



# *Rain Garden Curricular Sampler*



## **Rain Garden Curricular Sampler**

A Publication of the  
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## Rain Garden Curricular Sampler: Introduction

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Earth Partnership for Schools (EPS) collaborates with K-12 teachers, students, and other school community members to enhance learning through the process of restoring native habitats as outdoor classrooms. Schoolyard ecological restoration provides meaningful learning opportunities to students as they plan, plant, manage, monitor and study their native plantings. In science, social studies, language arts, fine arts, and music classes, students are learning about the cultural and natural history of local ecosystems by applying their work to these real-life projects. In addition to interdisciplinary, hands-on learning, the process of planning and planting native habitats may be one of the few opportunities students have to experience and connect with the natural world.

As the EPS program evolved, we became aware that schoolyard ecological restoration has the potential to improve the natural environment on a larger scale. Native plantings can actually improve the ecological functioning of the school grounds and enhance the health of the landscape and water quality beyond the schoolyard boundaries. How? One way is by planting native species in rain gardens. A rain garden is simply a garden planted in a shallow depression that slows down and traps runoff after a rain. EPS programming related to rain gardens led to the creation of this curriculum sampler.

In undisturbed, natural areas, water flows over a vegetated landscape with much of it soaking into the ground before ever reaching a body of water. Movement of water through the land helps to keep water clean and reduces serious flooding. In built environments, including school grounds, rainwater flows over hard surfaces such as parking areas, roof tops, and compacted lawns. The rainwater picks up debris: gas, oil and other contaminants from cars; pesticides, fertilizer and sediments from lawns; and residue from roofs; it then flows into storm sewers. This untreated water often flows directly into lakes and streams, threatening their ecological integrity. Rain gardens collect rainwater from roofs and paved areas and allow the water to infiltrate the school ground. As a result, some of the natural hydrology on the school landscape is restored and water pollution is reduced. Students' involvement in creating rain gardens provides opportunities to be active participants in lessening storm water impacts.

This Rain Garden Curricular Sampler is a collection of 15 activities aligned to WI state standards. The sampler is set up to follow steps in building a rain garden. The steps include: 1) learning about the value of rain gardens; 2) performing site analysis to study site conditions and where water flows; 3) planning and designing a rain garden, determining its size and shape, and selecting species; 4) preparing and planting the site; 5) maintaining a rain garden initially and for the long-term; and, 6) making community connections to inform the community about the project, to seek assistance, and to educate the community about the value of rain gardens.

This curricular sampler does not provide an activity for grading the site. However, the complementary guidebook, *Rain Gardens: How-to Manual for Homeowners*, provides basic instructions for grading a rain garden. The manual is listed in the Resource section and can be downloaded at no cost from the Web ([www.dnr.state.wi.us/ORG/WATER/WM/dsfm/shore/documents/rgmanual.pdf](http://www.dnr.state.wi.us/ORG/WATER/WM/dsfm/shore/documents/rgmanual.pdf)).

Transforming a schoolyard to an environmentally healthy landscape is an exciting way for students to learn. Students come to know that they are improving the ecological functioning of the school grounds and improving water quality in their community. We hope you enjoy this process of building a rain garden with your students!



*Whitehorse Middle School students photographed with their newly-planted rain garden, Madison, WI. Photo: Kit Rittman.*

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# Rain Garden Curricular Sampler

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## Why Build Rain Gardens?

Students learn how rain gardens improve water quality and lessen impacts from storm water in their local watershed.

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## Perform Site Analysis

Students investigate their school grounds and collect information for developing a rain garden.

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## Plan a Rain Garden

Students locate and design their rain garden including determining its size, shape, and species composition.

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## Prepare and Plant a Rain Garden

Students lay out and plant their garden.

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## Maintain a Rain Garden

Students care for and maintain their rain garden.

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## Make Community Connections

Students prepare outreach materials to inform the community about their project.

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## Why Build Rain Gardens?

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# A Rain Garden Year

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## Activity Overview

Students take part in a play that illustrates the seasonal march that happens in a rain garden as native plants bloom and set seed.

## Objectives

### Students will:

1. Use a model to explain an event in the natural world
2. Take part in a play to illustrate the sequences of events in natural ecosystems that are repeated each year
3. Identify changes in plants at different times of the year
4. Increase their understanding of prairie plant adaptations
5. Gain an understanding of rain gardens and their purpose

## Subjects Covered

Science, Language arts, Music, Movement and Drama

## Grades

K through 8

## Activity Time

30 minutes

## Season

Any

## Materials

1 plant phenology card per student (1 set is 20 cards; see masters for making cards or have students create their own set of cards), musical instruments (if available)

## State Standards

### Language Arts

Use effective reading strategies (A.4.1, A.8.1)

Read to acquire information (A.4.4, A.8.4)

## Background

Rain gardens are specialized gardens that can reduce polluted runoff. Rain gardens made up of native plants capture water and allow it to soak into the ground instead of running off into storm sewers. Allowing storm water to soak into the ground while the native plants filter out pollutants reduces non-point source pollution going directly into lakes, rivers and other nearby waterways. Storm water is considered non-point pollution because as precipitation falls it collects and picks up pollutants from many surfaces such as roads, parking areas, rooftops, lawns, etc. Non-point source pollution is pollution that does not start from an obvious point, such as an industrial pipe. It is harder to determine where non-point source pollution started.

Rain gardens are often planted with prairie plants that have an ability to live in both wet and dry conditions. Some gardens are planted with woodland plants if the site is shady. In order to avoid intense competition and to adapt to weather cycles, prairie and other native plants have different seasonal periods of growth, flowering, pollination and seed dispersal. As a result, we can experience a changing vista of colors, scents, insects and textures throughout the year. One of the best-known and most dramatic sequences involves plants blooming from April through October; as one blooming plant wanes, another takes center stage. During the growing season, approximately one new plant blooms each day in a natural prairie ecosystem. You can observe this plant blooming cycle on a small scale in your rain garden. “Phenology” is the sequential study of changes that happen in nature over time. Following phenology is exciting because changes in nature are somewhat predictable in different seasons and easily observable. Yet, there is an element of surprise in seeing what’s happening in your school’s rain garden!

Varied growth patterns are one way native plants have adapted to their environment. For instance, most plants planted in a rain garden are long-lived perennials that are able to slow down their growth rates to share water, light and minerals with crowded neighbors to create a complex and rich mixture of vegetation. Perennials are herbaceous plants that die back to the ground at the end of the growing season but survive underground through their root systems. Staggering growth and flowering times is one way plants adapt to competition for resources. Many native grasses and forbs (i.e., wildflowers) have extensive root systems that allow them to survive fires, harsh winters, droughts and flooding because they have buds at or below the soil surface and more root mass below ground compared to the biomass of the plant aboveground. The root systems of species planted in a rain garden can reach depths of over six feet, and some even extend as deep as twenty feet! By having extensive root systems, plus a variety of blooming times and different stem heights, these plants have adapted to their environment and are able to coexist, filling every niche, or space, available.

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## A Rain Garden Year (cont.)

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Create or produce writing  
(B.4.1, B.8.1)

Plan, revise, edit & publish writing  
(B.4.2, B.8.2)

Orally communicate (C.4.1, C.8.1)

Listen & comprehend oral communications (C.4.2, C.8.2)

Participate in discussion (C.4.3, C.8.3) Conduct then communicate research (F.4.1, F.8.1)

### Science

Decide which collected data is pertinent to new problems (A.4.2)

Decide which data should be collected (A.4.3)

Decide on science themes (A.4.5)

Develop themes for questions  
(A.8.1)

Use models to predict actions and events (A.8.6)

Use scientific sources & resources  
(B.4.1)

Use scientific vocabulary & themes  
(C.4.1)

Ask questions, plan investigations, make observations, predictions  
(C.4.2)

Select multiple information sources  
(C.4.3)

Communicate results (C.4.6)

Support conclusions with logic  
(C.4.7)

Identify questions using available resources (C.8.1)

Identify data and sources to answer questions (C.8.2)

Use inference and observations  
(C.8.4)

Use knowledge, models, and theories to explain results (C.8.5)

The dense root systems underground is why rain gardens are so successful infiltrating and filtering water. The roots provide millions of channels for the water to soak deep into the ground. Additionally, the roots absorb pollutants and clean the storm water as it moves down into the ground water (or as subsurface flows) to lakes and rivers. With every rain garden built, water quality improves for drinking, swimming, and aquatic wildlife.

In this activity, 20 plants are used to illustrate the seasonal changes that occur in a rain garden: Bee Balm, Black-eyed Susan, Blazing Star, Compass Plant, Cream Baptisia, Fox Sedge, Golden Alexander, Little Bluestem, Marsh Milkweed, New England Aster, Prairie Cord Grass, Prairie Dock, Prairie Dropseed, Prairie Phlox, Prairie Sedge, Shooting Star, Spiderwort, Stiff Goldenrod, Switch Grass, and Yellow Coneflower.

Select the above plants you have in your rain garden and/or add additional plants. The goal is to have at least one or two plants blooming in each month.

### Activity Description

Everyone receives a card with a plant “in flower” illustrated on one side and “in seed” illustrated on the other side. If musical instruments are available, have each student choose an instrument to represent their plant in bloom. To start the play, everyone should be in a group and crouching down. Read the play narrative. Students stand up and hold their card above their heads when they hear their plant is blooming. If using instruments, students also play their instruments. When their plant sets seed, they lower and turn their cards and remain standing. When winter comes again and the above ground portion of their plant dies, they crouch down into the winter dormant state.

### Sample Play Narrative:

It is a cold winter season. The days are cold and short. Nights are long. To most humans, the rain garden looks lifeless. All aboveground portions of the plants are brown and brittle. But underneath, the roots are quite alive. *(All students should be in a group and crouched down. They are the roots of their plant.)*

You are our rain garden. You are the living roots of your plants with a blanket of snow over your heads. The covering of snow keeps the soil and roots protected. At the same time, the dry plant parts above ground provide winter cover to small animals.

As the days start to get warmer and longer, the snow melts, and the soil warms. Spring rains begin, and plants start to grow—leaves start to emerge from the ground. The growing plants in the rain garden absorb the snowmelt

## A Rain Garden Year (cont.)

### Science (cont.)

Use computer software to organize data (C.8.8)

Find patterns and cycles in Earth's changes (E.4.6)

Explain Earth's cycles using observation (E.8.8)

Investigate how organisms respond to internal/external cues (F.4.2)

Illustrate organisms' life stages (F.4.3) Show organisms' adaptations (F.8.2)

Understand an organism's internal and external regulation (F.8.7)

Show organism's place in ecosystems (F.8.8)

Explain survival and population growth of species (F.8.9)

and spring rains, filtering out pollutants along the way. (*Students start to sit up a bit. As their plant blooms, they stand up and hold their card up.*)

“Now it is (insert month) and the (insert plants in bloom) begin to bloom while the (insert names of plants) stop blooming and begin to set seed.”  
[*Continue through the months listed below*]

Now it is May...

	BLOOMS	STOP BLOOMING, SET SEED
May	Shooting Star Prairie Phlox Golden Alexander Fox Sedge	
June	Spiderwort Cream Baptisia Black-eyed Susan Marsh Milkweed Prairie Sedge	Shooting Star Prairie Phlox Fox Sedge
July	Yellow Coneflower Compass Plant Bee Balm Blazing Star Prairie Sedge Prairie Dock	Spiderwort Cream Baptisia Golden Alexander Marsh Milkweed
August	Cord Grass Stiff Goldenrod Switch Grass Prairie Dropseed	Blazing Star Prairie Sedge Compass Plant Bee Balm Black-eyed Susan
September	New England Aster	Prairie Sedge Yellow Coneflower Prairie Dock Cord Grass Switch Grass
October		Stiff Goldenrod New England Aster Prairie Dropseed

Now the temperatures are getting colder and the days shorter and the nights longer. The aboveground portion of the plants die and only the roots are alive. (*The students crouch back down*)

The winter is back, and our school's rain garden once again looks lifeless. But it is not lifeless; it is alive and waiting—waiting for another year.

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## A Rain Garden Year (cont.)

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### Discussion

Discuss how adaptations such as extensive root systems and different blooming times enable native plants to survive in their environments. What are some threats to these plants' survival? Emphasize that there is a wide variety of ways plants and animals adapt to their environment.

Talk about how plant adaptations support the functioning of a rain garden to reduce polluted runoff and to improve water quality. (Topics to consider include deep root systems, different growing times, and the ability to withstand both droughty and wet conditions.)

### Extensions

- Create your own cards. Draw the flowering plant form on one side and the seed form on the other. Use a field guide or other reference to draw and color the picture accordingly.
- Visit the library to research other plant and animal adaptations. Expand on this play to include different plant and animal adaptations throughout the year.
- Write a story that describes a plant and its seasonal adaptations.
- Keep a phenology journal and record plant changes during different times of year.
- Create other phenological sequences from either observations or research projects (see Earth Partnership for Schools activities, "Observations from a Single Spot" and "Ecosystem Observation Cards").
- Write and direct a phenological play with younger students.
- Create a Phenology Book or Calendar that describes observations throughout the year.
- Create a computer database to record seasonal observations in your school's rain garden.

### Additional Resources

- Bates, J. (1997). *A northwoods companion: spring and summer*. Mercer, WI: Manitowish River Press.
- Bauer, C. & M. Smith Fry. (2000). *My nature journal: Explorations of the natural world using phenology*. Madison, WI: University of Wisconsin-Arboretum.
- Curtis, J.T. (1959). *Vegetation of Wisconsin*. Madison, WI: University of Wisconsin Press.
- Leopold, A. (1949). *A sand county almanac*. New York: Oxford University Press.
- Levine, Carol. (1995). *A guide to wildflowers in winter*. New Haven: Yale University Press.
- Locker, T. (1995). *Sky tree*. Harper Collins Publishers, USA.
- Nichols, N., Entine, L., & E. Howell. (1996). *Prairie primer*. Madison, WI: University of Wisconsin-Extension.
- Stokes, D.W. (1976). *A guide to nature in winter*. Boston: Little, Brown & Co.
- Weber, L. (1996). *Backyard almanac*. Duluth, MN: Pfeifer-Hamilton Publishers.

#### Web sites

- Earth Alive: <http://www.naturenet.com/earthalive/nnhome.asp>
- Rain Garden Plant List <http://dnr.wi.gov/org/water/wm/nps/rg/plants/PlantListing.htm>
- Rain Garden Resources <http://www.danewaters.com/private/raingarden.aspx>

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## A Rain Garden Year (cont.)

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### Assessments

- Describe how rain gardens help reduce the amount of pollution going into local waterways.
- List and explain at least 2 ways plants have adapted to their environment.
- Describe how adaptations enable plants to live in their environment.
- Write a short story describing a rain garden plant's adaptations and seasonal changes.
- Create a mobile with drawings illustrating the blooming and setting seed versions of different rain garden plants and the time of year these changes occur.
- Research a native plant found in your school's rain garden; describe its characteristics, its seasonal adaptations, and its life history. Make an oral report to the class, and conduct peer reviews of these reports.
- Develop a web page on a specific plant(s) using photos, drawings, and life history information.
- Create a phenology journal or calendar, and record observations of the rain garden for a specific period of time.



*EPS 2005 Institute participants experiencing "A Rain Garden Year" at the Urban Ecology Center, Milwaukee, WI. Photo: Libby McCann.*

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## A Rain Garden Year (cont.)

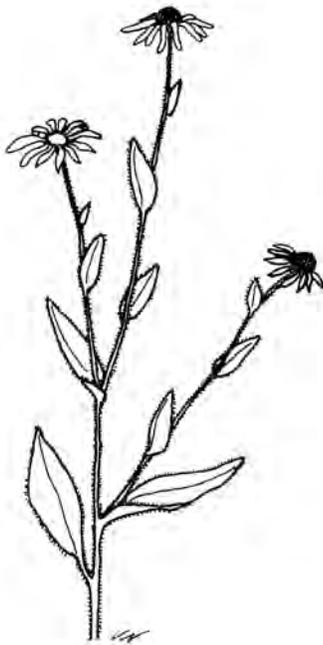
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Spiderwort



Prairie Dock



Black-eyed Susan



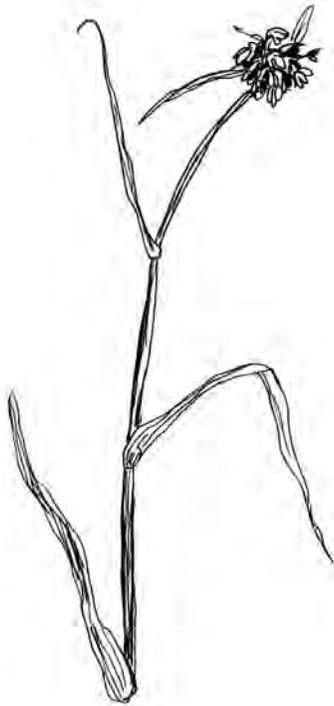
Cord Grass

Sample Rain Garden Year Cards with plants in flower.

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## A Rain Garden Year (cont.)

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Spiderwort



Prairie Dock



Black-eyed Susan



Cord Grass

Sample Rain Garden Year Cards with plants in seed.

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# Bimodal Botany Bouquet

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## Activity Overview

A warm-up activity to introduce students to rain garden plant species and encourage their observational, organizational, and taxonomic skills.

## Objectives

### Students will:

1. Use their observational skills
2. Learn how plants differ structurally from one another
3. Learn the scientific naming system for plants
4. Appreciate unique characteristics of native rain garden plants

## Subjects Covered

Science and Language Arts

## Grades

1 through 12

## Activity Time

30-45 minutes

## Season

Any

## Materials

Sample plant specimens representative of the native rain gardens you have planted (or plan to plant) on your school grounds.

## State Standards

### Science

People in science (B.4.2)

Changes in science concepts (B.8.2)

How science is shared (B.8.5)

Cultural & individual contributions to science (B.12.1)

Major themes & progress (B.12.3)

### Language Arts

Orally communicate (C.4.1, C.8.1, C.12.1)

## Background

### Rain Garden Plants Are Unique

Plants suitable for rain gardens are adapted to both wet and dry soil conditions. This select group of native plants is able to survive drought and floods. Plants growing in a rain garden will not survive if they cannot withstand these extremes. After a rainfall, plants are inundated with water. During times of no or little rainfall, plants are without water. This characteristic of being able to withstand opposite conditions is called “bimodal.” Native plants used in rain gardens have long, deep-growing roots that are able to direct water downward through channels in the soil, which moves water quickly. They also take in water along their entire root system and transpire (release) it out into the atmosphere. These long roots also help the plants reach available moisture during the driest times, therefore not requiring special irrigation. Rain garden plants are unique and perfectly suited for the job of taking rainwater out of the storm water system.

### Plant Names are Unique

There are a variety of languages spoken around the world. In North America, you can find many different languages, ranging from English, Hmong, and French to Spanish, German, and indigenous languages such as Cayuga and Oneida, among others.

Scientific names are basically another language system, which uses Latin as the root source. Latin, which is often a combination of Latin and Greek, was historically the language used by educated people and is the reason why Latin was chosen to give scientific names to plants and animals.

For a long time scientists were confronted with the challenge that one plant or animal species could have many different names, depending on what language was spoken. This challenge created all sorts of language barriers when scientists from different parts of the world wanted to talk about their research. In 1758, a Swedish biologist, Carl Linnaeus, decided everyone should use the same name to describe a given species and proposed a universal naming system, now known as “binomial nomenclature” (bi = two, nomen = name, calo = call, so it translates as “two-name name-calling”). This naming system gives each species a surname and a personal name, just like people in North America have. If you are called Pat Jones then Jones is your surname, and Pat is your personal name. Scientists call the equivalent of a person’s last name the “genus” or “generic name.” The genus always has a capital letter as the first letter. The equivalent of a person’s first name is called the “specific name” and is written entirely in lower case letters. Unlike people’s names in North America, the generic name comes first and the personal (specific) name is second in this binomial system. For example, the Latin name for the tree species, red maple, is *Acer rubrum*. *Acer* is the Genus name. There are at least another dozen different maples found in North America that have the same genus name. This is just like you and your siblings, all of

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## Bimodal Botany Bouquet (cont.)

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### Language Arts (cont:)

Listen & comprehend (C.4.2, C.8.2, C.12.2)

Participate in discussion (C.4.3, C.8.3, C.12.3)

Use vocabulary (D.4.1, D.8.1, D.12.1)

Interpret uses of language (D.8.2, D.12.2)

Conduct then communicate research (F.4.1, F.8.1, F.12.1)

whom have the same last name. The species name *rubrum* is similar to your first name and tells you it is a red maple.

These Latin names have other meanings, too. For instance, “*rubrum*” means “red” in Latin, and red is generally the color red maple leaves turn in the fall season. Sometimes the scientific name is based on people’s names, such as *Heuchera richardsonii*; *Heuchera* after Johann Heinrich von Heuchera, an early German medical botanist, and *richardsonii* after Sir John Richardson, a 19th century North American explorer. Some plants are given a name based on where the plant was first discovered, such as *Elymus virginicus*. *Virginicus* refers to the state of Virginia.

The following activity will help students understand the scientific naming process and familiarize them with the diversity and unique attributes of rain garden species they plant on their school grounds. Students will learn the variety of patterns and shapes of plant parts. The next step can be applying names to what they observe in terms of plant structure (see Earth Partnership for Schools’ activities, “Plant Families” and “Taxonomy and Field Guide Warm-up”).

In addition to acquainting students with rain garden species and their names, this activity is a good introductory activity to a plant unit and/or can be used as an “ice-breaker” among a group of students who do not know each other well. Likewise, this activity can sharpen participants’ observation skills and build upon their creativity as they learn more about plant structure and diversity.

### Activity Description

1. Prepare a bouquet of plant species, representing a rain garden. The number of sample plants will depend on the size of the group and should be approximately a third to a quarter of the number in the group. For example, a group of 30 students will break into 6 groups of five, which will require five samples from 6 different plant species.
2. Have the bouquet well mixed and pass out one plant to each person.
3. Ask those who know names of the plants being passed out not to share that information until the end of the activity.
4. Allow group members to find others who have the same plant, and then form a small group. If participants do not know one another, ask them to introduce themselves to the other group members.
5. Ask groups to come up with a creative description of the plant based on their close observations that would help others identify that plant.
6. Next, ask them to come up with a creative name for their plant.

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## Bimodal Botany Bouquet (cont.)

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7. Request representative(s) from each group to present their plant's name and description.
8. Once a small group has shared their creative name and related plant description, ask the entire group if they know the common and scientific names of the plant. If the name is unknown, share common and Latin names and a further description (especially ecological and human uses) of each plant.



EPS Institute participants getting to know their plant's characteristics. Photo: Libby McCann.

### Discussion

Ask group members why they think there are scientific names for plants—then review the history of why plants have scientific and common names. Have students visit the library to further research the plants used during this activity, the related habitat preferences, and the human uses for the plants.

Conclude with a discussion of why these particular native plants are perfectly suited for infiltrating water in rain gardens and the characteristics that make them suitable.

### Extensions

- Complete Earth Partnership for Schools activity “Taxonomy and Field Guide Warm-up” to learn more about plant structure and identification.
- Collect weed plant samples that appear in the native rain garden that need to be identified and removed.
- Write a story that describes a plant and its characteristics and explains the related adaptations to wet/dry conditions and its ability to infiltrate and filter storm water.
- Create a phenology calendar, journal, or computer database that describes your plant observations throughout the year.
- Develop a Web page on the plant species from this activity using photos, drawings, and life history information.

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## Bimodal Botany Bouquet (cont.)

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### Additional Resources

- Cochrane, T.S., Elliot, K., Lipke, C.S. (2006). *Prairie plants of the University of Wisconsin-Madison Arboretum*. Madison, WI.
- Densmore, F. (1974). *How Indians use wild plants for food, medicine, and crafts*. New York: Dover.
- Eggers, S. D. et al. (1997). *Wetland plants and plant communities of Minnesota & Wisconsin*. Second edition. St. Paul, MN: U.S. Army Corps of Engineers, St. Paul District.
- Foster, S. (1990). *Field guide to medicinal plants: Eastern and Central North America*. Boston: Houghton Mifflin.
- Kindscher, K. (1992). *Medicinal wild plants of the prairie: An ethnobotanical guide*. Lawrence, KS: University Press of Kansas.
- Meeker, J.E., Elias, J.E., & Heim, J.A. (1993). *Plants used by the Great Lakes Ojibwa*. Odanah, WI: Great Lakes Indian Fish and Wildlife Commission.
- Neal, Bill. (2003). *Gardener's Latin*. Chapel Hill, NC: Algonquin Books of Chapel Hill.
- Newcomb, Lawrence. (1977). *Newcomb's wildflower guide*. Boston: Little, Brown & Co.
- Runkel, S.T. & Roosa, D. M. (1989). *Wildflowers of the tallgrass prairie: The Upper Midwest*. Ames, IA: Iowa State University Press.
- Harlow, W.M. (1957). *Fruit key and twig key to trees and shrubs*. New York: Dover.
- Wisconsin Department of Natural Resources. (1990). *Forest trees of Wisconsin: How to know them*. Madison: Bureau of Forestry (PUBL-FR-053 90REV).

