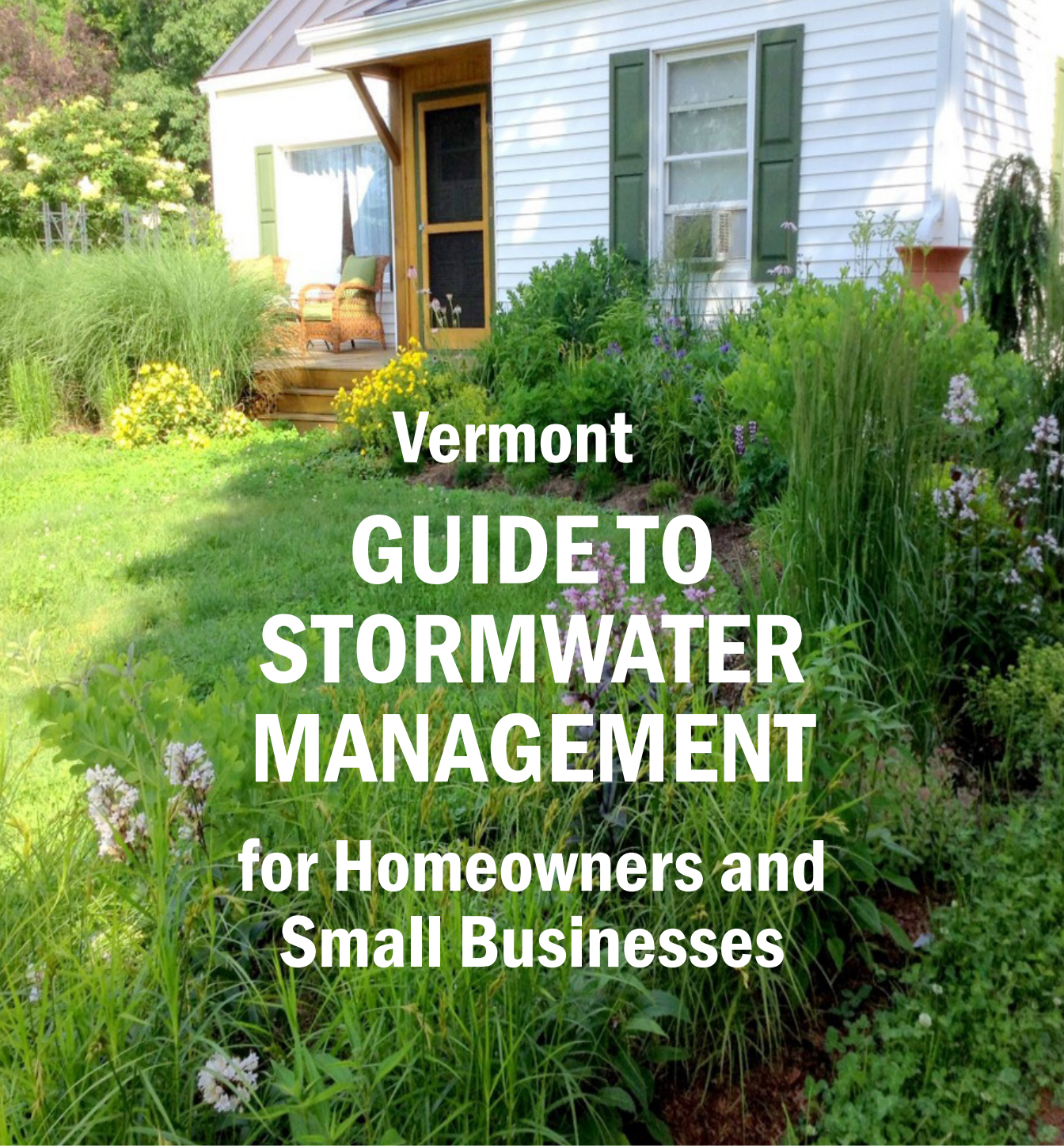

Vermont GUIDE TO STORMWATER MANAGEMENT

for Homeowners and Small Businesses

VERMONT CLEAN WATER INITIATIVE

VERMONT
AGENCY OF NATURAL RESOURCES
Department of Environmental Conservation

Sea Grant
Lake Champlain

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For more resources and detailed information on each practice, visit:
http://dec.vermont.gov/watershed/cwi/green-infrastructure

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INTRODUCTION

Vermont's waterways are a vital part of our community. They provide drinking water, recreational opportunities, scenic views, irrigation for crops, and habitat for our native plants and animals. However, our waterways are threatened by high volumes of polluted stormwater and associated contaminants. Due to the nature of stormwater, there is not one easy fix that can remedy the problem. The solution must be watershed-wide. We all must work together to protect our waterways.

The purpose of this guide is to help homeowners and small business owners who are not subject to stormwater permits and regulations identify ways to improve and protect water quality and manage stormwater runoff at its source.

The practices described in the guide infiltrate, filter, store, evaporate, and detain runoff on site, minimizing environmental impact and pollution. You can customize these designs to fit your needs and site-specific constraints.

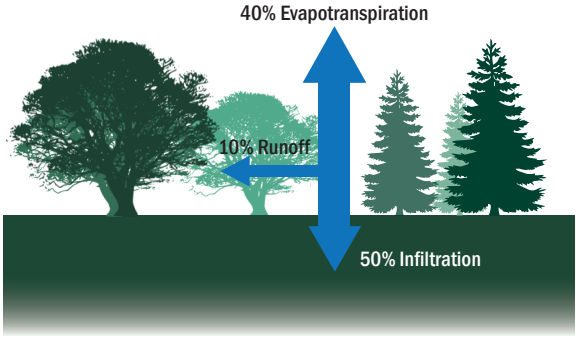
Green Stormwater Infrastructure (GSI) is an important part of this work. These practices either prevent runoff from occurring or treat it as close to the source as possible. GSI mimics nature as the practices slow down, filter, and infiltrate stormwater that would otherwise pollute our waterways. GSI increases groundwater recharge and property values; mitigates urban heat islands; reduces pollutants in stormwater and combined sewer overflows; improves air quality and human health; and improves and creates wildlife habitat and recreational space. GSI can improve your property, both in terms of stormwater treatment and aesthetic appeal.

Thank you in advance for helping to improve and protect your watershed.

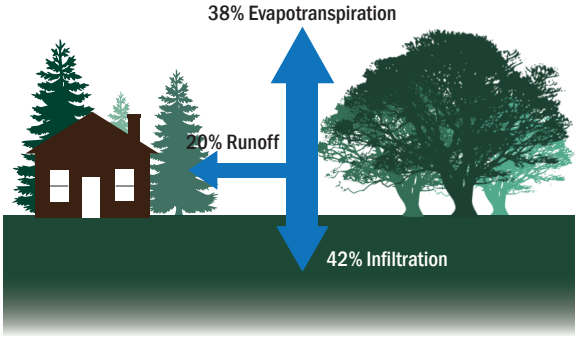
Connecticut River at Bellows Falls, Vermont

WHAT IS STORMWATER RUNOFF?

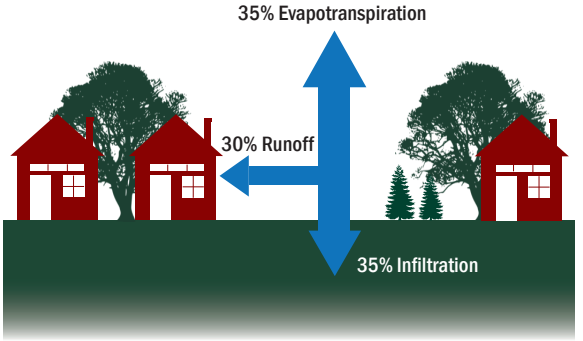
Stormwater runoff is rain or snowmelt that runs across the land surface and discharges to rivers or lakes. In natural areas, most stormwater infiltrates into the ground, evaporates, or is transpired by plants (the combination of which accounts for evapotranspiration). In urbanized areas with more impervious surfaces, greater volumes of stormwater runoff are generated and discharged to our waterways. This runoff increases the quantity and force of water in streams and can transport sediment, nutrients, pollutants, and debris that negatively impact water quality.



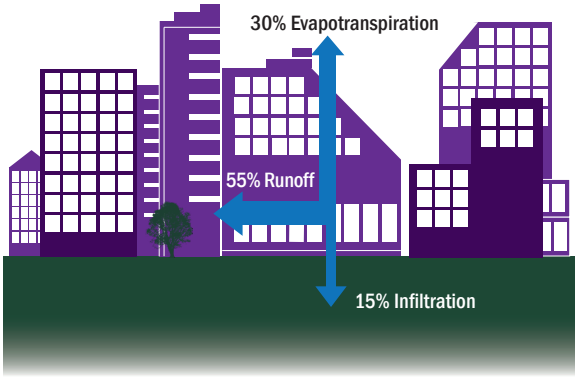
NATURAL, GROUND COVER
0% Impervious Surface



LOW DENSITY RESIDENTIAL (e.g., rural)
10–20% Impervious Surface



MEDIUM DENSITY RESIDENTIAL (e.g., subdivision)
30–50% Impervious Surface



HIGH DENSITY RESIDENTIAL/INDUSTRIAL/COMMERCIAL (e.g., town center)
75–100% Impervious Surface

Source: Arnold and Gibbons (1996) Impervious Surface Coverage

WHAT IS THE PROBLEM WITH STORMWATER RUNOFF?

INCREASED FLOODING

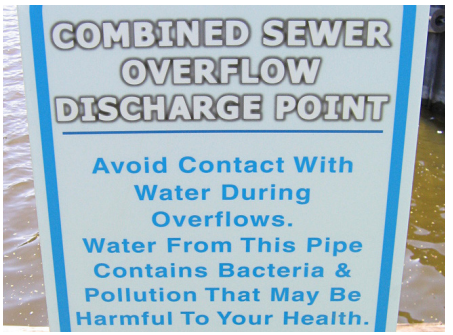
Excess stormwater increases the extent, severity, and frequency of floods since stormwater runoff reaches waterways much faster and in greater quantities than it would in natural landscapes.

DEGRADED WATER QUALITY

Stormwater can carry with it a number of pollutants like sediment, nutrients (a driver for harmful algal blooms in Lake Champlain), road salt, oil, grease and coolants from automobiles, and others.

