PROJECT-BASED LEARNING:  
DESIGN AND BUILD A RAIN GARDEN  
Part 2: Site Inventory and Basemap Creation

**Purpose and Overview:**  
In this lesson, students conduct a site inventory about the area selected for the rain garden, including existing structures and natural features, and measure the area of the impervious surface (the source of runoff) to determine the size of the garden. They record the information on a Google map to create a hand-drawn base map of the site. This lesson prepares students to create the final rain garden design and planting plan for the rain garden in Part 3.

**Time:** Four 45-minute sessions or more

**Objectives:**

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

**BEFORE YOU BEGIN:**  
**UTILITIES AND SLOPE**

**Utilities**  
Note that you will need to have utilities identified before the specific rain garden location is determined. Call your local utility locating service and ask them to visit the site and mark-out underground utility locations with spray paint in the field. In most states, this free service can be contacted by dialing 811 and describing your project to the operator. The 811 Service sometimes cannot mark utilities on a private site and you may need to call and hire a private utility locating service to mark your site.

**Slope**  
If your selected location is on a slope of more than 10%, we recommend you consult an expert, such as a landscape architect or engineer.

To calculate slope yourself or engage students in the task, see the handout **Calculating Slope** ([https://www.natureworkseverywhere.org/resources/design-and-build-rain-garden/](https://www.natureworkseverywhere.org/resources/design-and-build-rain-garden/)).
BEFORE YOU BEGIN: SOIL TYPE AND DRAINAGE

You will need to understand the type of soil and rate of soil infiltration where you want to site your rain garden. We have laid out a process for both below, although you may want to consult an expert.

Testing for soil type
For an overview of soil science, see the Nature Works Everywhere video How Dirt Works.

Collect enough soil from just below the surface to fit in the palm of your hand. Add and mix in a small amount of water to make the soil pliable but not enough to turn it into mud.

Form the soil into a ball.
• If the soil will not hold shape as a ball, it is sandy;
• If the soil forms a tight ball and does not easily break apart, it is clayey;
• If the soil forms a ball but falls apart easily, it is silty.

A soil test yields silty (left) and clayey (right) soils. Image credit: Devan King/TNC

A good rule of thumb is the more sandy a soil, the faster water will percolate through it because there are a lot of small spaces or microscopic pores for the water to move between the grains of sand. The more clay there is in a soil, the less water will infiltrate because the clay particles are the smallest and are tightly bound together, inhibiting the movement of water.

Your local extension agency is a good source of information about soil amendment. See https://nifa.usda.gov/land-grant-colleges-and-universities-partner-website-directory?state=All&type=Extension for a national list of Extensions.

Calculating infiltration rate
In the general area you have decided to locate the rain garden:
• Dig a hole about 10 inches deep and 6 inches wide.
• Fill the hole with water. Leave the water to soak into the whole to saturate the surrounding soil.
• Fill the hole again and mark the top of the water, e.g., by pushing a stick or other market horizontally into the side of the whole.
• After 1 hour, measure the depth of the water and record how much it has dropped from the marker. This is your infiltration rate: the amount the water drops/hour. To confirm the rate, repeat measurements every hour for a day. The rate of infiltration should remain about the same.
• If the rate of infiltration is ½ in or more/hour, you can amend the soil as needed for planting;
• If the rate of infiltration is ¼ in or less/hour, you may need to further amend the soil. Your local extension agency is a good source of information about soil amendment. See https://nifa.usda.gov/land-grant-colleges-and-universities-partner-website-directory?state=All&type=Extension for a national list of Extensions.
Materials:

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
**Suggested Flow:**

**Day One: Planning for the Site Inventory**

**Engage**

1. Ask students to think about their relationship with nature. Where do they interact with natural environments? What role does nature play in their lives? Ask students to sketch a map, showing where and how they interact with nature. The map can be geographic or conceptual and does not need to be intricate or well-drawn; the purpose is for students to identify their relationship with nature for the group discussion to follow.

2. Elicit student responses. Move the discussion toward school grounds. Did they include any part of school grounds on their maps? How do they interact with nature at school? How do they think other students spend time on school grounds?

