United States Environmental Protection Agency New England

Incorporating Low Impact Development into Municipal Stormwater Programs

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Executive Summary

Managing stormwater with Low Impact Development (LID) techniques can help jurisdictions meet National Pollutant Discharge Elimination System (NPDES) requirements, reduce construction costs, and provide a variety of other benefits over traditional stormwater management approaches. The goal of LID is to reduce runoff and to mimic a site's predevelopment hydrology by infiltrating, filtering, storing, evaporating, and detaining stormwater runoff. LID employs principles such as preserving and recreating natural landscape features and minimizing imperviousness to create functional and appealing site drainage that treat stormwater as a resource, rather than a waste product. There are many practices that have been used to adhere to these principles such as bioretention facilities, rain gardens, vegetated rooftops, rain barrels, and permeable pavements. LID practices need to be sited and designed carefully and work in conjunction with other stormwater management efforts.

This fact sheet describes the benefits of LID, and various types of LID practices. It also discusses the importance of good land use planning and outlines steps that municipalities and/or developers could take to implement LID.

Stormwater and TMDLs

In New England, many streams are impaired by stormwater and, as a result, a total maximum daily load (TMDL) water quality study is required. Research has shown that there is a strong correlation between pollutant loads, stormwater flows, and runoff from impervious landcover in the watershed. Therefore, TMDLs have been developed using Impervious Cover (IC) as a surrogate parameter for a mix of pollutants conveyed by stormwater. Using LID techniques and other best management practices (BMPs) will help with the implementation of these TMDLs and result in restored water quality. Additional information on incorporating green infrastructure and/or LID concepts into TMDLs and implementing stormwater TMDLs can be found at:

http://www.epa.gov/owow/tmdl/stormwater/pdf/tmdl_lid_final.pdf

http://www.epa.gov/region1/eco/tmdl/assets/pdfs/Stormwater-TMDL-Implementation-Support-Manual.pdf

Green Infrastructure: Management approaches and technologies that infiltrate, evapotranspire, capture and reuse stormwater to maintain or restore natural hydrology. At the largest scale, green infrastructure approaches also work to preserve and restore natural landscape features (e.g., forests, floodplains, wetlands).

Introduction

As more undeveloped land is being converted to impervious surfaces, it becomes increasingly important to consider the effects of construction and land development on water resources. The effects of urbanization on water resources are well known and include degraded habitat, incised channels, impaired aquatic life, high pollutant loads, depleted and contaminated groundwater, and higher incidence of flooding, among others. The mid-20th century approach to stormwater management—to dispose of stormwater using engineered systems of curbs, gutters, pipes, and open channels—resulted in significant damage to water quality. Recently, new approaches have evolved to mitigate effects and reverse damage caused by existing development. These approaches, commonly referred to as LID, focus on emulating the functions of natural systems to reintegrate rainfall into the water cycle. LID is an approach to land development (or redevelopment) that works with nature to manage stormwater as close to its source as possible.

LID is an environmentally sensitive approach to stormwater management. By implementing LID principles and practices, water can be managed in a way that reduces the effects of built areas and promotes the natural movement of water in an ecosystem or watershed. Applied on a broad scale, LID can maintain or restore a watershed's hydrologic and ecological functions and provide numerous other environmental, economic, and social benefits.

Benefits of LID

- Reduce urban heat island effect
- Increase aquifer recharge
- Reduce stream temperatures
- Reduce treatment costs
- Improve water quality
- Reduce flooding and sewer overflows
- Reduce energy and water use
- Add green space
- Increase base flow to streams
- Reduce costs
- Manage stormwater

LID, in the broader view, includes land use strategies. To fully protect water resources, communities should consider incorporating a wide range of environmentally sound land use strategies—such as maintaining natural resource areas, preserving critical ecological and buffer areas, minimizing land disturbance, minimizing impervious cover, and following smart growth principles.

Smart growth is development that serves the economy, the community, and the environment. It changes the terms of the development debate away from the traditional growth/no-growth questions to "how and where should new

development be accommodated?" When a community zones for smart growth or a developer chooses a smart growth site for development, this further minimizes environmental impacts - particularly if employed in combination with the LID practices described in this fact sheet. For example, compact, mixed-use, transit-oriented, pedestrian-friendly development results in fewer car trips and vehicle emissions, avoids sprawl, and minimizes impervious surfaces and stormwater runoff. For more information on smart growth practices and tools, see **http://www.epa.gov/smartgrowth**.

