Activities to Accompany

Streams in the City

For Grades 6-8

Objectives:
These exercises are designed to guide a student to an understanding of how rainfall and storm events result in runoff over the surface of the earth. Runoff is influenced by the nature of the surface of the earth. Streamflow is particularly influenced by urbanization—the paving over of permeable surfaces with impermeable ones. In light of this, students are encouraged to think about design elements that incorporate more permeable surfaces into their own environments, including their school parking lots and neighborhoods.

Exercise:
Exercise I. How Does Rain Become Runoff?
Exercise II. From Rainfall to Runoff: Making the Connection
Exercise III. Calculating Runoff from a Rainstorm
Exercise IV. Designing a Better Neighborhood

Time Required:
Individual exercises are designed to be approximately 45 minutes to an hour long. These exercises are also ordered progressively: each builds on concepts introduced in the previous.

Curricular standards and Skills:

<u>Science:</u>
- water cycle
- accuracy
- cause and effect

<u>Math:</u>
- volume calculations

<u>Social Studies:</u>
- differences in urban and rural areas
- challenges of urbanization

Vocabulary:
evaporation
impervious
infiltration
interception
permeable
puddling
runoff
sediment
topography
transpiration
urbanization

Web sites:
None

Exercise I.
How Does Rain Become Runoff?

Know the language...

Read the article Streams in the City to find the meanings of the following words:

Infiltration–

Evaporation–

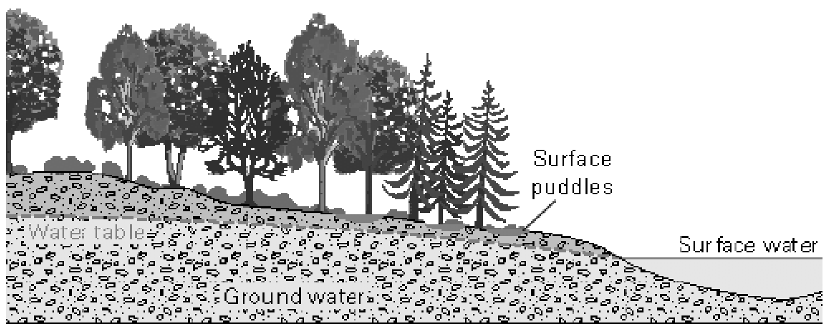
Interception–

Puddling–

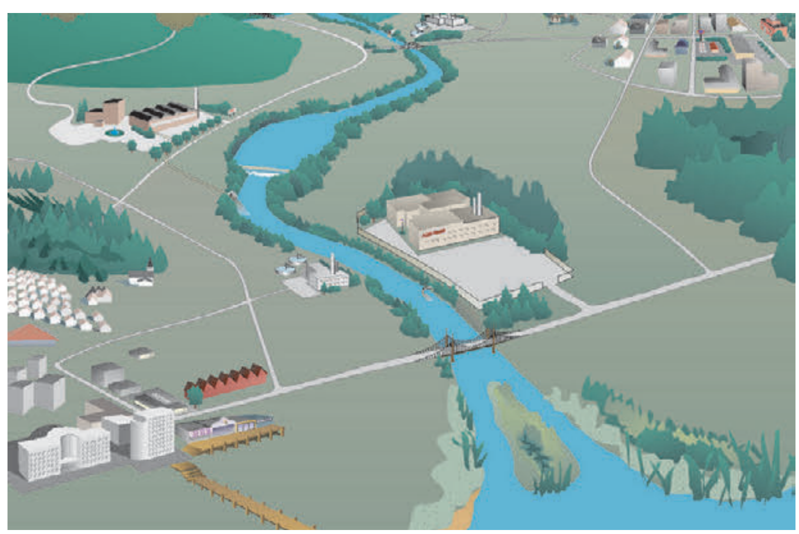
Runoff–

In the pictures below, label the different things that can happen to rainwater after a storm. Use the words in the box to the left.