### Web sites:

- Rain Garden Plant List: <http://dnr.wi.gov/org/water/wm/nps/rg/plants/PlantListing.htm>
- Vascular Plant Species of the Wisconsin State Herbarium: <http://www.botany.wisc.edu/wis-flora>
- Basics of Tree ID: <http://www.cnr.vt.edu/dendro/forsite/Idtree.htm>

### Assessments

- Name (common and scientific name) and describe at least 2 plant species.
- Write a short story describing the plant species used in this activity, the human uses of the plant (e.g., medicinal uses), and the root words of the plant's scientific name.
- Create a mobile with drawings illustrating various plants and their unique physical characteristics. Include the scientific and common names on the mobile.
- Describe the adaptations and beneficial and unique characteristics of plants used in rain gardens.

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# Conjunction Function

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## Activity Overview

A warm-up activity using observational, critical thinking and scientific skills to introduce rain gardens and how they function to improve the health of a watershed.

## Objectives

### Students will:

1. Use their observational skills
2. Learn how rain gardens contribute to a healthy watershed
3. Increase their understanding of the hydrologic cycle
4. Understand human impact on the landscape

## Subjects Covered

Science, Language Arts and Social Studies

## Grades

1 through 12

## Activity Time

30-45 minutes

## Season

Any

## Materials

Sets of props/objects that may include sponges, band aids, funnels or pitchers, coffee filters, small bags of bird seed, before and after pictures of rain gardens, watering cans, small fans, Monopoly houses, “certified organic” labels on boxes and flat bottomed bowls.

## State Standards

### Science

Decide which questions to ask (A.4.1)

Develop themes for questions (A.8.1)

Apply themes to develop future visions (A.12.1)

## Background

In urbanized areas, fallen rainwater picks up dirt, leaves and pollutants and flows directly to lakes and streams as dirty storm water. We have learned ways to keep water clean so our waterways are healthy for fish, wildlife, and people. One way is by building rain gardens at schools, homes, and businesses. A rain garden is placed where runoff is coming off roofs, driveways, sidewalks, parking lots, and other hard (i.e., impervious) surfaces. The principle of a rain garden is to keep rainwater close to where it falls. A rain garden simply models a natural system, and as a result manages storm water to allow for natural functions and to restore natural hydrology. Such hydraulic cycles include infiltration, evaporation, plant uptake of water, transpiration, and groundwater recharge. This activity provides students with an opportunity to become familiar with how rain gardens restore the natural water cycle, reduce pollution to lakes and rivers, and provide a native landscape with food and nectar for wildlife. “Conjunction Function” uses everyday items to demonstrate ecological and environmental functions of a rain garden.

## Activity Description

1. Prepare sets of objects/props representing the functions and benefits of a rain garden. The number of sets and number of props in each set depends on group size. For example, a group of 28 students may divide into 7 groups of four. Each group will need one set of four objects or props. A total of seven sets of props or objects are needed.
2. Have the props well mixed, and pass out one item to each person.
3. Allow everyone to find others who have the same prop, and form a small group. If participants do not know one another, ask them to introduce themselves to the other members in their small group.
4. Ask groups to come up with a description of what function and benefit the object symbolizes.
5. At this point, have representatives from each group present their item and what it symbolizes in regard to function in the rain garden.
6. Once a small group has shared their descriptions, ask the entire group why they think the function is important for the health of their watershed.

## Activity objects and the function/benefit they represent:

1. Sponge: Absorbs water
2. Band aid: Protects and heals the land surface and mends short cuts in the water cycle
3. Funnel or pitcher: Recharges the aquifer and replenishes ground water
4. Coffee filter: Traps, treats and cleans pollutants from surface water
5. Bag of bird seed: Provides food sources for birds, butterflies and other insects

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## Conjunction Function (cont.)

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### Science (cont.)

Reexamine evidence & reasoning (A.12.7)

Describe changes in models (B.8.2)

Describe reasoning to make conclusions (B.8.4)

Explain how science is shared (B.8.5)

Show cultural & individual contributions to science (B.12.1)

Identify major scientific themes & progress (B.12.3)

Project how human trends influence the environment (E.8.10)

Investigate local problem & propose scientific or technological solution (G.8.5)

Analyze scientific or technological innovation (G.12.3)

Choose a problem & identify scientific or technological solution (G.12.5)

Identify how science and technology help or hinder a local or state problem (H.4.2)

Evaluate policy recommendations (H.12.2)

Analyze resource management (H.12.1)

### Social Studies

Describe examples of land use, communities, shelters (A.4.4)

Identify community connections (A.4.7)

Describe short-term and long-term environmental changes (A.8.6)

Give examples of current global issues (A.8.11)

Analyze effects of population changes on environment (A.12.4)

6. Before and after pictures of a rain garden: Offers landscape beauty (aesthetics)
7. Certified organic label: Improves soil and increases water absorption by adding organic matter to the soil. (The plant's roots slough off organic matter in the soil.)
8. Small fan: Aerates the soil and increases air and water movement (The long and fibrous root masses create channels for oxygen and water movement.)
9. Flat bottomed bowl: Temporarily holds and stores water (Water drains within 6 -12 hours after a rain.)

### Extensions

- Brainstorm other objects that could symbolize functions and benefits of rain gardens.
- Build a model of a rain garden to demonstrate how rain gardens collect, filter and move water into the ground.

### Additional Resources

- Kesselheim, A.S., Slattery, B.E. (1995). *WOW! The wonders of wetlands*. St Michaels, MD: Environmental Concern Inc.
- Mitsch, William J., and J.G. Gosselink. (1993). *Wetlands*. New York: Van Nostrand Reinhold.
- Nadeau, Isaac. (2003). *The water cycle: water underground*. New York: Rosen Publishing Group, Inc.
- Nadeau, Isaac. (2003). *The water cycle: Water in lakes and rivers*. New York: Rosen Publishing Group, Inc.

### Assessments

- Describe why objects in the activity were chosen to represent the different functions of a rain garden.
- Provide three reasons why rain gardens are important for contributing to a healthy watershed.

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## Conjunction Function (cont.)

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### **Social Studies (cont.)**

Analyze cultural factors that influence design of places (A.12.9)

Assess land use policies (A.12.12)

### **Language Arts**

Listen & comprehend oral communications (C.4.2, C.8.2, C.12.2)

Participate in discussion (C.4.3, C.8.3, 12.3)

Orally communicate (C.12.1)

Develop vocabulary (D.4.1, D.8.1, D.12.1)

Interpret uses of languages (D.8.2, D.12.2)

Conduct then communicate research (F.4.1, F.8.1, F.12.1)



Before and after photos of a rain garden planting at Edgewood College, Madison, WI.

*Photos: Jim Lorman*







## Perform Site Analysis

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# Noting Notable Features for Rain Gardens

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## Activity Overview

Students survey their schoolyard to begin to identify characteristics and features relevant to building a rain garden.

## Objectives

### Students will:

1. Practice observation and investigative skills
2. Survey and collect information about their school site
3. Describe interactions and details about their school site

## Subjects Covered

Science and Math

## Grades

K through 12

## Activity Time

1 hour on the school grounds, 3/4 hour discussion in the classroom

## Season

Any, Spring and Fall are best

## Materials

Clipboards, pencils (or colored pencils), Noting Notable Features field sheets, map of schoolyard showing property lines and building locations, 1 air thermometer, 1 soil thermometer, map transparency, overhead projector, and colored markers

## State Standards

### Math

Use reasoning abilities (A.4.1, A.8.1, A.12.1)

Communicate mathematical ideas (A.4.2)

Use vocabulary, symbols, notation (A.4.4)

Analyze non-routine problems (A.8.3)

## Background

Before making any decisions about locating and building a rain garden, students need to understand the characteristics of their school yard. Site analysis activities are a great way to involve students from the very beginning of the project. All of these activities can be represented on a final site analysis map. The map will help you and your students determine where to locate rain gardens and what types of rain gardens are suitable for your site. The exact form a rain garden takes can be determined by design and educational considerations as well.

The site analysis data gathered will include information about physical objects such as buildings and other structures, topography, water movement, land use, existing vegetation, slopes, traffic patterns, patterns of sun and shade, views, and other characteristics such as predominating wind patterns, wildlife, and underground utilities. Students learn about the soil on their school grounds in more depth through experiencing Earth Partnership for Schools activities “Getting to Know Your Soil for Rain Gardens” and “Infiltration Test: Exploring the Flow of Water Through Soils.”

## Pre-activity preparations

- The first step in the process is to outline the physical area of the school grounds. Many schools already have site plans showing measurements of property boundaries and buildings. If you don't have such a plan, you have an excellent opportunity for students to measure and present a site map. See Earth Partnership for Schools activity, “Mapping Your Schoolyard” in the *EPS K-12 Curriculum Guide*.
- Make a copy of an existing map showing the location of buildings, drives, and property lines. Locate north, east, south, and west on the map. Create a transparency of the schoolyard map for focused discussions after the outside portion of the activity. Make enough copies of the map and field sheets for each student or student team.
- If desired, divide the schoolyard into sections. Investigate one section at a time.

## Activity Description

Introduction: This activity will help you get acquainted with your schoolyard. It is the first step in understanding the natural and cultural features of your schoolyard. The data you gather will provide information to help make decisions about where to locate rain gardens on your school grounds and what type of rain gardens to build.

## Follow these steps –

1. Divide into 8 teams of 2 - 4 students. Each team is responsible for completing instructions on their assigned field sheet. A brief description of what each team will investigate follows:

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## Noting Notable Features for Rain Gardens (cont.)

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Apply proportional thinking (B.8.5)

Use coordinate systems to find map locations (C.4.4)

Analyze properties and relationships of figures (C.12.1)

Demonstrate understanding of measurable attributes and units (D.4.2)

Select & use tools to determine measurements directly (D.12.2)

### Science

Explain survival and population growth of species (F.8.9)

Find connections among living and non-living things (F.4.4)

Investigate cooperation & competition (F.12.7)

Infer changes in ecosystems (F.12.8)

### **Water Flow Team – This team will identify**

**Water Movement** – Diagram the flow of water on the school grounds. Find areas where water is standing for a period of time after a rain and areas that dry out more quickly than others. (See Earth Partnership for Schools activity, “Follow the Drop” for more information or a more in-depth investigation.)

**Downspouts and Storm Drains** – Locate downspouts where water drains from the roof. Locate storm drains where water might exit the school property.

### **Topography Plus Team – This team will identify**

**Topography** - Find high spots in the schoolyard. Determine the highest spot. Find low spots. Determine the lowest spot. Locate steep slopes, ditches, and flat areas.

**Prevailing Wind** - Determine wind direction. Winter winds are predominantly from the northwest, summer winds from the southwest.

### **Sun/Shade Team – This team will identify**

**Sun/Shade Patterns** - Map shade from trees and buildings. Shade from buildings is different than shade from vegetation because it is solid and nearly shady year-round. Shade from deciduous trees is usually dappled, and the ground under the trees may be sunny from fall to late spring. Map areas of full sun.

### **Land Surface Team – This team will identify**

**Hard (impervious) and Porous Surfaces** - Locate hard surfaces (impervious) such as parking lots and sidewalks where water runs off. Next locate porous surfaces (pervious) such as planted beds or lawn areas, where water may soak (infiltrate) into the ground.

**Soil** - Identify areas with bare soil or where you observe erosion. Determine what may be causing the erosion such as foot traffic, steep slopes, or water movement.

### **Vegetation Team – This team will identify**

**Existing Vegetation** - Locate existing vegetation on site, starting with trees and shrubs. Look for trees, shrubs, and plants that provide food (berries, nuts, or seeds) and cover for wildlife. Locate different ground covers such as lawn grass, flower beds, unmowed areas (or old fields), prairies, woodland ground covers, agricultural areas, etc.

### **Wildlife Team – This team will identify**

**Wildlife** - Identify wildlife or signs of wildlife and where you observed them on your school yard. Do any patterns emerge where you sighted wildlife?

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## Noting Notable Features for Rain Gardens (cont.)

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### **Traffic Patterns Team – This team will identify**

**Traffic Patterns** - Identify traffic patterns for cars and people in and around the school.

**Views** - Identify good and bad views from drives, walkways, and classrooms.

### **Land Use Team – This team will identify**

**Site Use** - Locate play areas, sports fields, and play equipment.

**Structures** - Indicate locations of bike racks, signs, benches, picnic tables, and fences.

**Utility features** - Locate obvious utility lines above or below ground.

2. Walk the school grounds and follow the instructions on the field sheets.
3. Return to the classroom. Teams orally present their findings and use a map transparency on an overhead to display their observations.
4. Discuss the possible locations for building a rain garden based on the class' observations. Consider the following guidelines:
  - a. **Location**
    - Near drain spouts
    - Where water collects and drains off of a hard surface
    - To catch water before it flows over a sidewalk to reduce ice forming in winter
    - Along a ditch or swale
  - b. **Sun/Shade**
    - The amount of sunlight determines plant selection. Generally, gardens in full sun are more effective.
  - c. **Wildlife**
    - Knowing what wildlife is currently living on the school grounds will inform you about the existing habitat. This way you are able to plan a rain garden that will complement or enhance wildlife habitat on your school grounds.
  - d. **Traffic Patterns**
    - Well-worn shortcuts or other traffic patterns are more easily accommodated than changed. Habits are hard to break, and people usually take the most direct route to a destination. Therefore, try not to plant a rain garden directly over an existing path.
    - Consider locating the rain garden in a visible spot for others in the community to see as an example of sustainable landscaping.
    - Locate a rain garden conveniently for classes to visit and study.

### **Extensions**

- Survey the school grounds to identify current maintenance practices such as use of fertilizers and herbicides, lawn mowing, composting, mulching, and salt use in winter. Research practices that help to improve water quality and make recommendations based on your research.
- Discuss where you see wildlife on your school ground. How does it interact with its environment? Given your observations, how could you enhance wildlife habitat at your school?

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## Noting Notable Features for Rain Gardens (cont.)

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### **Additional Resources**

- Boume, Barbara. (1990). *Taking inquiry outdoors: Reading, writing, and science beyond the classroom walls*. Portland, ME: Stenhouse Publishers.
- Ripple, Karen, Garbisch, Edgar W. (2000). *POW! The planning of wetlands*. St. Michaels, MD. Environmental Concern Inc.
- Wyzga, Marilyn. (1993). *Homes for wildlife: A planning guide for habitat enhancement on school grounds*. New Hampshire Fish and Game Department.
- Diggers hotline

### **Assessments**

- Describe your schoolyard and how it affects the flow of water during a rainfall.
- Describe a cause and effect relationship on your school grounds.
- Determine the best place to locate a rain garden on your school grounds and explain why.

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## Noting Notable Features for Rain Gardens (cont.)

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### Water Flow Team

Team Members: \_\_\_\_\_

Location: \_\_\_\_\_

1. Locate the following on your site map:

- a. Direction of water movement from high points to low spots
- b. Areas where water puddles
- c. Areas that dry out quicker than other areas
- d. Places where ice might form on sidewalks or drives
- e. Locate downspouts
- f. Locate storm drains

2. If you observe areas where water puddles, explain why the water doesn't seem to be draining. Considerations include compacted soil from traffic (foot and vehicular); heavy, clay soil; existing or previous wetland; or large quantities of water draining to the site.

3. Are there any downspouts draining directly onto pavement or other hard surfaces? Can the water be directed to a lawn area, other porous surface or rain garden? If so how?

4. Have you noticed downspouts that may release more water than others? If so, why?

5. Based on your observations, list possible locations for a rain garden. Why do you suggest these areas?

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## Noting Notable Features for Rain Gardens (cont.)

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### Topography Plus Team

Team Members: \_\_\_\_\_

Location: \_\_\_\_\_

1. Locate the following on your site map:
  - a. High spots and the highest spot
  - b. Low spots and the lowest spot
  - c. Steep slopes
  - d. Ditches or swales
  - e. Flat areas
  - f. Where winter winds blow over the school ground. Winter winds come from the northwest
  - g. Where summer winds blow over the school ground. Summer winds come from the southwest

2. Describe the topography of the school yard. Are there any hills, valleys or slopes?

3. Where are places that offer shelter from winter winds and places that may be cooler in the summer?

4. If any, are there places where snow drifts develop naturally or where snow is piled by snowplows? (These areas are a source of water during snowmelt.)

5. Based on topography, list possible locations for a rain garden. Why do you suggest these areas?

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# Noting Notable Features for Rain Gardens (cont.)

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## Sun/shade Team

Team Members: \_\_\_\_\_

Location: \_\_\_\_\_

<p>1. Locate the following on your site map:</p> <ul style="list-style-type: none"><li>a. Shade from trees</li><li>b. Shade from buildings</li><li>c. Areas of full sun</li></ul>
<p>2. Record air and soil temperature at each site.</p> <p>a. <b>Shade from trees</b>                      Location: _____</p> <p>Air temperature: _____</p> <p>Soil temperature: _____</p> <p>b. <b>Shade from buildings</b>                      Location: _____</p> <p>Air temperature: _____</p> <p>Soil temperature: _____</p> <p>c. <b>Full sun</b>                                      Location: _____</p> <p>Air temperature: _____</p> <p>Soil temperature: _____</p>
<p>3. Based on your measurements, what conclusions can you make about temperature variation in different sun/shade conditions?</p>
<p>4. If a sunny spot is desirable for a rain garden, where would you locate it and why?</p>
<p>5. If you decide to locate a rain garden in a shady spot, where would you choose? Consider that the garden needs some sun and, therefore, cannot be in shade all day long.</p>

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## Noting Notable Features for Rain Gardens (cont.)

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### Land Surface Team

Team Members: \_\_\_\_\_

Location: \_\_\_\_\_

- |   |
|---|
| <p>1. Locate the following on your site map:</p> <ul style="list-style-type: none"><li>a. Hard (impervious) surfaces such as driveways, sidewalks, and parking areas (water cannot soak in and runs off)</li><li>b. Porous (pervious) surfaces such as planted beds, lawn or natural areas (water soaks in)</li><li>c. Locate areas of bare soil or where you observe erosion or gullies.</li></ul> |
|---|

- |   |
|---|
| <p>2. Do you observe spots where water flows off hard surfaces and collects? (These are potential sites for rain gardens.) Describe the location and mark it on your map.</p> |
|---|

- |  |
|--|
| <p>3. If you observed bare or eroded soil, determine what may be causing it such as traffic (foot or vehicular), steep slopes, water or other cause.</p> |
|--|

- |  |
|--|
| <p>4. Rate the quality of pervious surfaces on the school ground from 1 to 5 with one being the best. Natural areas allow most of the water to soak into the ground and lawn allows the least. Provide a rationale for the rate you assigned the school ground as a whole.</p> |
|--|

- |   |
|---|
| <p>5. Based on the rating you gave above, how could you increase infiltration on the school ground?</p> |
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- |  |
|--|
| <p>6. Name 2 or 3 locations for possible rain gardens. Why did you choose these spots?</p> |
|--|

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## Noting Notable Features for Rain Gardens (cont.)

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### Vegetation Team

Team Members: \_\_\_\_\_

Location: \_\_\_\_\_

1. Locate the following on your site map:

- a. Trees
- b. Shrubs (areas of shrubs not individual shrubs)
- c. Different ground covers such as lawn, flower beds, unmowed areas, natural areas such as prairie or woodland.

2. Identify trees, shrubs and plants that provide fruit, nuts or nectar for wildlife. What kinds of wildlife food do you observe?

3. Does any of the vegetation provide cover for wildlife? If so, what types of cover?

4. Identify plantings that are pleasant to be around. Why do these places feel good to you?

5. Based on your observations, where are possible locations for a rain garden that are near a pleasant spot to sit or gather as a class and/or would enhance habitat for wildlife?

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# Noting Notable Features for Rain Gardens (cont.)

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## Wildlife Team

Team Members: \_\_\_\_\_

Location: \_\_\_\_\_

1. Locate the following on your site map:
  - a. Locations where you observe wildlife
  - b. Indicate the type of wildlife observed
  - c. Signs of wildlife use such as chewed leaves, holes in trees, holes in the ground, ant mounds, etc.

2. Describe what each animal is doing that you see.

3. Consider habitat needs for wildlife—space, water, food, shelter—how well does your school ground provide for these needs?

4. Based on your observations, what would you recommend to improve the habitat?

5. Are there any places on the school ground that are well suited for locating a rain garden as well as providing habitat? Where are they?

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## Noting Notable Features for Rain Gardens (cont.)

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### Traffic Patterns Team

Team Members: \_\_\_\_\_

Location: \_\_\_\_\_

1. Locate the following on your site map:
  - a. Driveways and parking areas with direction of traffic flow
  - b. Sidewalks
  - c. Pathways (watch where people walk and/or look for signs of pathways such as well-worn trails and shortcuts)
  - d. Where people enter or exit the school ground
  - e. Good views as a pedestrian or passenger in a car
  - f. Bad views as a pedestrian or passenger in a car

2. Describe any things of interest or concern as you analyze the traffic patterns on your site.

3. How well are the needs of walkers and bike riders met on the school ground?

4. How would you change traffic patterns for reasons of safety or to improve movement in and around the school ground?

5. Where would you locate a rain garden when considering views and access to the garden for students and people interested in learning about rain gardens?

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## Noting Notable Features for Rain Gardens (cont.)

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### Land Use Team

Team Members: \_\_\_\_\_

Location: \_\_\_\_\_

1. Locate the following on your site map:

- a. Play areas
- b. Sports fields
- c. Play equipment
- d. Bike racks
- e. Benches and picnic tables
- f. Fences
- g. Obvious utility lines above or below ground

2. Is there anything missing on the school ground that you would like to add? If so, explain.

3. How do the adjoining neighbors use their land?

4. Based on your observations, where could you locate rain gardens that would not conflict with existing uses? What would you describe as potential conflicts?

5. Based on your observations, where could you locate rain gardens to complement existing uses? Why would these locations enhance the space?

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# Identifying Your Soil for Rain Gardens

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## Activity Overview

Students identify soil type at their proposed rain garden location(s) using a soil texture feel test key.

## Objectives

### Students will:

1. Manipulate and feel soil to classify soils by texture using a key
2. Understand the relationship between soil particle size and water movement through soils
3. Compare the composition of soil types

## Subjects Covered

Science

## Grades

K through 12

## Activity Time

1 hour

## Season

Any

## Materials

Soil samples, spray bottles of water, paper toweling, Key to Soil Texture by Feel

## State Standards

### Science

Ask questions, plan investigations, make observations, predictions (C.4.2)

Select multiple information sources (C.4.3)

Use scientific equipment (C.4.4)

Use data to answer questions (C.4.5)

Support conclusions with logic (C.4.7)

Ask new questions (C.4.8)

Identify questions using available resources (C.8.1)

## Background

Determining the soil type for your proposed rain garden is an important factor for calculating its size. Two other factors needed to size a garden are drainage area and percent slope. Together these three factors give you the square footage needed to collect and infiltrate 100% of the rain water that falls in the drainage area. The type of soil influences the size and depth of the garden area. If the soil is sandy, rain gardens can be smaller and deeper because water drains quickly. If the soil has more clay, the garden will need to be larger and shallower because water drains more slowly. It is important to allow water to drain quickly so that mosquitoes will not complete their life cycle from egg to insect. Determining soil type, drainage area and slope will ensure that water will soak into the garden within 6 to 12 hours.

There are several methods to identify the type of soil in your proposed rain garden. It is not necessary to use expensive equipment to analyze your soil type; simply feeling the soil with your hands is adequate. If interested in learning more about your soil, such as its fertility, you can have your soil tested. It is also possible to test water flow through your soil to determine soil type. This soil test is described in Earth Partnership for Schools activity, “Infiltration Test: Exploring the Flow of Water Through Soils.”

## What is soil type?

Soil is made up of three particle sizes—sand, silt, and clay. Sand is the largest particle (0.05 to 2 mm diameter); silt is intermediate (0.05 to 0.002 mm); and clay is the smallest (less than 0.002 mm). Soils have different textures depending upon the proportions of sand, silt, or clay particles in the soil. A soil texture is graded into 14 texture classes or types such as sand, sandy loam, silty clay loam, loam, sandy clay, or clay. Sandy soil is any mix with over 90% sand; sandy loam is 70% sand, 15% silt, and 15% clay; clay soil is 50% clay, 25% silt, and 25% sand; heavy clay is any mix with over 60% clay particles.

The texture of the soil influences the moisture holding capacity of soil, the drainage rate, and the soil’s ability to hold nutrients. Coarse, sandy soils drain water quickly, are poor storehouses of nutrients, and create droughty conditions for plants. In clay soils water drains slowly; as a result, soil remains wet for long periods and often hinders root development. Plants growing in clay must be able to tolerate long periods of excessive moisture with low oxygen conditions, or endure dry, hard soil. The medium texture of silt-sized particles creates a loamy soil that is well drained and holds nutrients. It is ideal for most plant growth.