LID techniques are flexible and can be applied to nearly any site, including both infill/redevelopment sites and new development. LID techniques are relatively new, and they need to be sited and designed carefully. For additional information on concerns related to LID, see the EPA fact sheet: *Managing Stormwater with Low Impact Development Practices: Addressing Barriers to LID* on EPA Region 1's website.
www.epa.gov/region1/topics/water/stormwater.html

*A green roof in Essex, Connecticut (**www.ecohusky.uconn.edu**)*

LID Benefits

LID offers a number of advantages over traditional, engineered stormwater drainage approaches, including

- **Addresses stormwater at its source:** LID practices seek to manage rainfall where it falls, reducing or eliminating the need for detention ponds and flood controls.
- **Preserves streams and watersheds:** Because LID practices infiltrate rainfall and prevent runoff, they reduce both pollutant loads and streambank erosion associated with peak flows.
- **Promotes ground water recharge:** Many LID techniques allow stormwater to infiltrate the earth, recharging ground water aquifers and providing baseflow to streams during dry weather. The stormwater, cooled as it flows underground, helps keep stream temperatures low.
- **Allows for more flexible site layouts:** Whereas traditional stormwater management required large ponds and wetlands that consume valuable real estate, the small-scale, dispersed nature of LID practices means that designers can include stormwater management in a variety of open spaces and smaller landscaped areas.
- **Enhances aesthetics and public access/use:** Well-designed vegetated practices, such as rain gardens, can provide a visual amenity, particularly when compared to hardened drainage infrastructure such as pipes, curbs, gutters, and concrete-lined channels. Some practices can double as park space, offering recreational amenities.
- **Reduces costs:** A common myth is that LID costs more than traditional stormwater management, but case studies have shown the opposite to be true. Savings can arise from the reduced amount of pipes, asphalt, detention basins or other infrastructure needed to handle runoff, reduced energy costs, and increases in developable land area due to the availability of land that would not have been available had traditional stormwater management approaches been employed. A recent EPA report titled *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices* finds that total LID capital costs are lower than conventional methods, with savings ranging from 15 to 80 percent. For a complete copy of the report, see: **http://www.epa.gov/owow/nps/lid/costs07/documents/factsheet-reducingstormwatercosts.pdf**

Bioretention cell in South Burlington, Vermont

"Our research data tell us that it's possible to design and install systems that do an excellent job of treating pollutants in stormwater, dampening the peak flows of runoff, and reducing the volume of stormwater through infiltration, even in cold climates with poor soils."

– UNH Stormwater Center 2007 Annual Report

State/City Requirements featuring Low Impact Development

Municipalities throughout New England and the country have adopted bylaws emphasizing or requiring LID techniques to more effectively meet stormwater control standards.

Maine emphasizes combining BMP design with LID design practices to improve overall water quality, help lower temperatures, decrease risk of flooding, effectively remove pollutants, and protect water channels. Maine's BMPs include using vegetated buffers, soil media filters, infiltration, and wet ponds with underdrained gravel filters. State BMP design requirements include required treatment for the first 1 inch of runoff from impervious surfaces and 0.4 inch from landscaped areas. For more information, see the *Maine DEP Stormwater Management Manual* at **http://www.maine.gov/dep/blwq/docstand/stormwater/stormwaterbmps/index.htm**

Boston requires that real estate development projects be reviewed by the Boston Redevelopment Authority to determine the impact of a project on the surrounding community and the city as a whole. The city promotes green buildings by requiring projects over 50,000 square feet be designed such that they can reasonably be expected to be certified by LEED (see sidebar on page 8 for more on LEED). The city also includes incentives by creating credits for four additional attributes that are not in LEED, but are desirable in Boston. For more information, see the Boston Redevelopment Agency zoning documents at **http://www.cityofboston.gov/bra/zoning/zoning.asp**

Types of LID Best Management Practices (BMPs)

At the site level, practitioners should consider the following LID BMPs (refer to Table 1 for examples):

- **Redu ce and disconnect impervious surfaces:** Runoff from rooftops, sidewalks, driveways, and roads can be directed to landscaped areas or porous pavement to promote infiltration and reduce runoff volumes.
- **Preserve natural areas and natural features:** Areas of a development site that will not contain buildings or other infrastructure can be protected from clearing, grading, and other construction-related impacts, reducing the amount of disturbed land and maintaining mature vegetation and native soil permeability.
- **Bioretention techniques:** Also known as rain gardens, biofilters, bioswales, and bioinfiltration practices, these are landscaped depressions that collect runoff and manage it through infiltration, evapotranspiration, and biological uptake of nutrients and other pollutants.
- **Planters and tree boxes:** Planters and tree boxes enhance streetscapes and courtyards with attractive vegetation and shade and also provide pervious areas for rainfall interception and stormwater infiltration.
- **Porous pavement:** A variety of paving surfaces, including porous concrete, porous asphalt, and interlocking pavers, contain pore spaces that store and allow runoff to infiltrate into the ground. Porous pavement is expected to last twice as long as conventional asphalt. Additionally, porous pavement speeds snow and ice melt, dramatically decreasing the amount of road salt needed in winter.
- **Water collection (rain barrels, cisterns):** Rainfall from rooftops can be collected via downspouts and stored for reuse. Rain barrels are typically used to store water for landscaping; cisterns offer more storage volume and can store water for toilet flushing, landscape irrigation, or other gray water applications.

With University of New Hampshire Stormwater Center support, the New Hampshire Department of Transportation constructed two pilot gravel wetland treatments to help meet TMDL requirements for impaired waters as part of the Interstate 93 widening project.

