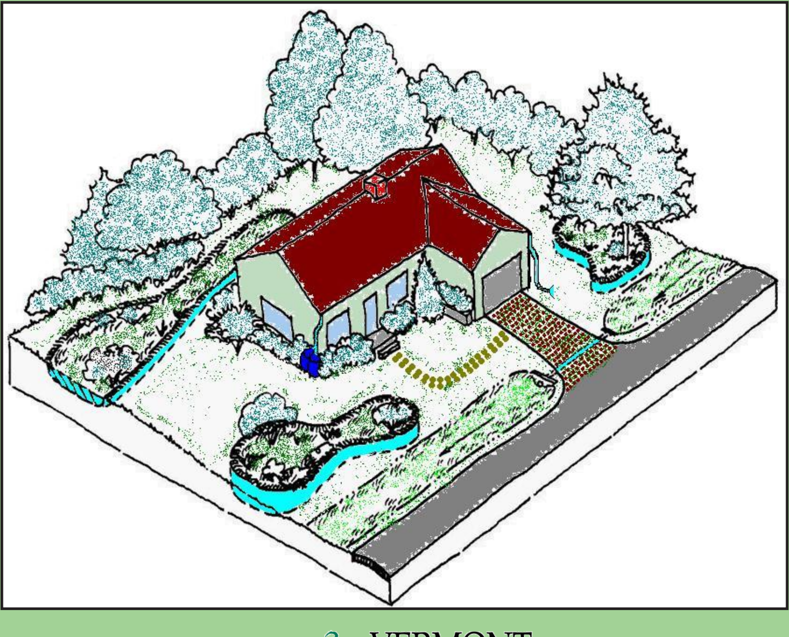
Vermont Low Impact Development Guide for

Residential and Small Sites



VERMONT
ENVIRONMENTAL CONSERVATION

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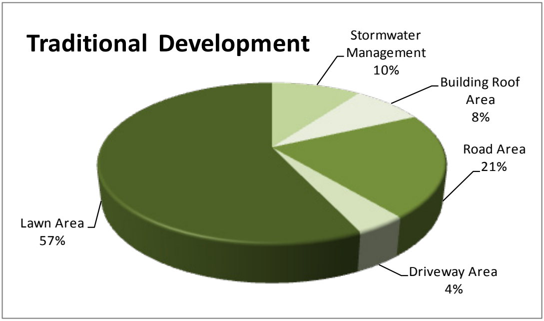
Introduction

What are BMPs and why are they important?

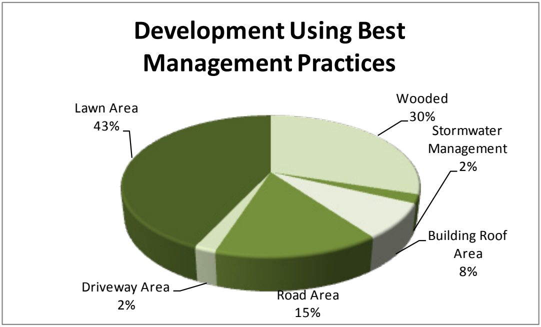
During a rainstorm, water hits the ground and either infiltrates the surface or flows overland. Flowing water can pick up and carry sediment and pollutants which can compromise water quality and habitat in surface waters. Excess runoff can also cause damage such as erosion on the land or in our streams. Excessive runoff conditions are intensified by impervious surfaces. Low Impact Development BMPs help to increase infiltration, filtration, and storage, while reducing pollutants. Small residential and commercial sites, new or existing, can use practices in this guide to reduce the amount of runoff from their site which, in turn, reduces stress on water bodies and treatment systems.

In this guide tools are grouped into three categories: maximizing sheet-flow and infiltration; preventing soil erosion; and preventing and eliminating delivery of pollutants to conveyances. These BMPs lessen the amount and negative effects of runoff, thereby protecting downstream lakes, streams, and rivers.

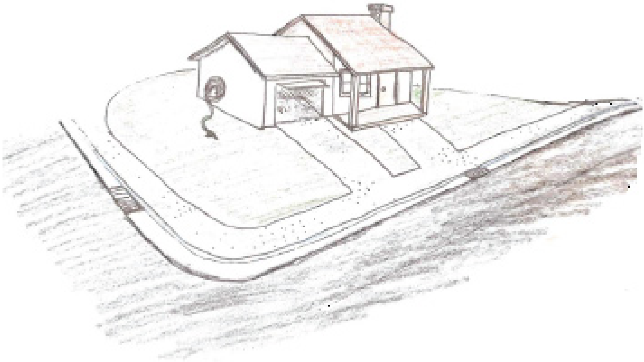
On the following page, two pie charts display the relative abundance of land cover, one for traditional development practices and the other for LID BMPs. Strictly comparing the impervious surfaces (driveway, road and roof surfaces) there is an 8% decrease using LID BMPs. Consider that most lawns are oversized and soak up less stormwater than woods - the LID lawn is 14% smaller and there is 30% wooded cover added. The final point is the difference in the need for stormwater management - a five-fold decrease from traditional development practices to the LID BMP practices. These charts don't quantitatively assess the amount of runoff being treated on site but when you take into account the decrease in site area dedicated to stormwater management and the cost savings, the LID benefits and reduced environmental impact becomes clear.



Versus

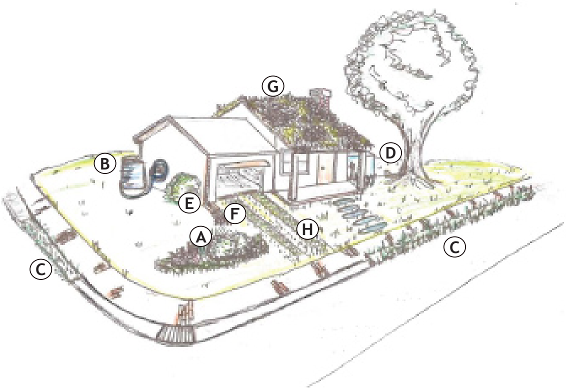


Traditional Small Lot Development Stormwater Practices



The above illustration portrays a conventional home or small site without LID BMPs. Conventional stormwater management focuses on quickly removing runoff from the site by collecting it via a network of gutters, catch basins and pipes. These collection systems most often discharge runoff directly to a river or lake without any treatment at all.

LID Stormwater Practices



The above illustration shows an example of a small site utilizing many different LID BMPs that are explained in further detail on the following pages.

- (A) Rain Garden
- (B) Double Rain Barrel
- (C) Vegetated Swale
- (D) Cistern
- (E) Roof Top Disconnection
- (F) Infiltration Trench
- (G) Green Roof
- (H) Pervious Pavement

It is not necessary to use every technique illustrated. Installing just one of the noted techniques will help reduce runoff and protect local water bodies.