STREAMBANK EROSION

Stormwater runoff unnaturally increases stream volume and velocity, which can exacerbate streambank erosion, putting homes, roads, and other infrastructure at risk.



SEWER OVERFLOWS

Increasing stormwater volumes contribute to combined sewer overflows in areas with combined stormwater and sanitary sewer systems.

WHAT IS GREEN STORMWATER INFRASTRUCTURE (GSI)?

Green Stormwater Infrastructure (GSI) incorporates complementary and alternative methods to manage runoff from urban land. Unlike traditional stormwater management practices, GSI focuses on improving water quality and decreasing the total quantity of stormwater runoff within developed areas. A decrease in stormwater runoff benefits water quality through reductions in nutrient pollution and erosive forces.

GSI is used to either treat runoff as close to the source as possible or prevent runoff from occurring altogether. This is accomplished by utilizing techniques that imitate natural hydrologic processes including infiltration, evapotranspiration, storage, and use (also called reuse).

INFILTRATION

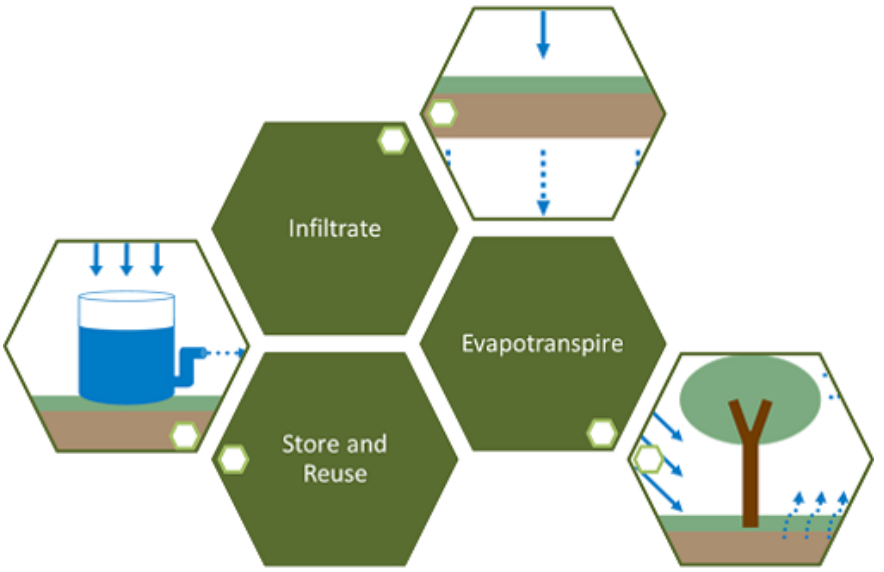
How water on the ground surface enters and moves through soil or other porous materials.

EVAPOTRANSPIRATION

How water gets transferred from the land to the atmosphere (evaporation and plant transpiration).

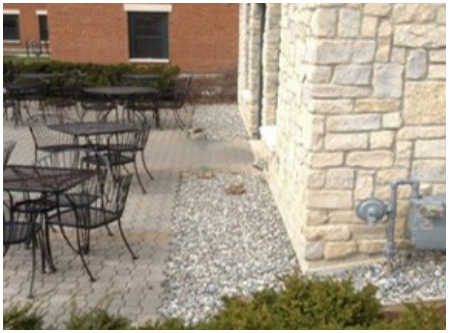
STORE AND USE

Capturing and storing stormwater runoff from impervious surfaces to use for non-potable purposes such as irrigation or car washing.



EXAMPLES OF GREEN STORMWATER INFRASTRUCTURE

INFILTRATION



INFILTRATION TRENCH. Filters and infiltrates runoff in existing flow paths, along walkways and driveways, or in the drip line of non-guttered roofs.

DRY WELL. This sand or gravel filled hole filters and infiltrates stormwater runoff. It is a great practice for properties with limited space.

EVAPOTRANSPIRATION

PLANT A TREE. Trees require little maintenance once established, and slow and infiltrate runoff while improving aesthetics.

RAIN GARDEN. Captures runoff from areas such as rooftops, driveways, or parking lots. Slows, filters, and infiltrates runoff while irrigating plants in the garden.

STORE AND USE

RAIN BARREL. Collects and stores stormwater from guttered roof downspouts. Water can be used later for activities such as car washing or irrigation.

WHAT IS BEST FOR MY PROPERTY?

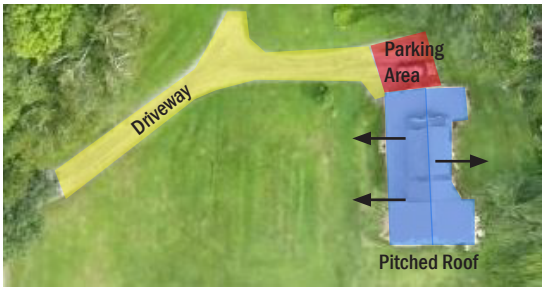
The best first step is to understand your property layout and come up with a plan. The next several pages will help you decide which practices are appropriate for the conditions of your property.

You can obtain an aerial image of your property online from the Vermont Agency of Natural Resources (VT ANR) Natural Resources Atlas, Google Maps, a town mapping website, or another source you find. You can also obtain a map of your property from your town or county's tax assessor's office, or your deed may include the size of your building(s) and lot.

Utilizing the VT ANR Atlas, you can measure impervious cover on your property and determine your soil type. Under "Quick Tools", select "Zoom to a Town" or "Find an Address" to locate your property. Visit: http://anrmaps.vermont.gov/websites/anra5/

MEASURING IMPERVIOUS ON SITE

Once you locate your property and zoom in to the site scale, use the measurement tool to determine impervious cover, such as paved or gravel driveways, parking areas, and roofs. Click the "Open Toolbar" button in the top right corner of the map. Then, select the polygon drawing tool under the "Measurement" tab and outline the perimeter of each area. You can choose units (such as feet and feet^2) in the "Select Length" and "Select Area Unit" dropdowns. Remember that a pitched roof will drain to different areas of your property and can feed into separate GSI practices. The same is true of crowned driveways (see "Rural Driveways" section for more information).



Print out the map and use it to sketch out the GSI practices you would like to implement.

In the example residential site above, the impervious areas have been marked with colored polygons. Approximate measurements include: Driveway = 2,100 ft^2, Parking Area = 630 ft^2, Roof (left) = 1,000 ft^2, Roof (right) = 850 ft^2. The arrows depict the approximate direction of flow off of either side of the pitched roof. You can use these measurements to help you plan and size your GSI practices.

WHAT IS BEST FOR MY PROPERTY?

DETERMINING SOILS ON SITE

Certain soil types allow water to infiltrate into the ground, while others do not. It is important to find out what soils are on your property in order to choose the GSI practices that will work best for you.

Use the VT ANR Atlas (http://anrmaps.vermont.gov/websites/anra5/) to determine the soil composition of your site. To locate your property, select "Show Layers" under the "Map Data" tab. The layers will be displayed to the left of your map. Click on the plus sign next to "Geology" and scroll down to select "Soils-Hydrologic Groups". Click on the colored polygon that covers your property and go to "View Additional Details" on the pop-up. Scroll down to locate the Hydrogroup classification.

See the table below for information to help understand your soil's hydrologic grouping.

HYDROLOGIC GROUP	INFILTRATION RATE	RUNOFF POTENTIAL
A (Best)	High	Low
B	Moderate	Moderate
C	Low	Moderate
D (Worst)	Very Low	High

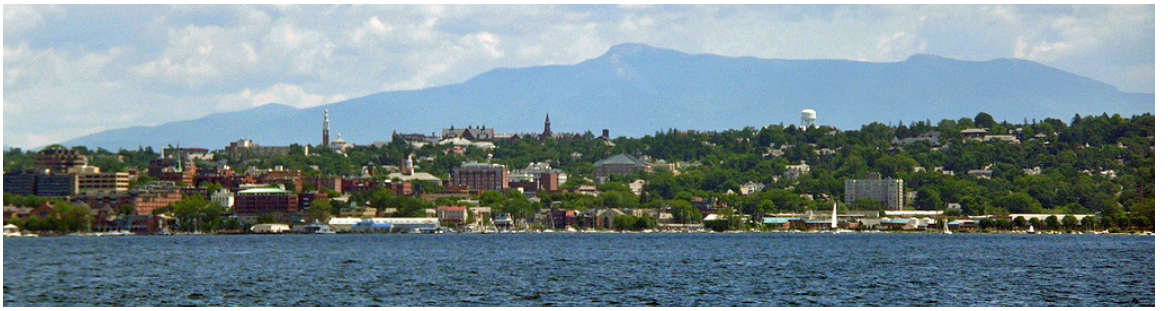
IS MY SOIL WELL-DRAINED?

It is important to know if your soil is well-drained before implementing an infiltration practice and determining the hydrologic soil group at your location is a good start. You should also conduct the following test to confirm this classification is correct as there are often site-specific soil variations.

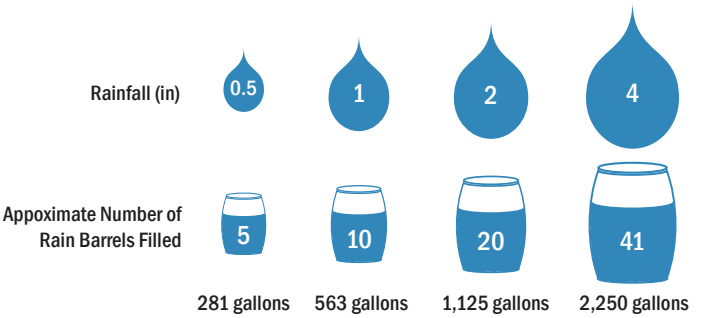
1. Dig an 18″ hole (~6″ diameter) in the area where you want to implement an infiltration practice.
2. Fill the hole to the top with water and let it drain completely.
3. Refill the hole with water.
4. If the water does not drain within 48 hours, this indicates that the soil has a poor infiltration rate and is not a good location to implement an infiltration practice.

WHERE TO APPLY GSI?

GSI can be applied almost anywhere. Whether your property is in a city, rural area, or somewhere in between, there are GSI practices that can work for you.



Even a fairly small roof or driveway can produce a significant amount of stormwater runoff. The average size roof of a single-family home or small business is approximately 1,750 ft^2. The chart below provides examples of how much runoff can be generated from differing rainfall amounts.



WHERE TO APPLY GSI?