A Rural Example



An Urban Example



Questions About the Rural and Urban Examples

Name the places where rainwater was intercepted.

Where could the water have ponded on the surface?

Where could the rainwater have infiltrated?

The Day After the Storm

Water does not just stay where it lands. The day after the storm, what has probably happened to the water from the following places?

Tree and shrub leaves–

Surface ponds–

Surface puddles–

A grassy field–

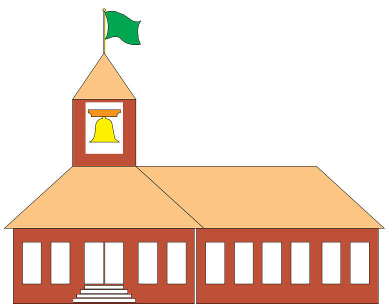
The forest floor–

Infiltration and the Weather

Researchers have concluded that urbanization might contribute to longer unusually dry periods and droughts. Using what you have learned about rainwater runoff, explain how urbanization and droughts might be related.

The Benefits of Infiltration

Infiltration is very important to the water cycle. It recharges groundwater, providing people with source water for wells, and reduces the amount of water streams need to hold during rain events.



Infiltration and Your School

Think about your school property. On a separate sheet of paper, draw a picture of your school grounds. Label permeable areas, impervious areas, and places where the water is likely to be intercepted or to pond on the surface.

List all the areas where permeable surfaces would allow infiltration.

List all the surfaces that would allow little or no infiltration.

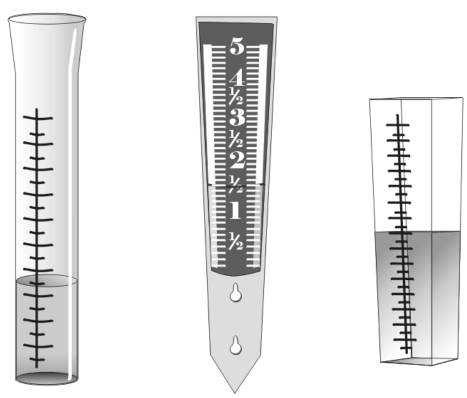
Compare the amount of area that would allow infiltration with the areas that would allow little or no infiltration. Are the amounts about equal? If so, your schoolyard is about 50 percent permeable. If there are more areas that would allow infiltration, your schoolyard is more than 50 percent permeable. If there are fewer areas that would allow infiltration, it is less than 50 percent permeable. What is the percent permeability of your schoolyard?

Improving the Accuracy of Your Estimate

Take measurements of each of the different areas you included in the sketch of your schoolyard. Redraw the picture of your schoolyard to include the measurements you made. Using graph paper might help you create an accurate drawing. Is your estimate of the percent permeability of your schoolyard different when based on your new drawing?

Exercise II.
From Rainfall to Runoff
Making the Connection

Make Your Own Rain Gauge



Before you get started with the activities in this exercise, it would be helpful to make a rain gauge for your home or classroom.

To do this, take a container that will hold water (an old plastic milk container with the top cut off works well) and mark off inches on the side of the container. Make sure that you mark off the inches correctly to get the most accurate measurement of the number of inches of rainfall. Then attach the gauge in a secure and undisturbed place to measure how much it rains during a particular storm.

Check the rain gauge after several storm events to see how much rain fell during each storm.

Determining Rainfall from a Rain Gauge
Rain gauges are used to measure the amount of rainfall from a storm event. The readout on a rain gauge tells how many inches of rain fell during the rainstorm.

However, runoff depends on more than just the number of inches of rain that fell. The volume of runoff in a watershed also depends on the area of the watershed. To calculate the volume of runoff, you multiply the amount of rain that fell by the area of the watershed.

The Volume of Your Rain Gauge
You can calculate the volume of your rain gauge by measuring its diameter and using a couple of simple geometric formulas. Calculate the volume of your rain gauge in the space provided below. Check the accuracy of your rain gauge with a graduated cylinder.