- **Green roofs:** These consist of a layer of soil and plants installed on a roof surface. Green roofs not only provide aesthetic benefits, but also retain stormwater, reducing stormwater volumes and promoting evaporation and transpiration. Green roofs have energy-saving benefits and help to reduce the heat-island effect in urban areas.
- **Ecological landscaping:** Choose native plants that are easy to maintain and are adapted to local climate and soil conditions to decrease the need for watering, fertilizers, and pesticides. For more info on EPA Greenscapes, see **http://www.epa.gov/epawaste/conserve/rrr/greenscapes**
- **Better site design:** Reduce the amount of IC, increase natural lands set aside for conservation, and use pervious areas for more effective stormwater treatment. To meet these goals, designers must scrutinize every aspect of a site plan—its streets, parking spaces, setbacks, lot sizes, driveways, and sidewalks—to see if any of these elements can be reduced in scale. At the same time, designers should develop creative grading and drainage techniques to reduce stormwater runoff and encourage more infiltration. See Table 1 for examples of LID practices in New England.

Table 1. *Examples of LID designs in each New England state*

Rain Gardens	South Windsor, CT Orono, ME Cohasset, MA Merrimack, NH North Kingston, RI Winooski, VT	**Cohasset, MA** The town constructed more than 40 rain gardens in the town's rights-of-way to treat suburban stormwater runoff before it could enter Lily Pond, one of the town's two drinking water sources.
Stormwater Wetlands	Groton, CT Waterville, ME Westport, MA Stratham, NH South Burlington, VT	**Waterville, ME** Colby College built 3 bioretention ponds, planted with native wetland plants, to reduce the effects of a new parking lot constructed near a wetland.
Stormwater Swales	Old Saybrook, CT Dexter, ME Pittsfield, MA Amherst, NH Providence, RI Fairfax, VT	**Fairfax, VT** The Rose Hill Development constructed swales to infiltrate runoff from the impervious driveways and access road.
Porous Pavement	Waterford, CT Scarborough, ME Ipswich, MA New London, NH Kingston, RI South Burlington, VT	**Kingston, RI** The University of Rhode Island paved two parking lots (combined capacity 1,000 vehicles) with pervious asphalt.
Green Roofs	Essex, CT Portland, ME Boston, MA Manchester, NH Providence, RI Putney, VT	**Essex, CT** A green roof was installed atop the Centerbrook Architects building using various species of sedum in modular trays over the existing rubber roof. The building owner reports reduced runoff and cooler summer temperature in the offices.
Multiple LID Designs	**Cambridge, MA** Genzyme Corporation built its headquarters on a polluted Brownfield site. The facility was built with recycled and local material and was designed to use natural light. It has its own stormwater collection system and a green roof and received Platinum LEED Certification. The annual savings from reduced energy costs are $400,000.	
	Townsend, MA Coppersmith Way Development includes 40 affordable homes in an environmentally friendly residential subdivision. The streets in the development have reduced widths, and the walkways are porous. There are numerous bioretention cells and swales, and each home has its own rain garden. Individual homes use solar-electric energy and solar-heated hot water resulting in savings of 60% to 100% on each month's energy bill.	

The Greenscapes Massachusetts program conducted several popular rain garden workshops in partnership with local municipalities and are planning more by request from citizens. For more information and instructions on how to create a rain garden, see the Greenscapes website:
http://www.greenscapes.org/Page-198.html

LID Online BMP Inventory

The University of New Hampshire Stormwater Center (UNHSC) and the University of Connecticut's Nonpoint Education for Municipal Officials program (NEMO) created an online inventory of innovative BMPs, especially LID designs, throughout the six New England states. The inventory contains hundreds of examples ranging from rain gardens on a residential property in Maine to a green roof on City Hall in Boston. Readers can easily add examples from their region using a submission form on the homepage. One can search the inventory either by state or by LID technique.

http://www.unh.edu/erg/stormwater/lid-bmp

Steps for Municipalities

Managing stormwater with LID techniques can help jurisdictions meet five of the six minimum requirements under NPDES Phase II requirements, including: public education and outreach, public participation, construction site and post-construction runoff control, and pollution prevention/good housekeeping. For more details on this, visit the website: **http://www.lowimpactdevelopment.org/lidphase2**.

Municipalities can take the following steps to help promote and implement LID in their community.

Update development and redevelopment standards and pass ordinances with LID incentives