AN EXAMPLE OF APPROPRIATE GSI

The following diagrams provide a comparative example of the same residential site with and without appropriate GSI. This example site contains many GSI practices, but it is expected that most property owners would not implement this number of practices. Installing any of the practices described in this guide will help to protect and improve our water resources.

CURRENT SITE

1. Streambank erosion
2. Unused area of mown, short turf
3. Runoff from impervious parking area reaching storm drain
4. Ponding due to lawn compaction
5. Runoff from impervious driveway reaching storm drain
6. Erosion at base of downspout from roof runoff
7. Erosion in slightly sloped area
8. Erosion at base of downspout from roof runoff

SITE WITH GSI

1. Buffer backyard stream
2. Low mow zone
3. Permeable paver parking area
4. Aerate lawn
5. Driveway infiltration trench
6. Downspout disconnection to #7
7. Rain garden
8. Rain barrel

KEY TO THIS GUIDE

Each of the stormwater management practices listed in this guide has been assigned a series of values to help you weigh the pros and cons of each practice in the context of your site. The icons are described here. Note that most of these factors will fluctuate based on the size of the area you are managing.

COST

Minimal (<$200) **$**

Moderate ($200–$600) **$$**

High (>$600) **$$$**

INSTALLATION

Minimal (requires 1–3 hours)

Moderate (requires half day)

High (requires full day +)

MAINTENANCE

Minimal (check a couple times per season)

Moderate (check 1–2 times per month)

High (check weekly)

SPACE REQUIRED

Minimal (approximate size of a 4-door sedan)

Moderate (4-door sedan to approximate size of a short school bus)

Large (approximate area of a tractor-trailer truck)

BENEFITS

Slow:

This practice reduces the velocity of stormwater. Reducing the velocity of stormwater lessens the likelihood of flash flooding, erosion, and the altering of stream morphologies.

Filter:

This practice removes pollutants from stormwater. Removing pollutants from stormwater decreases the occurrence of harmful nutrient loading, loss of species diversity, higher water temperatures, and sedimentation.

Infiltrate:

This practice allows stormwater to infiltrate into the ground. Allowing stormwater to infiltrate into the ground recharges groundwater and reduces the influx of runoff into storm drains.

Use:

This practice allows stormwater to be used for things like watering a garden or washing your car.

811

Know what's **below.**
Call 811 before you dig.

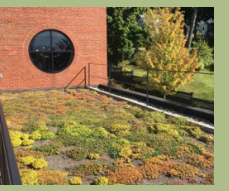
If you see this icon, consult Dig Safe System, Inc. **Call 888-DIG-SAFE** at least 3 days before digging to ensure that you do not impact buried utilities. **IT'S FREE!**

GSI PRACTICE DECISION TREES

Use these flowcharts to determine the best GSI practices for your site. For more information on each practice, continue reading.

I am managing a roof

- Flat → **Green Roof**



For slightly-sloped roofs; promotes wildlife habitat; aesthetically pleasing

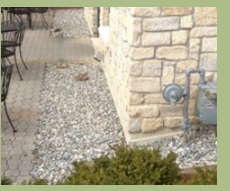
- Sloped
  - Guttered
    - Confined Area → **Dry Well**

For guttered roofs; well-drained soils ideal

    - Unconfined Area → **Rain Barrel**

For guttered roofs; wide applicability

  - Non-Guttered → **Drip Line Infiltration Trench**



For non-guttered roofs

- Unconfined Area → **Rain Garden**

For rooftops, driveways, and parking lots; creates wildlife habitat

- Unconfined Area → **Disconnection to Vegetated Area**

Direct to rain garden or stable, vegetated area

I am managing a lawn

Small (≤0.5 acres)

Large (>0.5 acres)

Aeration

Decreases runoff; improves infiltration and lawn health

Longer Grass

Mowing your lawn to 3″ or more improves lawn health; decreases runoff

Low Mow Zone

Promotes wildlife habitat; decreases runoff

Planting Trees

Aesthetically pleasing; requires little maintenance

GSI PRACTICE DECISION TREES

I am managing a driveway or walkway

- Paved
  - Confined Area
    - **Permeable Pavers**

      For flat areas that can infiltrate; use in place of impervious paving materials
    - **Vegetated Swale**

      For flat/sloped driveways, walkways, and parking lots; low maintenance
    - **Infiltration Trench**

      For nonguttered roofs, along driveways and sidewalks
  - Unconfined Area
    - **Rain Garden**

      For rooftops, driveways, and parking lots; creates wildlife habitat
    - **Filter Berm**

      Captures runoff from parking lots, driveways, or walkways
- Unpaved
  - **Water Bars**

    For sloped, unpaved paths or driveways

I am managing a parking lot

Confined Area

Unconfined Area

Permeable Pavers

For flat areas that can infiltrate; use in place of impervious paving materials

Filter Berm

Captures runoff from parking lots, driveways, or walkways

Rain Garden

For rooftops, driveways, and parking lots; creates wildlife habitat

Vegetated Swale

For flat/sloped driveways, walkways, and parking lots; low maintenance

Dry Well

For concentrated flows; ideal for well-drained soils and where space is limited

Infiltration Trench

For nonguttered roofs, along driveways and sidewalks

PRACTICE TYPE	APPLICABILITY	SPACE REQUIRED	LIMITATIONS
Rain Barrels	Guttered roof downspouts		Limited capacity to store water from larger storms
Dry Wells	Guttered roof downspouts, parking lot runoff		Not applicable in poorly drained soils
Infiltration Trenches	Dripline of non-guttered roofs, along driveways, walkways, or parking lots		Not applicable in poorly drained soils
Water Bars	Unpaved walkways		Must ensure area of disconnection can accommodate stormwater volume
Filter Berms	Captures runoff from parking lots, driveways, or walkways		Cost of topsoil, fill, and plants; difficult to implement in ultra-urban areas
Vegetated Swales	Along walkways, driveways, or parking lots		Limited capacity to infiltrate water from larger storms depending on soil
Rain Gardens	Captures runoff from parking lots, driveways, walkways, or roof downspouts		Not applicable in poorly drained soils
Infiltration Stairs	Moderately sloped (<45%) unpaved walkways		Not applicable in poorly drained soils
Permeable Pavers	Paved areas (driveways, walkways, parking lots)		Not applicable in poorly drained soils
Green Roofs	Flat roofs		High cost; requires engineering

INSTALLATION		MAINTENANCE	COST	BENEFITS
Place barrel and stand; may need to cut down-spout and seal pipe			$	Slow – Use
Digging hole and filling with crushed stone			$$	Slow – Filter – Infiltrate
Excavate trench and fill with crushed stone			$$	Slow – Filter – Infiltrate
Install timber and fill trench with crushed stone			$$	Slow – Filter – Infiltrate
Construct berms and plant vegetation			$$	Slow – Filter – Infiltrate
Excavate and plant trench			$$ to $$$	Slow – Filter – Infiltrate
Digging and planting			$$ to $$$	Slow – Filter – Infiltrate
Construct stairs, cover soil with fabric, and backfill with stone			$$$	Slow – Filter – Infiltrate
Excavate area; install fabric and crushed stone; install pavers			$$$	Slow – Filter – Infiltrate
Requires engineering; planting			$$$	Slow – Filter

RAIN BARRELS

Rain barrels are designed to intercept and store runoff from guttered rooftops. Stored water can be used for purposes such as irrigation. If you will be utilizing all stored water frequently, or have a larger roof, you can consider a series of connected rain barrels (see "What is Best for My Property" for directions about measuring your roof).

APPLICABILITY

Guttered rooftop downspouts

INSTRUCTIONS

- Rain barrels should be installed on a platform capable of supporting a full rain barrel (approximately 400 lbs when full). Cinder blocks are inexpensive and work well.
- A screen should be installed on the top of the barrel to ensure that debris and bugs do not get into the barrel.
- Installation may require cutting your downspout to the appropriate height, or installing a rain chain to direct stormwater runoff.
- If your downspout currently connects to the storm sewer system, it should be capped after the downspout is cut.
- Direct overflow from the rain barrel to a vegetated area. Rain gardens are ideal for this purpose.
- Multiple barrels can be used in sequence for larger roofs although a larger storage volume increases the risk for water stagnation to occur.

MATERIALS AND TOOLS

- Premade or homemade rain barrel (for more information about DIY barrels, visit: http://dec.vermont.gov/watershed/cwi/green-infrastructure)
- Raised platform that can support ≥ 400 pounds
- Overflow hose and mosquito-proof screen (if not included in commercial rain barrel purchase)

MAINTENANCE

- Drain between storm events to maximize storage capacity
- Drain and store upside down in the winter
- Inspect annually for cracks

BENEFITS

- Provides supplemental, non-potable water supply for irrigation
- Reduced water bill for outside watering
- Wide applicability

LIMITATIONS

- Limited capacity to store water from larger storms; standard rain barrels can hold about 50 gallons of water
- For larger roofs, several rain barrels in a series can be utilized
- Alternatively, a larger storage receptacle called a cistern can capture significantly larger volumes
- Cisterns may require professional installation and more involved maintenance

DID YOU KNOW?
A 1,000 ft^2 roof will yield nearly 600 gallons of rainwater in a 1 inch rainstorm; that is enough to fill an 8′ x 8′ hot tub!

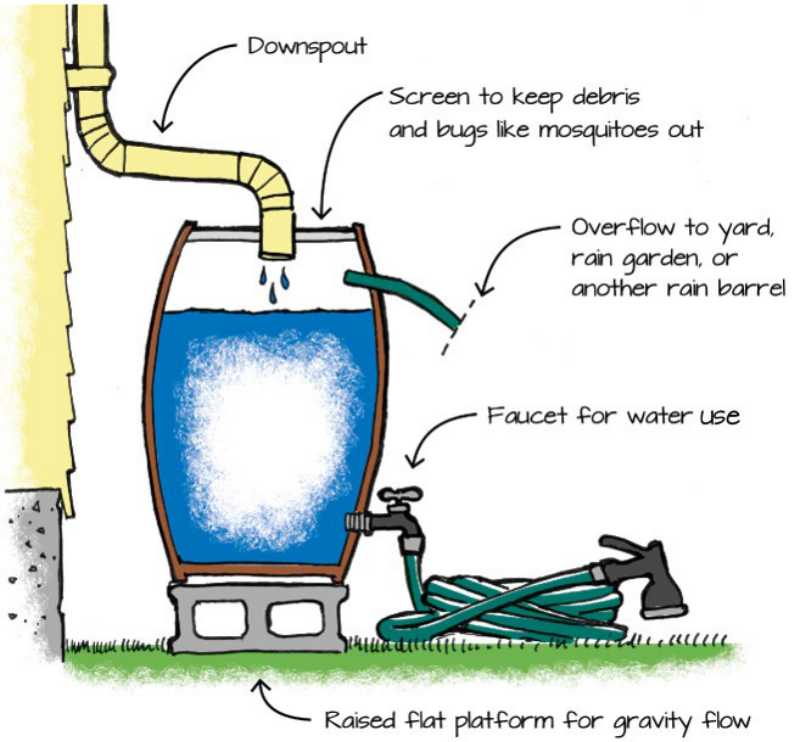
COST
$

SPACE

INSTALLATION

MAINTENANCE

BENEFITS
Slow – Use



DRY WELLS

Dry wells collect and infiltrate stormwater runoff from concentrated areas. They are most often used to mitigate roof runoff. Before considering this practice, make sure that your soil is well-drained. For instructions, see page 7.