Geometric Formulas for Area

rectangle
length x width = area

circle
π x radius^2 = area

From Weatherperson to Watershed

Above, you learned how to find the volume of your rain gauge, but how do you find the volume of rain that fell in your watershed in a rainstorm? You start with the weather report. The weatherperson reports rainfall in inches. This number represents the amount of rain collected by the rain gauge at a monitoring station. If you multiply this number by the base surface area of your watershed, you can find the volume of rain released by the rainstorm into your watershed.

Every Place on Earth Is in a Watershed

You can figure out the boundaries of your watershed by connecting the highest points in the topography around a stream outlet. This will form a basin, and all the rain that falls anywhere within the basin will flow to the stream outlet. Calculate the area of that basin, and you will have the base surface area over which rain is falling.

What is the volume of rain expected in a 120-acre watershed in southeastern Pennsylvania if it rains 3.5 inches in a 24-hour period? Give your answer in acre-inches.

What is the volume of rain expected in a 375-acre watershed in central South Dakota if it rains 1.5 inches in a 24-hour period?

Partnering with Your TV News Team

Many local TV channels have special programs that involve schools in their weather forecasting segments. Write to the producer of your local TV channel news (look for the address in the Yellow Pages), or investigate on the Internet whether your local TV channel has a program that involves schools tracking local weather conditions. Ask about making your school a weather center, and mention that you are interested in presenting the weather.

Exercise III. Calculating Runoff from a Rainstorm

Finding the Fate of a Raindrop
As you discovered in Exercise I, not all rainfall becomes runoff. Draw a diagram below and label all the different things that could happen to a raindrop as it falls to the earth.

What About Volume?
You live in a 120-acre watershed in southeastern Pennsylvania. In a rainfall event, it is common for 3.5 inches of rain to fall in a 24-hour period. Approximately one-third of the water that falls is intercepted by leaves or collects in surface puddles and ponds and evaporates.

1. Calculate the total volume of rain that would fall in the watershed.

Rainfall volume

The volume of rainfall in a watershed is calculated in acre-inches and is found by the equation:

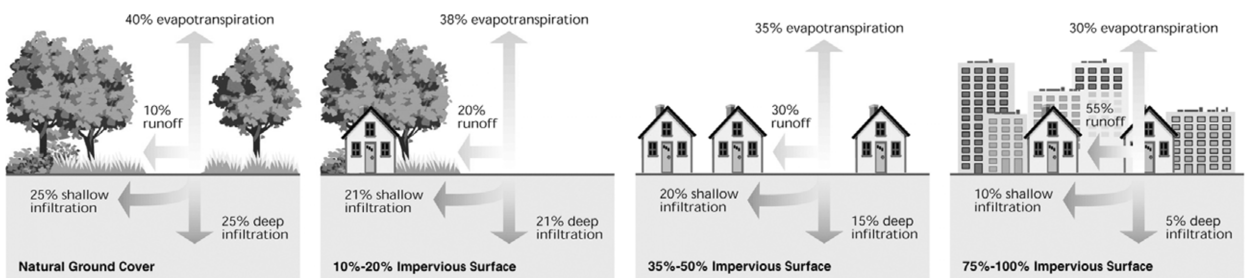
rainfall volume = acres in watershed x inches of rain

2. How much water from the rainfall event remains after the water in leaves, puddles, and ponds evaporates?

3. Assume the watershed is 40 percent permeable. That means that 40 percent of the rain that reaches the ground (after evaporation) will soak into the ground. What is the volume of rain that permeates the ground?

