Rainwater Runoff

Home Connection

Dear Family,
During the last few weeks, your student designed a rain garden—a kind of landscaping feature that prevents polluted rainwater runoff from flowing into rivers and lakes or the sea. The students acted just like engineers! They…

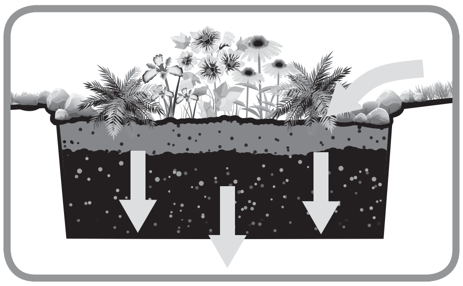
- identified and learned about a problem
- designed ways to solve the problem
- made and tested a model of their design
- revised their design to make it even better

In this challenge, students developed an understanding of how water is distributed on earth and how several kinds of pollution affect natural sources of fresh water. They learned how soil, plants, and landscaping can filter out pollutants and reduce the amount of pollution reaching waterways. They also learned about the engineering design process and practiced skills such as developing and using models, collecting and analyzing data, making claims based on evidence, and communicating technical information. In addition, they used mathematics skills to develop budgets for implementing their designs.

Let your child tell you what his or her team did in this engineering challenge. Ask your child these questions if he or she needs help.

- What was the problem you were solving?
- What were the criteria (goals) that your design had to meet?
- What constraints (limits) did you have to work within?
- What soil particles did you use to make your model?
- How did you measure the success of your model?
- How did you improve your design? What information did you learn that lead to that improvement?

On the back of this sheet, work with your child to extend his or her work in the challenge.



This STEM project has been developed in partnership with Texas A&M University.

Rainwater Runoff

Home Connection

About Rain Gardens

When rainwater runs off hard surfaces, it can also carry pollutants such as oil, grease, and salt. Landscape features such as rain gardens can trap this polluted water before it reaches public waterways. Rain gardens are shallow ditches designed to slow down flowing water and allow it to seep into the ground. The plants and soils in a rain garden filter nutrients and pollutants out of the water. Rain gardens also help increase the amount of groundwater.

Ask your child to describe how a rain garden works. If needed, ask your child these questions:

- How do people in cities and suburbs contribute to water pollution?
- How does a rain garden help keep rivers and lakes clean?
- What are the different parts of a rain garden?
- What kinds of materials make up soil?
- Which soil particles are best at filtering out sediments?
- Which are best at filtering out excess nutrients, such as phosphate?

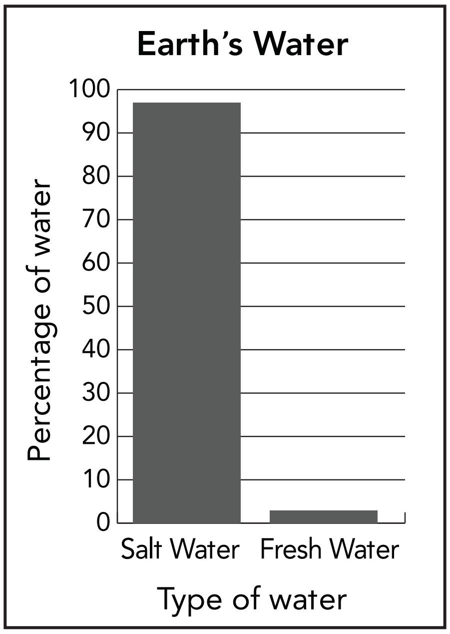
Try It!

Activity	Possible pollutants	Action to reduce pollution
Cleaning	Chemicals in paints, cleaning products	Store and dispose of materials according to the labels. Do not pour them into sinks, gutters, or storm drains.
Transportation (cars and trucks)	Oil, antifreeze, and fluids that leak onto pavement	Fix car leaks. Recycle oil from cars. Clean up oil spills on paved surfaces such as driveways.
Yard maintenance	Excess fertilizer, herbicides, pesticides	Keep these materials off paved surfaces; do not sweep or hose them into the street. Compost yard wastes.
Construction, landscaping	Erosion of exposed soil	Cover exposed surfaces with mulch. Seed bare areas with grasses or other plants.

