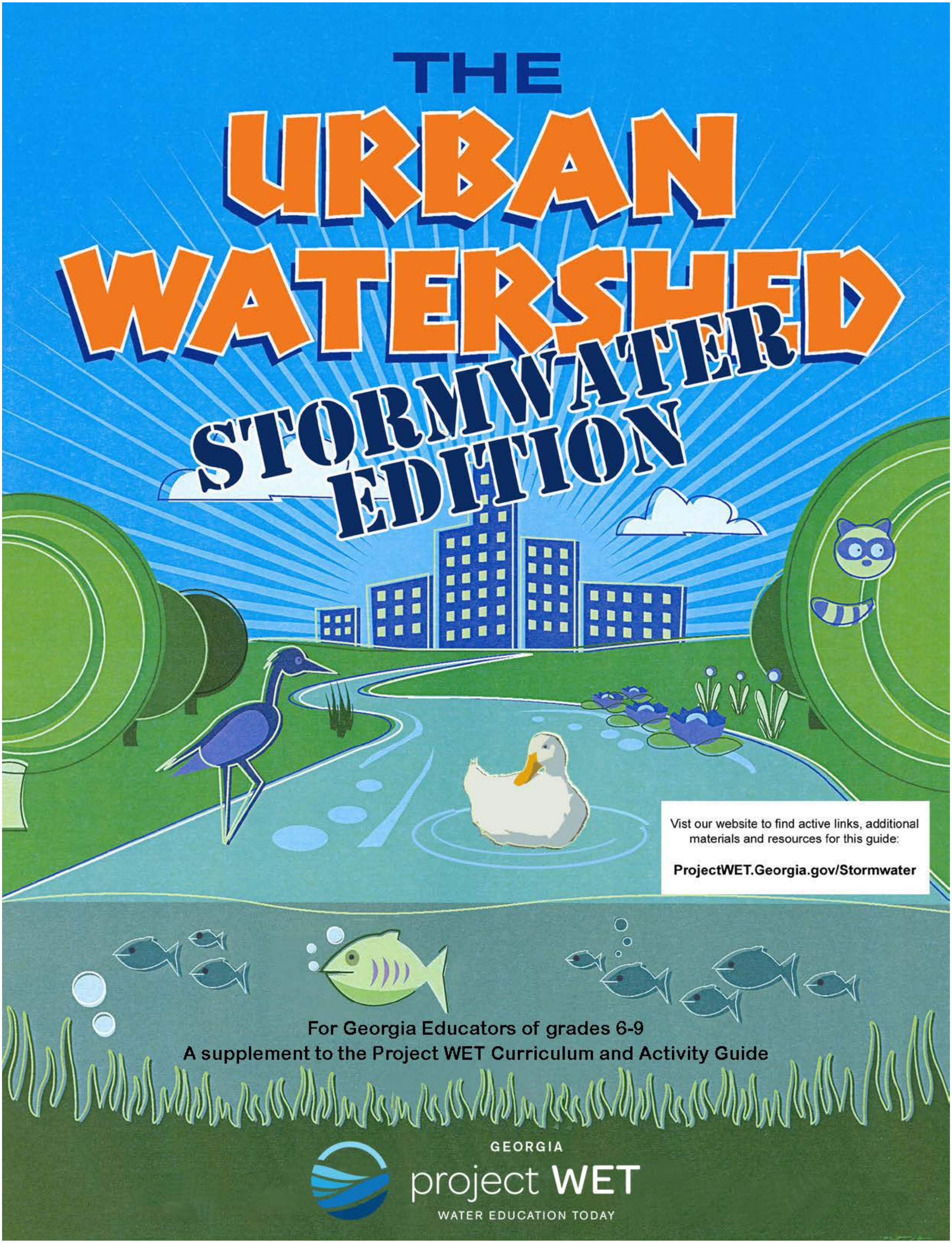
THE URBAN WATERSHED
STORMWATER EDITION



Vist our website to find active links, additional materials and resources for this guide:

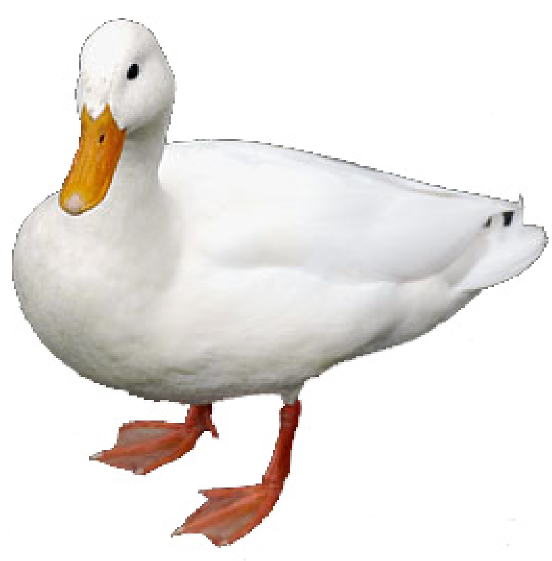
ProjectWET.Georgia.gov/Stormwater

For Georgia Educators of grades 6-9
A supplement to the Project WET Curriculum and Activity Guide

GEORGIA
project WET
WATER EDUCATION TODAY

The Urban Watershed – Stormwater Edition– Educator's Guide

Grades 6-9



THE URBAN WATERSHED – STORMWATER
AN EDUCATOR'S GUIDE FOR GRADES 6-9

It is becoming increasingly clear that our young learners urgently need to connect to their environment through information and action. With ***The Urban Watershed Educator's Guide*** they have the opportunity to study the effects development has on the Earth and the impact those effects have on our water resources. A greater understanding of the Urban Watershed and Stormwater will give all of us an insight into the reasons behind the protection and the need for stewardship. When we invest in education it is with the hope that an informed citizenry will work toward the best possible water quality for everyone living in cities and all of those downstream, now and far into the future.

Are you ready to find out the mystery of . . .

- **where water comes from and where it goes when you turn on a faucet?**
- **how wastewater is cleaned before returning to the river?**
- **where rainwater flowing into a storm drain goes and what it takes with it?**

The Urban Watershed engages students and educators through hands-on, thought-provoking activities about our urban water resources. The activities within this guide are intended to be used alongside the *Project WET Curriculum and Activity Guide*, a K-12th grade interdisciplinary water education curriculum available to educators through training workshops. Many of the suggested Project WET activities have been extended to meet Stormwater objectives. These are available on the **Project WET Portal** at **portal.projectwet.org** under the activity's name.

When you see this symbol, connections to STEM principles have been made. Additional resources such as web links, videos, and webcasts on the topic may also be found on page 145 of this guide.

Introducing **Aqua Duck**, your guide to Urban Watershed history and STEM education connections!

The Urban Watershed Guide was first developed in 2005 as a curricular accompaniment to the changes Atlanta needed to make in their water and wastewater systems. This edition focuses on Stormwater within the Urban Watershed and applies to all urban communities throughout Georgia.

Ancient Water Systems- http://www.pbs.org/wgbh/nova/ancient/roman-aqueducts.html

ACKNOWLEDGEMENTS

Georgia Project WET staff owes a debt of gratitude to those experts who helped us in the writing, development, and field testing of *The Urban Watershed – Stormwater Guide*. Thanks so much!

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Special thanks to the Project WET Products & Publications WETteam and the USA WET Network of Coordinators who worked to develop Stormwater extensions for many of the Project WET Activities located on the Portal. Portal.projectwet.org

Visit ProjectWET.Georgia.gov/Stormwater to access active links, additional material and resources for this Guide.

This Guide is dedicated to Petey Giroux (1945-2008), the first Georgia Project WET coordinator and driving force behind the original Urban Watershed Guide. It was in Petey's creative and fertile mind that this curriculum was born. She saw a need for greater understanding of the inner workings of our water and wastewater systems because she believed that it would lead all of us to better protect and preserve our natural resources, especially precious water.

For more information on Georgia Project WET and the outreach programs for the Georgia Environmental Protection Division, Watershed Protection Branch, visit **ProjectWET.Georgia.gov.** The preparation of this guide was financed in part through a grant from the U.S. Environmental Protection Agency under provisions of Section 319(h) of the Federal Clean Water Act of 1987, as amended.

TABLE OF CONTENTS

The Activities within this guide are intended to be used as a supplement to the Project WET Curriculum and Activity Guide in your study of the Urban Watershed and Stormwater. Some of the suggested activities from the Project WET guide have been extended to meet Stormwater objectives and are available on the Project WET Portal at **Portal.projectwet.org** under each activity's name. Others listed may be used as written.

Suggested Project WET Activity Connections

Natural and Urban Watersheds:

- Blue Planet / A Drop in the Bucket
- Incredible Journey
- Seeing Watersheds
- Rainy Day Hike
- Reaching Your Limits
- Urban Waters

project WET

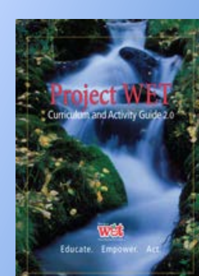
Stormwater:

- A-Maze-ing Water
- Blue River
- Common Water
- Color Me a Watershed
- Macroinvertebrate Mayhem
- Nature Rules
- Storm Water
- Super Sleuths

Taking Action:

- My Water Address, Take Action!
- There is No Away

Stormwater extensions are available for some activities on Portal.projectwet.org



Georgia education standards correlations for activities are available on ProjectWET.Georgia.gov/Stormwater

EVERYONE LIVES IN A WATERSHED

It doesn't matter how far you live from a stream, river, or lake, you live in a watershed. A watershed is an area of land from which all water drains, running downhill, to a shared destination - a river, pond, stream, lake, or estuary.

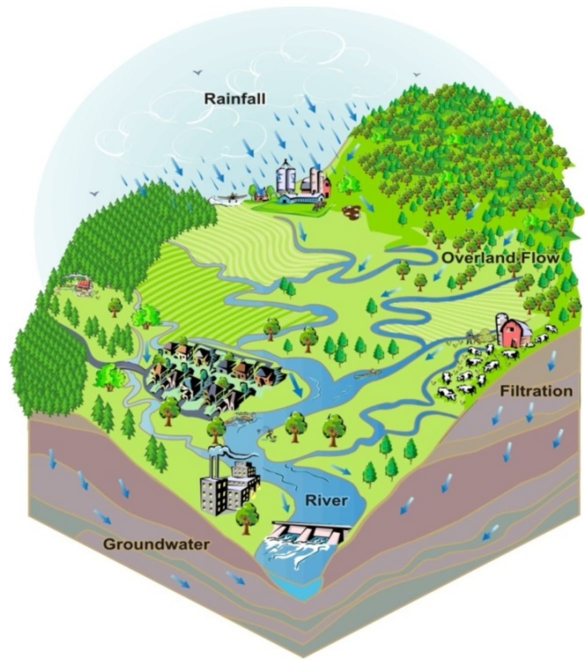
A watershed has three main functions.

1. It **captures** water that falls from the atmosphere, soaking into the ground where it falls.

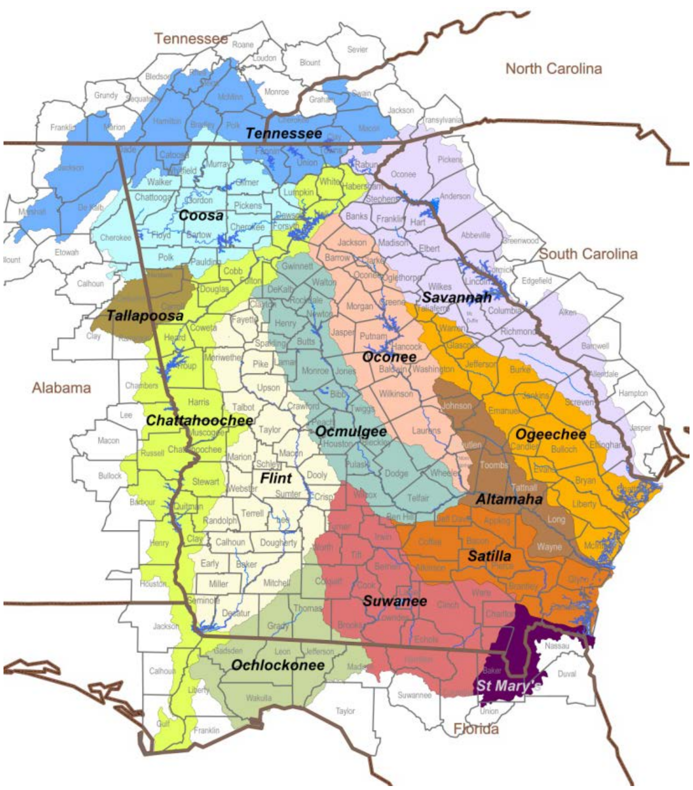
2. It **stores** rainwater once it filters through the soil, percolating deeper into aquifers and springs.

3. It **moves** water through the soil to seeps and springs and is ultimately released into streams, rivers, and the ocean.

Eventually, the moisture will return to the atmosphere by way of **evaporation** and **transpiration** and the hydrologic cycle (also known as the *Water Cycle*) is ready to go again.



WATERSHEDS OF GEORGIA



Our state's history and growth was directly determined by a system of rivers and streams that empty into a series of coastal estuaries. We have 14 major river basins fed by 52 watersheds, with more than 70,150 miles of streambed. Nearly half of the river systems eventually drain into one of the estuaries found along Georgia's 100 miles of coast. The others flow into Florida and Alabama and finally into the Gulf of Mexico.

Water links our five distinct regions from the mountains to the ocean (Cumberland Plateau, Blue Ridge, Ridge and Valley, Piedmont, and Coastal Plain). And there are vast quantities of water hidden beneath the ground in a system of intermeshed aquifers.

Rivers and bays were the first highways; every great city in the state grew where it did because of water. Water nurtured wildlife, the land, and the people. However, across Georgia, people also drained the bottomlands to harvest the trees and farm the rich soil. While this has produced timber and agricultural products, it has also destroyed many naturally occurring benefits of these riparian areas, including the cycling of nutrients, flood buffering, and natural treatment of agricultural, industrial, and human wastes. It also has eliminated important wildlife habitat.

Georgia has no naturally occurring large lakes but we do have the highest density of dams in the Southeast. The 1998 Environmental Protection Agency's National Dam Inventory showed 4,435 reservoirs and impoundments in the state created by dams 6 feet or higher. These reservoirs eliminate a percentage of natural flowing stream habitats essential to many of our endemic or native fishes by creating lake-type habitat that is a warmer environment.

Surface water accounts for about 80 percent of the state's water use. In north Georgia, groundwater is not as easily accessible as in the southern part of the state. For example, in and around metropolitan Atlanta, 85 percent of the water supply comes from the surface water sources of the Chattahoochee River, the Etowah River, Lake Lanier and Lake Allatoona. The Chattahoochee River alone provides more than half of Atlanta's water requirements.

Georgia Rivers: Chattahoochee River, Adopted from Teaching Conservation 2004 , Karen Garland , Part 4 of a 4 part series – Focus on the 14 Georgia river basins.

THE URBAN WATERSHED

Most of us live in cities -- almost 80% -- so an *Urban Watershed* is what most of us have to deal with. Of course wherever cities were built, there was once upon a time a natural watershed. Perhaps a river with tributaries flowed through the landscape now changed, redirected and concreted. As it flows through the city after a storm, water in narrowed, non-absorbent channels increases in speed leading to flooding and erosion. Heat and pollutants picked up as the water flows over roofs and roads, are carried with runoff into the river and can adversely affect fish, wildlife, plants, and even our drinking water supply.

STORMWATER

Stormwater starts out as rain or snow that encounters the city environment. In the Urban Watershed precipitation that does not soak into the ground becomes surface runoff when it flows across streets and rooftops. The runoff either flows directly into rivers or streams or is channeled into storm sewers, which eventually discharge to surface waters.

Stormwater is of concern for two main reasons: one is the increased volume of runoff water which leads to flooding and the other is the potential contaminants that the water carries across the city and into the rivers and streams.

Urban threats to water quality and habitat:

Point and Nonpoint Source Pollution

As the water flows through the urban environment some of the pollutants it gathers can be identified and the source found, such as a direct pipe into a stream. This is known as **Point Source Pollution**.

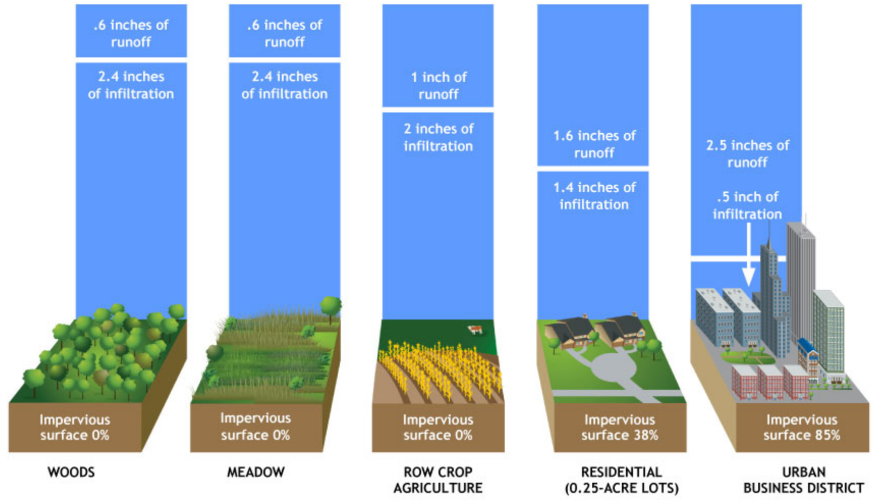
The majority of pollutants that enter our waters, however, come from unidentified sources. They could be something like fertilizers, detergents, construction run off, sediment, oil, grease, pet waste or pesticides but no one can tell exactly where they originate. This is called **Nonpoint Source Pollution**.

Building on the land

The soil does a remarkable job of filtering out contaminants. But once buildings and pavement are introduced, less water is able to penetrate the soil. When vegetation is cleared for construction, it decreases a watershed's capacity to capture moisture, increasing the amount that runs off. The loss of vegetation also destabilizes stream banks and reduces the shade produced by the canopy. Increased solar pollution raises stream water temperatures during the summer months, affecting habitat for wildlife and disrupting the ecosystem.

Impervious Surfaces

As a watershed area becomes more populated, natural surfaces that absorb water and recharge ground water supplies, are covered with hard, impervious surfaces (streets, sidewalks, rooftops, driveways, and parking lots). This reduces the amount of infiltration and increases the amount of runoff.



Climate Change

Yes, we must face it – the overwhelming consensus of researchers today is that global warming is real and is caused by human activity, primarily the burning of fossil fuels that pump carbon dioxide (CO_2), methane and other greenhouse gases into our thin ribbon of atmosphere. See the Third U.S. National Climate Assessment (NCA) unveiled in May 2014 http://nca2014.globalchange.gov/ for details.

The warming of our atmosphere, land and water is expected to have far-reaching, long-lasting and, in many cases, devastating consequences for planet Earth.

These effects are happening on the planet right now:

Increase in average temperatures

Extreme weather events

Shift in climate patterns

Decreased Snow and ice

Rising sea levels

Ocean acidification

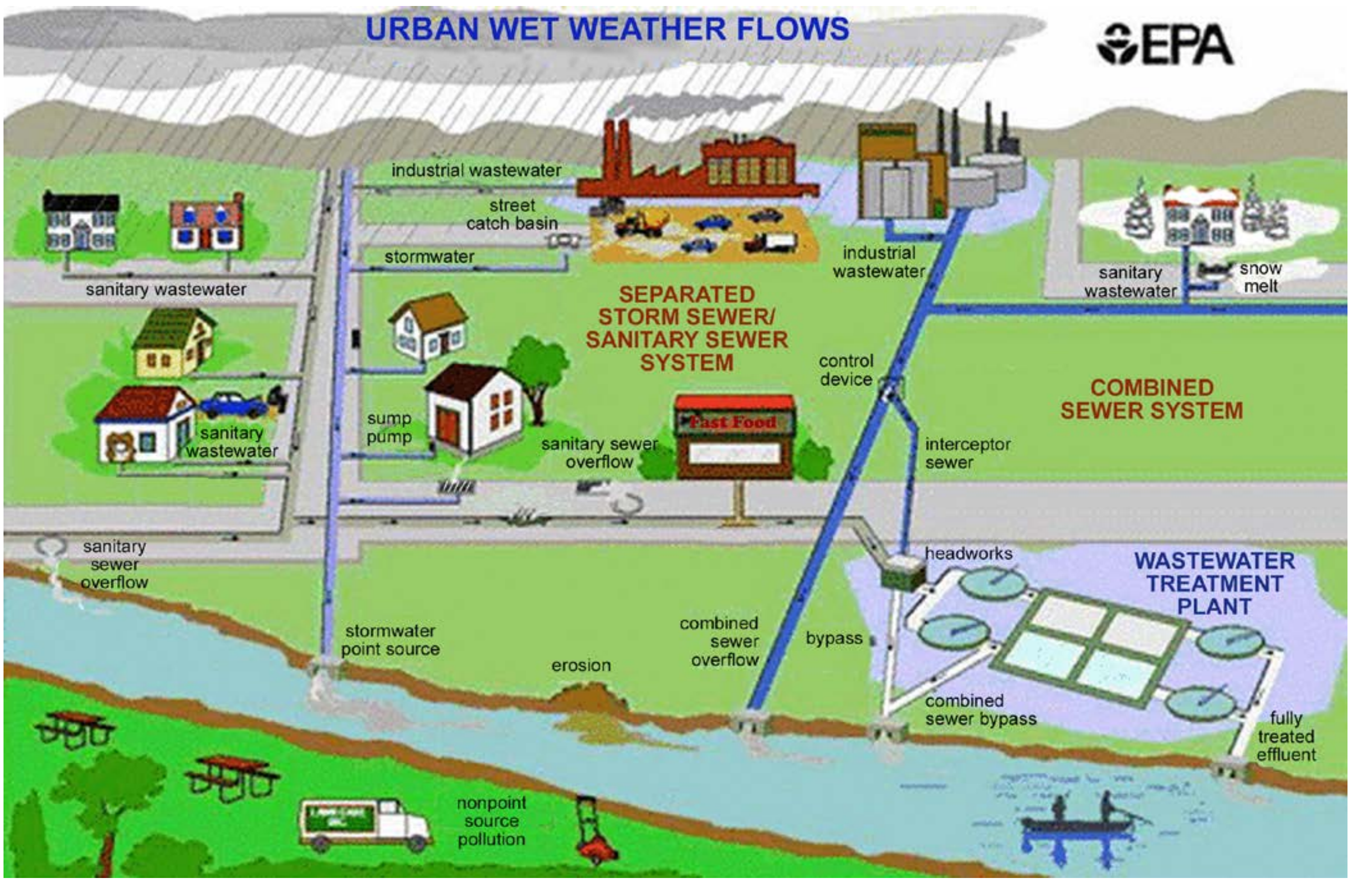
Plant and animal impacts

Social impacts

The southeastern United States is likely to experience these effects as the "redistribution of water" brings increased extreme weather events to this region in the coming years. Storm induced urban runoff carries pollutants from roadways, yards, parking lots, storage areas, and flows directly into streams via storm drains and ditches. Up to 90% of the atmospheric pollutants, deposited on impervious surfaces, are delivered to receiving streams. These too will enter waterways in increasing amounts.

WHERE DOES STORMWATER GO?

Cities want to move stormwater away from streets, homes, and businesses as quickly as possible. They do this through a series of drains and pipes, usually under the streets. Since storm sewer systems are generally hidden from our view, you may not know how it is handled in your area. This graphic from the US Environmental Protection Agency shows two common storm sewer systems. Your community probably has one of these or a combination of the two:



One system is called a **Separated Storm Sewer/Sanitary Sewer System** (see the left side of the EPA graphic). In this system, there are two sets of pipes. One set carries stormwater and nonpoint source pollution from the storm drains and releases it directly into the nearest river or stream without treatment. The other set of pipes carries residential and industrial wastewater to the Wastewater Treatment Plant before it is released into the river. In Atlanta's collection system alone, there are over 1,500 miles of separated sewer lines.

The second system is called the **Combined Sewer System**, which combines sanitary sewer, industrial wastewater and stormwater in the same pipes. Under normal circumstances, this wastewater mixture is sent to the Wastewater Treatment Plant before it is released into the river. This would seem like it would work well but during heavy rainfalls and storm events, when the treatment plant fills up, the excess water is channeled into the Combined Sewer Overflow (CSO) sending untreated human and industrial waste and more flowing into the river with minimal treatment! This type of sewer system was built from the late 1800s to mid-1900s in many American cities and has largely been discontinued now. Some cities, such as Atlanta, still have CSOs and have improved their systems by adding storage tanks and tunnels to capture the overflow and treating it before it is returned to the river.

What is being done about stormwater?

Georgia is now requiring more communities than ever before to address urban runoff water quality. There are Federal and state requirements for local stormwater management programs, community planning and development. Georgia's urban stormwater is managed through stormwater control structures, best management practices (BMPs), regular inspections, enforcement activities, stormwater monitoring and public education efforts.

Under Georgia Environmental Protection Division's Municipal Separate Storm Sewer System (MS4), local governments in regulated areas are required to have a comprehensive stormwater management program and to develop a plan and program to control stormwater pollution discharges to waters of the State. They must also work to eliminate non-stormwater discharges from entering the stormwater system.

An ideal **Stormwater Management Program** covers public involvement, construction site runoff control, pollution prevention, and of course, outreach and education.

What can we do?

We can educate others and ourselves to figure out how to help protect our own watersheds. A GOOD PLACE TO START: **Tackle nonpoint source pollution**! It poses a serious threat to the health of urban watersheds but it results from an accumulation of many small actions. What *small actions* can you do something about?

Now that you know more about stormwater here is your chance to become a "watchdog" in your own watershed and report occurrences of flooding, contamination, and illegal dumping. You are in the best position to act as steward and help to monitor water quality and enhance wildlife habitat, as well as introduce others to the situation through education.

- Join a **Rivers Alive** cleanup group or organize your own at http://RiversAlive.Georgia.Gov
- Learn to monitor the water quality near you through **GA Adopt-A-Stream**, http://AdoptAStream.Georgia.Gov
- **Support your local Watershed alliance.** Find yours here: http://www.garivers.org

Use this section to introduce the water cycle, watersheds and man-made water treatments to your students as a basis for understanding how stormwater affects all of these processes and the quality of our water resources.

NATURAL AND URBAN WATERSHEDS

ADD these Project WET Activities to your study of Watersheds--

Water on Earth:	Blue Planet, pg. 125
	A Drop in the Bucket, pg. 257
Water Cycle:	Incredible Journey, pg. 155
Watersheds:	Seeing Watersheds, pg. 187
	Just Passing Through, pg. 163
Water Treatment:	Reaching Your Limits, pg. 371
	Urban Waters, pg. 413

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STEM Connection

SCIENCE • TECHNOLOGY • ENGINEERING • MATHEMATICS

Find these Engineering Connections to WATERSHEDS on www.teachengineering.org

*How Clean is that Water?

*Introduction to Water Chemistry

*Stream Consciousness

Use ProjectWET.Georgia.gov to find Georgia Science and Mathematics Standards for Project WET and Urban Activities

Find Technology connections on www.discoverwater.org

Students first use their hands and then build a model of crumpled paper to form a watershed.

Charting the Course

Use this activity as the introduction to the Urban Watershed - Stormwater.

Objectives

Students will:

- Explain the configuration of a natural watershed making a model using their hands
- Discuss how water flows and what it carries with it through an urban area using a constructed paper watershed model

Materials

Scrap 8.5 x 11" paper
Newspaper
Water soluble markers
Blue permanent markers
Spray bottles filled with water
Map of Georgia Watersheds/River Basins (pg 145)

Background

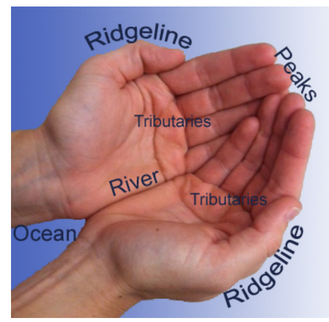
Wherever cities are built, there was once a natural watershed, which has three functions:

1. It **captures** water that falls from the atmosphere, soaking into the ground where it falls.
2. It **stores** rainwater once it filters through the soil, percolating deeper into aquifers and springs.
3. It **moves** water through the soil to seeps and springs and is ultimately released into streams, rivers, and the ocean.

Eventually, the moisture will return to the atmosphere by way of **evaporation** and **transpiration** (see glossary) and the hydrologic cycle (also known as the *Water Cycle*) is ready to go again.