- Evaluate street design specifications (such as road widths or type of curbing), erosion and sediment control ordinances, landscaping requirements, and other standards that might prohibit the use of LID practices. Identify language that could be incompatible with LID and work with other municipal departments to discuss alternatives. It is important to address the other departments' concerns about safety, cost, parking ratios, and such to ensure their support.
- Depending on how new requirements are codified in the community, develop new code language, propose changes to the zoning or development ordinance, or develop a separate stormwater ordinance that outlines the new standards. For model ordinances that promote LID see the following websites: **http://www.mass.gov/envir/smart_growth_toolkit/pages/SG-bylaws-lid.html or http://www.des.nh.gov/organization/divisions/water/wmb/repp/innovative_land_use.htm**
- Identify possible incentives that can be offered to encourage LID implementation. Incentives can be in the form of density bonuses, reduced size of required drainage infrastructure, discounted utility fees, and tax credits.
- Provide guidance for implementing the new standards. Develop a standards manual or adopt your state's manual if it is sufficient. Wherever possible to conserve resources, adapt existing resources to local situations. Massachusetts developed a *Stormwater Policy Handbook* **http://www.mass.gov/dep/water/laws/swmpolv1.pdf** with information on the regulations, and a *Stormwater Technical Handbook* **http://www.mass.gov/dep/water/laws/swmpolv2.pdf** with information on implementing BMPs.
- Implement demonstration projects and monitor them for effectiveness and suitability of design. Municipalities should take the initiative to experiment with BMP designs and identify those that work well in local conditions. Demonstration projects show developers and citizens the effectiveness of stormwater BMPs and instill confidence in their performance.
- Evaluate constraints (areas of high ground water, poorly drained soils, etc.) and inform the development community about where the new BMP requirements apply and where site constraints prohibit LID implementation. However, many site constraints can be overcome. The city of Seattle infiltrates stormwater on soils with 0.10 inch/hr permeability.

LID Certification Program in Rhode Island

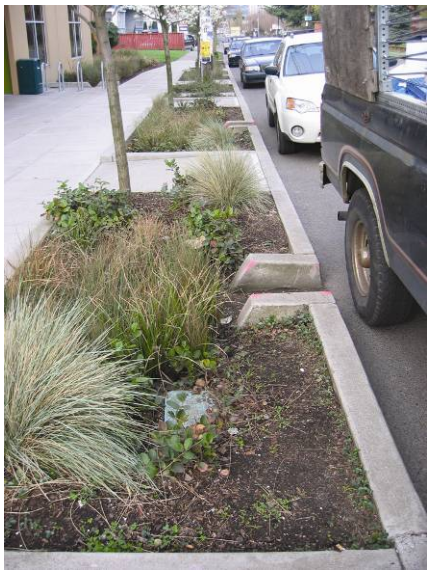
The Rhode Island Coastal Resources Management Council's (CRMC) 2006 Urban Coastal Greenway Policy requires LID practices as the primary means to manage stormwater treatment for the Metro Bay area (Cranston, Pawtucket, Providence, and East Providence). All construction projects within 200 feet of a coast must be approved by CRMC, and CRMC accepts applications only from those certified in LID by their program, which was created by the CRMC, the University of Rhode Island's Coastal Resources Center, and the consulting firm Horsley Whitten Group. To date, about 100 people have been certified, and there are plans for more courses after the LID requirement becomes statewide with the new Rhode Island Stormwater Manual, expected in 2009.

Require LID for capital improvement projects and educate maintenance crews

A municipality can set a good example, show confidence in the use of new technology, and demonstrate success with pilot projects in the public right-of-way. Municipalities have jurisdiction over development activities in the right-of-way and on public lands, which allows greater design flexibility and more reliable maintenance using municipal crews. LID projects adapt well to linear applications (e.g., streetscapes, courtyards, medians) and small-scale open spaces. Work with facilities management and landscaping crews because maintenance of vegetated LID practices sometimes requires special handling, such as hand-weeding and prohibiting heavy equipment and pesticide use. Also, consider adopting Leadership in Energy and Environmental Design (LEED) Green Building Rating System standards for all municipal building and development projects (for more information, see the "Building Rating System" sidebar).

Educate designers and developers

Allow time and dedicate resources for bringing design engineers and landscape architects up to speed on new requirements. Provide checklists to help ensure compliance with new procedures. Consider unique local conditions, where appropriate, to ensure accurate sizing calculations and include example calculations to ensure consistency and transparency in project submittals. Hold periodic training sessions on LID applications, and request that plan reviewers provide specific comments when submitted designs do not meet standards.



Curb cuts allow water to flow into a bioretention area

Establish a maintenance tracking system

Determine whether property owners or the municipality will be responsible for maintenance. If property owners will be responsible, there are a number of ways in which the municipality can assure maintenance:

- Require maintenance agreements, recorded with the property deed, for new and existing BMPs
- Require a performance bond for new BMPs
- Perform spot inspections to identify problems and check maintenance records
- Require that property owners submit records or other evidence that maintenance was performed as prescribed

Municipalities should consider a balance between compliance assistance and enforcement mechanisms to ensure that property owners uphold their maintenance responsibilities.

Maintain a database or geographic information system (GIS) of locations of all LID BMPs. This database is needed for maintenance assurance and can also be used for other efforts, such as watershed modeling, stormwater master planning, and inspection programs. Publicly-owned BMPs should be tracked for maintenance purposes, as well as for asset inventories required under Governmental Accounting Standards Board (GASB) Statement No. 34 **http://www.gasb.org**.

Quantify the benefits of LID

Present case studies showing the water quality and community benefits of LID, whether modeled or measured. Good examples and reliable data will help to make a case for changes in development standards by describing potential cost savings and other amenities offered by LID. This information can be part of a larger effort to educate municipal decision-makers, such as city councils, the mayor, commissioners and others about the benefits of LID, and to dispel any myths and misconceptions surrounding *green* infrastructure. These studies can also be used to gain buy-in from state permitting authorities and to quantify stormwater management benefits in terms of volume reductions and pollutant removal. One tool that can be used to estimate the benefits of LID and conservation practices is the Center for Neighborhood Technology's Green Values Stormwater Calculator **http://greenvalues.cnt.org/calculator**. Users input site development characteristics and green practices, and the calculator returns the financial and hydrologic outcomes for different scenarios.