APPLICABILITY

Guttered rooftops or other concentrated stormwater flows

INSTRUCTIONS

- Locate your dry well at least 10′ from building foundations, and slope slightly away from structures.
- If necessary, a swale or a downspout extension can be used to transport roof runoff to drainage area.
- Dig an appropriately sized hole in the desired location. Use the table below for sizing guidance.
- Line the hole with non-woven geotextile fabric, leaving enough fabric to cover the hole once filled. Fill the hole with washed drainage stone (½″–1½″ diameter) to within 3″ of the ground surface.
- Alternatively, add 2″ of washed drainage stone and install a perforated container.
- Cover the top of the stone with non-woven geotextile fabric.
- Add large decorative stones on top of the practice area.

DID YOU KNOW?
Dry wells are ideal for well-drained soils and can be installed where space is limited.

MATERIALS AND TOOLS

- Washed drainage stone (½″–1½″ diameter)
- Non-woven geotextile fabric or a perforated container
- Measuring tape
- Shovel

MAINTENANCE

- Periodically inspect dry well to ensure it is not clogged and is infiltrating stormwater appropriately

BENEFITS

- Slows, filters, and infiltrates stormwater

LIMITATIONS

- Can only be used in well-drained soils

DRY WELL SIZING GUIDE		
DRAINAGE AREA (FT^2)	DRY WELL DEPTH (FT)	DRY WELL DIAMETER (FT)
100	3.5	3
200	3.5	4
400	3.5	6
500	4	6
1,000	4	9

COST

$$

SPACE

INSTALLATION

to

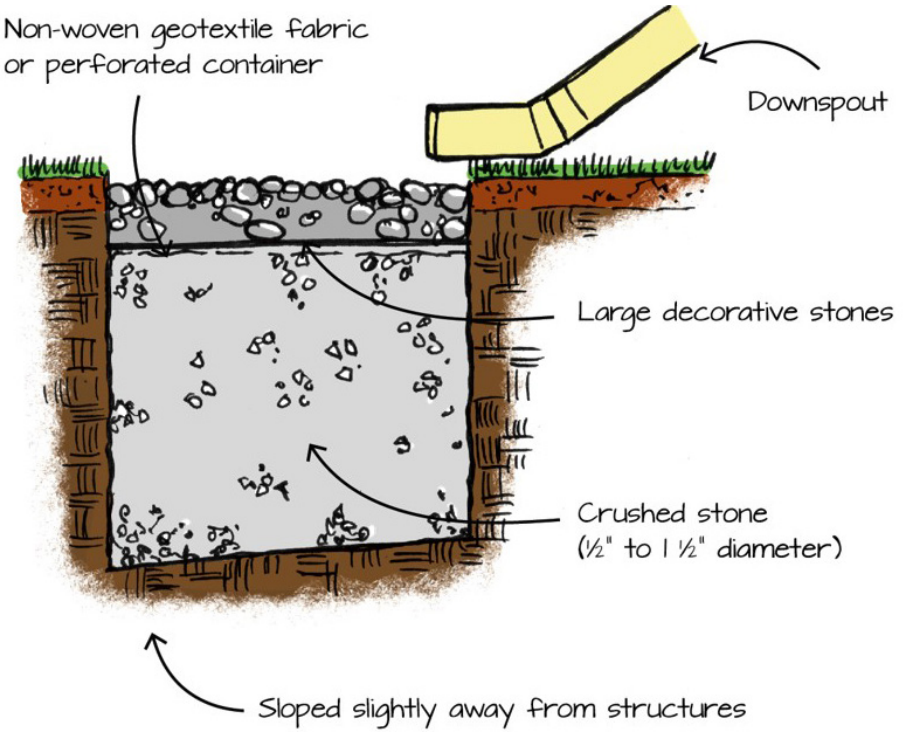
MAINTENANCE

BENEFITS

Slow

Filter

Infiltrate



811

Know what's **below.**
Call 811 before you dig.

INFILTRATION TRENCHES

An infiltration trench is a shallow, stone-lined channel that collects and infiltrates stormwater from impervious surfaces. Before considering this practice, make sure that your soil is well-drained. For instructions, see page 7.

APPLICABILITY

Non-guttered roofs (roof dripline), along driveways, walkways, parking lots, existing drainage paths

INSTRUCTIONS

- For a drip line trench: measure 6″ towards house from drip line and 12″ away from house from drip line. Mark this 18″ wide area with spray paint or string.
- For other trenches: depending on available space, measure a 12″–18″ wide area where stormwater runoff flows. If you are unsure where an area drains, watch the area during a rainstorm.
- Dig an 8″–10″ deep trench in the marked area. Ensure the bottom of the trench is sloped slightly away from any structures.
- If soil is well-drained, line with non-woven fabric, fill the bottom 5″–6″ of the trench with washed drainage stone, add a layer of fabric, and fill the remaining area with large stone.
- If soil is not well-drained, line with fabric, fill the bottom 1″–2″ of the trench with washed drainage stone, add a 4″ diameter perforated pipe (holes pointing up) sloped slightly towards the outlet. Cover pipe with a layer of small washed drainage stone to within a few inches of the top of the trench. Add another layer of fabric, and fill the remaining area with larger washed drainage stone.
- Ensure that the pipe drains to a stable, vegetated area or another GSI practice.

MATERIALS AND TOOLS

- Spray paint or string for marking
- Shovel
- Non-woven geotextile fabric
- ½″–1½″ washed drainage stone
- 3″–6″ washed drainage stone
- Optional: perforated plastic piping

MAINTENANCE

- Inspect structure after rainfall events
- Periodically remove accumulated debris
- Pooling or slowly draining water may indicate clogging
- If clogged, remove and wash all stone and fabric before replacing

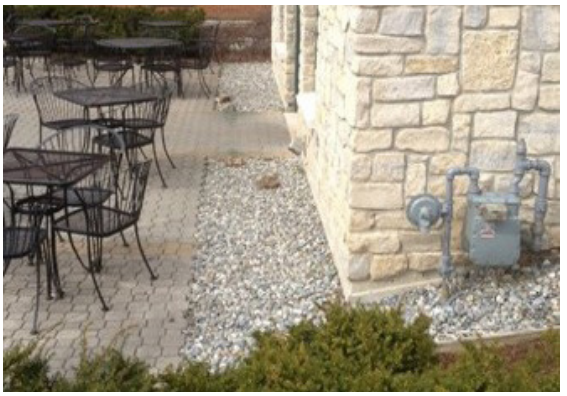
BENEFITS

- Slows, filters, and infiltrates stormwater
- Low maintenance once installed
- Recharges groundwater

LIMITATIONS

- May be hard to implement if space is very limited
- Not a good practice in unstable areas or on steep slopes
- Limited applicability in areas with a high water table

DID YOU KNOW?
Infiltration trenches improve water quality and can be scaled for implementation at small or large sites.



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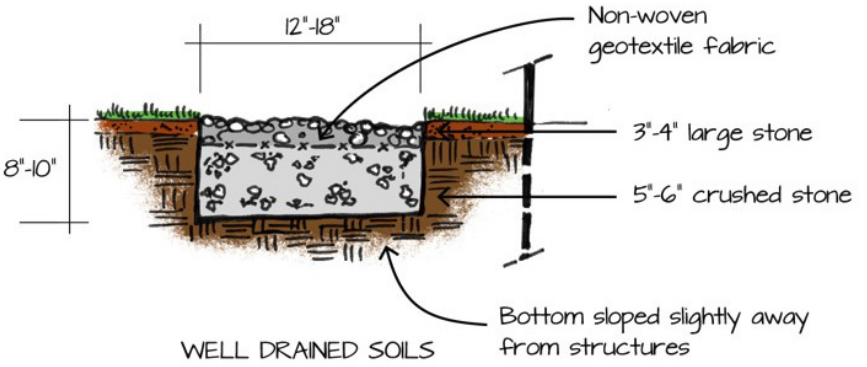
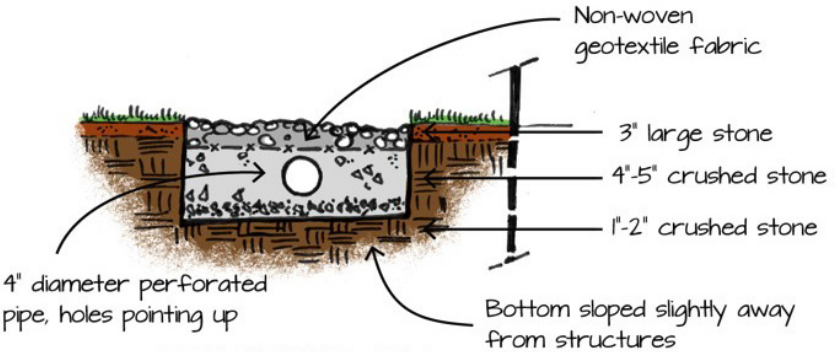
MAINTENANCE

BENEFITS
Slow
Filter
Infiltrate



WELL DRAINED SOILS



POORLY DRAINED SOILS

811
Know what's below.
Call 811 before you dig.

WATER BARS

Water bars intercept water flowing down unpaved paths or driveways and redirect it to stable, vegetated areas. This helps mitigate erosion, prevents sediment from reaching waterways, and slows and infiltrates stormwater.