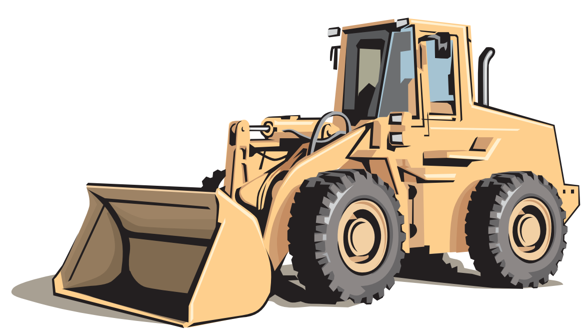
4. What is the volume of runoff? (Hint: If you add this answer to the answer in number 3, you will get the answer to number 2.)

Incoming Urbanization



5. New construction is taking place in your watershed, and half of all the permeable space is now paved over with concrete, an impervious surface. Since your watershed now has only half the permeable land it once had, how much runoff would there be now? (Hint: The original amount of water that reaches the ground after evaporation doesn't change.)

6. How much more runoff is there after construction?



Exercise IV.
Designing a Better Neighborhood

Whenever an area is developed, grassy meadows and fields are replaced by houses, shopping malls, and commercial and industrial buildings. The fields and meadows where rainwater could infiltrate are replaced by impervious buildings and streets.

Whenever natural areas are replaced by impervious surfaces, the rain that falls in an average rainstorm is forced to behave differently.

- More rainfall can become runoff because less infiltration and interception takes place. In urban areas, a small storm event can result in a large amount of runoff because there are not many places that catch rainwater and allow it to soak into the ground.
- The larger amount of runoff is forced to fit into existing stream channels. For this to happen, the runoff water must travel faster in the stream channel. The larger amount of water and the faster speed at which the water travels increase the risk of flooding downstream.
- The faster-moving water in the streams erodes stream channels and carries sediment downstream.
- The runoff picks up pollutants from streets and sidewalks. Because there is less vegetated surface in an urban setting, the pollution is less likely to be filtered out of the water before it is carried downstream to other waterbodies.

Helping Water Behave Naturally

Many new urbanization projects, such as housing developments or shopping malls, have storage ponds built in a corner, as part of the landscaping, or behind the main construction. The ponds store the water that runs off parking lots and paved areas. These ponds benefit the area by reducing the amount of water that streams need to carry after a rain event and allowing water to infiltrate into the ground and recharge groundwater supplies.

This storage pond is being constructed behind a suburban development. Such ponds have become part of the scenery of many newly suburbanizing areas. Can you locate any storage ponds in or near where you live?

Searching for Drainage Systems
Pick a local shopping mall, grocery store, or professional park. Find out what drainage systems are used at the edge of the parking lots.

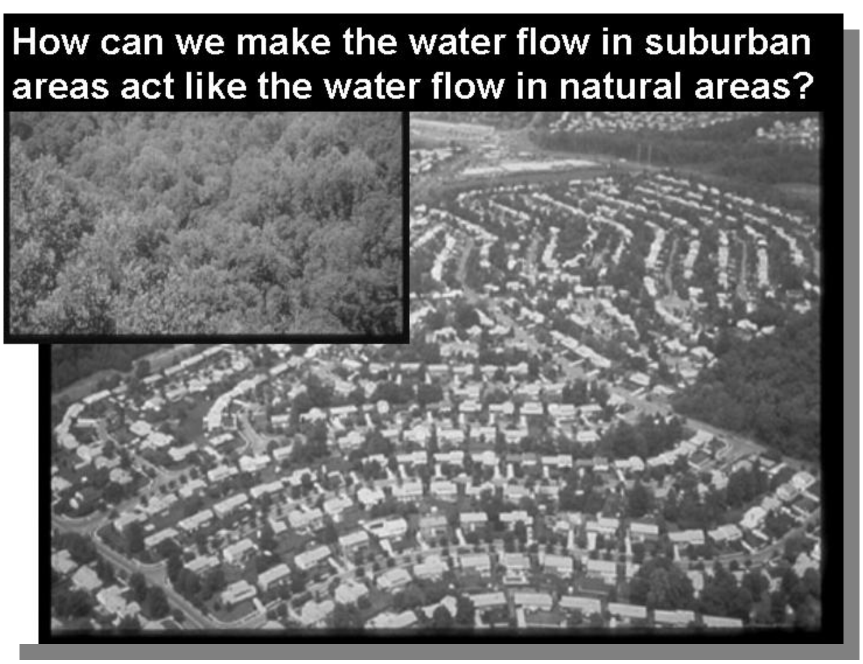
Location:____

Type of system:____

Where does the water go? How is it collected? Are there pipes that convey the water down into a storage pond?