LID Tools
I. Maximize Sheet Flow and Infiltration

LID BMPs in this chapter are designed to facilitate onsite runoff management through techniques that slow and disperse the energy in the flow of stormwater runoff allowing it to soak into pervious surfaces. Depending on the site specifications, incorporating one or more practices from this category can maximize the ability to manage runoff onsite, as opposed to directing it into ditches, pipes or other means of conveyance.


Infiltration Trench

Of important note before digging, check with **Dig Safe System, Inc. (888-DIG-SAFE)** to ensure the placement of LID BMPs does not interfere with buried utility lines.


Vegetated Swale

Source: http://youngsierrans.files.wordpress.com

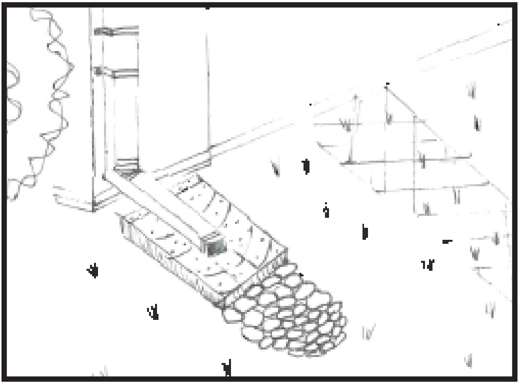
Above Ground Cistern

Roof Top Disconnection and Rain Garden

Photos supplied by and credited to: Linda Boudette Blasch of Better Backroads and Northern Vermont Resource Conservation & Development

Roof Top Downspout Disconnection

Disconnecting roof gutter downspouts from the sewer system, driveways or roads allows roof water to drain to lawns and gardens. It's a more natural way to manage roof runoff because it allows water to soak into the ground, plants and soils to filter pollutants.



Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	Medium
Commercial	Yes	Groundwater Recharge	High
Industrial	Yes	Peak Rate	Medium
Retrofit	Yes	**Stormwater Quality Functions**	
Road	N/A	TSS	Varies
		TP	Varies
Recreational	Yes	TN	Varies

Additional Considerations	
Cost	Low
Maintenance	Low
Winter Performance	Varies

Considerations
- Direct flows into stabilized vegetated areas
- Encourages sheet flow through vegetated areas
- Minimizes piped drainage systems
- Maximizes over-land flows

Benefits
- Reduces runoff volume and peak rate
- Increases water quality
- Easy installation and maintenance

Variations
- Rain barrel or cistern installation for reuse
- Directed to a bio-retention area

Limitations
- Requires area for infiltration

Roof Top Downspout Disconnection

Disconnecting your downspout from a sewer intake pipe (standpipe), road or driveway, and then redirecting the flow of water to a grassy area or garden is a simple way to keep runoff onsite and reduce runoff impacts to surface water resources.

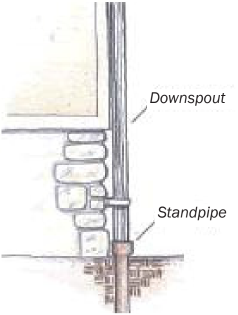
Do it yourself directions for completing a roof top downspout disconnection

Supplies

Hacksaw	Sheet metal screws
Drill	Downspout elbow
Tape measure	Downspout extension
Pliers	Standpipe cap
Splash block	Gravel

Note

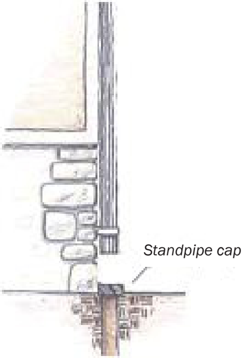
There are different types, lengths and sizes of standpipe caps, so be sure to take measurements before shopping. Capping the standpipe prevents water from going in and keeps pests (such as rodents) from entering/exiting the pipe.



Downspout connected to standpipe

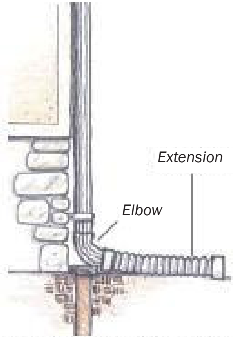
Instructions:

- Cut the existing downspout approximately 9 inches above the sewer standpipe with a hacksaw.



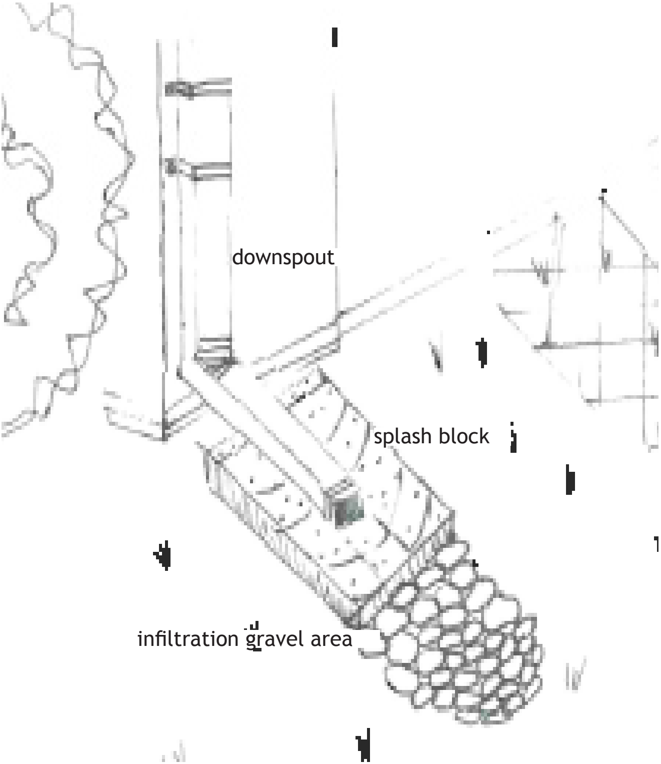
- Cap the sewer standpipe.
- Attach elbow, crimping the downspout with pliers to ensure a good fit.
- Connect elbow to downspout using sheet metal screws. It may be necessary to pre-drill holes.

- Attach the elbow to the extension, securing with sheet metal screws. Water should drain at least five feet away from the house, so direct the extension accordingly. A splash block will help direct water further away from the house.



Elbow and extension attached to downspout

• Placing gravel at the end of the splash block can help slow the velocity of the water, preventing localized erosion and allows additional time for it to infiltrate into the yard.



Rain Barrels

Rain barrels are designed to intercept and store runoff from rooftops to allow for reuse, typically for irrigation. The Department of Environmental Conservation recommends double rain barrels or cistern use, as these are able to store a larger amount of water, increasing their value both as a water quality practice and at times when greater storage is necessary and water is less readily available.

Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	High
Commercial	Yes	Groundwater Recharge	Medium
Industrial	Yes	Peak Rate	Low
Retrofit	Yes	**Stormwater Quality Functions**	
Road	No	TSS	Medium
		TP	Medium
Recreational	Yes	TN	Medium

Additional Considerations	
Cost	Low
Maintenance	Medium
Winter Performance	Low

Considerations
- Small storm events are captured in most structures
- Design overflow for large events
- Drain between storm events
- Locate to provide gravity flow to eliminate pump needs

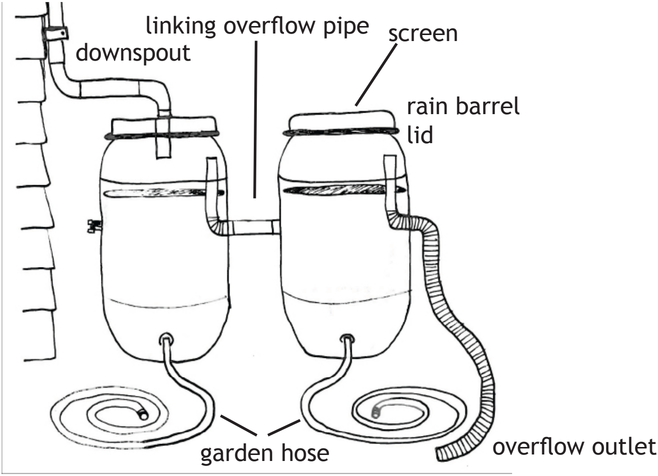
Benefits
- Reduces need for potable water for outside watering (check for metals content level in water before watering produce for consumption)
- Provides supplemental non-potable water supply
- Wide applicability

Variations
- Cisterns
- Sub-surface storage

Limitations
- Can only manage small storm events

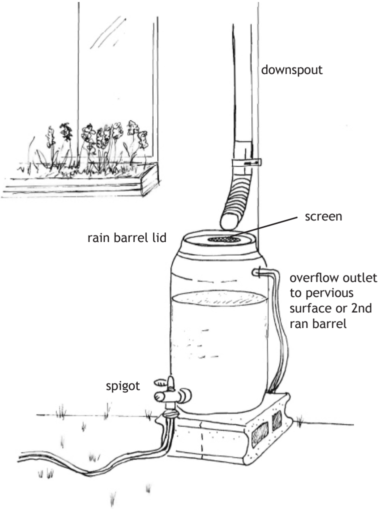
Design Guidance for Double Rain Barrels

- Rain barrels should be installed near collection point on the building.
- Water should be used or drained between storm events.



- Downspouts should be piped directly into the rain barrel through a screen to eliminate debris and prevent insect access.
- The overflow outlet should be three inches below the top of the rain barrel and should connect to the next barrel. The overflow from the second barrel should be directed to an area to infiltrate.

• Drain rock or a splash block should be positioned at the overflow outlet, similar to a downspout disconnection



Standard barrel size = 24”wide X 36” tall and holds 50 gallons

<u>Maintenance</u>

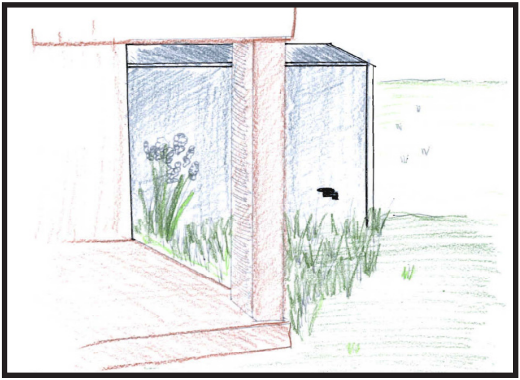
• Drain before a major storm.
• Drain before winter.
• Clean roof surfaces and gutters of animal droppings and leaves.

Photos supplied by and credited to Ashley Lidman of Winooski Natural Resources Conservation District

• Check the rain barrel(s) at least once a year for possible leaks.
• Remove deposits from the bottom of the tank as necessary.

Cisterns

A cistern is a container or tank that has greater storage capacity than a rain barrel. Cisterns may be comprised of fiberglass, brick, concrete, plastic or wood and can be located above or below ground. A cistern can range in size from 200 gallons to upwards of 10,000 gallons. Typically cisterns are used to supplement gray water and irrigation needs.



Applications		Stormwater Quantity Functions	
Residential	Limited	Volume	High
Commercial	Yes	Groundwater Recharge	Medium
Industrial	Yes	Peak Rate	Low
Retrofit	Yes	**Stormwater Quality Functions**	
Road	No	TSS	Medium
		TP	Medium
Recreational	Yes	TN	Medium

Additional Considerations	
Cost	Medium
Maintenance	Medium
Winter Performance	Varies

Conserations
- Design overflow for large events
- Drain between storm events
- Locate to allow gravity flow to eliminate pump needs

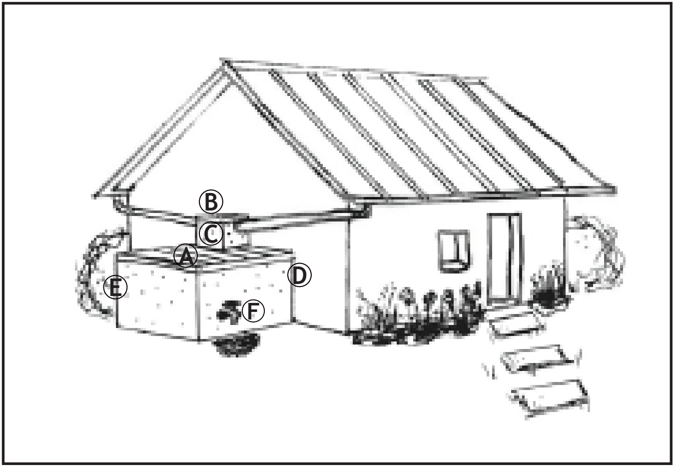
Benefits
- Reduces need for potable water for outside watering
- Provides supplemental non-potable water supply
- Wide applicability

Variations
- Rain barrels
- Sub-surface storage
- Groundwater infiltration system

Limitations
- May need to be sized properly by an engineer or designer to handle larger storm events

There are three main types of cisterns: above ground, partially buried, and underground. Generally, all types include the following components:

Ⓐ secure and solid cover
Ⓑ screen at entrance to prevent insects from entering
Ⓒ coarse inlet filter with clean out valve
Ⓓ overflow pipe
Ⓔ manhole, sump, and drain to facilitate cleaning
Ⓕ water use spigot



Other features may include:
- Water level indicator
- Sediment trap, tipping bucket or other “foul flush” mechanisms
- Tank lock
- Pump, if below ground

Design Guidance for Cisterns

Cistern volume is a function of roof area, precipitation required to fill the cistern, and anticipated use. In order to calculate the amount of runoff to be stored in a cistern and provide overflow for exceptional amounts of rainfall, use the following equation:

V = (A2) (R) (U) (7.5 gallons/cubic feet)

V = volume of cistern (gallons)
A2 = surface area of roof (square feet)
R= rainfall (feet)
U = anticipated use (gallons)
7.5 = conversion factor (gallons/cubic foot)

http://www.flickr.com/photos/rainwater-collection/

Similarly, the table below shows an estimate for water collected per 1,000 square feet of roof.

