Rain Garden Manual for Vermont and Lake Champlain Basin

Landscape Strategies to Absorb the Storm

Windflower
(*Anemone canadensis*)

Dedication to Roger Bannerman

Authorship of one of the primary references used in development of this manual was led by Roger Bannerman, a 40-year veteran of the Wisconsin Department of Natural Resources. Throughout his career—and following it—Roger worked tirelessly to conduct critical ground-breaking research that improved our understanding of stormwater management techniques that used nature-based approaches. With results in hand, he worked passionately to communicate those in a manner that allowed individuals to take action to protect water quality in a meaningful way. Roger was taken too soon—by cancer—during development of this revised version. As such, we wish to dedicate this manual to him in recognition of his efforts to improve stormwater management in ways that have benefitted people and the environment across thousands of miles.

Acknowledgements

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On the Web

Use this QR code to download a pdf file of this manual from the Lake Champlain Sea Grant website and also to access additional information for various sections of the document. The URL to this website is:
https://www.uvm.edu/seagrant/rain-garden-manual

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Red Osier Dogwood
(*Cornus sericea*)

About this Manual

This manual is developed for homeowners, landscape architects, city planners, or anyone else interested in installing a rain garden to protect local rivers and lakes in Vermont or the Lake Champlain basin of New York. This manual explains the installation process, demonstrates how rain gardens are cost-effective green stormwater infrastructure (GSI) tools, and illustrates how they can be incorporated into a variety of landscapes. "Rain Garden Manual for Vermont and Lake Champlain Basin" also illustrates the importance of reducing the volume of stormwater runoff to improve water quality.

As you consider building your own rain garden, this manual will help you answer questions like:

- How much stormwater might need to be managed on my property?
- Is a rain garden a good solution for managing stormwater on my property?
- Are the soils within my property suitable for soaking up stormwater?
- How do I want the rain garden to look? Similar to a flower bed? A more natural area?
- How much money and labor am I able to put into construction of the rain garden? Will I have volunteers or contractors helping me?
- How much maintenance is required for the rain garden I plan to install and who do I envision doing the maintenance?

This rain garden manual is not a guide for regulatory stormwater management. If you are building a rain garden for permit purposes, refer to the *Vermont Stormwater Management Manual* and *Design Guidance or the New York State Stormwater Management Design Manual*.

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Stormwater 101

How much stormwater might need to be managed on my property ?

The water that falls to the earth as precipitation or that melts from snow, ice, or other type of frozen precipitation is called "stormwater." Stormwater runoff is stormwater that makes its way over the land and enters streams, rivers, lakes, wetlands, and other surface water bodies. Along its journey, stormwater runoff flows across different types of land—like forests, lawns, and the built environment that includes buildings, streets, and driveways. Each one of these land uses has a different ability to absorb the runoff. Figure 1 illustrates some of the ways natural systems help to manage stormwater runoff.

Soil can soak up the water similarly to a sponge. Some soils are better sponges than others. In our towns and neighborhoods, there are a lot of impervious surfaces that don't soak up runoff. Instead, water flows quickly over these surfaces, picking up debris and sediment. Where many impervious surfaces are present, larger amounts of stormwater runoff reach streams in a shorter period of time. This can cause an increase in on-site and downstream flooding (including in nearby basements) and may result in erosion of stream banks, creating additional problems. While stormwater runoff is natural, reducing impervious surfaces and incorporating vegetation into landscaping helps reduce runoff, pollution, and erosion, resulting in healthier lakes and rivers.

Vegetation slows down runoff, spreads it out, and acts as a filter for eroded sediments, debris, and other types of pollution, such as trash, oil or grease drippings from cars, and nutrients like nitrogen and phosphorus, that can be picked up and moved with the runoff. Keeping nutrients on the land instead of letting them flow into streams, rivers, and lakes can help prevent cyanobacteria blooms (sometimes called harmful algal blooms) and protect ecosystem health.

Deeper-rooted vegetation found in tall grass, meadows, and forests does a better job at filtering and soaking up runoff than vegetation found in a lawn that is cut shorter than two inches in height.

Green stormwater infrastructure (GSI) are practices that mimic nature to clean and minimize stormwater runoff on-site. Besides reducing the impact of stormwater runoff, GSI practices also provide many additional co-benefits. They are beautiful elements in our neighborhoods and towns. They provide ecosystem services such as food for pollinators, and habitat for birds and wildlife. Plus, GSI practices such as larger shrubs and trees can provide shading, cooling, and improved air quality.

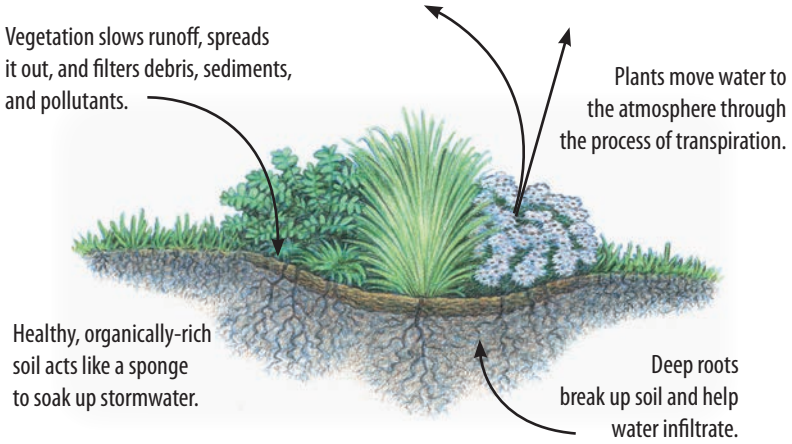


Figure 1

A Holistic Approach

Reduce the need for a rain garden.

Filter and soak in stormwater closer to where the rain falls.

Installing a rain garden is only one of many nature-based solutions you can use to manage runoff on your property. Implementing a diverse suite of GSI practices will disperse stormwater runoff, allowing each individual practice to manage a smaller amount of stormwater runoff. Figure 2 highlights a few other GSI practices you might consider installing on your property. To learn more about these and other GSI options, see the *Vermont Guide to Stormwater Management for Homeowners and Small Businesses,* that you can download from the Vermont Department of Environmental Conservation website.

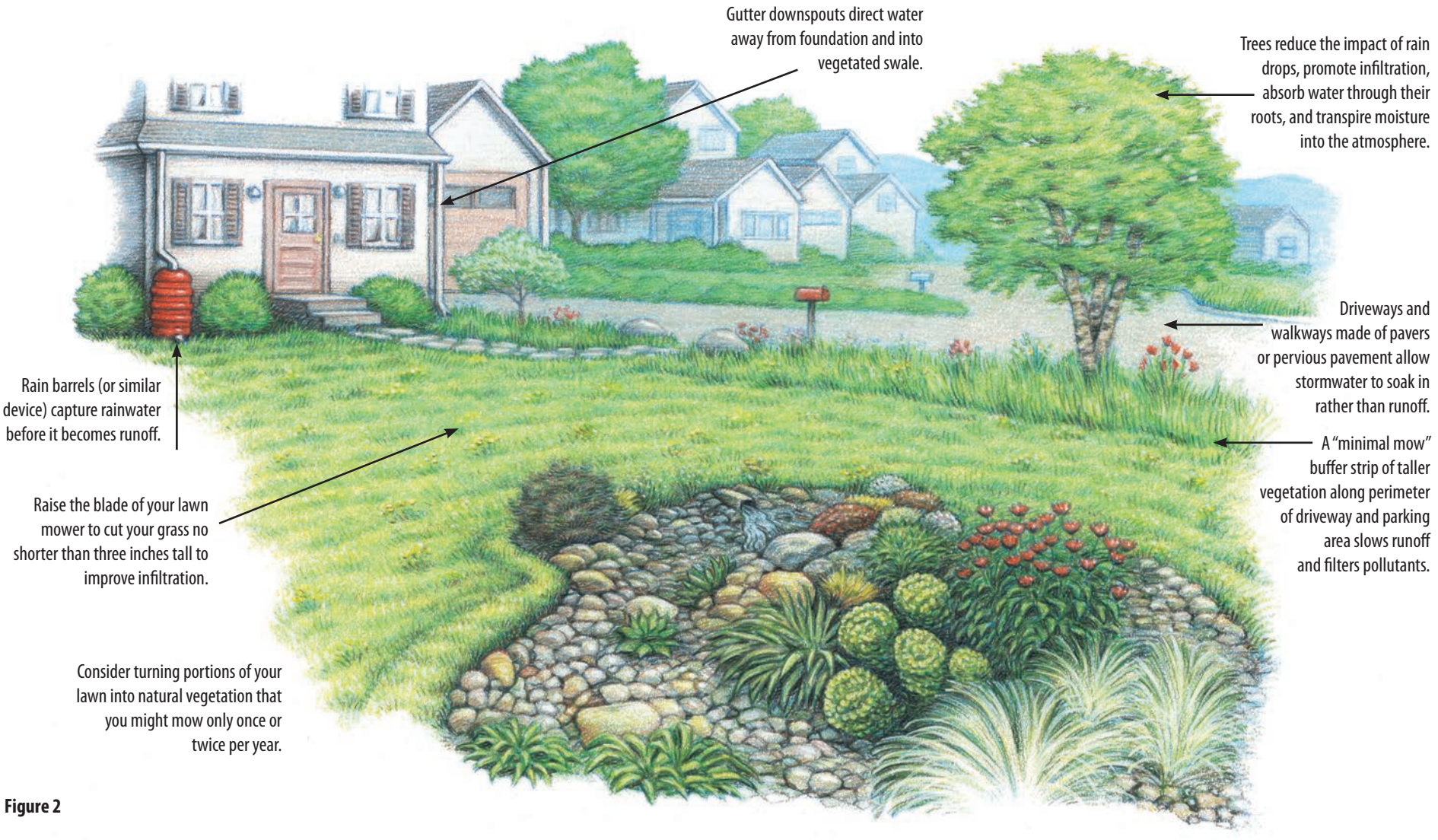


Figure 2

What Is a Rain Garden?

A rain garden is a bowl-shaped garden designed to capture and absorb stormwater runoff by allowing it to infiltrate into the ground much faster than that of a typical lawn. The rain garden's depression temporarily stores runoff, filters it through plant and other organic material, and enables that water to percolate into the ground rather than running off. This is an important part of a larger stormwater strategy of slowing down stormwater runoff, spreading it out, and soaking it in close to where the rain falls on the ground.

Figure 3: Stormwater that soaks into the ground close to where it falls is an important strategy for managing stormwater.

Rain gardens are part of a broader category of stormwater management practices, called "bioretention systems," that capture and treat stormwater runoff from impervious areas. Rain gardens are generally used to treat runoff from smaller impervious areas (generally 10,000 square feet or less), whereas some bioretention systems manage stormwater runoff from much larger drainage areas. Accordingly, these systems are often larger in size and may include underdrains or other advanced engineering features not found in most rain gardens.