Soils can be classified into texture classes or types by the way they feel and respond to handling. Sand feels gritty, and the grains do not stick together when squeezed. Silt feels velvety or flour-like when dry and forms a weak ribbon when wet. Pulverized dry clay feels smooth; aggregates and clods are

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## Identifying Your Soil for Rain Gardens (cont.)

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### Science (cont.)

Identify data and sources to answer questions (C.8.2)

Use inferences and observations (C.8.4)

Use knowledge, models, and theories to explain results (C.8.5)

Explain data & conclusions (C.8.7)

Evaluate questions, hypotheses, conclusions (C.8.9)

Discuss results (C.8.10)

Identify further questions (C.8.11)

Ask questions, build hypotheses, design investigations (C.12.1)

Identify issues, questions, research; design & conduct investigations (C.12.2)

Evaluate data (C.12.3)

Use explanations & models to describe results (C.12.5)

Present results (C.12.6)

Understand physical properties of objects (D.4.1)

Group/classify objects based on properties (D.4.2)

Use rocks, minerals, and soils vocabulary (E.4.1)

Identify different physical & chemical properties of earth materials (E.4.2)

Use earth and space science vocabulary (E.4.3)

Describe changes on the earth's surface (E.8.3)

Analyze influence of living organisms on earth's systems (E.8.4)

Find connections among living and non-living things (F.4.4)

very hard and difficult to crush by hand. Wet clay feels sticky or very smooth and satin-like when rubbed and forms a long, flexible ribbon.

### Where does organic matter fit into the soil mix?

Organic matter is the biological components of the soil. Organic matter is either decomposed material or material in the process of decomposition; or fresh organic material; or living organisms. Organic material plays vital roles in the soil. It acts like a sponge, being able to absorb six times its weight in water. It holds onto nutrients that would otherwise wash away. Organic matter loosens heavy clay soil by creating spaces for air and water movement. Also, it adds nutrients such as nitrogen, phosphorus, potassium, and carbon.

You will notice over time that your rain garden will drain water more quickly. That is because the plants have a tremendous ability to infiltrate more water than soil alone. The deep-rooted plants encourage infiltration two ways. First, the long roots create channels that direct water down into the ground. Second, they slough one third of their roots each year, adding organic matter to the garden. Additionally, the plant roots have a great capacity to absorb water that will eventually transpire from the leaves and stems.

### Activity Description

Collect soil samples from proposed rain garden locations on the school grounds. Collect one and one-half cups of soil per sample for your classroom. Place about two teaspoons of soil in your hand. Spray water from a spray bottle to moisten the soil enough to form a ball. Next, use the soil texture feel test key to determine soil type. The step-by-step directions on the key will guide you through the process of soil identification. As a warm-up exercise, practice determining soil type with samples that are clearly comprised of sand, silt, or clay.

### Extensions

- Soil textures vary from one horizon (soil layer) to the next; therefore, try to determine the texture in each of the A, B, and C horizons. Learning the soil texture of each horizon will help you assess the soil's permeability at different levels. In some soils, the water drains quickly in the topsoil but drains poorly in subsoil. See Earth Partnership for Schools activity, "Soil Profile Investigations 3-12," for more information about soil horizons.
- Take soil samples in the schoolyard, and send samples to a soil testing lab for professional testing and analysis.
- Determine soil type using a soil texture triangle to determine percentages of sand, silt, and clay in a soil sample.

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## Identifying Your Soil for Rain Gardens (cont.)

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- Classify and compare soil texture at different locations on a slope or in eroded areas. Which particles collect at the base of the slope or remain on top? Which particles erode first? Is the pattern similar to particle movement on a slope? Can you predict which soils are more susceptible to erosion?

### Additional Resources

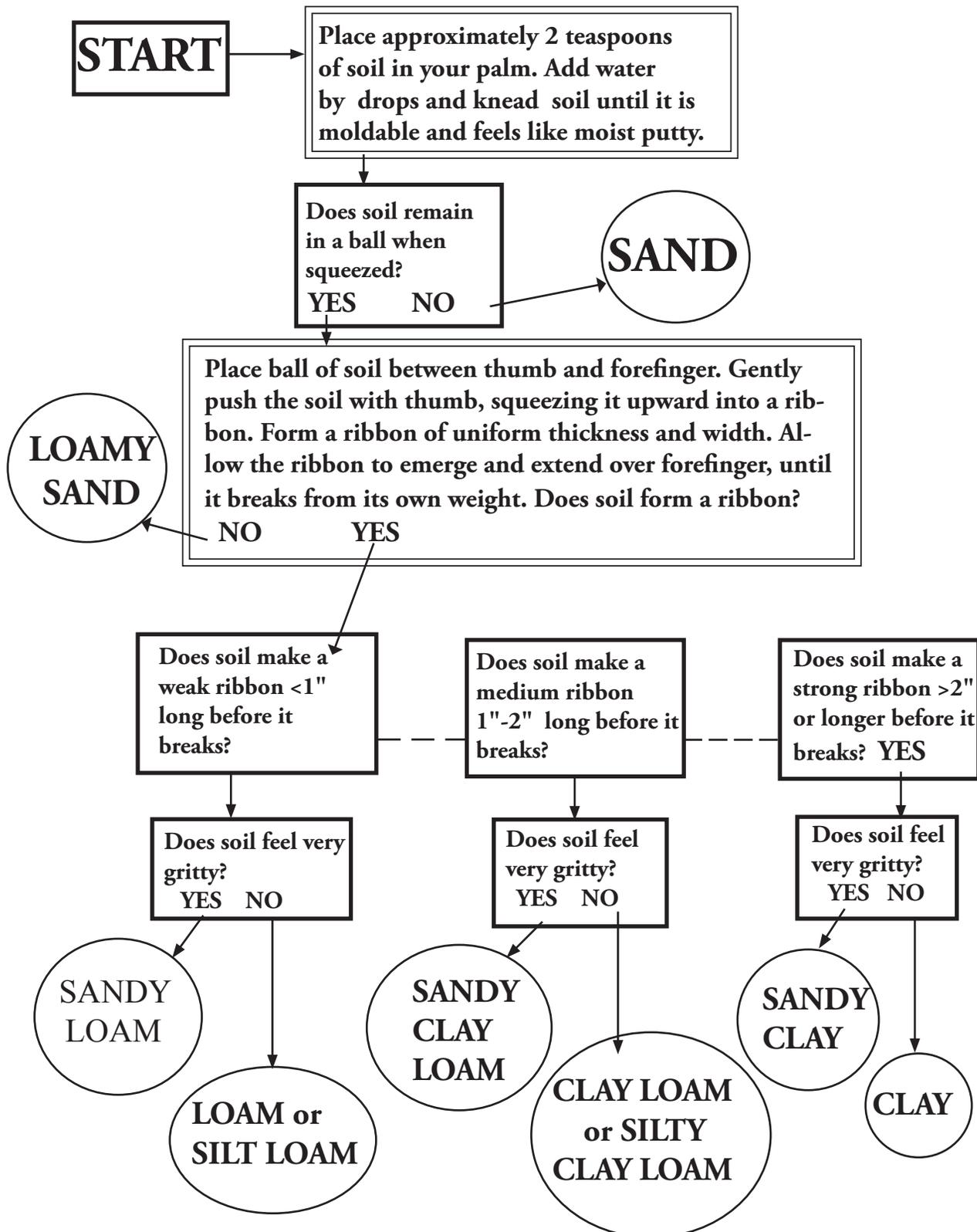
- Hole, F. (1976). *Soils of Wisconsin*. Madison, WI: The University of Wisconsin Press.
- Kesselheim, A.S., Slattery, B.E. (1995). *WOW! The wonders of wetlands*. St Michaels, MD: Environmental Concern Inc.
- Lynn, B. (1988). *Discover wetlands: A curriculum guide*. Olympia, WA: Washington State Department of Ecology Publications Office.
- Mitsch, W. J., Gosselink, J. G. (1993). *Wetlands*, 2nd ed. New York, N.Y.: Van Nostrand Reinhold.
- Project WILD. (1992). *Aquatic Project WILD*. Bethesda, MD: Western Regional Environmental Education Council.

### Assessments

- Explain how soil is classified, and describe two to three properties of each soil textural type.
- Explain the relationship between soil particle size, plant growth, and water.
- Determine the soil texture of three soil samples.

# Soil Texture Feel Test Key

Begin at the place marked "start" and follow the flow chart by answering the questions, until you identify the soil sample. Please note that soils having a high organic matter content may feel smoother (siltier) than they actually are.



Source: Adapted from WOW!: The Wonders of Wetlands, Environmental Concern Inc.

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# Follow the Drop

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## Activity Overview

Students observe and collect information about water runoff on their school property.

## Objective

### Students will:

1. Practice observation and investigative skills
2. Survey and collect information about their school site
3. Calculate the volume of rain water falling and forming runoff on their school grounds
4. Use critical thinking skills to develop ideas for storm water management on their school ground

## Subjects Covered

Science and Math

## Grades

4 through 12

## Activity Time

2 hours: 1 hour on the school ground, 1 hour in the classroom

## Season

Any, preferably spring or fall

## Materials

Clipboards, pencils (or colored pencils), “Follow the Drop” handout, map of schoolyard showing property lines and building locations (and/or graph paper), average annual rainfall data obtained from the weather bureau, local newspapers or TV weather newscaster, etc.

## State Standards

### Math

Use reasoning abilities (A.4.1, A.8.1, A.12.1)

Communicate mathematical ideas (A.4.2)

## Background

Water movement across the landscape during a rain event is basically the same in a large city, a medium-sized subdivision and a single school yard. Only the scales are different. A larger volume of water moves across the landscape in a large city compared to a small school yard. Nevertheless, in either case, water may flow in a sheet-like way, collect in channels, drain into pipes, accumulate in puddles, or soak into the ground during a rain storm. Rain water will eventually drain to a river, to a lake, or to groundwater. To have clean water in a life sustaining, healthy watershed, each site—whether large or small—requires thoughtful storm water management planning. One of the best ways to ensure clean water is to control runoff near its source where precipitation first comes in contact with the land. Keeping water out of storm sewer systems lessens erosion and sediment carried into lakes and rivers, reduces pollutants carried by moving water, and decreases chances of flooding. See Background Section of Earth Partnership for Schools’ Storm Water Curriculum and Teaching Guide for more information.

The purpose of this activity is to promote students’ understanding of the patterns of water movement on their school ground and the larger watershed. It will provide a firsthand experience that will hopefully lead them to think critically about issues related to storm water and to develop water-friendly ideas about storm water management. The information they collect can be used to determine ways to reduce runoff leaving the school and to improve water quality in the watershed.

## Activity Description

You will survey the school grounds, identify how water moves across the landscape, and mark this information on a map. Then you will measure designated areas and calculate the amount of runoff produced from those areas. Once you have this information, you will be equipped to identify locations for infiltrating water on the school grounds.

### Pre-activity Preparations:

- Make a copy of an existing school map that shows the location of buildings, drives, and property lines. Mark north and indicate a scale on the map.
- If desired, divide the map into sections. Assign a section to each student team. The team will locate and record the features described below that are inside their section. The sections can be reassembled to form a composite map.
- Obtain the rainfall depth of a recent storm from the weather service, a local newspaper, etc.

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## Follow the Drop (cont.)

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### Math (cont.)

Use vocabulary, symbols, notation (A.4.4) Analyze non-routine problems (A.8.3)

Apply proportional thinking (B.8.5)

Use coordinate systems to find map locations (C.4.4)

Analyze properties and relationships of figures (C.12.1)

Demonstrate understanding of measurable attributes and units (D.4.2)

Select & use tools to determine measurements directly (D.12.2)

### Science

Explain survival and population growth of species (F.8.9)

Find connections among living and non-living things (F.4.4)

Investigate cooperation & competition (F.12.7)

Infer changes in ecosystems (F.12.8)

### Step 1: Identify Water Patterns.

Find the following features in order to identify the rainwater flow paths:

- Locate high and low points.
- Locate impervious (hard) surfaces such as parking lots and sidewalks, where water runs off. Next, locate pervious (porous) surfaces such as planted beds or grassy areas where water may soak in or infiltrate into the ground.
- Identify patterns in water movement such as where water might flow sheet-like, in gullies, or in channels. Draw arrows to show the direction of water movement.
- Locate storm drains on school property.
- Locate points where water enters the school ground from hillsides, streets, and other locations.
- Identify spots where water exits the school ground such as through ditches or off school parking lots.
- Locate places where water puddles. Areas that puddle may have different plants than the surrounding area. The soil is often wet or it may become hard and cracked when dry.
- Identify where water spills from one surface onto another such as where water is moving from a hard, impervious surface like a sidewalk to a pervious, vegetated area or vice versa.
- Locate downspouts on the school buildings or identify where water falls off roofs.

### Step 2: Measure Areas and Calculate Surface Runoff.

Select an area and measure its size—then calculate the amount of runoff it generates. Possible areas include the school roof, a parking lot, a sports field or a play area. Use measuring tapes to make on-the-ground measurements.

#### *Indoor Option*

Access a satellite map of the school grounds such as one from Google Earth. Print the map, including the scale and a grid. Grids may also be added using a ruler to draw a grid on a printed map or using PowerPoint 2010 to take a screen shot of the map; then place a table with square cells over the screen shot to make the grid.

#### *Calculations:*

1. Determine the area of your selected site (roof, parking lot, play area, etc.); multiply length by width to obtain the area in square feet. For example, 30 ft. x 50 ft. = 1500 sq. ft. If using a map indoors, count the square cells and multiply the number of cells by the square area of each cell.

2. Determine the volume of rainfall falling on your site; multiply the area by the rainfall depth for a sample storm. In this example, 3 inches of rain fell during the storm.

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## Follow the Drop (cont.)

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- a) Convert the rainfall depth from inches to feet. For example, 3 in.  $\div$  12 in. = 0.25 ft.
- b) Multiply the site area (square feet) by the rainfall depth (feet) to get the volume of rainfall (cubic feet) at the site. For example, 1500 sq.ft.  $\times$  0.25 ft = 375 cu.ft.

3. Calculate how much of the rainwater becomes surface runoff. More runoff is generated on harder surfaces than pervious surfaces. If rain is falling on a roof or parking lot, all becomes runoff. Runoff amounts from lawns vary, but approximately 60% of rain falling on lawns becomes runoff. If rainwater runs into a native planting approximately 40% becomes runoff. If rain water runs into a rain garden potentially 100% collects and infiltrates and no water becomes runoff. With a native planting, the surface runoff calculation for the example storm is 375 cu.ft.  $\times$  0.4 = 150 cu.ft.

4. Add the runoff volumes from the different surfaces to find the total volume of surface runoff from the school grounds in cubic feet.

### **Step 3: Discuss Observations, Results, and Possibilities.**

As a class, share your findings based on observations and data generated. Discuss the big picture of water movement by identifying characteristics observed, possible problem areas, etc. Talk about ways the school can reduce runoff on school grounds. Identify likely areas to create rain gardens to collect and infiltrate water.

### **Extensions**

- Go outside when it is raining, and observe storm water runoff in action. (See Rainy-Day Hike activity in Project Wet: Curriculum and Activity Guide. Bozeman, MT: The Watercourse and Council for Environmental Education. Pages 186 – 190.)
- Pour a bucket of water or balls on the ground to get a sense of how water moves. Make predictions before pouring the contents of the bucket.
- Identify the watershed(s) the school is located in, and then map what route the school's runoff will take to the nearest body of water.
- Observe what the rain water runoff is picking up along its route – sediment, trash, oil, etc.

### **Additional Resources**

- Higgins, S., Kesselheim, A., Robinson, G. (1995). Project wet: Curriculum and activity guide. Bozeman, MT: The Watercourse and Council for Environmental Education.
- Leopold, Luna B. (1974). Water: A primer. San Francisco, CA: W.H. Freeman & Co.
- Nadeau, Isaac. (2003). The water cycle: Water in plants and animals. New York: Rosen Publishing Group, Inc.
- Nadeau, Isaac. (2003). The water cycle: Water in the atmosphere. New York: Rosen Publishing Group, Inc.
- .....Where does water runoff after school? Project WILD. Bethesda, MD: Western Regional Environmental Education Council.

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## Follow the Drop (cont.)

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### **Assessments**

- Describe the topography of your schoolyard and how it affects the flow of water during a heavy rainfall.
- Tell a story about a rain drop falling on the school ground. Describe its journey as it moves on the school property. (See “Odyssey” in Aldo Leopold’s Sand County Almanac and Sketches Here and There. Oxford University Press.)
- List positive water-friendly landscape features and things that could change on the school ground to provide for a healthy watershed.
- Give an oral report on your findings along with follow-up suggestions for increasing infiltration and reducing surface runoff.

# Follow the Drop

Calculate Surface Area in Square Feet					
Surface	Width	x	Length	=	Area
Roof	ft.	x	ft.		sq.ft.
Parking Lot	ft.	x	ft.		sq.ft.
Lawn	ft.	x	ft.		sq.ft.
Native Planting	ft.	x	ft.		sq.ft.
Rain Garden	ft.	x	ft.		sq.ft.
Convert Rainfall Depth from Inches to Feet					
Rainfall Depth	in.	÷	12 in.	=	ft.
Determine Volume of Rainfall in Cubic Feet					
Surface	Area	x	Rainfall Depth	=	Volume
Roof	sq.ft.	x	ft.		cu.ft.
Parking Lot	sq.ft.	x	ft.		cu.ft.
Lawn	sq.ft.	x	ft.		cu.ft.
Native Planting	sq.ft.	x	ft.		cu.ft.
Rain Garden	sq.ft.	x	ft.		cu.ft.
Estimate Surface Runoff					
Surface	Rainfall Volume	x	Runoff %	=	Runoff Volume
Roof	cu.ft.	x	1		cu.ft.
Parking Lot	cu.ft.	x	1		cu.ft.
Lawn	cu.ft.	x	0.6		cu.ft.
Native Planting	cu.ft.	x	0.4		cu.ft.
Rain Garden	cu.ft.	x	0.0		cu.ft.
<b>Total Runoff</b>	<b>Add runoff volumes for all surfaces</b>				<b>cu.ft.</b>

If the impervious surfaces were reduced by 20% how much runoff would be removed from the storm water circuit? \_\_\_\_\_

Bonus: See the runoff volume in a new context.

\_\_\_\_\_ cu.ft. x 7.48 = \_\_\_\_\_ gallons

\_\_\_\_\_ gallons ÷ 70 = \_\_\_\_\_ days for the average American to use the volume of water

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# Identifying Your Soil for Rain Gardens

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## Activity Overview

Students identify soil type at their proposed rain garden location(s) using a soil texture feel test key.

## Objectives

### Students will:

1. Manipulate and feel soil to classify soils by texture using a key
2. Understand the relationship between soil particle size and water movement through soils
3. Compare the composition of soil types

## Subjects Covered

Science

## Grades

K through 12

## Activity Time

1 hour

## Season

Any

## Materials

Soil samples, spray bottles of water, paper toweling, Key to Soil Texture by Feel

## State Standards

### Science

Ask questions, plan investigations, make observations, predictions (C.4.2)

Select multiple information sources (C.4.3)

Use scientific equipment (C.4.4)

Use data to answer questions (C.4.5)

Support conclusions with logic (C.4.7)

Ask new questions (C.4.8)

Identify questions using available resources (C.8.1)

## Background

Determining the soil type for your proposed rain garden is an important factor for calculating its size. Two other factors needed to size a garden are drainage area and percent slope. Together these three factors give you the square footage needed to collect and infiltrate 100% of the rain water that falls in the drainage area. The type of soil influences the size and depth of the garden area. If the soil is sandy, rain gardens can be smaller and deeper because water drains quickly. If the soil has more clay, the garden will need to be larger and shallower because water drains more slowly. It is important to allow water to drain quickly so that mosquitoes will not complete their life cycle from egg to insect. Determining soil type, drainage area and slope will ensure that water will soak into the garden within 6 to 12 hours.

There are several methods to identify the type of soil in your proposed rain garden. It is not necessary to use expensive equipment to analyze your soil type; simply feeling the soil with your hands is adequate. If interested in learning more about your soil, such as its fertility, you can have your soil tested. It is also possible to test water flow through your soil to determine soil type. This soil test is described in Earth Partnership for Schools activity, “Infiltration Test: Exploring the Flow of Water Through Soils.”

## What is soil type?

Soil is made up of three particle sizes—sand, silt, and clay. Sand is the largest particle (0.05 to 2 mm diameter); silt is intermediate (0.05 to 0.002 mm); and clay is the smallest (less than 0.002 mm). Soils have different textures depending upon the proportions of sand, silt, or clay particles in the soil. A soil texture is graded into 14 texture classes or types such as sand, sandy loam, silty clay loam, loam, sandy clay, or clay. Sandy soil is any mix with over 90% sand; sandy loam is 70% sand, 15% silt, and 15% clay; clay soil is 50% clay, 25% silt, and 25% sand; heavy clay is any mix with over 60% clay particles.

The texture of the soil influences the moisture holding capacity of soil, the drainage rate, and the soil’s ability to hold nutrients. Coarse, sandy soils drain water quickly, are poor storehouses of nutrients, and create droughty conditions for plants. In clay soils water drains slowly; as a result, soil remains wet for long periods and often hinders root development. Plants growing in clay must be able to tolerate long periods of excessive moisture with low oxygen conditions, or endure dry, hard soil. The medium texture of silt-sized particles creates a loamy soil that is well drained and holds nutrients. It is ideal for most plant growth.

Soils can be classified into texture classes or types by the way they feel and respond to handling. Sand feels gritty, and the grains do not stick together when squeezed. Silt feels velvety or flour-like when dry and forms a weak ribbon when wet. Pulverized dry clay feels smooth; aggregates and clods are

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## Identifying Your Soil for Rain Gardens (cont.)

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### Science (cont.)

Identify data and sources to answer questions (C.8.2)

Use inferences and observations (C.8.4)

Use knowledge, models, and theories to explain results (C.8.5)

Explain data & conclusions (C.8.7)

Evaluate questions, hypotheses, conclusions (C.8.9)

Discuss results (C.8.10)

Identify further questions (C.8.11)

Ask questions, build hypotheses, design investigations (C.12.1)

Identify issues, questions, research; design & conduct investigations (C.12.2)

Evaluate data (C.12.3)

Use explanations & models to describe results (C.12.5)

Present results (C.12.6)

Understand physical properties of objects (D.4.1)

Group/classify objects based on properties (D.4.2)

Use rocks, minerals, and soils vocabulary (E.4.1)

Identify different physical & chemical properties of earth materials (E.4.2)

Use earth and space science vocabulary (E.4.3)

Describe changes on the earth's surface (E.8.3)

Analyze influence of living organisms on earth's systems (E.8.4)

Find connections among living and non-living things (F.4.4)

very hard and difficult to crush by hand. Wet clay feels sticky or very smooth and satin-like when rubbed and forms a long, flexible ribbon.

### Where does organic matter fit into the soil mix?

Organic matter is the biological components of the soil. Organic matter is either decomposed material or material in the process of decomposition; or fresh organic material; or living organisms. Organic material plays vital roles in the soil. It acts like a sponge, being able to absorb six times its weight in water. It holds onto nutrients that would otherwise wash away. Organic matter loosens heavy clay soil by creating spaces for air and water movement. Also, it adds nutrients such as nitrogen, phosphorus, potassium, and carbon.

You will notice over time that your rain garden will drain water more quickly. That is because the plants have a tremendous ability to infiltrate more water than soil alone. The deep-rooted plants encourage infiltration two ways. First, the long roots create channels that direct water down into the ground. Second, they slough one third of their roots each year, adding organic matter to the garden. Additionally, the plant roots have a great capacity to absorb water that will eventually transpire from the leaves and stems.

### Activity Description

Collect soil samples from proposed rain garden locations on the school grounds. Collect one and one-half cups of soil per sample for your classroom. Place about two teaspoons of soil in your hand. Spray water from a spray bottle to moisten the soil enough to form a ball. Next, use the soil texture feel test key to determine soil type. The step-by-step directions on the key will guide you through the process of soil identification. As a warm-up exercise, practice determining soil type with samples that are clearly comprised of sand, silt, or clay.

### Extensions

- Soil textures vary from one horizon (soil layer) to the next; therefore, try to determine the texture in each of the A, B, and C horizons. Learning the soil texture of each horizon will help you assess the soil's permeability at different levels. In some soils, the water drains quickly in the topsoil but drains poorly in subsoil. See Earth Partnership for Schools activity, "Soil Profile Investigations 3-12," for more information about soil horizons.
- Take soil samples in the schoolyard, and send samples to a soil testing lab for professional testing and analysis.
- Determine soil type using a soil texture triangle to determine percentages of sand, silt, and clay in a soil sample.

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## Identifying Your Soil for Rain Gardens (cont.)

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- Classify and compare soil texture at different locations on a slope or in eroded areas. Which particles collect at the base of the slope or remain on top? Which particles erode first? Is the pattern similar to particle movement on a slope? Can you predict which soils are more susceptible to erosion?

