PROJECT-BASED LEARNING:
DESIGN AND BUILD A RAIN GARDEN
Teacher's Guide

This Teacher's Guide provides an overview of the four parts of Design and Build a Rain Garden, including background information, essential questions, standards, objectives, vocabulary, and materials. Instructions for each activity are included in the lesson plans for Parts 1, 2, 3, and 4 found on the *Nature Works Everywhere* website at this URL: https://www.natureworkseverywhere.org/resources/design-and-build-rain-garden/)

Subject Area: Biology, Environmental Science, Sustainability

Grade Levels: 9-12

Purpose and Overview:

The Design and Build a Rain Garden lesson series leads students through the siting, design, and installation of a rain garden. The activities provide the basis for a rich, interdisciplinary, hands-on learning experience.

Whether or not you are able to install a rain garden, completing parts 1-3 and the final evaluation form Part 4 will provide students with many opportunities for learning, enjoyment, and collaboration.

- Part 1: Includes background content for students to understand how rain gardens address and fit into larger stormwater management issues and approaches. The lesson lays the foundation for the class to locate, design, and install a rain garden.
- Part 2: Students work to identify the best site, size, and shape for the garden.
- Part 3: Students engage in a creative design process to come up with a class design for the rain garden.
- Part 4: Focuses on the installation of the rain garden and includes the final evaluation.

Time:

- Part 1: Two to three 45-minute sessions
- Part 2: Four 45-minute sessions or more
- Part 3: Two to three 45-minute sessions
- Part 4: Two-three 45-minute sessions or after school/weekend work party, plus homework

IS THIS THE RIGHT PROJECT?

For assistance in determining whether a rain garden project is right for your classroom and site, see the Nature Works Everywhere Sustainable Urban Design Toolkit Introduction and Quick Guide to Projects. For an overview of the selection and installation process, see Green Stormwater Infrastructure: Rain Gardens.

Essential Questions:

- What is green infrastructure and how is it used to manage stormwater?
- What is a rain garden and how does it function to manage stormwater?
- What are the key steps in siting, designing, and installing a rain garden?

Nature Works Everywhere Themes:

Rain gardens manage and filter runoff to help keep natural water bodies and our drinking water clean.

Rain gardens help prevent flooding by managing stormwater runoff.

Introduction:

Rain gardens are one of a group of stormwater management solutions known as *green infrastructure*. Other green infrastructure projects include rainwater harvesting, bioswales, permeable paving, green roofs, and more. Generally, a rain garden manages water from impervious surfaces such as roofs, sidewalks or paths, driveways or parking areas, or other relatively small, discrete areas.

According to Hans Hesselein, landscape architect, green infrastructure related to stormwater is "when you intentionally manage stormwater in an environment that mimics a more natural system… treating stormwater as a resource rather than a waste product." More broadly defined in a paper on educational opportunities in green infrastructure (http://www.thenatureofcities.com/2016/07/03/accessing-urban-environmental-education-opportunities-via-green-infrastructure/), it is "a network of human-managed and natural ecosystems that together enhance ecosystem health and resilience, contribute to biodiversity, and benefit human populations through the maintenance and enhancement of ecosystem services."

Why manage stormwater at all? Stormwater is a wonderful thing: All life depends on it, it fills our rivers and lakes (and reservoirs!), and it is a core part of the water cycle. At the same time, stormwater can cause flooding and, especially in urban environments, can pick up pollutants as it runs off roads, roofs, and other impermeable surfaces that ultimately get carried into bodies of water.

In a natural environment, stormwater gets absorbed into the ground and the soil, rocks, and plant roots filter the water. A rain garden is designed to mimic this process and absorb stormwater in a given area that might otherwise overflow or run across impermeable surfaces. Rain gardens are also simply that—gardens that beautify our lives and provide us an opportunity to engage with nature.