What happens to the water in the storage pond if it rains excessively? Is there a spillway for the storage basin?

If all the water from the parking lot runs off into the storage basin, and only a small amount of the water is being infiltrated into the ground, what would happen to the groundwater in the area?



Low-Impact Development
Engineers are trying to come up with ways to make the water flow in urban and suburban areas act like the water flow in natural areas. To do this, they have come up with practices that help improve the interception and infiltration of water. *Low-impact development* is the phrase used to describe urban and suburban development that uses these practices.

Examples of Low-Impact Development Practices

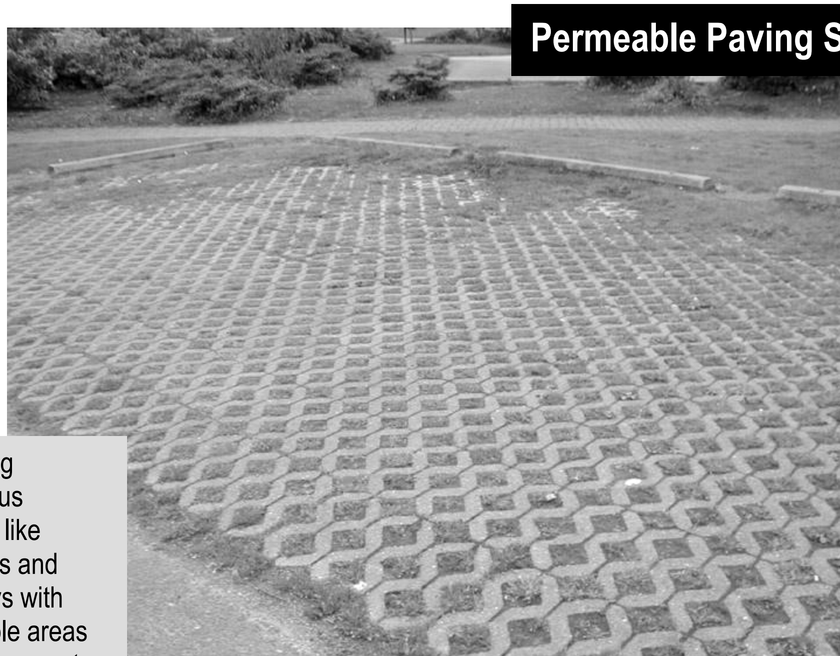
Bioretention Islands in Parking Lots

A bioretention filter consists of a grass buffer strip, a sand bed, a ponding area, an organic layer or mulch layer, planting soil, and plants such as leafy shrubs. These filters look like beds of shrubbery and can be placed as islands on parking lots. They use soils and woody and leafy plants to remove pollutants from storm water runoff. Runoff from large paved surfaces like parking lots passes first over or through a sand bed, which slows the speed of the flowing water. It also distributes the water evenly along the length of the ponding area. The ponding area is made of soil, but it slopes into the center. Water gradually infiltrates the bioretention area, evaporates, and is taken up by the plants.

Grass-Lined Channels

Natural drainage courses can be maintained by using grass-lined channels as much as possible instead of concrete canals, pipes, and gutters.