Grant credit for LID and conservation measures

Communities can offer incentives to developers to preserve open space, protect or plant trees, and implement LID site design techniques by offering stormwater credits. Municipalities can offer credits to those using BMPs in their residences or commercial buildings. The goal of the credits is to reduce the required capacity (and therefore the cost) of stormwater treatment practices (STPs) by using nonstructural site design and conservation measures. These credits can also decrease a utility fee, if applicable. Stormwater utility fees, proportional to the amount of runoff generated by a lot, can be used by a municipality to fund stormwater management practices. In Reading, Massachusetts and South Burlington, Vermont, two municipalities with a utility fee, citizens can receive up to a 50 percent credit on the utility fee for implementing stormwater BMPs.

Consider drinking water sources

If the development is near a public drinking water source, consider the development's cumulative effect on drinking water sources, especially if the project includes any infiltration BMPs. BMPs should provide pollutant removal before discharge and be sited a sufficient distance away from ground water or surface water sources. For examples of bioretention areas, rain gardens, gravel wetlands, and pervious pavement throughout New England, see the UNH Stormwater Center at **http://www.unh.edu/erg/cstev.**

Consider your community's current and future drinking water supplies and the need to protect them from contaminants that might threaten the drinking water source. Contact your state about limitations on where stormwater infiltration is, or is not, allowed near ground and surface drinking water supply areas (see Table 2). Requirements may include pretreatment or spill control to protect drinking water sources, as well as notification of accidental spills or other discharges to local emergency, public health, or drinking water supply agencies, and owners of public drinking water supplies.

Also be aware of the possible need to register your practice under the Underground Injection Control (UIC) Program. Practices such as rain gardens, bioretention areas, vegetated swales, stormwater wetlands, and permeable pavement are typically not regulated under the UIC program. Systems that are deeper than they are wide, or that include a subsurface distribution system for more than a single-family dwelling are subject to the UIC program; check with your state water agency for more details.

Table 2. State limitations on stormwater infiltration near drinking water, as of December 18, 2008

State	Stormwater infiltration systems policy on wellhead protection area	Stormwater infiltration systems policy on surface water drinking supply
Connecticut	Prohibited within 100 ft of a public well	Prohibited within 200 ft of surface water supplies and within 100 ft of their tributaries
Maine	Prohibited in contributing area of a public supply well	Allowed with treatment requirements
Massachusetts	Prohibited in Zone I (Immediate Wellhead Protection Areas) Allowed in Zone II or Interim Wellhead Protection Areas with additional pretreatment	Prohibited in Zone A Surface Water Supply Protection Area (400 ft around Class A source and 200 ft around tributaries to source) Allowed in Zone B Surface Water Supply Protection Areas with additional pretreatment. (Within ½ mile of Class A surface water source)
New Hampshire	Prohibited within given setbacks from water supply wells ranging 75–400 ft. Prohibited in ground water protection areas where the stormwater comes from high-load areas No infiltration to ground water supplies from high-load areas	Prohibited within water supply intake protection area (area 250 ft of normal high water mark) or to ground water within 100 ft of surface water Allowed within a water supply intake protection area if the seasonal high water table and bedrock are at least 4 feet below the bottom of the practice
Rhode Island	Prohibited within 400 ft of a public water supply well	Prohibited within 200 ft of surface water supplies and their tributaries
Vermont	Prohibited within 500 ft of a public community water supply well	Prohibited within 500 ft of a public community water supply

Benefits of Tree Canopies

The Urban Ecology Institute's (UEI's) goal for the *Tree Canopy Program* is to promote awareness of the benefits of trees and to increase the urban tree canopy in Boston. According to Boston's Urban Forest Coalition headed by UEI, trees in three Boston neighborhoods provide $12 million in benefits to the city by removing air pollutants such as sulfur dioxide, particulate matter, and ozone that contribute to cardiovascular and respiratory diseases. The air quality benefits were generated by Urban Forest Effect Model, which uses the data collected to assign a dollar value to each tree on the basis of air quality improvements from removing ozone, carbon monoxide, nitrogen dioxide, particulate matter, carbon storage, and sequestration. Urban Forest Coalition has also set a target of planting 100,000 new trees by 2020 to increase the city's tree canopy to 35 percent from the current 29 percent. Additional benefits of tree planting include:

- A single mature urban tree is capable of reducing the heating and cooling cost of an urban household by 15 to 30 percent by blocking winds in winter and providing shade in summer.
- Trees are also very effective in absorbing stormwater and returning it to the local aquifer. According to a study performed by Urban Forest Coalition, Boston's existing tree canopy captures 42 million cubic feet of stormwater per year that would otherwise run into the sewer. It would also cost the city and taxpayers more than $142 million to build a system to capture the extra stormwater.
- Trees have also shown to bring a sense of community in neighborhood by creating attractive and engaging meeting places. Furthermore, community tree planting programs engage residents and promote further community development.

