# Chapter 3
# Low Impact Development

**Benefits of LID:**

- Preserves the hydrologic cycle
- Protects streamflows
- Protects drinking water quantity
- Keeps drinking water pure
- Fish and wildlife benefits
- Promotes water conservation
- Reduces flooding and property damage from peak flows
- Saves communities money
- More attractive and diverse than traditional developments

Low Impact Development, known as LID, is the process of developing land while minimizing impacts on water resources and infrastructure. It is a site-based process, unlike Smart Growth and New Urbanism, which are community or regionally based and directed at minimizing sprawl and making developments more people-friendly. LID is geared to protecting the hydrologic cycle that is normally badly damaged during development. The benefits of LID are shown at left.

Photo courtesy of Maplewood Public Works Department.

*This raingarden is located in Minnesota, where some communities have reduced the total stormwater load on their water resources by building connected raingardens at each home along the street. Where homeowners do not want a raingarden, they instead get a shallow grass swale that can be mowed. These projects have reduced flooding problems and are attractive. Maplewood, Minnesota, where this garden is located, has developed seven different designs with different looks and maintenance requirements.*

LID can be applied to existing, as well as new developments. How? By retrofitting existing paved or otherwise impervious sites with infiltration or storage units. Dispersed units are better than single end-of-pipe treatment devices since they come closer to replicating the natural hydrology of the site. Reestablishing the hydrologic connection has many benefits, but of course it's more expensive than doing it right in the first place. Still, the benefits outweigh the costs in many cases, particularly since the costs can include repeated flooding events and groundwater decline.

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## 3.1 Problems LID Addresses

Many people are surprised to find out that today's traditional developments are causing so much harm to the environment. It wasn't intentional, but somewhere along the line, it became cheaper and easier to clear cut large swaths of land for new developments. Then topsoil began to be sold off, and just a little loam was left for the lawns. The extensive clearing of the lots also left little shade, so the poor soils and grass bake in the sun and create high water demand. Meanwhile, the runoff calculations, if there even were any, designed to protect communities from increased runoff never got significantly updated to reflect the new, more impervious lawns and wider streets, so runoff from these new developments may be significantly more than planned. LID addresses many of these issues.

Photo courtesy of the National Oceanic and Atmospheric Administration (NOAA).

*The photo above shows a flooded road — could be anywhere. Increased flooding is one of the most obvious problems caused by today's development practices. The water lost downstream should have recharged an aquifer that may now begin to decline—a less obvious problem.*

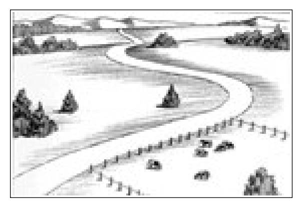
### Why Developments Can Cause Environmental Harm and Flooding

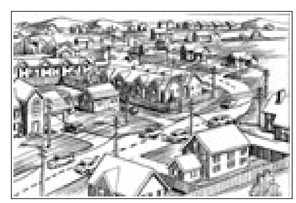
- Farmland converted to suburbia or commercial and industrial development has more runoff. Some big box retailers, for example, have 30 acres or more of parking area
- Compacted lawns and playing fields have more runoff than the undisturbed woods
- Erosion during construction continues to be a major problem in many areas
- Undersized stormwater treatment units in older developments may demand high maintenance, and when they don't get maintained, they fail, leaving the site worse off than without them
- Peak flow controls focus on larger storms, passing smaller, more frequent storms through, which damage stream channels.

### Results of Traditional Development

Low Impact Development (LID) focuses on replicating the natural hydrologic cycle as much as possible. The results of today's high impact development is damage to the hydrologic cycle, which can result in:

- Lower low flows in streams;
- Higher peak flows and flooding;
- Less clean recharge and dropping groundwater levels;
- Pollution of drinking water;
- Loss of wildlife habitat and damage to fisheries;





Drawing courtesy of NASA.