### Additional Resources

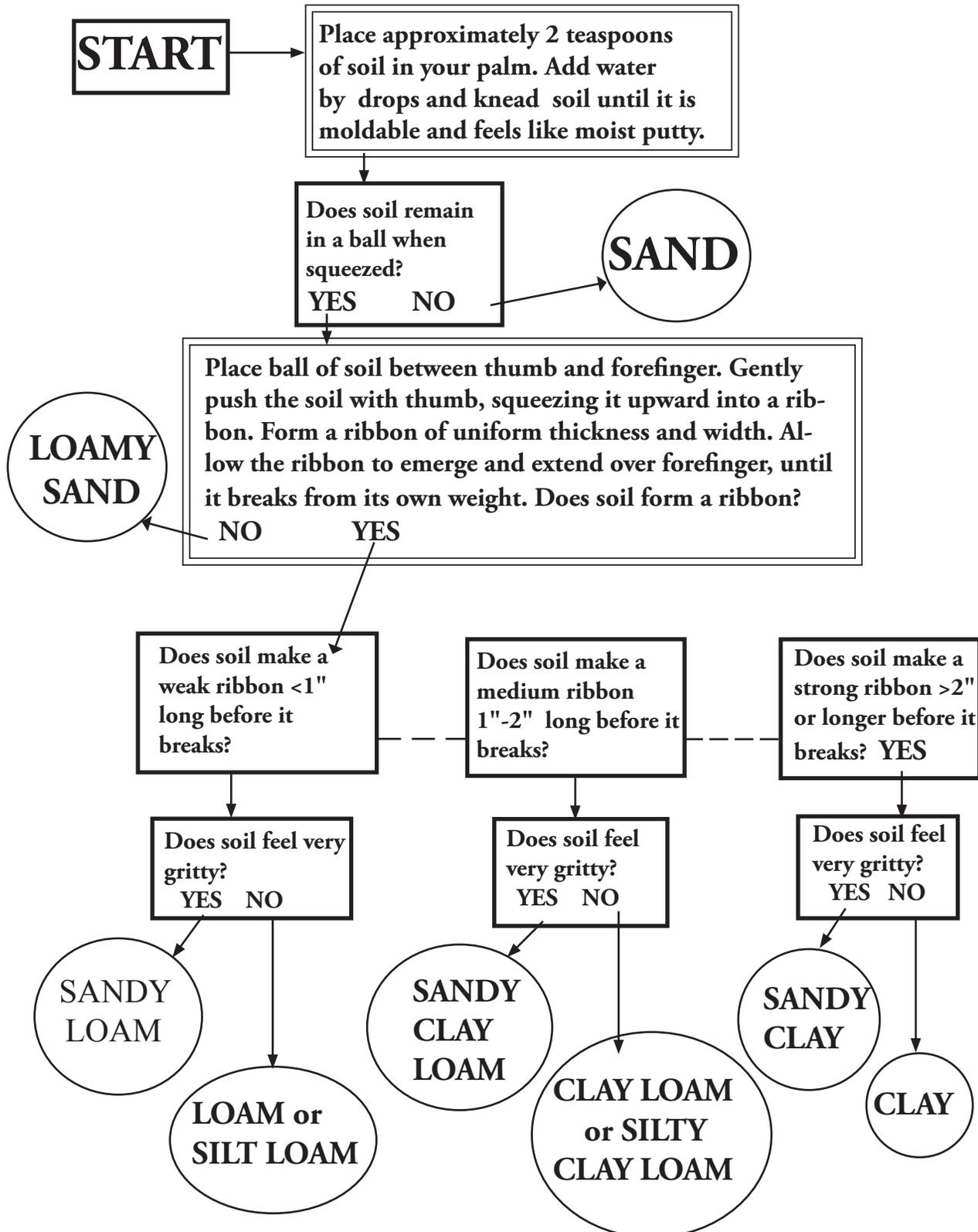
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- Kesselheim, A.S., Slattery, B.E. (1995). *WOW! The wonders of wetlands*. St Michaels, MD: Environmental Concern Inc.
- Lynn, B. (1988). *Discover wetlands: A curriculum guide*. Olympia, WA: Washington State Department of Ecology Publications Office.
- Mitsch, W. J., Gosselink, J. G. (1993). *Wetlands*, 2nd ed. New York, N.Y.: Van Nostrand Reinhold.
- Project WILD. (1992). *Aquatic Project WILD*. Bethesda, MD: Western Regional Environmental Education Council.

### Assessments

- Explain how soil is classified, and describe two to three properties of each soil textural type.
- Explain the relationship between soil particle size, plant growth, and water.
- Determine the soil texture of three soil samples.

# Soil Texture Feel Test Key

Begin at the place marked "start" and follow the flow chart by answering the questions, until you identify the soil sample. Please note that soils having a high organic matter content may feel smoother (siltier) than they actually are.



Source: Adapted from WOW!: The Wonders of Wetlands, Environmental Concern Inc.

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# Infiltration Test: Exploring the Flow of Water Through Soils

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## Activity Overview

Students measure water flow into and through soils.

## Objectives

### Students will:

1. Compare water movement through soil at different test sites and over time
2. Collect data
3. Interpret results to inform decision-making about school ground plantings
4. Increase understanding of water soil dynamics
5. Understand human impact on the landscape

## Subjects Covered

Science, Math, and Social Studies

## Grades

4 through 12

## Activity Time

45 minutes (2 hours wait time)

## Season

Spring or Fall

## Materials

**Option 1:** Cut-can Infiltrometer: metal cylinders (approximately 15 cm (six inches) in diameter and 13 to 20 cm (five to eight inches) in length); hammer; scrap wood board (an 18 inch two by four works well); stopwatch, or watch which reads in seconds; and a measuring cup with capacity for one half a liter, or 1 pint.

**Option 2:** Water Absorption Test: shovel, ruler, stopwatch, 2 - 3 gallons of water

## Background

How water flows into and through a soil has great implications for the diversity of plants that can be supported by that soil. Different species of plants will be favored by a slow versus fast draining soil. Accordingly, the choice of plant species for a native planting or ecological restoration is determined in a large part by the dynamics of soil and water. Water flow through soil also plays a significant role in how large to build a rain garden.

There are a number of factors which can influence how wet or dry a particular soil is and how water infiltrates the soil. The physical structure and texture of the topsoil is a key characteristic affecting water flow. A sandy soil has larger pore spaces than a clay soil. Pore spaces are the air spaces between particles. This allows water to percolate or infiltrate the soil more quickly. Clay soil is made up of smaller particles and pore spaces slowing water's ability to infiltrate.

Subsoil characteristics can also play a major role in water movement. A heavy (clay) subsoil layer can act as a seal underneath the topsoil. If there is enough rain, the topsoil will become saturated and there will be no place for the water to go regardless of the characteristics of the topsoil.

Soil compaction can lead to destruction of soil structure (the arrangement of soil particles and pore spaces), and thus reduce water flow. The pore spaces and natural cracks are squeezed out in a compacted soil creating a cement-like soil. Heavy construction vehicles, poor farming practices and even walking on wet soil destroys soil structure and impedes water flow.

The amount of water being held by a soil at the time of testing can also greatly affect how water soaks into the ground. A saturated soil will usually have a different flow rate than the same soil in an unsaturated state. This is due to the presence of soil-water matrix forces in unsaturated conditions. These matrix forces are complex and result from a combination of adhesion forces (the attraction between soil surfaces and water) and cohesion forces (the attraction of molecules of water to each other). In saturated conditions gravitational forces alone are responsible for water movement in soils.

The first infiltration test described below is used to quantify the ability of water to move into and through a soil. Because of the great number of factors which can affect the flow of water through soils, it is best to use this test on a relative basis. This means that a number of tests could either be run at the same time at different sites or at the same site at different times. The results from that particular set of tests are then only directly compared to each other. This technique is suitable to long-term soil infiltration testing. Usually as native plants mature and their roots spread, infiltration changes. This procedure can be used to track change over time.

# Infiltration Test: Exploring the Flow of Water Through Soils (cont.)

## State Standards

### Science

Use scientific sources & resources (B.4.1)

Select multiple information sources (C.4.3)

Use data to answer questions (C.4.5)

Identify data and sources to answer questions (C.8.2)

Evaluate data (C.12.3)

Choose & evaluate data collection methods (C.12.4)

### Math

Use reasoning abilities (A.4.1, A.8.1, A.12.1)

Work with algebraic expressions (F.8.1)

Model & solve mathematical & real-world problems using algebra (F.12.4)

The second infiltration test is often used to learn soil type for determining how big to build a rain garden. The rate at which the water soaks into the ground indicates if the soil is sandy, silty, or like clay. Soil is a critical factor for calculating the size of a rain garden. See Earth Partnership for Schools activity “Sizing a Rain Garden” for more information and/or to take the next step in planning a rain garden. Learning soil type will also inform plant selection for any planting. Matching plants to soil type will help in choosing plants that will survive your proposed planting.

## Activity

### Description

#### Option 1: Cut-Can Infiltrometer (Best for follow-up infiltration tests.)

Carefully choose and prepare a test site. A level location will give the best results by allowing the water to infiltrate evenly into the soil. A site with gravel will most likely be difficult or impossible because of difficulties in sinking the cylinder into the soil. A heavy lawn sod will create similar difficulties because of the dense mat of roots. Work around living plants, and expose bare soil by removing any leaf litter. Disturb the soil surface as little as possible.



*Winnequah Middle School students performing water flow testing, Madison, WI. Photo: Cheryl Bauer-Armstrong*

Sink the cylinder into the soil approximately five to seven centimeters (two to three inches) to create a tight seal between the bottom of the cylinder and the soil. You will most likely need to use a hammer to do so. It is best to place a wood board on top of the cylinder when hammering to keep from denting its top. Hammer in circles around the top to keep the cylinder perpendicular with the soil surface. During the test, if water leaks out the bottoms and sides of the cylinder, your results will be skewed. You will need to repeat the test with the cylinder either further in the soil or sunk more carefully so the soil is less disturbed along the cutting edge of the cylinder.

Have your watch ready and add the water to the cylinder. Time how long it takes for all of the water to move into the soil with complete elimination of all puddles.

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## Infiltration Test: Exploring the Flow of Water Through Soils (cont.)

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### Additional considerations

Some soils have very slow infiltration rates, and this can lead to unnecessarily long run times. If you suspect you might have this problem you can use an alternative procedure which is a bit more complicated, but also more efficient. Graduate your cylinder by making one centimeter (or one half inch) marks up its inside. To calibrate your gradations measure how deep a given amount of water will fill an uncut can and extrapolate to your scale.

As an interesting related math activity, this same measurement can be achieved by calculating the volume corresponding to your gradations. Measure the diameter of your cylinder and calculate its cross-sectional area. (Remember the area of a circle =  $\pi r^2$ .) Multiply this number by the length of your gradation to determine the corresponding volume. Your calculations will be greatly simplified if you use metric units (one cubic centimeter = one milliliter).

### Option 2: Water Absorption Test (Best for rain garden planning.)

Perform the following infiltration test at each location selected for a potential rain garden.

1. Dig a hole 6 inches deep by 6 inches in diameter.
2. Fill hole with water and let stand for one hour.
3. Refill hole with water. Measure depth of water with a ruler.
4. Let stand 1 hour. Then measure the depth again.
5. Use the following chart to determine soil types based on the rate at which water soaks into the soils.

Soil type	Sand	Silt	Clay
Rate	2.5 inches/hour or 4 hours total	1/2 inches/hour or 12 hours total	1/3 inches/hour or 18 hours total

1. Record soil characterization data on field sheets.
2. Use data collected in Earth Partnership for Schools activities, “Designing a Rain Garden” and “Sizing a Rain Garden.”

### Extensions

- Test the difference in water flow through saturated versus unsaturated soils. Does the rate of infiltration vary with different soils?
- Investigate infiltration through subsoil. Carefully dig off the topsoil, and place the infiltrometer into the subsoil layer.
- Compare infiltration rates between compacted soil and uncompacted soil. Observe and identify visual characteristics of compacted soil on the school grounds.
- Research what you can do to improve soil infiltration.

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## Infiltration Test: Exploring the Flow of Water Through Soils (cont.)

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### **Additional Resources**

- If interested, purchase a double ring infiltrometer for infiltration testing. They are available from Turf -Tec International at 1.800.258.7477 or <http://www.turf-tec.com/index.html>

### **Web sites**

- Globe in the City - Infiltration: [www.centerx.gseis.ucla.edu/globe/protocols/infilt.htm](http://www.centerx.gseis.ucla.edu/globe/protocols/infilt.htm)

### **Assessments**

- Using the results of the infiltration tests, describe how different soil types and/or soil compaction influences water flow through soil.
- Based on the results of the infiltration tests, where would you locate a rain garden for best infiltration?
- Describe the factors that influence soil permeability.

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# Infiltration Field Test Data Sheet

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Date: \_\_\_\_\_

Soil type	Sand	Silt	Clay
Rate	2.5 inches/hour or 4 hours total	1/2 inches/hour or 12 hours total	1/3 inches/hour or 18 hours total

## Water Absorption Test Data Sheet - 1

### Vegetation Type

Lawn, garden, field, other \_\_\_\_\_

### Soil Characteristics

Tilth -- compacted, intermediate, fluffy, other \_\_\_\_\_

Moisture -- rate 1-5 where 1 is bone dry, 5 is saturated and 3 is moderate/moist \_\_\_\_\_

Infiltration Rate \_\_\_\_\_ inches/hour

Soil Type \_\_\_\_\_

## Water Absorption Test Data Sheet - 2

### Vegetation Type

Lawn, garden, field, other \_\_\_\_\_

### Soil Characteristics

Tilth -- compacted, intermediate, fluffy, other \_\_\_\_\_

Moisture -- rate 1-5 where 1 is bone dry, 5 is saturated and 3 is moderate/moist \_\_\_\_\_

Infiltration Rate \_\_\_\_\_ inches/hour

Soil Type \_\_\_\_\_

## Water Absorption Test Data Sheet - 3

### Vegetation Type

Lawn, garden, field, other \_\_\_\_\_

### Soil Characteristics

Tilth -- compacted, intermediate, fluffy, other \_\_\_\_\_

Moisture -- rate 1-5 where 1 is bone dry, 5 is saturated and 3 is moderate/moist \_\_\_\_\_

Infiltration Rate \_\_\_\_\_ inches/hour

Soil Type \_\_\_\_\_

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# Infiltration Field Test Data Sheet

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## Cut-Can Infiltrometer Data Sheet - 1

### Vegetation Type

Prairie, woodland, savanna, garden, other \_\_\_\_\_

### Soil Characteristics

Texture -- sand, loam, clay, other \_\_\_\_\_

Tilth -- compacted, intermediate, fluffy, other \_\_\_\_\_

Moisture -- rate 1-5 where 1 is bone dry, 5 is saturated and 3 is moderate/moist \_\_\_\_\_

Infiltration Rate \_\_\_\_\_ minutes/500 ml

(Note: If a different volume was measured, give the rate as minutes per 500mls)

## Cut-Can Infiltrometer Data Sheet - 2

### Vegetation Type

Prairie, woodland, savanna, garden, other \_\_\_\_\_

### Soil Characteristics

Texture -- sand, loam, clay, other \_\_\_\_\_

Tilth -- compacted, intermediate, fluffy, other \_\_\_\_\_

Moisture -- rate 1-5 where 1 is bone dry, 5 is saturated and 3 is moderate/moist \_\_\_\_\_

Infiltration Rate \_\_\_\_\_ minutes/500 ml

(Note: If a different volume was measured, give the rate as minutes per 500mls)

## Cut-Can Infiltrometer Data Sheet - 3

### Vegetation Type

Prairie, woodland, savanna, garden, other \_\_\_\_\_

### Soil Characteristics

Texture -- sand, loam, clay, other \_\_\_\_\_

Tilth -- compacted, intermediate, fluffy, other \_\_\_\_\_

Moisture -- rate 1-5 where 1 is bone dry, 5 is saturated and 3 is moderate/moist \_\_\_\_\_

Infiltration Rate \_\_\_\_\_ minutes/500 ml

(Note: If a different volume was measured, give the rate as minutes per 500mls)

# Measuring Slope for Rain Gardens

## Activity Overview

Students measure the slope and calculate percent slope for their rain garden project.

## Objectives

### Students will:

1. Measure and calculate degree of slope using simple tools
2. Use math concepts in problem-solving a real-world situation
3. Understand how the percent slope, i.e., steepness of a slope, affects the construction of a rain garden

## Subjects Covered

Science and Math

## Grades

3 through 12

## Activity Time

1-2 hours

## Season

Spring or Fall

## Materials

For each team of 4 students - 1 Line level\*, 15 feet of string, 2 wooden stakes, 1 ruler, clipboard and field sheet

## State Standards

Math

Use reasoning abilities (A.4.1, A.8.1, A.12.1)

Connect mathematical learning with other subjects (A.4.3)

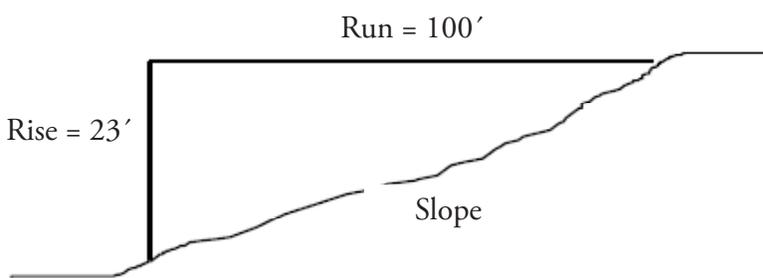
Use vocabulary, symbols, notation (A.4.4)

Explain solutions to problems (A.4.5)

Analyze non-routine problems (A.8.3)

## Background

Slope is the change in elevation between two points. It is expressed as a percent change in elevation per unit of distance. When planning a rain garden the percent slope of the garden space determines the depth of the rain garden and how deep to dig your garden. The goal is to keep the garden level so that water spreads out and does not puddle. When digging your garden, you will cut soil from the upper slope and fill in the lower slope to create a flat bottom. To determine how much cut and fill is necessary, you calculate the depth of the garden based on the slope. Generally the greater the slope the deeper the garden will need to be dug. A slope less than 4% equals a 3 – 5 inch deep garden, 5 – 7% slope equals a 6 – 7 inch deep garden, and 8 – 12% slope equals an 8 inch deep garden. If the slope is more than 12%, it's best to talk to a professional landscaper or find a different site.



The easiest way to determine the percent slope of an area is to measure the change in height (elevation over a measured distance), then calculate the percentage of slope. Use the following formula to determine slope:

$$\text{Rise} \div \text{Run} \times 100 = \text{Slope \%}$$

OR

$$(\text{Change in elevation (rise)} \div \text{horizontal distance (run)}) \times 100 = \text{slope \%}$$
$$23' \div 100' \times 100 = 23\%$$

## Pre-Activity Preparation

For each team:

- Make two 20 inch stakes
- Cut a piece of string about 10 feet long plus 6 inches for tying the string to the stakes. It is helpful to use a nylon-type string that is less prone to knotting. Mark the string at 10 feet (120 inches). You may mark the string in 10 inch intervals for easier measuring. Tie the string to one of the stakes and wrap the string around the stake. Make a loop at the other end of the string that will slip over the second stake.
- Assemble a measuring tool packet with stakes, string, line level, ruler, clipboard, field sheet and a pencil.

# Measuring Slope for Rain Gardens (cont.)

Math (cont.)

Explain mathematical concepts, procedures, & ideas (A.8.5)

Analyze non-routine problems & arrive at solutions (A.12.3)

Organize work & present mathematical procedures & results (A.12.5)

Represent & explain whole numbers, decimals, & fractions (B.4.1)

Read, write, & order whole numbers, fractions, & decimals (B.4.3)

Select & use appropriate computational procedures (B.4.5)

Read, represent, & interpret rational numbers (B.8.1)

Generate & explain equivalencies among fractions, decimals, percents (B.8.3)

Apply proportional thinking (B.8.5)

Use appropriate computational procedures with rational numbers (B.8.7)

Use complex counting procedures (B.12.1)

Compare real numbers (B.12.2)

Create & critically evaluate numerical arguments (B.12.5)

Routinely assess the acceptable limits of error (B.12.6)

Describe simple two- & three-dimensional figures (C.4.1)

Identify & use relationships among figures (C.4.3)

Use coordinate systems to find map locations (C.4.4)

Describe complex two- & three-dimensional figures (C.8.1)

figures (C.8.2)

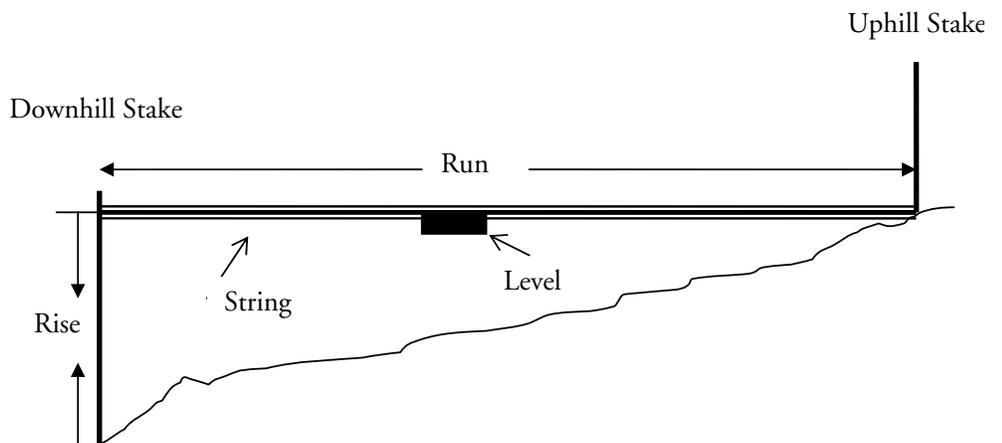
Identify & draw two- & three-dimensional shapes (C.8.3)

## Activity Description

1. Form teams of 5 students each, and hand out measuring tool packets. Each student has a different role. One student holds the uphill stake, another holds the downhill stake. One student records the data, and 2 students pull and level the string. All students calculate the numbers.
2. Practice measuring slope in the classroom following the instructions below. Go out to proposed rain garden site.
3. Select measuring sites in and around the proposed rain garden. Not all students will be able to measure the slope in the rain garden. Locate other sites for comparison, especially if different slopes are evident. Another option is to have all students practice in different spots, then measure the rain garden as a group, in which students take turns doing and describing each step.
4. Record measurements on the field sheets.
5. Return to the classroom to calculate slope and determine depth of rain garden using the field sheet.

## Directions for measuring the slope

1. Hold the stake with the string attached at the uphill end of the measuring site. Push the string down to the bottom of the uphill stake.
2. Place the second stake at the downhill end.
3. Run the string to the downhill stake. You may need to move the stake to meet the string. The distance between the stakes is 10 feet or 120 inches. Write this number as the run on the field sheet.
4. Loop the string around the downhill stake.
5. Attach the line level to the string. It should hang down. Slide the string up or down on the downhill stake until the line level indicates the string is horizontal and level.
6. Measure the height in inches on the downhill stake between the string and ground. Write this number as the rise on the field sheet.



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## Measuring Slope for Rain Gardens (cont.)

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Math (cont.)

Use geometric models to solve problems (C.12.2)

Recognize & describe measurable attributes & units (D.4.1)

Demonstrate understanding of measurement (D.4.2)

Read & interpret measuring instruments (D.4.3)

Determine measurements by using standard tools (D.4.4)

Demonstrate understanding of measurement facts, principles, techniques (D.8.2)

Determine measurement directly by using standard units (D.8.3)

Determine measurement indirectly (D.8.4)

Select & use tools to determine measurements directly (D.12.2)

Determine measurement indirectly (D.12.3)

Work with data in real-world situations (E.4.1, E.8.1, E.12.1)

Describe a set of data (E.4.2)

Use graphs, tables, or charts (E.4.3)  
cal investigations (E.8.2)

Analyze information from organized & displayed data (E.8.3)

Use results of data analysis (E.8.4)

Work with data in real-world situations (E.12.1)

### Extensions

- Measure a slope at three places along a line, and plot the results on a graph.
- See Earth Partnership for Schools activity “Topography: Measuring Slope” for additional information about the relationship among slope, soil, vegetation and human uses. This activity also provides an alternative technique for measuring slope.