Steps for Developers

Review new requirements and standards

Obtain and review new BMP standards and requirements from the municipal planning department including technical design manuals, sample review checklists, and other educational materials. Send design staff to any training workshops offered by the municipality or any other organization that offers this kind of training (e.g., the Center for Watershed Protection or the UNH Stormwater Center).

Get early buy-in for stormwater BMP plans

During the conceptual design stage, meet with a representative from the municipal planning department to discuss ways that LID can be incorporated into the site to avoid multiple design iterations. Identify areas that are especially well-suited to LID BMPs, such as areas with well-

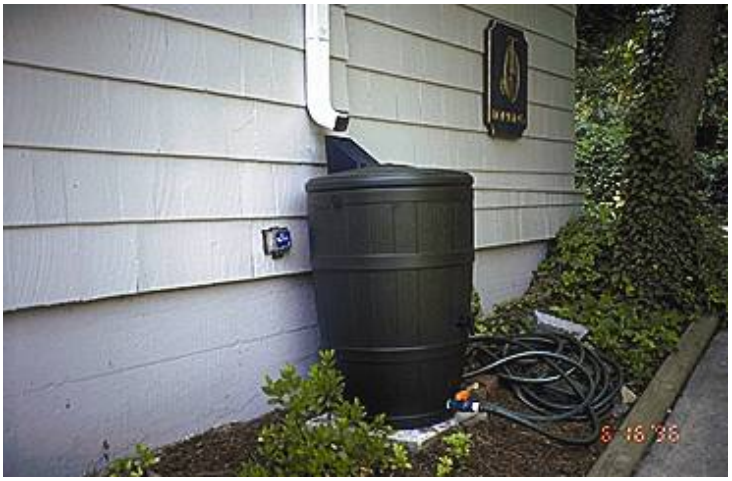
drained soils, stands of mature trees and other mature vegetation, and natural depressions or low-lying areas of the site. Attempt to construct buildings, roads, and other infrastructure around these features when possible. Arendt (1996) describes in detail a methodology for evaluating a development site to maximize open space, reduce impervious surfaces, and optimize stormwater management. Massachusetts's (2008) *Stormwater Handbook* **http://www.mass.gov/dep/water/laws/policies.htm#storm** provides additional guidance on designing low-impact site layouts, including photographs and design schematic for LID systems.

Space for BMPs is more limited in infill developments, though many options are still available, such as the use of flow-through planters in courtyards and along sidewalks, green roofs, and narrow swales along the site's perimeter. Porous pavers can be substituted for traditional pavement, and cisterns can be used to store roof runoff for reuse.

Design for long-term maintenance

Developers should design BMPs with maintenance in mind. Native plants adapted to site conditions should be selected wherever possible to reduce chemical inputs and eliminate the need for watering. Limited access areas or those that require special maintenance can be set off from the surrounding landscape using low walls with cuts to allow stormwater to enter, a row of stones, or other physical or visual barriers. Access should be provided for periodic maintenance that might require heavy equipment.

Developers should include detailed guidance on BMP maintenance with the property deed, including prescribed maintenance activities, inspection schedules and checklists, plant lists, and guidance on how to recognize problems or malfunctions. The maintenance information should distinguish between inspections and maintenance activities that require special expertise versus those that can be performed by homeowners or laborers.



Rain barrels are appropriate for residential settings

Phase construction activities and practice site fingerprinting

When planning construction activities, developers should identify ways to minimize the amount of earth disturbed at any one time. This can be accomplished by phasing construction activities so that only a portion of the site is cleared and graded at a time. The remainder of the site can be left undisturbed to reduce erosion. Also, developers should make every effort to disturb as little of the site as possible. This practice, called *site fingerprinting*, involves clearing only the areas of a site that will contain buildings or infrastructure, leaving open spaces in a natural condition to preserve existing vegetation.

Building Rating System

The U.S. Green Building Council developed The LEED Green Building Rating System™ as a nationally accepted benchmark for the design, construction, and operation of high performance green buildings. The LEED rating system includes *points* or credits for on-site stormwater management, including construction site pollution prevention, protecting/restoring habitat, maximizing open space, controlling stormwater quantity and quality, and using water-efficient landscaping. The council has recently developed a Neighborhood Development Rating System that integrates the principles of smart growth, urbanism, and green building into a national standard for neighborhood design. This rating system provides greater specificity related to water quality enhancement, offering up to five points for a comprehensive stormwater management plan that infiltrates, reuses, or evapotranspires runoff from impervious surfaces. Infill development has less stringent requirements than new development. For more information about the LEED rating system, see **http://www.usgbc.org**.

Revise corporate policies to promote LID

Developers can choose to implement LID and other environmentally friendly business practices across the board by adopting a corporate policy to require site analyses for all development projects in order to identify opportunities for greening developments. Because consumers are becoming more aware of the effects of development on the environment, developers who regularly incorporate environmentally sensitive features into their projects can market their properties as environmentally friendly to appeal to this increased level of awareness.