*As farmlands are converted to residential areas in the developed parts of Maine, runoff volumes are multiplied.*

**New homes in suburban areas, with their massive lawns and sprinkler systems have a high water demand and high runoff.**

## 3.2 LID Design Practices

There are several land planning and design practices that can be used to achieve LID. These focus on developing land in a manner that helps mitigate potential environmental impacts. Ideally, these planning and design practices should be incorporated at the design phase to be most cost-effective, but can also be used to redevelop sites. Specific technologies that can be used to implement these practices are discussed later in this section.

### LID Principals

- **Minimize Impervious Areas**
- **Limit Areas of Clearing and Grading**
- **Minimize Directly Connected Impervious Areas**
- **Manage Stormwater at its Source**

### Minimize Impervious Areas

Impervious areas increase the amount of runoff that leaves a site, as undeveloped lands that allow for natural infiltration of rain water are replaced with impervious surfaces such as buildings, sidewalks and pavement. Less impervious area equals less runoff from the site. Means to minimize impervious areas include:

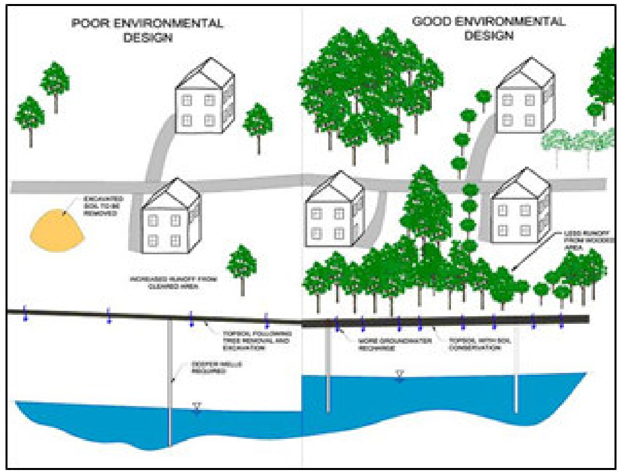
- Minimize building setbacks to reduce driveway lengths
- Use vertical construction over horizontal
- Incorporate smart growth concepts such as clustering
- Reduce unnecessary parking areas and aisle widths
- Design pervious overflow parking areas and emergency access ways
- Design narrower streets and driveways wherever possible• Design narrower streets and driveways wherever possible
- Keep sidewalks to one side of primary roads, preferably separated from the road by a vegetated or pervious buffer

Photo courtesy of Center for Watershed Protection.

*This photo shows pervious pavement on an overflow parking lot.*

## Limit Areas of Clearing and Grading

One way to preserve pre-development conditions is to minimize land disturbance activities to the extent possible. Development should be located in areas that are less sensitive to disturbance (i.e., developing on clay soils will have less impact than developing on sandy soils). At a minimum, buffers to sensitive areas (i.e., waterbodies, floodplains, wetlands and steep slopes) should be left undisturbed. The limits can be applied through use of Landscape Design Guidelines or Standards referenced in the subdivision regulations or stormwater bylaws. The limits also need clear marking on development plans and in the field.



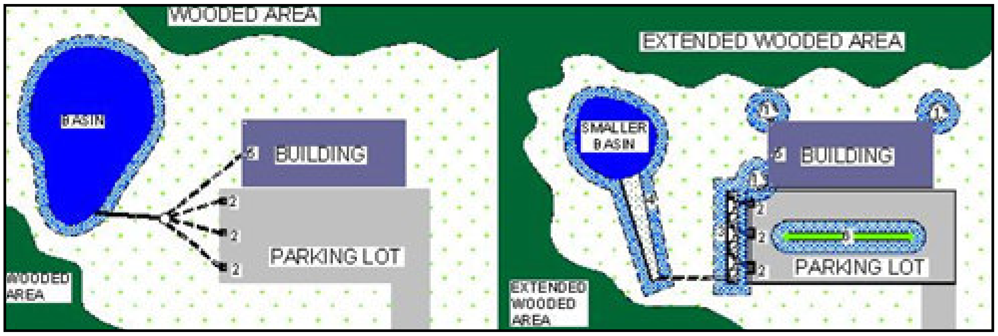

*The drawing above shows how a site that is extensively cleared might affect groundwater recharge and aesthetics of the overall development. Leaving mature trees has also been shown to increase the value of the homes even though it may be resisted by onsite contractors, who may see it as a major inconvenience. Despite the inconvenience to some, it is a major benefit to the future homeowners, the community and the environment.*

