Fifth Grade Engineering Curriculum
"How Can Storm Water Be Cleaned Before it Enters the Brook?"

2016 Massachusetts Science, Technology, and Engineering Standards that are addressed:

5-ESS3-1. Obtain and combine information about ways communities reduce the impact on the Earth's resources and environment by changing an agricultural, industrial, or community practice or process. [Clarification Statement: Examples of changed practices or processes include treating sewage, reducing the amounts of materials used, capturing polluting emissions from factories or power plants, and preventing runoff from agricultural activities.] [Assessment Boundary: Assessment does not include social science aspects of practices such as regulation or policy.]

3-5-ETS1-1. Define a simple design problem that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost that a potential solution must meet.*

3-5-ETS1-2. Generate several possible solutions to a design problem. Compare each solution based on how well each is likely to meet the criteria and constraints of the design problem.*

There are two 45-minute lessons, presented back-to-back in a 90-minute time frame. One lesson is run by the town engineers and water department, and the other is run by school personnel at Westford's Living Lab. Two classes can be accommodated during one 90-minute time frame, with each starting at a different location and switching midway.

Town Engineer/Water Department Lesson

Outdoor Lesson:
Location: Outdoors at storm drain on school property
Time frame: 10 minutes (plus 5 minutes travel time)
Preparation: The storm drain has been opened so students can look at the catch basin. Saw horses have been placed around the opening for safety.

Visiting Engineer (Paul Starrat, Town Engineer; or Jeremy Downs, Assistant Town Engineer) explains the storm drain and rain garden, and how each functions to clean storm water before it enters the nearby brook.

Indoor Lesson:
Location: Classroom
Time frame: 30 minutes (2 15-minute mini-lessons)
Preparation: The town engineers provide geological maps of the town and a model of a catch basin. The Westford Water Department provides a 3-D plastic model of a landscape with model hay bales and a silt fence. A plastic spray bottle is used to simulate rain, and food coloring is used to simulate pollution. As a class arrives in the classroom, students are split into two groups; one with the town engineer, one with the Water Department.

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Visiting Engineers/Scientists: Paul Starratt/Jeremy Downs and Mark Warren, Environmental Compliance Manager, Westford Water Department. The engineer's presentation uses the map to point out the topography and location of storm drains relative to natural bodies of water. The model catch basin displays elements that could not be viewed through the hole outside. The water department's presentation is on the effect of farm runoff on public water systems, and ways the water department acts to mitigate problems. Each presentation is 15 minutes long, and then groups switch locations within the classroom.

Living Lab Lesson (adapted from STEM in Action: Rainwater Runoff Design Challenge by ETA Hand2Mind.)

Location: Classroom
Time frame: 45 minutes
Preparation:

Setup:

Three tables, two group setups at each table (total six groups), no chairs. Pull the tables away from the wall so a team can group around the area.

Computer, projector, PowerPoint presentation

For each group:

- Four pre-loaded tubes and catch basins, labeled with the type of soil
    - 1 mesh square plus 20 cc gravel
    - 1 mesh square plus 20 cc sand
    - 1 mesh square plus 20 cc clay
    - 1 mesh square plus 20 cc Sorbtive Media
- One graduated cylinder, marked at the 20 ml line
- 1 small measuring cup of sediment water (100 ml)
- 1 craft stick for stirring
- 1 laminated color card with color scale for each test
- 1 worksheet per group
- pencils

In separate design kit set aside for each group:
1 empty tube with mesh square
10cc of Sorbtive Media
1 small cup each of clay, sand, gravel
1 graduated cylinder of sediment water (40 ml)

Additional setup:
1 five-gallon bucket of rinse-water
paper towels (lots!)

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empty 2-liter bottles for mixing sediment water

To prepare sediment water:
    1 liter water plus 2 spoonfuls (10 cc) of silt

Tip: Sorbtive Media and gravel can be reused. Do not use wet sand or Sorbtive Media.

Procedure:

Students sit on the rug facing the presenter.

Ask students: "Can you tell me the difference between a scientist and an engineer?" (Scientists learn about the world around them. Engineers use science, math, and creativity to solve problems.) Using the poster, explain the Engineering Design Process using the problem of storm runoff at the Day School, which reiterates the presentation from the engineers outside. Point out that there were two solutions to the problem, one man-made (the storm drain), and one natural (the rain garden.) Explain that today we are going to be environmental engineers. Environmental engineers help make air, water, and soil cleaner and safer.

The problem we are solving today is "How can we keep pollutants out of Reed Brook?" One way is to design and build a rain garden (show the slide of the picture of a rain garden.)
What kind of things can pollute water? Sometimes water is polluted by fertilizer, which causes too many weeds to grow in brooks, rivers, and lakes. Sometimes water is polluted by soil, called sediment, which causes the water in brooks, rivers, and lakes to be muddy and cloudy. (Show slide of lake with algal bloom, and river carrying too much sediment.)

Let's model the process that the Westford town engineers went through when they designed the rain garden at the Day School. We'll begin by testing four kinds of soil to see how well they filter out fertilizer and sediment. Then you can use what you learn to design the layers of soil in your rain garden.

First, let's look at five kinds of soil. Soil is made up of tiny particles of rock mixed with decaying plant and animal matter. (Show a sample of silt, sand, clay, gravel, and Sorbtive Media on a paper plate. Silt, sand, clay, and gravel occur in nature. Sorbtive Media is a soil substitute that can reduce pollution. However, it is expensive.) What kind of soil do you think has the smallest spaces between particles? (clay, then silt, then sand, then gravel.) Do you think small spaces between particles would be a good or bad at filtering pollution out of water?

Next, we will test each kind of soil to see how well it removes sediment. Each group of four will have a tube of soil and a catch basin for each kind of soil. That means

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that each of you will do your own test to see how well it removes sediment. Shake the bottle of sediment water, then pour 20 ml into your graduated cylinder. Then pour it into your tube. Be sure your tube is aimed at the catch basin below. Wait until all of the water has gone through the soil. Compare the color to the scale on the card at your station. Record your results on your group's chart. Also record how quickly the water went through your filter (fast, medium, slow.) Why is speed important?

Finally, your group will take what you learned from these two tests to create a soil combination that will effectively filter fertilizer and sediment. You will use one tube for your group. Because Sorbtive Media is expensive, you may only use 10cc of it in your syringe. Which soils will you choose? In what order will you layer them? The total volume of subsoil in your rain garden must be 60 cc. To make accurate measurements, use quantities that are easy to measure, such as 5 cc, 10 cc, or 20 cc. Design your rain garden subsoil using the diagram on the back of your chart. Then, using the materials in the buckets, create your subsoil model according to your diagram. Then, test your model using 40 ml of polluted water. Be sure your tube is aimed at the catch basin below. Wait until all of the water has gone through the soil. Compare the color to the scales on the card at your station. Record your results on your group's chart.

Wrap-up: Students should bring their worksheet, clipboard, and pencil and return to the rug. Ask the group the following questions: Was your subsoil model able to filter silt from the polluted water so that it was clear? What part of your model worked well? What part of your model did not work well? Which group's model was most successful? Why? Using the projector and document camera, show the diagrams and charts of successful designs. How can you weigh clarity versus speed? What would you change if you could make a new design?

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