APPLICABILITY

Unpaved paths, walkways, driveways

INSTRUCTIONS

- Choose location to install water bar(s) based on the site's current runoff patterns. Unsure of where an area drains? Watch the area during a rainstorm.
- Dig a trench at a 30° angle across the path. Extend the trench off of both sides.
- For paths and walkways: Trench depth is dependent on the height of the timber which will be almost flush with the downhill side. Place timber snug and level into the trench. To secure, partially bury large stones on the downhill side. If using rebar stakes, drill one, ½″ hole into the timber, 6″ in from each edge on either side of wood. Pound in stakes until flush. Dig another trench along the uphill side, 1′ wide by ½′ deep, and line with fabric. Leaving a few inches of the wood exposed, fill with washed drainage stone. Build up the downhill side of the water bar until level with the path by backfilling with soil and gravel.
- For driveways: Excavate the trench 6″–12″ below the road's surface. Line bottom of trench with fabric and reinforce with a layer of washed drainage stone. Backfill with soil and gravel along the downhill edge of the trench, creating a berm 6″–12″ above the road's surface.
- Ensure trench outlets to a stable, vegetated area to prevent erosion. Outlet can be reinforced with a flared apron of washed drainage stone.

MATERIALS AND TOOLS

- Measuring tape
- Shovel
- Drill
- Sledge hammer
- Non-woven geotextile fabric
- ¾″ washed drainage stone
- Rot-resistant timber (6″–8″ diameter)
- Rebar or large stones

MAINTENANCE

- Periodically clean of debris
- Check structure after rainfall
- Watch for erosion at outlet

BENEFITS

- Slows, filters, and infiltrates stormwater
- Prevents erosion

LIMITATIONS

- Bars must be well-marked in areas that are plowed so the operator can lift the plow when going over the bars

FOOD FOR THOUGHT

Consider integrating with another practice like a rain garden or vegetated swale where the outlet from the water bar could serve as a source of irrigation.

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BENEFITS

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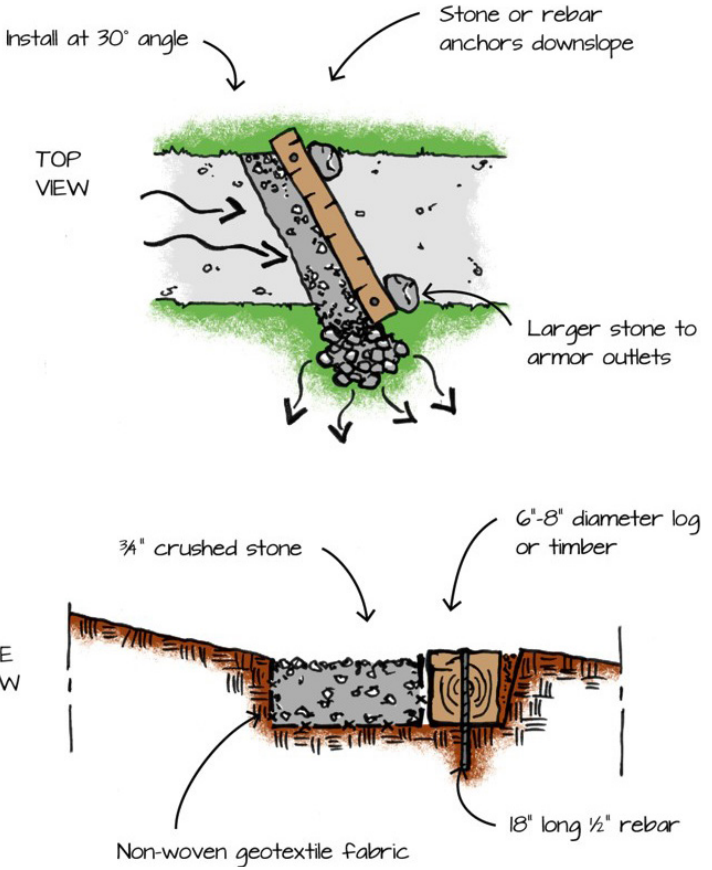

FILTER BERMS

A berm is a mound of earth with gradually sloping sides between areas of similar elevation. Composing the inner portion of the berm with stable, well-drained fill or sand enables this feature to redirect and retain flow while slowing, filtering, and infiltrating stormwater runoff.

APPLICABILITY

Capture runoff from parking lots, driveways, or walkways

INSTRUCTIONS

- Clear the area of vegetation, then remove soil.
- Break up the exposed soil and bring in the fill. Determine the size and shape of the berm with the fill.
- For an average ponding depth of 6″–12″, adjust berm height to between 6″ and 24″. Berm height should not exceed 24″ to ensure maximum drainage within one day.
- Construct the berm's peak so that it is closer to one end, not the middle, as asymmetrical berms offer a more natural shape.
- The slope of the sides should not exceed a 4:1 ratio.
- Spread a 1′ deep layer of topsoil over the fill. Lightly tamp the soil down and smooth the sides of the berm.
- Plant the berm, keeping in mind that although turf grass is acceptable, native trees and shrubbery are ideal.

DID YOU KNOW?
Landscaping your berm(s) improves its structural stability and aesthetic value.

MATERIALS AND TOOLS

- Shovel and rake
- Fill: sand or inorganic clean fill dirt
- Topsoil
- Plants

MAINTENANCE

- Check after every rainfall
- Periodically clean of sediment and debris
- Mow if vegetated with turf grass

BENEFITS

- Slows, filters, and infiltrates stormwater runoff
- Simple construction
- Little disturbance to area of implementation

LIMITATIONS

- Cost of topsoil, fill, and plants
- Avoid compaction via use of heavy machinery/equipment
- Difficult to implement in ultra-urban areas

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MAINTENANCE

BENEFITS

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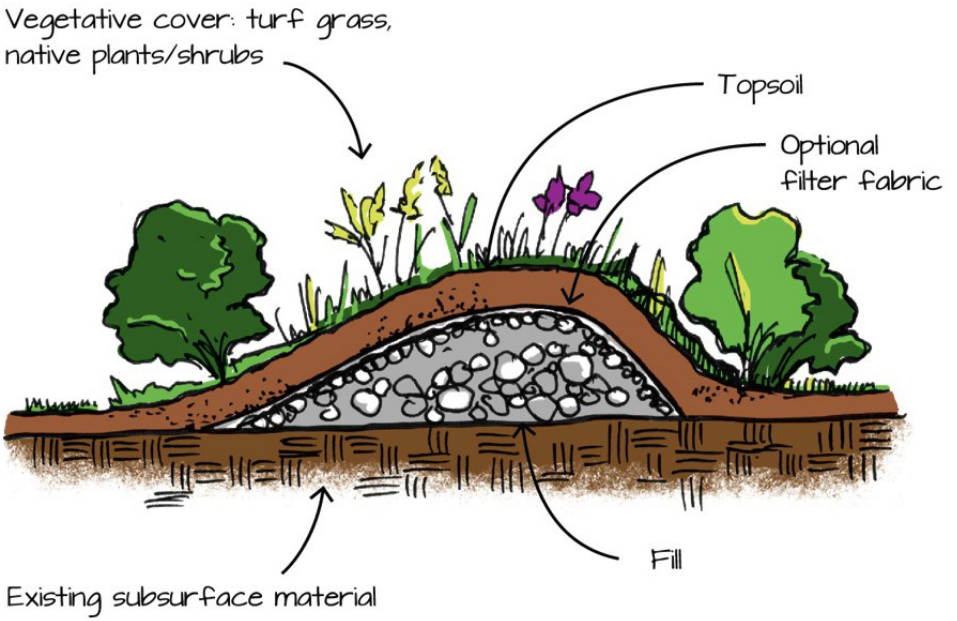

VEGETATED SWALES

Vegetated swales are shallow channels that slow, infiltrate, and redirect stormwater runoff to areas where it can be further treated, infiltrated, or dispersed. They slow and clean stormwater using native plants and check dams (optional).

APPLICABILITY

Driveways, walkways, parking lots

INSTRUCTIONS

- Swales should be located where stormwater runoff flows. Oftentimes, this is along driveways or parking lots.
- Slope swales for a 1″ grade change per foot towards where the water should be draining. If your swale slope is fairly steep, consider installing check dams (see next page).
- Dig out the trench to approximately 1’ in depth, with a flat center. Slope the sides away from the center (1–4% slope). The deepest part of the center should be approximately ⅓ the width of the sides. Swale size can be tailored to best fit your property.
- Armor the inlet to the swale with washed drainage stone piles to prevent erosion.
- Plant the swale with native plants that are tolerant of both wet and dry conditions, and of salt if the swale is near a driveway or parking lot.

TIP
Direct runoff away from swales until plants are established.

MATERIALS AND TOOLS

- Native plants
- Shovel
- Washed drainage stone for armoring inlet
- Optional: stone, sand bags, gravel bags, or fiber rolls for check dams
- Non-woven geotextile fabric

MAINTENANCE

- Periodically clean swale and check dams of sediment and debris
- Maintain plants

BENEFITS

- Slows, filters, and infiltrates stormwater
- Improves site aesthetics

LIMITATIONS

- Limited capacity to infiltrate water from larger storms depending on soil

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MAINTENANCE

BENEFITS

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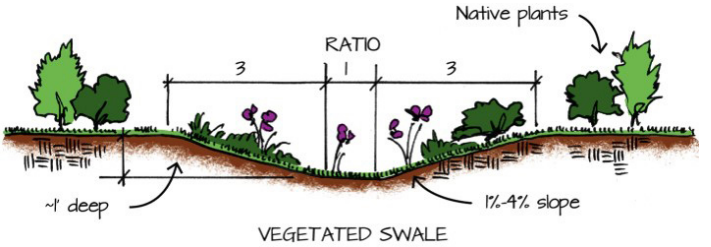
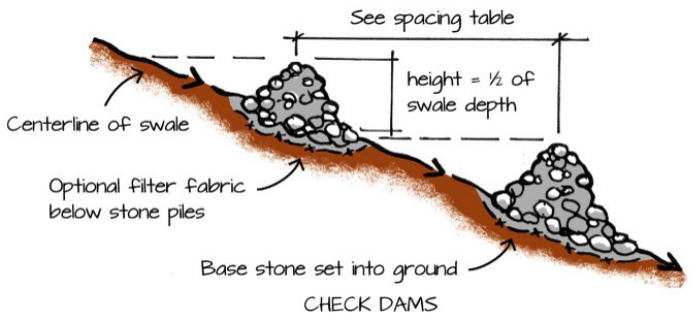


WHAT ARE CHECK DAMS?