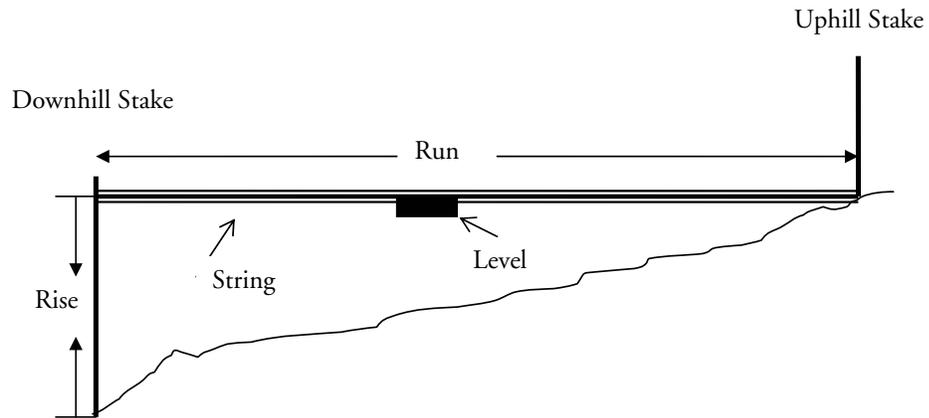
### Additional Resources

- ...*Soil erosion: The work of uncontrolled water*. Agriculture Information Bulletin #260, Soil Conservation Service, U.S. Department of Agriculture.
- ...*Teaching soil and water conservation*. Program Bulletin #341, Soil Conservation Service, U.S. Department of Agriculture.
- Line Levels are available at hardware stores for about \$1 to \$2.

### Assessments

- Describe the steps to accurately measure the slope on your schoolyard.
- If you had to dig a rain garden by hand, identify what kind of slope you would prefer to minimize your work, and why.

# Measuring Slope for Rain Gardens - Field Sheet



## Slope Formula

Rise (change in elevation) ÷ Run (horizontal distance) x 100 = slope %

## Rain Garden Depth

- < 4% slope = 3" – 5" deep garden
- 5 – 7% slope = 6" – 7" deep garden
- 8 – 12% slope = 8" deep garden

Location	Rise	Run	% Slope	Rain Garden Depth
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				



## Plan a Rain Garden

# Sizing a Rain Garden

## Activity Overview

Students calculate the size of a rain garden using measuring tools, tables, and formulas.

## Objectives

### Students will

1. Determine the drainage area through observation and data collection.
2. Measure the area draining into the rain garden using measuring tools.
3. Use strategies in real-world situations to solve multiplication problems.

## Subjects Covered

Math, Science, and Geography

## Grades

4 through 12

## Activity Time

Two 50-minute class periods

## Season

Any

## Materials

Measuring tapes, map of school-ground including location of buildings and paved surfaces; information about soil type (from Earth Partnership for Schools activity, “Getting to Know Your Soil for Rain Gardens” or “Infiltration Test: Exploring the Flow of Water Through Soils”), slope (from Earth Partnership for Schools activity, “Measuring Slope for Rain Gardens”); sizing a rain garden worksheet

## State Standards

### Math

Use reasoning abilities (A.4.1, A.8.1, A.12.1)

Connect mathematical learning with other subjects (A.4.3)

## Background

Determining the size of a rain garden is not an exact science. Experts have different opinions. With that said, how big will you build your rain garden? There are two answers: any size you want, or if you want 100% runoff control, you need to make calculations. The first answer may seem like an odd response. But it means that a rain garden of any size will reduce the amount of precipitation that becomes surface runoff. Each water drop that stays on the school property is one less drop that potentially carries pollutants to lakes, rivers and streams. The second answer involves learning how large the drainage area is, what type of soil is in the garden, and what is the percent slope of the site. Next take this information and plug it into formulas to obtain a square foot area for the garden. The following activity description covers each step of the process for sizing a rain garden.

## Activity Description

### Calculate Drainage Area

1. Go out to the area designated for the rain garden. Identify the section of roof that will drain into the downspout. Measure the length and width of this area. Take measurements of other hard surfaces such as driveways, parking areas, or sidewalks that may drain into the rain garden. Repeat measurements of lawn that noticeably drain into the proposed rain garden. (It is not necessary to include the lawn area between the building and the garden site. Insert these numbers in the “Sizing a Rain Garden” worksheet.
2. Calculate areas draining into the rain garden. See Figure 1 showing the drainage area for one downspout on a school roof.

**Bird's Eye View of a School**

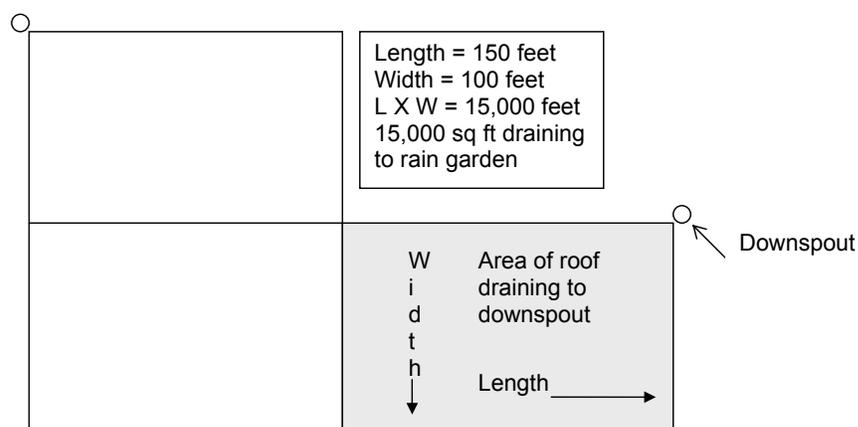


Figure 1: Drainage area for a section of roof leading to one downspout.

## Sizing a Rain Garden (cont.)

### Math (cont.)

Explain solutions to problems (A.4.5)

Select & use appropriate computational procedures (B.4.5)

Read, represent, & interpret rational numbers (B.8.1)

Use appropriate computational procedures with rational numbers (B.8.7)

Recognize & describe measurable attributes & units (D.4.1)

Demonstrate understanding of measurement (D.4.2)

Read & interpret measuring instruments (D.4.3)

Determine measurements by using standard tools (D.4.4)

Determine measurements by using basic relationships or estimations (D.4.5)

Identify & describe attributes in situations not directly or easily measurable (D.8.1)

Demonstrate understanding of measurement facts, principles, techniques (D.8.2)

Determine measurement directly by using standard units (D.8.3)

Determine measurement indirectly (D.8.4)

### Science

Select multiple information sources (C.4.3)

Use data to answer questions (C.4.5)

Identify questions using available resources (C.8.1)

3. Add all drainage areas together if more than one area drains into your proposed rain garden. Otherwise continue to the next step.

### Determine Rain Garden Depth

1. The existing slope of the proposed rain garden site determines how deep to dig your garden. The bottom of the garden needs to be flat so that water spreads out and does not puddle. When digging your garden you will be removing soil from the top of the slope and adding it to the bottom end. See Figure 2. Because of this change in grade you must calculate the depth of the garden based on the slope. Generally the greater the slope the deeper the garden. A 4% slope equals a 3 – 5 inch deep garden, while a 12% slope equals an 8 inch deep garden. Use the results from Earth Partnership for Schools activity, “Measuring Slope for Rain Gardens,” to learn what the existing slope is for your proposed rain garden. Add this number to the worksheet.

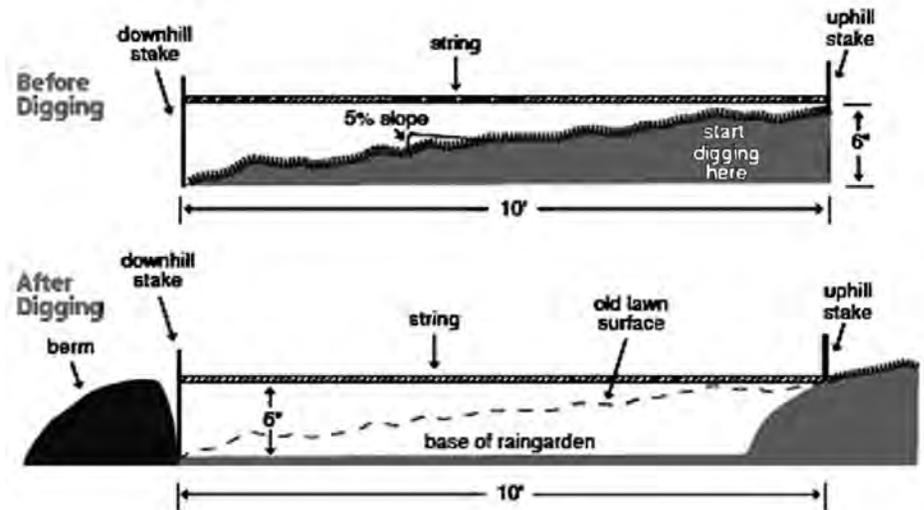


Figure 2: Schematic for digging a rain garden. Illustration from UW-Extension Basin Education Rain Garden Educator's Kit.

### Identify Soil Type

1. Soil type influences the time water takes to soak into the ground and the ultimate size of the rain garden. Sandy soil with large particle sizes drains quickly so that a garden can be built deep and small. Slow-draining clay soil requires a large and shallow garden so that the water can spread out over a big surface area. Circle the soil type—sand, silt (loam) or clay—on the worksheet. Learn how to identify your soil type in Earth Partnership for Schools activities, “Identify Your Soil for Rain Gardens” or “Infiltration Test: Exploring the Flow of Water Through Soils.”

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## Sizing a Rain Garden (cont.)

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Determine the Soil Factor

1. The soil factor is a number derived from soil type and rain garden depth. Locate the correct soil factor on the tables to use as the multiplier with drainage area.
2. The worksheet has two sets of factors. Use the table #1 for rain gardens closer than 30 feet from the downspout. Use table #2 for rain gardens 30 feet or more from the downspout and rain gardens collecting water from lawn areas. The two tables are different because some water will infiltrate as it flows over the lawn for 30 feet or more.

Determine Rain Garden Size for 100% Runoff Control

1. Multiply total drainage area by the soil factor. This gives you the size to build the rain garden in square feet.
2. For the next steps in the planning process, go to Earth Partnership for Schools activities, “Designing a Rain Garden” and “Rain Garden Species Selection.”

### Extensions

- Determine the size of a rain garden for a community building such as your local library or post office.
- Compare rain garden sizes using different soil types, drainage areas and slopes. Discuss how the differences may affect the landscape.

### Additional Resources

- ... *Build your own rain garden*. Chesapeake Bay Foundation. [http://www.cbf.org/site/DocServer/rain\\_garden\\_guide-web.pdf?docID=2869](http://www.cbf.org/site/DocServer/rain_garden_guide-web.pdf?docID=2869)
- ... *How to install a rain garden* (Instructional Flyer). South River Federation and Center for Watershed Protection. [http://www.cwp.org/Community\\_Watersheds/brochure.pdf](http://www.cwp.org/Community_Watersheds/brochure.pdf)
- ... *How to build a rain garden*. Dane County Lakes and Watershed Commission. Madison, WI. [www.co.dane.wi.us/commissions/lakes/](http://www.co.dane.wi.us/commissions/lakes/)
- ... (2005). Rain garden educator’s kit. UW-Extension Basin Education Program and the WI DNR Runoff Management Section.
- ... *Rain gardens: A how-to manual for homeowners*. (DNR Publication PUB-WT-776 2003, UWEX Publication GW0037) Available at Dane County’s Extension Office: (608) 266-4106 or through Rock River Basin Educator, UW-Extension, Jefferson County, 864 Collins Road, Jefferson, WI 53549-1976; Phone: 920-674-8972; order on the Web at <http://cecommerce.uwex.edu> or <http://dnr.wi.gov/education/> Download at [http://myfairlakes.com/what\\_more.asp#yardgarden\\_raingardens](http://myfairlakes.com/what_more.asp#yardgarden_raingardens)
- ... *Rain gardens: A household way to improve water quality in your community* (UWEX Publication GWQ034). Available at Dane County’s Extension Office: (608) 266-4106 or through Rock River Basin Educator, UW-Extension, Jefferson County, 864 Collins Road, Jefferson, WI 53549-1976; Phone: 920-674-8972; order on the Web at <http://cecommerce.uwex.edu> or <http://dnr.wi.gov/education/> Download at [http://myfairlakes.com/what\\_more.asp#yardgarden\\_raingardens](http://myfairlakes.com/what_more.asp#yardgarden_raingardens)

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## Sizing a Rain Garden (cont.)

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Web sites:

- How to Build a Rain Garden. Rain Gardens of West Michigan. [www.raingardens.org](http://www.raingardens.org)
- Native Plant List for Wisconsin Rain Gardens (Interactive HTML) <http://www.dnr.state.wi.us/org/water/wm/nps/rg/plants/PlantListing.htm>
- Dane County Lakes and Watershed Commission: Rain Garden Information. <http://www.co.dane.wi.us/commissions/lakes/raingardens.html>
- ... A Web based homeowner guide for building and maintaining a rain garden. Rain Garden Network: <http://www.raingardennetwork.com/index.htm>

### **Assessments**

- Describe the process of sizing a rain garden.
- Develop two rain garden scenarios and calculate the final rain garden sizes.

# Sizing a Rain Garden Worksheet\*

To size a rain garden, you will need to measure your drainage area, determine the percent slope of your lawn, and identify your soil type. This worksheet will walk you through these steps. Use Earth Partnership for Schools activities, “Identifying Your Soil for Rain Gardens” and “Measuring Slope for Rain Gardens” to determine your soil type and percent slope.

**1. Drainage Area:** Measure your drainage area.

- a. Roof area: \_\_\_\_\_ feet X \_\_\_\_\_ feet = \_\_\_\_\_ square feet
- b. Lawn area: \_\_\_\_\_ feet X \_\_\_\_\_ feet = \_\_\_\_\_ square feet
- c. Paved surfaces: \_\_\_\_\_ feet X \_\_\_\_\_ feet = \_\_\_\_\_ square feet
- d. Total drainage area: \_\_\_\_\_ **square feet**

**2. Rain Garden Depth:** Find the slope of your rain garden site to determine how deep to dig your garden.

- a. Less than a 4% slope = 3 – 5 inch deep rain garden
- b. 5 – 7% slope = 6 – 7 inch deep rain garden
- c. 8 – 12% slope = 8 inch deep rain garden

\_\_\_\_\_ **inches deep**

**3. Soil Type:** Determine your soil type.

- a. Soil Type: (*Please circle*) sand                      silt (loam)                      clay

**4. Soil Factor:** Use the appropriate table below to find your soil factor. The soil factor is derived from soil type and rain garden depth.

- a. **Soil factor:** \_\_\_\_\_

**Table #1: Rain gardens up to 30 feet from a downspout.**

	3 – 5 inches deep	6 -7 inches deep	8 inches deep
Sandy soil	0.19	0.15	0.08
Silt/loam soil	0.34	0.25	0.16
Clayey soil	0.43	0.32	0.20

**Table #2: Rain gardens more than 30 feet from the downspout.**

Sandy soil	.03
Silt/loam soil	.06
Clayey soil	.20

**5. Rain Garden Size:** Multiply total drainage area (#1) by the soil factor (#4).

\_\_\_\_\_ (sq ft.) total drainage area X \_\_\_\_\_ soil factor = \_\_\_\_\_ **(sq ft.) rain garden**

*\*Based on Rain Gardens: A how-to manual for homeowners*

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# Designing a Rain Garden

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## Activity Overview

Students create a rain garden design and optional planting plan.

## Objectives

### Students will

1. Create a rain garden design plan based on information gathered about the site, the size of the drainage area, and soil conditions
2. Develop a planting plan for the rain garden using ecological and aesthetic guidelines
3. Work cooperatively as a team
4. Use group processes to select a master rain garden design

## Subjects Covered

Science, Math, Language Arts, and Art

## Grades

3 through 12

## Activity Time

70 minutes to complete the rain garden design process, 50 minutes to create an optional planting plan.

## Season

Any

## Materials

Map of rain garden site on grid paper where 1 square equals one square foot; markers and colored pencils, rulers; “Post-it” notes; soil type results from EPS activities, “Getting to Know Your Soil for Rain Gardens” or “Infiltration Test: Exploring the Flow of Water through Soils”; rain garden size results from EPS activity, “Sizing a Rain Garden,” and species list from EPS activity, “Rain Garden Species Selection.”

## Background

Designing a rain garden on the school ground with native plants is an exciting process that improves the quality of water, provides habitat for wildlife, and offers opportunities for educational and serendipitous experiences with nature. A rain garden is simply a depression in the ground that allows water to soak into the ground to reduce surface runoff and to recharge groundwater. Rain gardens catch runoff from roofs, driveways, sidewalks, yards and other hard surfaces, which reduces pollutants entering waterways. The idea is to capture rain water close to where it falls rather than allowing it to collect and increase in volume and speed as it travels to the nearest waterway picking up pollutants and washing away soil.

When locating a garden, observe the drainage area and where storm water naturally runs over the school grounds. Locate a garden where water collects in a low spot or along a swale. Low areas with bare and/or eroded soil are ideal for rain gardens because the plants will cover the soil and stop it from eroding. Typically, rain gardens are located near downspouts to collect water draining from a roof. To avoid water problems, locate the garden at least ten feet away from building foundations and septic fields. Also, avoid locating rain gardens over underground utilities. If planning to capture rain water coming off streets and large parking areas, request advice from an engineer or landscape architect owing to increased complexity.

For a design perspective, consider how the garden fits with the surrounding landscape. Fit the garden into the landscape so that it relates to other landscape features rather than looking like a blob plopped in the center of a space. Think about how it looks from different positions such as from a window or around the corner or from the street. Design a rain garden with curvilinear shape that will look more natural. If you are interested in planting a rain garden with a particular theme or purpose, such as a song bird, butterfly, sensory, shade, or ethno-botanic garden, see Earth Partnership for Schools activity, “Where Does Your Garden Grow?” This activity describes site conditions necessary for theme gardens such as shelter from wind for a butterfly garden.

Once the rain garden location is determined, the next step is determining its size. The size of the garden is dependent upon the amount of water draining into the garden (i.e., the drainage area), the soil type, slope, and distance from a downspout (if applicable). The type of soil probably has the greatest influence on the size of the garden. Basically, sandy soils that drain quickly can handle smaller and deeper rain gardens. Clay soils that drain slowly require larger and shallower gardens. The guiding principle for size is to ensure water drains within 6 to 12 hours after a rainfall. See Earth Partnership for Schools activity, “Sizing a Rain Garden” to calculate the square area of the rain garden that fits your site conditions.

# Designing a Rain Garden

## State Standards

### Language Arts

Use effective reading strategies (A.4.1, A.8.1, A.12.1)

Orally communicate (C.4.1, C.8.1, C.12.1)

### Math

Use reasoning abilities (A.4.1, A.8.1, A.12.1)

### Science

Present a scientific solution to a problem (H.8.2)

Investigate a resource management plan or proposal (H.12.5)

Evaluate data and information sources (H.12.6)

Use scientific knowledge & reasoning (H.12.7)

With the size and location of the rain garden determined, you may begin designing a native rain garden. The process involves creating a shape for the garden and determining a layout for the plants. Please see following activity directions for implementing these steps with students.

## Activity Description

### Creating a Rain Garden Design (Integrating the garden into the landscape)

1. Go out to the area designated for the rain garden. Walk the area to get a feel of the space and review the site analysis data such as sun availability, slope, and existing landscape features.
2. Go back to the classroom and discuss what was observed.
3. Brainstorm design criteria such as the goals and objectives for the rain garden. Examples may include creating habitat for wildlife, using native species, educating the community, providing seating nearby, planting trees for shade, signage, etc.
4. Divide into teams of three or four students.
5. Draw rain garden design plans for the site. Allow 10 to 15 minutes.
5. Identify designated team speaker(s) and present plans to the class within two to three minutes.
7. Display each design plan. As teams, discuss and choose the best features of each design. Write your favorite feature on a “Post-it” and apply it on the plan. Group the “Post-its” with similar desired features on each plan. As a class, summarize the best elements to incorporate into a master design.
8. Choose a committee or have a professional take these ideas and create a composite design plan.



## Designing a Rain Garden (cont.)



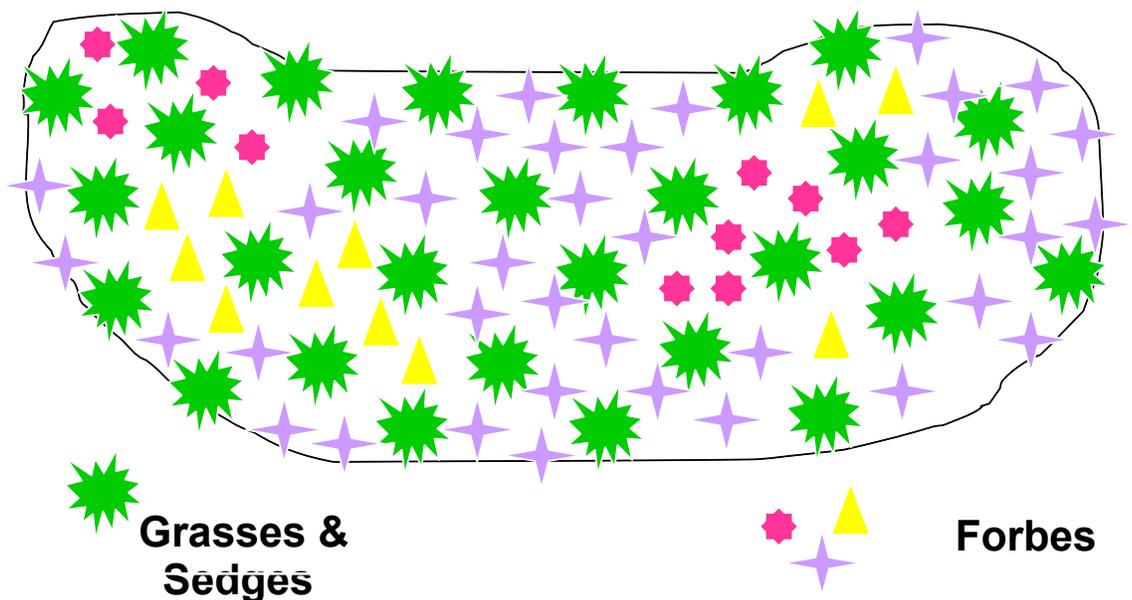
Student teams drew their designs and presented their ideas to their classmates at Winnequah Middle School, Monona, WI. Photos: Cheryl Bauer-Armstrong

### Developing a Planting Plan (Locating plants in the garden)

There are many techniques for laying out a planting design on paper. Each method has pros and cons. Choose the method that will work for your class given student ages, time, interest and subject applicability. Techniques include using graph paper where one square represents one plant, drawing circles/shapes indicating individual plants, or drawing shapes to indicate groups of plants. (Please see an example at the end of the activity description.) Another option is to divide the plants by height and draw zones for tall, medium, or short plants. Within each identified zone, students locate and plant the appropriate species on planting day. The exact location of each plant is not identified on a plan.

The following directions suggest using the graph paper technique. This activity can be accomplished in student teams, individually, or by a student committee.

1. Transfer rain garden design to graph paper. Have one square represent one square foot. Assign one plant per square. Develop a code for each species on the rain garden species selection sheet. Use colored pencils to indicate flower colors. Use green for grass-like species. Combine colors and symbols so there is one color/symbol combination per plant species.
2. Assign every other or every third square to a grass-like species such as a grass, a sedge, or a rush. These plants form the matrix for the planting, physically support the forbs/wildflowers, and help reduce weed competition.



Sample rain garden planting plan. Plan drawn by Susan Kilmer.

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## Designing a Rain Garden (cont.)

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3. Locate the wildflowers on the design plan. Color coding the wildflowers by season—spring, early summer, late summer and fall—will help you to visualize what is blooming at similar times and what the garden will look like at a given time of year.
4. Landscape designers/architects often use design guidelines to determine plant placement so that the rain garden will look attractive and well-designed. Consider the following guidelines for your rain garden:
  - Locate shorter plants in the foreground and larger species in the rear or middle.
  - Place plants in groups of three, five, or more. Avoid planting in pairs—the eye jumps back and forth between the two.
  - Species such as the sunflowers and blazing stars tend to self-spread by rhizomes, stolens, corms, or bulbs. These types of species can form large masses. When planting transplants, plant these species in groups to mimic the spatial patterns of these species. Some designers cluster a few plants together and a few plants outside the cluster to form “drifts” of color.
  - Avoid planting in straight lines or perfect circles.
  - Use repetition of groups of plants and colors to allow the eye to flow through the planting.
  - Be aware of each plant’s ultimate height and spread at maturity. This is most important when planting shrubs or trees. Space shrubs 3 to 6 feet apart depending upon their mature size. Spacing varies for trees; in a woodland planting space trees about 5 – 10 feet apart; for open-grown trees space plants 20 or more feet apart.
5. Present planting plans to the class.
6. Display plans on school bulletin boards.

### Extensions

- Design a rain garden planting for a local park or other public land or for your home.
- Build models of the design plans.
- Write descriptions of the rain garden plants with a photo and compile into a rain garden book.

### Additional Resources

- ... Build your own rain garden. Chesapeake Bay Foundation. [http://www.cbf.org/site/DocServer/rain\\_garden\\_guide-web.pdf?docID=2869](http://www.cbf.org/site/DocServer/rain_garden_guide-web.pdf?docID=2869)
- ...Landscaping with native plants. 4th Edition Wild Ones Handbook. Wild Ones Natural Landscapers, Ltd.
- ... (2005). Rain garden educator’s kit. UW-Extension Basin Education Program and the WI DNR Runoff Management Section.
- ...Rain gardens: A how-to manual for homeowners. (DNR Publication PUB-WT-776 2003, UWEX Publication GW0037) Order on the Web at <http://cecommerce.uwex.edu> or <http://dnr.wi.gov/education/> Download at [http://myfairlakes.com/what\\_more.asp#yardgarden\\_raingardens](http://myfairlakes.com/what_more.asp#yardgarden_raingardens)

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## Designing a Rain Garden (cont.)