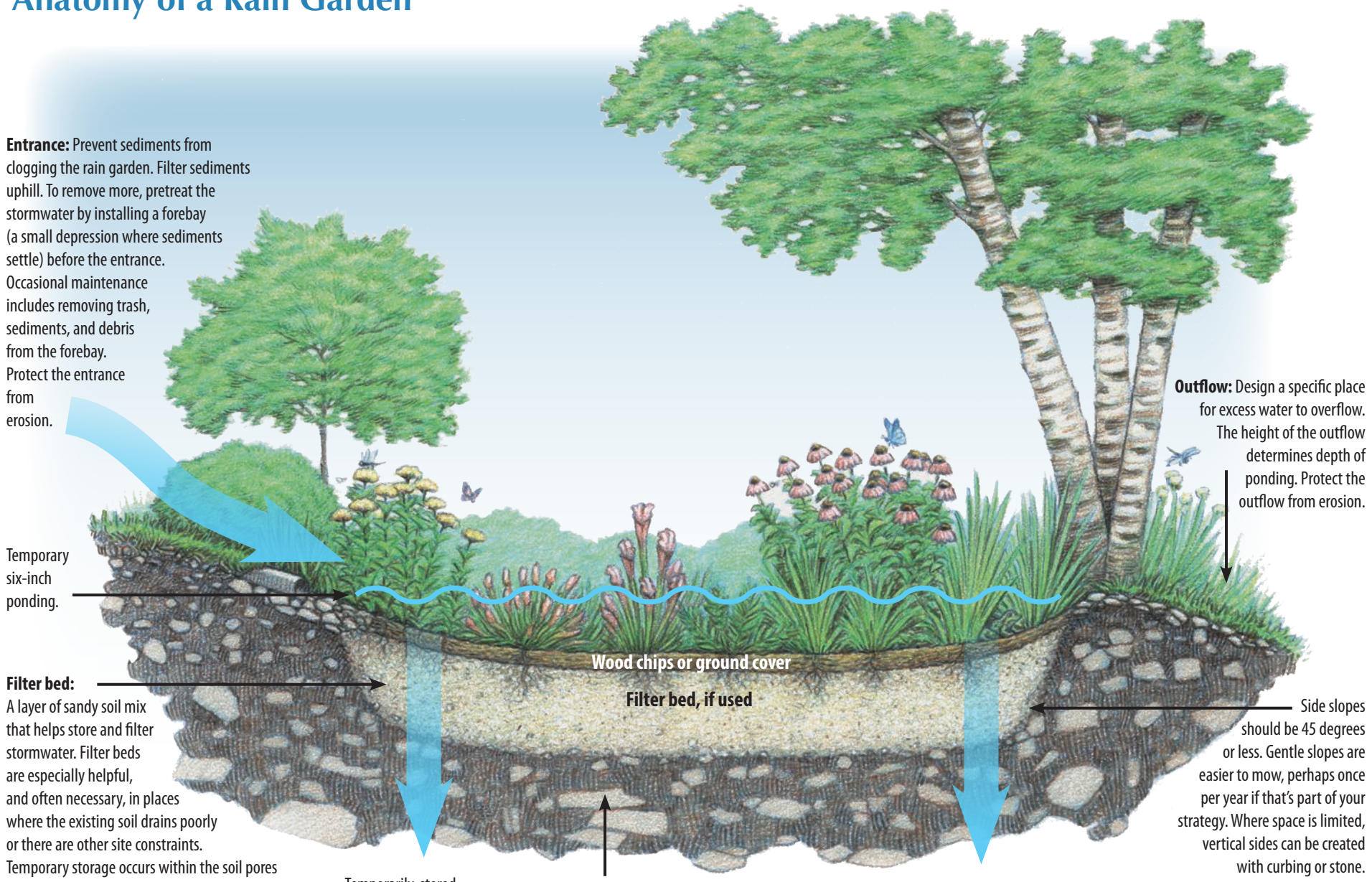
Rain garden at Harwood Union High School, a partnership between Friends of the Mad River, Harwood Union Unified School District, and the Vermont Department of Environmental Conservation. Photo by Marc Companion.

GSI practices that use native plants provide many co-benefits and ecosystem services, such as food for pollinators and habitat for birds and wildlife.

Benefits of a Rain Garden

- Reduces stormwater runoff
- Improves water quality
- Helps control flash flooding
- Removes pollutants
- Easy and inexpensive to install and maintain
- Recharges groundwater
- Provides wildlife habitat
- Helps to sustain stream base flows
- Can be retrofit into existing urban landscapes
- Can be scaled to any size
- Creates a beautiful landscape feature
- Attracts pollinators and birds

Anatomy of a Rain Garden



Entrance: Prevent sediments from clogging the rain garden. Filter sediments uphill. To remove more, pretreat the stormwater by installing a forebay (a small depression where sediments settle) before the entrance. Occasional maintenance includes removing trash, sediments, and debris from the forebay. Protect the entrance from erosion.

Temporary six-inch ponding.

Filter bed: A layer of sandy soil mix that helps store and filter stormwater. Filter beds are especially helpful, and often necessary, in places where the existing soil drains poorly or there are other site constraints. Temporary storage occurs within the soil pores of the filter bed.

Temporarily-stored stormwater soaks into the ground within 24 hours.

Existing soil: Minimize compaction. Healthy biological communities living within plant root zones help reduce the amount of pollutants that reach groundwater.

Outflow: Design a specific place for excess water to overflow. The height of the outflow determines depth of ponding. Protect the outflow from erosion.

Side slopes should be 45 degrees or less. Gentle slopes are easier to mow, perhaps once per year if that's part of your strategy. Where space is limited, vertical sides can be created with curbing or stone.

Figure 4

Climate Change and Rainfall

How will climate change affect rainfall in my area? What stormwater management strategies might I need to handle future conditions ?

Rainfall extremes intensify as the climate warms. Oceans encompass almost 70% of the Earth's surface, and as global temperatures increase, more water will evaporate into the atmosphere from oceans, lakes, and soils. Every increase of 1°F temperature enables the atmosphere to hold 4% more water vapor. This increase in water vapor held by the air is predicted to result in more frequent and heavier downpours, which can amplify the risk and severity of flooding. Data compiled by the National Oceanic and Atmospheric Administration (NOAA) show:

- Temperatures in Vermont have increased more than 2°F since the beginning of the 20th century.
- Average annual precipitation is projected to increase in Vermont over the 21st century, particularly during winter and spring. Corresponding increases in temperature will increase the proportion of precipitation falling as rain rather than snow.
- Extreme precipitation events are projected to increase, potentially increasing the frequency and intensity of floods.

Source: NOAA State Climate Summaries (data through July 2020)

A change in heavy precipitation can be measured by its effect on design storms. Design storms represent the largest storm that a given piece of infrastructure must be designed to withstand within a set time (known as the "return time").

Return Time	Approx. Storm Size in 24 hours
2 years	2.1 to 2.8 inches
10 years	3.0 to 4.0 inches
100 years	5.0 to 6.9 inches

Table 1: Design storms through 2030 / Source: Vermont Climate & Health Profile Report – Building Resilience Against Climate Change in Vermont. September 2016. Vermont Department of Health.

Based on data in Table 1, a storm that brings between 2 and 3 inches of rain in a 24-hour period can be expected to happen statistically about every two years. A storm that delivers approximately 5 to 6 inches of rain in a 24-hour period has a probability of occurring once every 100 years, but that does not mean it will be 100 years before a storm of that size could happen. As climate change intensifies rainfall events, extreme precipitation events like a 100-year storm are likely to happen more frequently.

How Big Should Your Rain Garden Be?

Any stormwater system can be overwhelmed by extreme rainfall events. Because storm intensities are expected to increase in the future due to climate change, you should consider designing your rain garden to handle larger amounts of rain than typically falls today. It is also helpful to incorporate a variety of stormwater management strategies on your property—like those described in "A Holistic Approach" on page 2—to reduce the amount of runoff flowing into your rain garden.

A Roadmap to Design and Build Your Rain Garden

- Rainfall data: how large of a storm will the rain garden handle?
- Identify strategies for soaking in stormwater uphill of the rain garden
- Determine drainage area
- Determine your soil type
- Find the slope of your land
- Determine the size of your rain garden
- Determine the shape of your rain garden
- Design the inflow and outflow location(s)
- Select plants and/or seed mixes
- Make a final rain garden sketch
- Define borders
- Remove grass and sod
- Dig and level the bed
- Plant and/or seed
- Apply ground cover
- Water regularly during year one to help plants become established, and as needed over time
- Inspect after big rains. Maintain and repair as needed throughout the garden's life

Site Assessment and Rain Garden Size

Is a rain garden a good solution to manage stormwater runoff on my property ?

When Selecting Possible Locations...

Try to locate your rain garden so that it collects as much stormwater runoff as possible from impervious surfaces like your roof and driveway. Take advantage of the existing drainage patterns where water already drains naturally, but stay away from places where water ponds for long periods of time. Also, keep in mind these considerations:

- If capturing roof runoff, place the garden at least 10 feet away from the building to prevent potential water seepage into the basement.
- Place rain gardens away from septic tanks and leach fields.
- Place rain gardens away from drinking wells.
- If possible, select a flat area to make installation easier. Ground slopes less than about 8% are recommended.
- Place rain gardens in areas that are not naturally/commonly wet.
- Avoid disturbing tree roots. Trees may be affected by digging and may not be able to tolerate the additional soil moisture.
- Try to find an area with full or partial sun so that the plants you select will thrive.

Safety Considerations

- Call Dig Safe® at 811 or 1-888-DIG-SAFE at least two days before digging to avoid underground pipes and utilities.
- Check for private wiring or underground utilities such as driveway lights and sheds with electricity.

Soak in stormwater uphill of the rain garden. Options include vegetated buffer strips, minimal-mow areas and porous pavement.

Sizing: How Big to Make the Rain Garden (4 Steps)

Is your property able to soak in a two-year storm event?

Your rain garden should be designed to temporarily store stormwater so that it can soak into the ground within 24 hours or less (and certainly not more than 48 hours). As shown in Figure 5, this storage occurs both in the standing water that ponds on the surface of the garden bed and also within the soil pores of the filter bed that forms the bottom of the garden. Note that most plants don't like to be even partially submerged for too long. The sizing calculations in this section use a ponding depth of six inches.

Where the native soil under the rain garden is good at infiltrating water, you can use the native soil as the bottom of the garden (called a "filter bed"). You can reduce the size of your rain garden by adding a blanket of sandy material on top of the native soil to increase temporary storage capacity in the pores of the layer. Another reason to add a sandy filter bed layer would be if groundwater is within two feet below the bottom of the bed. The additional layer can provide a better filter to treat water before it reaches groundwater.

Step 1: Determine the drainage area

The area of land that drains to a water body is called a watershed. Related terms are catchment area and drainage area, which often refer to smaller sub-watershed portions of the larger watershed. One watershed is separated from another watershed by a rise in land elevation. Depending on the landscape, this might be a subtle rise in the land, the crest of a hill, or something as large as a mountain range. Rain or snow that falls on opposite sides of the high point in the land results in water flowing into different watersheds.