Estimated quantity of runoff per 1,000 square foot of roof	
Rainfall in inches	Water collected in gallons
0.10	56
0.25	140
0.50	281
0.75	422
1.0	563
2.0	1,125
3.0	1,688
4.0	2,250

Alternative design considerations

• Concrete in-ground, cast-in-place cistern walls are recommended to be at least 6 inches thick.
• Place above ground cisterns in open spaces to aid in maintenance and cleaning. Specifically, access to each cistern compartment should be provided through a removable surface plate.
• Site cisterns in close proximity to buildings for roof runoff collection or near the area where the gathered water will be used most.
• Size, material, holding capacity, and flow for above ground cisterns should be assessed by a site designer.

Above ground cisterns can be used with an irrigation system for outside use and non-potable functions. All water should be filtered prior to use to remove any solids.

Maintenance

• Clean roof surfaces and gutters of animal droppings and leaves.
• Check the cistern at least once a year for possible leaks.
• Remove deposits from the bottom of the tank as necessary.

Photos supplied by: Emma Melvin with credit to UVM Lake Champlain Sea Grant

Rain Gardens

A rain garden is a depressed area with native plantings used to capture, slow, infiltrate, and treat runoff from impervious surfaces, including rooftops, streets, parking lots and driveways.

Key Design Features
- Flexible in size & infiltration
- Native plants

Benefits
- Volume control and groundwater recharge & filtration
- Versatile with broad applicability
- Improved aesthetics and habitat

Variations
- Subsurface storage and infiltration bed
- Use of under drain

Limitations
- Higher maintenance until vegetation is established
- Initial plant selection and growth requires care
- May not work if soils drain poorly

Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	Med/High
Commercial	Yes	Groundwater Recharge	Med/High
Industrial	Yes	Peak Rate	Medium
Retrofit	Yes	**Stormwater Quality Functions**	
Road	Yes	TSS	High
		TP	Medium
Recreational	Yes	TN	Medium

Additional Considerations	
Cost	Medium
Maintenance	Medium
Winter Performance	None

Steps to Install a Rain Garden

- Assess the soil drainage - conduct an infiltration test
- Calculate slope of the location of the rain garden and assess other aspects of the rain garden location
- Construct a non-erodable outlet or spillway to discharge overflow
- Install amended soil for drainage using a mixture of loose aggregate and compost
- Plant native species able to withstand drought and wet conditions
- Mulch plantings and maintain garden by weeding, pruning, etc.

Design Guidance for Placement

To test the drainage of the possible rain garden location, dig a 6-8 inch deep and wide hole and fill with water. If the water does not drain within 12 hours, the location is not appropriate for a rain garden.

Rain gardens should be placed where their potential can be maximized. For example, although placing a rain garden under a mature tree will intercept runoff, the tree is most likely taking up more water than the garden would take up; therefore, a rain garden is unnecessary in this location.

Placement of rain gardens should:

- be 100 feet from wells
- be at least 10 feet from building foundations

• not be above septic systems
• not be on soils where the water table is within 24 inches of the surface
• avoid utility crossings

Design Guidance for Size

Soil type will affect the size of the garden. The correct size garden will maximize groundwater recharge and ensure proper drainage. A general size estimate for the rain garden should be:

• 60% of the impervious area draining to the garden site for clay soils
• 10-20% of the impervious area for sandy soils
• Between 20-60% of the impervious area for loamy soils (info on soil types for your location can be found in the US Dept. of Ag., Natural Resource Conservation Service, National Cooperative Soil Survey)

Shapes of the rain gardens may vary, but are most effective when:

- curvy (increased surface area)
- situated with the longest length of the garden perpendicular to the slope of the land

Smaller distributed rain gardens are more effective than a single large scale one.

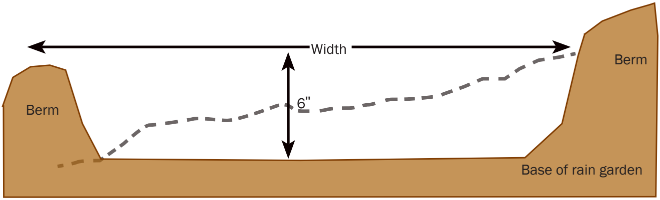
Design Guidance for Depth

Rain gardens are typically between 4-8 inches in depth depending on slope. When slope is:

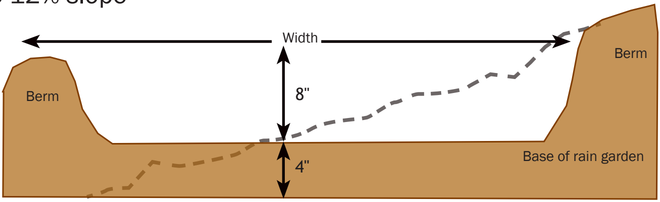
- < 4%, the depth should be 3-5 inches
- between 5-7%, the depth should be 6-7 inches
- between 8-12%, the depth should be 8 inches
- > 12% slope, should be individually assessed by a site designer

Design Guidance for Construction

3-8% slope



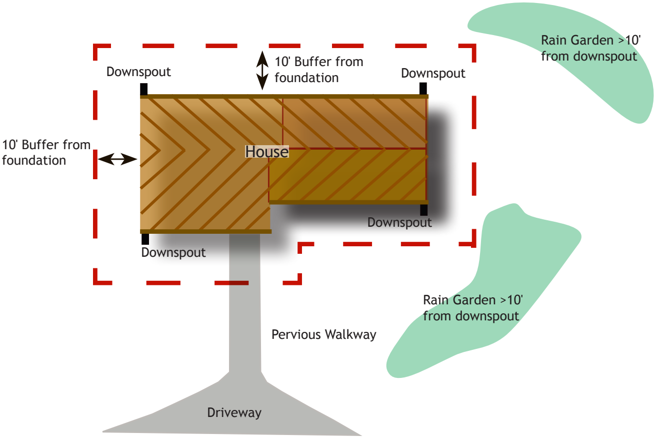
8-12% slope



Steps for calculating surface area of a rain garden
1. In the tables below, find the size factor for the depth and soil type of the rain garden 2. Multiply the impervious area that will drain into the garden by the size factor 3. If the answer is > 300 sq. feet, create multiple smaller rain gardens