This STEM project has been developed in partnership with Texas A&M University.

Where's the Water?

Name ____

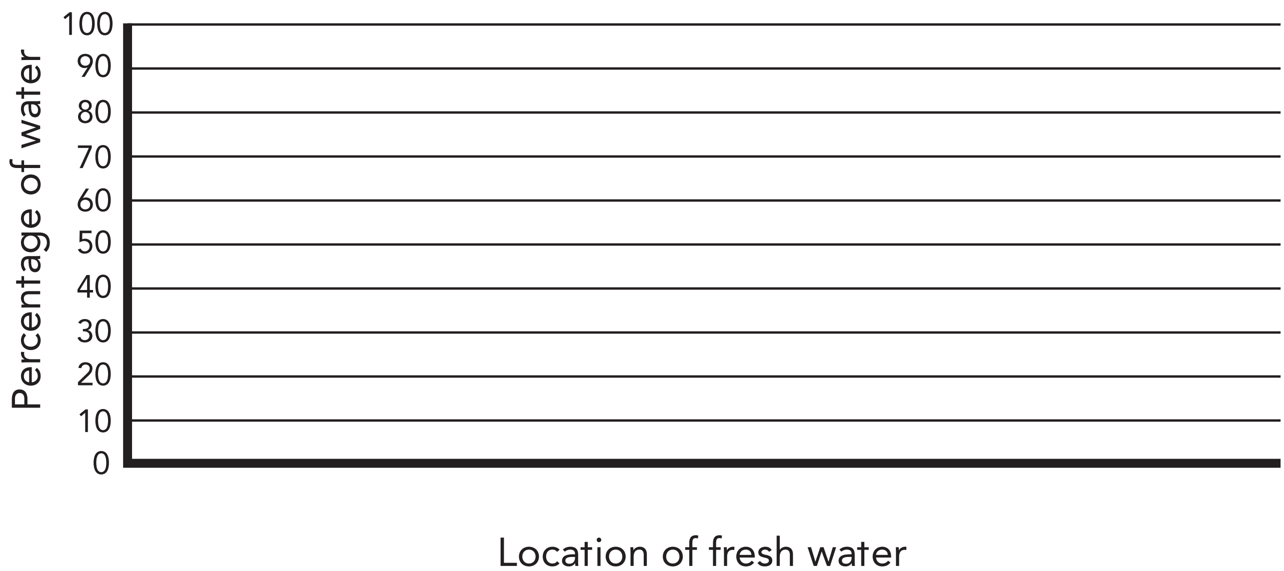


The bar graph on the right compares earth's salt water and fresh water. (Most salt water is in the ocean, but some lakes also have salt water.) The table below shows how earth's fresh water is distributed.

Earth's fresh water	
Frozen in ice caps and glaciers	69.6%
Groundwater	30.1%
Lakes, rivers, swamps	0.3%
Total	100%

1. Use the data in the table to make a bar graph that shows the location of fresh water. Label the bars and give the graph a title.

Title of graph: ______________________________



Analyze

1. Where is most of earth's water located?

____

2. Where is most of earth's fresh water found?

____

3. Why is it important to keep lakes and rivers clean?

____

How Does Pollution Move?

Name ____

Analyze what happened.

1. **Observe** Where did the water go when it was poured over the sand?