Not all watersheds are the same. Some are hilly, while others are flat plains. At our homes and businesses, the area that drains to a common point might include such things as roof tops, driveways, sidewalks and lawns. For example, the drainage area for your rain garden may include a portion of your roof where water flows to the ground either by a gutter and downspout or by water simply dripping from the edge of the roof. Once on the ground, this water might flow over your lawn where it merges with stormwater runoff that falls on part of your driveway.

The volume of stormwater runoff flowing into your rain garden is based on the amount of rain (in inches) falling on the drainage area that captures and directs runoff to the rain garden. This area may contain portions of a roof, driveway, parking lot and other impervious surfaces, in addition to portions of lawn uphill of the rain garden. Note that your drainage area may include area off your property such as a neighbor's land or a part of a sidewalk or street.

Gravel driveways and dirt roads are considered impervious because of their compacted nature.

The impervious surface area draining into the rain garden should not be greater than 10,000 square feet.

Calculate the drainage area by measuring the total surface area collecting stormwater. Sometimes it can be difficult to ascertain the precise boundaries of a drainage area, or accurately measuring its surface area, especially when different parts of the property are involved. Irregular shapes can be measured by breaking the total area into smaller rectangles and adding those areas together. The area of each rectangle is determined by multiplying the length by the width.

(length in feet) × (width in feet) = _____ square feet (drainage area)

Estimating the stormwater that runs off streets, sidewalks, and parking lots can be tricky. It is best to visit the impervious area during a rain event to clearly see the extent of the drainage area.

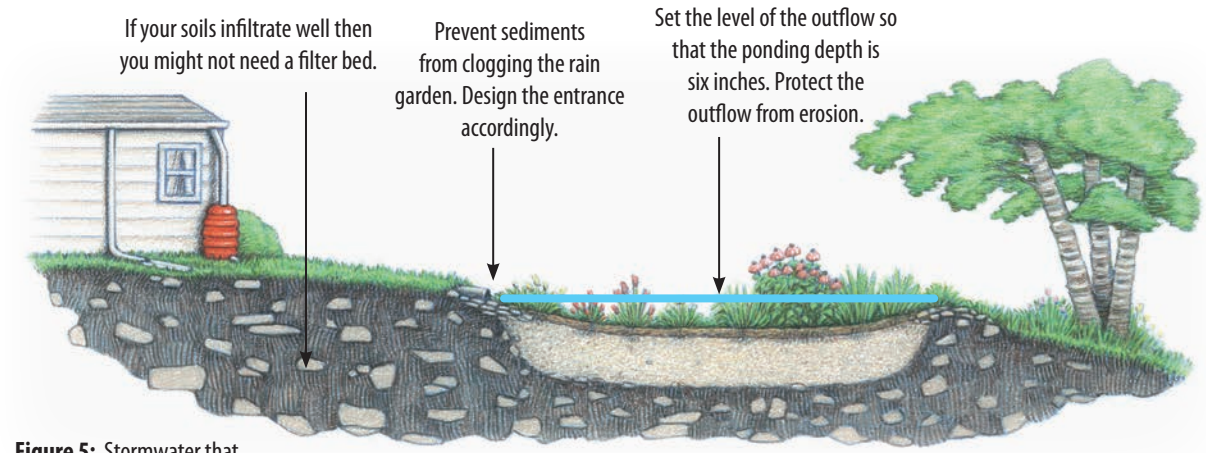


Figure 5: Stormwater that enters the rain garden is temporarily stored in the six-inch ponding depth plus the soil pore spaces of the filter bed (if used).

Step 2: Identify the soil type at the proposed rain garden location

Sandy soils have the fastest infiltration rates; clay soils have the slowest. Since clay soils take the longest to drain water, rain gardens located in such areas must be larger to absorb the same amount of stormwater runoff as other soil types. Soils must infiltrate water at a rate of one half inch (1/2") per hour to be suitable to support a functional rain garden. To determine if the soil type is suitable for a rain garden, perform a **percolation test**. This will enable you to calculate the infiltration rate of the soil in inches per hour.

Sandy soils have the fastest infiltration rates; clay soils have the slowest.

How to Perform a Percolation Test

1. **Dig a hole** at least two feet deep, but closer to three feet if you can. Use a post-hole digging tool if available. The best time to do this is the springtime when the ground is not frozen and the groundwater levels are likely to be highest. Measure the depth of the hole in inches. If there is standing water in the hole, measure how far it is below the ground level. If the standing water is within 24 inches of the ground surface, then you should consider a different location for your rain garden. This is because it's a good idea to ensure there will be enough soil between the bottom of the rain garden bed and the seasonal high groundwater table to adequately filter water percolating downward from the rain garden.

When digging the percolation test hole, if you see standing water within 24 inches of ground surface, find another location for the rain garden.

2. **Fill the hole** with water to just below the rim. Record the exact time you finish filling the hole and begin measuring the time (in minutes) it takes for the water to drain from the hole completely. Convert this time to hours.
3. **Repeat two more times** by filling the hole with water again and measuring the time for water to drain from the hole. The final test will give you the best estimation of the rate at which your soil absorbs water during a series of storms that deliver a high amount of rainfall in a short period.
4. **Calculate the infiltration rate.** Divide the distance the water dropped (in inches) by the amount of time it took to drop (in hours) to get the "inches per hour" infiltration rate for the soil test. If your slowest time of all three tests is less than one half inch (1/2") per hour, then you should dig the hole one foot deeper to see if more permeable soil is further down. Repeat the steps above. If you still don't achieve a minimum infiltration rate of at least one half inch (1/2") per hour, choose a new area for your rain garden if possible and conduct the percolation test there.

Blue-eyed Grass (*Sisyrinchium angustifolium*)

Are there soils within my property suitable for soaking up stormwater ?

Do at least one percolation test in the area where you want to locate your rain garden. Doing two percolation tests in different locations of the planned rain garden area is even better!

After conducting the percolation test, determine what kind of soils you have. An easy way to do this is using the **ribbon test**:

1. Grab a handful of moist soil and roll it into a ball in your hand.
2. Place the ball of soil between your thumb and forefinger and gently push the soil forward with your thumb, squeezing it upwards to roll it into a ribbon about one quarter inch (1/4") thick (like the shape of a pencil).
3. Try to keep the ribbon a uniform thickness and width. Repeat the motion to lengthen the ribbon until it breaks under its own weight.
4. Sandy and coarse loamy soils do not form a ribbon very well. The soil falls apart as you try to roll it into a ribbon. Soils with high clay and/or silt content can be more easily rolled into a ribbon.

Heavy clay soils with low infiltration rate are not suitable for a rain garden without engineering an underdrain.

The soil types best suited for a rain garden are sandy and coarse soils that allow water to easily pass through them—thereby enabling water in infiltrate to deeper depths.

For more information on soils, see the Lake Champlain Sea Grant website:

What Does it Mean if You Have Clay Soil?

Some soils can soak up water better than others. Clay soils generally do not allow water to drain downward into the ground, and as a result, water can pool for a longer period of time. In this case, plants in the rain garden would need to be more water tolerant, and transpiration by the plants becomes a more significant way for water to leave the rain garden, although more slowly.

You may improve the performance of a rain garden in soils with high clay content by placing at least 12 inches of sand on the bottom of the garden to create a filter bed. This layer will store stormwater within its soil pores and reduce the time plants are submerged in ponding water.

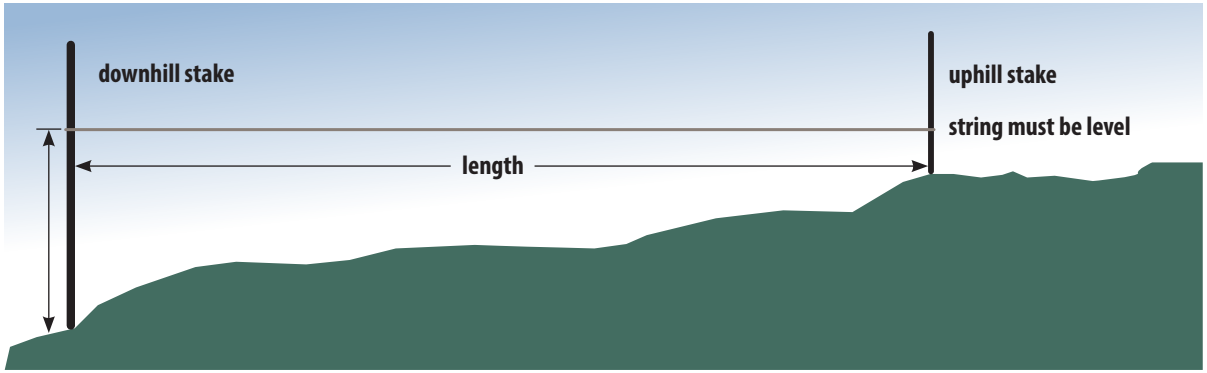


Figure 6: Determine the slope of the landscape.

Step 3: Slope of the land

Calculate the slope of the ground to further assess the suitability of the site for your rain garden. The flatter the land, the better. Slopes less than about 8% are highly recommended, as steeper slopes require more elaborate design and construction. Also, rain gardens built into a slope will require greater excavation into the uphill side to create a flat bottom in the rain garden.

How to Assess the Slope of the Land

1. Place one stake at the uphill end of the rain garden and another at the downhill end as illustrated in Figure 6.
2. Level the string between the two stakes. Measure the length (in inches) of string from stake to stake and also the height of the string above the ground at the downhill stake.
3. Divide the height by the length and multiply the result by 100 to get the slope in percent. If greater than 8% slope, the site may be too steep unless additional design and construction techniques are used.

St. Johns Wort (*Hypericum kalmianum*)

Culver's Root (*Veronicastrum virginicum*)

Step 4: Size (surface area) of the rain garden

The size of your rain garden is based on the volume of stormwater entering the garden and the soil's ability to absorb that water. When it rains, the rain garden will fill with water temporarily until that volume of water soaks into the ground. Table 2 enables you to match your drainage area with the depth of the filter bed material covering the native soil on the bottom of your excavation. A zero-inch filter bed depth means you are using native soil as the bottom of the rain garden instead of adding a filter bed layer. Deeper filter bed depths of 12 inches to 24 inches mean you are adding a layer of sandy material on top of the native soil before planting. Note that you will need to excavate deeper to accommodate a filter bed layer.

Table 2 is adapted from the 2015 Simplified Sizing Tool developed for the design of bioretention systems in Vermont—which includes rain gardens. The table is based on the following parameters:

- A one-inch rainfall event over a 24-hour period
- A six-inch temporary ponding depth of water
- A soil infiltration rate of 1/2 inch per hour

Use your drainage area (calculated in Step 1) and your desired filter bed depth to determine the size of your rain garden. For example, a one-inch rain event falling on a 2,000 square feet drainage area would need a 198 square feet rain garden if a 12-inch-deep filter bed layer is used. Similarly, if you only have a certain amount of space available for the rain garden, you can reverse this calculation to see how thick a filter bed is required to keep the garden the size that you want. If your soils infiltrate well (an inch or more per hour) and groundwater is not too high, then no additional filter bed depth is needed.