*Common practice in urban areas is to deal with erosion problems by paving them over to protect the soil. This compounds the problem, and can be corrected using LID methods that disconnect roofs and other impervious areas from the street by diverting the roof leader to a dry well or the like away from the building.*

## Minimize Directly Connected Impervious Areas

Some impervious area is unavoidable, but the impervious areas can be separated from the discharge point by using low impact techniques such as dry wells, raingardens, level spreaders and others. These can be used to cut down on the Directly Connected Impervious Area or DCIA as coined by EPA. For example:

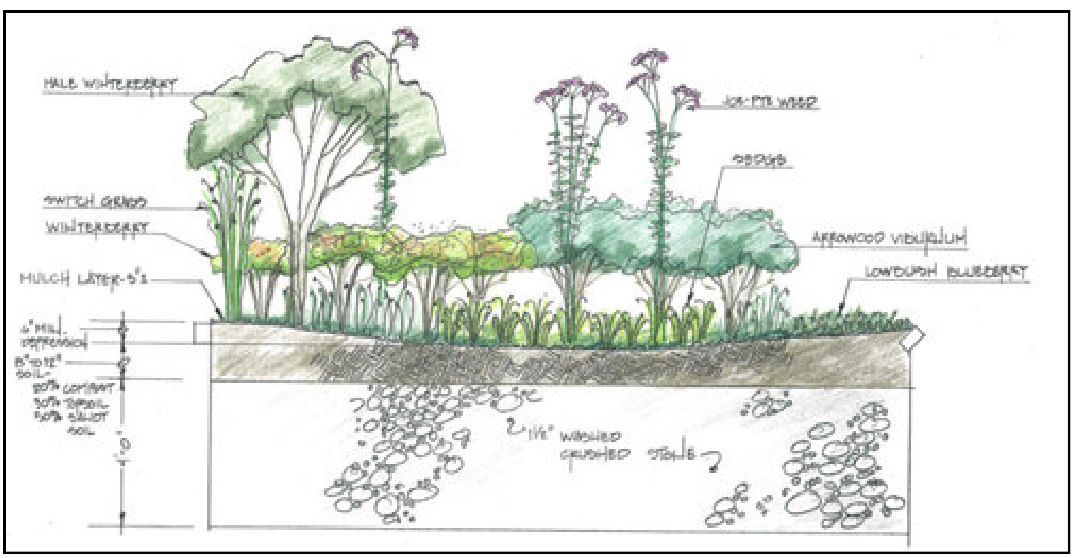
- Drain impervious areas as sheet flow to natural systems such as vegetated buffers.
- Break up flow directions from large paved surfaces to allow for on-site treatment of smaller flows.
- Avoid situations like that shown in the opposite photograph, where roof leaders are directly connected to streets by paving due to erosion problems created by the velocity of the roof leader discharge. Instead, collect roof leader water in dry wells or raingardens set 8 feet or more from the building.




*The drawing above shows how a typical commercial site is usually drained (left), with some LID improvements to the same site shown on the right. On the right side, there is a) less clearing; b) the roof leaders are handled in dry wells; c) the emergency access way and some overflow parking are in pervious materials; and d) an infiltration divider is used in the parking lot to collect some of the drainage in a vegetated island. This reduces the size of the basin, but more importantly, small storms are almost completely collected and treated, resulting in a major reduction in the overall water quantity leaving the site via runoff and an accompanying improvement in water quality leaving the site.*

## Manage Stormwater at the Source

Although end-of-pipe treatment structures can be used to control peak-flows, they cannot mimic natural hydrologic conditions of a site. To most closely mimic the natural functions of a site, stormwater must be handled as close as possible to the source. This is best accomplished with numerous smaller systems that fit in with the site's natural topography and drainage conditions. Breaking up the drainage in this way results in much greater overall control of the runoff during smaller storms and for the "first flush" of each storm when most of the pollution occurs.