Check dams are stone piles, fiber rolls, or sand or gravel bags placed in a swale that allow stormwater ponding. This encourages infiltration and prevents erosion. Uninfiltrated water flows through the porous material slowly and is filtered by the material. Do not use check dams on >8% slopes, nor should hay bales be used as dams.



SWALE SLOPE (%)	CHECK DAM SPACING (FT)
1	200
2	100
4	50
6	30
8	25

TO INSTALL:

- Determine check dam spacing (see table above, right). Check dam height should be no more than ½ swale depth.
- If using stone, excavate a trench and place stones. Optionally, line trench with non-woven geotextile fabric. Place larger stones along the bottom and on the downstream side.
- If using sand or gravel bags, ensure they are tightly stacked.
- If using fiber rolls, dig a trench and secure with stakes.

RAIN GARDENS

Rain gardens are depressed areas with native plants that capture, slow, filter, and infiltrate stormwater runoff. Before considering this practice, make sure that your soil is well-drained. For instructions, see page 7.

APPLICABILITY

Rooftops, driveways, parking lots

INSTRUCTIONS

- Plant rain gardens down-slope from impervious areas. Water can access the gardens either by overland flow or through a pipe or swale.
- Stabilize the entrance to the garden with washed drainage stone to prevent erosion.
- Rain gardens are typically 10–30% the size of the impervious surface draining to the garden.
- For planting, choose native plants that are tolerant of moisture fluctuations. Plants which can tolerate wetter conditions should be planted around the inlet. Similarly, plants which can tolerate drier conditions should be planted farther from the inlet.
- Gardens are typically depressed 4″–8″ from the surrounding ground surface. The bottom of the garden must be flat.
- Ensure that soils are well-drained where the rain garden is to be constructed. Do not construct where water currently ponds, as this indicates low infiltration rates.
- Small amounts of compost can be used around the plant's roots during initial planting, but not throughout the entire garden.

DID YOU KNOW?

In Vermont, adding fertilizers containing phosphorus to your yard is banned unless labeled as a starter fertilizer and applied during the first growing season.

MATERIALS AND TOOLS

- A mix of native plants (for a recommended list, visit: http://dec.vermont.gov/watershed/cwi/green-infrastructure)
- Shovel
- Washed drainage stone for armoring inlet

MAINTENANCE

- Replace plants that fail to thrive
- In very dry conditions, plants that are not drought tolerant will need to be watered
- Weeding

BENEFITS

- Slows, filters, and infiltrates stormwater
- Aesthetically pleasing
- Wildlife habitat

LIMITATIONS

- Limited capacity to infiltrate water from larger storms depending on soil-type; well-drained soils are ideal
- Gardens cannot be built in areas with >12% slope
- Limited applicability in areas with a high water table or low infiltration rate
- Do not construct in a tree's drip line as it can cut roots, near septic systems, or within 10′ of building foundations

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MAINTENANCE

BENEFITS

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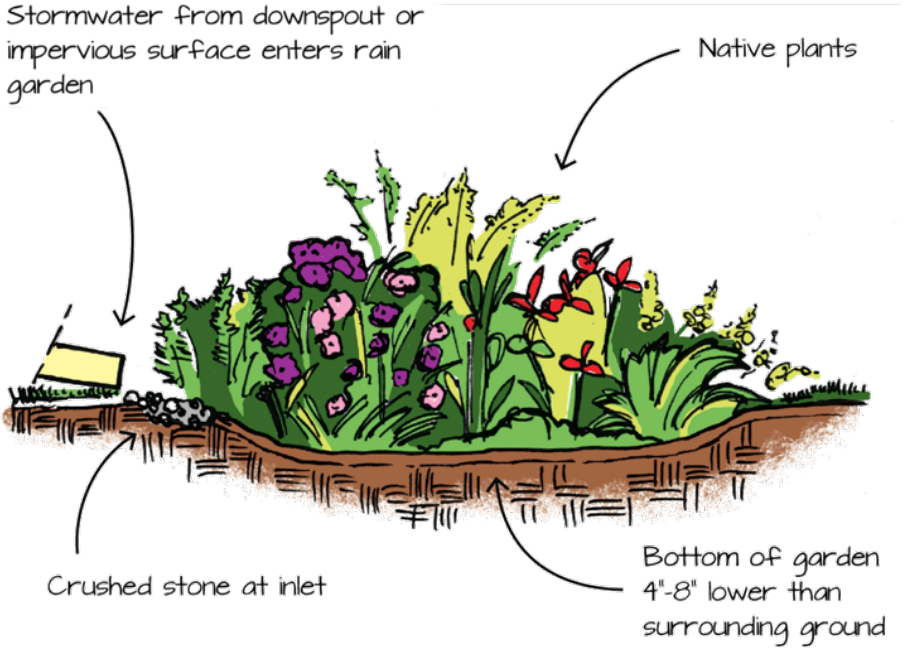


For more information, see the Vermont Rain Garden Manual: http://www.uvm.edu/seagrant/sites/default/files/uploads/publication/VTRainGardenManual_Full.pdf

INFILTRATION STAIRS

Infiltration stairs slow stormwater runoff and promote filtration and infiltration through a layer of washed drainage stone, or pea stone. They can prevent erosion in steep areas. Before considering this practice, make sure that your soil is well-drained. For instructions, see page 7.

APPLICABILITY

Moderately sloped (<45°), unpaved walkways, yards

INSTRUCTIONS

- Measure rise and run of area (see schematic part 1).

  # of steps = (Rise in ft) ÷ (timber width in ft)
  Step tread depth (ft) = (Run in ft) ÷ (# of steps)

- Stake outermost corners. Tie string around stakes to mark staircase area. Use spray paint to mark steps.

- Build from the bottom up. Excavate shallow, level trenches for front (riser) and side timbers. Trenches for side timbers must extend 6″ beyond riser of next stair. Side timbers are not necessary in stable areas.

- Measure and cut timbers. Drill ½″ holes, 6″ in from the ends of each timber. Position riser timber, level it, and drive rebar flush into the holes to anchor. Repeat for side timbers.

- Excavate soil from step creating a surface level with the timber bottom.

- Measure back from the first riser. Dig trenches for the riser and side timbers. Place the riser on the ends of the first step's side timbers. Drill pilot holes 5″ in from both ends of the riser. Anchor by spiking riser into the side timbers of first step. Repeat instructions above to set, anchor, and excavate between the side timbers.

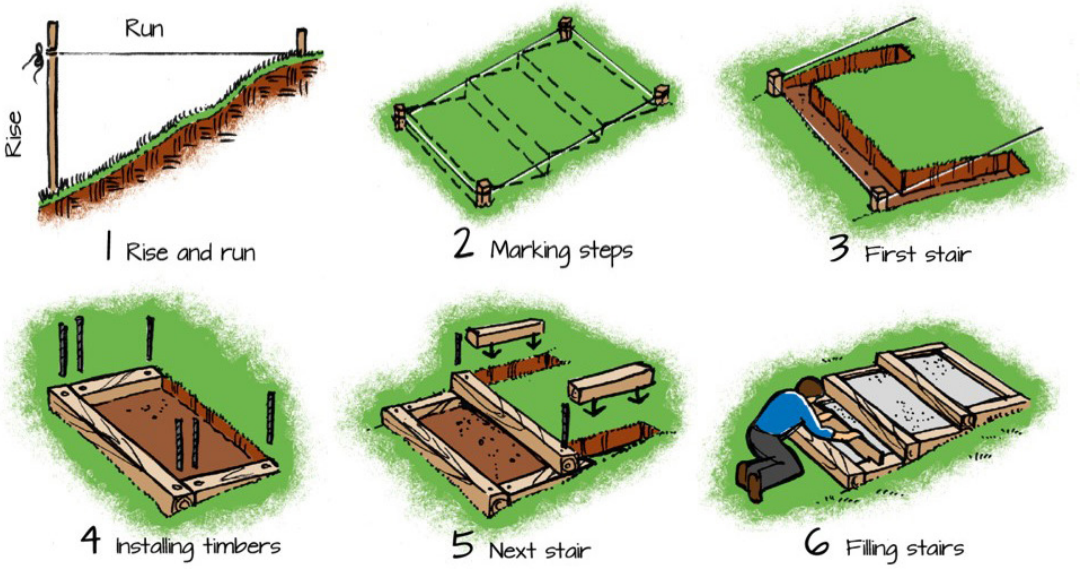
- When installing the last step, cut side timbers 6″ shorter than previous steps.

- Line steps with fabric. Extend fabric 3″ up the sides of the timber. Fill steps with washed drainage stone or pea stone to 1″ below the top of the timbers.

- To further prevent erosion, plant area around the steps. You can place paving stones into the washed drainage stone for a more comfortable walking surface.

MATERIALS AND TOOLS

- Spray paint, tape measure, and string
- Shovel
- Drill
- Hack saw (for sizing rebar)
- Sledge hammer
- Steel rebar (½″ x 18″)
- Galvanized spikes (12″)
- Pressure treated timbers or cedar landscape timbers (6″ x 4′ is a comfortable size)
- Washed drainage stone or pea stone (¾″)
- Non-woven geotextile fabric



DID YOU KNOW?
Existing timber staircases can be retrofitted to infiltrate stormwater runoff.

MAINTENANCE

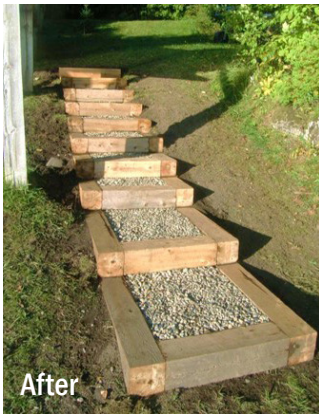
- Inspect after rain events
- Replace timbers if rotting occurs
- Remove and clean stone if steps become filled with sediment

BENEFITS

- Slows, filters, and infiltrates stormwater
- Adds functional set of stairs to your property
- Erosion control

LIMITATIONS

- Not applicable in poorly drained soils
- Moderately difficult to install
- Cost of materials



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BENEFITS
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Infiltrate

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PERMEABLE PAVERS

Permeable pavers allow for treatment of stormwater without requiring additional area. Pavers look like traditional paving stones, but have spaces between and a stone reservoir beneath to capture stormwater. Before considering this practice, make sure that your soil is well-drained. For instructions, see page 7.