3. Ask students to revisit their maps and, if they have not already included it, add the school grounds. As a class, discuss whether there are any commonalities or patterns to how they interact with nature on school grounds. How might a rain garden support and enhance people’s connection to the school and nature?

**Explore**

1. Before beginning the Site Inventory, show students slides 1-8 of the [Rain Garden Design Process](#) PowerPoint presentation found in the teacher materials section of the website page. These slides provide an overview of the process the students will engage in for the remainder of the lesson.

2. Distribute copies of the Google map and **Activity A - Rain Garden Site Inventory Checklist**. Let students know they will use the Google map in the field to guide and record information about the selected location for the rain garden. The inventory will ensure that all the important areas have been measured and that other key considerations, such as where the runoff will come from, the location of trees and other fixed items, and the amount of sun the site receives, are taken into account when they design the garden.

![A map created from a satellite image of a site. Image credit: Apiary Studio](#)
Back in the classroom, students will place tracing paper on the Google map to create movable prototypes for the shape and size of the rain garden in order to choose their desired location. They will then use the Google map and measurements to draft a base map for use in creating the final garden design and planting plan.

3. As a class, review what students understand about rain gardens and generate a list of considerations for siting a rain garden based on their current understanding, including their own relationship with nature and use of school grounds. Review their responses against the Activity A - Rain Garden Site Inventory Checklist that may be specific to your school (e.g., specific requests made by stakeholders, school history, et al.).

4. Let students know they will need to record the information legibly on their printed Google maps as well as in their notebooks if they run out of space.

5. Plan to have a select group of students, or one student from each group, take site photographs to record the look, feel and important elements of the site to refer to when back in the classroom. This is particularly important if the site is located some distance from your classroom.

**Day Two: In the Field!**

**Explore**

1. Briefly review the Site Inventory handout and make sure students understand the day’s work.

2. Assign a group of/student(s) to 1 or more tasks on the Activity A - Rain Garden Site Inventory Checklist handout.

3. Have students bring the Google maps, checklists, clipboards, notebooks, pens, and measuring equipment outside.

4. Inventory the site!

5. Have students record the key information from their task to share with classmates, for example, using Padlet (https://padlet.com) or another collaborative software. Or create a master inventory list on Google Docs or similar sharing site for each group to add their information. Provide each student/group access to this master list. Students will need this information when they create their base map in the next step.
Day Three: Calculate Catchment Area Runoff and Garden Size

1. After students have inventoried the site, the next step is to calculate the runoff that will enter their proposed rain garden location (the stormwater capture volume). This will provide the information needed to appropriately size the rain garden.

   Use the Activity B - Calculate Catchment Area Runoff and Determine Rain Garden Size handout to work through the steps as a class or distribute the handout and have students work on it in groups or on their own. Slides 9-15 of the Rain Garden Design Process PowerPoint presentation include images to illustrate the process. Whether or not you work as a class, it can be helpful to review the steps and calculations together.

   Before you begin, discuss the proposed location as a class and determine whether you will use Process 1 or Process 2 to calculate the catchment area runoff (see handout). Process 1 is used for sites that can be easily measured and broken down into regular polygons for which it is easy to calculate area. Process 2 is used for large and irregularly shaped sites, where using field measurements to determine catchment area may be difficult.

   Note that these directions assume the rain garden will need to handle a maximum rainfall of 1 inch at any given time. This is an industry standard, known as a “design storm.” It reflects the typical large rainstorm most regions receive, as well as an understanding that a rain garden is not meant to manage high volumes of rainfall.

2. Next, students will calculate the size of the rain garden by following the guidance on the Activity B handout. In this step, the volume of rainwater captured, is converted into the required rain garden area.

   Note that in addition to overall size, the garden will store rainwater at a ponding depth of 6 inches – this is the maximum amount of water stored above the soil surface. Students will use this ponding depth throughout their calculations. Six inches allows a relatively small garden footprint and does not present a drowning hazard. Some municipalities require or recommend other ponding depths. If you adjust the ponding depth, make sure the change is reflected in the calculations.
Day Four: Draft the Base Map and Garden Layout

Explore

1. In this step, students bring together all the information they have identified and calculated about the rain garden site to produce a base map and garden layout. Students use an architectural scale to accurately represent the location, size, and features of the garden site on the map. This process mimics the way in which landscape architects design rain and other gardens and is detailed below. They will use this map to create the final garden design in Part 3.