In the urban environment, the hills and valleys of the natural watershed often remain. There may even be a river with tributaries but often the landscape and hardscape within this watershed has changed, interrupting the natural flow of water, eliminating the protective vegetation, and creating impervious surfaces where once was absorbent soil. As water flows through the city after a storm in narrowed, non-absorbent channels it increases in speed which may lead to flooding and erosion. Heat and pollutants picked up as the water flows over roofs and roads, are carried with runoff into the river and can adversely affect fish, wildlife, plants, and even our drinking water supply.

Procedure



1. Have students cup their hands together and imagine that they are trying to hold water. Ask them how the water would flow if it first hit the tips of their fingers (*downward toward the seam between their hands).*

2. Tell them that they have just made a model of a watershed. **A watershed** is an area of land from which all water drains, running downhill, to a shared destination - a river, pond, stream, lake, or estuary. It is defined by surrounding high points, or ridgelines. With gravity, the water flows downward to the body of water which eventually reaches the ocean.

3. Discuss the three functions of a watershed and have students suggest what animals, plants and natural features might be part of the watershed in their hands. List on board. **Show Georgia's watershed map and discuss where water flows in their area and the impacts to its functions that might occur downstream if it is altered.**

Paper Watershed Model

1. Have the students cover their desks with newspaper. Pass out the markers and 1 sheet of scrap paper/student.

2. On the scrap paper with the water soluble markers, have students draw their town or neighborhood where they live. They should label each place, such as school, home, doctor's office, park, etc. (Panel 1, next page)

3. Students then crumple the drawing into a ball and gently open it back up to reveal ridges and valleys in the paper. Have them use the permanent marker to outline the ridgelines that define their watershed and low points of their watershed and trace where they think water might flow if it should rain (streams or rivers). (Panels 2 & 3)

4. Distribute the water spray bottles to several students and adjust the spray to a light mist. Have these student be the rain makers and gently spray the other students' paper watersheds just enough to make the colors run. (Panel 4)

5. Students can discuss where the water flowed. What did they observe? Was it the same as they had predicted? Where did the water accumulate? Did anyone build a home in a flooded area? Why is it a good idea to know something about the watersheds before you build?

6. Discuss stormwater and what damage heavy water could have done to the watershed. Could any of the runoff from the various buildings on the drawing bring pollution to other areas in the paper watershed? What kind of pollution might be carried with the water?

Assessment

Have students decide what changes happened to the watershed when a city was built on it. Have them make a list of ideas for helping re-establishing the three functions of a watershed in an urban environment. Share and discuss these ideas as a class. Have students discuss in what ways were their models like and unlike an actual watershed.

*A Watershed and a River Basin are the same thing, distinguished by size. A River Basin includes several Watersheds.

Atlanta has the smallest watershed of any major city in the U.S.

Extensions

Invite someone from the local water authority to visit and talk about the watershed they live in and how what we do impacts life downstream.

WATERSHED SONG BY PETEY GIROUX

CHORUS

WATERSHEDS! (C A G)

Let's hear it for watersheds (C C B C D B A)

Everybody lives in a watershed! (B B- B B- G A B C A G)

When the rain comes down, (G A B C A G)

It's mountain ridge bound. (C D D B A)

Branching into tributaries all around. (B B- B B- B G A B C A G)

The tributaries to the rivers they go (B C A G C D D B A)

And the rivers to the ocean, (C A B B- B B- G)

Make the mighty flow. (A B C A G)

CHORUS

In Georgia there are 52 watersheds*.

52, oh so cool watersheds.

There are 14 River Basins*. Do you know them all?

Some are very big, and some are very small.

There's the Tennessee, Ochlockonee, the Altamaha

And the St. Mary's, Satilla and the Tallapoosa.

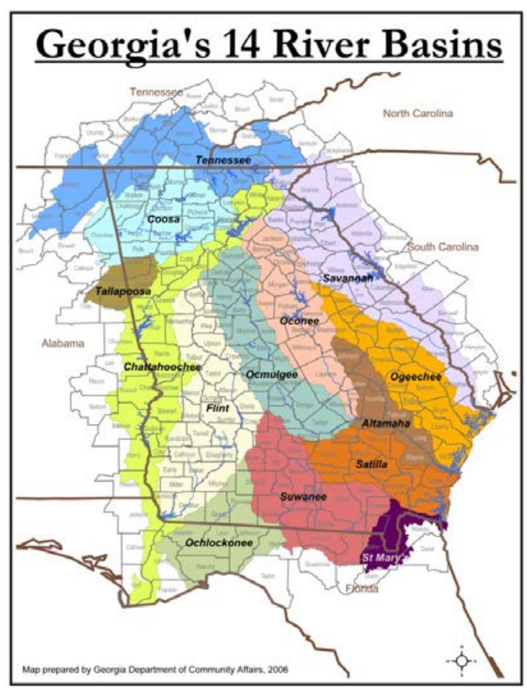
There's the Flint, the Oconee and the Ocmulgee.

The Coosa, Chattahoochee and the Ogeechee.

Let's not forget the Suwannee, the Savannah too

Protect our River Basins in all that you do!

CHORUS



WHAT'S YOUR STANDARD?

Students simulate a drinking water treatment process in order to better understand the effort and cost involved in meeting water quality standards.

Charting the Course

Use the Warm Up from Project WET's *Reaching Your Limits* prior to this lesson to help students understand parts per million. Review the drinking water quality report for your city.

Objectives

Students will:

- Explain how the distribution of state revenue to provide services might affect water quality.
- Demonstrate the process used to meet drinking water standards through a physical activity.
- Discuss the relationship between water treatment and water quality standards.
- Explain that there is a relationship between clean water and what it costs to keep the water clean and safe for drinking.
- Relate how microorganisms can benefit or harm our water resources.

Materials

- 1 cup of "river water" to begin the lesson (water mixed with sediment, rocks, sand, leaves, etc.)
- Copy of the Georgia Water Quality Report from http://water.epa.gov/drink/local/ga.cfm (also available annually for your city using a web search)
- Cones or flags to mark field area
- 21 small open containers (buckets, bowls or tubs) to hold the contaminants and additives cards. Provide one container for each contaminant and additive
- Contaminant and Additive cards, cut apart and laminated, enough for one of each per student, (pages 23-24)
- Clips or tape to affix contaminant and additive labels to each container
- 2 hula hoops to simulate pipe entrance and exit
- 4 large cards labeled coagulation, sedimentation, filtration, and disinfection, and a copy of small process chart for Treatment Plant Manager (pg. 19)
- 1 whistle for the Treatment Plant Manager

<u>For each student:</u>

- 1 Contaminant and Additive Class Total score card (pg. 26)
- 2 resealable baggies, one labeled "C" for contaminant and the other labeled "A" for additive.
- pencil or crayon
- 1 student standards score card (pg. 25)

Making Connections

Students may be aware that clean water comes from the faucet but they may have no idea how that happens and who sets the standards for safety and quality. They may not have thought about the connection between clean water, health, and cost to the consumer that comes with drinking water treatment.

Background

Each day Georgia's cities supply over a billion gallons of treated drinking water to residents. Most of the water processed is surface water that is pumped from a river. Some cities, such as Savannah and Brunswick, get their drinking water from groundwater or aquifers.

Drinking water, no matter its source, must meet or exceed all safety and quality standards set by the State of Georgia and the U.S. Environmental Protection Agency (EPA). Since 1970 the EPA has had the responsibility to protect the quality of the American environment and control the effects of pollution on public health. There are also laws that help protect citizens concerning water quality. The ***Federal Water Pollution Control Act*** was amended and became a law known as the ***Clean Water Act in 1977***. The Clean Water Act established the structure for regulating discharges of pollutants into the waters of the United States. It gave EPA the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act also mandated requirements to set water quality standards for all contaminants in surface waters. The Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. It also funded the construction of sewage treatment plants under construction grants programs and recognized the need for planning to address the critical problems posed by **nonpoint source pollution** (pollution carried by runoff during heavy rains that ends up in storm drains and eventually our waterways where the source is not easily identifiable).

Another law that protects our water quality in Georgia is the **Safe Drinking Water Act (SDWA)**, which requires water systems to monitor for unregulated parameters in order to assist the EPA in determining where certain contaminants occur and whether additional regulations may be necessary. Annually, over 12,000 samples of untreated (raw) and treated (finished) water are collected and over 50,000 tests are conducted that screen for more than 150 potential contaminants. Water quality standards are set and contaminants are carefully monitored. Each contaminant has a standard or level at which it can be in the water without causing harm to human and aquatic health.

Stormwater is a major contributor to contaminants in a river. As stormwater travels over various surfaces it picks up contaminants along the way. These contaminants include: bacteria and viruses, pesticides and herbicides from agriculture and lawn care, stormwater runoff that carries many types of nonpoint source pollution, salts and metals from industrial or domestic wastewater discharges, oil and gas production, sediment from erosion and development, organic chemicals from urban runoff, septic tank pollutants, and radioactive waste from oil/gas production and mining.

To remove contaminants from the water, the raw river water enters the water treatment plant pipe. Control room operators add lime for pH control, potassium permanganate for disinfection, and powdered carbon for taste and odor control. Then the alum and other chemicals are added to the water causing coagulation to occur. Tiny sticky particles form that are called “floc” and the “floc” attracts other particles. The “floc” finally gets heavy and settles to the bottom during sedimentation. The clear water moves to the filtration process where water passes through filters that help to remove even smaller particles. The next step is disinfection where a small amount of chlorine is added to kill any remaining bacteria or microorganisms, phosphate to prevent any corrosion contamination, and fluoride to prevent tooth decay. Water is then placed in a closed tank or reservoir and sent on through the water delivery system that takes water to homes, schools, and businesses in the community.

Preparation

Use the contaminant and additive copy pages and make enough contaminant cards so that each student will have at least 14 different contaminants in his/her contaminant baggies marked “C” and make at least one additive card of each per student that can be gathered on the field.

Designate a field area for the water treatment facility and place cones or flags around the perimeter of the area. Make the field area large enough to accommodate the 14 contaminant containers and the 7 additive containers and enough space for students to move around freely, the larger the space, the more difficult the challenge to clean the water.

Place 14 containers in the center of the field randomly, each labeled with a different contaminant. (See field diagram).

Set up 4 additive containers near the beginning of the water treatment facility/field area labeled carbon, lime, potassium, and alum and 3 near the end of the treatment process to represent the additives in the disinfection area. Label these fluoride, chlorine, and phosphate. Make the additive areas look different from the contaminant area. Use different colored containers or labels to help students distinguish between contaminants and additives. Place the additive cards in the matching containers. There should be at least one additive card for each student in each container. Students will pick up one additive from each area and add it to their additive bag during treatment.

Procedure

Warm Up

1. Begin by asking students if they have standards they set for themselves. Write their answers on a board. Explain that there are also standards for water quality that are set by laws and by the State of Georgia.

2. Use the warm up activity in the lesson ***Reaching Your Limits* from the Project WET Curriculum and Activity Guide.** The warm up activity gives students a visual of what parts per million might look like. Since removing all the pollutants is economically impractical, explain that the government sets standards to define how much of each pollutant is allowable in the water while remaining at safe levels for human health. Most of these standards are set in parts per million (ppm) or parts per billion (ppb).

3. Hold up the glass of "river water" and ask students if they would like to drink it. Ask them why they wouldn't like to drink it. Tell the students that it is easy to say no when you see the sediment, rocks, wood, litter, debris etc. but what if it contained contaminants you couldn't see, like bacteria or chemicals? This is why water treatment is necessary. Ask students what has to be done to the river water prior to becoming the drinking water that comes from their faucets.

Activity (Field Portion)

1. Tell students they are going to do an activity that simulates the effort required to clean water for drinking and meeting water quality standards. Brainstorm possible contaminants they might find in raw water prior to water treatment. **Tell them they are going to be raw water from the river and will go through water treatment.** They will try to get rid of their contaminants and pick up the additives that help clean the water.

Use the glossary at the back to review vocabulary.

2. Select a Water Treatment Manager (or use an adult). The remaining students in the class will represent raw water in the field activity and the Water Treatment Budget Managers in the class portion of the activity. The Water Treatment Manager is in charge of the movement through the process. The Manager begins by having everyone enter the field through a hula hoop to represent water moving through a pipe from the river. Water students will also leave the field through a hula hoop at the end of the treatment process for distribution to homes, schools and businesses. At the end the Treatment Manager will also collect all of the completed contaminant scorecards. Managers are held accountable for standards and for any fines.

Give the four large process cards labeled **coagulation, sedimentation**, **filtration**, and **disinfection** and this chart to the Treatment Manager:

Blow Whistle, hold up Sign and Shout:	Water Student Action
COAGULATION	Immediately hold hands with 2 other students and walk together to the next stations
SEDIMENTATION	Drop the hands of the floc group and will sit down and count to 10, which represents the settling of particles on the bottom
FILTRATION	Circle at least 3 other students to represent filtration of the water.
DISINFECTION	Go to the 3 containers at the end of the field and gather phosphate, chlorine, and fluoride before going to storage tanks and then to homes, schools, and businesses

3. Select a time keeper to give the water students 5 minutes to move through the treatment plant. To provide more safety have the students walk through the water treatment area.

4. Give each water student a baggy marked with a "C" containing the 14 contaminant cards. Ask students to find a contaminant in their bag and read it to the class. Ask the class where the contaminant might come from. *You can have students do research on the contaminants ahead of time by going to --* *http://www.epa.gov/ccl/types-drinking-water-contaminants*

5. The water students will also each have a baggy marked with an "A" that has nothing in it. This is the additive bag and will be used to gather one each of the additives.

6. Lead students to the field area and give these instructions: *"You are now "raw" water moving through water treatment and you will need to get rid of the contaminants in your bag in the next few minutes.*

"You will walk/run to the buckets and drop in the ***contaminant*** *that is labeled for that bucket. Fecal Coliform goes in the Fecal Coliform bucket and Oil goes in the Oil bucket for example.*

"You will also have to pick up ***additives*** *that the treatment plant puts in the water to disinfect, or to protect your teeth or to make the water clump together for example. There are 7 additives all together, 4 up near the front in the pre-treatment process that include: lime, alum, potassium, and powdered carbon, and three at the end that are picked up when the manager shouts* ***'disinfection'*** *before finished water leaves the treatment plant. You will need to get one of each of these additives and put it in your additive bag 'A'.*

*"At the same time you are moving, you will go through the treatment process. The Water Treatment Manager will blow a whistle and say "****COAGULATION****". That means that something is added to the water to create a clumping of particles that is called 'floc'.* ***Immediately hold hands with 2 other students and walk together to the next stations."***

*"Then the water treatment manager will blow a whistle and will say '****SEDIMENTATION****.* ***You will drop the hands of the floc group and will sit down and count to 10, which represents the settling of particles on the bottom.*** *Then you can resume visiting the containers.*

"Then the water treatment manager will blow the whistle and say ***'FILTRATON****.'* ***You will weave around at least 3 other students to represent filtration of the water.***

"Finally the water treatment manager will blow the whistle and say ***'DISINFECTION.' All raw water students must go to the 3 containers at the end of the field and gather phosphate, chlorine, and fluoride before going out the pipe to storage tanks and then to homes, schools, and businesses****."* Practice these movements with the students.

7. When students have released contaminants and have picked up their additives they can pass through the pipe (hula hoop) at the end of the treatment plant area. The timekeeper calls time. Some students may not have finished the course.

8. **At the end of the time period each water student will count the contaminants in their bag and check them off on the contaminant scorecard. They will also record the additives they do not have.** If any additives are missing, put an X on those that are missing. The Water Treatment Plant Manager will collect all the completed scorecards to compile the data and see if they have met standards. Return to the classroom.

Activity (Classroom Portion)

Tell the class that they are now part of the water treatment staff and have a budget for the year. The water treatment facility budget is $50,000 for the year.

Ask the students to look at their contaminant and additive Student Standards Scorecards. Remind them that water treatment must meet water quality standards set by the State and by EPA.

1. Ask the class to raise their hands if they had OIL left as a contaminant and record the total number on the board.

Continue to record the class totals for each contaminant. Note on the contaminant score card that each contaminant has a standard and it will say 20 ppm or 10 ppm for example. That means in this activity that the treatment plant cannot exceed more than 20 ppm of that contaminant or it will not be an acceptable standard and be considered unsafe and unhealthy for consumption and out of compliance with the law. **Therefore the plant will be fined according to the amount listed for every number over 20.**

If Oil is listed at 12 ppm and the class had 10 Oils total, the treatment for oil met standards. However if the standard for oil is 10 ppm and the class totaled 15 ppm, the Oil is 5 over the limit. The fine is $50.00 for each number over the standard. The treatment plant is fined **5 X $50.00 = $250.00** just for oil. **Ask the students to get out their Contaminant and Additive Total Worksheet. They should work through the rest of the totals for each contaminant. Point out that Very Toxic Contaminants cost $1000 for each point over the standard!**

2. For every additive missed add another $50.00.

3. When the total fine is assessed then the treatment plant will determine if they can pay the fine within their budget ($50,000 for the year).

Wrap Up

Each standard has a number of parts per million that is acceptable. If they go over that number during treatment they will be fined by the State EPD (Environmental Protection Division). They will add up the money that must be paid if they are out of compliance and not able to clean the water. Since the Water Treatment Plant has no money in the budget to pay a fine, EPD will send the fine to the Mayor. The Mayor will go to the City, the Department of Watershed Management, and ask for the funds. If the City cannot pay the fine, the Mayor and City Council will have to find another way to pay it, which could include a rate increase for citizens. Students can role-play using actors for the City and the Mayor, City Council, and residents. The students in their roles can decide how they will pay for the water treatment upgrades. The Mayor and City Council will have to make the final decision if no one else has a plan.

Have students discuss what expenses might have to be paid out of the water treatment plant's budget besides a fine (energy bill, infrastructure upgrades, employee salaries, etc.). Lead a discussion on why students think a water bill may sometimes need to increase.

Assessments

Ask the students to write the process for their "raw" water journey. What contaminants did they pick up? What additives did they pick up? Did the class meet the standard? How much did it cost the City to clean the water and where did the City get the money to do it? What physical and chemical processes happened along the way? (See rubric on pg. 27)

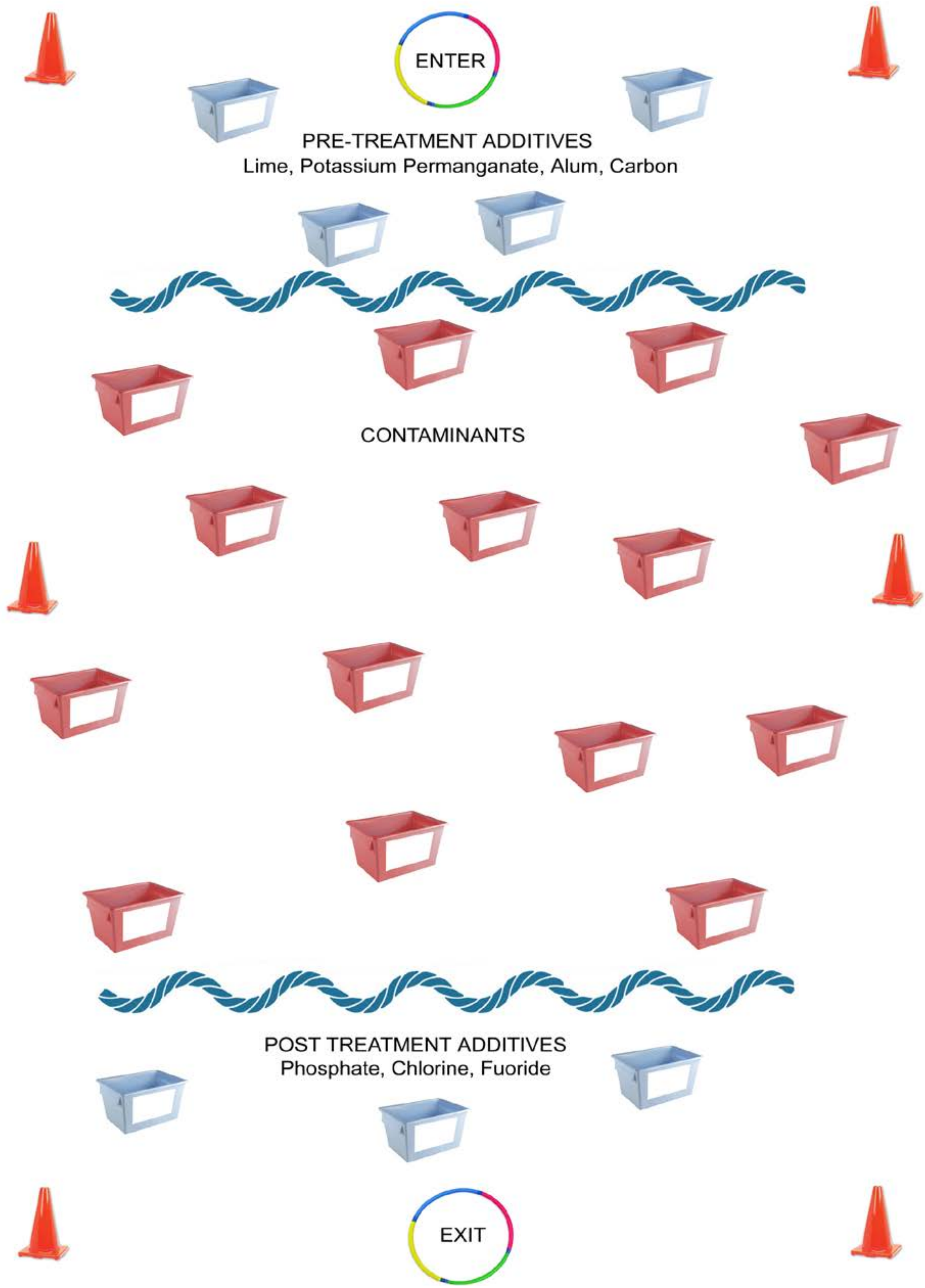
Extension

Choose a drinking water topic to report on from a reliable website such as this EPA site http://water.epa.gov/drink/info. Students could develop models and dioramas that show what they have learned.

Resources

1. National Environmental Services Center/Drinking Water https://www.nesc.wvu.edu/drinking-water
2. US Environmental Protection Division http://water.epa.gov
3. US Geological Society http://ga.water.usgs.gov/

FIELD DIAGRAM FOR WHAT'S YOUR STANDARD?



CONTAMINANTS

Duplicate this page x the number of students onto cardstock. Cut apart and place each set into baggies marked "C".
Enlarge as needed.

		CRYPTOSPORIDIUM	OIL
GAS	VIRUS	FLUORIDE (CONTAMINANT)	BARIUM
CHLORINE (CONTAMINANT)	FERTILIZER	TURBIDITY	PESTICIDE
FECAL COLIFORM	LEAD	COPPER	ARSENIC

ADDITIVES

	CHLORINE (ADDITIVE)	POTASSIUM PERMANGANATE	LIME
ALUM	PHOSPHATE	FLUORIDE (ADDITIVE)	CARBON

Duplicate this page x the number of students onto cardstock. Cut apart and sort into the additive containers. Enlarge as needed.

STUDENT STANDARDS SCORECARDS

CONTAMINANTS Check off what is still in your "C" bag.	✔
Oil	
Gas	
Fertilizer	
Pesticide	
Lead	
Copper	
Arsenic	
Fecal Coliform	
Cryptosporidium	
Viruses	
Turbidity	
Fluoride	
Chlorine	
Barium	

ADDITIVES X what is missing from your "A" bag.	X
Lime (pH control)	
Potassium Permanganate (disinfection)	
Powdered Carbon (odor/taste)	
Alum (coagulation)	
Phosphate (corrosion control)	
Chlorine (disinfection)	
Fluoride (tooth decay prevention)	

Cut here

STUDENT STANDARDS SCORECARDS

CONTAMINANTS Check off what is still in your "C" bag.	✔
Oil	
Gas	
Fertilizer	
Pesticide	
Lead	
Copper	
Arsenic	
Fecal Coliform	
Cryptosporidium	
Viruses	
Turbidity	
Fluoride	
Chlorine	
Barium	

ADDITIVES X what is missing from your "A" bag.	X
Lime (pH control)	
Potassium Permanganate (disinfection)	
Powdered Carbon (odor/taste)	
Alum (coagulation)	
Phosphate (corrosion control)	
Chlorine (disinfection)	
Fluoride (tooth decay prevention)	

CONTAMINANT AND ADDITIVE CLASS TOTAL

CONTAMINANTS	CLASS TOTAL	STANDARD	Is CLASS TOTAL < = > STANDARD?	IF > STANDARD Then calculate: (Class total)-(Standard)=	FINE: Multiply answer X $50 Very toxic X $1000
Oil (Xylene in water)		10 ppm			
Gas (Dioxin in water)		0 ppm			
Fertilizer (Nitrate in water)		10 ppm			
Pesticide (Alachlor) VERY TOXIC!		2 ppb			X $1000
Lead VERY TOXIC!		15 ppb			X $1000
Copper		1 ppm			
Arsenic VERY TOXIC!		10 ppb			X $1000
Fecal Coliform		0 ppm			
Cryptosporidium		0 ppm			
Viruses		0 ppm			
Turbidity		1 NTU			
Fluoride*		4 ppm			
Chlorine*		4 ppm			
Barium		2 ppm			
Total Contaminant Fine Owed					$

ppm = parts per million ppb = parts per billion NTU = Nephelometric turbidity unit

ADDITIVES	# of student that did NOT pick up this additive	FINE: Multiply X $50
Lime		
Potassium Permanganate		
Powdered Carbon		
Alum		
Phosphate		
Chlorine *		
Fluoride *		
Total Additive Fine Owed		$

COMBINED FINES =
$______________

This is the fine owed by the Water Treatment Plant! Is there enough money in the Budget to pay the fine?

*Chlorine and fluoride can be BOTH contaminants and additives.

ASSESSMENT RUBRIC FOR WHAT'S YOUR STANDARD?

Category	4	3	2	1
Organization	Information is very organized in a well-constructed story; each paragraph has a clear introduction, explanation, and conclusion.	Information is organized in a fairly well constructed story. Most paragraphs have an adequate introduction, explanation, and conclusion.	The paragraphs contain related information, but the story is not well constructed. Introduction, explanation, and/or conclusion sentences are frequently missing.	The information is disorganized. Paragraph structure is not clear and sentences are not typically related within the paragraphs.
Comprehension	Student is able to clearly demonstrate the process used to meet drinking water standards, including the roles of contaminants and additives.	Student is able to demonstrate the process used to meet drinking water standards and the roles of contaminants and additives for the most part.	Student is only partially successful in demonstrating the process used to meet drinking water standards OR only partially understands the roles of contaminants and additives.	Student is unable to successfully demonstrate the process used to meet drinking water standards AND does not understand the roles of contaminants and additives.
Comprehension	Student completely understands the relationship between water treatment and water quality.	Student mostly understands the relationship between water treatment and water quality standards.	Student partially understands the relationship between water treatment and water quality standards.	Student does not understand the relationship between water treatment and water quality standards.
Comprehension	Student clearly understands the economic costs of clean water.	Student mostly understands the economic costs of clean water.	Student partially understands the economic costs of clean water.	Student does not understand the economic costs of clean water.

JUST PIPE UP!

Students build a pipeline using tubes for pipes to make a delivery and collection system model that mimics the journey water takes from river to river in the man-made water cycle.

Charting the Course:

This activity is a good Icebreaker to use as a discussion on water and wastewater services provided by local governments and the process behind treating water for our use. Use it to introduce *What's Your Standard, River to River* and Project WET's *Urban Waters*. It also provides a visual background for *Piped on Water*.

Objectives

Students will:

- Explain the water supply and wastewater collection system provided by local governments
- Identify reasons for cleaning water from a source before and after we use it

Materials

- Paper towel tubes of various lengths, labeled (you will need 13 tubes/set)
- Markers, 2 colors (or colored paper labels) for tubes
- *Marbles or small balls (1/2")*

For each team

- Set of infrastructure placement cards, cut apart
- *Just Pipe Up!* Chart
- Infrastructure definitions

Making Connections

Students may be aware of their water source but they may not know that water must be pumped and stored at various locations as it flows through pipes to treatment plants. They will get a sense of the infrastructure and processes in water delivery and wastewater collection.

Background

In most Georgia cities a river is the source of drinking water and is the lifeblood of the metropolitan area. Water is pumped out of the river for us to use but must first be treated. After treatment, water is pumped to homes, schools, and businesses. When water is used and goes down the drain it is called wastewater. Wastewater flows mostly by gravity through sewer pipes to the wastewater treatment plant and back to the river.

In the larger Georgia cities there are over 2,000 miles of sewer lines for wastewater. Ninety percent are **Separated Sanitary/Stormwater Systems** and the remaining 10% are **Combined Sewer Lines**. A separate sewer line collects wastewater in one pipe and stormwater in another pipe. A combined sewer pipe carries both wastewater and stormwater in the same pipe (*see pg. 10*).