*This commercial raingarden or bioretention island is a good way to keep stormwater at the source of its generation in a parking lot. It has heat and salt tolerant species and is low maintenance as well as beautiful. Many versions are also available for residential use, as described further in Chapter 6. LID Techniques.*

## 3.3 Soil Considerations

### Minimize Compaction

Soils play a key part in LID. It is important to minimize soil disturbance and compaction from heavy equipment during development to maintain pre-developed conditions. Compaction of soils reduces the natural infiltrating ability of the soils. It is also important to avoid steep slope development, as these can quickly erode and runoff into nearby waterways degrading water quality and wildlife habitat.

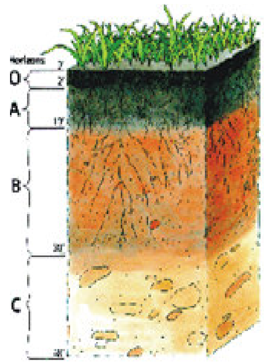
The site soils also help direct development activities. If possible, impervious surfaces and development disturbances should be directed towards the more impermeable soils of a site, leaving the pervious soils to continue infiltrating runoff. This will cost-effectively minimize the overall impacts to the hydrologic cycle reducing the cost of stormwater best management practices (BMPs). The types of soils available will also help with the selection, sizing and placing of LID techniques.

### Increase Organic Content of Soils

When constructing many of the LID techniques, it is important to provide a sufficient soil and organic layer to optimize pollutant removal. The soil bed should consist of at least 20-30% organic material and 30% planting or top soils. The organic materials should consist of a mulch layer over compost type materials such as composted leaves.

This highly organic layer traps contaminants, absorbs more rainfall or runoff and provides a medium for biological activity that helps break down pollutants. Planting soil provides a healthy growing medium for vegetation by encouraging strong root growth. In addition, microbes found in healthy soils transform nutrients into forms that are essential for plant growth. Compost is a particularly attractive amendment because it is readily available, has trace minerals and micronutrients and recycles a waste product.

Most gardeners swear by compost as the best soil additive for healthy plant growth, minimizing disease and insect problems and retaining soil moisture. This goes even further in LID in that compost absorbs more rainfall, acting as a sponge, and keeping rain where it fell rather than running off as stormwater.




Drawing courtesy of Natural Resource Conservation Service (NRCS)

*Typical soil profile.*

*LID calls for soils with a high organic content to absorb and cleanse rain and stormwater. Today's developments often lack adequate topsoil as it may be sold off during construction. This leaves little organic topsoil to support the growth of lawns and othervegetation, which may also increase irrigation use. Adding organic matter in the form of compost is relatively easy and effective.*

Compost or other organic amendments can be added at the site preparation level, typically by the truckload. It is also available for little or no cost from many community leaf compost programs.

For raingardens and bioretention areas, compost addition is also valuable in absorbing and retaining moisture for plant life, filtering pollutants and providing an active layer for microorganisms to reside and reproduce. A healthy microorganism population is key to the decomposition of many pollutants, whether in the home raingarden or in a parking lot.

### Avoid Pesticides

Healthy soil is alive with microorganisms that decompose and inactivate pollutants, but some of these microorganisms may be killed by the use of pesticides or excessive chemical fertilizers. Pesticides include herbicides that kill undesirable vegetation and insecticides that kill nuisance or pest insects and other similar organisms such as spiders. Although the soil microorganisms are not typically the target of these chemicals, many of them may fall victim to the use of pesticides. A loss of diversity of microorganisms in the soil and on the surface is the result, and the resulting soil can be "dead", with less pollutant removal capability. Additionally, insect species that prey on pests are also killed by pesticides. Since the predatory species tend to have slower reproduction than the pest species, a natural defense against insect pests may be lost.