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### Web Sites

- How to Build a Rain Garden. Rain Gardens of West Michigan. [www.raingardens.org](http://www.raingardens.org)
- Dane County Lakes and Watershed Commission: Rain Garden Information. <http://www.co.dane.wi.us/commissions/lakes/raingarden.shtml>
- Rain Garden Network: <http://www.raingardennetwork.com/index.htm>

### **Assessment**

- Describe three basic guidelines for locating and designing a rain garden.
- Develop a rubric for a rain garden design.
- Describe your experience as a team member in your design group; identify what went well and what you would change.

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# Rain Garden Species Selection

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## Activity Overview

Students create a list of native species for their school rain garden site as determined by environmental, ecological, aesthetic, and educational criteria.

## Objectives

### Students will

1. Identify criteria for selecting native species that will grow in their rain garden
2. Choose species based on functional, ecological and aesthetic considerations
3. Work cooperatively as a team
4. Outline reasons why their species selections are appropriate for their rain garden
5. Learn about native plants and identify species that can infiltrate rain water runoff

## Subjects Covered

Science

## Grades

3 through 12

## Activity Time

Two 50 minute blocks (10 minutes introduction, 10 minutes to develop criteria, 30 minutes to select species, 50 minutes to compile species selections and determine quantities desired for each species)

## Season

Any

## Materials

Rain garden criteria worksheet, rain garden species selection form, wildflower and grass field guides, native plant nursery catalogs/websites and the “Rain Garden Species List”

## Background

Rain gardens are simply a more natural system of managing storm water, allowing natural functions of infiltration and evaporation that contribute to a natural hydrologic cycle. Rain gardens are constructed shallow depressions designed to collect water primarily from downspouts. Storm water from driveways, streets, and parking areas can also be redirected to rain gardens. The concept is to let plants, bacteria, and soils clean and temporarily hold the water as it infiltrates into the ground close to where the rain falls. Before urban/suburban development, the unique relationship of water, vegetation, and soils resulted in very little runoff on the surface of the land. Today with more built surfaces and less porous ground, most of the precipitation becomes surface runoff. The rain garden keeps water close to where it falls by stopping the water from entering the storm water system as excess surface runoff. The principle for choosing species for a rain garden is to select native plants that infiltrate water into the ground. These species typically have deep root systems with water holding capacity and the ability to direct water through the soil. Instead of runoff, water either transpires through the plant's leaves and stems or seeps into the groundwater to later discharge as clean water into springs, fens, streams, or lakes.

Selecting the right plant species for your rain garden site helps ensure survival of your rain garden plants. A rain garden built on your school grounds collects water after a rain or snow melt, and then dries out. This alternating of wet and dry soils requires that you choose plant species that can tolerate these extreme conditions. Native plants that survive in this environment are usually flood tolerant species, which grow in flood plains, species that grow along rivers (i.e., riparian), and drought/flood tolerant prairie species. Plants suited for a rain garden often have a bimodal characteristic, which means they are able to grow well in opposite site conditions such as in wet or dry soils.

Other important considerations for selecting species for successful plant survival include light availability and soil type. Plant height, attracting wildlife, and aesthetics such as flower color, leaf textures and fruits can also play a role in plant selection. See “Criteria for Selecting Rain Garden Species” below for more details.

To begin the process of species selection, identify your rain garden site features (sun shade, soil type, etc). Then determine what plant characteristics will fit your site and needs. Review the following criteria and identify the criteria that fit your site characteristics and goals for your project. There are several resources available to help you choose appropriate plants. For instance, use the “Rain Garden Species List” from “Rain Garden Curricular Sampler,” nursery catalogs, plant field guides or regional Web-based, native rain garden plant lists to select species. List those potential species on the rain garden species selection form. You may need to adjust the number of species in your

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## Rain Garden Species Selection (cont.)

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### State Standards

#### Science

Decide which collected data is pertinent to new problems (A.4.2)

Decide which data should be collected (A.4.3)

Describe changes in knowledge and concepts (B.8.1)

Use scientific sources & resources (B.4.1)

Select multiple information sources (C.4.3)

Communicate results (C.4.6)

Support conclusions with logic (C.4.7)

Identify data and sources to answer questions (C.8.2)

State learning from investigations (C.8.6)

Present a scientific solution to a problem (H.8.2)

Use scientific knowledge & reasoning (H.12.7)

mix depending upon your budget, availability, and size of your rain garden. As a general rule, try to have a new flower come into bloom every week during the growing season — about 30 wildflowers plus grasses/sedges. Other suitable plant types include ferns, rushes, shrubs and trees. Herbaceous plant species are planted one foot apart; trees and shrubs are spaced according to their ultimate size (see below for more information about spacing).

### Criteria for Selecting Rain Garden Species

Necessary criteria for every rain garden:

1. **Sunlight availability:** The amount of sunlight an area receives determines the types of plants that will survive those light conditions so that they will flower and set seed. Plants that need full sun need at least 6 to 8 hours of direct sun during the growing season; plants that require shade cannot tolerate more than 3 hours of direct sun. The hours and angle of sunlight change with the seasons, too. Some areas shaded most of the day at one time of the year may be in full sun other times of the year, or areas sunny in the spring may be shady in summer.

Common guides for choosing plants based on the amount of sun or shade available are:

- **Sun** – Areas receive a minimum of 6 to 8 hours of sun per day during the growing season. Prairie and wetland species including sedge meadow species grow well under these conditions.
- **Partial shade** – Partially shaded areas receive 3 to 6 hours of sun per day. Savanna and some prairie and woodland species grow well in partial shade.
- **Shade** – Areas of shade receive less than 3 hours of direct sun. Woodland groundlayer species grow in this environment.

Trees and shrub species follow the same guidelines. Most species lists will identify a plant's sun/shade requirements.

2. **Grass/sedge to forb (wildflower) ratio:** The proportion of species for a reasonable mix of grass/sedge and forb species that mimics the natural structure and character of a native prairie rain garden can be anywhere between 30% and 60% grass. Aesthetically, grass species, including sedges and other grass-like species, define the visual character or essence of the prairie. Ecologically, grasses provide structural support for forbs, hold the soil with their fibrous root systems, and provide food and cover for wildlife. Forbs provide visual interest, food for wildlife on a continual basis, and enhance diversity. The ratio of grass/sedge to wildflowers in a woodland tends towards less grass-like species and more wildflowers with some ferns.

3. **Phenology:** One of the best known and most dramatic sequences in a rain garden involves flowers blooming from mid-April through October. During the growing season approximately one new plant blooms each week.

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## Rain Garden Species Selection (cont.)

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This sequential or phenological change is striking and attractive to pollinating insects such as butterflies. In shady areas, blooming peaks in the spring with a few species blooming during summer and fall. When choosing species, particularly in sunny areas, select plants for a continuous bloom.

4. Height: When selecting species, be aware of each plant's ultimate height and spread at maturity. Plant height should be in proportion with the size of your planting. Typically, small rain gardens are planted with short species. Large plants in a small area tend to overwhelm the site and appear unkempt. Large areas can be planted with a mix of short and tall prairie species. Short species are less than four feet; tall species are greater than four feet.

### **Additional Criteria:**

1. Color: Flower color is an aesthetic consideration. Look for color combinations and contrasts within each blooming interval. Pairing complimentary colors (yellow/purple, red/green, orange/blue) tends to intensify the colors.
2. Species that attract specific insects, birds, and other wildlife: Planting a diversity of native wildflowers and grasses, along with shrubs and trees nearby (or in the garden), provides maximum habitat and opportunity to attract a variety of butterflies and birds. Wildlife in the schoolyard adds life, beauty, discovery, and educational opportunities. Planning and proper plant selection will increase the number and variety of butterflies and birds attracted to a planting. A diversity of flying and crawling insects are attracted to flowers. Grazing insects such as grasshoppers, leafhoppers, and butterfly larvae feed primarily on the leaves of grasses and forbs. These insects form the base of the food web, especially for birds. Birds also feed on highly nutritious seeds produced by native plants. Tall and short grasses and trees and shrubs provide cover and nesting. Woody plants provide wind protection for butterflies and hummingbirds that seek nectar on prairie flowers.
3. Species desired for lessons, activities and research: A rain garden offers many hands-on learning activities and inquiry-based opportunities. You may select plants Native Americans used for food and medicinal uses or plants that illustrate plant adaptations. Consider species that have a variety of seed types to learn about seed dispersal mechanisms or to test seed germination methods. Also pick plants that awaken your senses and curiosity with fragrances, textures, shapes and sounds. Additionally, a rain garden provides a context to learn about storm water impacts and solutions in the local watershed.
4. Species blooming during the school year: Many species bloom during the summer months when students are on vacation. To make sure students experience plants in bloom during the school year, increase the number of species that bloom in the spring and fall months.
5. Species that are aggressive: Some plants can be overly aggressive either through vegetative reproduction or seed. These species, such as sunflowers, switch grass, common goldenrod, and cupplant often form large masses. Species with this type of growth habit are appropriate for large sites but may become too overpowering in smaller plantings.

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## Rain Garden Species Selection (cont.)

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6. **Plant sources and indigenous species:** Choose plants native to your region. Native plants are well adapted to your specific climate and soils and do not require winter protection or fertilizer. They also work more effectively infiltrating water on account of their long root systems.

### Activity Description

#### Select Species

1. As a group, review the rain garden site characteristics and identify criteria that fit your rain garden site and goals for your project. Fill out the rain garden species selection criteria worksheet.
2. Divide into teams. Each team may be responsible for choosing species within a bloom period such as April/May, June, July, August, September/October and a team to select grasses and other grass-like species or trees and shrubs, if desired. You will find that some species choices will overlap.
3. Next have each team select 4 to 5 potential rain garden species using “Rain Garden Species List,” nursery catalogs, plant field guides, and Web-based regional native rain garden plant lists.
4. Re-group; go into the round and share out as teams the species chosen and why.
5. Compile all species selected on a master species selection form.

#### Develop a Species List

1. Review master species list and make adjustments, if needed.
2. Begin to determine quantities for each species. First divide the grasses/sedges from the wildflowers. Use the criteria for your grass/sedge to wildflower ratio to calculate how many plants you need for each group. The total number of herbaceous plants needed equals the number of square feet of the rain garden. It is possible to space the plants wider to about 1.5 square feet per plant. If you are adding trees and shrubs, use the following spacing guidelines to determine quantities:
  - a. Trees: 10 to 20 feet apart.
  - b. Large to medium shrubs: 6 to 8 feet apart.
  - c. Small shrubs: 3 to 5 feet apart.
3. Assign quantities to each species. For design purposes, order wildflowers in groups of three, five, or more. Order shrubs in quantities of one, three or more. Avoid ordering plants in twos; planting in pairs causes the eyes to jump back and forth between the two plants. Order enough grass-like species to fill the required number needed.
4. The next step is determining the budget for the species selected. See Earth Partnership activity, “Balancing the Budget, 5-2.”

### Extensions

- Research plants selected using the Earth Partnership activity “Up Close and Personal, 5-12.”
- Make posters of plants selected.
- Create your own version of Earth Partnership activity, “A Prairie Year, 5-1” using the species selected.

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## Rain Garden Species Selection (cont.)

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### Additional Resources

- Brown, Lauren. (1979). *Grasses: An identification guide*. New York, NY: Houghton Mifflin Co.
- Brown, Lauren. (1976). *Weeds in winter*. New York, NY: W. W. Norton & Company, Inc.
- Cochrane, T.S., Elliot, K., Lipke, C.S. (2006). *Prairie plants of the University of Wisconsin-Madison Arboretum*. Madison, WI.
- Courtenay, Booth & Zimmerman, James H. (1992). *Wildflowers and weeds: A field guide in full color*. New York, NY: Simon & Schuster. (Out of print, but worth a search)
- Currah, R. & Van Dyk, M. (1983). *Prairie wildflowers: An illustrated manual of species suitable for cultivation and grassland restoration*. Friends of the Devonian Botanic Gardens-University of Alberta, Edmonton.
- Fassett, Norman C. (1951). *Grasses of Wisconsin*. Madison, WI: Regents of the University of Wisconsin, (Recommended for high school level)
- Kindscher, Kelly. (1987). *Edible wild plants of the prairie*. Lawrence, KS: University Press of Kansas.
- Kindscher, Kelly. (1992). *Medicinal wild plants of the prairie*. Lawrence, KS: University Press of Kansas.
- Kirt, Russell R. (1989). *Prairie plants of Northern Illinois: Identification and ecology*. Champaign, IL: Stipes Publishing Company.
- Kirt, Russell R. (1995). *Prairie plants of the Midwest: Identification and ecology*. Champaign, IL: Stipes Publishing Company.
- Mirk, Walter. (1997). *An introduction to the tall grass prairie of the Upper Midwest*. The Prairie Enthusiasts, c/o Gary Eldred, 4192 Sleepy Hollow Trail, Boscobel, WI 53805.
- Newcomb, Lawrence. (1977). *Newcomb's wildflower guide*. Boston, MA: Little, Brown & Co.
- Runkel, Sylvan T. and Roosa, Dean M. (1989). *Wildflowers of the tallgrass prairie: The Upper Midwest*. Ames, IA: Iowa State University Press.

### Web sites

- Wisconsin Department of Natural Resources. Wisconsin native plants for rain gardens. <http://www.dnr.state.wi.us/org/water/wm/nps/rg/plants/PlantListing.htm>
- Wisconsin Department of Natural Resources. Wisconsin native plants for shady rain gardens. <http://www.dnr.state.wi.us/org/water/wm/nps/rg/plants/shady/shady.htm>

### Assessments

- Explain why it is important to match species to the site conditions.
- Choose three criteria and explain why you think they are important for selecting plant species for your rain garden.
- Outline reasons why the species selected are appropriate for your rain garden.

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# Rain Garden Species Selection Criteria Worksheet

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**Location:** \_\_\_\_\_ **Size:** \_\_\_\_\_ (sq ft)

## Environmental Conditions:

Circle the site characteristics that describe your site.

**Soil Type:**      Sand              Silt/Loam              Clay

**Percent Slope:**              less than 4%              5% - 7%              8% - 12%

**Light:**              Full sun                      Partial shade              Shade

## Species Characteristics

**Necessary Criteria:** Determine your specifications for criteria based on site conditions.

**Number of plants needed (1 plant/square foot):** \_\_\_\_\_

**Ecosystem type (Habitat):**    Prairie (sun)    Savanna              (part sun)              Woodland (shade)

**Plant types: (circle all that apply.)**

Grasses    Sedges    Wildflowers    Ferns    Shrubs    Trees    Other \_\_\_\_\_

**Height:**              Minimum height: \_\_\_\_\_              Maximum height: \_\_\_\_\_

**Phenology (time of bloom):**

\_\_\_\_\_ % Spring (April – May),              \_\_\_\_\_ % Early Summer (June),

\_\_\_\_\_ % Summer (July),              \_\_\_\_\_ % Late Summer (August),

\_\_\_\_\_ % Fall (September – October)

**Additional Criteria:** Identify criteria that fit your project goals such as flower color, texture, fragrance, wildlife value, etc.

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## Rain Garden Species List

FORBS & WILDFLOWERS										SUN				Moisture Gradient			
GENUS	SPECIES	COMMON NAME	Bloom Time	Flower Color	Height	S	PS	Sh	Dry	DM	Mesic	WM	Wet				
Actaea	<i>rubra</i>	Red Baneberry	Apr-May	White	2'		x	x			x	x	x				
Agastache	<i>foeniculum</i>	Lavender Hyssop	July-Sept	Purple	1' - 3'	x	x					x	x				
Agastache	<i>scrophulariaefolia</i>	Purple Hyssop	July-August	Purple	1'	x	x				x	x					
Allium	<i>canadense</i>	Meadow Garlic, Wild Garlic	May-July	Pale Pink/White	1' - 2'	x	x	x	x	x	x	x					
Allium	<i>cernuum</i>	Nodding Wild Onion	July-Aug.	Pink-White	1' - 2'	x					x	x					
Anemone	<i>canadensis</i>	Canada Anemone	May-July	White	1' - 2'	x	x			x	x						
Angelica	<i>atropurea</i>	Great Angelica	May-July	White	2' - 8'	x	x				x	x					
Aquilegia	<i>canadensis</i>	Columbine	May-June	Orange	1' - 2'		x	x	x	x	x						
Arisaema	<i>triphylllum</i>	Jack-in-the-pulpit	Apr-June	Green	1' - 2'		x	x			x	x					
Arnoglossum	<i>atriplicifolium</i>	Pale Indian Plantain	July-Sept.	White	3' - 9'	x	x		x	x	x	x					
Arnoglossum	<i>plantagineum</i>	Prairie Indian Plantain	July-Aug.	White	3' - 5'	x					x	x					
Arnoglossum	<i>reniforme</i>	Great Indian Plantain	July-Sept.	White	4' - 6'	x	x				x	x					
Asarum	<i>canadense</i>	Wild Ginger	May-June	Red	1'		x	x			x						
Asclepias	<i>incarnata</i>	Marsh Milkweed	July-Aug.	Magenta	1' - 4'	x					x	x					
Aster	<i>ericoides</i>	Heath Aster	July-Oct.	White	1' - 3'	x	x		x	x	x						
Aster	<i>furcatus</i>	Forked Aster	Aug-Oct.	White	1' - 3'		x	x			x	x					
Aster	<i>laevis</i>	Smooth Blue Aster	Aug-Oct.	Purple	1' - 3'	x	x		x	x	x						
Aster	<i>lanceolatus</i>	Paniced Aster	Sept.-Nov.	White	2' - 5'		x	x			x	x					
Aster	<i>lateriflorus</i>	Calico Aster	Aug.-Sept.	White	1' - 2'	x			x								
Aster	<i>macrophyllus</i>	Large Leaved Aster	July-Sept.	Purple-White	1' - 5'		x	x	x	x	x						
Aster	<i>novae-angliae</i>	New England Aster	Aug-Oct.	Purple	3' - 7'	x	x			x	x	x					
Aster	<i>puniceus</i>	Bristly Aster	Aug-Nov.	Purple	2' - 8'	x	x			x	x	x					
Aster	<i>shortii</i>	Short's Aster	Aug.-Oct.	Blue	1' - 4'	x	x		x	x	x						
Aster	<i>umbellatus</i>	Flat-top Aster	Aug.-Sept.	White	2' - 7'	x	x				x	x					
Baptisia	<i>alba</i>	White Wild Indigo	June-July	White	3' - 4'	x	x			x	x	x					
Baptisia	<i>brateata</i>	Cream False Indigo	May-June	Cream	1' - 2'	x	x		x	x	x	x					
Blephilia	<i>ciliata</i>	Downy Wood Mint	May-Aug.	Purple	18" - 24"	x	x	x			x	x	x				
Blephilia	<i>hirsuta</i>	Hairy Wood Mint	June-Aug.	White	1' - 2'	x	x	x			x	x					
Caltha	<i>palustris</i>	Marsh-marigold	April-June	Yellow	1' - 2'	x	x	x				x	x				
Campanula	<i>americana</i>	Tall Bellflower	July-Aug.	Purple	1' - 2'	x	x	x		x	x	x					
Campanula	<i>rotundifolia</i>	Bluebell, Harebell	June-Sept.	Blue	6" - 2'	x	x			x	x	x					
Cardamine	<i>concatenata</i>	Cut-Leaved toothwort	Apr.-June	White	8" - 16"			x			x	x					
Caulophyllum	<i>thalictroides</i>	Blue Cohosh	May	Yellow/Green-Brown	1' - 3'		x	x			x	x					
Ceanothus	<i>americanus</i>	New Jersey Tea	June-Aug.	White	1' - 3'	x			x	x	x						
Chelona	<i>glabra</i>	White turtlehead	Aug.-Sept.	White	2' - 4'	x	x				x	x	x				

**Legend**

Sun: S = Full Sun, PS = Partial Shade, Sh = Shade

Moisture Gradient: (listed from dry to wet) D = Dry, DM = Dry Mesic, Mesic (Medium), WM = Wet Mesic, W = Wet

## Rain Garden Species List

FORBS & WILDFLOWERS (Con't)										SUN					Moisture Gradient				
GENUS	SPECIES	COMMON NAME	Bloom Time	Flower Color	Height	S	PS	Sh	Dry	DM	Mesic	WM	Wet						
<i>Claytonia</i>	<i>virginica</i>	Spring-Beauty	March-May	White Striped w/Pink	4" - 1'			x		x	x								
<i>Coreopsis</i>	<i>lanceolata</i>	Lance-leaf Coreopsis	June-Aug.	Yellow	1' - 3'	x			x	x									
<i>Dalea</i>	<i>purpurea</i>	Purple Prairie Clover	July-Aug.	Purple	1' - 3'	x			x	x									
<i>Desmodium</i>	<i>canadense</i>	Canada tick-trefoil	July-Aug.	Pink	2' - 4'	x	x		x	x									
<i>Dicentra</i>	<i>cucullaria</i>	Dutchman's Breeches	Apr.-May	White	4" - 1'			x		x									
<i>Dodecatheon</i>	<i>meadia</i>	Shooting Star	May-June	White/Pink	1' - 2'	x	x		x	x			x						
<i>Echinacea</i>	<i>purpurea</i>	Purple Coneflower	June-Oct.	Purple	2' - 3'	x	x			x									
<i>Eryngium</i>	<i>yuccifolium</i>	Rattlesnake Master	July-Sept.	Greenish-White	1' - 2'	x				x									
<i>Eupatorium</i>	<i>maculatum</i>	Spotted Joe Pye Weed	July-Sept.	Dull Pink	2' - 6'	x	x		x	x			x						
<i>Eupatorium</i>	<i>perfoliatum</i>	Boneset	July-Oct.	White	2' - 4'	x	x			x			x						
<i>Eupatorium</i>	<i>purpureum</i>	Purple Joe Pye Weed	July-Sept.	Pink	3' - 7'	x	x	x		x									
<i>Eupatorium</i>	<i>rugosum</i>	Black Snakeroot	July-Sept.	White	1' - 3'	x	x	x	x	x			x						
<i>Euthamia</i>	<i>graminifolia</i>	grass-leaved goldenrod	July-Oct.	Yellow	1' - 4'	x	x		x	x			x						
<i>Filipendula</i>	<i>rubra</i>	Queen of the Prairie	June-Aug.	Pale Pink	3' - 4'	x				x			x						
<i>Gentiana</i>	<i>andrewsii</i>	Bottle Gentian	Aug.-Oct.	Blue	1' - 2'	x	x			x			x						
<i>Geranium</i>	<i>maculatum</i>	Wild Geranium	May-June	Pink	1' - 2'		x	x		x									
<i>Hasteola</i>	<i>suaveolens</i>	Sweet Indian Plantain	June-Aug.	White	2' - 5'	x	x						x						
<i>Helenium</i>	<i>autumnale</i>	Sneezeweed	Aug.-Nov.	Yellow	2' - 5'	x	x				x		x						
<i>Helianthus</i>	<i>strumosus</i>	Woodland Sunflower	June-Aug.	Yellow	1' - 3'	x	x	x		x									
<i>Helopsis</i>	<i>helianthoides</i>	Ox-eye Sunflower	July - Sept.	Yellow	2' - 5'	x	x			x									
<i>Heuchera</i>	<i>richardsonii</i>	Alum Root	June - July	Green	1' - 3'	x	x		x	x									
<i>Hypericum</i>	<i>pyramidatum</i>	Saint John's Wort	June-Sept.	Yellow	2' - 5'	x	x			x			x						
<i>Iris</i>	<i>versicolor</i>	Wild Iris	May-July	Blue-Purple	2' - 3'	x	x			x			x						
<i>Iris</i>	<i>virginica</i>	Blue Flag Iris	May-July	Purple-Yellow	2' - 3'	x	x						x						
<i>Liatris</i>	<i>ligulistylis</i>	Blazing Star	July-Sept.	Purple/Pink	2' - 5'	x	x			x									
<i>Liatris</i>	<i>pycnostachya</i>	Prairie Blazing Star	May-July	Purple	1' - 2'	x	x			x			x						
<i>Liatris</i>	<i>spicata</i>	Marsh Blazing Star	May-July	Pink	2' - 5'	x	x			x			x						
<i>Lilium</i>	<i>michiganense</i>	Michigan Lily	July-Sept.	Orange	3' - 7'	x	x			x									
<i>Lobelia</i>	<i>cardinalis</i>	Cardinal Flower	July-Sep.	Red	2' - 5'	x	x	x		x			x						
<i>Lobelia</i>	<i>siphilitica</i>	Great Blue Lobelia	Aug.-Sep.	Blue	1' - 4'	x	x						x						
<i>Lysimachia</i>	<i>ciliata</i>	Fringed Loosestrife	June-Aug.	Yellow	1' - 4'	x	x	x			x								
<i>Lythrum</i>	<i>alatum</i>	Winged Loosestrife	June-Sept.	Pink	1' - 4'	x							x						
<i>Mertensia</i>	<i>virginica</i>	Virginia Bluebell	Apr.-May	Blue	1' - 2'	x	x				x		x						
<i>Mimulus</i>	<i>ringens</i>	Monkey Flower	June-Sept.	Blue-Purple	1' - 3'	x	x						x						