Georgia's metropolitan areas have grown dramatically over the past decade adding pressure to the watersheds and river basins that supply water. The cities are also limited in how much water they can withdraw daily from the river. Cost is another factor in limiting the water that is used and cleaned.

Wastewater from homes, schools, and businesses travels in a wastewater pipe collection. Along the way it might encounter a pumping station before it flows to the **wastewater treatment facility**. The first stage of treatment at the wastewater treatment facility is **primary treatment** where most of the solids are screened out through the physical processes of screening, skimming, and settling. Next the water goes through the sedimentation process where suspended solids drift to the bottom of the tank. Grease and oil rise to the surface and are skimmed off. Sedimentation is the end of the primary process of wastewater treatment.

During **secondary treatment,** biological processes are used to clean the water. During the activated sludge process, wastewater and microorganisms are mixed in a tank where air is added (aeration and agitation). The microorganisms in turn eat the organic pollutants in the water. A second round of sedimentation occurs followed by disinfection through the use of chlorine or ultra violet lights.

Advanced treatment is a higher degree of treatment through filtration. The water is filtered through sand and crushed stone to remove any small particles. When the filters become clogged with solids they are backwashed and then the collected solids are reprocessed in the plant. Some innovative counties are using constructed wetlands areas to do this final step in the process, benefiting wildlife and utilizing natural processes to do the filtration.

Preparation

Prior to the activity ask students and parents to save their paper towel and tissue rolls and collect enough to make two pipelines, or 26 tubes. Use different colored markers or labels to indicate drinking water delivery pipes (1–8) and wastewater collection pipes (8–13). Label the tubes/pipes in the correct order (see below) repeating the last station so that each tube can make a match with the next infrastructure stop. The first tube has **River** at one end and **Raw Pumping Station** at the other end. The next tube should be labeled **Raw Pumping Station** and **Raw Water Reservoir**. Continue labeling tubes using the chart below.

Label the opposite ends of each tube in a set as follows:

tube	Drinking Water BLUE	
1	River	Raw Pumping Station
2	Raw Pumping Station	Raw Water Reservoir
3	Raw Water Reservoir	Water Treatment Plant
4	Water Treatment Plant	Clear Wells
5	Clear Wells	Pumping Station
6	Pumping Station	Storage Tanks
7	Storage Tanks	Homes, Schools and Businesses
8	Homes, Schools and Businesses	Wastewater Pump Station
	Wastewater BROWN	
9	Wastewater Pump Station	Wastewater Treatment Plant
10	Wastewater Treatment Plant	Primary Wastewater Treatment
11	Primary Wastewater Treatment	Secondary Wastewater Treatment
12	Secondary Wastewater Treatment	Advanced Wastewater Treatment
13	Advanced Wastewater Treatment	River

Procedure

Warm Up

Divide students into teams and give each team a set of **Infrastructure Placement Cards** (pg. 34) that trace the flow of water from the river to their homes and back to the river.

1. Give each team 5 minutes to arrange the cards showing the actual process it takes to clean the water we use.

2. Ask each team to explain their design to the class. Have them describe what the water moves in and what is needed to keep it moving. Each team will present their design to the class. Discuss how the topography of land influences the need at some point for pumping water and at other points for gravity to do the work. *(Generally, water is under pressure when it moves to drinking water treatment and is moving mostly by gravity to wastewater treatment.)*

3. Hand a **Pipe It Up! Chart** (pg. 34) to each team and ask them to place their infrastructure cards on the correct answers on the **Just Pipe Up! Chart**. Collect the charts before starting the activity below.

Activity

1. Students are now ready to build the actual pipeline using the knowledge they have about the drinking water and wastewater pipe systems. They will sequence the pipes in order by holding together the pipes end to end.

2. Hand out the tubes randomly (one tube per student). If you have more than 13 students you will need 2 sets of pipes or tubes.

3. Ask students to find their match and hold the tubes together to form a pipeline. Tell them there are many community members who need to get their water and are quite anxious for this project to be completed.

4. When the pipeline is complete tell the students that you are going to see what kind of condition the water delivery and collection system is in. Place a marble or two in the end of the pipeline to see if the marble can pass all the way to the other end of the pipeline system. If the marble falls through it opens discussion about pipes that crack or break and the need for people in careers that will keep pipes, stations, and the delivery and collection system in good repair. If there is a break, discuss where it is and how that break could affect the health of people and animals. Students may have to use gravity to get the marble through the pipe. Or they may

need to push it through the tube (as with a pumping station).

5. Students bring their tubes back to their seats. Pass out the **infrastructure definition** page (pg. 32) and ask students to read aloud the definition of the section of pipe they hold beginning at the River and discuss what happens at their section of man-made water cycle.

6. For the tube that says **Clear Wells and Pumping Station** discuss what a Clear Well is and why a Pumping Station might be needed at that point in the man-made water cycle.

Wrap Up

Leave one pipeline connected and in view for all the teams to see. Ask student to list the reasons behind the use of this system to clean our water before and after we use it. Why do we need this system in the urban watershed? Does a natural watershed use the same system? Discuss what contaminates might be in the river before we treat it and where they might come from.

Sing the **Just Pipe Up! song** and let the students use the song to prepare for the assessment.

Check out these related Engineering activities on teachengineering.org:

- ✓ Do as the Romans: Construct an Aqueduct!
- ✓ Tippy Tap Plus Piping

Assessment

Give a complete set of infrastructure cards to students working in teams of three and four. Ask them to sequence the infrastructure for the man-made water cycle by ordering the cards from river to river. Remind them that they should begin and end with the river. Each team's list should be ordered as in the activity. Use the Just Pipe Up! Chart as your answer key.

Extension

Students can take each step in the process and identify it as physical or chemical.

References

City of Atlanta Department of Watershed Management, www.cleanwateratlanta.org

The ancient Romans constructed over 200 aqueducts in order to bring water from distant sources into their cities and towns, supplying public baths, latrines, fountains, and private households. Wastewater was removed by complex sewage systems and released into nearby bodies of water.

Infrastructure Definitions

Provide these definitions to students to read when they have completed the pipe puzzle.

River – the river is the source of most of Georgia's drinking water

Raw Water Pumping Station – a place where raw water (untreated) is pumped to the raw water reservoir

Raw Water Reservoir – a place where raw water is held before drinking water treatment

Water Treatment Plant – drinking water treatment is primarily a chemical treatment. Water goes through coagulation, sedimentation, filtration, and disinfection

Clear Wells – a place where water is held after drinking water treatment

Pumping Station – a place where water is put under pressure and pumped to a storage tank before delivery to homes, schools, and businesses

Storage Tanks – a storage area for treated water prior to delivery to homes, schools, and businesses

Homes, Schools, Businesses – water users who create wastewater

Wastewater Pump Station – a place where wastewater is pumped to the wastewater treatment facility

Wastewater Treatment Plant – a wastewater treatment facility that cleans the water through physical and biological processes prior to return of the water to the river

Primary Wastewater Treatment – physical process of screening where most of the solids are removed through skimming and settling

Secondary Wastewater Treatment – biological processes in secondary treatment include the use of microorganisms that eat the pollutants after air is added to the treatment process

Advanced Wastewater Treatment – a higher degree of treatment through filtration. Water is moved through layers of sand and crushed stone to remove any remaining small material or pollutants

River – the treated wastewater is returned to the River clean so that the water is safe for aquatic animals and downstream water users

Just Pipe Up, Song

(to the tune of Jingle Bells)
Add hand motions as appropriate.

Just pipe it up, pipe it up!
That's all you have to do,
If you want a drink of water
And to wash your dishes too.

Just go to the river
And put your pipe right in.
Pump that RAW WATER;
To the PUMPING STATION.

On to the RAW WATER RESERVOIR
To water treatment it goes,
On to the Clear Wells and Pump
Then STORE it before it flows.

To our HOMES and our SCHOOLS
And all our BUSINESSES too.
Everyone gets clean water.
Yippee Yip Yahoo!

We brush our teeth, and the water we use
To the sewer system it goes,
To the Wastewater Pump Station,
To Wastewater Treatment it flows.

There's PRIMARY TREATMENT,
SECONDARY TREATMENT
ADVANCED TREATMENT too.
Everyone likes clean water
Including fish and beavers too!

Now back to the RIVER
The water's all sparkling clean,
But it took a lot of work so
Help keep your river pristine!

JUST PIPE UP! CHART

Duplicate and cut apart to use as **Student Infrastructure Placement Cards**.
Make another uncut copy per team to use as an answer key.

RIVER
RAW WATER PUMPING STATION
RAW WATER RESERVOIR
WATER TREATMENT PLANT
CLEAR WELLS
PUMPING STATION
STORAGE TANKS
HOMES, SCHOOLS, BUSINESSES
WASTEWATER PUMP STATION
WASTEWATER TREATMENT PLANT
PRIMARY WASTEWATER TREATMENT
SECONDARY WASTEWATER TREATMENT
ADVANCED WASTEWATER TREATMENT
RIVER

RIVER TO RIVER

Students will learn about water and wastewater processes through an 18 station hands-on simulation.

Charting the Course

Use *Just Pipe Up! and What's Your Standard, and* Project WET's *Urban Waters* prior to this activity.

Objectives

Students will:

- Distinguish between the processes for drinking water and wastewater treatment
- Compare natural and man-made processes for cleaning water

Materials

- Clear plastic cups (at least 36 or 2 per station)
- Small jars for holding chemicals, labeled
- Larger containers for storage and wastewater
- Two different gauge of screens (large and small) that will cover the diameter of the cup
- Set of Station Identification Cards, cut out and folded
- Sand, gravel, coffee filters, sticks, leaves, cereal, rice, dish soap or other items that, when added, will imitate wastewater and river water
- Large jar to hold wastewater from homes, businesses
- Microorganism hats or masks (or make your own from construction paper)
- Dispensers for chemicals (baby food jars or small pill bottles)
- Flashlight for ultraviolet (UV) disinfection area or bottle labeled chlorine
- Plastic spoons (at least 18 or 1/station)
- Chlorine bleach and alum
- Turkey baster for aeration, funnel, measuring spoons
- Safety goggles and rubber or latex gloves

Making Connections

Students may realize that water is treated in some way prior to drinking it but they may not make a distinction between the two processes of drinking water treatment and wastewater treatment. They also may not realize that both of these processes do similar things and that they mimic the natural process in many ways.

Background

Water treatment, also referred to as drinking water treatment and wastewater treatment are often thought to be one process. They do have similar components but they are actually different processes occurring at different stages in the man-made water cycle.

Water Treatment

The sources of drinking water, both tap and bottled water, come from rivers, lakes, streams, ponds, reservoirs, springs, and wells. As water travels over the surface of land or through the ground, it dissolves naturally occurring minerals and, in some cases, radioactive material and can pick up substances from animal or human activity.

Organic contaminants are composed of hydrogen and carbon bonds and their derivatives are of plant or animal origin. They are made up of carbon molecules and are from naturally occurring living substances. Organic contaminants that can be present in source water before treatment include: microbial contaminants, such as viruses or bacteria, which might come from leaking sewer pipes, septic systems, agricultural livestock operations, and wildlife. There are also organic chemical contaminants that result from petroleum production and industrial processes or can come from stormwater, gas stations, and septic systems.

Inorganic contaminants are composed of matter other than plant or animal such as salts and metals and can be naturally occurring or produced synthetically. Inorganic contaminants such as salts and metals can be naturally occurring or result from urban stormwater runoff, industrial or domestic wastewater discharges, oil and gas production, and mining. The use of pesticides and herbicides that come from a variety of sources such as agriculture, stormwater runoff, and residential uses can also be contaminants in the water.

In most of Georgia's urban watersheds, millions of gallons of water are pumped from a river to the water treatment plant. To ensure proper water quality, the city's water management department collects samples of untreated (raw) and treated water (finished) and conducts over 50,000 tests, screening for more than 150 potential contaminants. Every year Georgia's water customers receive a report that lets them know if the water treatment plants have met all of the State water quality standards. This report is called the **Consumer Confidential Report and is available to you for your city**.

Wastewater Treatment

Wastewater is previously used water from a community. Most of the flow of wastewater is 99.9 percent water by weight. The rest is dissolved material that is suspended by water. This suspended material is called suspended solids. **On average, each person in the United States contributes approximately 150 gallons of water a day (that is two bathtubs full of water) to the wastewater stream.** Used water from homes, schools, and businesses, collects in a series of underground sewers.

The wastewater moves through the sewers downhill by gravity to the treatment facility. **Separated sewers carry only domestic and industrial sewage, while combined sewers carry wastewater and stormwater runoff.** In some cases, special pumps are needed to force the wastewater uphill into the facility. Often the wastewater contains materials such as rocks, paper and sand, so these pumps have to handle many different conditions.

Because they are so important to a city's operation, treatment plants have no holidays and operate 24 hours a day. To make sure wastewater is cleaned and meets requirements, a treatment facility has to be operated and managed skillfully. Wastewater treatment facility managers have to be skilled in many areas of operation. They are in charge of budgeting, personnel, communications, and need to have supervisory skills, know government procedures, mechanics, chemistry, hydraulics, biology and computer operation.

Water is a finite resource and because we have all that we will ever get on our planet, it must be protected. The wastewater treatment facility is critical in keeping our water clean. It replicates the natural water cycle in the way wastewater is processed, cleaning it like rain that percolates through the ground filtering out contaminants before returning it to the river or underground aquifers. **The function of wastewater treatment is to speed up the natural process of water purification by creating more controlled conditions where bacteria and other organisms consume the waste just like they do in a natural process.**

Wastewater treatment is much more complicated than water treatment. **There are three kinds of treatment in wastewater treatment: physical, chemical, and biological.** This treatment is also referred to as primary, secondary, and tertiary or advanced treatment. During **primary treatment** suspended solids are removed by screening, floating or settling and these are physical processes. In **secondary treatment**, contaminants are biologically removed that are dissolved in the wastewater and chemicals are added. **Advanced treatment** involves filtering the water through sand and gravel to remove smaller particles that still remain in the water and this is a physical treatment.

Preparation

Make a set of **station identification process cards** (beginning on pg. 45). Each card represents a different operation in the constructed or man-made water cycle. Each card has a diagram, a brief description of the process, and student directions. The station cards are to be folded in the center and placed in a tent position.

Procedure

Warm Up

Introduce your students to the **Water Treatment** process from the Savannah River to the delivery of clear, clean drinking water with this YouTube Video:
https://www.youtube.com/watch?v=i4CfhiUTeIE
and **Wastewater Treatment** with this video:
https://www.youtube.com/watch?v=FvPakzqM3h8 Discuss the differences in the processes.

1. Divide students into four or five teams. Set up the **Station Identification Cards** on a table in random order, *graphic only facing class*. Each team will have 10 minutes to decide the order of processes and record it on the **River to River Warm Up Exercise** (pg. 39). The teams will present their process station sequence rationale to the class.

2. Hand out copies of the **Man-Made Water Cycle diagram** (pg. 38) and let each team discover how close they came to sequencing the treatment processes correctly. Select a student to position the process cards in the correct order showing the water treatment process from River to River.

Activity

1. Set up the classroom with the 18 stations, in order, beginning with the drinking water intake (see the charts on pages 40-44). At each station, place a matching **Station Identification Card**.

2. Depending on the number of students in your class assign one or two students to each station. Give students time to become familiar with their station process by reading the description on the card and looking at the graphic. **Have students prepare their station by making sure they have all necessary materials and by reading the step by step procedures given on the Station Identification Cards.**

3. After students have prepared their presentation, the *River to River* simulation will begin. It is important to have stations in close proximity to one another so that everyone can see what is being done at each station during presentations. **Students need to present the process and demonstrate it at their treatment station to the class and pass the processed water to the next station until the water is returned to the river.** One station presents at a time and sends their treated water to the next sequential station. Assign an area in the room for the landfill and place an empty cup/ container there.

Caution: Chemical use with this activity must be supervised by an adult. Take every precaution necessary to provide a safe environment for the students, including safety goggles and gloves.

Wrap Up

Knowing now what it takes to have clean water for drinking and what it takes to clean wastewater so that others can use it downstream should stimulate discussion with students concerning the actions they can take at home and at school to protect water. They can conserve water, and avoid dumping harmful chemicals, and paints down a drain for example. They could work on erosion areas in their yard at home or at school so that sediment doesn't end up in the river for example. Have students make a commitment for water and write it down. At the end of the week have students write about the actions they have taken to protect and conserve water.

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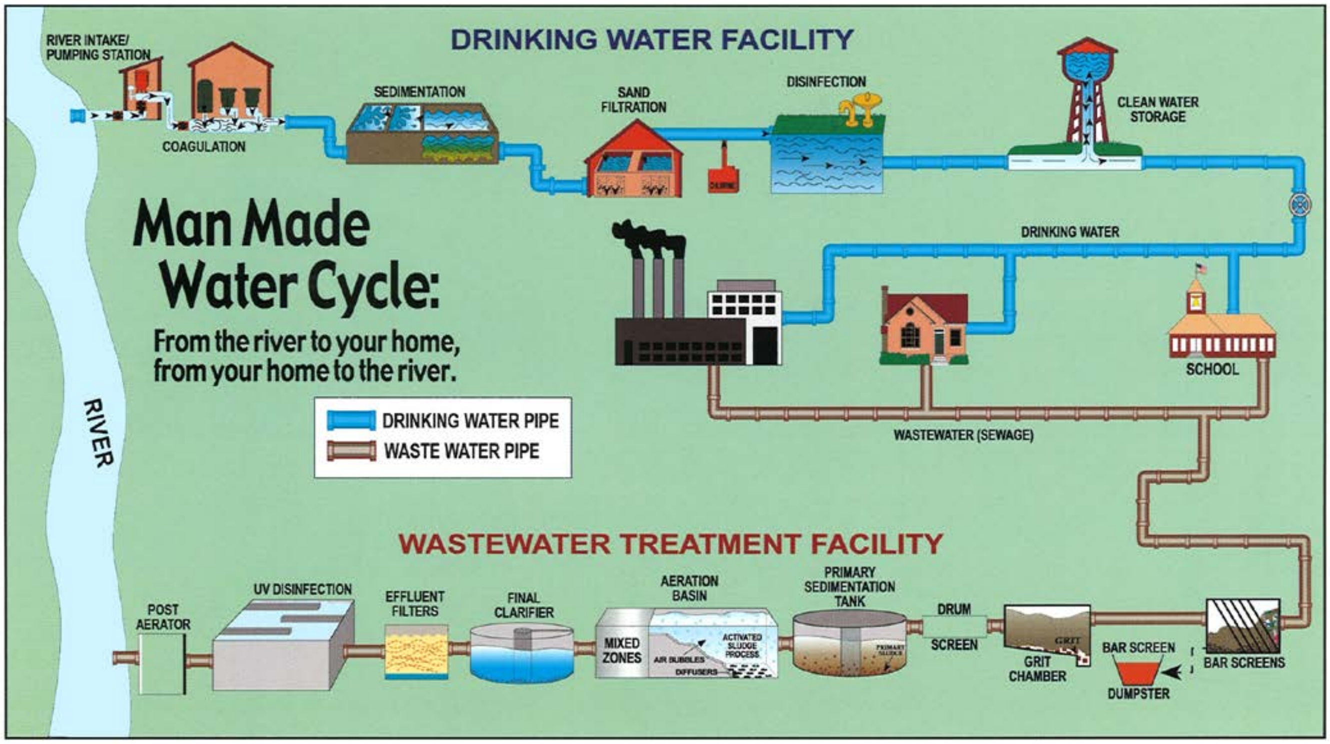
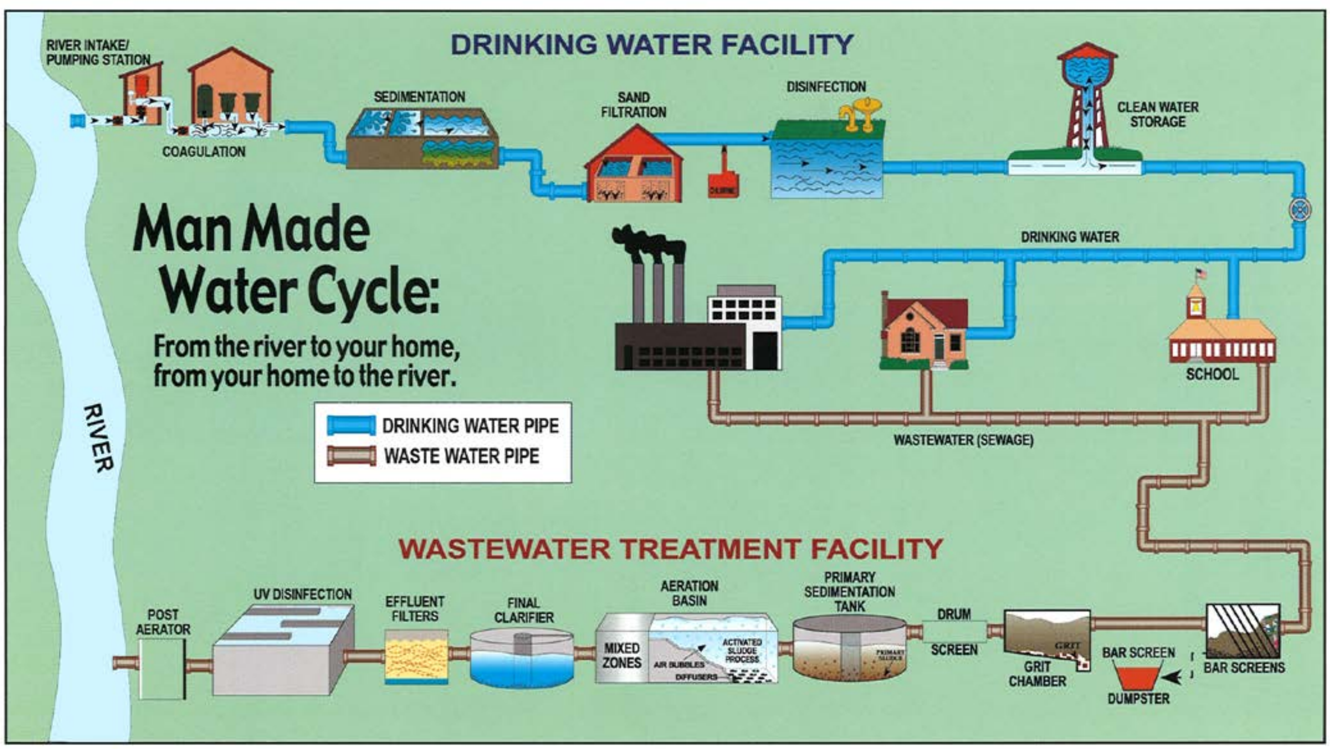
STEM Connection

Have a contest to design ways to clean water. Use the teachengineering.org site to find the activity "What happened to the Water?"

Assessment

Give students the diagram of the **Man-Made Water Cycle** without labels (pg. 63) and ask them to label each station using numbers that correspond to process stations below. Give the students the worksheet from the Warm Up with all of the stations listed in order and ask them to write one word or sentence that summarizes what happens at that stage of the process. Then ask the students to write a short essay that uses those words or sentences to explain the drinking water and wastewater treatment processes and the similarities and differences to a natural system.


DRINKING WATER FACILITY
RIVER INTAKE/ PUMPING STATION
COAGULATION
SEDIMENTATION
SAND FILTRATION
DISINFECTION
CLEAN WATER STORAGE
Man Made Water Cycle:
From the river to your home, from your home to the river.
DRINKING WATER
SCHOOL
RIVER
DRINKING WATER PIPE
WASTE WATER PIPE
WASTEWATER (SEWAGE)
WASTEWATER TREATMENT FACILITY
POST AERATOR
UV DISINFECTION
EFFLUENT FILTERS
FINAL CLARIFIER
AERATION BASIN
MIXED ZONES
PRIMARY SEDIMENTATION TANK
DRUM SCREEN
GRIT CHAMBER
BAR SCREEN
DUMPSTER
BAR SCREENS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POST AERATOR
UV DISINFECTION
EFFLUENT FILTERS
FINAL CLARIFIER
AERATION BASIN
MIXED ZONES
PRIMARY SEDIMENTATION TANK
DRUM SCREEN
GRIT CHAMBER
BAR SCREEN
DUMPSTER
BAR SCREENS

RIVER TO RIVER WARM UP EXERCISE

Please write the correct order of the drinking and wastewater treatment process steps next to the corresponding number in the blank provided.

1. River Intake

2. ____

3. ____

4. ____

5. ____

6. ____

7. ____

8. ____

9. ____

10. ____

11. ____

12. ____

13. ____

14. ____

15. ____

16. ____

17. ____

18. River Outfall

Follow these charts to set up the 18 stations in order:

<table>
<tr><td>DRINKING WATER TREATMENT</td><td>Each station will be performed one at a time as the water is passed along.</td></tr>
<tr><td>Station</td><td>Materials needed</td></tr>
<tr><td>1. River Intake and Pumping Station</td><td>A jar of “river water”-mix into the water a very small drop of food coloring, sediment, sand, sticks, leaves, seeds, bark and other debris; 3 clear empty cups; large and small screening tools to cover the cups</td></tr>
<tr><td colspan="2">Students at this station will
A. Pour water from the river jar into a clear cup in a lower position to simulate water flowing by gravity to the raw water pumping station.
B. Do a pumping motion for ten counts to represent the raw water pumping station that pumps water to the treatment facility.
C. Screen the water by placing a strainer/screen over an empty cup and pouring the river water through the screen into the empty cup to represent the screening out of larger debris at this stage. Pour the water through larger to smaller screens.
D. Take any remaining debris on the screen to the landfill.
E. The cup with the screened water is delivered to the coagulation station.

Three raw water intake conduits receive water from the river where it flows by gravity into underground wells before entering the pumping station. Electric pumps pump water to the water treatment plant raw water storage areas and then to the chemical house where the water treatment begins. Screening should be done with at least two screen sizes. As water moves through treatment, the processes are physical, chemical or biological. Most of the processes in water treatment are physical and chemical. This is a physical treatment.</td></tr>
<tr><td>2. Coagulation Station</td><td>Label 4 small jars with one additive each: phosphate, alum, lime, potassium permanganate, and carbon and put water in all jars except the alum jar. Put 2 Tablespoons of alum (from grocery) in that jar; plastic spoons; measuring spoons</td></tr>
<tr><td colspan="2">Students at this station will
A. Take the plastic cup with the river water that has been screened and do a chemical application. Wear goggles.
B. Pretend to add the chemicals by adding 1 teaspoon water from each additive jar to the river cup.
C. Add ½ teaspoon alum powder and stir it through the water. Wait several minutes for particles to “floc” together.
D. The cup is passed to the sedimentation station.

Control room operators will add lime for stabilizing the pH and buffering the water. The potassium permanganate kills the bacteria and virus in the water and the powdered carbon helps the water taste and smell good. The alum helps particles stick together and form larger particles called “floc.”</td></tr>
<tr><td>3. Sedimentation Station</td><td>1 clear plastic cup</td></tr>
<tr><td colspan="2">Students will
A. Take the water in the cup where the “floc” is attracting dirt particles and after a couple minutes, slowly pour off the water in the top of the cup into an empty cup.
B. Pass the cup to the filtration station.

The water and “floc” particles flow into a sedimentation basin. The “floc” settles to the bottom and is then removed from the water. The heavy particles that have settled to the bottom are taken to the landfill. The clear water on the top is now moved to filtration.</td></tr>
</table>

<table>
<tr><td>4. Filtration Station</td><td>2 clear cups, one (with hole in bottom) filled with alternating layers of sand and gravel; coffee filter cut to fit, is placed on the bottom of the cup before adding sand/gravel</td></tr>
<tr><td colspan="2">Students at this station will
A. Hold an empty cup underneath the sand and gravel cup. Pour the water from the sedimentation cup into the gravel and sand filter cup. The cleaner water will exit into the empty cup below. If time allows, pour this water through the second filter if you have made a second sand and gravel cup.
B. The cup then goes to the disinfection station

As the water passes through these filters smaller particles will be removed and trapped, imitating what happens in the natural cycle.</td></tr>
<tr><td>5. Disinfection Station</td><td>3 jars labeled chlorine, fluoride, and phosphate ½ filled with water; pipette to add drops of bleach; measuring spoon or plastic spoon; bleach in a small labeled jar. (use safety precautions- gloves and protective glasses)</td></tr>
<tr><td colspan="2">Students will
A. Add 1 teaspoon of each chemical to the water cup.
B. Add several drops of bleach.
C. Take the cup of water after chemicals are added to the storage station and pour water into a larger container that will hold all the water prior to sending it to homes, schools, and businesses.