   ____

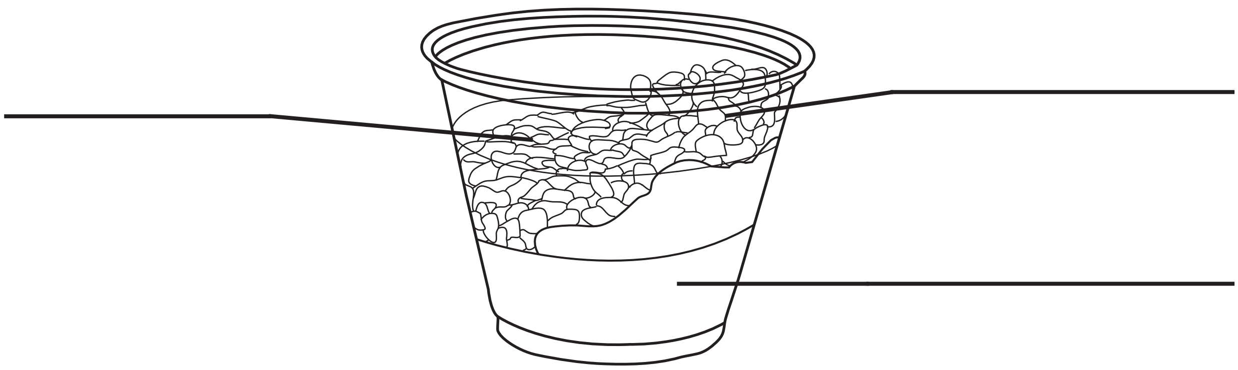
2. **Observe** Where did the water go when it was poured over the clay? ____________________

   ____

3. **Observe** Where did the water go when it was poured over the gravel? ____________________

   ____

4. **Make a model** The picture shows a model like yours. The layers of sand, clay, and gravel are similar to the layers of rock and other materials underground. Use the labels *hill, lake,* and *groundwater* to show what each part of the model represents.



5. **Observe** What happened to the food coloring over time?

   ____

6. **Compare** Circle the materials that water passed through.

   sand clay gravel

7. **Make a model** What does this model show about how polluted water can affect the groundwater and a lake?

   ____

8. **Draw conclusions** How can pollutants that are on the land affect the quality of water that is far away?

   ____

9. **Predict** What kinds of pollutants might move in this way?

   ____

Compare Soil Particles

Name ____

Observe Soil Properties

1. **Observe** Touch the soil particles. How does each feel? Use words such as lumpy, coarse, gritty, smooth, silky, sticky, or other words to describe what you feel. Record your observations in the chart.

2. **Observe** Use a hand lens to observe the samples. Use words such as coarse, fine-grained, smooth, or other words to describe the grain size. Record your observations in the chart.

3. **Test** Add a few drops of water to each sample. Roll each soil particle sample into a ball. Does the ball hold its shape?

Soil particle	Texture: How it feels	Texture: Grain size	Does it make a ball?
Clay			
Gravel			
Sand			
Silt			
Sorbtive Media			

Analyze

4. **Infer** Think about what you observed. Which soil particles do you think would mix with the water and cause it to look cloudy? ____

   Why? ____

5. **Predict** Which of the soil particles would allow water to flow through it most quickly? ____

   most slowly? ____

Which Soil Particles Remove Pollutants?

Name ____

Prepare Samples

1. Wet the mesh squares and use a craft stick to place one in the bottom of each of the four syringes. Place each syringe in a catch basin.

2. **Measure** Add 20 cc of gravel to a syringe, gently tapping it to settle the gravel. Label the catch basin “gravel.” Repeat this step for the sand, clay, and Sorbtive Media.

Test 1: Measure Phosphate Removal

1. **Predict** Which soil particle will most effectively remove phosphate from water? _________

2. **Measure** Use a graduated cylinder to slowly add 20 mL of fertilizer solution to each syringe.

3. **Measure** Start the timer when the fertilizer solution is added. (Each team member is responsible for the filtering time of one type of particle.)

4. Allow the liquid to filter through and drain into the catch basin. When there’s no more dripping, stop the timer.

5. **Record** the time it takes for the liquid to filter through each type of particle. Write your results in the chart below.

6. **Measure** Follow the Phosphate Test Procedure to measure the amount of phosphate in each catch basin.

Phosphate Test Procedure
1. Put 5 mL of filtered water from each catch basin into its own graduated tube. Label the tube. Rinse the dropper after collecting each sample.
2. Add one TesTab to each graduated tube. Make sure the cap is tight and gently shake until the TesTab is completely dissolved. Wait 5 minutes.
3. Place each graduated tube next to the phosphate color scale on page 10 of your book to determine the ppm.
4. Record the results in the table below.