Rain Gardens less than 30 feet from source of stormwater			
	Size factor		
	3-5 inches deep	6-7 inches deep	8 inches deep
Sandy Soil	.19	.15	.08
Loamy Soil	.34	.25	.16
Clay Soil	.43	.32	.20

Rain Gardens more than 30 feet from source of stormwater	
	Size factor for all depths
Sandy Soil	.03
Loamy Soil	.06
Clay Soil	.10



PLAN VIEW

Design Guidance for Construction Continued

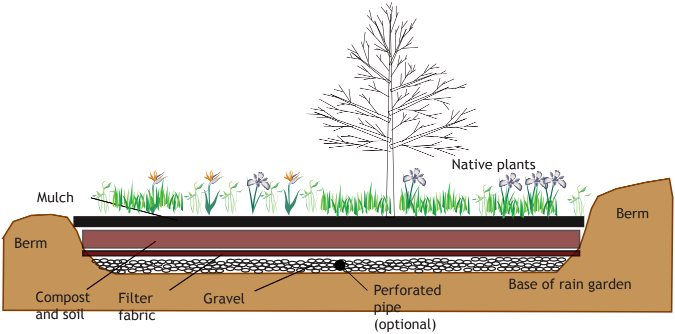
After removing 8-10 inches of soil, creating berms, and forming the shape of the rain garden, the following layers should be applied to the level bottom of earth in order from bottom to top.

- 2-4 inches of stone or sand
- filter fabric
- mix 2-4 inches of existing soil and organic compost (50/50 mix) and spread evenly (acidic soils may need lime application; clay soils may need a higher percentage of compost mix)

• plant native species suitable for the conditions
• 2-3 inches of mulch

<u>It is important that all layers of the rain garden be level.</u>

A grass swale, forebay or gravel entrance should be installed to slow the velocity of runoff to prevent channels from cutting into the garden.



PROFILE

<u>Engineered Rain Gardens with Underground Drainage System</u> (should be designed by an individual with relevant expertise - this could include a landscape architect or professional engineer).

Beyond the standard rain garden, four types of engineered rain gardens are described in the following table.

Type of Engineered Rain Garden	Description	Elements
Full Infiltration	All inflow infiltrates into subsoil and overflow is taken via underground pipe	• Rain garden as described previously • Overflow standpipe or swale • Secondary overflow inlet at catch basin • Outflow pipe to storm drain
Full Infiltration with Reservoir	Has the addition of a drain rock reservoir for surface water to move into the substrates of soil	• Same elements as Full Infiltration Rain Garden • Drain rock reservoir • Geotextile lining drain rock reservoir
Partial Infiltration	Infiltrates most water into soil - overflow drains through perforated pipe placed near the top of the drain rock reservoir	• Same elements as Full Infiltration with Reservoir • Perforated pipe
Partial Infiltration with Reservoir	Acts as a small detention facility; treats water by decanting the top portion of the reservoir and rain garden - allows for infiltration as well.	• Same elements as Partial Infiltration • Flow restrictor assembly

Vegetated Swales

Vegetated swales are shallow open channels lined with dense vegetation designed to treat, attenuate, and convey excess runoff. Vegetated swales can replace curb or gutter systems and although they require more space, they manage runoff better.

Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	Low/Med
Commercial	Yes	Groundwater Recharge	Low/Med
Industrial	Yes	Peak Rate	Low/Med
Retrofit	Limited	**Stormwater Quality Functions**	
Road	Yes	TSS	Med/High
		TP	Low/High
Recreational	Yes	TN	Medium

Additional Considerations	
Cost	Low/Med
Maintenance	Low/Med
Winter Performance	Medium

Key Design Features

- Check dams can provide additional storage and infiltration

Benefits

- Can replace curb and gutter for site drainage and provide significant cost savings
- Peak and volume control with infiltration

Variations

- Subsurface storage and infiltration bed
- Use of underdrain

Limitations

- Limited application where space is minimal

Vegetated swales are primarily designed to receive drainage from roads, parking lots, rooftops, and other impervious surfaces.

Vegetated swales can be designed to provide infiltration, but are primarily used to convey water.

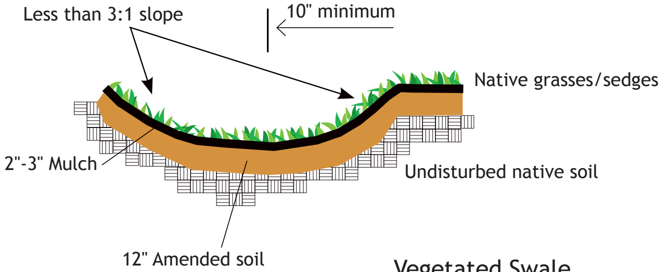
Photos supplied by: Emma Melvin with credit to UVM Lake Champlain Sea Grant

Design Considerations
The recommended slope for vegetative swales is 1-4%. For steeper slopes (up to 5%), check dams are recommended to reduce flow velocity and erosion potential. In areas of steep slopes, swales should run parallel to contours of the landscape. Swales may not be appropriate for highly sloped areas.

Grasses or sedges are typically used in vegetated swales, but other native plants can be used as well. Please refer to the *The Vermont Stormwater Management Manual Volume II* for a list of recommended native species.

The bottom of a swale should be 2-4 feet above the seasonal high water table.

Outlet protection should be provided at the swale's discharge point to prevent scour or erosion.



Vegetated Swale

Photos supplied by and credited to: Linda Boudette Blasch of Better Backroads and Northern Vermont Resource Conservation & Development

Infiltration Trenches or Galleries

Infiltration trenches are shallow open channels lined with dense vegetation. Infiltration trenches can be used to treat runoff. The first flush from a storm event can be diverted to an infiltration trench.

Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	Medium
Commercial	Yes	Groundwater Recharge	High
Industrial	Yes	Peak Rate	Low/Med
Retrofit	Yes	**Stormwater Quality Functions**	
Road	Yes	TSS	High
		TP	High/Med
Recreational	No	TN	Med/Low

Additional Considerations	
Cost	Medium
Maintenance	Low/Med
Winter Performance	Low

Key Design Features

- Requires level infiltration surface
- Proximity to buildings, drinking water supplies, karst features and other sensitive areas needs to be taken into consideration

Benefits

- Reduces stormwater runoff
- Increases groundwater recharge
- Reduces peak rate runoff

Variations

- Subsurface storage and infiltration
- Use of geotextile
- Use of crushed stone

Limitations

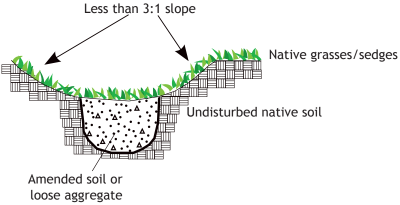
- Pretreatment necessary
- Not recommended for steep slopes

Design Considerations

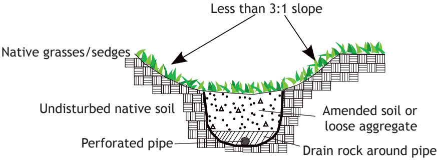
Infiltration trenches or galleries should be designed to hold water no longer than 24 hours in order to avoid a potential mosquito breeding ground. A 30-inch deep soil mix consisting of 50% topsoil and 50% sand should be used for water quality trenches and galleries. If native soils are not conducive to infiltration, an under-drain system should be installed beneath the soil layer to avoid long periods of standing water.