LEED for Neighborhood Development: Examples of Pilot Projects in New England

Connecticut

- Metro Green, Stamford
- Gilbert and Bennett Wire Mill, Redding
- Storrs Center, Mansfield

New Hampshire

- Evans Flats Mixed Use Development, Peterborough

Massachusetts

- Southfield, South Weymouth
- Westwood Station, Westwood
- Waterfront Square, Revere Beach
- Jackson Square, Roxbury

Rhode Island

- American Locomotive Works, Providence

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Additional Resources

Fact Sheets

This fact sheet is one of a series of four prepared by EPA Region 1. The others are listed below and are available on the EPA Region 1 website. **http://www.epa.gov/region1/npdes/stormwater**

- *Managing Stormwater with Low-Impact Development Practices: Addressing Barriers to LID*
- *Funding Stormwater Programs*
- *Restoring Impaired Waters: Total Maximum Daily Loads (TMDLs) and Municipal Stormwater Programs*

Green Infrastructure Approaches to Managing Wet Weather with Clean Water State Revolving Funds
http://www.epa.gov/OW-OWM.html/cwfinance/cwsrf/green_if.pdf

Incorporating Green Infrastructure Concepts into Total Maximum Daily Loads (TMDLs)
http://www.epa.gov/owow/tmdl/stormwater/pdf/tmdl_lid_final.pdf

Stormwater Management on Compacted, Contaminated Soils in Dense Urban Areas: Case Studies and Design Principles
http://www.epa.gov/brownfields/publications/swdp0408.pdf; and **http://www.epa.gov/brownfields/publications/swcs0408.pdf**
Set of four page publications produced by the EPA Brownfields program in cooperation with the Low Impact Development Center. Discusses opportunities, constraints and measures for implementing green infrastructure for stormwater management on Brownfield sites.

Manuals and Reports

Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices
http://www.epa.gov/owow/nps/lid/costs07
Information on the costs and benefits of using Low Impact Development (LID) strategies and practices to help protect and restore water quality.

EPA Green Infrastructure Municipal Handbook documents Four Handbooks: *Funding*; *Retrofit Policies*; *Green Streets*; *Rainwater Harvesting Policies*
http://cfpub.epa.gov/npdes/greeninfrastructure/munichandbook.cfm

Low-Impact Development Hydrologic Analysis
http://www.epa.gov/owow/nps/lid_hydr.pdf
Prepared by the Prince George's County Maryland Department of Environmental Resources Programs and Planning Division, with assistance from EPA.

Stormwater Best Management Practices - National Menu Stormwater Best Management Practices
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm
LID design strategies and fact sheets for meeting Phase II Stormwater requirements for Post-Construction Stormwater Management in new development and redevelopment.

Urban Stormwater Best Management Practices Performance Tool
http://cfpub.epa.gov/npdes/stormwater/urbanbmp/bmpeffectiveness.cfm
Provides easy access to approximately 220 studies assessing the performance of over 275 BMPs.

Using Smart Growth Techniques as Stormwater Best Management Practices (EPA), 2005
http://www.epa.gov/smartgrowth/pdf/sg_stormwater_BMP.pdf
Guidance to help communities (i.e. NPDES Phase II communities) develop comprehensive stormwater and planning documents, outreach programs and compliance tracking. Offers innovative measures for improving stormwater management through redevelopment, infill, urban parks and green building techniques.

Green Parking Lot Resource Guide
http://www.epa.gov/watertrain/smartgrowth/resources/resident.htm

Guidebook of Financial Tools: Paying for Sustainable Environmental Systems
http://www.epa.gov/efinpage/publications/GFT2008.pdf A reference document for officials with environmental responsibilities designed to assist with finding the means of financing environmental protection initiatives. Contains over 300 financial tools that can be used to pay for environmental systems.

Stormwater TMDL Implementation Support Manual
http://www.epa.gov/ne/eco/tmdl/assets/pdfs/Stormwater-TMDL-Implementation-Support-Manual.pdf

Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows
http://www.nrdc.org/water/pollution/rooftops/rooftops.pdf
Provides policy guidance for decision-makers and includes nine case studies of cities that employed green techniques successfully.

LID Guidance Manual for Maine Communities: Approaches for implementation of Low Impact Development practices at the local level, State Planning Office, 2007.
http://www.maine.gov/spo/landuse/docs/publications.htm
The purpose of this manual is to guide municipalities that review development of subdivisions and small commercial projects, and issue building permits, to help municipalities implement LID practices on small, locally permitted development projects.

Innovative Land Use Planning Techniques: A Handbook for Sustainable Development, New Hampshire Department of Environmental Services (DES). Includes 22 model bylaws.
http://des.nh.gov/organization/divisions/water/wmb/repp/innovative_land_use.htm

Vermont Rain Garden Manual
www.uvm.edu/~seagrant/communications/filelibrary.html

Websites

EPA New England's Stormwater website
http://www.epa.gov/region1/topics/water/stormwater.html

EPA Headquarter's TMDL and Stormwater website
http://www.epa.gov/owow/tmdl/stormwater
This web page contains resources for developing stormwater source TMDL's and implementing them in NPDES permits, particularly the "TMDL's to Stormwater Permits Draft Handbook."

