefore, an applicant should strive to provide treatment for the entire volume calculated above in Step 2d. If site constraints or other obstacles prevent treatment of the entire “2d” volume, the applicant should make a good faith attempt to treat as close to this volume as feasible, with priority treatment to surfaces most likely to discharge polluted flows, such as driveways, parking lots, and waste storage. The Planning Board reserves the right, under any and all circumstances, to require full treatment of the “2d” volume for any applicant wishing to implement a site plan with greater than allowed percent impervious.<sup>37</sup>

Figure 4, the Low Impact Development Matrix, lists Best Management Practices from Section 2 of this document, and the purpose to which each is best suited. The BMPs suited for treatment are listed in the bottom third of the table.

The applicant should select from the matrix one or more treatment BMPs that are suited to the soil conditions, land use, type of construction, and space available at the site. The applicant should also minimize required operations and maintenance (O&M), and consider how O&M will be provided. Aesthetics are also important, and must match the type of development.

The applicant should then size the selected BMP to treat the treatment volume calculated in Step 2d above for 80 percent removal of the annual load of Total Suspended Solids (TSS). The guidance documents provided for each BMP above in Section 2 will assist with the design.

In general, the applicant should consider the following:

- In aquifer protection area, a treatment BMP is required. See Figure 1 for the map of aquifer and water resource protection zones.

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<sup>37</sup>Note that within the jurisdiction of the Wetlands Protection Act, 80% removal of the average annual load for Total Suspended Solids removal is required by the Massachusetts Stormwater Management Policy. For discharges to critical resource areas, the volume to be treated is equivalent to 1.0 inches of depth over the planned impervious area. For all other discharges subject to the Policy, the volume to be treated is equivalent to 0.5 inches of depth over the planned impervious area. The Stormwater Management Manual, Volume One: Stormwater Policy Handbook [<http://www.mass.gov/dep/water/laws/swmpolv1.pdf>] provides guidance to meet this requirement.

- In some cases, treatment BMPs may not be required to treat all stormwater from a site to receive credit. For example, rooftop runoff is generally “clean” and could be directly infiltrated. The applicant wishing to directly infiltrate rooftop runoff without treatment should state so clearly in application materials, and subtract the rooftop area from the treatment volume calculations in Step 2d above. An infiltration BMP would still be required for rooftop runoff.
- BMPs that are not in the “Treatment” category in the matrix (Figure 4), but are to be used as a treatment method (such as those with treatment listed as a secondary benefit, including parking lot planters/buffers, wet swale, and rooftop detention) must detail the steps taken to ensure treatment capabilities for the planned discharge volume and rate are present in the BMP.
- For locations not in the Aquifer Protection Zone (Figure 1), treatment of all impervious surface runoff is highly encouraged for consideration as an LID site. The planning board may require treatment methodologies be employed if stormwater runoff is deemed to be in a potentially sensitive area.

#### *Example 3-1*

The developer from Example 2d-1 needs to include in her site plan BMPs to treat 9,075 ft<sup>3</sup>, 5 acres of impervious surface. She selects from the Matrix (Figure 4) tree box filters and constructed wetland. Considering the topography of the site, she decides that tree box filters will be distributed throughout the parking lot, increasing the shade on site and treating a total of 2.5 acres of runoff. The constructed wetland will be placed beside the buildings on site, adding aesthetic appeal to the development, and treating the remaining 2.5 acres of runoff from roofs and access roads.

One tree box filter, built according to the UNH Stormwater Center design<sup>38</sup>, can treat 0.1 acres of contributing area. Each tree box filter is capable of treating greater than the required volume under these regulations for 0.1 acres of impervious surface, but the design documents limit contributing area to 0.1 acres. To treat 2.5 acres of contributing area, 25 tree box filters will be installed.

The remaining 2.5 acres of impervious surface contributes half of the calculated treatment volume, or 4,538 ft<sup>3</sup> (1/2 \* 9,075 ft<sup>3</sup>). A pocket wetland will be designed to treat this volume. The developer follows the procedure in the Massachusetts Stormwater Manual<sup>39</sup> and referenced guidelines therein and successfully designs a small wetland to treat this runoff.

### **Step 4: Site Hydrology**

**(4a) Infiltration/Attenuation** - Figure 4, the Low Impact Development Matrix, lists Best Management Practices from Section 2 of this document, and the purpose to

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<sup>38</sup>UNH Tree Box Filter Fact Sheet [http://www.unh.edu/erg/cstev/fact\\_sheets/TUK.pdf](http://www.unh.edu/erg/cstev/fact_sheets/TUK.pdf)

<sup>39</sup><http://www.mass.gov/dep/water/laws/swmpolv2.pdf>

which each is best suited. The BMPs suited for infiltration and attenuation are listed in the top of the table.

Infiltration BMPs should be selected from the matrix and sized to infiltrate at least the volume calculated above in Step 2c.

The applicant should consult the Planning Board to determine if there is a priority for either infiltration or attenuation, especially if the proposed project is within the Aquifer Protection Zone (Figure 1).