An example of a drafted base map. Image credit: Apiary Studio

If you do not want to have students go through the process of drafting a base map to scale, they can more informally sketch the garden features using tracing paper on top of the Google map, but you will want to have an expert draft a final garden plan.

You may also want to provide students with plastic clay to build 3-D models of their proposed layout. They can construct their design ideas out of clay, rearranging them on top of either their base map or the Google map until they achieve their desired layout.

2. Make sure students/groups have access to the Site Inventory (Activity A) and garden size (Activity B) information from days 1-3 and distribute the Activity C - Draft the Base Map and Garden Layout handout.

Student using clay to practice the rain garden layout. In this image, the student is placing clay on a model of the site, but the clay can more simply be positioned on top of a base or Google map.
Image credit: Britta Culbertson/TNC
3. To organize this process, you may want to have individual students produce a base map and garden layout, then have students in each group review one another’s maps and work to create a group map. Alternatively, you can have each group work on a single base map and garden design together. The class can then review all the maps in a gallery walk and select one to use for the final design.

4. Review the various tools students have available for drafting. See https://www.papergardenworkshop.com/blog/2016/7/16/tools-to-draw-your-landscape-plans for descriptions of drafting tools.

FINDING THE RIGHT SCALE

Work as a class to determine the appropriate scale to use. The best scales for a site plan are \( \frac{1}{8} \) inch, \( \frac{1}{4} \) inch or \( \frac{1}{2} \) inch, listed in order of increasing scale. The larger the scale, the bigger and clearer the information will appear, but the scale needs to be able to incorporate the entire site on the size paper you’re using. Explain to students that the measurements on the scale are helpful because they save you from having to do the translation math repeatedly. Review the example with the class.

**Example:** When you look at your architectural scale, you will see the numbered markings that correspond to each listed scale size and these represent numbers of feet in the field.

![Example of architectural scale](image)

Using a \( \frac{1}{4} \) inch scale means that when you translate your field measurements onto paper, every foot in the field equals \( \frac{1}{4} \) inch on paper (\( \frac{1}{4}" = 1'\-0" \)). So, if a building is 40 feet wide by 40 feet long in the field, the measurement on paper will be 10 inches by 10 inches (\( \frac{1}{4} \) of 40 = 10).

Using a \( \frac{1}{8} \) inch scale, every foot in the field equals \( \frac{1}{8} \) inch on paper (\( \frac{1}{8}" = 1'\-0" \)). So, the same measurement in the field, 40 feet x 40 feet, will be 5 inches by 5 inches (\( \frac{1}{8} \) of 40 = 5).

- For a video on using an architectural scale see https://www.youtube.com/watch?v=rytS0e0_qw (through 1:31)
- For a lesson on using an architectural scale, with practice problems, see https://www.usfa.fema.gov/downloads/pdf/nfa/engineer-architect-scales.pdf

Step 1: Determine the longest distance across the site based on your field measurements.

Step 2: Use your architectural scale to determine the largest possible scale that will fit on your base map paper.

Note the selected scale on the board or other prominent location.

Write the scale that the class has agreed to use: _______________ = 1'-0"
5. Encourage students to create the most accurate drawing they can, but reassure them that they do not need to be 100% accurate in order to provide an adequate foundation from which to develop a garden design. Explain to students that several issues affect the layout of the garden: Where the water is coming from, the size and shape of the area you have available to store the water and, finally, where you want the water to end up. There is no exact formula or template for designing a rain garden layout because each site is different and no two rain gardens are the same.

6. Once students calculate the required rain garden area, let them know they can make one large rain garden or they can create multiple, smaller rain gardens if they add up to the same area they calculated. In the image to the right, the orange area represents the catchment area (a roof) that will feed the rain garden and the blue squares represent possible rain garden areas.

7. The images below show possible rain garden layouts for a project site. Note that the rain garden areas are roughly the same, but the number of gardens varies. Encourage students to use organic shapes (rounded edges, etc.) after they find the area they should be working with. Share the following images with students if they need support in understanding the variety of options for rain garden layouts. However, it is recommended that you let students work through the design process on their own without influencing their creativity too much!