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Objectives:

Part 1

The student will…
- Define green infrastructure
- Understand how water behaves in a natural environment
- Identify examples of green infrastructure
- Understand what types of stormwater problems green infrastructure can solve
- Understand what a rain garden is and what problems rain gardens solve
- Define and identify examples of ecosystem services
- Know what watershed their community and school is in
- Explore and understand the physical and health benefits of nature
- Have familiarity with the area's native plants
- Understand why and how native plants work best in a rain garden
- Develop a formal proposal
- (Optional) Develop a presentation using presentation software

Part 2

The student will…
- Reflect on how they interact with nature and describe their personal relationship with nature
- Consider how a rain garden might support people's connection to nature and the school
- Identify considerations for siting a rain garden on school grounds
- Perform a site inventory using a checklist
- Calculate runoff from impermeable surfaces
- Explore how a 3-dimensional space can be represented on paper
- Use measurement and architectural drafting tools
- Understand the concept of scale and learn to read an architect scale
- Work collaboratively to produce and select a design

Part 3

The student will…
- Explore how a 3-dimensional space can be represented on paper
- Utilize site information to make decisions about placement and design
- Use measurement and architectural drafting tools
- Apply creativity to a design
- Work collaboratively to produce and select a design

Part 4

The student will…
- Translate a 2D map to 3D space
- Become familiar with landscaping tool use and safety
- Understand the tasks required for garden installation
- Problem solve measurement and other issues and make decisions
- Work collaboratively and communicate effectively to create a final product
- Evaluate their personal growth and reflect on both technical and soft skills acquired throughout the project.

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Materials:

Part 1

Nature Works Everywhere videos that support this lesson plan:
- *How Natural Areas Filter Water* (https://vimeo.com/77811268)
- *Sustainable Cities: Nature-based Solutions in Urban Design* (https://vimeo.com/155849692)
- *Design and Build a Rain Garden for Your School or Community* (https://vimeo.com/234213950)

For teachers:
- Access to computer, Internet, computer, speakers
- PowerPoint Presentations on **Stormwater** and **Green Infrastructure and Rain Garden Function** (https://www.natureworkseverywhere.org/resources/design-and-build-rain-garden/)

For each individual or group of students:
- Copies of the student handout (https://www.natureworkseverywhere.org/resources/design-and-build-rain-garden/) to accompany the video *Sustainable Cities: Nature-based Solutions in Urban Design*
- Notebook
- Access to computer with internet
- Access to presentation software

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Part 2

Nature Works Everywhere videos that support this lesson plan:
- *How Dirt Works* (https://vimeo.com/77792712)

For teachers:
- Access to computer, Internet, computer, printer (preferably with 11"x17" capacity)
  - PowerPoint Presentation on **Rain Garden Design Process** (https://www.natureworkseverywhere.org/resources/design-and-build-rain-garden/)
- Instructions for creating a printed Google map:
  - Determine the street address of your site and enter that information into a Google Map.
  - Select "satellite view" and zoom into your site until the area under consideration is enlarged to fit on your screen.
  - Take a screenshot of the area that covers the project site, including the catchment area that is contributing rainwater runoff as well as the proposed location of your rain garden. Be sure to include the scale bar that is located in the right-hand corner of your screen, which will provide you with a reference to determine the size of some of your site elements that may be difficult to measure in the field.
  - Lighten the image slightly (to allow added notes to stand out). You can make your images lighter through Photoshop or another photo editing program.
  - Print copies of the screenshot on 11"x17" paper. A black & white copy or a color copy will both suffice.