Area of Your Rain Garden

Drainage Area (square feet)	Sandy Filter Bed Depth (inches)			
	0	12	18	24
	Area of Rain Garden (square feet)			
500	79	49	42	36
1,000	158	99	83	72
2,000	317	198	167	144
3,000	475	297	250	216
4,000	633	396	333	288
5,000	792	495	417	360
7,500	1,188	742	625	540
10,000	1,583	990	833	720

Table 2: This table is adapted from the Vermont GSI Simplified Sizing Tool for Small Projects, 2015, and is based on a one-inch storm event in a 24-hour period. Consider designing to accommodate a two-inch storm event.

As shown in Table 2, a deeper filter bed reduces your rain garden footprint area. This is because of the increased storage volume within the sandy layer's pores. There can be improved filtering of pollutants as well. If you would like a larger garden, choose a smaller filter bed depth or design your rain garden to manage stormwater runoff from a larger-sized storm.

Accommodating for Climate Change

As mentioned in "Climate Change and Rainfall" on page 5, it might be wise to design your rain garden for the larger storms anticipated in the future. To do this, simply multiply the Area of Rain Garden value in the table by the size of storm (in inches) that you would like to accommodate. For example, to size for a storm that's 1-1/2 inches over 24 hours, multiply the Area of Rain Garden value by 1.5. For a 2-inch rain event, multiply by 2.

Place rain gardens in areas that are not naturally/commonly wet.

Designing the Rain Garden

How do I want the rain garden to look? Similar to a flower bed? A more natural area ?

How your rain garden looks depends a lot on the kinds of plants you use. At one end of the design (and cost) spectrum is to use plants that you have purchased in containers from a nursery. In this scenario, you identify the species desired, arrange them in a particular pattern (such as organized or random), place the plants in the ground, and then water regularly to help them get established. There are many benefits to this approach, but it can get expensive.

Another approach is to use plant seed mixes instead of individual containerized plants. These can be native or locally-appropriate wildflower mixes, wetland restoration mixes, erosion control mixes or a variety of other types of plant mixes available from local nurseries and garden stores. You could also intermix containerized shrubs into the seeded garden if you want.

Finally, you may choose a seed mix of only native grasses to give a more uniform aesthetic, much like an un-mowed lawn. In rain gardens planted with native grasses, maintenance can be as simple as mowing once per year. In rain gardens that contain shrubs and wildflowers, required maintenance will be more substantial.

With that in mind, let's look at the other considerations that go into designing your rain garden.

Step 1: Determine the shape

Your rain garden can be any shape, but it MUST have a level bottom. Shapes that tend to work well are crescent, kidney, oval and teardrop shapes.

Step 2: Determine how to direct stormwater runoff to and from the rain garden

Stormwater will flow downhill by gravity over impervious surfaces like roofs and driveways, through gutters, downspouts and perhaps foundation drain pipes, and over vegetated surfaces like a lawn. **It's usually a good idea to soak stormwater runoff into the ground close to where it has fallen.** A rain chain is an effective and often artistic way to direct water from the roof to the ground in a controlled manner. Piping such as a gutter downspout extension will also direct water to the places you want it to go. Vegetated filter strips move water across the ground surface and also into the ground. To elaborate:

- **Above-ground gutter downspout extensions:** Can be attached to the end of your downspouts to direct water away from the building.
- **Underground PVC and plastic corrugated piping:** Can be attached to gutter extensions and buried to carry stormwater underground. While these materials will last a long time, they can contribute to plastic contamination of the environment.

- **Filter strip:** Increase the effectiveness of your rain garden by adding a vegetated filter strip between any impervious surface and the garden entrance. Another option is to mow this grassy area less so that the existing vegetation is taller. This will help to slow the flow of stormwater runoff, spread it out and allow the vegetation to act as a filter. See "A Holistic Approach" on page 2 for more details.
- **Grass-lined, vegetated & rock-lined swales:** Swales are wide, shallow water pathways that are not as deep or narrow as ditches. Swales should have a continual downward slope toward the rain garden so that water does not pond in the swale. However, the slope should, where possible, have less than a 5% grade to minimize erosion and scouring. If its slope is greater than 5%, then more complicated engineering and installations (e.g., check dams, step pools) are recommended to control the speed and to prevent sediments from clogging the bed or native soils.
- **Pretreatment:** If stormwater runoff is collected from a road or driveway, it is best to pre-treat the stormwater before it enters the rain garden to prevent clogging of the filter bed or native soils. Pretreatment reduces peak stormwater runoff volume and velocity, which, in turn, decreases erosion and increases infiltration. Any pretreatment device should have a surface area about 10% the size of the rain garden's surface area. Some options include filter strips, grass-lined or vegetated swales, and a "forebay," which is a small basin before the inlet of the rain garden that settles out sediments.
- **Entrance to rain garden:** At the point where water enters the rain garden, make sure the area is stabilized with stone or gravel to slow stormwater runoff flow and prevent erosion within the garden. Place hardy plants that thrive in moist conditions where the stormwater enters the garden.
- **Outflow (exit) of the rain garden:** In the case of a larger than normal storm, excess water might overflow from your rain garden. To prevent erosion of soils from your rain garden, it is important to design a specific place for water to exit the rain garden in a controlled manner. Design the rain garden exit on the opposite (downslope) end of your rain garden from its entrance. Place stone or gravel just outside of the rain garden to slow the speed of the water that's exiting. The height of the outflow should be carefully set to maintain a ponding depth at six inches (per the sizing calculations in Table 2 on page 10).

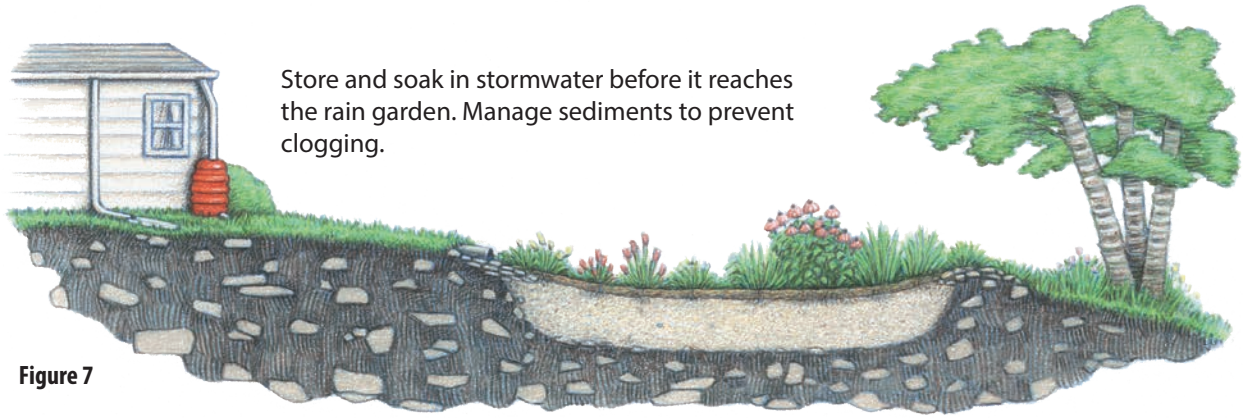


Figure 7

False Indigo (*Baptisia australis*)

Soft Rush (*Juncus effusus*)

☛ A simple and cost effective design is to not add a filter bed if site conditions allow. Instead, a six-inch deep shallow basin in good soil can be planted with native grasses and wildflowers. Gentle side slopes make it easier to mow, perhaps once per year.

Step 3: Select plants

Plants must be able to tolerate the extreme moisture conditions typical of a rain garden, from very wet to very dry. When choosing plants, it is important to remember that rain gardens are not wetlands. Rain gardens mimic upland forest systems. Plants that consistently require wet soils or standing water are not appropriate. Refer to "Selecting the 'Right' Plants" on page 18. For all plants, consider hardiness zone, sunlight and moisture needs, soil type, and whether they are native or not.

For aesthetic value, consider the texture, height, color, and bloom time. A group of three to six species can be repeated randomly throughout the garden to create cohesion and variety of colors. Having different varieties of plants that bloom throughout the season is important, but including non-flowering sedges, grasses, and rushes is essential to create a competitive root matrix for healthy soil.

There are many more plants suitable for Vermont and Lake Champlain basin rain gardens than what is included in the plant list of this manual. To evaluate the suitability of other types of plants, use the following criteria:

A suitable rain garden plant:

1. is greater than six inches in height when mature and does not have low basal leaves (that may cause these plants to struggle when overcome by heavy stormwater runoff flows);
2. can tolerate both wet and dry conditions; and
3. can survive in the local hardiness zone. Refer to the Plant Hardiness Zones in the maps included on the back cover.

Step 4: Draw a rain garden design sketch

Complete a to-scale drawing of the rain garden before breaking ground, as this will help you conceptualize the various aspects of the system. The drawing should include the drainage area, garden location, flow paths to the garden, and a vegetation (or planting) plan.

For examples of design sketches, see the Lake Champlain Sea Grant website:

What About a Rain Garden Along the Road?

If your rain garden will be near a road or driveway, or you are planning a curb cut rain garden that receives water from a gap in curbing, there are a few things to consider. For more information on salt tolerance, plant height, right-of-way, and pretreatment, please refer to the Lake Champlain Sea Grant website using the QR code.

Sometimes front yards visually extend into the public right-of-way along the side of the road or sidewalk. This can be a great place to establish a curb cut rain garden, where runoff drains from the pavement into a residential yard. However, projects like this should be done in consultation with your municipality (town or city). The municipality needs to be contacted to determine whether the proposed rain garden location is on your private property or within the public right-of-way, to clarify whether a permit is needed, to confirm whether there may be conflicts with tree roots or underground infrastructure, and to guarantee that the water flowing from nearby impervious surfaces would actually drain toward the proposed rain garden.

Cost and Labor Considerations

The matrix below will help you determine which kind of rain garden is best for you. It provides a relative comparison of potential costs and the labor effort you might expect to expend for different design elements.

How much money & time am I able to put into this rain garden ?