EPA Green Infrastructure
http://cfpub1.epa.gov/npdes/home.cfm?program_id=298

EPA National LID
http://www.epa.gov/owow/nps/lid
A compilation of a number of resources, with links to Web sites, a literature review, fact sheets, and technical guidance.

EPA Nonpoint Source Outreach Toolbox
http://www.epa.gov/nps/toolbox
Web-based resources to assist communities with watershed education and outreach activities. Includes a searchable catalog of print, radio, and TV ads and outreach materials and resources on LID techniques.

Low Impact Development Center
http://www.lowimpactdevelopment.org
A nonprofit organization whose goal is to promote water resource and environmental protection through proper site design techniques that replicate preexisting hydrologic site conditions. The Web site contains a variety of technical resources and case studies exemplifying LID techniques.

National LID Clearinghouse
http://www.lid-stormwater.net/clearinghouse
Tools and techniques for meeting regulatory and receiving water protection program goals for urban retrofits, re-development projects, and new development sites.

Center for Watershed Protection
http://www.cwp.org
A nonprofit organization that provides technical tools for protecting water resources to local governments, activists, and watershed organizations. The center has developed a number of excellent publications pertaining to site design and watershed protection.

Green Values Stormwater Toolbox
http://greenvalues.cnt.org
This site by the Center for Neighborhood Technology contains an overview and definition of green infrastructure practices and hosts the Green Values Stormwater Calculator that allows users to select green interventions and enter site characteristics, returning hydrologic and financial outcomes for each scenario. It also includes a pocket guide called Water: From Trouble to Treasure, A Pocket Guide to Green Solutions.

Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) Smart Growth/Smart Energy Tool kit. Low Impact Development concepts, model bylaw, case studies, presentation, brochure, and links.
http://www.mass.gov/envir/smart_growth_toolkit/pages/mod-lid.html

University of New Hampshire Stormwater Center
http://www.unh.edu/erg/cstev/index.htm
The Center serves as technical resource for stormwater practitioners by studying a range of issues for specific stormwater management strategies including design, water quality and quantity, cost, maintenance, and operations. The field research facility serves as a site for testing stormwater treatment processes, and for providing technology demonstrations and workshops.

Rhode Island Stormwater Low Impact Development (LID) Inventory
http://www.uri.edu/ce/wq/RESOURCES/STORMWATER/LID_tour.htm.
Shows LID sites from the inventory by clicking on the interactive map or selecting sites based on LID treatment practice. In the future, you will be able to find companies that design and install these LID practices.

The Massachusetts LID Toolkit, Metropolitan Area Planning Council
http://www.mapc.org/lid.html
Includes fact sheets on Low Impact Site Design, roadways and parking areas, permeable paving, bioretention, vegetated swales, filter strips, infiltration trenches and dry wells, cisterns and rain barrels, and green roofs.

New England Environmental Finance Center
http://efc.muskie.usm.maine.edu/pages/tools.htm
A U.S. EPA and Muskie School project to research, publish, and extend creative approaches to environmental protection and management. Provides a Directory of Watershed Resources, which is a searchable database of funding sources.

Innovative Stormwater Technologies Clearinghouse
http://www.mastep.net/
The Massachusetts Stormwater Technology Evaluation Project (MASTEP) has created this web site to host a source of verified technical information on stormwater Best Management Practices (BMPs) to provide information on innovative technologies to BMP users.

Innovative Stormwater Treatment Technologies Best Management Practices Manual-May, 2002, New Hampshire Department of Environmental Services (DES)
http://des.nh.gov/organization/divisions/water/wmb/was/manual.htm
Provides innovative stormwater treatment technology information for developed areas within New Hampshire, with detailed product information including function, installation, operation and maintenance, and relative cost, this manual also offers decision-making criteria to help in determining the most efficient Best Management Practice (BMP) system for specific site conditions

NEMO (Nonpoint Education for Municipal Officials) program provides information, tools/resources, education and assistance to local land use boards and commissions on how to accommodate growth while protecting natural resources and community character.

Connecticut NEMO (Non-Point Education for Municipal Officials
University of Connecticut Cooperative Extension-
http://nemo.uconn.edu/
Includes: Center for Land Use Education and Research-Clear-
http://clear.uconn.edu/ and LID inventory
http://nemonet.uconn.edu/hub/initiatives.htm

New Hampshire-UNH Stormwater center
http://www.erg.unh.edu/stormwater/index.asp

Natural Resources Outreach Coalition (NROC)
http://extension.unh.edu/CommDev/NROC/CANROC.cfm

Rhode Island NEMO program
http://www.uri.edu/ce/wq/NEMO/index.htm

Maine NEMO Program
http://mainenemo.org/

Operates under the auspices of the Partnership for Environment Technology Education (PETE)

Vermont NEMO Program
http://nemonet.uconn.edu/programs/about_members/vt/vermont.htm

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NOTE: This document is not law or regulation; it provides recommendations and explanations that MS4s may consider in determining how to comply with requirements of the Clean Water Act and NPDES permit requirements.

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