**Legend**

Sun: S = Full Sun, PS = Partial Shade, Sh = Shade

Moisture Gradient: (listed from dry to wet) D = Dry, DM = Dry Mesic, Mesic (Medium), WM = Wet Mesic, W = Wet

## Rain Garden Species List

FORBS & WILDFLOWERS (Con't)										SUN					Moisture Gradient				
GENUS	SPECIES	COMMON NAME	Bloom Time	Flower Color	Height	S	PS	Sh	Dry	DM	Mesic	WM	Wet						
<i>Monarda</i>	<i>fistulosa</i>	Bee Balm	July-Aug.	Pink-Lavender	2' - 3'	X	X		X		X	X	X						
<i>Napaea</i>	<i>dioca</i>	Glade Mallow	July-Aug.	White	3' - 7'	X	X				X	X							
<i>Parthenium</i>	<i>integrifolium</i>	Feverfew, Wild Quinine	July-Aug.	White	2' - 3'	X			X		X								
<i>Penstemon</i>	<i>digitalis</i>	Smooth Penstemon	May-July	White	1' - 4'	X	X		X		X	X							
<i>Phlox</i>	<i>divaricata</i>	Wild Blue Phlox	Apr.-June	Pale Blue/Purple	10" - 20"	X	X	X	X		X	X							
<i>Phlox</i>	<i>glaberrima</i>	Smooth Phlox	July-Aug.	Fuchsia	1' - 3'	X	X				X	X							
<i>Phlox</i>	<i>pilosa</i>	Prairie Phlox	May - July	Pink	1' - 2'	X	X		X		X	X	X						
<i>Physostegia</i>	<i>virginiana</i>	Obedient Plant	Aug.-Oct.	Purple-Pink	2' - 3'	X	X				X	X	X						
<i>Polemonium</i>	<i>reptans</i>	Jacob's Ladder	April-May	Violet	8" - 16"	X	X	X			X	X							
<i>Polygonatum</i>	<i>biflorum</i>	Solomon's Seal	May-June	Yellow-green	1' - 6'	X	X		X		X	X							
<i>Pycnanthemum</i>	<i>virginianum</i>	Mountain Mint	July-Sept.	White	1' - 3'	X	X				X	X	X						
<i>Ratibida</i>	<i>pinnata</i>	Yellow Coneflower	July-Sept.	Yellow	18" - 4'	X	X		X		X	X							
<i>Rudbeckia</i>	<i>hirta</i>	Black-eyed Susan	June-Oct.	Yellow-Dark Brown	1' - 3'	X	X		X		X	X							
<i>Rudbeckia</i>	<i>subtomentosa</i>	Sweet Black-eyed Susan	June-Oct.	Yellow	2' - 5'	X	X				X	X	X						
<i>Rudbeckia</i>	<i>triloba</i>	Brown-eyed Susan	Aug.-Oct.	Yellow	3' - 5'	X	X	X			X	X							
<i>Saxifraga</i>	<i>pensylvanica</i>	Swamp Saxifrage	May-June	Variable	1' - 3'	X	X	X				X	X						
<i>Scutellaria</i>	<i>lateriflora</i>	Skullcap	June-Sept.	Blue	1' - 3'	X	X					X	X						
<i>Senna</i>	<i>hebecarpa</i>	Wild Senna	July-Aug.	Yellow	3' - 6'	X	X				X	X	X						
<i>Silene</i>	<i>stellata</i>	Starry Campion	July-Sept.	White	1' - 3'	X	X	X			X	X							
<i>Silphium</i>	<i>integrifolium</i>	Rosinweed	July-Sept.	Yellow	3' - 6'	X			X		X	X							
<i>Silphium</i>	<i>laciniatum</i>	Compass Plant	July-Sept.	Yellow	6' - 9'	X	X		X		X	X							
<i>Silphium</i>	<i>perfoliatum</i>	Cup Plant	July-Sept.	Yellow	4' - 8'	X	X				X	X							
<i>Silphium</i>	<i>terrebinthinaceum</i>	Prairie Dock	July-Sept.	Yellow	6' - 9'	X	X		X		X	X							
<i>Smilacina</i>	<i>racemosa</i>	False Solomon's Seal	May-June	White	1' - 3'		X	X	X		X	X	X						
<i>Smilacina</i>	<i>stellata</i>	Starry Solomon's Plume	May-June	White	1' - 2'	X	X		X		X	X							
<i>Solidago</i>	<i>flexicaulis</i>	Zig-zag Goldenrod	Aug.-Oct.	Yellow	1' - 3'	X	X	X	X		X	X							
<i>Solidago</i>	<i>ohioensis</i>	Ohio Goldenrod	Aug.-Oct.	Yellow	1' - 3'	X					X	X	X						
<i>Solidago</i>	<i>riddellii</i>	Riddell's Goldenrod	Aug.-Oct.	Yellow	1' - 3'		X				X	X	X						
<i>Solidago</i>	<i>rigida</i>	Stiff Goldenrod	Aug.-Oct.	Yellow	1' - 5'	X	X		X		X	X	X						
<i>Thalictrum</i>	<i>dasycarpum</i>	Meadowrue	June-July	White	3' - 6'	X	X				X	X	X						
<i>Thalictrum</i>	<i>dioicum</i>	Early meadow-rue	Apr.-May	Yellow-green	8" - 30"		X	X			X	X							
<i>Tradescantia</i>	<i>ohiensis</i>	Spiderwort	May-July	Purple	2' - 4'	X	X		X		X	X							
<i>Valeriana</i>	<i>edulis</i>	Valerian	May-June	White-Purple	1' - 3'	X	X					X	X						
<i>Verbena</i>	<i>hastata</i>	Blue Vervain	July-Sept.	Blue-Purple	2' - 6'	X						X	X						

**Legend**

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## Rain Garden Species List

FORBS & WILDFLOWERS (Con't)							SUN				Moisture Gradient			
GENUS	SPECIES	COMMON NAME	Bloom Time	Flower Color	Height	S	PS	Sh	Dry	DM	Mesic	WM	Wet	
<i>Veronicastrum</i>	<i>faciculata</i>	Ironweed	Aug.-Oct.	Purple	2' - 6'	X	X				X	X		
<i>Veronicastrum</i>	<i>virginicum</i>	Culver's Root	June-Aug.	White	3' - 6'	X					X	X	X	
<i>Viola</i>	<i>canadensis</i>	Canadian White Violet	May-June	White	1' - 2'			X				X	X	
<i>Zizia</i>	<i>aptera</i>	Heartleaf Golden Alexander	May-June	Yellow	1' - 3'	X	X		X					
<i>Zizia</i>	<i>aurea</i>	Golden Alexander	May-July	Yellow	2' - 4'	X	X	X		X	X	X		
<b>FERNS</b>														
<i>Adiantum</i>	<i>pedatum</i>	Maidenhair Fern			2' - 4'	X	X	X			X	X	X	
<i>Athyrium</i>	<i>fili-femina</i>	Lady Fern			2' - 3'		X	X	X		X	X	X	
<i>Matteuccia</i>	<i>struthiopteris</i>	Ostrich Fern			3' - 5'	X	X	X			X	X	X	
<i>Onoclea</i>	<i>sensibilis</i>	Sensitive Fern			18" - 24"	X	X	X				X	X	
<b>GRASSES</b>														
<i>Andropogon</i>	<i>gerardii</i>	Big Bluestem	Apr.-May	Greenish-Grey	3' - 8'	X			X	X	X	X		
<i>Bromus</i>	<i>ciliatus</i>	Fringed Brome	Apr.-May	Yellow	1' - 5'	X	X					X		
<i>Bromus</i>	<i>kalmii</i>	Prairie Brome	June-July	Yellow	1' - 3'	X	X				X	X	X	
<i>Calamagrostis</i>	<i>canadensis</i>	Blue-joint Grass	Apr.-May	Green	4' - 5'	X	X				X	X	X	
<i>Cinna</i>	<i>arundinacea</i>	Wood Reed Grass	June-July	Green	3' - 5'	X	X				X	X	X	
<i>Diarrhena</i>	<i>obovata</i>	Beak Grass	June-July	Green	2' - 3'		X	X			X	X	X	
<i>Elymus</i>	<i>canadensis</i>	Canada Wild Rye	Apr.-May	Yellow	3' - 5'	X	X		X		X	X		
<i>Elymus</i>	<i>riparius</i>	Wild Rye	July-Aug.	Yellow	3' - 5'	X	X				X	X		
<i>Elymus</i>	<i>villosus</i>	Silky Wild Rye	July-Aug.	Yellow	3' - 5'	X	X		X	X	X	X		
<i>Elymus</i>	<i>virginicus</i>	Virginia Wild Rye	July-Aug.	Straw	3' - 5'	X	X		X	X	X	X		
<i>Glyceria</i>	<i>canadensis</i>	Rattlesnake grass	June-July	Green	2' - 4'	X	X					X	X	
<i>Glyceria</i>	<i>grandis</i>	Reed Manna Grass	June-July	Straw	3' - 5'	X						X	X	
<i>Glyceria</i>	<i>striata</i>	Fowl Manna Grass	June-July	Green	4' - 5'	X	X				X	X	X	
<i>Hierochloa</i>	<i>hirta</i>	Northern Sweet Grass	June-July	Green	2' - 3'	X	X				X	X	X	
<i>Hystrix</i>	<i>patula</i>	Bottlebrush Grass	June-Aug.	Straw	3' - 5'	X	X	X		X	X	X		
<i>Panicum</i>	<i>virgatum</i>	Switch Grass	Aug.-Sept.	Gold	3' - 6'	X	X		X	X	X	X	X	
<i>Schizachyrium</i>	<i>scoparium</i>	Little Bluestem	Aug.-Oct.	Crimson-red	2' - 3'	X					X	X	X	
<i>Spartina</i>	<i>pectinata</i>	Prairie Cord Grass	Aug.-Sept.	Gold	6' - 9'	X					X	X	X	
<i>Sporobolus</i>	<i>heterolepis</i>	Prairie Dropseed	Aug.-Sept.	Gold	2' - 3'	X			X	X	X			
<b>RUSHES</b>														
<i>Juncus</i>	<i>effusus</i>	Soft Rush	June-July	Green	6" - 24"	X					X	X	X	
<i>Juncus</i>	<i>torreyi</i>	Torrey's rush	June-July	Green	6" - 24"	X					X	X	X	

Legend

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## Rain Garden Species List

GENUS	SPECIES	COMMON NAME	Bloom Time	Flower Color	Height	SUN				Moisture Gradient			
						S	PS	Sh	Dry	DM	Mesic	WM	Wet
<b>SEDGES</b>													
Carex	<i>bebbii</i>	Bebb's Sedge	June - July	Green-Brown	1' - 3'	X	X					X	X
Carex	<i>bicknellii</i>	Prairie Sedge	May-July	Green	1' - 3'	X	X					X	X
Carex	<i>comosa</i>	Bristly Sedge	June - July	Green	1' - 3'	X						X	
Carex	<i>crinita</i>	Fringed Sedge	May-June	Green	3' - 5'	X	X	X				X	X
Carex	<i>grayi</i>	Bur Sedge	May-June	Green	2' - 3'	X	X	X				X	X
Carex	<i>hystericina</i>	Bottlebrush Sedge	May-July	Green	1' - 3'	X						X	X
Carex	<i>scoparia</i>	Pointed Broom Sedge	May-June	Green	1' - 3'	X						X	X
Carex	<i>sprengelii</i>	Woodland Sedge	May-June	Green-Brown	6" - 1'	X	X	X		X		X	X
Carex	<i>stipata</i>	Fox Sedge	May-July	Green	1' - 3'	X	X	X				X	X
Carex	<i>stricta</i>	Tussock Sedge	May-July	Green	1' - 4'	X	X					X	X
Carex	<i>vulpinoidea</i>	Brown Fox Sedge	May-June	Green	1' - 3'	X	X					X	X
Scirpus	<i>atrovirens</i>	Dark Green Bulrush	May-July	Green	3' - 5'	X						X	X
Scirpus	<i>cyperinus</i>	Wool Grass	May-July	Green/Rust	3' - 5'	X						X	X
<b>SHRUBS</b>													
<i>Amelanchier</i>	<i>laevis</i>	Allegheny Serviceberry	March-May	White	15' - 25'	X	X		X		X	X	X
<i>Amorpha</i>	<i>fruticosa</i>	False Indigo	May-July	Purple	3' - 7'	X	X				X	X	X
<i>Aronia</i>	<i>melanocarpa</i>	Black Chokeberry	May-July	White	1' - 3'	X	X				X	X	X
<i>Cornus</i>	<i>alternifolia</i>	Pagoda Dogwood	April-May	White	20' - 25'		X	X				X	X
<i>Cornus</i>	<i>stolonifera</i>	Red-osier Dogwood	May-June	White	4' - 6'	X	X	X				X	X
<i>Corylus</i>	<i>americana</i>	American Hazelnut	March-Sept.	Yellow-Orange	8' - 18'	X	X		X		X	X	X
<i>Hamamelis</i>	<i>virginiana</i>	Witch Hazel	Aug. - Oct.	Yellow	15' - 30'		X	X		X	X	X	X
<i>Hypericum</i>	<i>kalmianum</i>	Kalm St. Johnswort	July-Aug.	Yellow	2' - 4'	X	X		X		X	X	X
<i>Hypericum</i>	<i>pyramidalatum</i>	Great St. Johnswort	July-Aug.	Yellow	2' - 4'	X	X		X		X	X	X
<i>Ilex</i>	<i>verticillata</i>	Common Winterberry	June-July	Greenish-White	3' - 12'	X	X				X	X	X
<i>Physocarpus</i>	<i>opulifolius</i>	Common Ninebark	May-June	White-Pink	5' - 8'	X	X		X		X	X	X
<i>Ribes</i>	<i>americanum</i>	American Black Currant	May-June	White-Yellow	12' - 18'		X	X				X	X
<i>Salix</i>	<i>discolor</i>	Pussy Willow	March	White	15' - 20'	X	X	X				X	X
<i>Sambucus</i>	<i>canadensis</i>	Elderberry	June-Aug.	Yellow-Green	6' - 12'	X	X	X		X		X	X
<i>Spiraea</i>	<i>alba</i>	Meadow Sweet	Spring-Fall	Yellow-Brown	8' - 12'	X	X					X	X
<i>Viburnum</i>	<i>acerifolium</i>	Maple-Leaf Arrowwood	June	White	3' - 6'		X	X	X			X	X
<i>Viburnum</i>	<i>lentago</i>	Nannyberry	May-Sept	Purple	15' - 25'	X	X	X				X	X
<i>Viburnum</i>	<i>rafiniquianum</i>	Downy Arrowwood	May-June	White	6' - 10'		X	X		X		X	X
<i>Viburnum</i>	<i>trilobum</i>	American Cranberry	May-June	White	5' - 12'	X	X	X				X	X

**Legend**

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## Prepare and Plant a Rain Garden

# What's a Square Foot Anyway? Laying out the Design Plan

## Activity Overview

Teams of students lay out a rain garden design plan on the school ground using a scale drawing and square foot templates.

## Objectives

### Students will

1. Transfer points on graph paper to physical points on the ground
2. Apply mathematical concepts (e.g., geometry, graphing, measurement, perimeter, area, etc.) to a real-life design project
3. Demonstrate techniques of measurement using scale drawings
4. Generate a model for a real-world project

## Subjects Covered

Math

## Grades

3 through 12

## Activity Time

1 hour

## Season

Any

## Materials

A rain garden design plan drawn on graph paper, 2 "square foot" cardboard pieces and string per student (see illustration at the end of activity), surveyor flags, one 100 foot measuring tape, spray paint

## State Standards

### Math

Communicate mathematical ideas (A.4.2)

Connect mathematical learning with other subjects (A.4.3)

Develop effective oral & written presentations (A.8.4)

## Background

After students design their rain garden, they need to transfer the plan from paper to the school landscape. In this activity, students are able to make that transition from a concept on paper to an actual location on the school ground. This step not only lays out the restoration plot but also offers students a chance to see how a concept can materialize into a reality.

The following list of warm-up activities may help students not familiar with these mapping concepts:

- In the classroom, draw out sample designs or have students draw a design on graph paper. Have the students determine the area in square feet. One square on the graph represents one square foot.
- Practice using the cardboard square foot templates to create different shapes and visualize various square foot areas.
- Measure spaces such as a classroom or library using the square foot templates.

## Activity Description

In this activity, you will lay out your restoration design plan on the school ground. Follow each step and when you are finished, your schematic drawing will be physically marked on the ground ready for site preparation and planting.

First, measure, and cut out two, one square foot cardboard pieces. Attach a string to each cardboard piece to tie the cardboard to your feet. You will wear the cardboard-like shoes to layout the restoration plot.

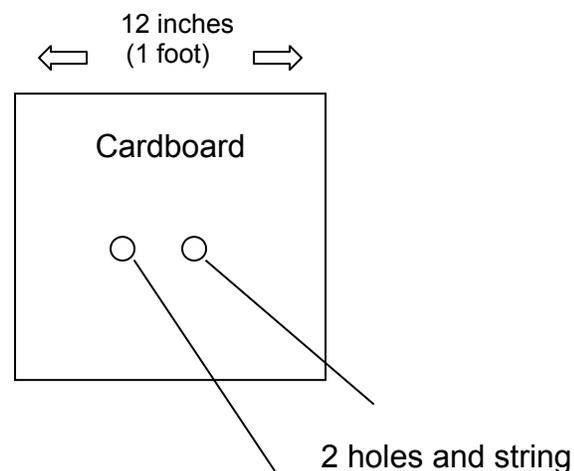


Illustration showing one "square foot."

## What's a Square Foot Anyway? (cont.)

### Math (cont.)

Analyze non-routine problems & arrive at solutions (A.12.3)

Represent & explain whole numbers, decimals, & fractions (B.4.1)

Read, represent, & interpret rational numbers (B.8.1)

Create & critically evaluate numerical arguments (B.12.5)

Identify & use relationships among figures (C.4.3)

Use coordinate systems to find map locations (C.4.4)

Analyze properties and relationships of figures (C.12.1)

Use geometric models to solve problems (C.12.2)

Recognize & describe measurable attributes & units (D.4.1)

Demonstrate understanding of measurement (D.4.2)

Read & interpret measuring instruments (D.4.3)

Determine measurements by using basic relationships or estimations (D.4.5)

Identify & describe attributes in situations not directly or easily measurable (D.8.1)

Demonstrate understanding of measurement facts, principles, techniques (D.8.2)

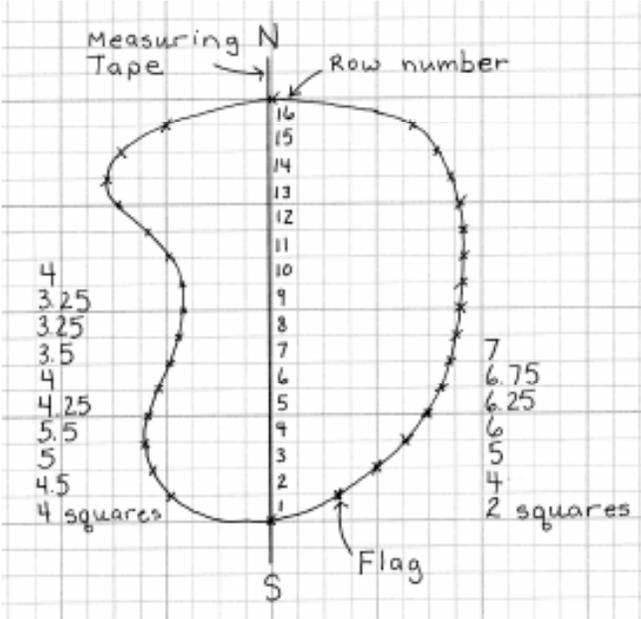
Determine measurement indirectly (D.8.4)

Select & use tools to determine measurements directly (D.12.2)

### Source

David Schultz, Central Middle School, Hartford, WI

### Option 1:

- Assign roles. You need 2 students to call out the design (“callers”) and two students to place flags (“flaggers”). The remaining students will wear the square feet cardboard pieces on their feet and step out the design (“line people”).
- Divide into two teams. Each team will have one “caller”, one “flagger”, and several “line people.”
- Draw a line through the middle of your design in a north/south or east/west direction, (using cardinal points is preferable). Number each row. Count the number of squares to the right of the line. Record this number on the row. Count the number of squares to the left of the line. Record this number on the row. (See illustration.)
- Go outside and lay out the measuring tape in a north/south or east/west direction at the site of the restoration. The measuring tape represents the line on the design plan.
 
- Divide into your two teams. Begin at one end of the garden. One team will lay out the design to the left of the line and the other team will lay out the design to the right of the line.
- To begin the mapping process, the “callers” call out the number of squares in the first row. The “line people” then line up shoulder to shoulder wearing the cardboard templates on their feet. For instance on the example below, in the first row, there are 2 squares (or 2 square feet) to the right of the line and 4 squares (or 4 square feet) to the left of the line. One student with cardboard squares tied to his/her feet stands to the right of the line to measure out two square feet. To the left of the line, two students will stand side-by-side to measure out 4 square feet.
- Once the “line people” are standing in position the “flaggers” place a flag at either end of the row.
- Repeat this process for each row in the design.
- After each flag is placed on the ground you will see the perimeter of your design laid out with flags. Walk the perimeter of the rain garden.
- Use landscape spray paint to mark the perimeter of the garden.

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## What's a Square Foot Anyway? (cont.)

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### Extensions

- Practice different layouts using a set number of square feet, e.g. 4, 6, 10, etc. Measure the perimeters of the different layouts. Which layouts create the largest perimeters? What effect would perimeter have on a garden plot?
- Measure the square feet of different existing features on the school ground. Compare and rank the areas in terms of size. What is the ratio of built areas to natural areas?
- Create a map of an area using cardboard pieces.

### Additional Resources

- Wyzga, Marilyn C. (1995). *Homes for wildlife*. United States Fish and Wildlife Service, Office of Extension Publications, through the University of New Hampshire Cooperative Extension.
- ..... (1995) *Project Wet curriculum & activity guide*. Bozeman, MT: The Watercourse and the Council for Environmental Education.



### Assessment

- Calculate square footage of shapes and designs drawn on graph paper.
- Draw a rain garden design and calculate square footage.
- Explain the relationship between perimeter and shape.

*EPS Institute participants using their square feet to lay out a rain garden. Photo: Libby McCann.*

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# Planting a School Rain Garden

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## Activity Overview

Students learn how to plant while planting transplants in their school rain garden.

## Objectives

### Students will

1. Learn how to properly plant transplants in their rain garden
2. Understand that plants need space, soil, water, and sunlight to grow
3. Participate in a project to improve water quality

## Subjects Covered

Science

## Grades

K through 12

## Activity Time

1 hour

## Season

Any

## Materials

Plants, trowels, source for water, watering containers, and mulch (if desired).

## State Standards

### Science

Discover how organisms meet their needs (F.4.1)

Investigate structure & function of organisms (F.8.1)

## Background

Planting a rain garden is a very special event in a school year and an important contribution to the environment. Therefore, consider including the entire school community by integrating some form of a ceremony or dedication into the planting project. Because of curriculum requirements, this may be the only opportunity some students will have with the planning and implementation of a rain garden.

Whether you are planting shrubs, trees, or herbaceous plants, there are a few tips for successful planting. First, dig a hole that is considerably wider and as deep as or just slightly deeper than the container or root system of the plant. It is not necessary to modify the soil, so use the soil you dig out to fill the hole back in once you have placed the plant. If you modify the soil within the hole too much you might discourage the plant from extending its roots away from the hole.

If you purchase plants in pots, it is possible that the plants have not been growing in the pots for very long; therefore, much of the soil will fall off when you remove the plant from the pot. That is OK. The pots are a way for the plant to be held until you get it into the ground. On the other hand, if the plants have been in the pot for too long, the roots can coil around the pot, becoming “pot bound.” If that happens, and you do not loosen and straighten the roots when you remove them from the pot, the roots will continue to grow in this pot form and eventually strangle the plant. In either case, when placing the plant in the hole, straighten the roots out. Do not coil the roots to fit them into too small a hole because they will continue growing in the direction you place them and could, once again, strangle the plant. If you cannot dig a large enough hole it is better to cut the root than to coil it.

A common error when planting woody plants is to plant them too deep. Woody plants have a root collar that should be level with or slightly above the grade of the soil when you are finished filling in the hole. The same is true when you are planting “plugs” or other herbaceous plants. Try to place them at the same soil height as they were originally growing. This might take some close inspection but is usually obvious. Plugs can seem root bound, but if the roots are not coiled you can just spread them out.