	Lower Cost or Effort	Medium Cost or Effort	Higher Cost or Effort
Overall project cost and effort 	• **Reduce the need for a rain garden.** • Soak in water with healthy soils. Mow less throughout the property to encourage taller grasses and plants with deeper roots. • Incorporate native seed mixes into your lawn and within the rain garden.	A smaller rain garden that requires less digging and less (or no) sandy filter bed material. Native seed mixes with few potted plants to purchase.	A larger rain garden with more excavation and sandy filter bed material. Many potted plants, shrubs and trees. Hardscape, like stone. Greater maintenance needs like that of a manicured flower bed.
Excavation 	A lower-cost rain garden is one that's in well-drained soils, is small in surface area size, and is shallow (less digging) but is deep enough for six inches of temporary ponding depth.	Volunteer labor versus hiring a contractor affects cost and effort by you.	More digging either because of steeper slope and/or deeper rain garden depth due to clay soils and need for thicker filter bed.
Filter bed 	Existing soil already drains well. No filter bed.	The less sandy filter bed material needed to purchase and transport results in lower cost.	A thicker filter bed of 18 or 24-inches
Plants 	Seed mixes of native grasses and plants.	Some potted plants and a shrub or tree among native grass ground cover.	Extensive use of potted plants, shrub and tree seedlings
Ground cover 	Native grass seed mixes.	Wood chips: a 2- to 3-inch-thick layer.	Rounded stone layer
Maintenance over the years (some is required each year) 	• Use vegetated strips uphill to reduce amount of water reaching the rain garden and to filter sediments that might clog the rain garden bed. • Mow native plants and grasses perhaps only once a year.	A combination of lower cost and higher cost strategies.	Specialty plants that require care. Keeping up with the removal of weed or invasive plants. Frequent removal of sediments. Repairing erosion at inlet or outflow. Rehabilitating a clogged filter bed that no longer infiltrates well.

Table 3: Project Design Matrix – Comparing Options

Compost: When and Where to Use It and When Not

Compost is fantastic for creating healthy soil. It enhances infiltration, which can help rainfall soak into the ground where it lands so that less reaches the rain garden. However, soils that remain saturated may not be places to add too much compost. Emerging research shows that compost that remains saturated in a rain garden can leach nutrients like phosphorus into downstream waterways. Phosphorus is essential for the growth of plants, but in excess amounts can cause water quality problems like harmful algal blooms and beach closings. Since stormwater runoff naturally has nutrients in it, often compost is not needed to enhance plant growth in rain gardens. If you choose to add a bit of compost at planting time, only put a scoop at the base of each plant, where the plant roots can use the nutrients during establishment. This compost can also help hold water at the base of each plant.

Installing the Rain Garden (7 Steps)

A simple rain garden can be a shallow 6-inch-deep basin with flatter side slopes that can be easily mowed, perhaps once a year.

Step 1: Define the borders

Delineate the outline of the rain garden on the ground using string or spray paint. The berm or edging will go outside the string.

Step 2: Remove the grass

To avoid digging through sod, kill the grass first by laying a material such as cardboard, layered newspaper, or a tarp on the lawn for several weeks. Using an herbicide is not recommended as it could harm newly installed plants and pollute waterways and groundwater.

Step 3: Start digging

Remember to call Dig Safe® before you start digging at 811 or 1-888-DIG-SAFE.

Building on a slope: If the rain garden is built on a slope, a berm or low wall on the downhill side is required to impound water within the rain garden. See Figures 8 and 9 on page 16. Create the berm by heaping the soil removed during excavation. The berm height should be level with the uphill side of the garden, therefore making the entire perimeter of the garden the same height. After shaping the berm, compact the berm's soil and cover with sod, ground cover, wood chips or hardscape material such as stones. Use straw or other matting to protect the berm from erosion while the grass or ground cover takes root. **TIP:** Think about where stormwater will go when the rain garden overflows during a very large storm. Design a slight dip in the berm/perimeter to direct potential overflow away from the neighbors' yard or other priority area. Protect this overflow from erosion.

Building on level ground: If the rain garden is built on level ground, the profile of the garden can vary depending on available space and aesthetic preference. If space permits, the rain garden can have gently sloping sides, as in Figure 10 on page 16. Note that soil conditions in the upper slope of this type of rain garden may be too dry for a true rain garden plant to survive, therefore a variety of upland plants might be appropriate here. If there is not a lot of space, then the profile in Figure 11, on page 16, might be appropriate. This design is common in urban settings where a curb cut is used to direct stormwater into the garden. A berm does not need to be constructed in a rain garden that is built on level ground because the stormwater runoff settles into the depression dug for the rain garden. Excavated soil therefore should be removed from the site. Landscaping stone, or other edging can be used to help hold water in the garden as well as to prevent grass from growing into the bed.

Step 4: Level the bed

Try not to compact the native soil on the bottom of the rain garden bed, as this might reduce its ability to infiltrate water into the ground. Make the bottom of the rain garden bed approximately level. Work from one side to the other, or from the center to the outside to avoid standing on soil. Loosen soil with a shovel if it becomes compacted. When the whole area is dug out to the approximate depth (see Table 2, "Area of Your Rain Garden," on page 10) a 2 x 4 inch board can be used to help form a flat and approximately level bottom. When the rain garden is level, rake the soil. **TIP:** Avoid digging and planting under wet conditions, especially when working in clay soils, as disturbing wet soils can result in compaction.

Step 5: Improve the soil

Add compost only around the base of new plant roots. Do not add a layer of compost across the entire rain garden bed. You might also consider having your soil tested to understand its nutrient needs (see "Compost" sidebar on page 15).

Step 6: Plant

Consider using plant seed mixes from a local nursery or garden center. If containerized plants are used, set the plants out in the garden to match your design sketch. When removing the plants from their pots, gently loosen the ball of roots with your fingers before placing them in the ground. This will encourage potted plant roots to grow outward. Add water immediately and deeply after planting, and also regularly during the first growing season.

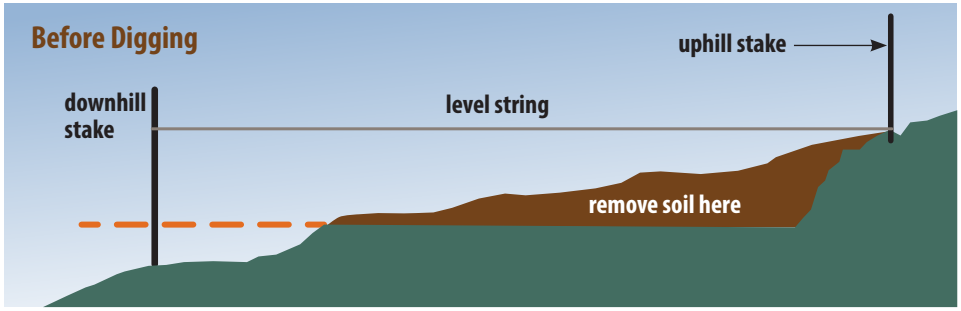


Figure 8: When building a rain garden on a slope, a level string between stakes will help you determine how much soil to remove.

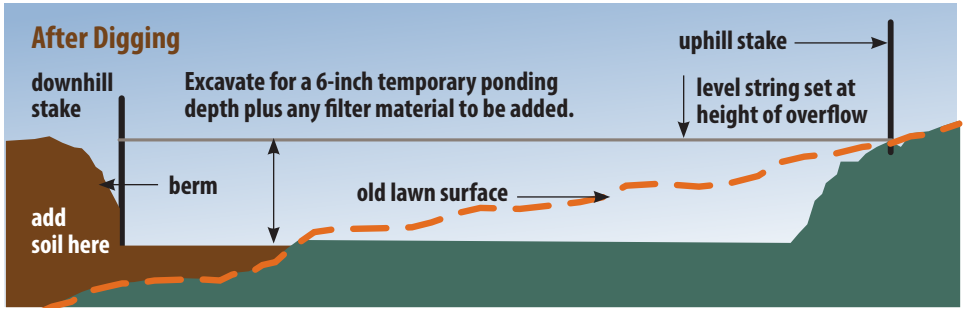


Figure 9: When building on a slope, a berm must be created to hold the water in the garden on the downhill side. When leveling the bed, use the soil that you remove to build the berm.

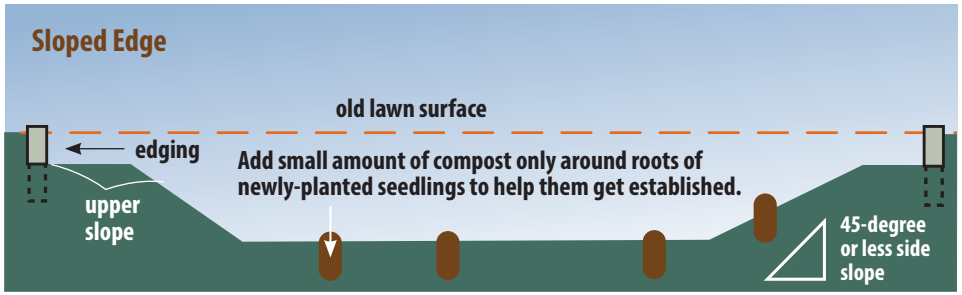


Figure 10: Level bed with sloping edges. This design requires more space. Only plants that can thrive in drier soil conditions can be planted on the upper slope of this type of rain garden; not all rain garden plants will thrive here.

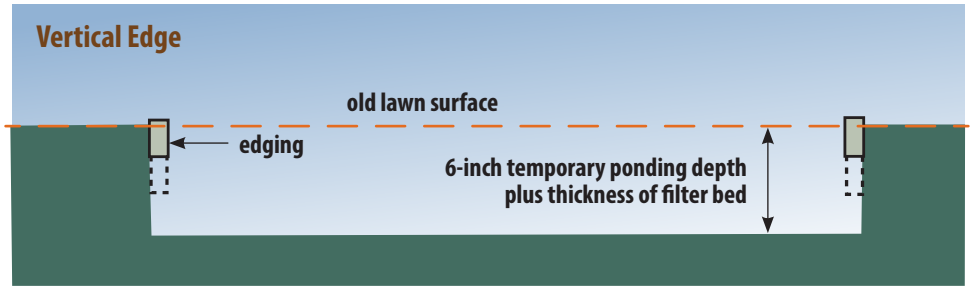


Figure 11: Level bed without sloping edges. Ideal design for tight spaces.

Step 7: Weed suppression: wood chips, grasses, and/or stone

Bare soil can easily become populated with seeds from undesirable plants, especially in the first one or two years after planting, before the beneficial plants get established. A solution is to use a ground cover; native grasses; a layer of wood chips or rounded stone; or a combination of these.

Wood chips: The typical approach in a flower bed is to use bark mulch. This can be okay in a rain garden, but is not recommended because bark mulch floats and therefore can be carried away as stormwater runoff enters the rain garden. A better alternative to bark mulch is wood chips.

