The Water Cycle: The Rain Garden

Grade Level: 9-12
Time: 1 Hour to design rain garden; 1 Hour to present in groups
Objectives: Students will research the issue of stormwater runoff and the impact of water pollution on the environment. They will establish a rain garden design as a potential for stormwater mitigation. Students will better understand how this measure will contribute to a decrease in ecological impact.
Materials:
- Rulers
- Pencils
- *Designing a Rain Garden* worksheet, for each student pair or group **
- *Rain Garden Design Plan graph paper* worksheet, for each student pair or group
- *What You Need To Know*: Rain Garden, worksheet for each student
- Research resources (e.g., Internet, plant identification books)
- Presentation materials (e.g., poster board, Powerpoint, Google slideshow)

Student Vocabulary

Drainage Area:	area of impervious surfaces that will drain into the rain garden (i.e., drive ways, rooftops, roads, etc.)
Hydrophyte:	plant that thrives in very wet conditions. Adaptive features of hydrophytes often include: a waxy cuticle, rapid transpiration rate, buoyancy, resistance to “water logging” and energy conservation
Impervious:	does not allow water to penetrate the surface
Mitigate:	moderate the force or intensity of a given condition or quality
Sediment:	naturally occuring breakdown of materials which are channeled through waterways. Sediment is often found in the form of sand, gravel, clay, or mud
Stormwater:	accumulation of precipitation that often carries pollutants which can either be absorbed into the soil or runoff into surface waterways

** Designing a Rain Garden worksheet: This worksheet is provided for students to complete the scenario provided in this lesson. The graph paper provides a total of 247 sq. feet for garden design. Each square represents 6". If you elect to use your own scenario, or landscape features, additional graph paper may be necessary. Also included, are symbols for plants which allow students to map their rain garden design. These symbols represent mature plants with growth ranging from 1-6 foot diameter in size. A sample design of a rain garden, using the provided scenario, is given at the end of the lesson plan.

Laying the Groundwork:

What is a rain garden?

Rain gardens provide a designated space to collect stormwater runoff. Rain gardens reduce stormwater runoff through the placement of a shallow, vegetative space. An increased amount of impervious surfaces, including rooftops, pavement, roads and even lawns, present challenges to local water sources that rain gardens can help alleviate.

What types of pollutants are carried into local streams, rivers, and lakes?

The United States Environmental Protection Agency (EPA) now considers pollution from all diffuse sources, including urban stormwater pollution, to be the most important source of contamination in our nation's waters. Pollution entering our streams, rivers, and lakes from stormwater include; oil, heavy metals, excess nutrients (e.g nitrogen), sediment, as well as mitigating above average water flow (flooding).

Exploration:

1. Challenge students with a rain garden scenario. Provide students with the worksheets to assist them in completing the mitigation project.
2. Read the Rain Garden Scenario to the class:

   Rain Garden Scenario

   Burlington, Vermont has a bike path that is used frequently by town residents and many visitors. A small portion of the bike path, approximately 80 feet by 10 feet, is often flooded, causing the path to erode and create a difficult space for bike riders and pedestrians on the trail. The land is sloped to about 8% and the soil type is clay.

   Help the city of Burlington, Vermont mitigate runoff and infiltrate excess stormwater by establishing a rain garden. Determine the drainage area, rain garden depth, size factor, and the size of the rain garden that would be recommended for this space. Then, determine plants that may be appropriate and build a basic garden design, using the plant diagrams and graph paper given to you.

   *Alternative scenarios may be provided. Make sure to work through each scenario before presenting to students to ensure the calculations make sense in terms of this assignment.

   Rain Garden Scenario Answers:
   - *Drainage: 80 (ft) x 10 (ft) = 800ft^2*
   - *Depth: 8+ inches*
   - *Size Factor: .20*
   - *Rain Garden Size: .20 x 800 ft2 = 160ft^2*

3. Pair students or place in small groups.
4. Ask students to determine the drainage area, how the slope corresponds with soil depth,

and size of the rain garden. Have the students use the information given on the "What You Need to Know" worksheet to complete this portion of the assignment. They should also use this worksheet to record their answers.