Chlorine is added for disinfection. This should be done with gloves and protective glasses. Fluoride is added to protect teeth from decay, and phosphate is added for corrosion control. This helps keep pipes from leaving metals and things that might be dangerous to human health in the water.</td></tr>
<tr><td>6. Clear Water Storage Station</td><td>3 clear cups; a larger clear storage container filled to the half mark with water</td></tr>
<tr><td colspan="2">Students at this station will
A. Pour 1/3 cup water from the storage container into an empty cup and take the cup to the home station and leave it.
B. Pour about 1/3 cup water from the storage container into an empty cup and take the cup to the school and leave it.
C. Pour 1/3 cup water from the storage container into an empty cup and take the cup to the businesses and leave it.
D Do a pumping motion 10 times to represent the pumping of water through the system at this point.

This station represents a closed tank reservoir that holds the water and sends it through pipes to homes, schools, and businesses. Potable or finished water (water that has been treated) is stored in underground clearwells that are safe, contained places for clean water. The larger container represents water that has been previously stored. The pumping motion is the flow of water through the pipes from the storage station to the homes, schools, and businesses. These storage facilities help maintain adequate pressures throughout the entire system and meet the need for use in fire protection. Make sure students notice how clean the water is as it leaves drinking water treatment.</td></tr>
<tr><td>7. Homes, Schools, Businesses/Distribution and Use</td><td>cereal, toothpaste water, rice, beans, tissue pieces, vegetable oil, dish soap, etc. to represent household, school, and business waste</td></tr>
<tr><td colspan="2">Three students representing homes, schools and businesses will
A. Sprinkle into cups of water various items available to represent household, school, and business waste.
B. Give the cups to 3 students representing Homes, Schools, and Business

People use water to wash dishes, to shower, to flush toilets, to wash clothes and on average use about 50–150 gallons of water daily. They will take their cups to Wastewater Collection to represent wastewater traveling by pipe to water reclamation plants or wastewater treatment.</td></tr>
</table>

<table>
<tr><td>WASTEWATER TREATMENT</td><td></td></tr>
<tr><td>Station</td><td>Materials needed</td></tr>
<tr><td>8. Homes, Schools, Businesses/ Wastewater Collection</td><td>Large container with lid for wastewater; a clear plastic cup labeled Headworks</td></tr>
<tr><td colspan="2">The students at this station
A. Gently shake the wastewater in the large container and pour it into an empty cup to represent the water moving toward the bar screen building.
B. Pour the water from the large container into an empty cup labeled Headworks (place where wastewater treatment begins)
C. Deliver it to the Bar Screen Station.

Miles of sewers collect the wastewater and with the help of pumping stations, deliver it to the wastewater treatment plant. An Atlanta Plant, for example, has three levels of purification - primary, secondary and advanced. The plant can handle 240 million gallons of water daily but normally handles about 100 million gallons a day.</td></tr>
<tr><td>9. Bar Screen Station and Bar Screen Dumpster</td><td>2 plastic cups: labeled Bar Screen Dumpster and the Landfill; screen for debris.</td></tr>
<tr><td colspan="2">Students at this station will
A. Place the large screen over an empty cup and pour the wastewater labeled Headworks through the screen to separate out the large debris.
B. Take the debris left on the screen to the dumpster. From there the debris is taken to the landfill.
C. Pass the cup of water to the Grit Chamber Station.

At this station large screens separate out large debris such as rags, bottles, soccer balls, and sticks from the water. This is a physical process.</td></tr>
<tr><td>10. Grit Chamber Station</td><td>Funnel and 2 clear cups</td></tr>
<tr><td colspan="2">Students at this station will
A. Place a funnel in an empty cup and very slowly pour the screened water into the funnel.
B. Pour water from the top of the cup off into another cup leaving any debris in the bottom.
C. Take any debris and particles left in the bottom to the landfill.
D. Pass the cup of water to the Drum Screen Station.

At this station, smaller debris and particles are removed through a process that slows the water. In the actual process the heavier inorganic particles settle to the bottom while the lighter organic solids remain suspended.</td></tr>
</table>

<table>
<tr><td>11. Drum Screen Station</td><td>Small screen like a tea strainer; 1 clear plastic cup for debris; and 1 clear plastic cup for screened water</td></tr>
<tr><td colspan="2">Students will
A. Place a fine screen across the top of the cup and pour the water through it into another cup. This removes smaller debris, plastics, and smaller particles.
B. The debris in the screen is put in a cup and sent to the landfill.
C. The cup is taken to the primary sedimentation tank.

This station contains a wheel that holds debris and drops it into a trough as it turns. This finer screening eliminates smaller debris. Gravity holds the solids and the wheel turns while particles fall into troughs. These particles are then taken to the landfill.</td></tr>
<tr><td>12. Primary Sedimentation Tank (Clarifier)</td><td>2 clear cups; spoon; cup labeled digester</td></tr>
<tr><td colspan="2">Students will
A. Let the particles settle further and use a spoon to skim any oil and grease from the top and pour in another cup.
B. Pour off water in the top of the cup into an empty cup allowing any particles that have settled to remain in the bottom of the other cup.
C. Take the settled particles to the digester and the water to the aeration basin.

During the primary sedimentation process, the heavier particles settle to the bottom of the tank. Water is held here for several hours to allow settling out of heavier particles. 70% of all the solids are removed at this point. Settled particles, or primary sludge go to a centrifuge to be thickened and then to a digester (special tank where it is disinfected and dewatered). The sludge, or biosolids, is landfilled, recycled by burning for fuel, used as fertilizer, or soil conditioner. Lighter materials such as oil and grease, float to the top and are skimmed from the surface.</td></tr>
<tr><td>13. Aeration Basin</td><td>Turkey baster; microorganism hats, “chemical” jars, construction paper, scissors, tape or stapler</td></tr>
<tr><td colspan="2">3 persons needed at this station: 2 microorganisms with masks or hats and 1 to do the process.
A. An aeration station student goes to the digester and brings the microorganisms to the Aeration Basin. Microbes gather at the digester and pretend to be eating frantically.
B. Third student pretends to add chemicals to the water.
C. Microorganisms sing the song (See song on process card). Squeeze air into the Aeration Basin using the turkey baster.
D. The microorganisms move to the final clarifier with the cup.

The Aeration Basin is a tank that mixes air with water to help microorganisms consume harmful materials. This tank also contains chemicals that cause settling to occur. During this chemical process the primary sludge is settled and the phosphorus is removed. This is a biological and chemical process and is secondary treatment.</td></tr>
<tr><td>14. Final Clarifier</td><td>1 cup; 1 spoon; and the microorganisms from the last station</td></tr>
<tr><td colspan="2">Students at this station will
A. Stir slowly the cup and then let the sedimentation occur.
B. Wait a couple minutes and pour the water off the top into another cup and take that cup to the filtration station.
C. The cup is passed to the effluent filters. Microbes stay at this station.

In this secondary process the microorganisms bond to the pollutants; flocculation occurs followed by settling. Clumps form with solids settling to the bottom. These clarifier tanks have large arms that rotate slowly so that the sludge and scum settle to the bottom. The arms are 150 feet in diameter and 20 feet deep.</td></tr>
</table>

<table>
<tr><td>15. Effluent Filters</td><td>4 clear cups; 2 sand and gravel cups; coffee filter; construction paper, scissors, tape or stapler</td></tr>
<tr><td colspan="2">Students at this station will
A. Put a hole in the bottom of the cups and line the bottom with a piece of coffee filter to keep the sand in the cup.
B. Construct filters in the cups by alternating layers of rock and sand making the rock layer at the bottom smaller.
C. Filter the cup of water from the clarifier by pouring water through both cups into another cup. If time is short use only one filter cup.
D. Someone at this station will take a younger microorganism back to the Aeration Basin to continue eating contaminants and take the other older bugs back to the digester

This process removes any final particles and sedimentation left after secondary sedimentation treatment. This step imitates the natural process by moving water through filters of rock and sand that scrub the water as it seeps through crushed stones covered with microorganisms that facilitate degradation of the sludge. Pumps pull water through stone filters that contain progressively smaller rocks finally going through sand filters. The stones scour and the backwash pump blows water around until it goes back to the system.</td></tr>
<tr><td>16. Ultra-violet (UV) Disinfection</td><td>Flashlight</td></tr>
<tr><td colspan="2">Students will
A. Take a flashlight and shine light on the water for 30 seconds to imitate the UV disinfection process
B. Pass the water to Post Aeration.

During this process ultraviolet light becomes a disinfection system. The ultra-violet light kills the microorganisms that remain in the water that can cause disease. In some treatment plants chlorine is used at this stage for disinfection.</td></tr>
<tr><td>17. Post Aeration</td><td>1 cup</td></tr>
<tr><td colspan="2">Students at this station will
A. Pour the treated water into a lower cup from a foot above the other cup to mimic the process of aeration.
B. Students at this station will take their water and show it to the class prior to its return to the river.

Post Aeration ensures an adequate amount of dissolved oxygen in the effluent or treated water prior to release to the river. In nature water passes over rocks called riffles in the stream providing oxygen to the water. As the water is poured from one cup higher than another cup it causes agitation of the water just like a riffle does in a stream where there is water moving over rocks.</td></tr>
<tr><td>18. River Outfall</td><td>Container labeled river</td></tr>
<tr><td colspan="2">The student at this station will
A. Return the water to the container that represents the river.

After treatment, the cleaned water will continue its journey from the river to the ocean. Others can use the cleaned water downstream for drinking water, for irrigation, for industry, or it might evaporate and become rain in some other part of the world. Water is used over and over again throughout the water cycle.</td></tr>
<tr><td colspan="2"></td></tr>
</table>

STATION IDENTIFICATION CARDS

Copy the 18 cards that follow onto card stock, cut out and fold in half so that they stand upright on the table.

1. River Intake and Pumping Station: A jar of "river water"-mix into the water a very small drop of food coloring, sediment, sand, sticks, leaves, seeds, bark and other debris; 3 clear empty cups; large and small screening tools to cover the cups

Students at this station will

A. Pour water from the river jar into a clear cup in a lower position to simulate water flowing by gravity to the raw water pumping station.

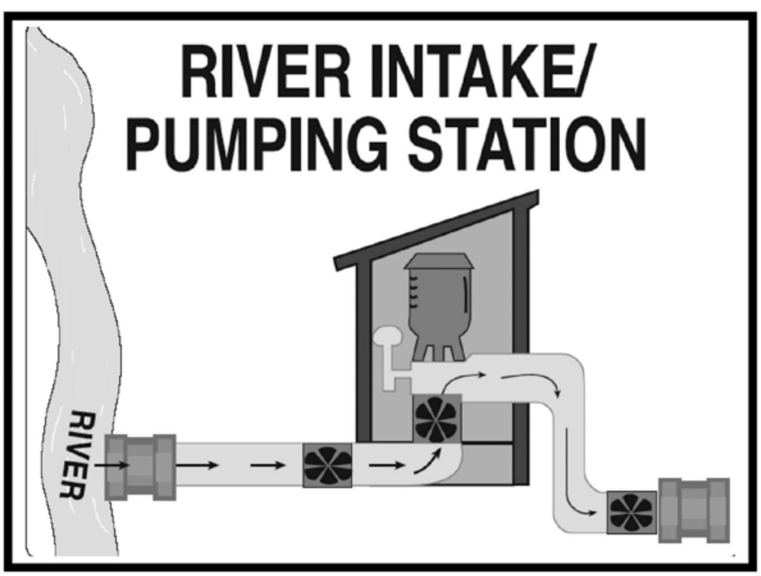
B. Do a pumping motion for ten counts to represent the raw water pumping station that pumps water to the treatment facility.

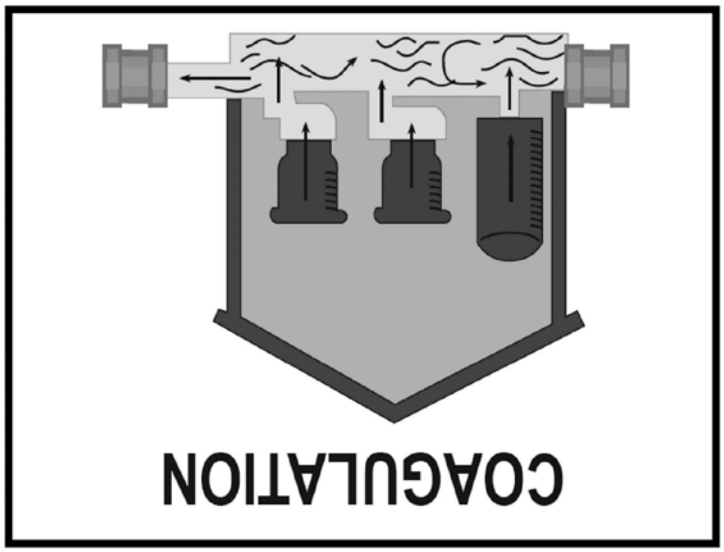
C. Screen the water by placing a strainer/screen over an empty cup and pouring the river water through the screen into the empty cup to represent the screening out of larger debris at this stage. Pour the water through larger to smaller screens.

D. Take any remaining debris on the screen to the landfill.

E. The cup with the screened water is delivered to the Coagulation Station.

Three raw water intake conduits receive water from the river where it flows by gravity into underground wells before entering the pumping station. Electric pumps pump water to the water treatment plant raw water storage areas and then to the chemical house where the water treatment begins. Screening should be done with at least two screen sizes. As water moves through treatment, the processes are physical, chemical or biological. Most of the processes in water treatment are physical and chemical. This is a physical treatment.





2. Coagulation Station Label: 4 small jars with one additive each: phosphate, alum, lime, potassium permanganate, and carbon and put water in all jars except the alum jar. Put 2 Tablespoons of alum (from grocery) in that jar; plastic spoons; measuring spoons

Students at this station will

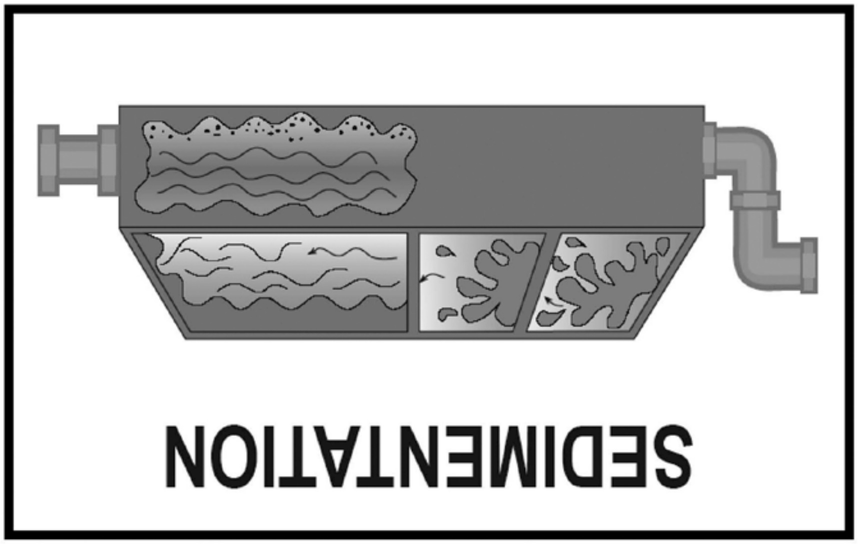
A. Take the plastic cup with the river water that has been screened and do a chemical application.

B. Pretend to add the chemicals by adding 1 teaspoon water from each additive jar to the river cup.

C. Add ½ teaspoon alum powder and stir it through the water. Wait several minutes for particles to “floc” together.

D. The cup is passed to the Sedimentation Station.

Control room operators will add lime for stabilizing the pH and buffering the water. The potassium permanganate kills the bacteria and virus in the water and the powdered carbon helps the water taste and smell good. The alum helps particles stick together and form larger particles called “floc.”



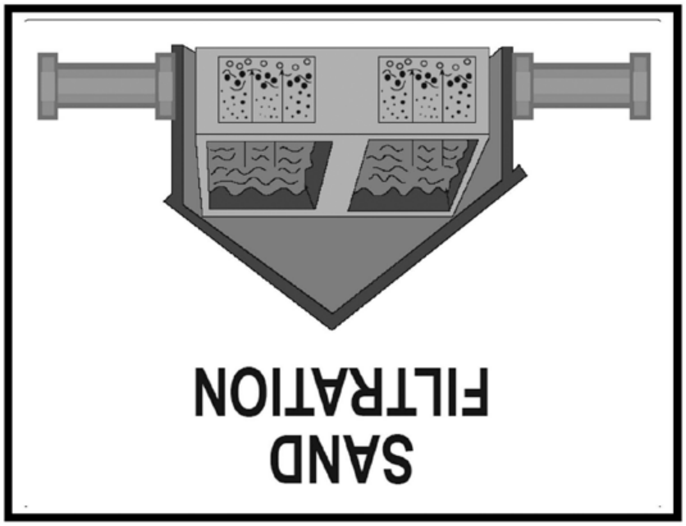
3. Sedimentation Station: 1 clear plastic cup

Students will

A. Take the water in the cup where the "floc" is attracting dirt particles and after a couple minutes, slowly pour off the water in the top of the cup into an empty cup.

B. Pass the cup to the Filtration Station.

The water and "floc" particles flow into a sedimentation basin. The "floc" settles to the bottom and is then removed from the water. The heavy particles that have settled to the bottom are taken to the landfill. The clear water on the top is now moved to filtration.



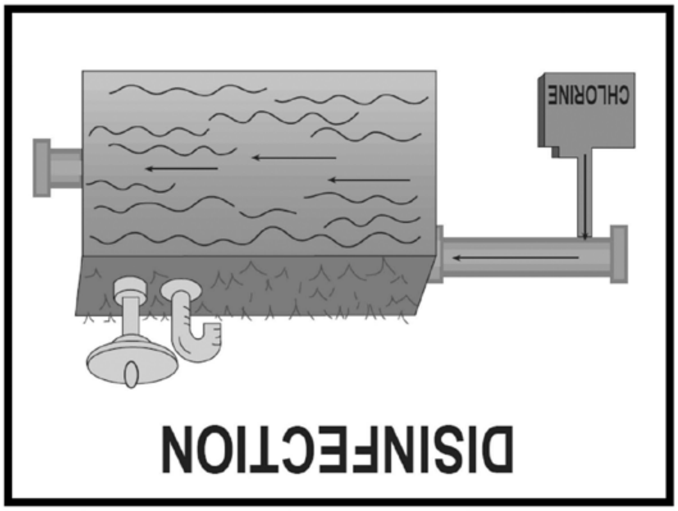
4. Filtration Station: 2 clear cups, one (with hole in bottom) filled with alternating layers of sand and gravel; coffee filter cut to fit, is placed on the bottom of the cup before adding sand/gravel

Students at this station will

A. Hold an empty cup underneath the sand and gravel cup. Pour the water from the sedimentation cup into the gravel and sand filter cup. The cleaner water will exit into the empty cup below. If time allows, pour this water through the second filter if you have made a second sand and gravel cup.Z

B. The cup then goes to the disinfection station

As the water passes through these filters smaller particles will be removed and trapped, imitating what happens in the natural cycle.

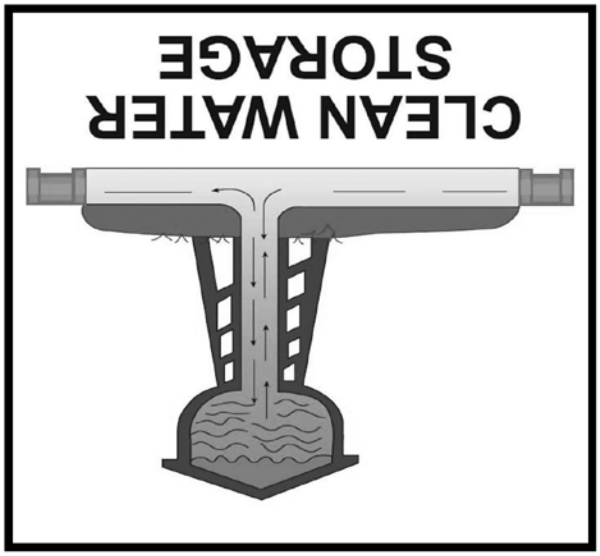


5. Disinfection Station 3 jars labeled chlorine, fluoride, and phosphate ½ filled with water; pipette to add drops of bleach; measuring spoon or plastic spoon; bleach in a small labeled jar. (use safety precautions- gloves and protective glasses)

Students will

A. Add 1 teaspoon of each chemical to the water cup.
B. Add several drops of bleach.
C. Take the cup of water after chemicals are added to the storage station and pour water into a larger container that will hold all the water prior to sending it to homes, schools, and businesses.

Chlorine is added for disinfection. This should be done with gloves and protective glasses. Fluoride is added to protect teeth from decay, and phosphate is added for corrosion control. This helps keep pipes from leaving metals and things that might be dangerous to human health in the water.



6. Clear Water Storage Station: 3 clear cups; a larger clear storage container filled to the half mark with water

Students at this station will

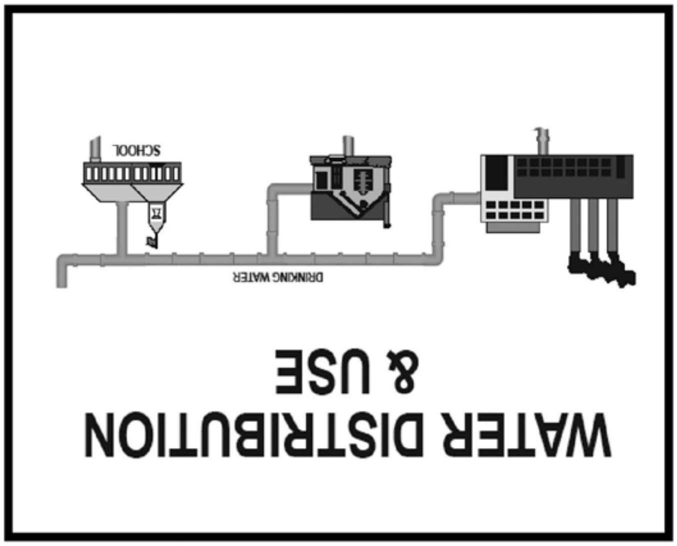
A. Pour 1/3 cup water from the storage container into an empty cup and take the cup to the home station and leave it.

B. Pour about 1/3 cup water from the storage container into an empty cup and take the cup to the school and leave it.

C. Pour 1/3 cup water from the storage container into an empty cup and take the cup to the businesses and leave it.

D Do a pumping motion 10 times to represent the pumping of water through the system at this point.

This station represents a closed tank reservoir that holds the water and sends it through pipes to homes, schools, and businesses. Potable or finished water (water that has been treated) is stored in underground clearwells that are safe, contained places for clean water. The larger container represents water that has been previously stored. The pumping motion is the flow of water through the pipes from the storage station to the homes, schools, and businesses. These storage facilities help maintain adequate pressures throughout the entire system and meet the need for use in fire protection. Make sure students notice how clean the water is as it leaves drinking water treatment.



7. Homes, Schools, Businesses/Distribution and Use: cereal, toothpaste water, rice, beans, tissue pieces, vegetable oil, dish soap, etc. to represent household, school, and business waste

Three students representing homes, schools and businesses will

A. Sprinkle into cups of water various items available to represent household, school, and business waste.

B. Give the cups to 3 students representing Homes, Schools, and Business

People use water to wash dishes, to shower, to flush toilets, to wash clothes and on average use about 50–150 gallons of water daily. They will take their cups to Wastewater Collection to represent wastewater traveling by pipe to water reclamation plants or wastewater treatment.

8. Homes, Schools, Businesses/ Wastewater Collection: Large container with lid for wastewater; a clear plastic cup labeled Headworks

The students at this station

A. Gently shake the wastewater in the large container and pour it into an empty cup to represent the water moving toward the bar screen building.

B. Pour the water from the large container into an empty cup labeled Headworks (place where wastewater treatment begins)

C. Deliver it to the Bar Screen Station.

Miles of sewers collect the wastewater and with the help of pumping stations, deliver it to the wastewater treatment plant. An Atlanta Plant, for example, has three levels of purification - primary, secondary and advanced. The plant can handle 240 million gallons of water daily but normally handles about 100 million gallons a day.

9. Bar Screen Station and Bar Screen Dumpster: 2 plastic cups: labeled Bar Screen Dumpster and the Landfill; screen for debris.

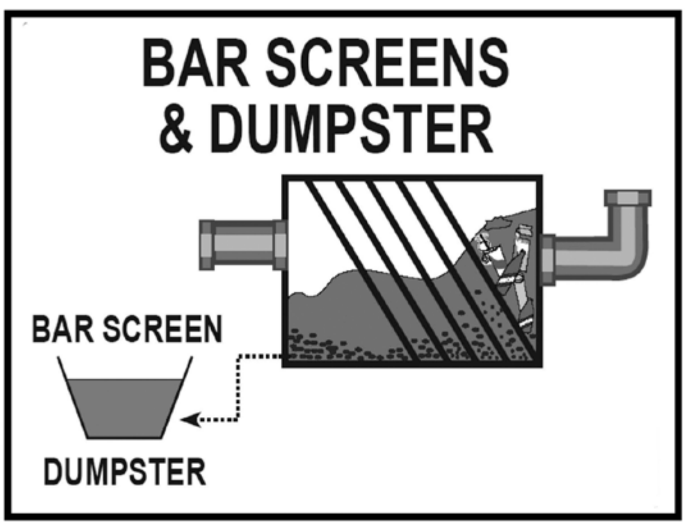
Students at this station will

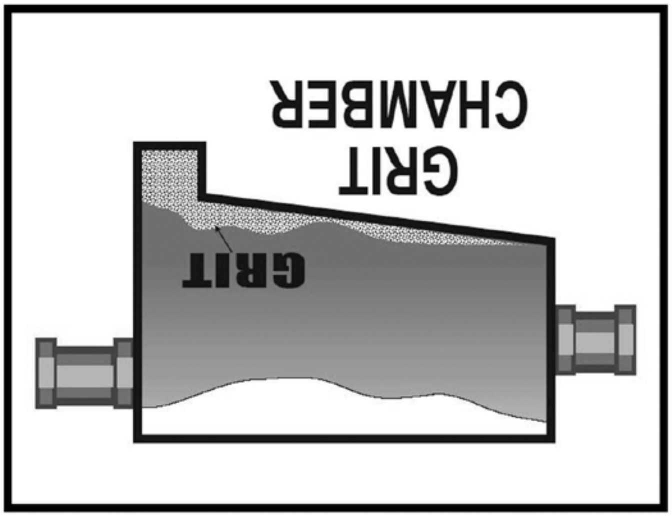
A. Place the large screen over an empty cup and pour the wastewater labeled Headworks through the screen to separate out the large debris.

B. Take the debris left on the screen to the dumpster. From there the debris is taken to the land fill.

C. Pass the cup of water to the Grit Chamber Station.

At this station large screens separate out large debris such as rags, bottles, soccer balls, and sticks from the water. This is a physical process.





10. Grit Chamber Station: Funnel and 2 clear cups

Students at this station will

A. Place a funnel in an empty cup and very slowly pour the screened water into the funnel.
B. Pour water from the top of the cup off into another cup leaving any debris in the bottom.
C. Take any debris and particles left in the bottom to the landfill.
D. Pass the cup of water to the Drum Screen Station.

At this station, smaller debris and particles are removed through a process that slows the water. In the actual process the heavier inorganic particles settle to the bottom while the lighter organic solids remain suspended.