A combination of infiltration and attenuation BMPs can then be selected and sized until the condition summarized in Step 4b is met, with consideration given to any stated priority from the Planning Board.

**(4b) Peak Discharge Rates** - The proposed plan, if percent impervious is greater than allowed percent impervious, is required to have a post-development peak discharge equal to the pre-development discharge for the 2-year 24-hour and 10-year 24-hour storm. The applicant should therefore design attenuation and/or infiltration BMPs to achieve this goal. The method presented in Chapters 2 through 4 of Natural Resources Conservation Service's TR-55 document<sup>40</sup> should be used for this purpose.

The depths of the relevant design storms for Littleton, interpolated from *Rainfall Frequency Atlas of the United States for Durations from 30 minutes to 24 Hours and Return Periods from 1 to 100 Years Technical Paper 40 (TP40, 1961)*<sup>41</sup> are:

<i>Storm</i>	<i>Depth</i>
2-year 24-hour storm	3.0 inches
10-year 24-hour storm	4.6 inches
100-year 24-hour storm	6.5 inches

Note that if porous pavement is proposed for use on a site, the applicant should also include the volume runoff expected from the porous pavement. For example, the porous pavement design described by the UNH Stormwater Center can treat 4 inches of rainfall. So for the 2-year 24-hour storm, 3.0 inches depth, there would be no runoff from this porous pavement. For the 10-year 24-hour storm, 4.6 inches, the volume of runoff is 0.6 inches over the area of the porous pavement.

The applicant must show that the following are satisfied:

- If soil types are unknown or the majority of a site is fill, a percolation test may be conducted and the results of that test used in the analysis and design of the BMP to ensure performance.

<sup>40</sup>[ftp://ftp.wcc.nrcs.usda.gov/downloads/hydrology\\_hydraulics/tr55/tr55.pdf](ftp://ftp.wcc.nrcs.usda.gov/downloads/hydrology_hydraulics/tr55/tr55.pdf)

<sup>41</sup><http://www.weather.gov/oh/hdsc/currentpf.htm#TP40>

- An adequate explanation of methods is included for BMPs designed to satisfy multiple goals.
- Appropriate infiltration and/or attenuation BMPs are designed and planned so that the pre-development peak discharge rate from the 2-year 24-hour and 10-year 24-hour matches the estimated peak discharge rate for the same storms for post-development conditions.

### **Step 5: Operation and Maintenance Plans**

On-going operation and maintenance of the selected Best Management Practices is necessary for continued treatment, attenuation and infiltration as designed. As such, the applicant should summarize the operation and maintenance required for each BMP planned on site, including schedule for required activities, estimated costs, and responsible parties.

### **Step 6: Checking LID Results**

All developers should:

- Comply with local, state and national laws, including the Massachusetts State Stormwater Policy and EPA's NPDES regulations where applicable;
- Consider Low Impact Development and environmentally conscious design (Step 1); and
- Prepare adequate operations and maintenance plans for all proposed BMPs (Step 5).

Any applicant proposing a site with greater than 20 percent impervious (Step 2b) is required to, in addition, prepare calculations, documents, and/or plans which clearly show that the BMPs planned on site will result in:

- treatment provided for impervious surfaces (possibly excluding roof discharge, Step 3);
- sufficient infiltration (Step 4a); and
- infiltration and attenuation designed such that post-development peak discharge rates do not exceed pre-development peak discharge rates for the 2-year and 10-year 24-hour storm (Step 4b).

### **Step 7: Provide Documentation to Town of Littleton Planning Board**

The developer should meet with the Planning Board. If the above steps are satisfactorily met in the presented plans and documents, the Town of Littleton Planning Board may choose to grant permission to develop a site to greater than allowed percent impervious area. The developer may additionally choose to meet with the Planning Board earlier in the project development to discuss requirements, level of effort expected, and proposed plans to avoid completing plans that are not acceptable to the Town.

# Section 4

## References

Useful weblinks and references for further information about stormwater management are listed below.

- Connecticut Stormwater Management Manual:  
<http://dep.state.ct.us/wtr/stormwater/strmwtrman.htm>
- Georgia's Stormwater Manual: <http://www.georgiastormwater.com/>
- Low Impact Development Center: <http://www.lowimpactdevelopment.org/>
- Massachusetts Stormwater Management, Volume 1: Stormwater Policy Handbook:  
<http://www.mass.gov/dep/water/laws/swmpolv1.pdf>
- Massachusetts Stormwater Management, Volume 2: Stormwater Technical Handbook: <http://www.mass.gov/dep/water/laws/swmpolv2.pdf>
- Massachusetts Low Impact Development Toolkit:  
[http://www.mapc.org/regional\\_planning/LID/LID\\_Links\\_References.html](http://www.mapc.org/regional_planning/LID/LID_Links_References.html)
- Virginia Stormwater Enforcement Manual:  
<http://www.dcr.virginia.gov/sw/docs/swm/stormmanual.pdf>