# 3.4 LID Techniques

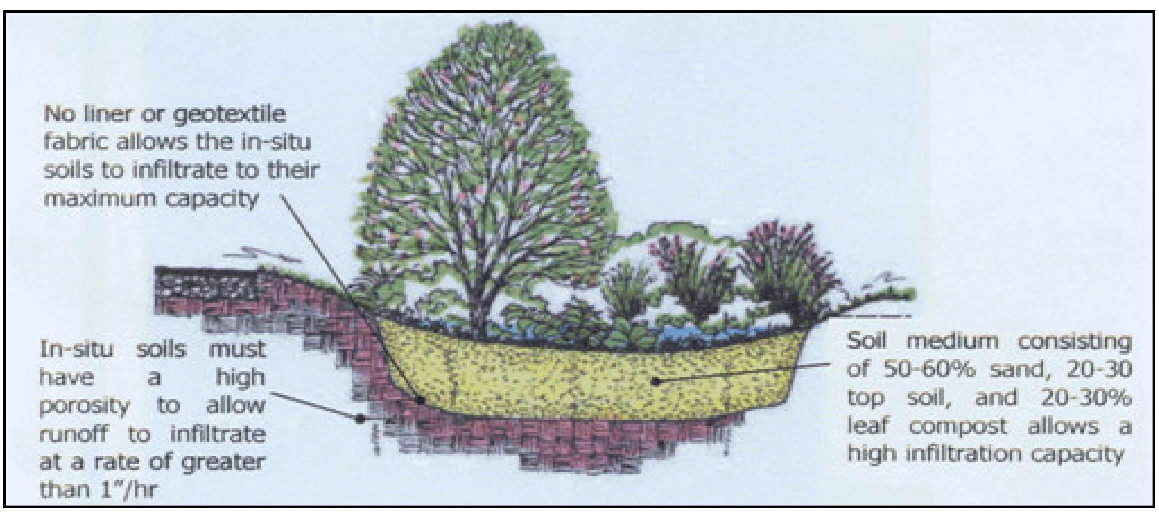
LID is a natural evolution of stormwater management, and as a result, some of the techniques are not new at all but have been used for years. For example, drywells for roof leaders are hardly new technology. Other techniques are relatively new, but no matter the age of the technique, all LID methods have one characteristics in common: keeping the rainfall or runoff as close to its point of generation as possible. The LID approach emphasizes multiple, dispersed on-site systems that mimic natural conditions as closely as possible. These are attractive, cost-effective solutions designed to retain and treat stormwater runoff at the source. Following are several LID techniques that can be used on a site:

Photo courtesy of Maplewood Public Works Department

*A raingarden in Maplewood Minnesota blends in with the neighborhood, infiltrating rain while providing an attractive garden. This one is one of seven styles, called "Sunny Border Garden" and features hardy low maintenance species.*

## Bioretention Areas or Raingardens

A bioretention area is designed to collect, infiltrate, and treat moderate amounts of stormwater runoff using conditioned planting soil beds, gravel beds and vegetation within a shallow depression. These are typically placed close to runoff sources, such as parking lot islands or along roadside edges. The vegetation generally consists of native or naturalized species to the area and are capable of handling periodic wet conditions such as the ponding that often occurs during storm events. The plants, soils, and organic matter such as compost and a mulch layer all play an important role in treating runoff by naturally breaking down pollutants. The underlying gravel beds serve to temporarily store and infiltrate treated stormwater after percolating through the organic soil layer. Maine soils have relatively poor infiltration capacity, and these systems may need to be underdrained so their storage capacity is available for the next storm. Maintenance involves annual sediment and debris removal, mulch replacement and trimming and weeding as necessary. Raingardens are a more popular name for a bioretention area and have been used near streets and driveways in some communities. Appendix I-A provides examples of various raingarden layouts.