11. Drum Screen Station: Small screen like a tea strainer; 1 clear plastic cup for debris; and 1 clear plastic cup for screened water

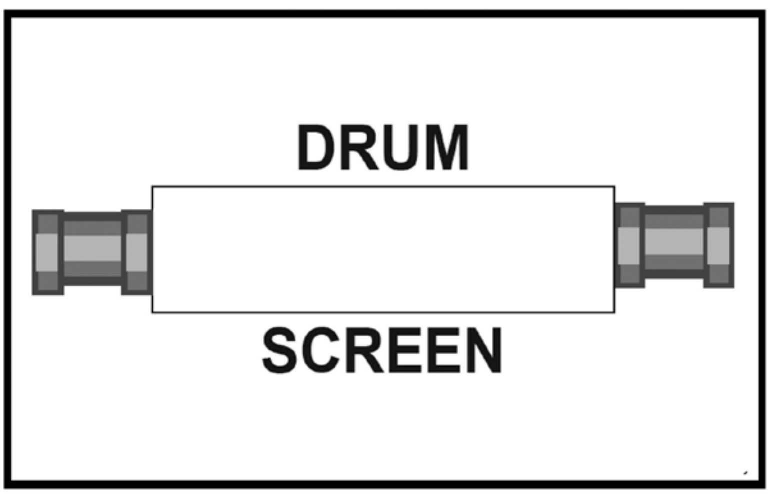
Students will

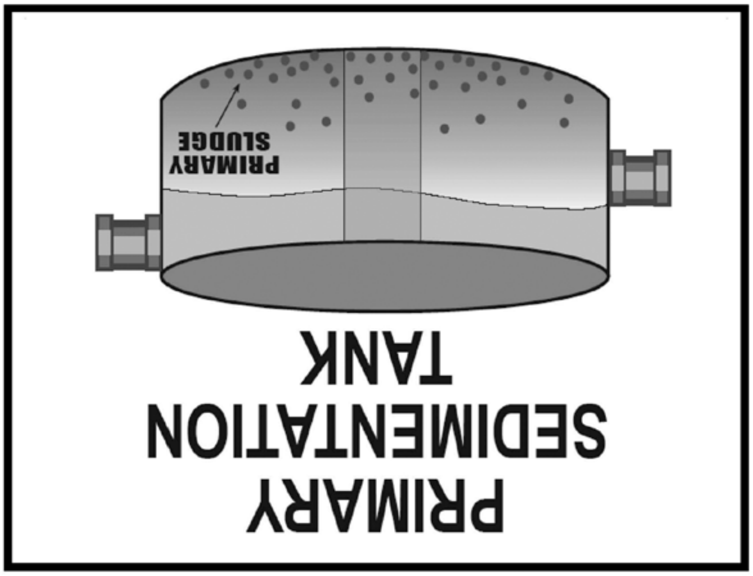
A. Place a fine screen across the top of the cup and pour the water through it into another cup. This removes smaller debris, plastics, and smaller particles.

B. The debris in the screen is put in a cup and sent to the landfill.

C. The cup is taken to the primary sedimentation tank.

This station contains a wheel that holds debris and drops it into a trough as it turns. This finer screening eliminates smaller debris. Gravity holds the solids and the wheel turns while particles fall into troughs. These particles are then taken to the landfill.





12. Primary Sedimentation Tank (Clarifier): 2 clear cups; spoon; cup labeled digester

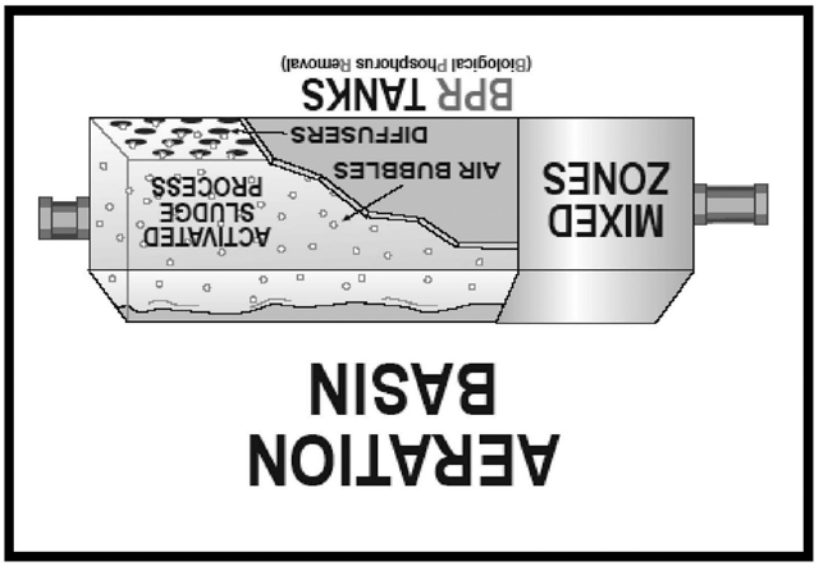
Students will

A. Let the particles settle further and use a spoon to skim any oil and grease from the top and pour in another cup.

B. Pour off water in the top of the cup into an empty cup allowing any particles that have settled to remain in the bottom of the other cup.

C. Take the settled particles to the digester and the water to the Aeration Basin.

During the primary sedimentation process, the heavier particles settle to the bottom of the tank. Water is held here for several hours to allow settling out of heavier particles. 70% of all the solids are removed at this point. Settled particles, or primary sludge go to a centrifuge to be thickened and then to a digester (special tank where it is disinfected and dewatered). The sludge, or biosolids, is landfilled, recycled by burning for fuel, used as fertilizer, or soil conditioner. Lighter materials such as oil and grease, float to the top and are skimmed from the surface.



13. Aeration Basin: Turkey baster; microorganism hats, "chemical" jars, construction paper, scissors, tape or stapler

3 persons needed at this station: 2 microorganisms with masks or hats and 1 to do the process.

A. Microbes make hats or masks to wear, wait at the digester. An aeration station student goes to the digester and brings the microorganisms to the Aeration Basin. Microbes gather at the digester and pretend to be eating frantically.

B. Third student pretends to add chemicals to the water.

C. Microorganisms sing the song (See song on process card). Squeeze air into the Aeration Basin using the turkey baster.

D. The microorganisms move to the final clarifier with the cup.

The Aeration Basin is a tank that mixes air with water to help microorganisms consume harmful materials. This tank also contains chemicals that cause settling to occur. During this chemical process the primary sludge is settled and the phosphorus is removed. This is a biological and chemical process and is secondary treatment.

14. Final Clarifier: 1 cup; 1 spoon; and the microorganisms from the last station

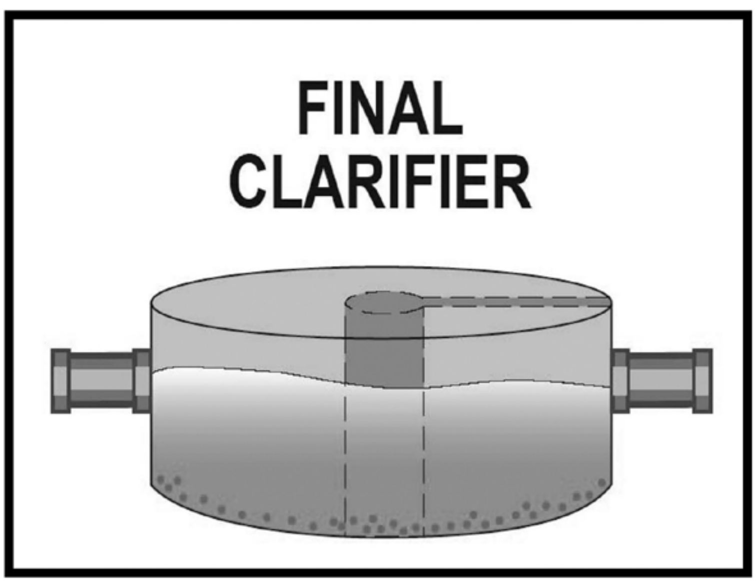
Students at this station will

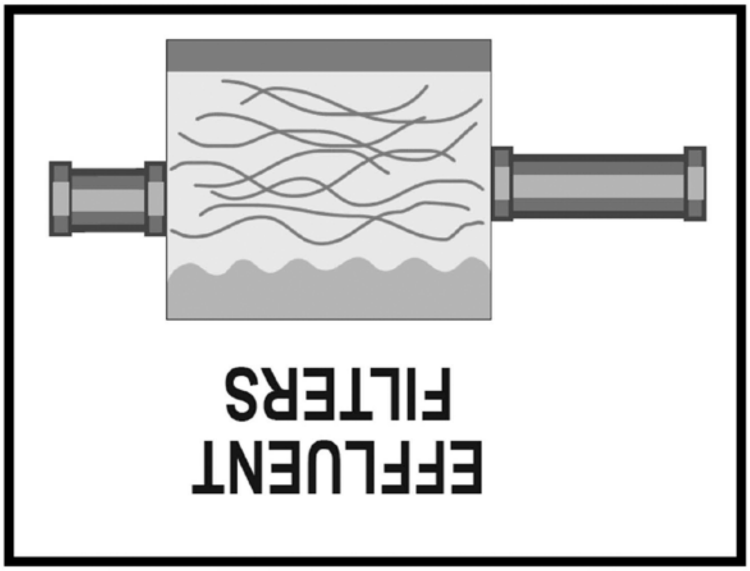
A. Stir slowly the cup and then let the sedimentation occur.

B. Wait a couple minutes and pour the water off the top into another cup and take that cup to the filtration station.

C. The cup is passed to the effluent filters. Microbes stay at this station.

In this secondary process the microorganisms bond to the pollutants; flocculation occurs followed by setting. Clumps form with solids setting to the bottom. These clarifier tanks have large arms that rotate slowly so that the sludge and scum settle to the bottom. The arms are 150 feet in diameter and 20 feet deep.





15. Effluent Filters: 4 clear cups; 2 sand and gravel cups; coffee filter; construction paper, scissors, tape or stapler

Students at this station will

A. Put a hole in the bottom of the cups and line the bottom with a piece of coffee filter to keep the sand in the cup.

B. Construct filters in the cups by alternating layers of rock and sand making the rock layer at the bottom smaller.

C. Filter the cup of water from the clarifier by pouring water through both cups into another cup. If time is short use only one filter cup.

D. Someone at this station will take a younger microorganism back to the Aeration Basin to continue eating contaminants and take the other older bugs back to the digester

This process removes any final particles and sedimentation left after secondary sedimentation treatment. This step imitates the natural process by moving water through filters of rock and sand that scrub the water as it seeps through crushed stones covered with microorganisms that facilitate degradation of the sludge. Pumps pull water through stone filters that contain progressively smaller rocks finally going through sand filters. The stones scour and the backwash pump blows water around until it goes back to the system.

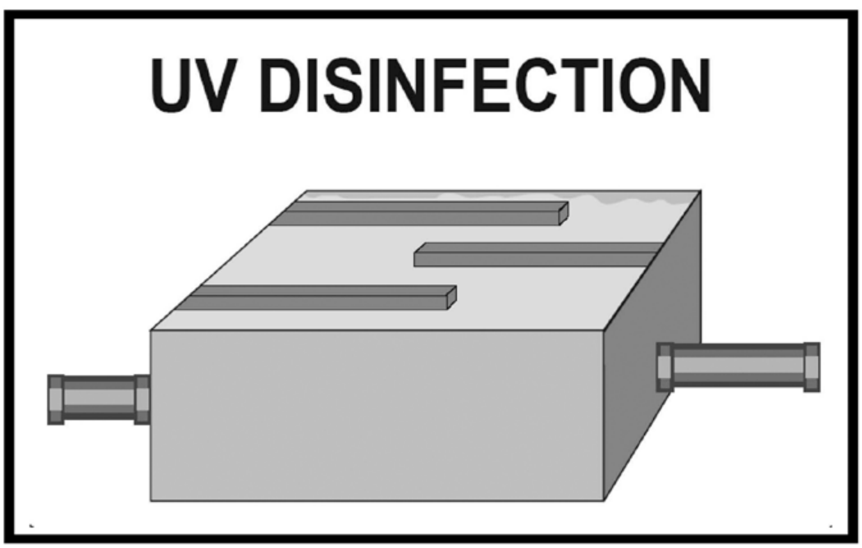
16. Ultra-violet (UV) Disinfection: Flashlight

Students will

A. Take a flashlight and shine light on the water for 30 seconds to imitate the UV disinfection process

B. Pass the water to Post Aeration.

During this process ultraviolet light becomes a disinfection system. The ultra-violet light kills the microorganisms that remain in the water that can cause disease. In some treatment plants chlorine is used at this stage for disinfection.



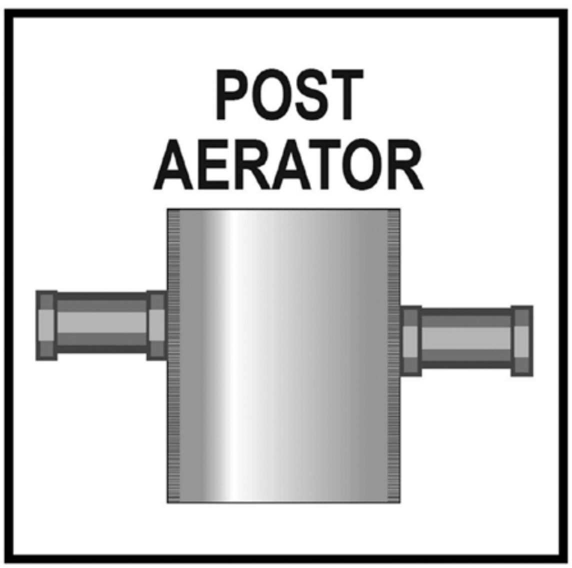
17. Post Aeration: 1 cup

Students at this station will

A. Pour the treated water into a lower cup from a foot above the other cup to mimic the process of aeration.

B. Students at this station will take their water and show it to the class prior to its return to the river.

Post Aeration ensures an adequate amount of dissolved oxygen in the effluent or treated water prior to release to the river. In nature water passes over rocks called riffles in the stream providing oxygen to the water. As the water is poured from one cup higher than another cup it causes agitation of the water just like a riffle does in a stream where there is water moving over rocks.

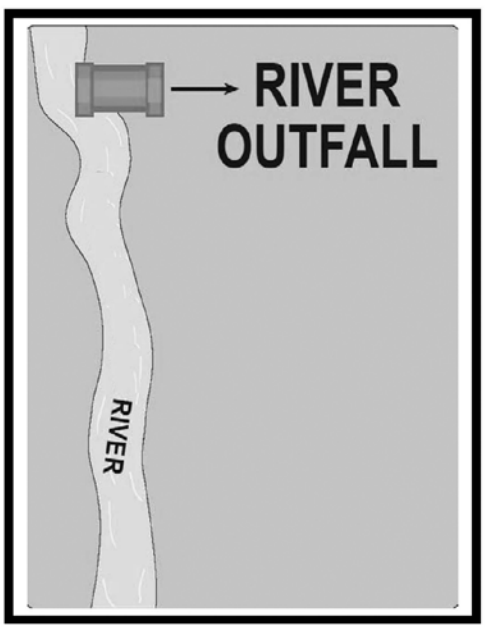


18. River Outfall: Container labeled RIVER

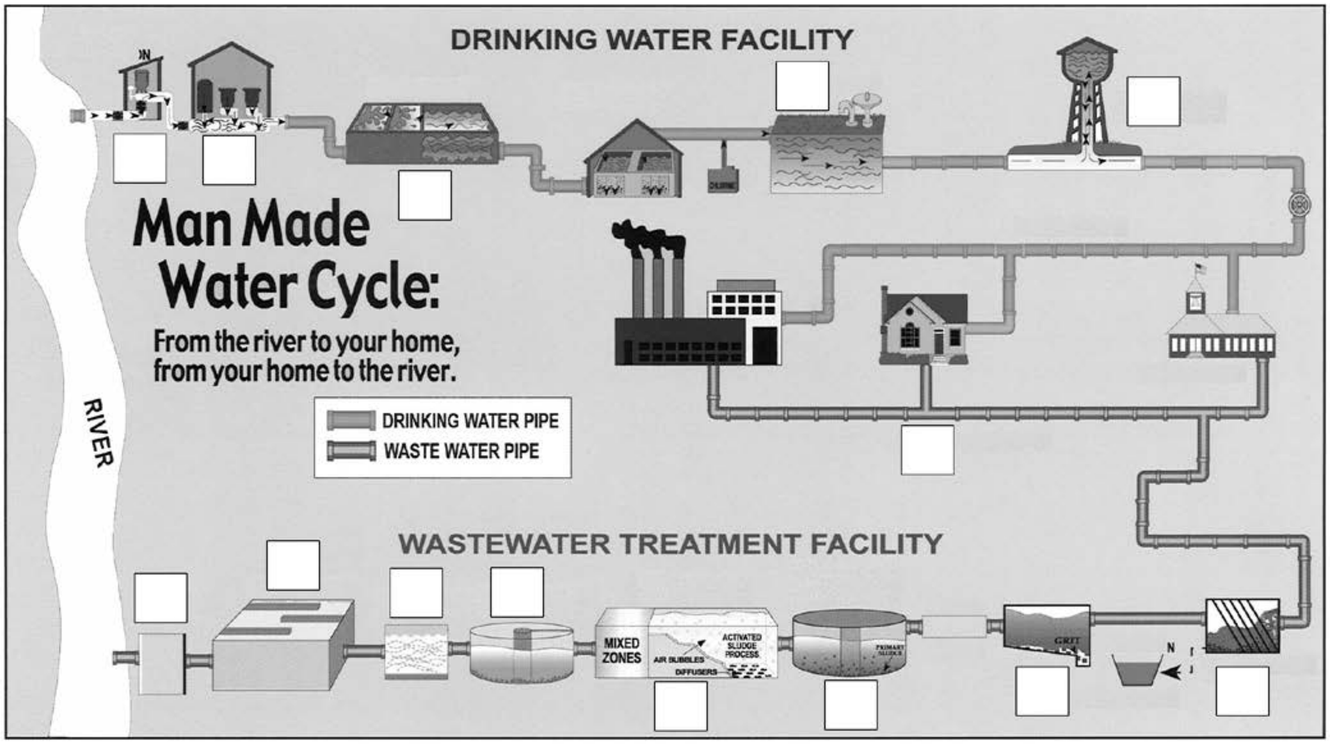
The student at this station will

A. Return the water to the container that represents the river.

After treatment, the cleaned water will continue its journey from the river to the ocean. Others can use the cleaned water downstream for drinking water, for irrigation, for industry, or it might evaporate and become rain in some other part of the world. Water is used over and over again throughout the water cycle.



STUDENT ASSESSMENT



Write the number located in parenthesis next to each process underneath the matching process graphic located on the Man Made Water Cycle: From the river to your home, from your home to your river

Primary Sedimentation Tank **(1)**

UV Disinfection **(2)**

River Intake/Pumping Station **(3)**

Clean Water Storage **(4)**

Bar Screen & Dumpster **(5)**

Sand Filtration **(6)**

Wastewater (Sewage) **(7)**

Drinking Water **(8)**

Coagulation **(9)**

Effluent Filters **(10)**

Grit Chamber **(11)**

Sedimentation **(12)**

Post Aerator **(13)**

Final Clarifier **(14)**

Drum Screen **(15)**

Disinfection **(16)**

Aeration Basin **(17)**

NAME ________________________________

Use this section to introduce Stormwater and its impact on the environment.

WHAT IS STORMWATER AND WHERE DOES IT GO?

ADD these Project WET Activities to your study of Stormwater--

River System:	**Blue River, pg. 135**
Urban Water Cycle:	**Incredible Journey, pg. 155**
Nonpoint Source:	**A-maze-ing Water, pg. 231**
	Sum of the Parts, pg. 283
Stormwater:	**Storm Water, pg. 395**
	Macroinvertebrate Mayhem, pg. 343

project WET

Stormwater adaptations available on Portal.projectwet.org

STEM Connection

SCIENCE • TECHNOLOGY • ENGINEERING • MATHEMATICS

Find these Engineering Connections to STORMWATER on www.teachengineering.org

- *Do a SEARCH for Stormwater and find 18 different engineering activities to choose from.*

Use ProjectWET.Georgia.gov to find Georgia Science and Mathematics Standards for Project WET and Urban Activities

Find Technology connections in the Resources Section at the end of this book!

HOW MUCH WATER FALLS HERE?

Students calculate the amount of water that runs off of paved areas when it rains.
From the Georgia Adopt-A-Stream Educator's Guide

Charting the Course

Use Project WET's *Blue River* and the *Incredible Journey/Blue Traveler* stormwater adaptations prior to this activity.

Objectives

Students will

- Calculate the volume of water that falls onto an area of the school parking lot.
- Compare this volume to common water-consuming activities
- Create methods for slowing the water runoff from impervious surfaces

Materials

- Yardstick
- Writing materials
- Tape measure
- Graph paper
- Map of area
- Rulers
- Long piece of twine (marked at meter and foot intervals)
- Trundel wheel (optional)
- Local rainfall data
- Clipboards (optional)
- Calculators

Background

When it rains, where does the water go? Some of it is absorbed by the soil and plants, some is evaporated back into the air and some runs off the land. When it rains in areas with lots of impervious surface (parking lots, roofs, roads), water runs off to storm drains and drainage ditches, often at a fast rate because it is not absorbed into the ground.

Urbanization and other development often adversely affect stream health by increasing the volume of surface runoff entering a local waterway. Urban stormwater runoff may contain sediment, debris, oil, gasoline, heavy metals, and other nonpoint source pollution that was picked up after traveling over impervious surfaces.

When potential pollutants are transported quickly from the land to a waterway, this can cause a phenomenon called "shock loading." Shock loading is the overloading of water with nutrients, sediment, oil, etc., over a very short period of time giving the organisms little time to adapt to the changes in their environment. Shock loading can result in fish kills or algal blooms depending upon the type of pollutants in the runoff. For example, suspended materials in the runoff can also absorb and store heat that increases the water temperature.

Preparation

To find the average annual rainfall for your area visit https://www.weather.gov/ffc/rainfall_scorecard then search for cities in Georgia. You could also contact the local weather center or Soil Conservation Service in your county.

Measure the area of study ahead of time and prepare a sketch to use on the board.

Procedure

Activity

Explain to the students they are going to calculate the volume of runoff from the school parking lot that flows to the nearest stream.

Part one: Calculate the area of the school parking lot and volume of runoff.

1. Divide the class into teams of 3-5 students.

Draw a sketch of the parking lot on the board. Have each team select an area they wish to measure. If the lot has multiple sections, give each group a certain area to measure. *Note: Make sure the students use the same measurement unit (feet or meters).*

2. Have the students take needed measurements outside. Transfer all measurements to the sketch on the board.

3. Have students copy the sketch of the parking lot with all measurements on a plain piece of paper and/or to scale on graph paper.

4. Teams determine the direction of runoff and distance to nearest stream. *Note: A map can be used to estimate a distance to the stream, if the stream is not next to the parking lot.*

5. Students estimate the area of the parking lot by breaking it up into even shapes. For example:

Square: Area = Length X Width
Triangle: Area = ½ Base X Height

Add together all the individual shapes' areas to find the total area of the parking lot.

6. Determine the volume of rain falling on the parking lot annually by multiply the average annual rainfall (convert inches to feet or meters) by the overall area of the parking lot (square feet or meters). Volume should be recorded in cubic feet (ft^3) or cubic meters (m^3).

Part Two: Comparisons of runoff volume to everyday water usage.

The following chart may be useful:

$1\ ft^3$ = 7.2827 gallons
$1\ m^3$ = 1,000 liters
5 minute shower = 25 gallons or 95 liters
Density of water = 1 gallon = 8.34 lbs.
1 liter = 1 kg.

1. Have students calculate the following:

Average annual rainfall:	_______________ inches
Convert rainfall from inches to feet	_______________ ft (X 1ft/12in.)
Surface Area of Parking Lot	_______________ ft^2
Volume of runoff	_______________ ft^3
Convert volume of runoff to gallons	_______________ gallons of runoff
Determine how many 5 min. showers can be taken with the amount of runoff	_______________ showers
If you took a shower every day, how long would it take to shower this many times?	_______________ years
Determine the weight of runoff in lbs.	_______________ lbs.

2. Compare the students' estimates to see the variations in values. Make sure all students understand how final answers were derived.

Discussion:

1. Where does the runoff go when it leaves the parking lot?
2. What route does the runoff take (stormdrain, drainage ditch, stream, culvert)? Is the area from the parking lot to the nearest stream vegetated or paved? If both, estimate percentage of each.
3. What was found in the parking lot that could be carried by stormwater into a local waterway?

Assessment

Brainstorm ways to slow the flow of water coming from the school's parking lot to the stream (rain gardens, rain barrels, increase permeable surfaces) to reduce shock loading. Student should draw or construct models to show their ideas, then share with the class.

Based on the Environmental Resource Guide, 1994, The American Institute of Architects, Joseph A. Demkin, editor.

FERTILE GREEN

Students discover what one type of stormwater runoff can do to a stream. This may be used as a semester- long activity.

Charting the Course

Use this activity after *Breathtaking so that students have a concept of dissolve O2*. Try Project WET's *A-Maze-ing Water* and *Sum of the Parts* as an introduction.

Objectives

Students will

- Identify sources of stormwater runoff
- Describe the effect fertilizer has on algal growth

Materials

- Clear plastic containers (1 liter soda bottles) or 500 ml beakers; 4/group
- 4 buckets
- Measuring spoons
- Water samples from stream, lake or pond
- Plant fertilizer (water soluble, like "Miracle Grow")
- Tap water
- Dissolved oxygen kit (optional)
- Camera (optional)
- Photographs of water bodies with algal problems and eutrophication (see resources)
- Student copy pages

Background

One problem caused by stormwater runoff is excess nutrients such as nitrogen and phosphorus entering waterways. The presence of nitrogen and phosphorous can cause an increase in the growth of algae and other aquatic plants, directly impacting the availability of oxygen to fish and aquatic organisms. It is important to remember that nutrients naturally occur in streams from leaf litter and plants. In fact, the proper amount of nutrients produces abundant plant life. However domestic sewage, industrial wastes, chemical fertilizers from lawns and fields can reach the stream and build up. Long-term nutrient enrichment may cause a lake to be choked by vegetation, covered with scum and have a foul odor. In addition, a heavy plant bloom can reduce the oxygen and result in a fish kill.

Preparation

Fill two buckets or other containers with tap water and let them sit for a day or so to allow any chlorine to dissipate. Fill two more buckets with aquarium/pond/lake water. Prepare fertilizer according to the package directions and double its strength. For example, if the directions call for one teaspoon/qt., use two teaspoons in the quart water sample. Be sure to read safety precautions listed in the MSDS (see ref.)

Procedures:

1. Discuss with the students that water pollution is any human-caused contamination of water that lessens its value to humans and nature.

2. Ask the students to make a list of all potential sources of pollution that might wash into a water body after a heavy rain. The list should include nutrients from agriculture, forests, plant nurseries, golf courses, home or business landscapes, and home gardens.

Experiment

The students will be observing the effects of fertilizer runoff on a water body. The plant fertilizer will represent the fertilizer runoff into waterways after a heavy rain.

1. Divide the class into groups of two or three. Have each group get four beakers/plastic containers and label them:

#1	Tap Water (Control)
#2	Tap water + fertilizer
#3	Aquarium/pond/lake
#4	Aquarium/pond/lake + fertilizer

2. **Set all four beakers/plastic containers (without tops) in a windowsill or a place where there is good light.** Be sure not to place them in a drafty or cold location because constant temperature is needed for best algal growth. ***Students must wash their hands after preparing jars.***

3. Have each group complete the **Lab Report Form** (pg. 70) stopping after Procedures.

4. **Observe the jars every day for a week and then once a week for a month.** Record any changes in the beakers/plastic containers on a data sheet (pg. 73). You may want to photograph the jars. If possible, check the dissolved oxygen in all four the beakers/plastic containers once a week at THE SAME TIME OF DAY (oxygen levels vary throughout the day and night)

5. At the end of the experiment, have each group write up their results and present them to the other groups. This presentation should include graphs and charts of data collected. Some students may choose to use a database to store data then create chart to compare each jar.

Ducks love algae!! Algae are essential to a healthy pond. But sometimes it can get out of control and become an algae bloom. A bloom occurs when there is a surplus of plant food, usually from runoff. The plant nutrients combine with carbon dioxide, water, sun light on the pond surface and warm temperatures, algae can easily grow out of control.

Wrap Up

Lead a discussion with these questions-

- Which beakers/plastic containers had the greatest algal growth? Why? the least algal growth? Why?
- As algal growth increases, what happen to the dissolved oxygen?
- In the beakers/plastic containers with algal growth, what might happen to the oxygen levels at night? Why?
- Name land uses and activities that contribute nutrients to streams.
- How is the environment affected by excessive algae growth?
- How does this experiment apply to real life?

Assessment

Have students research the effects nutrients have on aquatic life and report to the class.

Extension

Collect additional water samples from other locations of a stream or pond. Test the dissolved oxygen levels in each sample. Note the land uses of surrounding the sampling area. Have the students discuss how land uses affect the oxygen level of a stream.

Observe algae under a microscope. Have students identify types of algae based on graphic on page 74.
Students can research positive uses for algae and report to the class.

Art Extension- Have students select different algae or aquatic microorganisms and create a "wanted poster" with a photo/drawing, description, how it can be beneficial or cause harm, what actions to take to prevent harm, etc.