5. Using this information, have the students build a basic rain garden design plan. You may wish to provide students with a list of plants appropriate for these gardens, or have them use research tools to determine them as a group.
6. Students should build their design using the graph paper and *Designing a Rain Garden* worksheets (*see the explanation following the Materials List for specific details*). Instruct the students to consider the size of the rain garden when creating their garden to scale. The graph paper given with this lesson plan is already marked for them.
7. As a part of the assignment, students should research plant selections appropriate for rain gardens. Have the students consider the following questions (some potential responses have been included).
   - Why are perennials selected?
     (e.g., native and water loving plants are best, perennials come back each year)
   - Describe some of the benefits of the plants that have been selected.
     (e.g., Joe Pye is a late-blooming plant that was once used for medicinal purposes, High-bush Blueberry produces fruit and does well in moist soil.)
   - Where can these plants be purchased or obtained?
     (e.g., students can source a local nursery.)
   - Why did the group choose certain plants over others?
     (e.g., blooming time spread out over the summer, fruit production, attracts pollinators.)
   - What kind of maintenance will need to done to keep up the rain garden?
     (Perennial gardens often need to be weeded and occasionally thinned.)
   - Does the group have a cost estimate?
     (e.g., have students research prices for each plant.)
8. Each student pair or group should present their garden design to the class. The form of presentation may be determined by the instructor, remind students that there are several questions listed on their worksheet which will help them prepare a meaningful presentation.

Digging Deeper

1. Have students tour their schoolyard to determine ways in which stormwater could be mitigated on campus. Investigate drainage pipes, gutters, and areas where water collects or funnels directly into storm sewers. Ask the students to list solution suggestions for these critical areas.
2. Create your own campus rain garden. Have students monitor the school grounds for a rain garden location and follow the pattern of design and installation given within this lesson plan. More information about starting a rain garden at your school can be found at http://www.kidsgardening.org.

This lesson plan was developed by NGA staff.

The Rain Garden: What You Need to Know

The following tests and equations are useful for establishing rain gardens. Use these tools for successfully designing and/or installing a rain garden.

How to Calculate Drainage Area:
To determine the size of the area that will drain into the rain garden, measure the amount of impervious surfaces surrounding the location of your rain garden.

length (ft) x width (ft) = ______________ ft^2 (drainage area)

How to Determine the Location for the Rain Garden (The Pit Test):
1. Dig a 6" deep hole in the rain garden site and fill with water.
2. If the water is still standing after 24 hours you should select a new location as this indicates impermeable soil.
3. Repeat the pit test in the new location until you find a site where the water will drain through the soil.

How to Determine the Slope or Necessary Depth of the Rain Garden:
1. Place a stake at the uphill end for the rain garden and another at the downhill end.
2. Level the string between the two stakes.
3. Measure the total length of the string and height of the string at the downhill stake (in inches).
4. Divide the height by the length of the string and multiply the result by 100. This is the slope as a per centage.

Slope = (height/length) x 100

The slope into the rain garden will help you figure out how deep the soil in your garden needs to be. Once you have calculated the slope, use the chart to identify the appropriate soil depth for your rain garden.

Slope	Depth
<4%	3-5 inches
5-7%	6-7 inches
8-12%	8+ inches

How to Determine the Soil Type in Your Rain Garden:
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 the side of your forefinger and gently push the soil forward with your thumb, squeezing it upwards to form a ribbon about ¼″ thick.
3. Try to keep the ribbon with a uniform thickness and width. Repeat the motion to lengthen the ribbon until it breaks under its own weight. Measure the ribbon and evaluate according to these specifications:
   Sand: soil does not form a ribbon at all
   Silt: soil forms a weak ribbon <1.5″ before breaking
   Clay: soil forms a ribbon >1.5″ long

How to Determine the Size Factor of Your Rain Garden:

1. Locate the soil type of your rain garden on the left hand column of the table below.
2. Locate the depth you calculated for your rain garden in the second row of the table below.
3. Identify where the soil type and depth intersect in the table to find the proper size factor for your garden.
4. Use this number in the equation below to determine the appropriate size of your rain garden.

Soil Type	Depth		
	3-5 inches	6-7 inches	8+ inches
Sand	0.19	0.15	0.08
Silt	0.34	0.25	0.16
Clay	0.43	0.32	0.20

How to Determine the Size of Your Rain Garden:

Size Factor x Drainage Area = Rain Garden Area

Example: Suppose a rain garden was determined to have a drainage area of 1,000ft^2**.** It has a slope of 5%, requires a depth of 6-7 inches, and has clay soil. To determine the recommended size of the rain garden:

.32 (*Size Factor*) x 1,000 ft^2 (*Drainage Area*) = 320ft^2 (*Rain Garden Size*)

** Information in both tables adapted from the 2008 Vermont Rain Garden Manual.*

Designing a Rain Garden

Rain Garden Scenario Information:
Determine and record the following information to assist you in your calculations and rain garden design.

Bike Path Size: 80 ft x 10 ft = ________________ft^2 **(Drainage Area**)
Slope: 8%
Soil Type: Clay

Rain Garden Depth: ____

Size Factor: ____

Size of the Rain Garden: ____________________________________

Consider the following questions when determining which plants to use in the rain garden plan:

- Would perennials be a good choice? Why or why not?
- Can these plants be purchased or obtained locally?
- What kind of maintenance will be necessary for the plants in the garden?
- Do you have a budget? Are your plants too expensive?