7. **Record** what you find in the chart.

Material	Time to flow into the catch basin	Amount of phosphate in filtered water (ppm)
Gravel		
Sand		
Clay		
Sorbtive Media		

8. Follow your teacher’s directions to dispose of the water in the catch basins. Keep the catch basins and syringes with soil particles. You will use them in Test 2.

Which Soil Particles Remove Pollutants?

(continued)

Name ____

Test 2: Measure Sediment Removal

1. **Predict** Which soil particle will most effectively remove silt from water?____________________
2. Use the syringes, soil particles, and catch basins from Test 1. Assign each team member to measure and record the filtering time of one soil particle.
3. **Measure** Stir the silty water and then measure 20 mL in the graduated cylinder. Pour the silty water on top of the gravel. Begin timing.
4. **Observe** Stir the filtered water in the catch basin. Is the water clear? Compare the color of the water with the silt filtering color scale on page 12 of your book.
5. **Record** Write your results in the table.
6. Repeat Steps 3–5 for each soil particle.

Material	Time to flow into the catch basin	Color of filtered water
Gravel		
Sand		
Clay		
Sorbtive Media		

Test 3: Compare Layers and Mixtures

1. Empty, clean, and reuse the syringes and catch basins for sand and clay.
2. Wet mesh squares and place one in the bottom of each clean syringe.
3. Spoon 10 cc of clay in one syringe. Spoon 10 cc of sand on top of the clay.
4. In the other syringe, mix together 10 cc of sand and 10 cc of clay.
5. Follow the steps in Test 2 to compare how the soil particles remove silt from the water.
6. Record your results in the chart below.

Material in cup	Time to flow into the catch basin	Color of filtered water
Layers of clay and sand		
Mixture of clay and sand		

Which Soil Particles Remove Pollutants?

(continued)

Name ____

Analyze

Use the results from Test 1, Test 2, and Test 3 to answer these questions.

1. **Compare** Which soil particle allowed water to flow through it most quickly?________________

   Most slowly? ____

2. **Compare** Which soil particle removed the most phosphate? ______________________________

   The least phosphate?____

   Did your results match your prediction? ____

3. **Compare** Which soil particle removed the most silt? _____________________________________

   The least silt? ____

   Did your results match your prediction? ____

4. **Compare** Which removed more silt from the water—layers of clay and sand or a mixture of

   clay and sand? ____

   Which let water filter through most quickly? _____________________________________

5. **Draw Conclusions** Review the results of all your tests. How is the speed of water flowing through a soil particle related to the amount of pollutant removed from the water? Describe the pattern shown by your tests.

   ____

   ____

   ____

Subsoil Design Plan

Name ______________________________________

Think about the soil particles you will use in your model.

1. Which soil particles are the most effective for removing phosphate? ______________________
2. Which soil particles are the most effective for removing silt? ___________________________
3. Which soil particles will help you meet the criteria for filtering time?

   ____

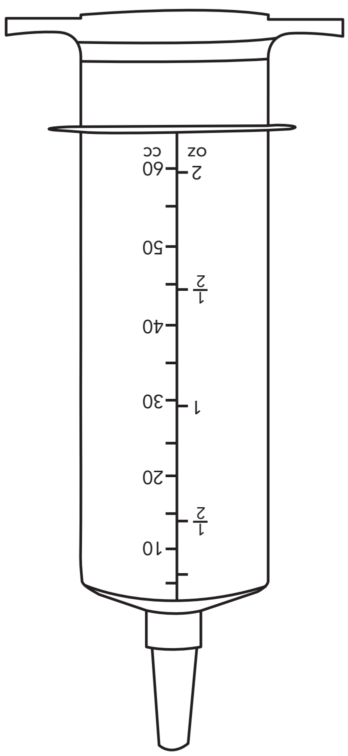
Complete this chart for your plan. You do not need to use all four soil particles.

Soil particle	Volume	Reason selected
Total volume	60 cc	

4. Will you mix the soil particles together or place them in layers? ________________________

Hint: Use geotextile circles to keep layers from mixing together. Also place a mesh square on the bottom of the syringe to make sure that the soil particles do not fall through the hole.