APPLICABILITY

Driveways, walkways, parking lots

INSTRUCTIONS

- Excavate 20″ in depth where pavers will be installed. Ensure the bottom of the trench is slightly sloped away from any structures.
- Install a layer of non-woven geotextile fabric.
- If your soil is well-drained, fill the bottom 12″ of the trench with washed drainage stone.
- If your soil is not well-drained, fill the bottom 2″ of the trench with washed drainage stone, add a 4″ perforated pipe (holes pointing up) sloped slightly towards the outlet, and fill the remaining 10″ with washed drainage stone. Ensure the pipe drains to a vegetated area or another GSI practice.
- Add another layer of non-woven geotextile fabric.
- Add 6″ of pea stone.
- Lay the pavers with appropriate spacing. This will depend on the type of paver you choose. The manufacturer will provide recommendations depending on the paver type.
- Fill spaces between the pavers with remaining pea stone.

MATERIALS AND TOOLS

Determine the quantity of materials you will need using the guidance on the next page.

- Measuring tape
- Shovel
- Pavers
- 1½″ washed drainage stone
- ⅜″ pea stone
- Non-woven geotextile fabric
- Optional: 4″ perforated PVC underdrain (for poorly drained soils)

MAINTENANCE

- Sediment should be swept or vacuumed from pavers
- Grass growing between pavers may need to be mowed
- Clean or replace pea stone as necessary

BENEFITS

- Slows, filters, and infiltrates stormwater

LIMITATIONS

- Limited applicability in areas with a high water table or low infiltration rate
- Not recommended for surfaces with >2% slope
- Avoid installing within 10′ of foundations, near contaminated soils, in areas prone to pollutant spills such as gas stations, or near septic systems

DID YOU KNOW?
Permeable pavers can actually last longer than conventional paved driveways and walkways.

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MAINTENANCE

BENEFITS
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CALCULATIONS TO DETERMINE THE AMOUNT OF STONE NEEDED:

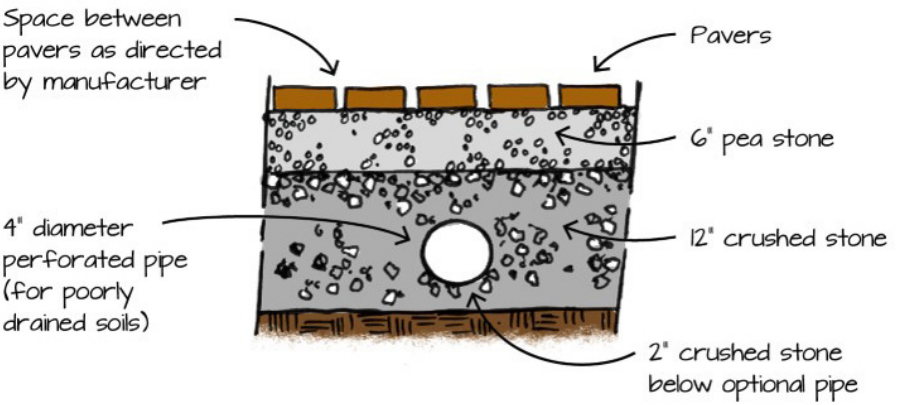
Yards of 1½″ washed drainage stone = (site area in ft^2) x (1 ft) x 0.037

Yards of ⅜″ pea stone = (site area in ft^2) x (0.5 ft) x 0.037

TO DETERMINE HOW MANY PAVERS YOU NEED:

1. Measure the length and width of your project space. Multiply these values to calculate the area.
2. Determine the area of each paver.
3. Use the following equation to determine the minimum number of pavers you will need. Purchase some additional pavers to ensure proper coverage.

pavers = (paver area (in^2) x 0.00694) x project area (ft^2)



GREEN ROOFS

Green roofs utilize conventional roofs to filter and slow stormwater. While green roofs can be installed on any roof, sloped roofs (>10%) or entirely flat roofs (<2%) require extra design considerations. Property owners should consult an engineer or architect prior to installing a green roof.

APPLICABILITY

Slightly-sloped roofs such as garages and sheds

INSTRUCTIONS

- Install a waterproof and root proof membrane over the roof. Heavy duty pond liners are recommended.
- Construct a rot-resistant timber frame around your roof for material containment. Ensure that the frame does not prevent appropriate drainage.
- Cut drainage outlets into the frame to ensure that excess water can drain from the roof. Connect outlets to downspouts directing drainage to a vegetated area.
- Install a layer of lightweight substrate (approximately 4″–6″). Gardening soils are generally too heavy and dense for a green roof installation. Choose soils with a high percentage of low-density inorganic material such as pumice or crushed brick. Do not use fertilizers.
- Plant heat- and drought-resistant plants that can tolerate minimal soil. Consider a green roof seed mix, pre-vegetated plant mats, or installing established plant trays. Plant in the spring or fall to ensure plants receive enough water while establishing.

TIP

Ensure that your roof can support the weight of a green roof. Always consult an architect or structural engineer before installing a green roof.

MATERIALS AND TOOLS

- Waterproof and root proof membrane (heavy duty pond liner)
- Rot-resistant timbers
- Low-density substrate
- Native plants

MAINTENANCE

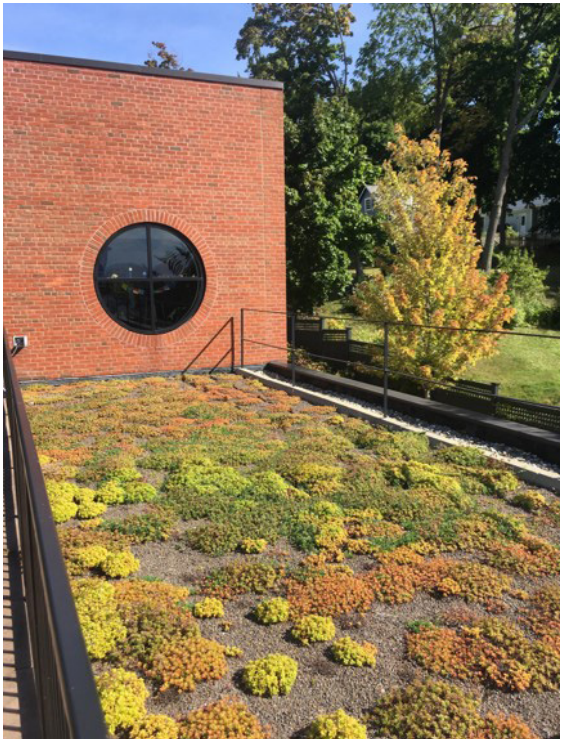
- Plants may need to be watered while establishing
- Replace plants as needed
- Ensure drainage outlets remain clear

BENEFITS

- Slows and filters water where it falls
- Wildlife habitat
- Insulates building
- Aesthetics

LIMITATIONS

- Limited capacity to mitigate stormwater from larger storms depending on soil



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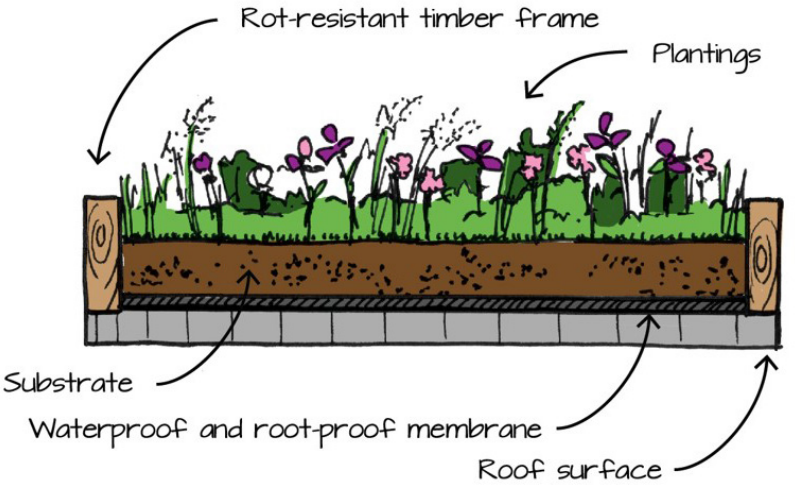


SMALL CHANGES CAN HAVE A BIG IMPACT

You can reduce stormwater impacts from any property, regardless of size or budget. Features such as low and no-mow zones do not require large amounts of space and are free. These low-to-no cost practices can help protect the health of our waterways.

PLANT A TREE

Trees help slow and infiltrate stormwater, require little maintenance after establishment, and improve the aesthetics of your property. Additionally, they provide shade, clean the air of pollutants, and buffer noise.

WASH YOUR CAR ON THE LAWN

Washing your car on the lawn instead of the driveway can prevent detergents and additional water from reaching waterbodies. No lawn? Bring your car to a carwash that properly disposes of sudsy water.

SWEEP, NOT SPRAY

Instead of washing sand and sediment off of your driveway or sidewalk, sweep it up instead. This prevents a large amount of sediment from reaching our waterways.

HOLD THE SALT

Applying chloride compounds to impervious surfaces for de-icing can negatively impact our waterways and wildlife, and can harm plants year-round. Consider using as little salt as possible to get the job done and use alternatives, like sand, for increased traction. Sweep up any unused salt or sand. De-icers like magnesium chloride, calcium chloride, potassium chloride, or acetates reduce the harmful effects of salt while keeping areas clear of ice. Check the label before you purchase.

AERATION

Many lawns are compacted by normal use including the weight of a lawn mower. This compaction prevents rain water from infiltrating well into the soil and degrades grass health. By aerating your lawn with a manual or automated aerator, you can improve lawn health and help manage stormwater.

LOW MOW ZONE

If you have a fairly large property, allowing a “low mow” zone to grow with native grasses and wildflowers will help to slow, filter, and infiltrate stormwater as well as provide wonderful habitat for wildlife. Areas are generally mowed 1–2 times per year (late winter or early fall are best) allowing the grassland to flourish without harming nesting wildlife.

DISCONNECT YOUR DOWNSPOUT

If your roof gutter is draining to a ditch or the stormwater system, you can easily disperse and redirect the water to a stable vegetated area or rain garden (>10′ from your foundation). If the downspout is connected to a pipe in ground, cut the pipe at an appropriate height, add an elbow connection or splash block, and cap the pipe in the ground. Adding gravel or small stones after the splash block can help prevent erosion.