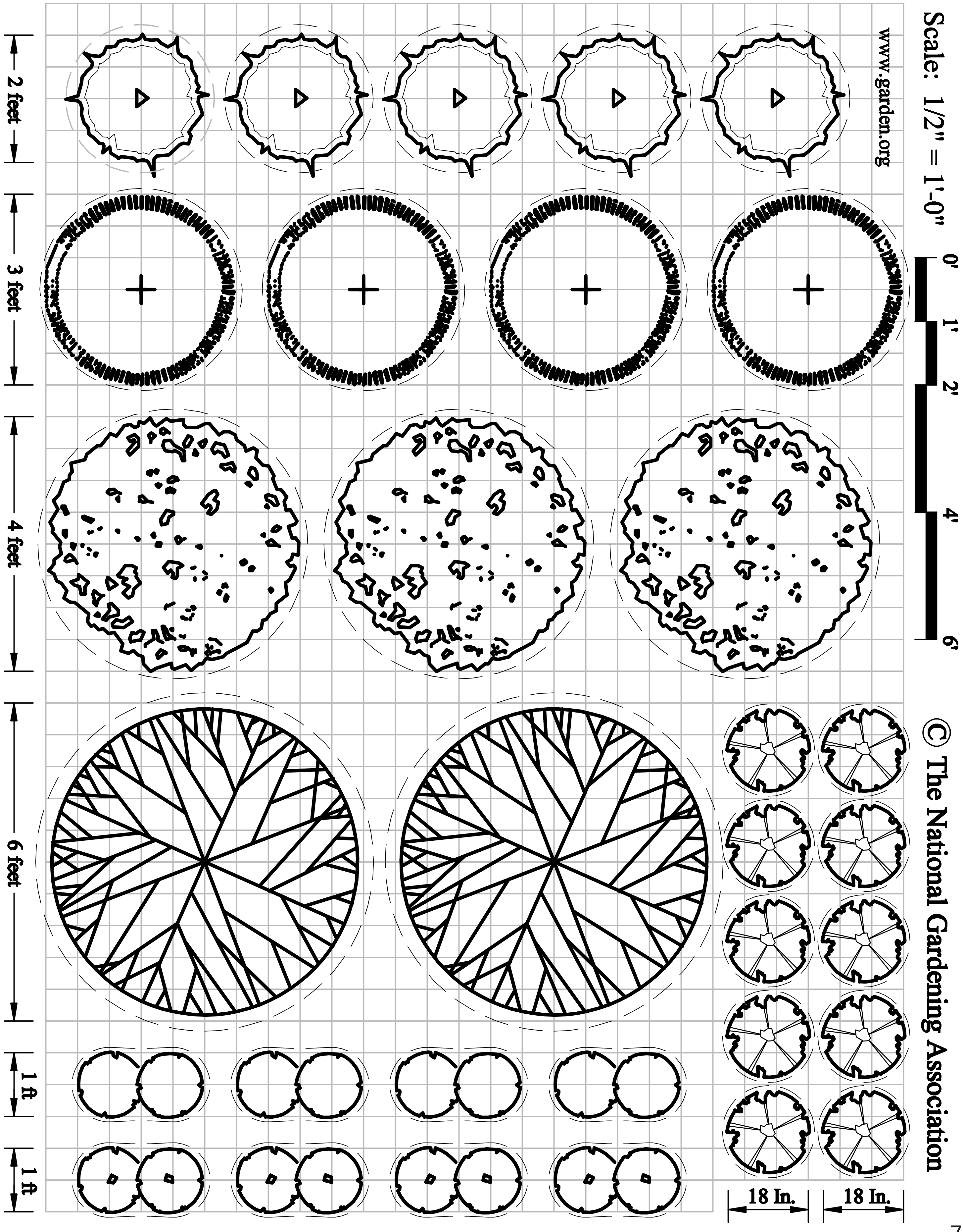
List the plants you have selected:

Describe a few of the benefits of the plants chosen:

Consider the following questions when preparing your class presentation:

- What is the impact of stormwater on rivers, streams, and lakes?
- What chemicals, pollutants, and other materials get picked up in stormwater runoff?
- What are some ways each individual can reduce their impact on local waterways?
- What are some long-term solutions to the problem?
- State some reasons to mitigate stormwater runoff.
- State the purpose of rain gardens.
- State your scenario conclusions.
- Showcase your garden design.
- Showcase a listing of selected plants and why they were selected for use in the rain garden.

Designing a Rain Garden: Plant Diagrams



Scale: 1/2" = 1'-0"   0' 1' 2' 4' 6'

Rain Garden Design Plan

Designed By: ______________________________

Designing a Rain Garden: Student SAMPLE