Infiltration trenches are generally a minimum of three feet in depth and backfilled with amended soil or loose aggregate.

Infiltration trench without underground drain



Infiltration trench with underground drain



General Best Practices:

Lawn and Garden Watering

Soils, yard wastes, over watering, and garden chemicals become part of the urban runoff mix that winds its way through streets, gutters, and storm drains. For example, poorly functioning sprinklers and over watering wastes water and can increase the amount of pollutants flowing into storm drains. Do not over-water. Conserve water by using irrigation practices such as drip irrigation, soaker hoses, or micro-spray systems. Avoid watering onto paved surfaces or areas that drain into storm drains.

Mowing and Natural Buffers

Reducing the amount of lawn on a site and allowing native vegetation to grow lessens the amount of fertilizer, fuel, and energy a site uses. Equally important, creating or maintaining natural buffers around streams, wetlands, and other sensitive areas will help intercept runoff, as well as infiltrate, filter and treat runoff. The Department of Environmental Conservation recommends a minimum width of naturally vegetated buffer of 50 feet on most streams, rivers, lakes and wetlands.

Plant Selection

Lessen lawn by planting gardens or use low growing native sedges to mimic lawn. Selecting native plants and grasses lessens the need for watering and pesticides as they are typically more drought tolerant and pest resistant.

II. Prevent Soil Erosion

Small construction projects, including the development of a LID project, around a home or business can be susceptible to erosion once the ground is disturbed.

All earth disturbance activities should implement proper erosion prevention and sediment control techniques to minimize the loss of soil, or sediment, from the site. These techniques include the measures described below. Check town zoning for other possible construction related requirements.

- Areas of existing active erosion, including raw or exposed soil, should be stabilized immediately with seed and mulch or protected by permanent cover such as stone.

- New construction projects should limit the amount of open or exposed area at any one time; limiting disturbance minimizes the potential for erosion.

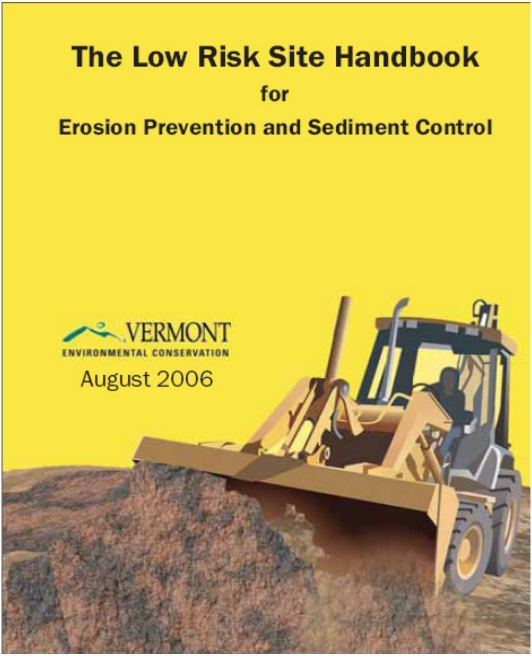
- Disturbed areas should be stabilized as quickly as possible with either temporary or permanent cover. Once final grade has been reached on a project, stabilize the site with seed and mulch or erosion control matting.

- Prevent soil and mud from being tracked onto your driveway, sidewalk or street.

- Define the limits of construction with clearly identifiable markings such as flagging or fencing.

- Protect existing large trees, where feasible.

Specific installation instructions for practices and additional measures for larger sites are available in the "Low Risk Site Handbook for Erosion Prevention and Sediment Control."



This handbook is available on line at: http://www.vtwaterquality.org/stormwater/docs/construction/sw_low_risk_site_handbook.pdf. A print copy may be requested by calling (802) 241-3770.

General Guidelines:

CONSTRUCTION

During construction or property work:

- Protect stockpiles and materials from wind and rain by storing them under tarps or secured plastic sheeting.

- Schedule grading and excavation projects for dry weather.

- Prevent erosion by planting fast-growing annual and perennial grasses to stabilize soils.

Source: www.flickr.com

Before beginning an outdoor project, locate the nearest storm drains and protect them from debris and other materials.

Sweep up and properly dispose of construction debris.

III. Prevent and Eliminate Delivery of Pollutants to Conveyances

Redirecting runoff away from to road gutters, storm drains, or catch basins is an easy and ideal place to start with implementing LID around your property. The following practices can be used to reduce or eliminate pollutants in runoff.

General Guidelines:

FERTILIZER APPLICATION

Source: http://www.lcbp.org/Casin/spring2007.pdf

Fertilizers and herbicides can wash off lawns and landscaped areas harming useful insects and vegetation. Ground and surface water can be contaminated by the chemicals washing off the land. Before applying fertilizer you should test your soil to determine appropriate fertilizers and quantity to use. Most Vermont lawns don't need fertilizer at all. Pesticides, fertilizers, and other chemicals should be stored in a covered area to prevent contaminated runoff. In addition, Phosphorus, a chemical in most fertilizers is one of the leading causes of diminished water quality in Vermont lakes. Several organizations have been promoting the ***Don't "P" on your Lawn*** campaign, informing landowners of the harmful effects excessive phosphorus has on the enviornment. For more information visit this site - **www.lawntolake.org**.

PESTICIDES

Instead of pesticides, use pest management involving physical controls such as barriers or traps, biological controls (e.g. green lacewings eat aphids), bacterial insecticides (e.g. Bacillus thuringiensis kills caterpillars). Chemical control should be considered a last resort.

Source: http://thailand.ipm-info.org/images/pesticides/7a-Spraying_farmer_contaminates_environment.JPG

The following are the least harmful: Dehydrating dusts (e.g. silica gel), insecticidal soaps, boric acid powder horticultural oils, pyrethrin-based insecticides.

If you must use a pesticide, use one that is specifically designed to control your pest and use only as directed. The insect should be listed on the label. Approximately 90% of the insects on your lawn and garden are not harmful.

Dumping toxics into the street, gutter or storm drain is illegal! Household toxics–such as pesticides, cleaners, paints and motor oil–can pollute and poison streams and rivers if disposed of in storm drains or gutters. Rinse empty pesticide containers and dispose of rinse water per the instructions on the product container. Dispose of empty rinsed containers in the trash.