5. Draw your plan below. Label all the materials, including the mesh square and any layers of geotextile.



Cost of Subsoil

Name ____

Follow these steps to calculate the volume of subsoil for a full-size rain garden.

1. **Calculate** What is the area of the parking lot (see diagram on page 15)?

   20 meters (Width of parking lot) × 35 meters (Length of parking lot) = __________ square meters (Area of parking lot)

2. **Calculate** The rain garden will be smaller than the parking lot. City Council guidelines for the soil type in your area say to multiply the parking lot's area by a size factor of 0.2.

   __________ square meters (Area of parking lot) × 0.2 (Size factor for soil type) = __________ square meters (Area of rain garden)

3. **Calculate** What is the volume of soil needed for the rain garden? Round to the nearest whole number.
   Hint: Be sure to convert the depth in centimeters to meters first.

   __________ square meters (Area of rain garden) × __________ meters (Depth of rain garden) = __________ cubic meters (Volume of subsoil for rain garden)

4. **Calculate** Determine what fraction of your subsoil model is made of each soil particle. Write the fractions in the table below.

5. **Calculate** Use the fractions to determine how many cubic meters of each soil particle is needed for the full-size rain garden. Then calculate the volume of each soil particle needed for the full-size rain garden.

6. Multiply the cubic meters by the price per cubic meter for each soil particle.

Soil particle	Fraction of total subsoil in model	Volume of subsoil (m^3)	Price per cubic meter	Total cost of soil particle
Clay			\$21.00	
Sand			\$19.00	
Gravel			\$33.00	
Sorbtive Media			\$143.00	
Totals for subsoil model	1	(From #3 above)		

Remember the constraint: The total cost of your subsoil may be no more than \$1,400.

7. **Analyze** If the plan does not meet the cost constraint, work with your team to improve your design until it does. Then complete a new **Subsoil Design Plan** page.

Test the Subsoil Model

Name ____

Follow these steps to test your model.

1. Stir the "polluted" water. There should be no silt on the bottom of the cup.
2. Use the graduated cylinder to measure 40 mL of "polluted" water.
3. Slowly pour the "polluted" water onto your subsoil model with catch basin. Wait a few moments if water reaches the top. Then continue.
4. Start the timer when all of the water is in the syringe.
5. **Measure** Observe until all of the water has filtered through the subsoil model (no dripping). Record the amount of time it took for the water to filter through in the table below.
6. Stir the filtered water in the catch basin.
7. **Compare** the color of the filtered water in the catch basin to the silt filtering color scale on page 12 of your book. Record what you find in the table at the bottom of the page.
8. **Measure** Use the Phosphate Test Procedure to measure the amount of phosphate in the filtered water. Then record what you find in the table at the bottom of the page.

Phosphate Test Procedure
1. Use a dropper to put 5 mL of filtered water into a graduated tube. 2. Add one TesTab to the graduated tube. Make sure the cap is tight and gently shake until the TesTab is completely dissolved. Wait 5 minutes. 3. Place the graduated tube next to the phosphate color scale on page 10 of your book to determine the ppm.

Time for "polluted" water to filter through the syringe	
Color of filtered water (from silt filtering color scale)	
Amount of phosphate in filtered water (ppm)	

9. **Record** any additional observations here:

____

____

____

Reflect On It

Name ____

Use your model and test results to finish these sentences.

Model Plan

1. Our subsoil model contained these soil particles:

Material	Volume	Reason selected
Total volume	60 cc	

2. Our subsoil model met these criteria (check those that apply):

   ☐ Filter silt from the "polluted" water so the filtered water is "clear."

   ☐ Remove phosphate from the "polluted" water so the filtered water contains no more than 1 ppm of phosphate.

3. One part of our model that worked well was ____

   because ____

4. One part of our model that did not work well was ____

   because ____

Compare Models

5. We compared our model to Group _________________. I observed that ___________________

   ____

6. The most successful model was made by Group _________________. It was successful because

   ____.

7. If we changed ____, our design might be more

   successful because ____