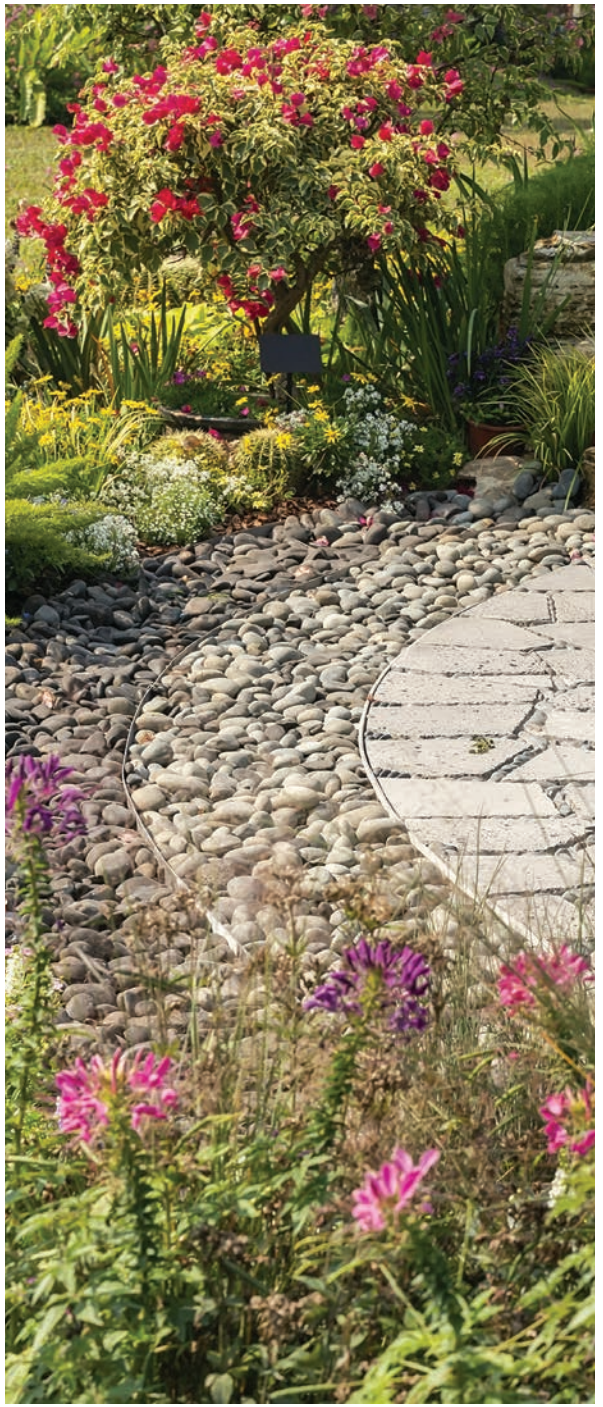
Apply a 2–3 inch layer of wood chips to areas not covered by plants or seeds. A cubic yard of wood chips will cover a 100 square foot area with a layer about three inches thick.

Native grasses and low-growing plants: Once established, a thick carpet of plants can be an excellent alternative to wood chips and a less expensive option than stone. You can plant different kinds of native grasses that will eventually fill in to form a continuous layer that can be effective at suppressing weeds. This will also reduce future maintenance by not having to replace wood chips after the first year.

Stone layer: Similar to the approach with grasses, a thin layer of pea stone (about one half inch [1/2"] in diameter) will form a barrier that suppresses weed growth and adds visual interest. While expensive, rounded river rock of (4–8 inches in diameter) can also be used as an aesthetic feature that helps prevent erosion while allowing plants to grow within the layer. Rounded stones that are relatively uniform in size are preferable to either crushed gravel (which can pack together tightly) or to mixed stone sizes (which can form a dense layer). Make sure that the stone you use is clean, pre-washed and free of dust and fine material that can wash off to potentially clog the bottom of the rain garden—reducing stormwater runoff infiltration ability.

Spotted Cranesbill (*Geranium maculatum*)

For more information on using wood chips in your rain garden, see the Lake Champlain Sea Grant website:



Selecting the "Right" Plants

More than 100 plants suitable for Vermont and Lake Champlain basin rain gardens are listed in this manual and the Lake Champlain Sea Grant website accessed via the QR code. Together, these sources include information about species of ferns, grasses, perennial wildflowers, trees and shrubs. Background information specific to the needs of each type of plant is also included. These plants can be placed in any part of your rain garden with success. However, some plants will be more successful in either the wetter or drier sections of your garden. Therefore, when designing the garden, be aware of each plant's ideal soil conditions and place in the garden accordingly. There are also a wide variety of native plant seed mixes available from local and regional suppliers.

A subset of the larger plant list is shown in Table 4 on page 22.

Native plants

Using species native to Vermont or the Lake Champlain basin is highly recommended when planting a rain garden (or any garden) in this region. Native plants require less watering, fertilizing, and overall maintenance and care as they have adapted to and thrive in this climate.

Salt tolerance

Salt can injure plants by scorching leaf margins, ultimately leading to leaf drop, poor vigor, or death. No plant is immune to salt damage, but some plants are more tolerant than others. Plants may accumulate salt from the soil over many years without revealing any overt sign of the problem until the accumulation reaches a toxic level. In winter, the road salt and ice water solution is whipped into fine droplets by passing vehicles and may be carried considerable distances by the wind. When selecting plants to install along paved roads, sidewalks, or in areas where snow runoff might drain to a rain garden, choose species that are tolerant of salt.

Sun exposure

Exposure refers to the amount of light a plant will receive. Plants assigned "full sun" should receive at least one-half day of sun, meaning at least six hours or more of direct sunlight. Plants assigned "partial shade" should receive full or dappled shade during the hottest part of the day, or 4–6 hours of direct sun. Plants assigned "shade" should be protected from the sun, with little or no direct sun exposure, usually less than two hours per day.

Seasonal interest

In designing your rain garden, plant selection is key to creating an inspiring landscape. Choosing plants that bloom at different times over the course of the growing season gives the garden an ever-changing impact. Some plants may provide a dramatic array of flowers for only a week, while others may carry a smattering of flowers throughout the season. Characteristics such as flower color, bloom time, shape, fruit, decorative bark, dramatic fall foliage color, or showy foliage should be considered when selecting plants. However, remember that neutral plants provide the background and unity for a comfortable yet interesting garden.

Oxeye Sunflower (*Heliopsis helianthoides*)

Blue Vervain (*Verbena hastata*)

Joe-pye Weed (*Eutrochium maculatum*)

Pollinators

Pollinators increase the genetic diversity of a plant community and are therefore an important ally. Many plants have evolved to depend upon the assistance of specific insects and other animals to complete the act of pollination and seed dispersal. ***Nearly 90% of all flowering plants require pollination by animals or insects.*** Plants have developed specific characteristics to attract potential pollinators. Creating a diverse garden that attracts a variety of pollinators will supply a food source for these important animals and insects while enhancing the rain garden. Different pollinators are attracted to specific characteristics of flowering plants:

Bees are attracted to brightly colored flowers with sweet scents and ample nectar and pollen.

Butterflies and moths prefer tubular flowers. Butterflies tend to be attracted to the bright colors whereas moths prefer duller colors (typically red or purple). The difference in colors is likely because butterflies are diurnal whereas moths are nocturnal.

Ladybugs are natural enemies to pesky insects, including aphids and other sap feeders. Like other beetles, ladybugs are attracted to flowers that are white to yellow or green, and open during the day with a bowl/cup-like shape.

Hummingbirds are sight feeders and have little to no sense of smell, thus they are attracted to brightly colored (especially red) trumpet shaped flowers with ample nectar. These flowers are designed to dust the bird's head and back with pollen.

Tolerance to drought

A species' drought tolerance indicates its comparative ability to survive drought stress, or lack of water. Although rain gardens capture and temporarily store stormwater runoff, they can also become dry for extended periods of time when rainfall is low. Well-established plants with deeper roots will help, but you may need to water the rain garden occasionally depending upon the plant species.

Tolerance to poor drainage (particularly important for trees and shrubs)

Poorly drained (wet) sites, often with a percentage of clay, will not allow water to drain freely and can limit the availability of oxygen to plant roots. Choosing species that can survive in this environment will often lead to long term success. Conversely, well-drained sites, often with a high percentage of sand, have very limited water holding capacity and may be too dry for some species if not watered regularly. To determine soil type, conduct the "ribbon test" on page 8 or have your soil tested.

Plant survival depends on numerous factors, but winter temperature is often the greatest challenge to a plant's performance. This is an especially important consideration for trees and shrubs since they are exposed to the winter environment. Before purchasing a plant, determine which hardiness zone the rain garden is located in by referring to the Plant Hardiness Zone maps on the back cover of this manual. Hardiness zones are affected by elevation, snow cover and nearness to large bodies of water. Remember that the hardiness zones represent only averages.

Buying Seed as Lower-cost Option to Potted Plants

Seeding your rain garden with locally or regionally sourced native plant species offers a low-cost option to establish vegetation. Seeding your rain garden, as opposed to planting larger plants from containers, will create a naturalized meadow look with a beautiful mix of wildflowers and grasses. The seeds will establish and organize themselves to create a dynamic rain garden ecosystem. If you are worried about a messy look, defining the edge of your rain garden with a clean mown line, rocks, or a fence will establish it as an intentional and cared-for area. You could even create a sign to explain the function of it! Make sure to buy your native seed mixes from businesses that source seed locally or regionally to help protect native plant communities.

A list of local and regional companies and the seed mixes they provide can be found on the Lake Champlain Sea Grant website:

In some years, temperatures will fall well below the average annual minimum. Plants that have survived and grown well for several years prior may be severely injured or killed when this happens. Talking to experienced neighbors or local nursery personnel may help to ensure you select plants with the highest likelihood of success over time.

Clay soils and shade

Building a rain garden in clay soil in the shade can be a challenge. Few plants can tolerate the extreme conditions found in this type of landscape. The plant lists in this manual and on the website associated with this manual include examples of species and cultivars that have proven to tolerate or even thrive in these conditions.

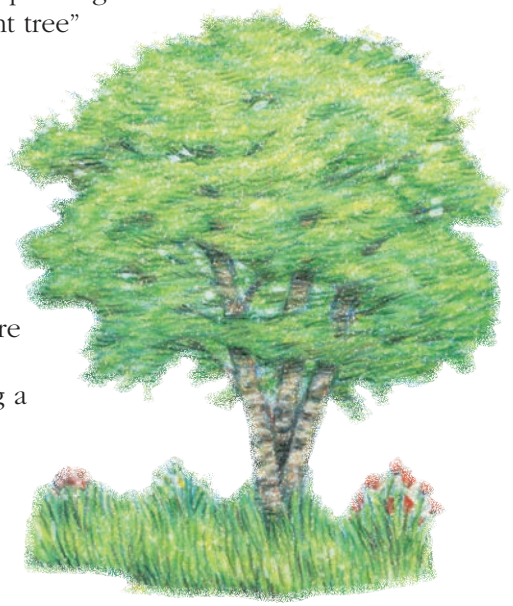
Rooting space (trees only)

Lack of rooting space is one of the most common ailments of urban trees. Heavily compacted soils, underground utilities, sidewalks, and pavement can all affect the amount of soil volume available to a tree's root system. Insufficient soil volume can lead to limited nutrient, water, and oxygen gathering capacity. Trees in compacted soil tend to have a very shallow rooting depth. Even small trees with a mature height of around 15 feet need a minimum of 56 square feet to survive, assuming a three-foot deep rooting area. Take a close look at your rain garden area and measure out the potential rooting space for a tree. The more rooting space that is available to your tree, the healthier it will be.