Drawing courtesy of Department of Environmental Resources, Prince George's County, Maryland

## Filter Strips

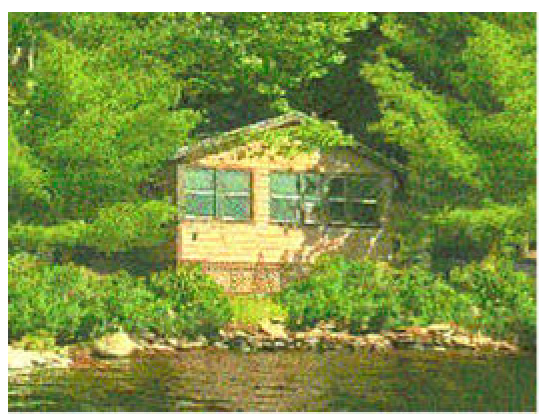
Filter strips are shallow pitched vegetated areas placed between developed areas, such as parking lots and road edges, and downstream waterways. Filter strips are designed to disperse stormwater runoff velocities and capture moderate sediment loads by eliminating any channeled or piped outlets. Vegetation used in these areas is often grasses and low-lying groundcovers that allow recreational activities and pedestrian access between developed areas. Filter strips are often used to augment other stormwater treatment practices. The filter strip shown at right likely has limited usefulness in that it may be relatively compacted, but it still probably provides better infiltration than would a paved or otherwise completely impervious strip between the lanes.

Photo courtesy of the Milwaukee River Basin Partnership

## Vegetated Buffers

Vegetated buffers are natural or planted vegetated areas between developed areas and waterways and other sensitive areas such as wetlands and vernal pools. Buffers serve to moderately infiltrate and disperse stormwater runoff. Native site-specific vegetation is used to duplicate natural site conditions if planting is necessary due to disturbances. Buffers serve as a crucial element in preventing runoff pollutants from entering into waterbodies. They should include several layers of vegetation as these multiple layers absorb more precipitation and provide better uptake of pollutants and water through the mixed root zones of trees, shrubs, possibly a herbaceous layer and groundcovers. The duff layer is also important. Duff consists of leaves, pine needles and other plant materials in various stages of decomposition. The duff layer acts as a sponge, absorbing water and filtering pollutants as well as providing habitat for microorganisms that help treat runoff. In manmade vegetated buffers, some type of mulch may be used for the duff layer until a natural one develops over time.

*The above camp on a lake in Maine has little buffer zone between the human activity and the water.*



*The retouched photo simulates a shrubby buffer that can help filter pollutants despite its small size.*

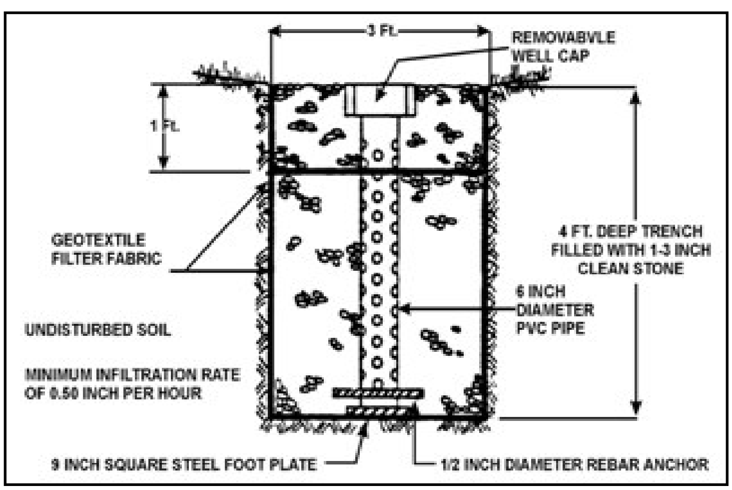
## Vegetated Wet or Dry Swales

Swales are shallow pitched elongated depressions seeded with grass or other suitable vegetation that are designed to transport and infiltrate moderate amounts of runoff, and capture sediment loads. A wet swale is often designed in areas with high water table levels and utilizes wet tolerant plants. Dry swales can be as simple as a grassed depression or planted with a diversity of native vegetation and underlined with a gravel bed to improve infiltration rates. An underdrain may also be provided in tighter soils, as in Maine, which will provide the absorption and pollutant removal benefits of the soil, while allowing the water to drain from the site. Swales are used along roadside edges and medians and in areas with site constraints.