BUFFER BACKYARD STREAMS

If you have a stream running through your property, allow vegetation to grow, and implement a no mow zone around the stream. Make the buffer as wide as possible. This can help filter and slow stormwater, stabilize the banks, and improve wildlife habitat.

SMALL CHANGES CAN HAVE A BIG IMPACT

LET THAT GRASS GROW

By mowing less frequently and allowing your grass to grow to at least 3 inches, you will improve your lawn health and decrease stormwater runoff. Longer grass slows stormwater runoff and allows for deeper and more dense roots. These roots absorb more stormwater and stabilize lawns. As an added bonus, denser grass roots can suppress weeds.

VEGETATE BARE AREAS

Unvegetated areas allow soils to wash off during storms. In addition to degrading water quality, this also increases erosion. Vegetate these areas with native grasses, shrubs, and trees.

FERTILIZE ONLY WHEN NECESSARY

Fertilizers are often over-applied to lawns and gardens. Test your soil to determine how much fertilizer is needed, and only use that amount. This prevents excess nutrients from causing algal blooms in our waterways. Remember, it is illegal in Vermont to apply fertilizers containing phosphorus after the first growing season.

PET WASTE

Pet waste can contribute bacteria, parasites, and viruses to our waterways. Make sure to always pick up after your pets, and place wrapped pet waste in the trash or unwrapped waste in the toilet. Never put pet waste in storm drains. You can also bury pet waste as long as it is at least 5″ deep, and away from waterways and vegetable gardens.

KEEP STORM DRAINS CLEAR

Leaves, lawn clippings, tree branches, and other yard waste can clog catch basins and stormwater conveyance pipes, causing backups and flooding. Also, excess decomposing yard waste can negatively impact aquatic life, so do not dump it near streams. Instead, take yard waste to a local transfer station or composting facility.

GO NATURAL

Instead of using pesticides and herbicides to manage weeds and pests, use natural methods. Pesticides and herbicides can wash off during rain and flow into our waterbodies, which can harm plants and animals. Try traps, barriers, natural repellants, soaps, beneficial insects that prey on pests, or integrated pest management methods.

KEEP YOUR CAR IN SHAPE

Make sure your car, truck, boat, or other machinery or equipment is not leaking by inspecting them regularly. If you find leaks, repair them promptly. Properly dispose of oil or engine fluids, and clean up any spills with kitty litter or sand. Ensure these harmful chemicals are not reaching our waterways.

REMOVE EXCESS IMPERVIOUS

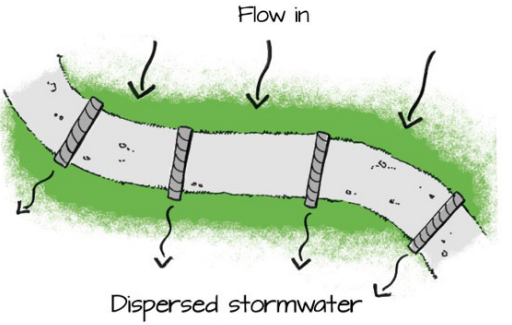
If there are any impervious areas around your property that you do not need or no longer utilize, remove and revegetate them. Restoring these areas will decrease the amount of stormwater runoff draining from your property.

STRATEGIES FOR RURAL DRIVEWAYS

Many Vermonters live in rural areas where long, gravel and dirt driveways are common. Unpaved driveways generate stormwater runoff by altering and concentrating natural runoff flow paths. This releases and transports sediment and nutrients into waterways. Implementing proper drainage systems for these driveways can be challenging. These strategies can help you manage your rural driveway.

DITCH RELIEF CULVERTS

Sloped driveways climb across inclines rather than directly upwards. This maintains safe driving conditions, but intercepts dispersed stormwater. Install culverts to transport concentrated runoff under the driveway. Frequently spacing culverts allows runoff to remain distributed throughout an area, lessening erosive forces.



INSTRUCTIONS

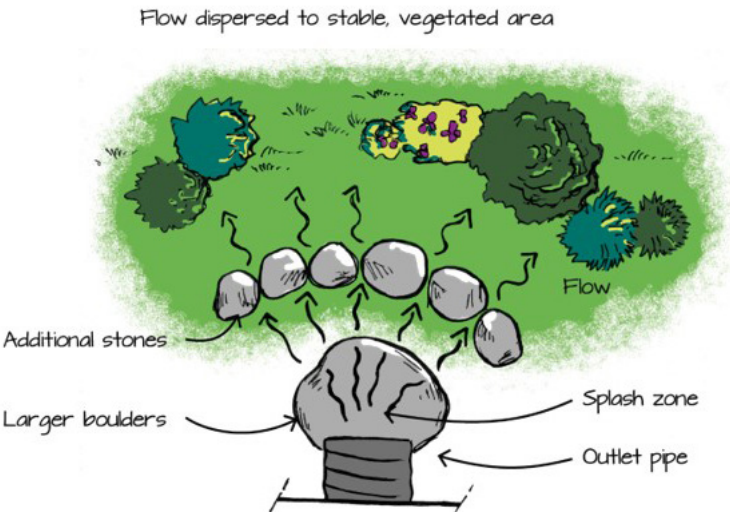
- Install drainage culverts under your driveway as shown in the table to the right.

RURAL GRADE (%)	1	2	5	10	15	20	25	30	40
DISTANCE BETWEEN STRUCTURES (FT)	400	250	135	80	60	45	40	35	30

- Direct runoff to stable, vegetated areas like another GSI practice.

DIFFUSER

Improperly managed culverts can cause erosion. Diffuser structures installed at the end of a culvert slow runoff and disperse flow. Diffusers are composed of larger boulders (≥1′ diameter field stone) and additional, smaller stones such as rip rap (material used to armor areas vulnerable to scour and erosion).



INSTRUCTIONS

- Place larger boulders under the end of culvert in the splash zone.

- Place additional, smaller stones a few feet downstream, perpendicular to the flow. This will create a perforated “wall” through which the runoff can be distributed.

DRIVEWAY SHAPING

To prevent erosion, flowing water should be directed off driveway surfaces as quickly as possible. Properly graded driveways have a crown (high point) to do this. Crowns are generally located in the middle of the driveway, although a high point can be established on either side. See cross-sections below. Additionally, water bars can direct runoff away from driveways. See page 23 for water bar instructions.

INSTRUCTIONS

Grade your driveway based on one of the following cross-sections. Shaping is site-specific and any of these variations will direct flow off your driveway.

CROWNED DRIVEWAY
High point in the center

IN-SLOPED DRIVEWAY
High point on outside edge

OUT-SLOPED DRIVEWAY
High point on inside edge

DRIVEWAY SURFACE STABILIZATION

Material used on driveway surfaces impacts stability and susceptibility to erosion (see photos below). Aggregate materials such as unprocessed bank gravel can be used to increase structural stability of driveways. For optimal erosion resistance, use processed ledge or clean bank material like Stay-Mat or SurePack. Once compacted, these materials form a highly durable surface that can be graded and can resist erosion.

INSTRUCTIONS

Resurface your driveway with unprocessed bank gravel, processed ledge, or clean bank material.

Unsuitable road surface

Unprocessed bank gravel

Processed ledge or clean bank material

NOTES

Use this page to sketch out the practices you would like to implement on your site.

OTHER GREEN PRACTICES BEYOND THE SCOPE OF THIS GUIDE

AGSTAR
AgStar with the U.S. EPA promotes the use of biogas recovery systems, helping to identify project benefits, risks, options and opportunities for those who wish to purchase or implement anaerobic digesters. https://www.epa.gov/agstar

ENERGY STAR
A joint program of the U.S. EPA and the U.S. Department of Energy designed to protect the environment by using energy efficient products and practices. http://www.energystar.gov/

ENTERPRISE GREEN COMMUNITIES
Enterprise Green Communities with Enterprise Community Partners is a nonprofit organization focused on affordable housing who works with state and local governments to develop sustainable housing and economic development policies by providing funding and technical expertise. http://www.enterprisecommunity.com/solutions-and-innovation/enterprise-green-communities

E3: ECONOMY, ENERGY, AND ENVIRONMENT PROGRAM
Comprised by the U.S. EPA and other federal agencies, E3 works to provide customized assessments supporting manufacturers in reducing pollution and energy use while continuing to increase profits and create new job opportunities. https://www.epa.gov/e3

GREEN VEHICLE GUIDE
A U.S. EPA-developed guide which provides information to the public on those vehicles which are more efficient and pollute less; examples include electric, plug-in hybrid electric, and fuel cell vehicles. https://www.epa.gov/greenvehicles

LEED CERTIFICATION
This green building certification program encourages and accelerates global adoption of sustainable green building and development practices through a suite of rating systems that recognize projects which implement strategies for better environmental and health performance. http://www.usgbc.org/

OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY (EERE)
With the U.S. Department of Energy, EERE offers financial assistance to businesses and organizations to develop and demonstrate the use of renewable energy and energy efficient technologies. http://energy.gov/eere/office-energy-efficiency-renewable-energy

SAFER CHOICE
Created by the U.S. EPA to provide a chemical standard which certain products must meet in order to reduce health risk to people and prevent environmental pollution. https://www.epa.gov/saferchoice

SIGNIFICANT NEW ALTERNATIVES POLICY (SNAP)
Part of the U.S. EPA's Clean Air Act. Reviews the acceptability of substitutes (aerosols, cleaning solvents, etc.) including environmental and human health impacts to encourage sustainability within industrial sectors. https://www.epa.gov/snap

VERMONT SMALL BUISNESS DEVELOPMENT CENTER (VTSBDC)
Offers free and confidential environmental opportunity assessments to small businesses aiming to identifying ways to conserve energy, reduce waste, and conserve resources. http://www.vtsbdc.org/programs/environmental-assistance

WASTEWISE
A voluntary program run through the U.S. EPA which encourages their partners (businesses, governments, and nonprofit organizations) towards sustainability and waste reduction through recycling and the incorporation of sustainable materials management into their waste handling processes. https://www.epa.gov/smm/wastewise

WATERSENSE
An EPA-sponsored partnership program that seeks to protect the future of our nation's water supply by promoting water efficiency and water-efficient products, programs, and practices. https://www3.epa.gov/watersense/

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