Resources

Why do harmful algal blooms occur?
https://oceanservice.noaa.gov/facts/why_habs.html
Advanced Biofuels Association
https://advancedbiofuelsassociation.com/
Georgia's Energy Future
http://www.georgiatrend.com/January-2007/Georgias-Energy-Future/
Harmful Algal Blooms:
http://www2.epa.gov/nutrientpollution/harmful-algal-blooms
Safety Data Sheets (SDS):
https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1200AppD
United Nations Environmental Programme, algae
https://www.unep.org/news-and-stories/story/what-do-you-know-about-algal-blooms

FERTILE GREEN LAB REPORT

Name: ___________________________ Date: ______ Class: ______

Title of Lab:
Materials:
Hypothesis: (Must be written in an If…then statement)

Continue on back of page

Procedure:

Conclusion/Analysis

STUDENT DATA COLLECTION SHEET

Name:

Hypothesis:

Beaker/plastic bottle #1

	COMMENTS	DISSOLVED OXYGEN (PPM)
Day 1		--
Day 2		--
Day 3		--
Day 4		--
Day 5		--
Day 6		--
Day 7		--
WEEK 2		
WEEK 3		
WEEK 4		

Beaker/plastic bottle #2

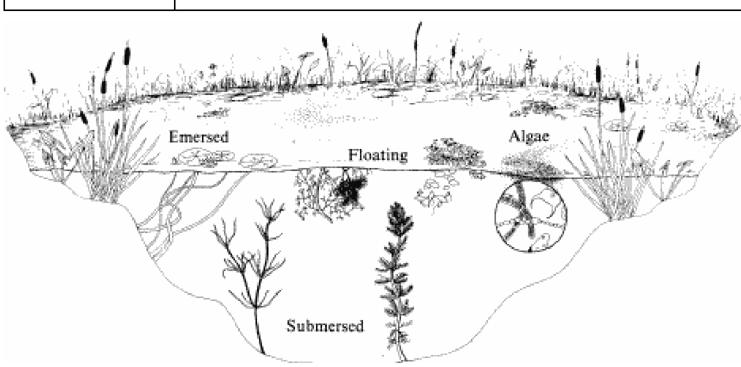
	COMMENTS	DISSOLVED OXYGEN (PPM)
Day 1		--
Day 2		--
Day 3		--
Day 4		--
Day 5		--
Day 6		--
Day 7		--
WEEK 2		
WEEK 3		
WEEK 4		

Beaker/plastic bottle #3

	COMMENTS	DISSOLVED OXYGEN (PPM)
Day 1		--
Day 2		--
Day 3		--
Day 4		--
Day 5		--
Day 6		--
Day 7		--
WEEK 2		
WEEK 3		
WEEK 4		

Beaker/plastic bottle #4

	COMMENTS	DISSOLVED OXYGEN (PPM)
Day 1		--
Day 2		--
Day 3		--
Day 4		--
Day 5		--
Day 6		--
Day 7		--
WEEK 2		
WEEK 3		
WEEK 4		



From the *Georgia Adopt-A-Stream Educator's Guide*.

WATER POLLUTION ON TRIAL

This role play activity engages students in the real-life process of an environmental compliance hearing.

Charting the Course

The Project WET activity *A-Maze-ing Water* should be done prior to this activity to help students better understand stormwater.

Objectives

Students will:

- Describe the role of the environmental compliance officers and the municipal court system in enforcing water quality and environmental laws.
- Explain how urban runoff and stormwater contribute to water pollution.
- Describe ways that people contribute to and can prevent point and nonpoint sources of pollution.

Materials

- Copies of the *Suspect Cards* and *Water Pollution on Trial* script (pg. 80-84), cut apart for each role.
- Water Pollution Fact Sheet for Panel Members (pg. 85-86)
- Pollution Panelist Voting Cards (1 for each, pg. 77)
- Best Management Practices (BMPs) on pollution topics page for each suspect (pg. 87)
- "You're the Solution to Water Pollution" Nonpoint Source Pollution copy page for each student (pg. 78)
- Students may collect costume props for their character portrayal

Making Connections

Students have all seen the storm drains in their neighborhoods and have probably seen pollution and litter wash down these drains. They may not have realized that water pollution goes straight to the stream from storm drains untreated and then to the river. They also may not have realized that human actions and choices everyday can cause point and nonpoint source pollution and that they can make a big difference.

Background

Have you ever wondered what happens to water after it rains? When it rains, water has two options. It can percolate through the soil or it can become runoff.

In areas where there is green space, water from rainstorms has an opportunity to soak into the soil and vegetation or percolate, which gives it an opportunity to be cleaned by passing through rock and sand layers that act as filters removing pollutants. However, when rainwater hits parking lots, highways, roads, and other hard surfaces that are impervious (water cannot seep down into the soil) it has no other choice than to runoff. This happens often in an urban watershed because there are more impervious surfaces in urban areas.

Rainwater becomes stormwater in urban settings and rushes to the nearest storm drain. As stormwater drains from streets, roofs, parking lots, lawns, construction sites, and industries, it carries with it many pollutants. Eventually, the polluted water goes down a storm drain, travels through pipes, and finally empties into nearby waterways.

Untreated pollution that comes from stormwater and runoff is often hard to source or identify and is called "nonpoint" source pollution. These nonpoint source contaminants include litter, motor oil, pet waste, pesticides, fertilizers, sediment from runoff, chemicals, and antifreeze, that all result from our daily activities. People are the source of nonpoint source pollution and they are also the solution to this kind of pollution.

Point source pollution is caused by a direct source, a pipe for example, dumping waste into a stream. It is called "point" source pollution because you can point to it and know where it comes from.

Nonpoint source pollution is the most serious pollutant in our waterways nationwide. It damages the environment and kills plants and wildlife along the way. It not only affects the local water supply, but those of our neighbors downstream as well.

Procedure

Warm Up

Begin by having the students examine the copy page "You're the Solution to Water Pollution" to find ways that people are contributing to water pollution. Make a list of all the possible pollutants and their sources. This review will help students when they are on the "Pollution Panel" and have to determine who is polluting the river. Ask the students to locate and identify their water supply and the name of the watershed in which they live.

It may be a good idea to do the warm up and give assignments on day one and let the students study their parts, gather props, and present on day two.

Activity

During this role-play, students sit on a Pollution Panel to determine whether characters portrayed by their classmates are doing all that they can to protect the city's water system. An environmental compliance officer will present an account of the suspects' violations to the pollution panel and the judge will call on expert testimony.

This scenario actually takes place when an environmental compliance officer finds a citizen violating environmental laws. The citizen is given a citation and has to appear with the compliance officer before a municipal court judge. If convicted, the citizen may be fined or may be assigned to do community service.

1. **Assign each student a role in this simulation.** You will need up to ten suspects (you may choose which scenarios to use); one environmental compliance officer (ECO); one judge (Judge Clearwater); and one expert witness (Dr. Lenzpoint). The expert witness role may be combined with ECO and an adult may play the judge. The rest of the class will become **the Pollution Panel.**

2. **Tell the "suspects" they may create props and costumes to bring their characters to life.** If they have no props, they can pretend to have them. This is an opportunity for some acting. Suspects should read their character description and be prepared to play the part.

3. **Have the Pollution Panel read the Water Pollution Fact Sheet (pg. 85-86) and the scripts and then come up with questions for the Suspects.** They can do this as a large group or break into smaller groups, each concentrating on a different set of facts. Remind them to select a person or two to record their questions. The group(s) should come up with at least four questions for each suspect. **The questions will help the Pollution Panel determine whether a suspect is contributing to the city's water pollution.** Give each panelist member a Panelist Voting Card (pg. 77).

4. **While the Panel is developing their questions, have the Suspects prepare their defense using the BMPs copy page (pg. 87) and their character's description (pg. 80).** This can be done as a group or individually. Instruct them to think of reasons why their characters might choose the actions they took.

5. **Set up the classroom so that the Suspects are facing the Panel.** Using the script, the Environmental Compliance Office (ECO) will begin by making a statement concerning the suspect to the judge and to the Pollution Panel. The ECO will make a statement to set the tone and describe the alleged environmental offense. Then the Panel will ask their questions of the Suspect.

6. Using the script, Dr. Lenzpoint will give an expert opinion about the pollution and violation during each suspect questioning.

7. **Each Panel member will decide individually whether the Suspect has done everything possible to protect the city's waterways and will fill in the Panel Voting Card after each Suspect is finished.** Voting cards will be collected after the last Suspect has presented and votes are counted and the count is given to Judge Clearwater. One or two Panelists will collect and total the votes and give them to Judge Clearwater who will announce the verdicts. **The Suspect is guilty if the majority of the Pollution Panel votes against him/her.**

8. **Guilty suspects will be given an opportunity to consider things they can do (Best Management Practices) to take more responsible action and present their plan to Judge Clearwater and the Pollution Panel.** If the plan is approved, the guilty party will be able to implement the plan and avoid a fine.

Wrap-Up

Discuss the results as a group.

- Were they unanimous or did some of the panel votes differ?
- Why did panelists vote the way they did?
- What did the innocent Suspects do right?
- What could the guilty Suspects do differently?

Assessment

Ask students to construct an argument about a particular issue related to water pollution. For example, they could write a persuasive argument to convince one of the suspects why they should protect the city's water system. Use evidence to support their claim/argument.

Student page

POLLUTION PANEL VOTING CARD

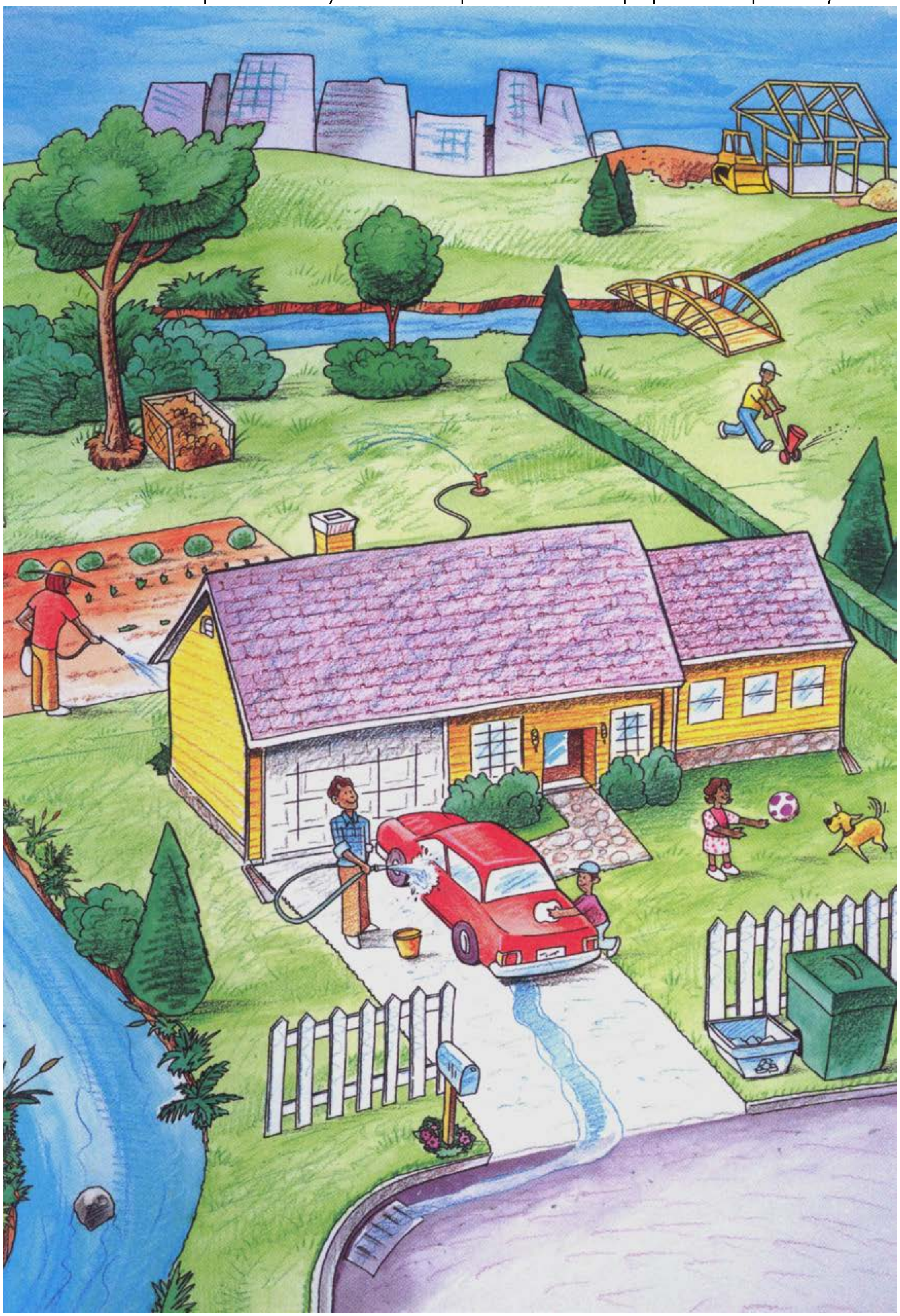
(copy 1 for each Pollution Panel Member)

After the Panel has voted, count up the total number of votes for each suspect or suspect group, and if there are more guilty votes than not guilty votes, then the suspect is found guilty and must come up with a plan of action based on BMPs.

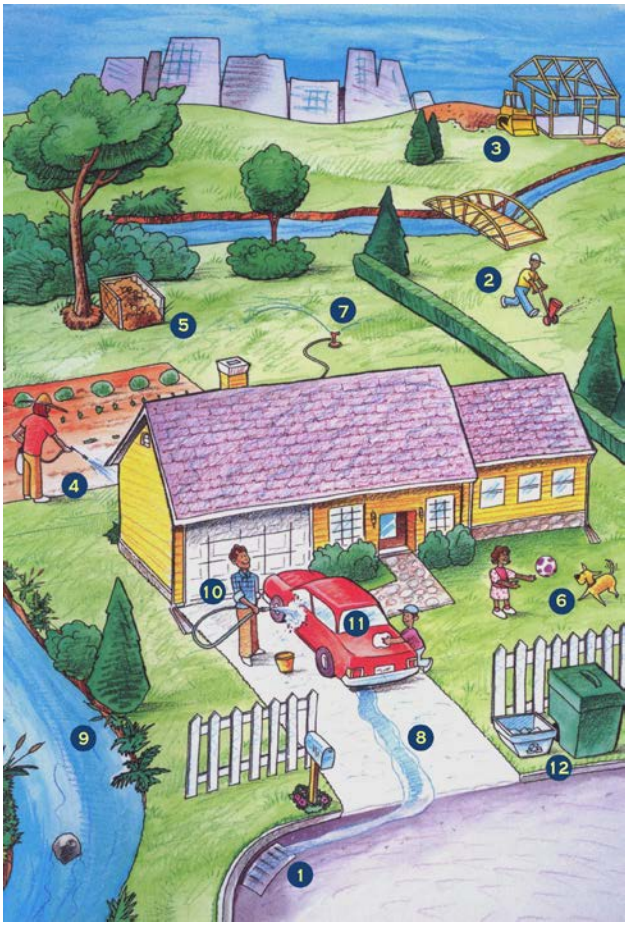
WATER POLLUTION ON TRIAL		
Panelist: Enter Suspect's environmental offense below.		
Suspect #1	GUILTY_______	NOT GUILTY_______
Suspect #2	GUILTY_______	NOT GUILTY_______
Suspect #3	GUILTY_______	NOT GUILTY_______
Suspect #4	GUILTY_______	NOT GUILTY_______
Suspects #5 & 6	GUILTY_______	NOT GUILTY_______
Suspects #7 & 8	GUILTY_______	NOT GUILTY_______
Suspects # 9 & 10	GUILTY_______	NOT GUILTY_______

You're the Solution to Water Pollution

Put an X on the sources of water pollution that you find in this picture below. Be prepared to explain why.



You're the Solution – Teacher's Key:



1. Stormdrain: When rain or water from hoses and sprinklers flow over our streets and yards, it carries pollutants into the stormdrains. Major pollutants include: soil, grass, fertilizers, litter, pesticides, motor oil, paint, and pet wastes.

2. Fertilizer: If too much is used, fertilizers can run off a yard into stormdrains and nearby streams. Fertilizers stimulate plant and algae growth, which decrease the dissolved oxygen content in streams, threatening aquatic life.

3. Erosion: Sediment is the #1 source of water pollution! Bare soil easily washes into stormdrains and streams, clouding water and suffocating aquatic life.

4. Pest Control: If it will kill an insect on the ground, it could kill a fish in the stream. Use pesticides as little as possible and know that many insects are beneficial to the environment.

5. Yard Trimmings: Keep yard trimmings out of stormdrains and waterways! Yard trimmings decomposing in a stream can use up the oxygen that aquatic animals need to survive. Build a compost pile and reuse the chippings and leaves to nourish your garden.

6. Pets: Scientists believe that animal waste is a major source of bacteria in urban waterways.

7. Irrigation: Over-watering your lawn increases runoff. One inch of water per week is all you need.

8. Driveway/Walkway: Take steps to minimize the amount of runoff from your driveway and walkway fixing oil leaks, using low phosphate soap, directing rainwater to the lawn, and using a permeable surface instead of solid surface.

9. Streamside: Keep stream healthy and contaminant-free. Remove all sources of possible runoff and keep the vegetation undisturbed at the edge.

10. Garage: Are you storing hazardous materials in your garage? Many household products contain hazardous products including gasoline, solvents, paints, paint thinner, used motor oil, antifreeze, pesticides, and mercury-based products. Never pour products on the ground or down a storm drain!

11. Vehicle: Automobile fluids are a common contaminant found in waterways. The good news is most of them are recyclable in Georgia.

12. Recycling/Waste Disposal: Do not allow wastes to enter a stormdrain or stream. They can injure or kill fish and wildlife!

Water Pollution on Trial

SUSPECT CHARACTER CARDS

Duplicate and cut apart for students playing each role. Give them time to study their roles and create props and costumes if desired.

Judge, Dr Lenspoint and ECO may study their roles using the script pages.

SUSPECT #1 - You own an auto body shop in the West End of the city. You have been in business for six years. While your specialty is body repairs, you also offer a *special* on oil changes. The special has brought the shop many new and returning customers. At the end of a busy day, you dispose of the old motor oil by pouring it down the nearby community storm drain.
Be prepared to tell why you do that.

SUSPECT #2- You live by yourself in a condo near the big Park. You have two dogs, Champ and Chester. While you take good care of your canine companions, you do not take time to clean up their waste. For years, you have walked Champ and Chester around the park's lake and allowed them to relieve themselves along the way.
Be prepared to tell why you do that.

SUSPECT #3- You are a retired teacher that started a community garden in your own neighborhood. Thanks to help from many enthusiastic neighbors, the garden produces beautiful fruits and vegetables. To cut down on pests, you use techniques you learned in a Cooperative Extension Service course on alternative pesticide use.
Be prepared to tell why you do that.

SUSPECT #4 - You have just embarked on a new venture:
– a cleaning service for day care centers. Most of the products you use are biodegradable. In addition, your staff has been instructed to read all labels regarding product disposal carefully.
Be prepared to tell why you do that.

SUSPECTS #5 & 6 - You are a married couple that have just relocated to the city from the West Coast. You love your new home here, especially the large front and back yards full of beautiful trees and flowers. In order to keep these two areas looking their best, you have signed a contract for lawn care services.
Be prepared to tell why you did that.

SUSPECTS #7 & 8 - You are joint owners in a family house painting business that was originally started by your grandfather. While you have learned to use many new tools and techniques over the years, many of your work habits were passed down from your grandfather and then reinforced by your father. You often pour leftover paints and paint thinner down drains located near the home on which you are working. Be prepared to tell why you do that.

SUSPECTS # 9 & 10- You are students on your way home from school who stopped at the corner store and bought a bag of candy. You walked by the neighborhood creek and dropped the wrappers in the creek knowing the creek will take them away. One of you finished your soda and tossed the can in the creek as well.

Be prepared to tell why you do that.

WATER POLLUTION ON TRIAL SCRIPT

Judge Clearwater begins the proceedings and calls on the Pollution Panel to prepare questions for each suspect as the information is presented *(pass out Voting Cards to Pollution Panel).*

Judge Clearwater – Welcome to the courtroom today. I am Judge Clearwater and I will expect your cooperation and attention as we determine guilt or innocence. We will be hearing the cases of 10 pollution suspects today. Is our Environmental Compliance Officer ready to begin? Please come forward.

SUSPECT #1 - O*wns an auto body shop in the West End of the city. He/she has been in business for six years. While his/her specialty is body repairs, suspect #1 offers a special on oil changes. The special has brought the shop many new and returning customers. At the end of a busy day, suspect #1 disposes of his/her old motor oil by pouring it down the nearby community storm drain.*

ECO – Your Honor, ______(insert name) has been dumping used motor oil down the storm drain near his/her place of business. We were alerted because local Adopt-A-Stream volunteers noticed that their creek had an odd smell, a sizable oil slick over the water, and there were dead fish on the bank. Their chemical monitoring reflected a change in the water downstream from the Auto Body Shop. We began checking in the area that the stream was impacted, and noted that one of the neighboring business owners had seen ______ dumping oil down the drain regularly over the past six months.

Judge Clearwater – At this time I call on the Suspect to defend his/her actions.

Suspect #1 – (Tell what you did and why)

Judge – Are there questions from the Pollution Panel?

Dr. Lenzpoint – Changing habits is difficult but it can be very beneficial for the environment because it will prevent water pollution. Why, a single quart of used motor oil can pollute 250,000 gallons of water and kill many different kinds of organisms. Recycling is the only proper means of disposing used motor oil.

SUSPECT #2- *lives alone in a condo near the big Park. He also owns two dogs, Champ and Chester. While he takes good care of his canine companions, he does not take time to clean up their waste. For years, he has walked Champ and Chester around the park's lake and allowed them to relieve themselves along the way.*

ECO – Your Honor _____(insert name) was reported to have walked their dogs recently in the park on ____(give a date) and allowed both dogs to relieve themselves near the water and did not attempt to clean it up. Another park visitor reported it to us.

Judge Clearwater – I call on the Suspect now to defend his/her actions.

Suspect #2 – (Tell what you did and why)

Judge – Are there questions from the Pollution Panel?

Dr. Lenzpoint – Pet waste may not be the largest or most toxic pollutant in urban waterways, but it is one of the many sources of pollution that can add up to a big problem. When pet waste gets into lakes, rivers and streams, it can contribute to increased levels of fecal coliform in the water. But, most important is the fact that pet waste carries diseases. Bacteria, like cryptosporidium for example, is a parasite carried by dogs, cats, mice, calves, and other mammals and can cause diarrhea, cramps, nausea and dehydration. It's so easy to pick up pet waste and put it in the garbage, down your toilet, or dig a hole away from water and bury it. Pet waste also adds nutrients like nitrogen and phosphate to the water often causing plant/algae growth turning the water into a green soup. This leads to decreased dissolved oxygen in the water that can increase fish kills.

SUSPECT #3- *is a retired teacher that started a community garden in his/her neighborhood. Thanks to help from many enthusiastic neighbors, the garden produces beautiful fruits and vegetables. To cut down on pests, suspect #3 utilizes techniques she/he learned in a Cooperative Extension Service course on alternative pesticide use.*

ECO – Your Honor, I would like to present _______ (insert name). He/she runs a community garden. There is a concern in the community about a local stream that is not healthy. Neighbors feel that the pesticides used on this garden may in fact be contributing to decreased water quality standards and several neighborhood ill- nesses. _____ has admitted to using some chemicals but states that they use Integrated Pest Management (IPM). IPM is the use of all means of pest control (chemical and non-chemical) but the use of pesticides is the last line of defense.

Judge Clearwater – What does this Suspect have to say?

Suspect #3 – (Tell what you did and why)

Judge – Are there questions from the Pollution Panel?

Dr. Lenzpoint – Users of pesticides and other agricultural chemicals need to take precautions to reduce the risks of these chemicals getting into our creeks and rivers contaminating aquatic life and affecting our drinking water. When it rains, water carries the pesticides and any other chemicals to storm drains where it becomes part of our waterways. Pest control is an ongoing problem and pesticides are chemicals that have been linked to illness and disease. It is hard to know exactly where a chemical will spread or drift when sprayed and it can get in the air we breathe and in the water we drink through the soil. It is also very important to apply chemicals carefully and not before expected rainfall. When people use pesticides on their gardens and lawns before a storm, it can cause large amounts of contaminants to enter waterways. Integrated Pest Management provides good management practices for using chemical and non-chemical pest control.

SUSPECT #4 - *has just embarked on a new venture – a cleaning service for day care centers. Most of the products he/she uses are biodegradable. In addition, his/her staff has been instructed to read all labels regarding product disposal carefully.*

ECO – Your Honor, I present you with_______(insert name). He/she has just recently opened a new cleaning service for day care centers. Instead of using harmful abrasive cleaners, he/she has decided to use earth friendly products that are biodegradable. However, the staff at the Center feels these products may not be safe and are being improperly disposed.

Judge Clearwater – What does the Suspect have to say in their defense?

Suspect #4 – (Tell what you did and why)

Judge – Are there questions from the Pollution Panel?

Dr. Lenzpoint – Earth friendly products can be as effective in killing germs as other brand name cleaners and can be better for the environment if disposed of correctly. Gentle cleaners should be used, especially around children, who can become sick while playing around harmful chemicals that some brand name cleaners contain. Children’s immune systems are continuously developing and so any contact with abrasive cleaners can cause harmful effects on their bodies. Some children may even be allergic to the chemicals in the cleaners. Biodegradable cleaners are better for the environment because they can be broken down by the earth’s elements and processes, such as filtration and erosion, through rainfall, heat from the sun and other weathering events. Other cleaners can be harmful to fish and other aquatic organisms if they are flushed into water systems. Consumers have to be careful and read labels before the products are used so that they clearly understand how to use and dispose of the product. Making your own safer cleaning products with materials like baking soda and vinegar is advisable.

SUSPECTS #5 & 6 - *are a married couple that have just relocated to the city from the West Coast. They love their new home here, especially the large front and back yards full of beautiful trees and flowers. In order to keep these two areas looking their best, suspects **#5 & #6** have signed a contract for lawn care services.*

ECO – Your Honor, Mr. and Mrs.______(insert name) have just moved from the West Coast into a new home in this city. Their yard is over four acres and they have large trees, colorful flowers, and beautiful green grass. The couple has contracted with a local lawn care service that will come three times weekly to keep their yard looking green and beautiful. The Green-A-Yard Company uses many chemicals and fertilizers each visit. The creek running through the neighborhood has shown evidence of degradation below the ____’s home. A local school group does biological and chemical monitoring of the creek and they noticed a change after the ____ have moved in. There are other neighbors using this company too but they only have service once a month. The students contend that the chemicals used on the lawns are unsafe for children and pets, and are also harmful to the stream environment.

Judge Clearwater – What do you both have to say in your defense?

Suspects #5,6 – (Tell what you did and why)

Judge – Are there questions from the Pollution Panel?

Dr. Lenzpoint – Lawn care services spray certain chemicals to kill pests, rodents and other organisms that can cause disturbances in and around homes. They apply fertilizers to keep the yards green, but they can create havoc when too much gets into streams, lakes and rivers. Fertilizers cause algae to grow in our waterways. When algae growth increases, it competes with natural plants and reduces the oxygen in the water that other organisms need to survive. Chemicals often tend to drift and do not always stay on the user’s land. Lawn care services used frequently could cause more fertilizers and pesticides to enter the nearby waterway causing problems in the aquatic habitat.

SUSPECTS #7 & 8 - *are joint owners in a family house painting business that was originally started by their grandfather. While they have learned to use many new tools and techniques over the years, many of their work habits were passed down from their grandfather and then reinforced by their father. To save time, they often pour leftover paints and paint thinner down drains located near the home on which they are working.*

ECO – Your Honor, Mr._______ and Mrs.______(insert names) are joint owners of a family painting business that was founded by their grandfather. Allegedly, the two current owners of the company have been resorting to time saving techniques, such as disposing their leftover paints and paint thinners down the storm drains where they were working. Though they have picked up new painting tools and techniques over the years, they continue to dispose their paint waste incorrectly impacting the local stream, creeks and river where it will harm other aquatic life. Storm drains lead to the nearest waterway and therefore the paint goes to the nearest stream, creek or river where it can harm the aquatic ecosystem.

Judge Clearwater– What would the suspects like to say in their defense at this time?

Suspect #7,8 – (Tell what you did and why)

Judge – Are there questions from the Pollution Panel?

Dr. Lenzpoint – Paints and paint thinners are some of the most harmful solvents that are frequently disposed of incorrectly. Due to their high toxicity level, these chemicals can cause great harm to various organisms that they come into contact with. Some painters dump their paint waste down home drains or dump it outside down storm drains. Disposing of paint down storm drains is illegal and can be incredibly harmful to the environment. Storm drains take the paint to the nearest waterway without being filtered or cleaned. The paint and paint thinner then disrupts the entire aquatic ecosystem by lowering levels of DO (Dissolved Oxygen), altering PH levels, and disturbing nutrient cycles.