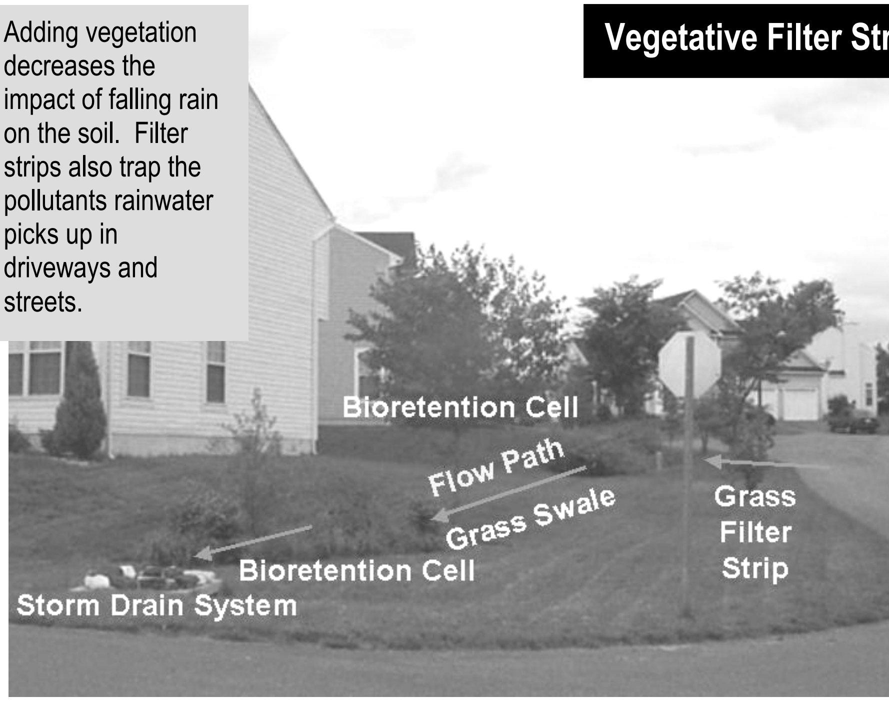
Permeable Paving Systems



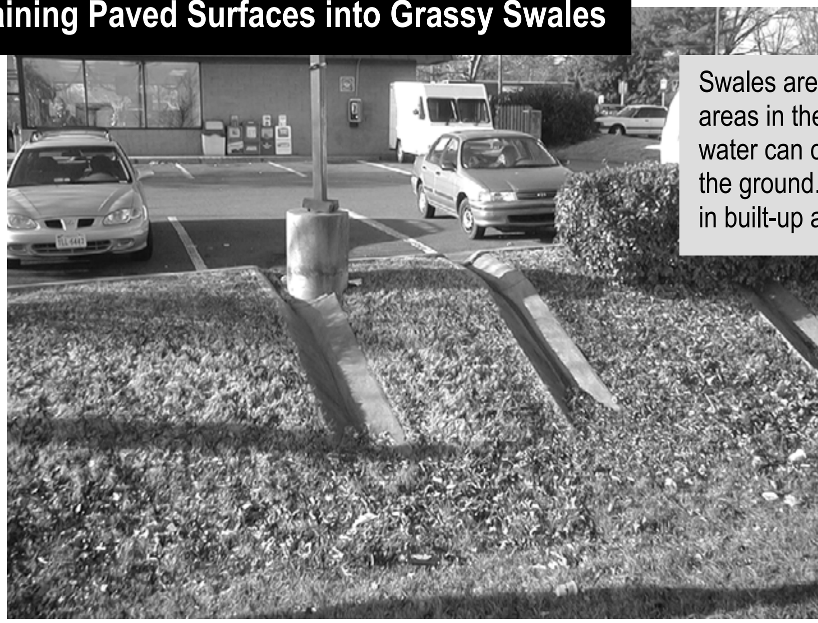
Replacing impervious surfaces like sidewalks and driveways with permeable areas allows more water to infiltrate into the ground.

Vegetative Filter Strips

Adding vegetation decreases the impact of falling rain on the soil. Filter strips also trap the pollutants rainwater picks up in driveways and streets.