*This dry swale is located in New Hampshire. It blends well with the landscaping and is low maintenance yet effective. It does have an overflow to the storm drain system that can be accessed once the water reaches more than halfway up the side slopes.*

## Infiltration Trenches

An infiltration trench is an in-ground usually crushed stone bed designed to capture and infiltrate stormwater in urban settings. All trenches should have some type of pretreatment to remove sediments from stormwater before it enters the trench, as they have been found to clog without this. Some types of appropriate pretreatment might include grass swales, deep sump catch basins, grassed areas after level spreaders, plunge pools or sediment forebays. Following the pre-sedimentation step, infiltration into the trench allows for the removal of most remaining pollutants. Collected stormwater may remain in the trench for several days depending on soil conditions.




*This cross section of a typical infiltration trench shows some of the basics of the design. In addition, pretreatment is needed and in Maine, the bottom of the stone should reach below the frost line to keep the trench working during the winter. This section is from U.S. EPA.*

## Porous Pavement

Porous or permeable pavements are designed to allow some amounts of rainfall to infiltrate through the road surface into the underlying gravel beds and soils. There are basically three types of porous pavement, including:

- **porous asphalt** resembles typical asphalt but is made with many void spaces throughout the surface material allowing water to pass through.

- **block pavers** are interlocking blocks of material resembling a grid that are usually made out of concrete allowing runoff to infiltrate through the exposed areas.

- **plastic grid pavers** generally come in a honeycomb pattern and the voids are filled with stone, or loamed and seeded. The grid provides strength to allow vehicles to park on it without compacting the soils in between.

All three types of pavements are susceptible to clogging in cold climates due to sanding applications although the block pavers have the best attributes in this regard and have been used in Canada. Both plastic grid pavers and porous asphalt can be problematic for plowing, as can block pavers if not bedded properly. All three of these types of porous pavement do hold promise for some applications, and testing is ongoing at several New England sites, including University of New Hampshire Cooperative Extension and the University of Rhode Island Cooperative Extension. The use of these pervious pavements is particularly suited to overflow parking, emergency access ways, unplowed lots and areas where pretreatment can be incorporated to remove sand. The use of any porous pavement requires approval by the Maine Department of Environmental Protection.

Courtesy of University of Connecticut, NEMO website

**Porous Asphalt**

Courtesy of University of Connecticut, NEMO website

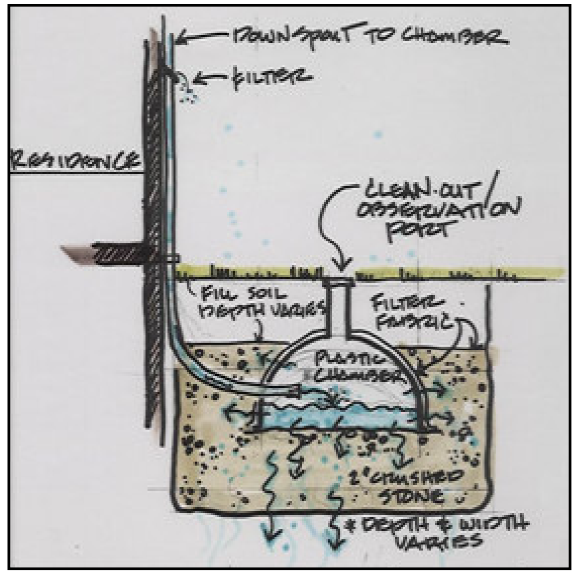
**Block Pavers**

Courtesy of University of Connecticut, NEMO website

**Plastic Grid Pavers**

## Dry Well

A dry well is an in-ground chamber filled with stone that is typically used to collect and infiltrate "clean" roof runoff. Roof runoff is usually free from clogging materials that shortens the life-cycle of this type of system. Roof leaders are generally diverted directly into the dry well. Rooftops,particularly in urban areas, contribute to the amount of impervious surfaces causing significant increase in runoff amounts. Diverting the rainfall into drywells diminishes the amount of runoff occurring from a site, minimizing downstream flooding conditions and allowing downstream BMPs to operate more effectively. As with other infiltration BMPs, dry wells require soils with a good infiltration rate and adequate separation from bedrock and groundwater.