Is this site appropriate for a tree?

Trees can be a valuable addition to any rain garden. To give your new tree(s) the best chance for long-term survival, proper selection of tree species and planting site is crucial. Careful planning should ensure that the "right tree" is established in the "right place." Consider the following questions, before deciding which tree to plant:

- What is the purpose and use of the planting?
- What are the site conditions above and below ground?
- What type of maintenance will be required?
- What are the best tree species for long-term success?



Rarely will you find the perfect tree that will fit an entire list of selected criteria, but answering these questions can avoid many unforeseen pitfalls. Remember that by planting a tree in or near your rain garden, you may be increasing the amount of shade over the garden area—choose perennials and shrubs accordingly.

Care and Maintenance

How do I plan to maintain the rain garden? Natural-looking spaces may need less maintenance than flower-bed style designs.

?

Keep an eye out: Inspect the rain garden after large storm events and at least monthly for improper water drainage, berm settling, soil erosion, and nuisance and invasive plants.

Water: New plants need to be watered regularly during the first season to help establish the plants, even though the rain garden catches stormwater. Deep watering less frequently is far better than shallow watering more frequently. Deep watering adds at least an inch of water in a single watering session and moistens soil deeper down. In drier conditions, roots will grow deeper to seek out this moisture. Shallow watering, however, wets only the top layers of the soil, which can cause plant roots to grow upward as they seek water. With the roots developing closer to the surface, this makes the plant more vulnerable to drier conditions. Always water plants throughout the first year after planting until they are established. Vermont and Lake Champlain basin-hardy species should be able to tolerate dry conditions on their own afterward.

Water plants with a thorough soaking that allows water to infiltrate deeply and encourages roots to grow downward. Shallow watering causes root growth near the surface, which makes the plant more vulnerable to drought as upper soil layers dry out.

Plants: Look for places to cut away excessive dead plant material from living plants and for species that have died or may need replacement if they are not thriving. Herbaceous perennials should usually be cut back 4–6 inches above the ground at the end of the season. Woody species only need occasional pruning depending on desired aesthetics.

Weeds: Remove weeds by hand pulling. Make sure to remove the entire root. Remove weeds before they flower or go to seed to prevent weeds from seeding themselves. After removal of extensive areas of weeds, consider adding vegetation or ground cover to prevent new weeds from establishing. Not all weeds are invasive species, but you can find a list of invasive species here: https://vtinvasives.org/gallery-of-land-invasives. Always bag and remove any invasive plants. Do not compost them on-site.

Soil: To prevent soil erosion, stabilize settled berms (with stone, quick-rooting species, or ground covers) and replace eroded soils. If the garden is holding water for more than 72 hours, soil compaction may have occurred. Resolve this problem through physical or vegetative methods such as deep tilling, soil amendment, or establishing deep rooted plant species.

Ground cover: If you use wood chips, some maintenance will be required. To maintain the flat-bottomed profile and stormwater holding capacity of the rain garden, covering with a layer of wood chips is suggested only in the first few years after the initial installation. Once the rain garden is established, wood chips may not be necessary, unless a more formal appearance is preferred. When applying wood chips, maintain a 2–3 inch thick layer.

Frequently Asked Questions

Does a rain garden form a pond?

No. After most storms a properly constructed rain garden will absorb water within a period of 24 hours and not more than 48 hours for larger storms, depending on the soil type.

Do mosquitoes breed in the rain gardens?

No. The larval stage of mosquito development occurs in standing water and lasts from 4 to 10 days. Standing water in a rain garden should last only a day or two after most storms, depending upon soil type.

Do rain gardens require maintenance?

Like any garden, occasional watering and diligent weeding will be needed in the first two years. As the garden matures, maintenance requirements will lessen. Plants may need to be thinned after a few years.

Should a rain garden be placed where there is typically standing water?

No. Standing water indicates poor infiltration and/or high groundwater table; directing additional water to these areas is not recommended.

What if there is a dry spell?

Plants suitable for a rain garden can handle both wet and dry conditions. However, during a dry spell it is best to water the rain garden.

Some Tried and True Plants

Name	Height/spread	Native to region?	Zone	Description
Fox Sedge *Carex vulpinoidea*	2' - 3' tall x 1' spread	VT & NY	3	Full sun to part shade, prefers wet soil, but dry soil tolerant, eaten by woodcocks, songbirds, upland game birds.
Windflower *Anemone Canadensis*	1' - 2' tall x 1' - 3' spread	VT & NY	4	White flowers in spring. Spreads well. Likes well-drained soil.
Tall Switchgrass *Panicum virgatum*	3' - 6' tall x 2' - 3' spread	VT & NY	4	July–February bloom, prefers moist soils, full to part sun, cut back in late winter
Cardinal Flower *Lobelia cardinalis*	2' - 3' tall x 18" spread	VT & NY	3	Blooms August–September, full sun, prefers moist soils, can be short lived. Hummingbird and butterfly host.
Swamp Milkweed *Asclepias incarnata*	4' - 5' tall x 2' - 3' spread	VT & NY	3	July–August bloom, full sun, medium to wet soils, attracts Monarch butterfly.
False Indigo *Baptisia australis*	3' - 4' tall x 3' - 4' spread	New England	3	Blooms June–July, nitrogen fixer, deer resistant, salt tolerant, full sun to part sun, tolerant of dry and clay soils.
Boneset *Eupatorium perfoliatum*	4' - 6' tall x 3' - 4' spread	VT & NY	3	July–September bloom, full sun to part sun, butterfly nectar source, prefers moist soils.
Joe-pye Weed *Eutrochium maculatum*	4' - 6' tall x 3' - 4' spread	VT & NY	3	July–September bloom, prefers moist soils, full sun, deer resistant, tolerates clay soils.
Blue Flag *Iris versicolor*	2' - 30" tall x 2' - 30" spread	VT & NY	3	Blooms June, full sun to part sun, prefers moist soils, deer resistant, tolerant of wet soils (rhizome is poisonous).
Spotted Cranesbill *Geranium maculatum*	1' - 2' tall x 18" spread	VT & NY	4	Blooms May–June, spreads vigorously in moist soils, full sun to part sun.
Turtlehead *Chelone glabra*	2' - 3' tall x 18" - 32" spread	VT & NY	3	July bloom, full sun to part sun, prefers moist soils, attracts butterflies.
Beardtongue *temon digitalis*	3' - 5' tall x 18" - 2' spread	US	3	Blooms May–June, full sun, deer resistant, clay/dry soil tolerant.
Oxeye Sunflower *Heliopsis helianthoides*	2' - 3' tall x 2' - 3' spread	VT & NY	4	Full sun to part shade. Yellow flowers bloom July–August. Tolerates some drought and many soil types. Attracts ground bees, butterflies and birds.

Table 4

Name	Height/spread	Native to region?	Zone	Description
Senecio *Packera aurea*	6" - 30" tall x 6" - 30" spread	VT & NY	3	Blooms April, full sun to part sun, prefers moist soils, tolerant of wet soils.
Blue Vervain *Verbena hastata*	2' - 4' tall x 3' spread	VT & NY	4	Full sun to partial shade. Purple flowers June–September. Prefers wet soils.
Culver's Root *Veronicastrum virginicum*	4' - 5' tall x 2' - 3' spread	VT & NY	3	Generally lavender spiked flowers in mid-to-late summer. Attracts bees and butterflies.
Soft Rush *Juncus effusus*	3' tall x 2' spread	VT & NY	2	June–July bloom, full sun to part sun, prefers moist soils (wetland), clump forming.
Winterberry *Ilex verticillata*	6' - 10' tall x 6' - 10' spread	VT & NY	3	Spring bloom, full sun to part sun, red berries in winter, bronze fall foliage. Needs male and female plants to yield fruit. Tolerant of erosion/clay soil/wet soil/air pollution.
Blue-eyed Grass *Sisyrinchium angustifolium*	8" - 10" tall x 12" spread	VT & NY	3	May–July bloom, full sun, self-seeds. Prefers moist to wet soils. Does not like dry conditions.
Red Osier Dogwood *Cornus sericea*	5' - 8' tall x 6' - 8' spread	VT & NY	3	June bloom. Full sun to part shade, prefers moist soil but tolerates dry. Red twigs in winter.
Pussy Willow *Salix discolor*	6' - 15' tall x 10' - 12' spread	VT & NY	4	Wetland plant, large white catkins in spring, fast growth.
St. Johns Wort *Hypericum kalmianum*	2' - 3' tall x 2' - 3' spread	VT & NY	4	Blooms July–August, prefers moist soils, full sun to part sun, salt tolerant, deer resistant.
Elderberry *Sambucus canadensis*	5' - 12' tall x 5' - 12' spread	VT & NY	3	June–July bloom, full sun to part sun, prefers moist soils, can tolerate wet and clay soils, sends out suckers.
Black Chokeberry *Aronia melanocarpa*	3' - 5' tall x 4' - 5' spread	VT & NY	4	Blooms in May, medium to slow growth, edible berries for jam or wine.

Table 4 continued

Glossary

Berm – a built up mound of soil that forms a high point or ridge to contain water.

Buffer – an area of vegetation next to the water's edge that protects water quality by slowing runoff, filtering pollutants and sediment, providing infiltration, and stabilizing shorelines.

Curb cut – an opening in a roadside or parking lot curb that allows the passage of water or people.

Design storm – a storm whose magnitude, rate, and intensity does not exceed the engineered capacity of a piece of infrastructure or system designed to manage stormwater runoff.

Drainage area – the total surface area from where water from rain, snowmelt, or irrigation flows to a common point.

Filter bed – a blanket of sandy material on top of the native soil at the bottom of the rain garden. The filter bed material stores water within its soil pores and filters pollutants that percolate through the layer.

Forebay – a device for capturing sediments before they enter a bioretention system. For a rain garden, the forebay is a small depression about 10% the size of the larger rain garden. Sediments that settle in the forebay need to be cleaned our periodically.

Grass swale – a graded, linear, shallow, open channel covered with grass; used to slow down, spread out, and filter stormwater.

Green stormwater infrastructure (GSI) – a suite of nature-based solutions and practices that restore and maintain natural hydrologic processes in order to reduce the volume and water quality impacts of stormwater runoff.

Ground cover – anything that lies on top of the soil, such as plants, mulch or fabric, that inhibits weeds and protects the soil from drought and erosion.

Herbaceous – plants that do not have woody stems and generally die back and are dormant over the winter.

Impervious surface – a surface that does not allow water to flow through it.

Infiltration – the process by which water enters the soil or other materials.

Native plant – a plant species that has occurred naturally in a particular region, ecosystem or habitat without human introduction.

Percolation test – a test to measure the speed at which water infiltrates into unsaturated soils.

Pollutants – materials and chemicals that have a negative impact on human or environmental health.