AUTOMOBILES

When washing automobiles use green products or those that will break down more easily and are less toxic to plants. Soap should be used sparingly. Wash your car on a grassy area to infiltrate and treat soapy water. Commercial

car washes reuse wash water several times before sending it to wastewater treatment facility for treatment.

Check your car, boat, motorcycle, and other machinery and equipment for leaks and spills. Make repairs as soon as possible. Clean up spilled fluids with an absorbent material like kitty litter or sand and dispose of the absorbent material properly. Never dispose of oil or other engine fluids by dumping it down storm drains, on the ground, or into a ditch. Many auto supply stores and gas stations accept used oil.

PET WASTE

Pet waste left on the ground can be carried away by runoff, contributing bacteria, parasites and viruses to downstream water bodies. Pet waste does not fertilize the ground, but can be the cause of significant pollution and present health risks to adults, children and other pets.

To properly dispose of animal waste, use newspaper, bags, or pooper-scoopers to pick up wastes and place wrapped pet waste in the trash or unwrapped in a toilet. Never discard pet waste in a storm drain.

Source http://www.zerowasteusa.com

Source: http://www.freyinnovations.com/home_garden/bag_holder/problem.jpg

YARD SCRAPS

Leaves, grass clippings, and tree trimmings can clog catch basins and storm drains, increasing the risk of flooding. Yard scraps that enter rivers absorb oxygen as they decompose, straining or killing aquatic life. Do not blow or rake leaves into the street (unless there is an active designated municipal leaf pickup scheduled), gutter, or storm drains. Use approved containers for curb side pick-up of lawn scraps, do your own composting, or take scraps to a landfill that composts.

HOUSEHOLD CLEANERS AND OTHER CHEMICALS

It is important to dispose of cleaners and chemicals in the proper manner. Read the instructions on the container or contact your local transfer station or waste management district for more information.

IV. Other LID Considerations

As stated at the beginning of this guide, the practices contained within are intended to be applied to residential and small commercial sites. The practices in this guide are relatively simple to implement and with some minor guidance a homeowner can get them on the ground under their own accord. This section describes other LID practices, both structural and nonstructural, that complement the practices described previously.

The structural BMPs listed in this section are more complex in nature and may require significant engineering to install. They include green roofs, pervious pavement and constructed wetlands.

Nonstructural best management practices have no physical structures associated with them. Nonstructural BMPs are designed to reduce the amount of pollutants available in the environment that would potentially end up in stormwater runoff. Nonstructural BMPs can lessen the need for the more costly structural BMPs. Nonstructural BMPs can be achieved through such things as education, management and development practices. Some examples include ordinances and practices associated with land use and comprehensive site planning.

Green Roofs

Vegetated roofs, or green roofs, are conventional rooftops that include a thin covering of vegetation allowing the roof to function more like a vegetated surface. The overall thickness of the vegetated roof may range from 2 to 6 inches, typically containing multiple layers of waterproofing, synthetic insulation, non-soil engineered growth media, fabrics, synthetic components and foliage.

Applications		**Stormwater Quantity Functions**	
Residential	Yes	Volume	Med/High
Commercial	Yes	Groundwater Recharge	Varies
Industrial	Yes	Peak Rate	Medium
Retrofit	Yes	**Stormwater Quality Functions**	
Road	N/A	TSS	Medium
		TP	Medium
Recreational	Yes	TN	Medium

Additional Considerations	
Cost	High
Maintenance	Medium
Winter Performance	Low

Key Design Features
- Extensive roofs are most commonly used for rainfall runoff mitigation
- Intensive roofs can support gardens and trees
- Roofs can be designed with replaceable cells

Benefits
- Good stormwater volume control
- Heating and cooling energy benefits
- Increased lifespan of roof
- Heat island reduction

Variations
- Intensive
- Semi intensive
- Intensive

Limitations
- Cost
- Maintenance until plants are established
- Extensive engineering
- Difficult to retrofit due to added load

Pervious Pavement

Pervious pavement combines structural pavement consisting of a permeable surface with a storage or infiltration reservoir. Pervious pavement is well suited for parking lots, walking paths, sidewalks, driveways, low speed-low volume lanes, plazas, and low vehicle weight streets. Various forms of pervious pavement include porous concrete, pervious asphalt, permeable pavers and reinforced turf.

Applications		Stormwater Quantity Functions	
Residential	Yes	Volume	High
Commercial	Yes	Groundwater Recharge	High
Industrial	Yes	Peak Rate	Med/High
Retrofit	Yes	Stormwater Quality Functions	
Road	Limited	TSS	Varies
		TP	Med/High
Recreational	Yes	TN	Medium

Additional Considerations	
Cost	High
Maintenance	High
Winter Performance	Varies

Key Design Features
- Do not infiltrate on compacted soils
- Level storage/ infiltration bed bottoms
- Surface permeability > 20"/hr

Benefits
- Volume control and groundwater recharge, moderate peak rate control
- Dual use for pavement structure and stormwater management

Variations
- Porous asphalt
- Pervious concrete
- Permeable paver blocks
- Reinforced turf/ gravel

Limitations
- Cost
- Pervious pavement not suitable for all uses
- High maintenance needs

Constructed Wetland

A constructed wetland effectively removes sediments and many other common stormwater pollutants, and enhances the visual appeal of the landscape, reducing peak flows and runoff volumes in general. A wetland utilizes a variety of biological, physical, and chemical processes for pollutant removal through uptake by vegetation and microorganisms; and physical and chemical treatment on and within the gravel sub-base and root matrices.

Key Design Features
- Provide passive recreation
- Increase land-scape value
- Provide wildlife habitat

Benefits
- Volume control and groundwater recharge
- Excellent peak rate control

Variations
- Gravel wetland design
- Vertical flow wetland
- Free water surface wetland

Limitations
- Space intensive
- Expensive to construct
- Labor intensive until established

Applications		**Stormwater Quantity Functions**	
Residential	Yes	Volume	Med/High
Commercial	Yes	Groundwater Recharge	Med/High
Industrial	Yes	Peak Rate	High
Retrofit	Yes	Stormwater Quality Functions	
Road	Yes	TSS	Medium
		TP	Med/High
Recreational	Yes	TN	Medium

Additional Considerations	
Cost	High
Maintenance	Medium
Winter Performance	Varies

Nonstructural Best Management Practices

Low impact development nonstructural BMPs are just that, a nonstructural approach to addressing runoff related impacts. More specifically, nonstructural BMPs take broader planning and design approaches, which are less "structural" in their form. Many nonstructural BMPs apply to an entire site and often to an entire community, such as wetland protection through a community wetland ordinance. They are not fixed or specific to one location.