*This is a typical dry well for a roof drain leader.*

## Rain Barrels & Cisterns

Rain barrels are simple collection devices, usually made out of plastic, that are designed to capture roof runoff. Like a dry well, roof leaders are diverted directly into the unit(s). Most barrel designs incorporate child resistant covers and mosquito screens. Rainwater is stored in a barrel or number of barrels for later reuse in the garden or the landscape. Weep holes or an intended leaky spigot are used to allow water to slowly seep into the ground and to ready the unit for the next storm. A cistern for LID usually refers to an underground irrigation storage unit that receives roof runoff, saving it for irrigation purposes.

*The above photo shows a rain barrel used to collect and store roof runoff for later use.*

## Level Spreader

A level spreader is designed to disperse stormwater runoff over a level, shallow pitched area to prevent erosion and capture sediment. Some designs incorporate an underlying gravel bed and water bar to improve runoff infiltration and storage. Vegetation is not usually part of the design as it can impair sediment cleanup operations. This low cost technique is often used on road edges and in median strips. Several level spreaders are sometimes used in parallel along sloping terrain. They often disperse runoff evenly to a vegetated area for further treatment. Volume III contains standards for designing level spreaders for buffers and for simple distribution of runoff to avoid gullying.

*The above photo shows a typical level spreader used to evenly disperse flows to a vegetated area.*

## Rooftop Greening

Rooftop greening is an innovative approach designed to temporarily store rainfall for vegetation on rooftops while simultaneously lowering the air temperature. It is particularly useful in urban areas that have become "heat sinks" with high summer temperatures creating uncomfortable, unhealthy microclimates because of vast amounts of imperviousness. Green roofs can improve local air quality and can absorb a significant volume of precipitation, depending on the depth of the soil profile provided. In new construction, green roof systems are generally installed on flat or shallow sloped roof tops that are engineered to withstand the added weight of vegetation and temporary water storage that occurs after a storm event. However, several vendors of green roofs also claim that they can be installed on existing buildings and they note the weight limits per square foot of saturated roof garden. Impervious layers are installed to prevent leaks. Benefits of the roofs include reducing solar damage of the roofing materials and providing additional greenspace, and of course reducing stormwater.

Photo courtesy of University of Connecticut, NEMO website.

*Fencing Academy of Philadelphia, Roofscapes, Inc.*

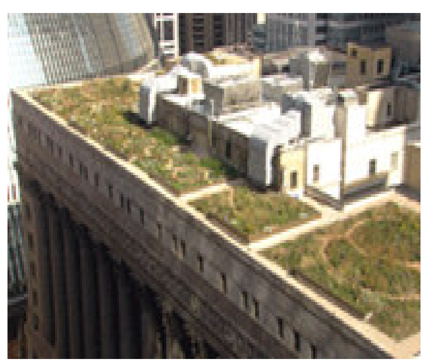


Photo courtesy of American Landscape Architects Association.

*Green roof on Chicago City Hall*

## More Information

More detailed information on each of these techniques, including plant selections and layouts is included in Volume III, Chapter ___.

## 3.5 Getting Started

LID is a great concept that can be implemented by communities as well as individuals. A collective effort is needed to preserve and protect streams, lakes and water supplies. Every project helps to make a difference. Many communities and individuals may wonder where to start. The following tips are provided to help with LID implementation.

*These children are learning about infiltration by building soil profiles and running liquids through them.*

### What Can Communities Do?

- Revise existing development controls through bylaws or subdivision and site plan review changes to promote retaining more total runoff on each site
- Minimize site disturbance through clustering and other methods and stake out clearing limits and stockpiles
- Review engineering calculations for overly optimistic pre and post runoff assumptions
- Adopt guidance and design criteria
- Set a good example on municipally owned properties
- Create a public education program and demonstration project

### What Can Individuals Do?

- Review property's drainage and find out where it goes during large rainstorms
- Disconnect roof leaders and direct connections to the street and reroute these to drywells or other infiltration
- Build a raingarden using one of the many guides available
- Cut down on lawn size and plant shrubs and trees instead—look for hardy, low maintenance varieties that don't need a lot of water or pampering once established
- Keep a raingauge and try to keep all of the rain that falls on the property!