Generally, plants are spaced about one foot apart when planted in the ground. See Earth Partnership for Schools Activity “Designing a Rain Garden” for design suggestions and plant layout. After planting, water the soil well and make provisions for continued watering the first summer. After a planting, new transplants need to be watered once each week for four weeks. Skip a week if there is a one-inch rainfall during that particular week. You can mulch with composted leaves or with wood chips to help hold in moisture. Create

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## Planting a School Rain Garden (cont.)

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a slight lip with soil around the planting hole to help when watering. The lip helps the water stay there long enough to soak in. You may find it helpful to mark the plants with tall markers to help you find them in mid to late summer or to identify them when weeding. What is readily apparent in May can be very hard to find in July or August.

### Activity Description

#### Preparation for planting day

Arrange for volunteers to assist students with planting. Develop and distribute a planting schedule. Many options are possible when planting with students. Pairing older with younger students has proved very successful. Having students planting in pairs works well, too. Give each class/group about 30 minutes of planting time on the schedule. Contact the media and have a student team prepared to write articles and take photographs. Plan a celebration and invite the school community.

#### On planting day

Set up plants, trowels, water, and watering containers near the planting site. If desired, place plant markers where transplants will be located or mark planting zones according to plant height on the ground.

#### Planting day

Once a class is at the planting site, begin by giving a planting lesson or demonstration. Describe the plant basics and what a plant needs to grow and thrive and give step-by-step planting instructions. Instructions can include locating a planting spot, digging a hole, removing the plant from the pot, separating roots (if needed), planting at the proper level, refilling the hole with soil, placing a marker, watering, and perhaps adding mulch.

Have students begin at the center of the garden and work out to avoid trampling the new transplants. After all the plants are in the ground, spread the remaining mulch between plants.

Step back and enjoy the work done and the future promise of a healthy watershed.

### Extensions

- Look for opportunities to plant in parks and other public areas.
- Follow the growth of your transplant by taking photographs and measurements, making drawings, and recording when the plant first blooms.
- Write a song or poem about your planting experience.

### Additional Resources

- Ripple, K., Garbisch, E. (2000). *POW! The planning of wetlands*. St. Michaels, MD: Environmental Concern, Inc.
- Cohen, J., Pranis, E. (1990). *GrowLab: Activities for growing minds*. Burlington, VT: National Gardening Association.

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## Planting a School Rain Garden (cont.)

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- Lovejoy, S. (1999). *Roots, shoots, buckets & boots: Gardening together with children*. New York, NY: Workman Publishing Company.
- Richardson, B. (1998). *Gardening with children*. Newtown, CT: The Taunton Press, Inc.

### Assessments

- Draw and describe how to plant a transplant as a cartoon feature.
- Draw correct and incorrect versions of planting. Explain how to fix the incorrect drawing.



*Students planting their rain garden at Lloyd Street Global Education School, Milwaukee, WI.  
Photos: Cheryl Bauer-Armstrong*





**Maintain a Rain Garden**

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# Rain Garden Maintenance

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## Activity Overview

Students learn about plant and garden care while managing a newly planted rain garden.

## Objectives

### Students will

1. Understand plant needs for growth and survival
2. Learn basic land care principles
3. Participate in a service-learning project

## Subjects Covered

Science and Health

## Grades

3 through 12

## Activity Time

50 minutes

## Season

Spring, Summer, and Fall

## Materials

Gardening gloves (optional); buckets, wheelbarrow or plastic garbage bags; water source, recycled milk jugs or equivalent.

## State Standards

### Science

Describe reasoning to make conclusions (B.8.4)

Use data to answer questions (C.4.5)

Communicate results (C.4.6)

Support conclusions with logic (C.4.7)

Ask new questions (C.4.8)

Use inferences and observations (C.8.4)

Use knowledge, models, and theories to explain results (C.8.5)

State learning from investigations (C.8.6)

## Background

A native rain garden planting is not maintenance free and will regularly need some maintenance to remove weeds and dead plant material. Fortunately, time spent caring for the garden decreases over time. Native rain garden plants do not need fertilizers, winter protection or irrigation. Native plants are adapted to the climate and soils and can tolerate excessive heat, bitter cold, drought, and flooding.

The first two years require the most care while the plants are establishing themselves in the garden. As they are maturing during the first year, they need regular watering to encourage good root development. Irrigate the plants so that the water soaks deeply into the ground, which is equivalent to a one-inch of rainfall. Short sprinkles of water encourage the roots to grow along the surface. When roots grow along the surface plants are less hardy during droughts and freezing temperatures.

Pull weeds to reduce competition for space, light, and water. Most weeds are pioneer species, which means they can grow very quickly. They fill in the open spaces and often can crowd out new rain garden plants. Additionally, they give the garden a messy, unkempt appearance. Spreading a three inch layer of wood chip or leaf mulch around the new planting helps control some of these uninvited species.

Much of the maintenance during the establishment years occurs during the summer months. Therefore, before summer vacation, enlist volunteers to monitor, water, and weed the garden during summer vacation. Local garden clubs, summer school students, scout troops, families, Wild Ones members and Master Gardeners may be willing to volunteer during the summer. Most potential volunteers will say, “yes,” when asked.

## Activity Description

### Specific instructions for rain garden care follows:

#### Year 1

#### **Watering**

1. For the first three weeks after planting, water the rain garden once per week. It is not necessary to water during a given week if one-inch of rain accumulates.
2. Water the garden during droughty periods in mid-summer, if needed.

#### **Weeding**

1. First identify what is a weed and what is a rain garden plant. Rain garden plants may be marked with planting stakes. Once the weeds are identified, assign a specific weed for each student or group of students to hand

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## Rain Garden Maintenance (cont.)

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### Science (cont.)

Explain data & conclusions (C.8.7)

Use computer software to organize data (C.8.8)

Evaluate questions, hypotheses, conclusions (C.8.9)

Discuss results (C.8.10)

Identify further questions (C.8.11)

Present results (C.12.6)

Evaluate articles & reports using scientific criteria (C.12.7)

Explain survival and population growth of species (F.8.9)

### Health

A.4.5, A.12.3, A.12.8, C.4.4, F.4.3

pull. This way ensures only the weeds are removed. Have students look closely at the weed to become familiar with its leaf shape and arrangement, current height and other noteworthy features.

2. Remove plants carefully in order not to disrupt the rain garden species. Pull from the base of the plant. It is easier to pull weeds when the weeds are young and small.
3. Keep track of how many different weeds are pulled and how many of each kind.
4. Take the pulled weeds to a compost pile.
5. Return to the classroom and make a chart of the weeds pulled. Save the chart to compare with future weeding sessions. Take note how numbers and types of weeds change over time.

Check status of weeds and pull them, if necessary, once every three weeks during the summer. A layer of mulch helps to reduce weed growth, therefore, weeding time.

### Year 2

#### General maintenance

- In spring when new growth begins, cut off dead plant material. (Keep stems and seedheads on during winter for visual interest, winter lessons, wildlife cover, and food for birds.)

#### Watering

- Water only if in a drought.

#### Weeding

- Continue weeding as needed. Rain garden plants will fill in the spaces and form a dense root mass, which will significantly reduce weeding over time. It is still worthwhile to monitor the garden for weeds once every three to four weeks during the summer.

### And Beyond

#### General maintenance

- Each spring when the rain garden plants begin to grow, go out to the rain garden and clip last year's growth.

#### Burning

- If desired, and permitted in your community, burn the rain garden in spring. Burning is not necessary for a healthy rain garden community.

#### Litter Removal

- Periodically remove litter that may blow into the rain garden.

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## Rain Garden Maintenance (cont.)

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### Extensions

- Create a field guide of the rain garden plants and weeds.
- Identify and research the rain garden and weed species. Find out if the weeds are native or non-native. Learn about their history and life cycles.

### Additional Resources

#### Web sites

- National Gardening Association: <http://www.garden.org/home>
- Kids Gardening: <http://www.kidsgardening.com/>
- Weed Library: <http://www.garden.org/weedlibrary/>

### Assessments

- Develop a poster describing the importance of weeding.
- Write a management plan for how to care for a new rain garden.



*2006 Institute participants are removing Sweet White Clover (*Melilotus alba*) at Prairie View Elementary School, Oregon, WI. Photo: Libby McCann*



**Make Community Connections**

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# Getting the Word Out

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## Activity Overview

Students write and develop outreach materials such as a brochure, flyer, door hanger, article or poster that informs the community about their rain garden project.

## Objectives Students will

1. Explain the purpose of rain gardens and their project
2. Learn how to develop outreach materials
3. Participate in a service-learning project

## Subjects Covered

Language arts, Science, Environmental Science and Social studies

## Grades

4 through 12

## Activity Time

In class: 10 minutes introduction, ~50 minutes for student presentations

## Season

Any

## Materials

Access to information about rain gardens (see resource lists in “Resources and Vocabulary”), card stock, poster board, a computer and printer (optional), markers, pens and pencils, clip art, pictures, scrap booking materials, and other design materials, etc.

## State Standards

### Language Arts

Read, interpret, and critically analyze literature (A.4.2, 8.2,12.2)

Read & discuss texts to understand human experience (A.4.3, 8.3, 12.3)

## Background

An important component of building a rain garden on the school ground is making the connections with surrounding community members and sharing the story of the project. Getting the word out can be as simple as writing invitations to celebrate the planting to developing colorful brochures explaining what a rain garden is and why build one.

In all probability, citizens in the community may not be aware of rain gardens or understand the storm water and water quality issues that rain gardens address. The development of informational brochures or articles can bring about awareness, understanding, and citizen action. Student-developed outreach materials is a powerful way to inform and advise local citizens about local issues.

## Activity Description

Your assignment is to create an attractive and inviting outreach product that you will use to inform the community about your rain garden project and/or related topics. Follow the three steps below to develop your rain garden outreach product.

1. Form teams.
2. Decide on the purpose, content, and format for your outreach product. Other things to consider when deciding on an outreach approach include your time frame, the audience(s) you want to reach, the message you intend to send, and financial resources available (if any).

There are several types of outreach materials to choose from including:

- brochure or informational pamphlet
- poster
- door hanger
- invitation
- article for a school or community newspaper or newsletter
- Web page on the school Web site
- radio or television news broadcast
- P.S.A. (Public Service Announcement)
- video

Many topics, stories and messages are possible. Consider the following suggestions, or brainstorm other ideas with your teammates:

- invite the public to the school rain garden planting and celebration
- develop a sequence of posters announcing the coming new rain garden
- write advertisements for help with short and long-term maintenance
- organize an open house featuring the new garden

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## Getting the Word Out (cont.)

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### Language Arts (cont.)

Read to acquire information (A.4.4, 8.4, 12.4)

Create or produce writing (B.4.1, 8.1, 12.1)

Plan, revise, edit, & publish writing (B.4.2, 8.2, 12.2)

Understand forms, structures, & punctuation marks (B.4.3, 8.3, 12.3)

Orally communicate (C.4.1, 8.1, 12.1)

Listen & comprehend oral communications (C.4.2, 8.2, 12.2)

Participate in discussion (C.4.3, 8.3, 12.3)

Use computers (E.4.1, 8.1, 12.1)

Create media products (E.4.3, 8.3, 12.3)

Analyze & edit media (E.4.5, 8.5, 12.5)

Conduct then communicate research (F.4.1, F.8.1, F.12.1)

### Science

Decide which questions to ask (A.4.1)

Decide which collected data is pertinent to new problems (A.4.2)

Decide which data should be collected (A.4.3)

Decide on science themes (A.4.4)

Decide on changes that have occurred (A.4.5)

Develop themes for questions (A.8.1)

Collect and organize data that explains or critiques models (A.8.3)

Use models to predict actions and events (A.8.6)

Design investigations to test models (A.8.7)

- publicize the event along with a contest to choose a rain garden name
- put together a PowerPoint presentation to show at a PTO/PTA or school board meeting
- design a T-shirt introducing the garden (You may consider selling T-shirts as a fundraiser.)
- compose a song dedicated to the rain garden
- write a persuasive article to motivate community members to build rain gardens on their properties
- provide information about what a rain garden is, how it improves water quality, and why the school is building a rain garden
- explain the value of rain gardens
- offer information on how to build a rain garden and where to find help and resources
- design a permanent sign and other signage
- create a map of the watershed and locate your rain garden (and others, if known). Show the distance the garden is from its water body (lake, river, creek, etc.).

### 3. Present and distribute outreach materials.

After your outreach materials are developed, present your project to the class for constructive feedback. Disseminate your materials.

### Extensions

- Develop a documentary of the rain garden project.
- Invite public relations professionals to share how they develop new products and materials.
- Compile materials and photographs to keep as a record for the rain garden project.

### Additional Resources

- ... (2006). Outreach materials: Creating solutions to storm water pollution. *Storm water curriculum and teaching guide*. Madison, WI: Earth Partnership for Schools. University of Wisconsin-Madison Arboretum.
- ... (2003). *Getting in step: A guide for conducting watershed outreach campaigns*. Washington, D.C.: United States Environmental Protection Agency. (EPA 841-B-03-002) [www.epa.gov/nps/outreach.html](http://www.epa.gov/nps/outreach.html)

## Getting the Word Out (cont.)

### Science(cont.)

Apply themes to develop future visions (A.12.1)

Use scientific vocabulary & themes (C.4.1)

Ask questions, plan investigations, make observations, predictions (C.4.2)

Use scientific equipment (C.4.4)

Use data to answer questions (C.4.5)

Communicate results (C.4.6)

Support conclusions with logic (C.4.7)

Ask new questions (C.4.8)

Design and conduct investigations (C.8.3)

Use inferences and observations (C.8.4)

State learning from investigations (C.8.6)

Evaluate data (C.12.3)

Choose & evaluate data collection methods (C.12.4)

Explain & predict changes in earth's systems (E.8.1)

Show organism's place in ecosystems (F.8.8)

Infer changes in ecosystems (F.12.8)

### Social Studies

Use reference points to locate positions on earth's surface (A.4.1)

Describe examples of land use, communities, shelters (A.4.4)

Identify environmental changes (A.4.6)

Identify human caused changes and effects (A.4.8)

Use atlases, aerial photos, satellite images, databases (A.8.5)

### Web sites

- University of Wisconsin Extension, Environmental Resources Center.

<http://wateroutreach.uwex.edu/>

### Assessments

- Use the following rubric.

	Not so hot	Getting warmer	Hot!
Audience	It is not clear who my/our audience is or what they are asked to do.	My/our audience is identified; but the information is not useful to my/our audience.	My/our audience is identified and the information applies directly to their situation.
User-friendly	My/our materials are messy and difficult to read.	My/our materials help explain the issue and solution but include too many points.	My/our materials are eye-catching and help make my issue and solution clear to the audience.
Message	The message is long, wordy and confusing.	The message is clear but not written in an active voice.	The message is clear and direct.
Grammar and Punctuation	Words are misspelled, and punctuation is sloppy.	A few careless mistakes and typos are missed.	Grammar and punctuation is correct.

## Getting the Word Out (cont.)

### Social Studies (cont.)

Describe short-term and long-term environmental changes (A.8.6)

Describe interactions with physical environment (A.8.8)

Give examples of current global issues (A.8.11)

Analyze effects of population changes on environment (A.12.4)

Assess land use policies (A.12.12)

Explain influence of factors on individual learning (E.4.1)

Give examples of factors on individual learning (E.8.1)

Describe contributions to social continuity & change (E.8.4)

Analyze institutions' role in social continuity & change (E.12.4)



## You're invited!!

**Why:** For the unveiling of a rain garden and sign

**When:** Wednesday June 7<sup>th</sup> at 8:15-8:30

**Where:** Winnequah park across from the gazebo

**Questions:** Call Bob Schlaefer 221-7676

## Hope to see you there!!



Student-designed rain garden sign, dedication invitation, and display board, Winnequah Middle School, Monona, WI.

*Photos: Bob Schlaefer.*





## Rain Garden Examples

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## Rain Garden Examples

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The following examples of rain gardens show a variety of ways rain gardens are built on the landscape. Please go to Earth Partnership for Schools, University of Wisconsin-Madison Arboretum's Web site to download a Power Point Presentation with these photos and more. College campus photos are by Jim Lorman, other photos are by Cheryl Bauer-Armstrong. Web site: [www.uwarboretum/education/eps](http://www.uwarboretum/education/eps).

### K- 12 School Rain Garden, Prairie View Elementary, Oregon, WI



### College Rain Garden, Edgewood College, Madison, WI



# Rain Garden Examples (cont.)

Formal Rain Garden



Natural-Looking  
Rain Garden



Rain Garden In  
Shade



Rain Garden Shaped by  
Boulders



## Rain Garden Examples (cont.)

### Rain Gardens in Swales



### Rain Gardens Along Streets, Adams Street, Madison, WI





## Resources

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## Rain Garden Resources

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### Rain Garden Basics and How to Build a Rain Garden

- Barr Engineering (Minneapolis, MN) - Landscape Ecology & Landscape Architecture (PDF) [http://www.barr.com/PDFs/ShellsQEs/ecol\\_land.pdf](http://www.barr.com/PDFs/ShellsQEs/ecol_land.pdf)
- Chicago's Rain Garden Network Web site - steps to build and to maintain rain gardens. <http://www.raingardennetwork.com>
- Clear Water Conservancy - conservation techniques for watershed-wise backyards and businesses. <http://www.clearwaterconservancy.org/>
- Dane County Lakes and Watershed Commission (WI) - rain garden resources and links <http://www.danewaters.com/private/raingarden.aspx>
- Edgewood College (Madison, WI) - rain garden guide including a 10-step process to build your own rain garden. <http://natsci.edgewood.edu/wingra/management/raingardens/default.htm>
- Friends of Bassett Creek (Minneapolis, MN) - rain garden guide including a plant/shrub list for both sunny and shady areas. <http://www.mninter.net/%7Estack/rain/>
- Friends of Lake Wingra (Madison, WI) <http://lakewingra.org/>
- Milwaukee Metropolitan Sewerage District (WI) - slide presentation about water quality including rain gardens and rain barrels. <http://www.mmsd.com/home/index.cfm>
- North Carolina Cooperative Extension - backyard rain gardens. <http://www.bae.ncsu.edu/topic/raingarden/>
- Rain Gardens: A How-to Manual for Homeowners. <http://dnr.wi.gov/runoff/pdf/rg/rgmanual.pdf>
- Rain Gardens of West Michigan - rain garden basics <http://www.raingardens.org/>
- The City of Maplewood (MN) - rainwater garden Web site includes photos and a care guide. <http://www.ci.maplewood.mn.us/index.aspx?NID=456>
- University of Wisconsin - Extension and Wisconsin DNR - Rain Garden Educator's Kit. Milwaukee County UWEX, 932 South 60th Street, West Allis, WI 53214-3346 or call (414) 290-2434.
- University of Wisconsin – Extension Basin Education Program <http://clean-water.uwex.edu/>
- Virginia Department of Forestry - [http://www.dof.virginia.gov/mgt/resources/pub-Rain-Garden-Tech-Guide\\_2008-05.pdf](http://www.dof.virginia.gov/mgt/resources/pub-Rain-Garden-Tech-Guide_2008-05.pdf)
- Wild Ones - Web site offers advice on how to amend local weed and vegetation control ordinances to promote responsible native plant landscaping. This site also contains model ordinances to adapt for your community. <http://www.for-wild.org/weedlaws/weedlaw.htm>
- Wisconsin Department of Natural Resources - native plant list for rain gardens. <http://dnr.wi.gov/runoff/pdf/rg/RaingardenPlantList.pdf>
- Wisconsin Department of Natural Resources - rain garden Web site. <http://dnr.wi.gov/runoff/rg/links.htm>

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## Rain Garden Resources (cont.)

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### Rain Garden Examples

- Low Impact Development Center - examples and photos of transportation related rain gardens. [http://www.lid-stormwater.net/biotrans\\_home.htm](http://www.lid-stormwater.net/biotrans_home.htm)
- Puget Sound Action Team - <http://www.psat.wa.gov/stormwater.php>
- Seattle Stormwater Utility - Green Stormwater Infrastructure. [http://www.seattle.gov/util/About\\_SPU/Drainage\\_&\\_Sewer\\_System/GreenStormwaterInfrastructure/index.htm](http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/GreenStormwaterInfrastructure/index.htm)

### Rain Garden Articles

- [EPA to Staunch Flood of Storm Water Runoff Polluting U.S. Waterways](http://www.scientificamerican.com/article.cfm?id=stormwater-runoff), by Sarah Coe field. Scientific American. <http://www.scientificamerican.com/article.cfm?id=stormwater-runoff>
- Field evaluation of rain gardens as method for enhancing groundwater recharge, Ken Potter. UW Water Resources Institute: [http://www.wri.wisc.edu/Downloads/Projects/Final\\_WR01R002.pdf](http://www.wri.wisc.edu/Downloads/Projects/Final_WR01R002.pdf)
- Maryland developer grows rain gardens to control residential runoff. UW EPA. <http://www.epa.gov/owow/info/NewsNotes/pdf/42issue.pdf>
- Rain gardens help recharge, by Kenneth Potter. University of Wisconsin Communications <http://www.news.wisc.edu/releases/7385.html?month=04&year=2002>
- Rain gardens: Something for everyone, by Ellen Considine. <http://digicoll.library.wisc.edu/cgi-bin/UW/UW-idx?type=turn&entity=UW.WIEv106no1.p0014&id=UW.WIEv106no1&isize=M>

### Rain Barrels

- EPA - Rain barrel pdf includes purchasing information. <http://www.epa.gov/region03/p2/what-is-rainbarrel.pdf>
- Harvest H2O Web site - <http://www.harvesth2o.com/>
- How to collect the water with rain barrels, by Jeanne Ralston. <http://www.thisoldhouse.com/toh/photos/0,,20405190,00.html>
- What is a rain barrel? US EPA. <http://www.epa.gov/region03/p2/what-is-rainbarrel.pdf>





## Glossary

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# Glossary

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- Adaptation: Changes an organism makes to adjust to a different or changing environment.
- Aquifer: Underground porous rock that holds groundwater.
- Competition: The simultaneous demand by two or more organisms for limited environmental resources, such as nutrients, water, space, or light.
- Drainage area: An area from which direct surface runoff from precipitation normally drains to a specified point, catchment area, river, lake, reservoir, etc.
- Ecosystem: Community of organisms interacting with one another and with the chemical and physical factors making up their environment.
- Evaporation: A physical change where a liquid turns into a vapor or gas.
- Filter: A porous material through which a liquid is passed in order to separate the water from suspended particulate matter.
- Forbs: Herbaceous plants, excluding grasses and sedges; especially used to describe broad-leaved, flowering plants. An herb that is not a grass, sedge, or rush.
- Function: The purpose or benefit provided by a specific stage/aspect of a process.
- Groundwater: Water that infiltrates into the ground and renews/recharges underground aquifers.
- Headwaters: The source of a stream or river
- Herbaceous: Green and leaf-like in appearance or texture. A non-woody plant.
- Hydrologic cycle: A circulation of water from a water body to the atmosphere, to the land, back to open water either above or below ground, or directly back into the atmosphere.
- Impervious: Not capable of being penetrated.
- Infiltration: The movement of water through the soil.
- Native species: An indigenous species. A native plant historically occurs naturally somewhere within the boundaries of a given region.
- Niche: The function or position of an organism or population within an ecological community.
- Non-native species: A non-native species, or exotic, is a species introduced to a location outside its natural geographic range. Exotics enter an area as intentional horticulture, agriculture, or arrive accidentally.
- Non-point source pollution: This comes from diffuse, undefined sources; it is usually associated with land uses like urban development and agriculture. This kind of pollution and the stormwater runoff it occurs in is considered the most threatening to the nation's water quality.
- Order: A taxonomic category of organisms ranking above a family and below a class.
- Perennial: A plant that lives for more than two growing seasons. Perennial plants live for many years. Usually they flower every year. Herbaceous perennials die back each year.
- Pervious: Able to be penetrated or permeable. This is a surface that allows rainwater to be absorbed into the soil.
- Phenology: The study of seasonal change.
- Pollution: The destruction or contamination of a natural resource usually by harmful substances entering the environment.

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## Glossary (cont.)

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- Rain garden: A specialized garden made up of native plants that captures water and allows it to soak into the ground instead of running off into the storm sewers.
- Runoff: Rainwater that flows over the land because the ground and vegetation cannot absorb it.
- Slope: A stretch of ground forming a natural or artificial incline.
- Soil type: Usually refers to the different sizes of mineral particles in a sample of soil. Soil is made up of three soil particles, grouped according to size as sand, silt, and clay.
- Species: A group of populations reproductively isolated from other such groups.
- Storm water: The overflow of surface water due to a heavy rain or snowstorm.
- Taxonomy: The science of classification.
- Transpiration: A process where water moves up a plant and out of its leaves as water vapor, and into the atmosphere.
- Watershed: The entire land area draining into a specific body of water. These areas are divided by ridges of high land.