Rain barrel – a small collection tank installed at the end of a downspout to collect and temporarily store rain water runoff from a roof for later use.

Rain garden – a planted shallow depression that temporarily holds stormwater runoff from impervious areas until it evaporates, is absorbed by the plants, or infiltrates into the ground.

Runoff – water that flows from impervious surfaces during a rain event, or from pervious surfaces if the precipitation rate is greater than the infiltration rate. Also called "stormwater."

Sediment – soil, rock, or biological material particles formed by weathering, decomposition, and erosion.

Soil ribbon test – a technique used to estimate soil texture and the amount of clay in a soil.

Stormwater – water that originates from rain that can flow over the land, soak into the soil (infiltrate), be stored in ponds and puddles, evaporate, or contribute to surface runoff water that flows over impervious surfaces during rain events. Also called "runoff."

Transpiration – the process of water movement through a plant and its evaporation into the atmosphere from leaves, stems, and flowers.

Vegetated swale – a gently sloping landscaped depression that collects and conveys stormwater runoff from one place to another. It is planted with vegetation that filters stormwater as it flows the length of the swale and allows infiltration of water into the ground.

Water table – the depth at which soils are fully saturated with water.

Watershed – the area of land that drains to a water body.

Black Chokeberry
(*Aronia melanocarpa*)

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Additional Resources

Cornell Cooperative Extension Master Gardeners:
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Essex County, New York at (518) 962-4810 ext. 416
Washington County, New York at (518) 746-2560
Warren County, New York at (518) 668-4881

University of Vermont Extension Master Gardeners:
by phone: 1-802-656-5421
or email: master.gardener@uvm.edu

Vermont Urban & Community Forestry:
http://vtcommunityforestry.org/

Vermont Lakeshore and Lake Wise Part of the Vermont Lakes and Ponds Program:
https://dec.vermont.gov/watershed/lakes-ponds

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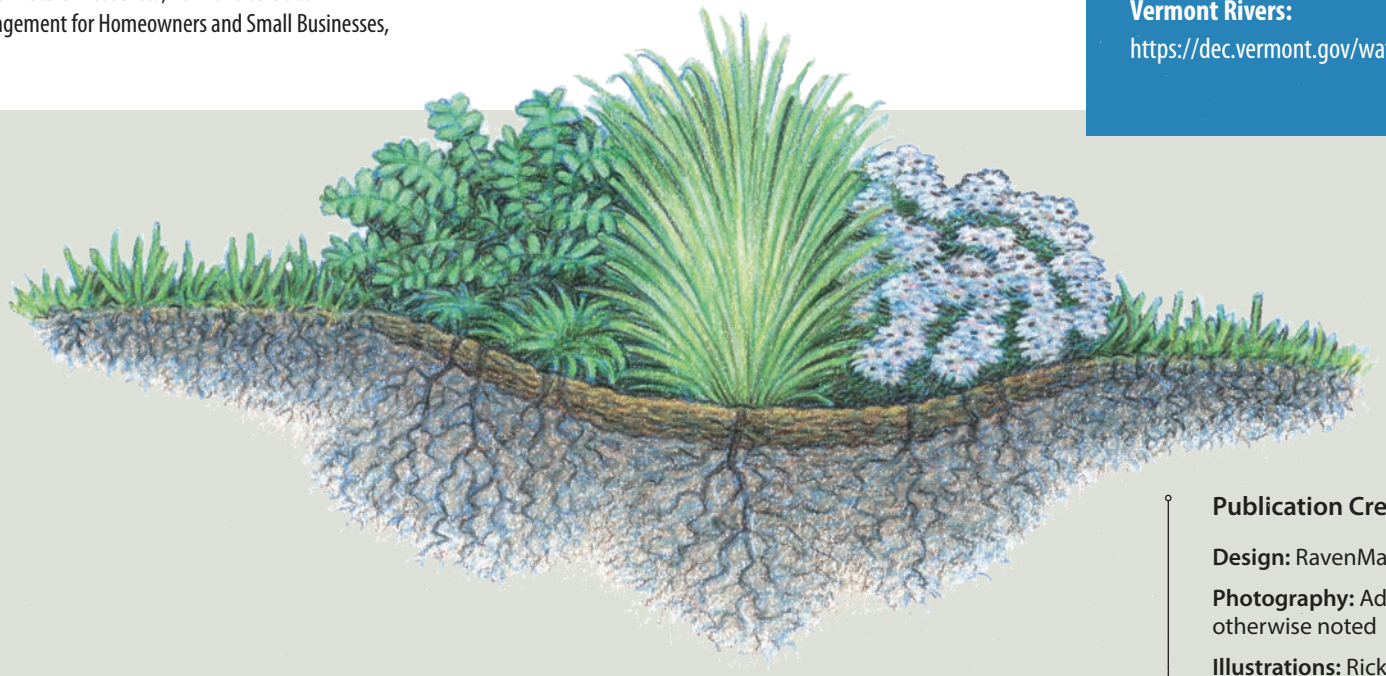
https://dec.vermont.gov/watershed/rivers



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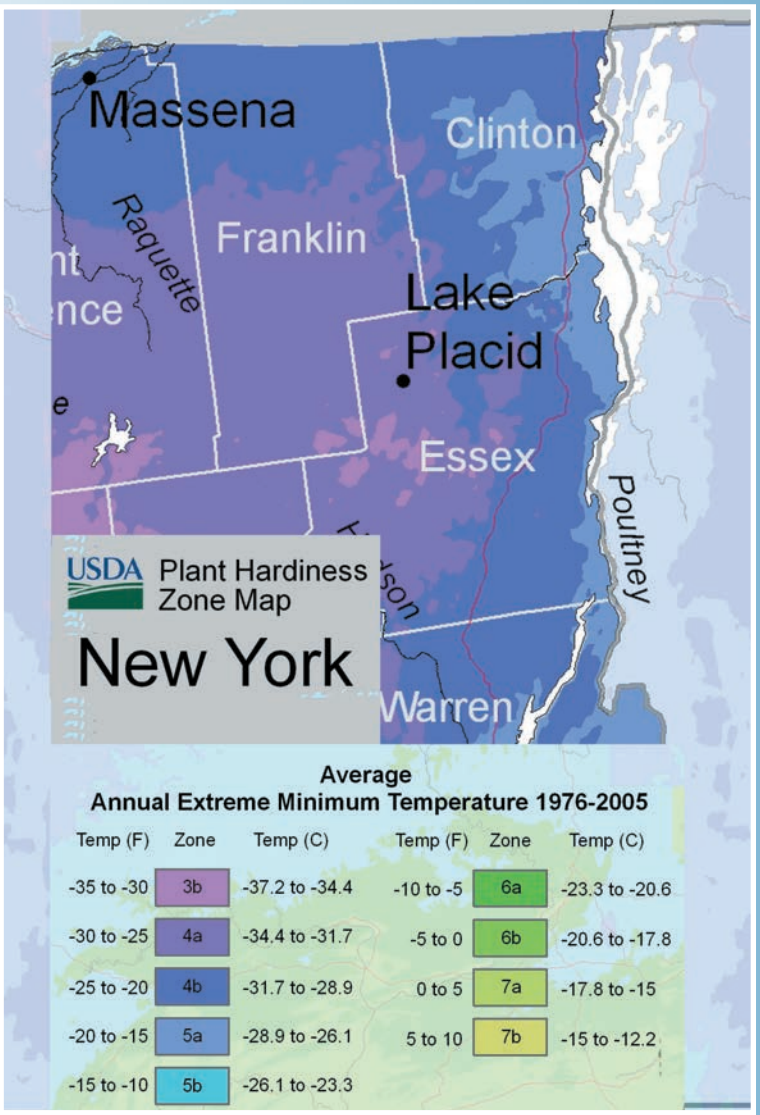

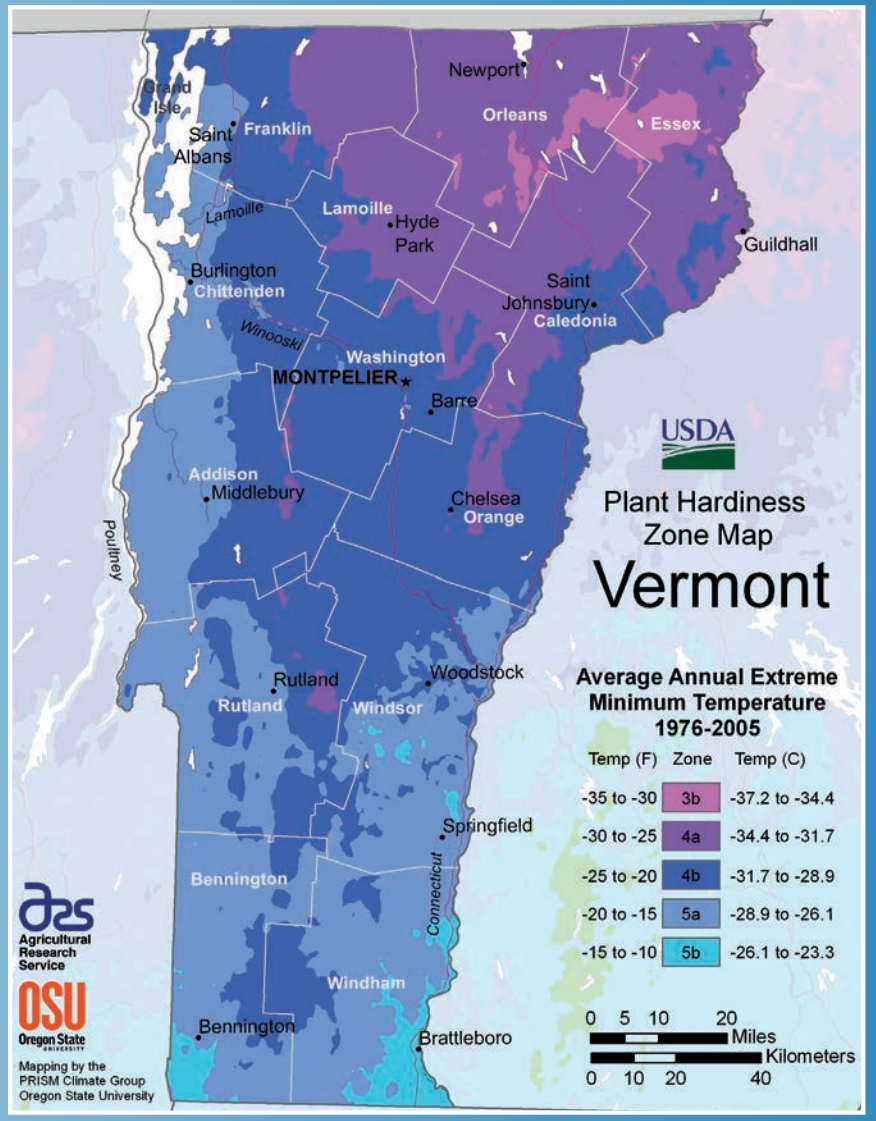

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