<u>SUSPECTS # 9 & 10</u>- *are students on their way home from school who stopped at the corner store and bought a bag of candy. The students walked by the neighborhood creek and dropped the wrappers in the creek knowing the creek will take them away. One student had just finished her soda and tossed that in the creek as well because there were no trash cans nearby and the stream would take care of it.*

ECO – Your Honor, the following students, ________, and _______(insert names) were seen throwing their trash into a stream after they had visited a local convenient store. One of the students threw his/her soda can and the six-pack ring holder into the stream thinking that the stream would take care of it. The other student threw their candy wrappers on the streambank. The local Adopt-A-Stream organization is reporting heavy litter pollution of the local stream.

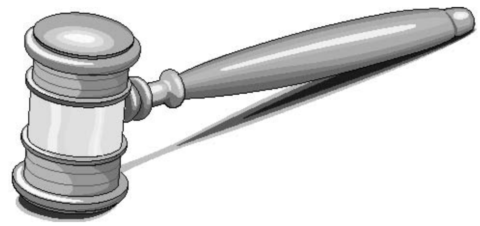
Judge Clearwater – What do these Suspects wish to say regarding their actions?

Suspects #9, 10 – (Tell what you did and why)

Judge – Are there questions from the Pollution Panel?

Dr. Lenzpoint – Trash and litter left in or near a stream can be dangerous for aquatic animals. Litter is a sign of disrespect to the environment and can cause harmful effects to waterways. Plastics, such as six-pack ring holders on soda pop cans, can trap and kill birds and fish that come into contact with them. Other forms of trash like paper products and metals can leach out chemicals that are harmful to the chemical make up of our waterways. Paper, plastic and aluminum can be recycled. Trash that can't be recycled should be held until it can be disposed of properly in a trash can.

JUDGEMENT



Judge Clearwater-- (*choose someone to collect and total votes from Pollution Panel)*

We will now collect the votes from the Pollution Panel regarding each of these cases. They will determine guilt or innocence of the suspects.

(*turn to the suspects*) If you are determined guilty, you will be required to research **Best Management Practices** (or BMPs) and identify actions you can take to reduce pollution in the water related to your crime so you can avoid a fine.

(Read out each total vote. Those guilty have the majority of guilty votes. Give the guilty party the list of BMPs and ask them to select actions they can take that will help reduce water pollution)

Each guilty suspect in turn announces to the judge and the Pollution Panel what steps they will take to reduce water pollution.

Water Pollution Fact Sheet for Pollution Panel Members

Motor Oil Facts:
- Used motor oil contains many harmful substances including contaminants such as chromium, copper, lead, zinc, and other metals.
- A single quart of used motor oil can pollute 250,000 gallons of water.
- Four quarts of oil can cause an eight-acre oil slick if spilled or dumped down a storm drain.
- Used motor oil can kill organisms in the water that fish rely on as a food source and can contaminate drinking water supplies.
- Used motor oil can cause harmful effects on the skin, body fluids, and ability to fight disease after both short and long-term exposure.

Pet Waste Facts:
- Pet waste can be a serious pollutant in our waterways. Even if you can't see any water near you, pet waste can wash into storm drains after a rain and travel to the nearest creek or stream untreated.
- Pet waste contains nutrients that encourage weed and algae growth that can lead to reduced oxygen and the release of ammonia that can cause fish kills. Nutrients are substances that nourish and promote development. In this case nutrients create too much plant growth in the water.
- Pet waste contains bacteria and viruses that can cause sickness to humans.

Diseases or parasites that can be transmitted to humans include:
- Campylobacteriosis – Bacterial infection carried by dogs and cats that frequently causes diarrhea in humans.
- Cryptosporidium – A protozoan parasite carried by dogs, cats, mice, calves and other mammals that causes diarrhea, stomach cramps, nausea, and dehydration.
- Toxocariasis – Roundworms are not usually transmitted from dogs to humans but could cause a cough, fever or rash.
- Toxoplasmosis – A protozoan parasite carried by cats that can cause birth defects such as intellectual disabilities and blindness and is especially dangerous to pregnant women.

Pesticide Facts:
- Pesticides can be harmful to aquatic systems and have been linked to illnesses.
- When farmers and gardeners spray crops, the pesticides enter the soil and can enter waterways.
- There are natural alternatives to pesticide use such as the use of beneficial insects like the ladybug and the praying mantis for example.
- When pesticides are applied to a garden or field some of the chemical may drift downwind and outside the intended application site, which could include nearby surface water.
- Pesticides can leach into groundwater therefore it is important to know what kind of soil you have.
- Pesticides are rated for their risk of leaching or moving with surface runoff after being applied. This is done by checking their absorption, water solubility and persistence. Absorption is the chemical process that results in a pesticide being bound or absorbed to a soil particle. Solubility is measured in parts per million (ppm) and measures how easily a pesticide may be washed off the field or garden, and leach into the soil or move with the surface runoff. Pesticides with a solubility's greater than 30 ppm are more likely to move with water. Pesticide persistence is measured in terms of the half-life, or the time in days required for a pesticide to degrade in soil to one-half its original amount. For example, if a pesticide has a half-life of 15 days, 50 percent of the pesticide applied will still be present 15 days after application and half of that amount (25 percent of the original) will be present after 30 days. The longer the half-life, the greater the potential for pesticide movement.

Household Cleaner Facts:
- Many household cleaners contain volatile organic compounds, known as VOCs. VOCs come from chemicals that get in the air as gases. One of these compounds for example, is methylene chloride found in paint strippers and aerosols.
- These compounds can escape into the atmosphere, where they can react with other compounds to form smog. VOCs come in a wide variety of products and include: paint strippers, cleaning supplies, pesticides, building materials and furnishings, office equipment such as copiers and printers, correction fluids, glues and adhesives, permanent markers and photographic solutions.
- When flushed down the toilet or sewer drains, household cleaners can find their way into local waterways. The chemicals contained in these cleaners can have detrimental effects on water ecosystems.
- Many cleaners are packaged in non-recyclable materials. Check with your local recycling center to see what types of plastics they process.

WATER POLLUTION FACT SHEETS FOR POLLUTION PANEL MEMBERS

Lawn Chemical and Fertilizer Facts:

- Lawn chemicals are usually a mix of concentrated nitrogen fertilizer and pesticides.
- Though lawn chemicals help lawns grow faster and greener, they also have unintended consequences.
- Excessive application of nitrogen can deplete a lawn's self sufficiency. Grasses grow shorter roots because they become dependent on fertilizer for sustenance.
- An increase in soil acidity from lawn chemicals forces worms and other decomposers who aerate the soil to vacate the soil.
- Many common lawn chemicals used by lawn maintenance companies are possible carcinogens and may cause damage to the nervous system.
- Lawn chemicals can "drift", meaning they end up in places where they are not intended; such as our rivers, streams, lakes and oceans.
- Heavy exposure of nitrogen and other fertilizers found in lawn chemicals can cause extreme algae growth in our waterways.
- Pesticides from lawn applications for example, can be washed into nearby streams and creeks and can kill stream organisms.
- The most common forms of fertilizer alternatives are manure, compost, and mulch.
- Manure comes from livestock waste and helps to open up the soil to air and retain water.
- Compost is rotted plant material that can add nutrient rich organic material to the soil.
- Mulch is primarily made up of chips, straw, leaves, and grass. Mulch helps to retain moisture and warm soil temperatures.
- The natural decomposition of organic matter forms a dark, soil like substance called humus.
- Decomposition is performed by microorganisms, like bacteria and fungi that produce enzymes, which break down organic material.

Paint Facts:

- By volume, paint is the largest category of waste that is brought to household hazardous waste collection programs.
- The two major types of paint are oil based and water based.
- Oil based paints use a petrochemical product, such as mineral spirits, toluene and xylem as a solvent, while water based paints, such as latex and water colors, use water as a solvent.
- On average, there are three gallons of paint stored in a home, most of which is old and unusable.
- The pigment, the solvent and other additives found in paints, can be hazardous.
- Years ago, lead was used in paints to make it harder, last longer and weather better. But due to its' hazardous nature, lead has been banned in paints for many years.
- Mercury, another hazardous substance, was banned in indoor paints in 1990. Outdoor paints may still use mercury, but now require a warning label.

Trash Facts:

- Americans throw away over 160 million tons of solid waste or trash, every year.
- A plastic cup can take 50–80 years to decompose.
- 50% of the aluminum cans Americans use are recycled, making aluminum the most recycled product.
- Paper and paperboard make up the largest percentage of trash with 38% overall.
- Landfills are the most common depository of trash with over 57% of our trash ending up in one.
- There are over 2,300 landfills across the U.S.
- The easiest method to reduce our trash accumulation is to remember the 3 R's: Reduce, Reuse, Recycle.

BEST MANAGEMENT PRACTICES: (BMPS) a practice, or a combination of practices that not only minimize water pollution, but also meets the needs of the total ecosystem, that is soil, water, air, plants, animals. This is the most effective means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.

Motor Oil: Recycling is the only proper means of disposing used motor oil. Environmental companies can recycle used motor oil into new lubrication products and use it as an alternative fuel source in asphalt plants, boilers, cement kilns, and steel mills. It is important to locate a service station that does recycle used motor oil.

Pet Waste:

- Carry a plastic bag and pick up after your dog.
- Dispose of the waste by flushing it down your home toilet, putting it in the garbage, (check ordinances first), or you can dig a hole 5 inches deep and make sure to keep the waste away from water, vegetable gardens, or ditches.
- Being a good pet neighbor is good for you and your neighbors.

Pesticides:

- Incorporate alternative forms of insect killers such as the use of beneficial insects into your gardening (Ladybugs, Praying Mantis, Assassin Bugs). These can be found at any garden center and are a better choice for the environment.
- When a decision is made to use pesticides, choose the products that are the most suitable for use on the target species.
- Using alternative pesticides shows that you care about the earth, which helps others do the same.
- If you do use a chemical read the label carefully and apply with caution noting weather conditions. A rain or storm can wash the chemicals into a nearby waterway.
- ▪ Choose a pesticide that has more absorption (sticks to the soil) and a quick breakdown or half-life in the soil.

Household Cleaners:

- Use "green" cleaners that do not contain the abrasive dyes, fragrances, and other chemicals found in standard cleaners.
- After cleaning, throw any waste into the trash can instead of the toilet. Chemicals will leach out in a landfill instead of your local stream or river.
- Recycle the cleaning containers.
- Never mix household cleaners with other cleaners.
- "Green" cleaners are more environmentally friendly and show that you care about your health and the health of others. If you use abrasive cleaners, read the warning labels, so that you can keep you, your family and your pets safe.
- Provide plenty of fresh air while using cleaners.

Lawn Chemicals:

- Avoid using lawn chemicals excessively.
- When scheduling a spraying, check the weather forecast. Make sure rain is not predicted in the following few days.
- Make sure your children and the children of your neighbors understand not to play on a freshly sprayed yard for many hours after application.
- Check for alternative fertilizers at local garden shops.
- Avoid using treated railway ties for landscaping or gardening. Some ties are treated with creosote, which is a mixture of toxic chemicals, which can leach out over time.

Paint:

- Do not wash unused paint down your household drain or a storm drain.
- ▪ Give unused paint to a friend, save it for touch ups, or use it for other household improvement jobs. Extra paint you do not intend to use can be added to kitty litter and thrown in a trash can.
- ▪ If you want to save your extra paint do not place it on a concrete floor, such as your basement. The metal packaging will rust from exposure to moisture and let in oxygen that will ruin the paint.
- ▪ Position unused paint cans on their tops. This will help keep the paint "fresh" by sealing the can from oxygen.

Trash:

- Remember the 3 R's: Reduce, Reuse, Recycle.
- Place all trash in a proper receptacle, such as a trash can, recycling bin, or dumpster.
- Never throw trash out of your car, into waterways, or anywhere other than a trash can.
- Set up a compost pile. Don't throw your banana peels and eggshells in the garbage. Put them in your compost pile with coffee grounds and other organic material. Composting is a great way to give your garden an incredible amount of nutrients and it is an easy way to recycle your waste!

DR. RUNNOV

Students will hear from an "expert" about some basic ideas on the connection between increased stormwater and climate changes. Get your drama on!

Objectives

Students will

- Explain aspects of the science behind Climate Change
- Discuss the impact of Climate Change on local area
- Research Climate Change action organizations

Materials

- Download Dr. Runnov Power Point presentation (ProjectWET.Georgia.gov/stormwater) with script (pg. 91)
- Dr. Runnov costume and props
- Climate Change Fact Sheet for each student (pg.93)
- Copies of Climate Change Graphic Organizer for each student (pg.90)
- Projectable copy of Graphic Organizer (optional)

Preparation

Gather costume items to wear as "Dr. Runnov", such as a lab coat, ID badge, or wig.

Procedure

Warm Up

Have students watch the video on Climate Change from the EPA Climate Change Students page.
https://archive.epa.gov/climatechange/kids/index.html

Activity

1. The day before you give your presentation, tell students that you will host special guest expert in class tomorrow-Dr. Runnov. S/he will be speaking on Climate Change and its effect on the Urban Watershed.

2. Assign the first two rows of the Climate Change Graphic Organizer (What I know and What I want to know) to be completed prior to the presentation. Students should also be prepared to ask at least one question each of Dr. Runnov.

3. On the day of the presentation, follow the Dr. Runnov PowerPoint and script. If you read the script put a little drama into it. Try using an accent and making hand gestures.

4. Hand out the Climate Change Fact Sheets to your students. Give students the opportunity to ask their questions. **Write each question on the board and assign students to find the answers via a web quest or using the Fact Sheets.**

Students should fill out the "What I learned" and "Where can I go to get more information?" sections on the Graphic Organizer using the information they have gained.

Wrap Up

Discuss with students the information they learned about Climate Change. **Have the students find Global Climate Change Organizations and groups with a web search**. Each student or small group should select an organization to follow on social media and answer the following questions: What is the organization's message? How is climate change communicated? - through fear, information, action, etc.? Are the facts they use accurate? What does the organization says is the effect Climate Change has on the Urban Watershed?

Assessment

Students calculate their carbon footprint and list ways to reduce their impact through simple everyday actions.
https://www3.epa.gov/carbon-footprint-calculator/
Carbon Footprint Calculator

Resources

For more information on climate change impacts on water, please visit the Water Resources Impacts page on EPA
Southeastern Climate Change Impacts:
https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-southeast_.html
The Carbon Dioxide Information Analysis Center
https://cdiac.ess-dive.lbl.gov/home.html

CLIMATE CHANGE GRAPHIC ORGANIZER

WHAT I KNOW

WHAT I WANT TO KNOW

WHAT I LEARNED

WHERE TO GO TO LEARN MORE

Questions for Dr. Runnov:

DR RUNNOV SCRIPT for use with PowerPoint (ProjectWET.Georgia.gov/Stormwater*)*

Slide 1 Title Page (*with drama*) Good day! My name is Dr. Runnov and I would like to teach you a bit about how Climate Change is going to affect all of us.

Slide 2 First of all, do you know what Climate Change is? *(look around at audience)* No, no, no—

[Click] it is **not** warm day in the middle of winter or

[Click] a **cold** day in summer —that's weather. Weather happens every day, its seasonal, and it changes a lot.

Slide 3 We're talking Climate Change – what do you know? *(Pause for audience input)* Alright, those are all good.

Slide 4 To scientists it means a world-wide **measurable** change in temperature and precipitation that lasts for decades or longer.

Slide 5 Some people call it the **redistribution of water**.

Climate change can be caused by **natural processes** or ***external forces*** or to changes in the ***atmosphere*** or in ***land use***.

Slide 6 But in the latest Climate Change Report, scientist says that Climate Change is attributed directly and indirectly to human activity. And it is happening now.

Slide 7 So let's take a look at where we live-- **the Southeastern United States.** Did you know that over 70 million people live here? This area has many cities with populations over 250,000, like Houston, Jacksonville, Charlotte, Atlanta, Miami, and New Orleans. The Southeast also has about 29,000 miles of coastline.

Slide 8 We generally have warm and wet weather, with mild and humid winters.

[Click] Since 1970, average annual temperatures in the region have **increased by about 2°F**. It doesn't seem like much--- why, during the summer the difference between nighttime and daytime temperatures can be as much as 40-50°F. When the day to day temperatures of weather vary so much, 2°F seems insignificant.

Slide 9 By the year 2080 average temperatures in the region are projected to increase by 4 to 9°F. With just this amount of warming, hurricane-related rainfall will increase and rainfall will arrive in heavier downpours with more dry periods between storms. This brings on a greater the risk of both flooding and drought.

Slide 10 The coasts will have stronger hurricanes and sea levels will rise. Storm surge could present problems for coastal communities and ecosystems.

Slide 11 To put it in perspective: Over the past 25 years, the population of Adélie penguins, who live on the icepack of the western Antarctic Peninsula, decreased by 22%. Their population decrease is directly related to warming temperatures. During the past 50 years, a 7-9°F increase in midwinter temperatures in that area has led to a loss of sea ice and a shrinking habitat for Adélie penguins.

So a couple of degrees can make a huge difference.

Slide 12 You may have heard the catch phrase: **"2 degrees",**

[Click] if not, I think you soon will. You see, governments and many organizations have eagerly adopted the limit of **2°Celcius**

[Click] (that is the same as 3.6°F) – the temperature rise we need to stay **under** to avoid catastrophic effects of Climate Change.

What does that mean- **2°C**?

Slide 13 One way is to imagine what the world was like when it was **2°C colder** -- It was the **ice ages**!

[Click] There was an ice sheet one mile thick that extended over the northern half of North America right down to New York City.

Slide 14 But that happened 18,000 years ago, over hundreds of years, as a result of changes in the earth's orbit and other natural forces.

Slide 15 What should worry us today is that human-forced Climate Change is happening at 1,000 times the rate of Climate Change caused by these natural cycles.

The changes we're seeing now may be happening quickly compared to the past, but still slowly compared to human lifespans, so it is hard for us to understand and react.

Slide 16 And climate is complicated. For instance, 90% of warming is going into the oceans – at the rate of four atom bombs per second. But even with all that heat going in the oceans, they will still take a great many decades to warm.

Slide 17 We're fast approaching **2°Celsius** warmer than before the industrial revolution and before we had cars and factories.

Slide 18 With increased water vapor in the atmosphere, loss of reflective ice surface, and increased other gases, 2°C could be reached before the year 2080, maybe even as early as 2060.

Here are a few impacts Climate Change is predicted to have on our region:

Slide 19 Higher temperatures will increase evaporation and water loss from plants and droughts will last longer and be more frequent.

Slide 20 With less water traveling in the rivers leading to the coast and less soaking into the ground, it is likely that saltwater will begin to mix with shallow aquifers in some coastal areas of the Southeast, particularly in Florida and Louisiana.

Slide 21 If the region increases groundwater pumping to get more fresh water, then aquifers will be further emptied.

Slide 22 Stronger storm systems will bring increased stormwater and urban areas will be greatly affected.

Slide 23 ***What can you do?***

You were asked to prepare questions to ask me. Many of those questions may have already been answered. Raise your hand if you have a question that I have already answered.
(write the questions on the board)

Now who has a question I have not answered?
(write the questions on the board, add others if necessary to include:
What can we do about Climate Change?
What happens if the temperature goes above 2°C**?**
Why do some people think it is only a temporary fluctuation in global temperatures?
What habitat impacts will be seen in our region?
How will stormwater problems be affected by Climate Change?)

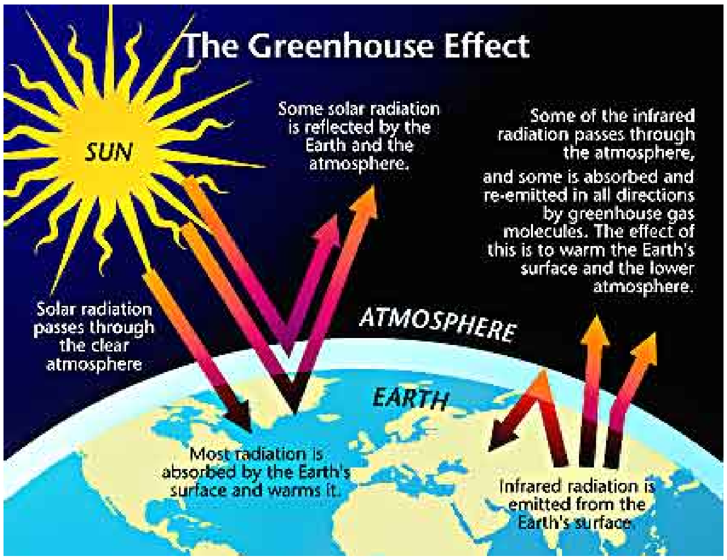
How can we find the answers?

NOTE:

The PowerPoint without narration is available on ProjectWET.Georgia.gov/Stormwater.

CLIMATE CHANGE FACT SHEET

NACC/USGCP graphic



What does the greenhouse effect have to do with global warming?

The "greenhouse effect" is the natural phenomenon that keeps the Earth in a temperature range that allows life to flourish. The sun's energy warms the Earth's surface and its atmosphere. As this energy radiates back toward space as heat, part of it is absorbed by heat-trapping gases in the atmosphere – among them carbon dioxide and methane – which creates an insulating layer. With the temperature control of the greenhouse effect, the Earth has an average surface temperature of 59°F (15°C). Without it, the average surface temperature would be 0°F (-18°C), a temperature so low that the Earth would be frozen and could not sustain life.

What is the difference between Global Warming and Climate Change?

Global warming is the increase in the average temperature of the biosphere. **Climate change** is significant changes in the pattern of weather, resource availability, and other climate conditions. Global warming causes most (but not all) of the climate change we have been experiencing lately.

What is causing global warming?

Scientists have concluded that human activities are contributing to global warming by adding large amounts of heat-trapping gases to the atmosphere. The trapped heat changes the climate, causing altered weather patterns that can bring unusually intense precipitation or dry spells and more severe storms. Our **fossil fuel use** is the main source of these gases. Every time we drive a car, use electricity from coal-fired power plants, or heat our homes with oil or natural gas, we release carbon dioxide and other heat-trapping gases into the air. The second most important source of greenhouse gases is **deforestation**, mainly in the tropics, and other land-use changes. The primary cause of global warming (increased emissions of CO2), has caused another of the major climate changes we have experienced, ocean acidification.

What is the best source of scientific information on Climate Change?

In 1988, the United Nations Environment Programme and the World Meteorological Organization set up the **Intergovernmental Panel on Climate Change (IPCC)** to examine the most current scientific information on global warming and climate change. More than 2,500 of the world's leading climate scientists, economists, and risk experts contributed to the panel's most recent report, *Climate Change 2014* released in May 2014**.** Scientists from 195 countries were involved in this new report. The scientists reviewed all the published scientific information produced during the previous few years to assess what is known about the global climate, why and how it changes, what it will mean for people and the environment, and what can be done about it. The Assessment Report serves as the basis for international climate negotiations.

Is Climate Change already happening?

Yes. According to the IPCC the kinds of changes already observed are:

- Increase in global average surface temperature of about 1°F in the 20th Century.

- Decrease of snow cover and sea ice extent and the retreat of mountain glaciers in the latter half of the 20th Century.
- Rise in global average sea level and the increase in ocean water temperatures.
- Likely increase in average precipitation over the middle and high latitudes of the Northern Hemisphere, and over tropical land areas.
- Increase in the frequency of extreme precipitation events in some regions of the world.
- Thawing of permafrost.
- Lengthening of the growing season in middle and high latitudes.
- Poleward and upward shift of plant and animal ranges.
- Decline of some plant and animal species, earlier flowering of trees, earlier emergence of insects, earlier egg-laying in birds.

How much warmer is the Earth likely to become?

The IPCC projects that the Earth's average surface temperature will increase between 2.5° and 10.4°F (1.4°-5.8°C) between 2000 and 2100 if nothing is done to reduce the emissions of greenhouse gases. Scientists predict that even if we stopped emitting heat-trapping gases immediately, the climate would not stabilize for many decades because the gases we have already released into the atmosphere will stay there for years or even centuries.

Would a temperature rise of a couple degrees really change the global climate?

Scientists predict that continued global warming on the order of 2.5°-10.4°F over the next 100 years (as projected in the IPCC's fifth Assessment Report) is likely to result in:

- a rise in sea level between 3-35 inches leading to more coastal erosion, flooding during storms and permanent inundation;
- severe stress on many forests, wetlands, alpine regions and other natural ecosystems;
- greater threats to human health as mosquitoes and other disease-carrying insects and rodents spread diseases over larger geographical regions; and
- agricultural problems in some parts of the world due to increased temperature, water stress and sea-level rise in low-lying areas such as Bangladesh or the Mississippi River delta.

Is there anything we can do about global warming?

Yes! The most important action we can take to slow global warming is to reduce emissions of heat-trapping gases. Governments, individuals and businesses can all help.

Governments can adopt a range of options for reducing greenhouse gas emissions, including:

- increasing energy efficiency standards;
- encouraging the use of renewable energy sources (such as wind and solar power);
- eliminating subsidies that encourage the use of coal and oil by making them artificially cheap; and
- protecting and restoring forests, which serve as important storehouses of carbon.

Individuals can reduce the need for fossil fuels and often save money by:

- driving less and driving more fuel-efficient and less-polluting cars;
- using energy-efficient appliances;
- insulating homes; and
- using less electricity in general.

BREATHTAKING

Students soon discover the importance of oxygen to animals living in the water and how stormwater can threaten the delicate balance needed for life. *From the Georgia Adopt-A-Stream Educator's Guide, 2009, "Breathtaking."*

Charting the Course

Use Project WET's *Sum of the Parts* and *Macroinvertebrate Mayhem* after this activity to give students an idea of how nonpoint source pollution can enter a waterway and the affect it has on aquatic life.

Objective

- Students will describe the importance of dissolved oxygen (DO) to the survival of aquatic plants and animals by performing a controlled experiment with fertilizers, debris, and sediment.

Materials *Note: Some of the equipment may be shared between groups*

- 10 1-quart wide-mouth jars
- 10 sample bottles
- 10 gallons of pond water
- ½ cup grass clippings
- ½ cup liquid fertilizer (like "Miracle Grow")
- ½ cup topsoil from garden, not from a bag
- 10 measuring spoons and measuring cups
- 10 thermometers
- 10 turkey basters
- Masking tape
- Permanent ink pen
- Dissolved oxygen kit or meter
- Aluminum foil
- Goggles
- Gloves
- Data chart (pg. 99)
- Optional: ½ cup manure (Make sure to wear gloves when handling animal waste); may use composed type found in bags at home improvement stores
- Optional: Grow light (in place of a window) for more consistency with light and heat

Background

Oxygen is as important to the animals living in the water as it is to those living on land. Although oxygen does not dissolve very well in water, enough does to support a variety of living organisms. The solubility of oxygen in water depends on water temperature**. Cool water can hold more oxygen than warmer water** because gases are more soluble in cooler water.

The amount of dissolved oxygen (DO) may vary significantly from one place to another and during times of the day in aquatic habitats for a variety of reasons. The highest concentration of DO occurs at sunset. After sunset, plants respire (use oxygen). The lowest concentration of DO occurs at sunrise. This is the most likely time that a fish kill will occur. DO is measured in parts per million (ppm). DO in aquatic environments can range from 0 to 14 ppm, but 6-10 ppm is required for most aquatic animals.

However, stormwater carrying nonpoint source pollution negatively impacts DO levels. Excessive nutrients from fertilizers, livestock wastes, leaking septic tanks, urban runoff and phosphate detergents entering the waterway via surface water runoff can accelerate plant growth or cause "algal blooms." Algal blooms can produce thick surface mats, turn the water green, stain boats, and may be toxic to animals that drink the water. When algae die, oxygen is consumed by the decaying process which reduces the amount of oxygen remaining for use by aquatic animals.

Heavy rains can affect DO levels by washing a variety of suspended materials into waterways. As sedimentation increases, light transmission decreases through the water, thus decreasing plant photosynthesis, a key process for adding oxygen back into the water. Sediment can also cause the temperature of the water to increase as individual particles absorb heat thus decreasing the amount of oxygen water can hold. Sediment can cover spawning areas and smother fish eggs, aquatic insects and oxygen producing plants. Increased turbidity also makes it harder for fish to locate and capture prey.