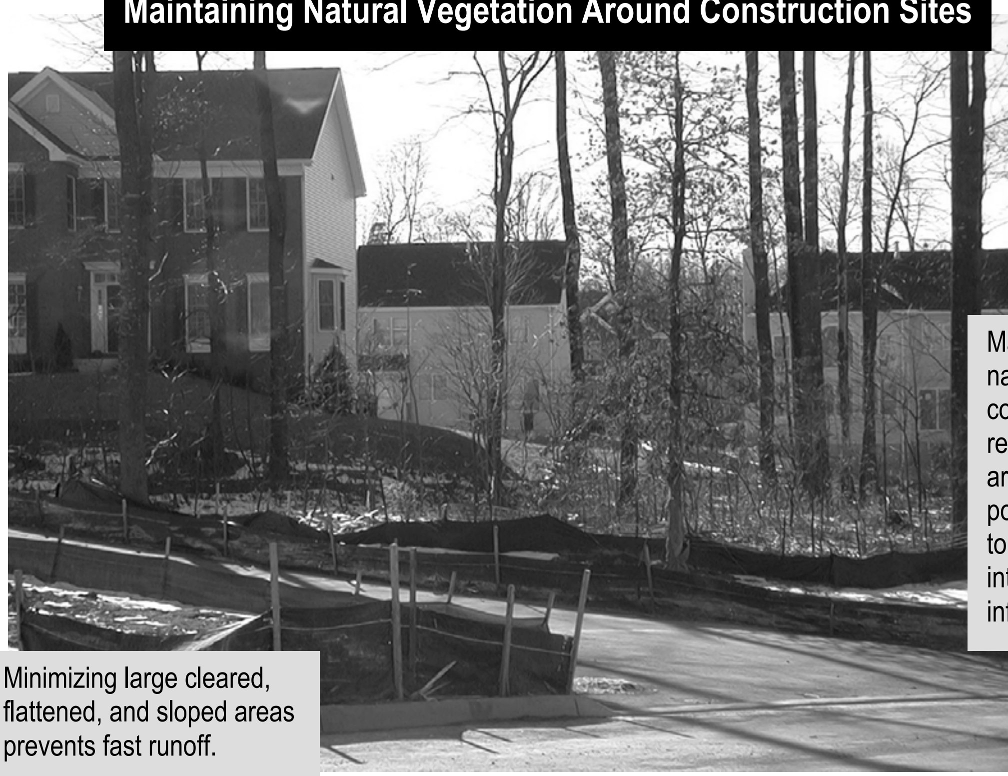


Draining Paved Surfaces into Grassy Swales



Swales are low-lying grassy areas in the landscape where water can collect and soak into the ground. They can be used in built-up areas.

Maintaining Natural Vegetation Around Construction Sites



Maintaining natural tree cover and revegetating areas wherever possible helps to increase interception and infiltration.

Minimizing large cleared, flattened, and sloped areas prevents fast runoff.

Redesign Your Schoolyard for Low-Impact Development

1. Draw a sketch of your school and its property from a bird's eye view (top down). In the sketch, label the areas that are impervious, that are somewhat impervious, and that allow water infiltration. (If you completed the *Infiltration at Your School* section of Exercise I, you will already have a sketch of your school.)

2. In a second sketch, use some low-impact development practices to redesign your schoolyard. Label all the low-impact development practices you used to help infiltrate runoff from impervious surfaces around your school.

Redesign Your Neighborhood for Low-Impact Development
Look at the areas around streets in your neighborhood. Are there are strips of open spaces or areas that are not directly used as roadway, bike path, or walking pavement/trail? What is the land cover of these surfaces?

1. Draw a cross section of your street here. Try to give a to-scale depiction of the diameter of cul-de-sacs, the width of your street, and the width of sidewalks and parking areas.

2. Now draw a cross section of your street in which you have implemented some of the practices that will increase the infiltration, detention, and retention of water that comes down in a storm. Also, think about ways to delay the conveyance time (the time it takes for rainwater to enter streams) and try to incorporate those.