For each individual or group of students:

- 11" x 17" copy of Google map of school grounds
- Copies of the following handouts, which can be found at https://www.natureworkseverywhere.org/resources/design-and-build-rain-garden/
  - Part 2 Activity A - Rain Garden Site Inventory Checklist
  - Part 2 Activity B - Calculate Catchment Area Runoff and Determine Rain Garden Size
  - Part 2 Activity C - Draft the Base Map and Garden Layout
  - (Optional) Part 2 Calculate Slope handout

- 11"x17" blank paper
- Architectural scale
- T-square
- Drafting triangles
- Drafting dots or drafting tape (masking tape will suffice)
- Circle template
- Colored pens and pencils
- Digital camera
- Calculator
- Clipboard
- Tape measure
- Measuring wheel (this can be shared if you don't have one for each student or group)
- Notebook

Part 3

For teachers:

- Access to computer, Internet, computer, speakers, projector
- **Rain Garden Design Examples** PowerPoint https://www.natureworkseverywhere.org/resources/design-and-build-rain-garden/

For each individual or group of students:

- Copy of **Part 3 Rain Garden Design Guidelines** handout https://www.natureworkseverywhere.org/resources/design-and-build-rain-garden/
- Access to computer with internet
- Poster-sized paper
- Base map with garden layout
- T-square

- Architectural scale
- Drafting triangles
- Drafting dots or drafting tape
- Circle template
- Tracing paper
- Colored pencils
- Wood or metal stakes
- Flagging tape

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Part 4

- Final garden design layout and planting plan
- Wood or metal stakes
- Flagging tape
- Measuring wheel
- Tape measures
- Spray paint
- Pitch forks
- Shovels
- Trowels
- Hand cart(s) and/or wagon(s)
- Wheelbarrow(s)
- Shoes and clothes that can get dirty
- Mulch, soil, plants, hardscaping materials, etc.

Standards:

Next Generation Science Standards:

Disciplinary Core Ideas:
- LS2.A Interdependent Relationships in Ecosystems
- LS2.B Cycle of Matter and Energy Transfer in Ecosystems
- LS2.C Ecosystem Dynamics, Functioning, and Resilience
- ESS3.A Natural Resources
- ESS3.B Natural Hazards
- ESS3.C Human impacts on Earth Systems
- ETS1.A Defining and Delimiting Engineering Problems
- ETS1.B Developing Possible Solutions
- ETS1.C Optimizing the Design Solutions

Crosscutting Concepts:
- Cause and Effect
- Stability and Change
- Systems and Models

Science and Engineering Practices:
- Asking Questions/Defining Problems
- Constructing Explanations
- Arguing from Evidence
- Communicating information

Performance Expectations High School
- HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
- HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

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- HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Common Core English and Language Arts Standards for Science and Technical Subjects for Grades 9/10 and 11/12

Grades 9/10
- CCSS.ELA-LITERACY.RST.9-10.3
  Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- CCSS.ELA-LITERACY.RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

Grades 11/12
- CCSS.ELA-LITERACY.RST.9-10.7
  Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- CCSS.ELA-LITERACY.RST.11-12.3
  Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Vocabulary:

- **Ecosystem Services:** the benefits that nature provides and on which humans depend for clean water, fertile soils, food, fuel, storm protection, minerals and flood control.
- **Green Infrastructure:** 1) The systems that exist in nature that "manage" natural processes (such as the way in which natural areas absorb and filter water) and 2) The human management of natural resources that works with and mimics natural processes or systems.
- **Groundwater:** water located beneath Earth's surface.
- **Impervious:** a surface such as rock or pavement that water cannot penetrate.
- **Infiltrate:** for water to move or be filtered into soil.
- **Pervious:** a porous surface such as mulch or soil through which water can flow.
- **Rain garden:** a garden that collects, manages, and filters runoff in a shallow, depression before it reaches natural bodies of water.
- **Runoff:** water that falls as rain and washes across urban surfaces like streets and rooftops. It often picks up pollutants along the way.
- **Stormwater:** precipitation that can cause flooding and/or high levels of runoff.
- **Sustainability:** Sustainability in an urban environment means to produce and maintain conditions where humans and nature can exist in productive harmony.
- **Swale:** a wide, shallow, manmade ditch meant to replace traditional gutters and curbs in parking lots and streets.