Some of the more commonly used nonstructural BMPs include:

- Cluster/conservation development,
- Minimizing soil compaction,
- Minimizing total disturbed area,
- Protecting natural flow pathways,
- Protecting riparian buffers,
- Protecting sensitive areas, and
- Reducing impervious surfaces.

There are numerous benefits of incorporating nonstructural BMPs into a site or community. The following is a sample of the benefits that may accrue from nonstructural BMPs:

- Reduced land clearing costs,
- Reduced costs for total infrastructure,
- Reduced total stormwater management costs,
- Enhanced community and individual lot aesthetics, and
- Improved overall marketability and property values.

Nonstructural BMP deployment is not a singular, prescriptive design standard but a combination of practices that can result in a variety of environmental and financial benefits. Reliance on nonstructural BMPs encourages the treatment, infiltration, evaporation, and transpiration of precipitation close to where it falls while helping to maintain a more natural and functional landscape. Nonstructural BMPs preserve open space and working lands, protect natural systems, and incorporate existing site features such as wetlands and stream corridors to manage runoff at its source.

Some nonstructural BMPs also focus on clustering and concentrating development, minimizing disturbed areas, and reducing the size of the impervious foot print. Blending these BMPs into development plans can contribute to the desirability of a community, environmental health and quality of life for its residents. Longer term, they sustain their runoff management capacity with reduced operation and maintenance demands.

Traditional land development frequently results in extensive site clearing, where existing vegetation is destroyed, and the existing soil is disturbed, manipulated, and compacted. All of this activity significantly affects runoff quantity and quality. These conventional land development practices often fail to recognize that the natural vegetative cover, the soil mantle, and the topographic form of the land are integral parts of the water resources system that can and should be conserved and kept in balance, even as land development continues to occur.

Identifying a site's natural resources and evaluating their values and functional importance is the first step in addressing the impact of

Traditional vs. Conservation Land Development Non Structural LID

runoff generated from land development. Where they already exist on a proposed development site, these natural resources should be conserved as a part of the runoff management solution.

Glossary and Definitions

Best Management Practice (BMP)
A structural or nonstructural technique for managing stormwater to prevent or reduce pollutant delivery and/or control stormwater runoff to surface water or ground water. Structural BMPs include, basins, discharge outlets, swales, rain gardens, or filters. Nonstructural BMPs include source control or pollution prevention practices.

Check Dams
Dams constructed across a swale or channel to slow water flow. Dams are typically made of rock, gravel, sandbags, logs, or turf berms.

Conveyance
The process of or system for water moving from one place to another.

Buffer Strips
Bands of dense vegetation, typically ground cover or turf, planted between pollution sources and downstream receiving waters.

Gray Water
Gray water is wash water - all wastewater except toilet wastes and food wastes derived from garbage disposals. Gray water can be recycled for irrigation and wastewater uses.

Impervious
Not allowing infiltration. Impervious surfaces include roads (paved and unpaved), parking areas, sidewalks, roofs, bike paths, and compact soils.

Infiltration
Is the process by which water on the ground surface enters the soil. Infiltration rate in soil science is a measure of the rate at

which soil is able to absorb rainfall.

Low Impact Development (LID)
Low Impact Development seeks to manage rainfall at its source. LID's goal is to mimic a site's pre-development hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain stormwater runoff close to it's source.

Permeable/Pervious
Allowing runoff to filter into or pass through.

Sedges
Sedges are close botanical cousins of grasses. Properly selected and planted sedges can function as a traditional lawn, yet require little or no maintenance and can tolerate a variety of environments.

Sheet Flow
The portion of precipitation that moves initially as overland flow in very shallow depths before eventually reaching a stream channel.

Runoff (stormwater runoff)
Precipitation, snow melt, and the material dissolved or suspended in precipitation or snow melt that flows off impervious surfaces and discharges into surface waters or into groundwater via infiltration.

General Sources:
Vermont DEC Stormwater Management Program
http://www.anr.state.vt.us/dec/waterq/stormwater.htm

Lake Champlain Sea Grant - NEMO Program
http://www.uvm.edu/~seagrant/education/nemo.html

Winooski Natural Resources Conservation District
http://www.vacd.org/winooski/index.shtml

Urban Design Tools - LID
http://www.lid-stormwater.net

Pennsylvania Department of Environmental Protection
http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305

Southeast Michigan Council of Governments
http://www.semcog.org/Stormwater.aspx

West Coast Environmental Law
http://www.wcel.org/wcelpub/2007/14255.pdf

US Environmental Protection Agency
http://www.epa.gov/greeningepa/stormwater/hq_lid.htm
http://cfpub.epa.gov/npdes/home.cfm?program_id=298

U.S. Department of Housing and Urban Development
http://www.huduser.org/publications/destech/lowimpactdevl.html

Urban Forest Values:
Economic Benefits of Trees in Cities
University of Washington, College of Forest Resources
http://slf-web.state.wy.us/forestry/econ.aspx

Rain Gardens:
Metro Vancouver - British Columbia
http://www.metrovancouver.org/Pages/default.aspx

Infiltration of Stormwater in a Rain Garden: Richards
Equation Numerical Model and Field Experiment
http://www.iemss.org/iemss2004/pdf/hydroresponses/dussinfi.pdf

SvR Design Company
www.svrdesign.com/docs/TSM%20-%20complete%20-%20reduced.pdf

Additional Rain Gardens information:
http://vacd.org/winooski/VtRainGardenManual.pdf
http://www.abbey-associates.com/splash-splash/blue_standards/rain_garden.html

Rain Barrels:
SustainIndy - City of Indianapolis
http://www.sustainindy.org/assets/uploads/4.3%20Cisterns%20and%20Rain%20Barrels.pdf

Cisterns:
Louisiana Department of Environmental Quality
http://www.abbey-associates.com/splash-splash/blue_standards/above_ground_cistern.html

The Low Impact Development Center, Inc.
www.lowimpactdevelopment.org/qapp/lid_design/raincist/raincist_specs.htm

Additional cistern information -
http://www.oas.org/usde/publications/Unit/oea59e/ch10.htm
http://www.wvu.edu/~exten/infores/pubs/ageng/sw12.pdf
http://www.clermontstorm.net/cistern.pdf

Roof Top Disconnection:
Mid-America Regional Council
http://www.marc.org/Environment/Water/

Vegetated Swales:
http://test.www.mapc.org/sites/default/files/LID_Fact_Sheet_-_Vegetated_Swales.pdf

Lawn Fertilization:
http://www.lawntolake.org/
http://www.anr.state.vt.us/dec//waterq/lakes/docs/lpseries/lp_lps-dontp.pdf

The Vermont Department of Environmental Conservation is an equal opportunity agency and offers all persons the benefits of participating in each of its programs and competing in all areas of employment regardless of race, color, religion, sex, national origin, age, disability, sexual preference, or other non-merit factors.

VT Relay Service for the Hearing Impaired
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