Preparation

Order or borrow dissolved oxygen kits or meters (contact Georgia Adopt-A-Stream to see what is available for loan 404-651-8517). The day before the experiment, obtain topsoil, manure, fertilizer and grass clippings *(ALWAYS handle any animal waste with gloves and wash hands afterwards.).* Collect the pond/stream water the morning of the experiment. Water can also be obtained from an established aquarium. *Follow standard safety procedures if students collect samples.*

Procedures

1. Discuss the concept of dissolved oxygen (DO) and how the following can influence DO levels: water temperature, photosynthesis respiration, and decomposition of organic wastes.
2. Divide the class into groups of two or three and give each group a clean jar.
3. *Review with students all safety precautions. SEE MSDS LINK.*
4. Using the chart above, assign one of the ten water samples to each team and have them prepare their samples as indicated.

(If you want students to run duplicate tests, assign 2 jars to each group and double the number of material needed for the first 6 items)

5. Have the students swirl their samples (including controls) to stimulate the natural mixing of a body of water. Keep the pond/aquarium water sample to refill the jars on day 3 and 7.

Sample	Treatment
1 & 2	None; 3 cups pond water only
3 & 4	¼ cup liquid household fertilizer in 3 cups water
5 & 6	¼ cup manure in 3 cups water (Estimate)
(Opt.) 7 & 8	¼ cup grass clippings or leaf litter in 3 cups water
9 & 10	¼ cup top soil or potting soil in 3 cup of water

6. Have the students label the jars with their sample number.
7. Have the students measure and record the room and water temperature and the appearance of their samples on the data sheet.
8. Place the uncapped jars in a sunny location near a window. A gardener's light can be used if a window isn't available.
9. Have the students record observations on their water samples daily for 10 days. Students should answer the following questions each time:

a) Is the water cloudy?

b) Has the color changed?

c) Is there algal growth?

d) Is a film forming on the surface?

10. On days 3 and 7, have the students add ½ cup of the extra aquarium water into the samples and swirl. Make sure the water is at room temperature.
11. Using the DO kit or meter, measure and record the DO level of their water samples on day 10 and 15. (Use a turkey baster to transfer the water into the test bottle.)
12. Calculate the Biochemical Oxygen Demand by

taking the difference between Day 15 and Day 10. Use Table 2 to determine the level of organic waste.

13. Compile all the class data and discuss:

    a) Can nonpoint source pollutants reduce DO levels in the water? *(Yes – in the case of sediment, it can block sunlight thus preventing photosynthesis)*

    b) Can DO levels be reduced when phosphates and nitrates from fertilizers are mixed with water? *(Yes – with increased plant growth, there is an increase in plant respiration during the night and algae growth/decomposition)*

    c) Does bacteria that decompose organic material compete with other oxygen-demanding organisms? *(Yes - often actively completing)*

Discussion

1. Which samples had the highest DO?
2. Arrange the DO's of the samples from highest to lowest and discuss why you got these results.
3. Assuming the water was taken from a stream, what types of fish and macroinvertebrates would likely be present in each of the streams?
4. What are the most likely nonpoint sources of organic waste pollution in streams?
5. If you ran duplicate samples, was there any difference in the results? What might have caused those differences?

Assessment

Find a stream and test DO upstream and downstream from a suspected nonpoint source of fertilizer or livestock waste. Does the DO content differ in these two areas? Why? What factors may be responsible for these differences?

Remember: Follow safety precautions. Any waste and left over solutions should be disposed of properly.

Extensions

1. Perform DO test as before on freshwater streams containing different sediment loads. Correlate DO with sediment loads and discuss the results with each student.
2. Have students research *Pfiesteria*, a microorganism that broke out in waterways in North Carolina and Maryland killing fish as a result of animal wastes getting into those waterways.

Resource

Safety Data Sheets (SDS): https://www.osha.gov/Publications/OSHA3514.html

TABLE 1:

Effect of Inorganic Nutrient Pollution on Oxygen Levels and Aquatic Life of a Stream

Amount of Pollution	Low	Medium	High
Dominant Fish	Game fish: trout, black bass, etc.	Non-game fish: bullheads, carp, gar, etc.	Fish Absent
Index Animals Present on River Bottom	Mayfly larvae, stonefly larvae, water penny larvae	Clams, crane fly larvae, dragonfly, crayfish, damselfly nymphs	Aquatic worms, blackfly larvae, leeches, midge larvae
Dissolved Oxygen (ppm)	> 8 ppm	4-8 ppm	2-4 ppm
Status of Water	Clean water	Decline	Severe damage, decomposition
Physical Features	Clean water with cobble, rocks, riffles No bottom sludge	Cloudy water Evidence of erosion	Cloudy water Bad-smelling gases Sand, silt, clay

TABLE 2:

Biological Oxygen Demand and Corresponding Levels of Organic Waste Pollution

BOD (mg/l)	Indication of organic waste level
1-2	-Very clean water, little organic waste
3-5	-Moderately clean water, some organic waste
6-9	-Polluted water, much organic waste and bacteria
10+	-Very polluted

STUDENT DATA SHEET

Jar: ____________________

Name____ Date (Day 1)_____________

	Temperature	Clear or cloudy	Color	Growth	Appearance
Day 1					
Day 2					
Day 3					
Day 4					
Day 5					
Day 6					
Day 7					
Day 8					
Day 9					
Day 10					

DO on Day 10: ____________ DO on Day 15: _______________ BOD: ___________

Conclusions:

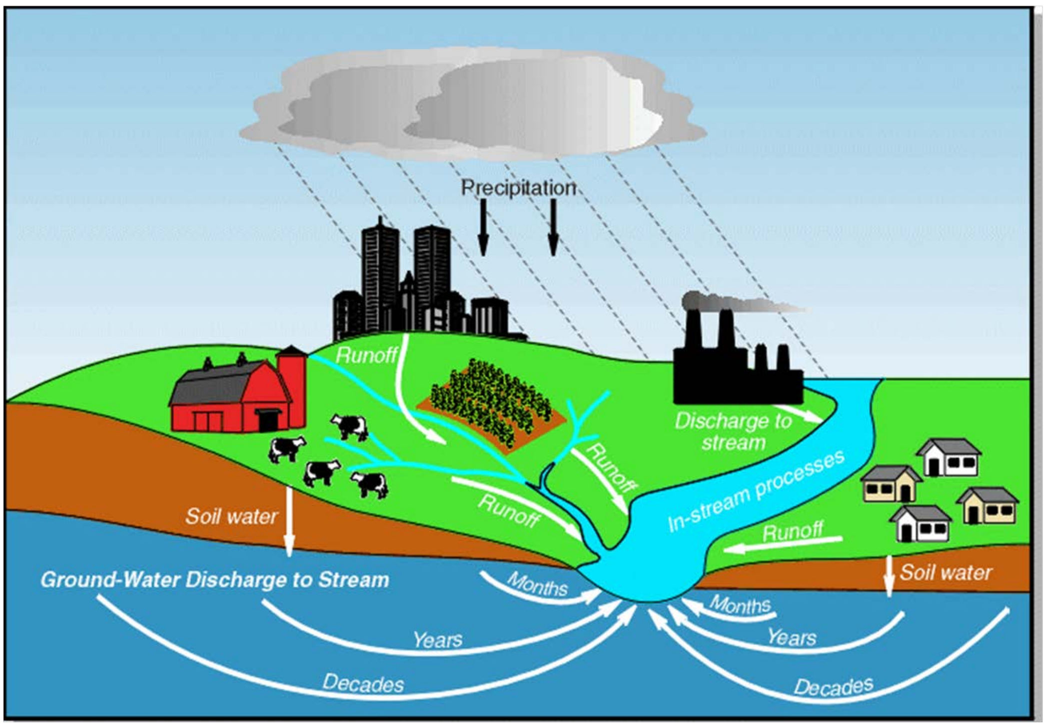
____

____

____

Use this section to teach what safeguards and practices are in place to help us protect our Urban Watershed and the waterways to which it drains.

STORMWATER MANAGEMENT



md.water.usgs.gov

ADD this Project WET Activity to your study of Stormwater Management--

There is No Away, pg. 453

project WET

STORMWATER MANAGEMENT

STEM Connection

SCIENCE • TECHNOLOGY • ENGINEERING • MATHEMATICS

Use ProjectWET.Georgia.gov to find Georgia Science and Mathematics Standards for Project WET and Urban Activities

Find these Engineering Connections to STORMWATER MANAGEMENT on www.teachengineering.org

*Sugar Spill

*The Dirty Water Project

*Things that Matter to Flocculants

Find Technology connections with a YouTube Video search.

GREENING THE ASPHALT

Students will experience the dilemma of being a city planner and making decisions which balance green space and pervious surface with hardscape in a card game that develops a new eco-friendly corridor in the City.

Charting the Course

Use Project WET's *A-Maze-ing Water* prior to this lesson.

Objectives

Students will:

- Analyze their development choices for the city and the impact on water quality and stormwater management.
- Identify the effects of impervious surfaces and green space development on stormwater management.

Materials

- Playing cards sets (1 set per group of 4-6 students)
- 1 score sheet per student (print 2-sided), group instructions and score sheet (1/team)
- 1 property board piece per team of 4-6 students
- Crayons to color in property board (1 identifying color and 1 green crayon per student), black markers
- 2 Trays filled with soil or mulch
- Spray bottle with water
- Black plastic or black trash bag
- 2 Thermometers
- Grass and sod, optional
- Rocks and sand
- Tape

Making Connections

Students will see how difficult it is to be a city planner and balance the needs of people, animals and our natural resources when developing an urban area. They will realize that the actions of everyone, even in their own backyard, will make a difference in the quality of the water and environment. It is important for them to realize the consequences of impervious surface and green space development in an urban area, and the impact such development has on streams.

Background

What are the impacts of impervious surfaces on an urban watershed? In an urban watershed, impervious surfaces increase as the city develops. This increase has inflicted a heavy toll on the state's watersheds. **Runoff from these impervious surfaces erodes soil, pollutes streams, degrades habitat, and disrupts normal water seepage. They impact water quality and quantity and have higher thermal temperatures than do vegetated areas.** Many nonpoint sources of pollution collect on these surfaces and are then transported by stormwater to the nearest stream or river.

What is green space and why is it important in an urban watershed? Green space is land that is left undeveloped, or developed in a way that allows water to filter through the soil before it reaches the aquifers. Green space can be in the form of a park, garden, rooftop garden, forest conservation site, or any place that does not restrict the percolation of water or the natural ability of soil and vegetation to absorb moisture. City developers must be careful to maintain a balance between impervious surface and green space development. **A city covered with impervious surfaces and no green space will result in much water pollution, while it is unrealistic to plan a city to have all green space and no impervious areas.**

Automobile-oriented development

Since the development of the automobile in the early years of this century, its use has been subsidized with public investment and land use regulation. Local governments spent millions of dollars to widen the cobbled streets and repave them with asphalt. With the new roads, Georgia's citizens moved from farms to urban areas, and from the central sections of cities to the fringes. Sewer and water lines were extended into low-density suburbs. City development was refitted to accommodate the car. Parking lots became essential for suburban stores and offices and more roads were necessary to bring goods and services back and forth. **The United States has paved 3.9 million miles of roads, enough to circle the Earth at the equator 157 times.**

Striking a Balance: impervious and green space development. City planners and developers can prevent many water-related problems in urban areas by planning for and building green space areas in the city to strike a balance between the two types of development.

Research has shown that watershed health begins to decline with any impervious surface coverage and becomes severely impaired if this number climbs beyond 30 percent of the total watershed area (Arnold and Gibbons 1996).

Replacing impervious surfaces with green space reduces urban heat island effect and increases energy savings because impervious surfaces absorb heat during the day and release it at night when the outside temperature falls.

It is very good to have green space near a water source because it helps filter out runoff chemicals before they enter the water body. Many pollution prevention controls, such as vegetation buffers beside streams and rivers, should be in place to assure the city that chemicals are not entering directly into the water.

Green Roofs (also known as rooftop gardens) are roofs of buildings partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. These roofs prevent direct runoff from tops of buildings and slow and clean water as it continues along the path toward the nearest water source. What water does come off of the building is much cleaner and slower than off of unplanted roofs.

Porous pavement has been engineered to allow water to fall on the pavement, and then reenter the environment in a very different way than traditional pavement. Stormwater and chemicals released from cars are percolated through the pavement, thereby reducing the amount of chemicals flowing from roads and neighborhood storm drains to the nearest water body.

Preparation

The Property Board -- Copy one/team of 4-6 students.
Playing Cards -- For each team make a set as follows:

1. Make 3 copies of the Impervious Surface Cards (pg. 110-112).
2. Make 4 copies the Green Space Cards (pg. 109), which includes double copies of the rooftop bonus and porous pavement cards.
3. Cut cards apart. Color and laminate if desired. Shuffle together into one set.

Procedure

Warm-up presents the concept of non-point source pollution runoff using a demonstration model.

Warm-Up Demonstration

1. Prepare tray A

a. Fill the tray with a layer of sand, rock or small gravel, and clay or soil.

b. Cover the top of the tray with a piece of black plastic (cut a piece of a black garbage bag to fit the top of the tray). Tape the plastic around the sides. This represents an impervious surface such as asphalt on a graded parking lot.

c. Cut a small hole in the plastic just large enough for the probe of a thermometer. The thermometer's probe should be positioned just below the surface of the soil (not too deep but out of the air pocket inside of the plastic).

2. Prepare tray B

a. Begin with a layer of sand on the bottom, filling about one third of the tray.

b. Fill next third of the tray with a layer of rock.

c. Fill the top third with a layer of soil and mulch.

d. You may place a layer of sod or grass on the top of the soil if available, but this is not necessary for the demonstration.

e. Place a second thermometer in tray B so that the probe is just under the surface layer of soil.

3. Incubate the trays

a. Place the two trays in a window receiving direct sun-light, outside in a sunny area, or under a heat lamp.

b. Leave the trays to heat for about an hour.

4. Compare the trays

a. After an hour of incubation, have the students read and record the temperatures of tray A and tray B.

b. The surface of tray A should have a substantially higher temperature than tray B. Why might this occur? What impact does the increased temperature will have on a stream?

5. Demonstration of runoff

a. **Ask the students what they think will happen when it rains on the two surfaces.**

Tilt the trays slightly to give them a gradient for runoff. Using a spray bottle full of water, simulate rain falling on tray A. Note that the rain rapidly runs off the impervious surface into the nearest stream, carrying with it any pollutants in its path.

Simulate rain falling on tray B. Note that the rain soaks into the soil and does not run off, even though the tray is tilted.

Activity

1. Your students will be developing a section of the city and they will have to make choices about that development. They must decide what size projects they will have and where they will develop them. Their decisions should include the needs of the people, wildlife, and the environment. What kind of developer will they be? Remind them about the demonstration and what they have learned about impervious surfaces. Make sure that your students understand what an impervious surface is and how it affects water quality and stormwater runoff.

2. Divide students into City Planning Teams with 4-6 students per team. **The group should strategically develop green space and impervious surfaces**, but each player is ultimately responsible for his/her own individual development.

3. Give each team a property board that represents the city and a set of cards. **Each student receives a scorecard (pg 109-111), a green crayon, and a different color crayon to mark their own developed areas on the property board**. Green is the color that represents pervious surfaces, while each player needs a different color crayon for his/her own impervious surface development.

4. One player on each team will be the dealer and passes out **six cards to each player**, including self, **face up** in front of each player. The remaining deck of cards is put face down. Turn over the first card and place it face up next to the deck.

4. The object of this activity is to get a matching pair of cards. Starting from the dealer's left, each player in turn either draws a card from the deck or the discard pile, following these rules:

- If a player gets a **matching pair of cards**, the player can develop the project on the cards; can save it for later; or can discard the pair and pick up two more cards to make a total of six cards in front of that player.
- **If a pair is made**, then no discard is required for that turn.
- If a player **chooses to develop the project** on the matching pair, he/she will color in the number of acres indicated on the card:
  -Color in spaces with green for **Green Space Surface**
  -Make an X in the spaces with identifying color for **Impervious Surface**
- Students may complete the acre blocks vertically, horizontally, or diagonally, as long as the spaces are touching. Use a **black marker to outline** each player's developments. Put the used paired cards aside.
- **Student records acreage developed on score sheet.** Each time a player "develops" or fills in acres on the board, that player must check it off on the score sheet next to the corresponding name.

Green Roof and **Porous Pavement Cards** are bonus cards and can **replace half of any impervious surface** developed on the board with green space surface.

- **A player must get a pair of the bonus cards to apply the bonus to an impervious surface.**
- The player that originally developed the impervious surface on the board must go back to his/her score sheet and reduce the impervious acres by half of the original amount.
- The player that applied the bonus writes in the number of acres that replaced the impervious surface with green acres in his/her own bonus section.

When the deck is finished, shuffle and reuse. Do not include the pairs used for development. **The players continue to pick up, discard, and fill in their developed acres on the board until it is completely filled in.**

Wrap Up

1. Each player now needs to complete the final calculations section of the score sheet for both the individual and the group. Each player will determine the type of developer he/she is based on impervious and green space calculations. Have students determine based on their scores if they are a conventional, new urbanist, or conservation developer.

2. The group will complete the final calculations section of the group score sheet to find out what percentage of total development is impervious and green space and the type of developer they represent.

Types of Developers:

A **Conventional** developer (0% – 15% of city is green space) is the traditional city planner, who does not necessarily plan for a balance between impervious and green space development. This developer needs to pay attention to the discussion concerning the importance of this balance and find ways that he or she can plan for more green space during future planning.

A **New Urbanist** developer (16% – 67% of city is green space) has a better grasp on balancing impervious and green space development. He or she recognizes the impacts certain surfaces can have on nearby water bodies. If this developer continues to lead planning in the city, there might well be an improvement in the health of our streams and rivers.

A **Conservation** developer (68% – 71% of city is green space) has a very progressive take on development. Green space development is over half of all development in the city. Not many cities are like this, but more are on the rise. This developer has a great sense of the importance of green space, and the city residents are privileged to live in such a green, healthy, and beautiful city.

*Consider this! If the developer has developed over 71% green space, then there may be **too much green space** and not enough impervious surface. Will the city still function well for people?*

3. Once the players know what kind of developer the group and the player (individual) is, ask if they agree or disagree with the environmental implications. Teams will share their development plan. Ask the students which team they would hire to be city planners for the city? Which individual developer would lead the project?

Assessment

1. Ask students to construct an argument on how they planned their city. Have them use evidence, data, and research to justify their decisions. They should include how impervious surfaces and green space development impacts water quality. (Use Rubric 1 to evaluate)

2. Have students take a walk on their school campus and make a design of the school, parking areas, nature trail, gardens and walkways. After they have created the school campus design, ask them to color the areas that are impervious surfaces and the areas that are green space. What percent of the school campus do they think is impervious and what percent is green space? (Rubric 2)

Early urban development

A hundred years ago, trains and streetcars supported downtown business districts by bringing shoppers and workers from all over the region. Development in the suburbs was kept within walking distance of streetcar lines. Land use combinations evolved within the constraints of daily walking distances. City streets were paved with cobblestones, which were permeable to small amounts of rainfall and runoff. Minor residential streets had no curbs; instead they were usually flanked by swales or ditches that kept streets passable during moderate rainfalls.

GREENING THE ASPHALT
RUBRIC 1 FOR ASSESSMENT

Ask the students to write a paragraph on how they planned their city. Did they put in impervious surfaces? Did they include green space? How do impervious surfaces and green space development affect water quality?

Score	4	3	2	1
Organization	Information is very organized in a well-constructed paragraph. There is a clear introduction, explanation, and conclusion, and all ideas presented are logical.	Information is organized in a well-constructed paragraph. The student included an introduction, explanation, and conclusion.	Information is organized, but the paragraph is not well-constructed. The student presents related ideas but does not properly construct an introduction, explanation, and conclusion.	The information appears to be disorganized. The ideas presented are unrelated and there is no paragraph structure.
Comprehension	Student included more than 4 ways that impervious surfaces and green space development affect water quality.	Student included 3-4 ways that impervious surfaces and green space development affect water quality.	Student included 2 ways that impervious surfaces and green space development affect water quality.	Student included 1 or no ways that impervious surfaces and green space development affect water quality.
Comprehension	Student exceeded expectations in his or her understanding of the concepts of impervious surfaces and green space.	Student understands the concepts of impervious surfaces and green space for the most part.	Student somewhat understands the concepts of impervious surfaces and green space.	Student does not understand the concepts of impervious surfaces and green space.
Analysis	Student exceeded expectations in own understanding of the impact of development choices for the city and the impact on water quality.	Student understands the impact of own development choices for the city and the impact on water quality for the most part.	Student somewhat understands the impact of own development choices for the city and impact on water quality.	Student does not understand the impact of own development choices for the city and the impact on water quality.

GREENING THE ASPHALT
RUBRIC 2 FOR ASSESSMENT

Have students take a walk on their school campus and make a design of the school, parking areas, nature trail, gardens, and walkways using graph paper. After they have created the school campus design, ask them to color the areas that are impervious surfaces gray and the areas that are green space green or another color. Calculate the percentage of impervious and green space surfaces on the school campus.

Score	4	3	2	1
Neatness	The design was completed extremely neatly and carefully and all significant areas were included in the design.	The design was completed neatly and most significant areas were included in the design.	The design was messy OR significant areas were not included in the design.	The design was messy AND significant areas were not included in the design.
Comprehension	Student correctly identified all impervious surfaces and green spaces.	Student correctly identified most impervious surfaces and green spaces.	Student correctly identified some impervious surfaces and green spaces.	Student did not correctly identify any impervious surfaces or green spaces.
Comprehension	Student completely understands the concepts of impervious surfaces and green space.	Student understands the concepts of impervious surfaces and green space for the most part.	Student somewhat understands the concepts of impervious surfaces and green space.	Student does not understand the concepts of impervious surfaces and green space.
Accuracy	Student calculated percentages correctly.	Student's calculations were close to the actual percentages.	Student's calculations were not close to the actual percentages.	Student did not calculate percentages OR the calculations based on the drawing were extremely different from actual percentages.

INDIVIDUAL SCORE SHEET **NAME** ____________________

✔ add a check next to the impervious surface development you added to the Property Board.

IMPERVIOUS SURFACES

Amphitheater ____ 1.5 acres (6 spaces)

Amusement Park ____ 2 acres (8 spaces)

Apartments ____ 2.75 acres (11 spaces)

Athletic Field ____ 2.5 acres (10 spaces)

Basketball Court ____ 0.25 acres (1 space)

Bridge ____ 2.5 acres (10 spaces)

City Complex ____ 3 acres (12 spaces)

City Sidewalk ____ 0.5 acres (2 spaces)

Condos ____2.5 acres (10 spaces)

Courthouse ____ 1.25 acres (5 spaces)

Deli ____ 0.5 acres (2 spaces)

Gas Station ____ 0.25 acres (1 space)

Government Bldg. ____ 0.75 acres (3 spaces)

Grocery Store ____ 0.5 acres (2 spaces)

Highway ____ 4 acres (16 spaces)

Interstate ____ 4.5 acres (18 spaces)

Large Airport _____ 3 acres (12 spaces)

Large House ____ 2 acres (8 spaces)

Large Industry ____ 2.25 acres (9 spaces)

Library ____ 0.5 acres (2 spaces)

Mechanic shop ____ 0.5 acres (2 spaces)

Water Treatment ____ 3.25 acres (13 spaces)

Medium House ____ 1 acre (4 spaces)

Movie Theater ____ 0.75 acres (3 spaces)

New Car Dealer ____ 0.75 acres (3 spaces)

Office Building ____ 1.5 acres (6 spaces)

Office Complex ____ 2.5 acres (10 spaces)

Parking Garage ____ 1 acre (4 spaces)

Parking Lot ____ 0.75 acres (3 spaces)

Paved Playground ____ 0.25 acres (1 space)

Pharmacy ____ 0.5 acre (2 spaces)

Place of Worship ____ 2 acres (8 spaces)

Police Station ____ 1 acre (4 spaces)

Retail Store ____ 0.5 acres (2 spaces)

Road ____ 2 acres (8 spaces)

School ____ 1.25 acres (5 spaces)

Shopping Mall ____ 2.5 acres (10 spaces)

Skyscraper ____ 1.75 acres (7 spaces)

Small Airport ____ 2 acres (8 spaces)

Small Building ____ 0.5 acres (2 spaces)

Small House ____ 0.25 acres (1 space)

Small Industry ____ 1.5 acres (6 spaces)

Sports Arena ____ 2 acres (8 spaces)

Suburban House ____ 1.5 acres (6 spaces)

Swimming Pool ____ 0.25 acres (1 space)

Train Station ____ 1.25 acres (5 spaces)

University ____ 2 acres (8 spaces)

Used Car Dealer ____ 0.75 acres (3 spaces)

Continue on back.

INDIVIDUAL GREEN SPACE SURFACES

Botanical Garden ____ 1.25 acres (5 spaces)

Conservation Site ____ 1 acre (4 spaces)

Eco Green House ____ 1 acre (4 spaces)

Eco Playground ____ 0.25 acres (1 space)

Forest Park ____ 1.5 acres (6 spaces)

House Garden ____ 0.25 acre (1 space)

Landscaped Garden ____ 0.5 acres (2 spaces)

Neighborhood Park ____ 0.5 acres (2 spaces)

Preserved Forest ____ 2 acres (8 spaces)

Preserved Land ____ 1 acre (4 spaces)

Recreation Park ____ 0.75 acres (3 spaces)

River Walk ____ 1 acre (4 spaces)

Trail Park ____ 1 acre (4 spaces)

Urban Park ____ 1.25 acres (5 spaces)

BONUS POINTS

If you have a PAIR of MATCHING BONUS CARDS you may replace half of any impervious surface developed on the board with green space surface.

GREEN ROOF

Deduct half the acres from ANY developed impervious surface on the board (original developer records on own score sheet) and enter number of new green acres below:

Green acres ____ acres

Green acres ____ acres

Green acres ____ acres

POROUS PAVEMENT

Deduct half the acres from ANY developed impervious surface on the board (original developer records on own score sheet) and enter number of new green acres below:

Green acres ____ acres

Green acres ____ acres

Green acres ____ acres

YOUR TOTALS

Impervious Surface Total = _______ acres

Green Space Total = _______ acres

Green Bonus Total = _______ acres

TOTAL ACRES Developed = _______ acres

YOUR PERCENTAGES

% Impervious Surface (Impervious/Total Acres) x 100 = ___________ %

% Green Space (Green Space + Green Bonus/Total Acres) x 100 = ___________ %

Type of Individual Developer you are based on % Green Space ________________________________.

Greening the Asphalt Group Instructions

1. The Object **is to create a balanced green space for the city. To begin you must get a matching pair of cards.**
2. **One player is dealer** who deals each player 6 cards face up, including self. Place the remaining cards face down in a stack in the middle. Turn over the top card and place to the side to start the discard pile.
3. Starting from the dealer's left, each player takes a turn and either **draws a card from the deck or the discard pile** trying to get a matching pair. If a pair is not made the player must discard a card to keep 6 only.
4. **With a matching pair of cards, <u>follow these rules:</u>**
   - The player makes a choice: a) develop the space; b) save it for later (set to the side and develop on another turn); or c) discard the pair and pick up two more cards for a total of six cards in front of that player.
   - If a pair is made, then no discard is required for that turn.
   - If a player **chooses to develop the project** on the matching pair, consult with your team on the placement, then complete the number of acres indicated on the card like this:

   \- **For Impervious Surface Development** use your own color crayon to make **an X in squares**

   \- **For Green Space Surface Development** use green crayon to **fill in the squares**
   - Players may complete the acre blocks vertically, horizontally, or diagonally, as long as the spaces are touching. Use a black marker to outline each player's finished developments.
5. **Record developed acreage onto individual score sheet.**
6. **Green Roof** and **Porous Pavement Cards** are bonus cards and can **replace half of any impervious surface** developed on the board with green space surface.
   - **A player must get a pair of matching bonus cards before using them.**
   - When bonus cards are used the player that originally developed the impervious surface on the board must go back to his/her score sheet and reduce the impervious acres by half of the original amount.
   - The player that applied the bonus writes in the number of acres that replaced the impervious surface with green acres in his/her own bonus section.

Group Calculations

1. Use a calculator to add up all IMPERVIOUS SURFACE ACRES from each person in the group.

   _____ Total group impervious surface acres

2. Add up all GREEN SPACE AND BONUS GREEN SPACE ACRES in the group.

   _____ Total group green space acres

3. Add IMPERVIOUS and GREEN acres together.

   _____ Total group acres.

4. Find group's percentages:

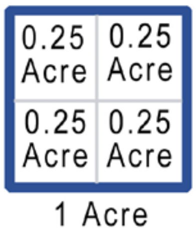
% Impervious Surface (Impervious/Total Acres) x 100 = ____________ %

% Green Space (Green Space + Green Bonus/Total Acres) x 100 = ____________ %

Type of Group Developer based on % Green Space ________________________________.

Conventional: 0 – 15% green space New Urbanist: 16 – 67% green space Conservation: 68 – 71% gs

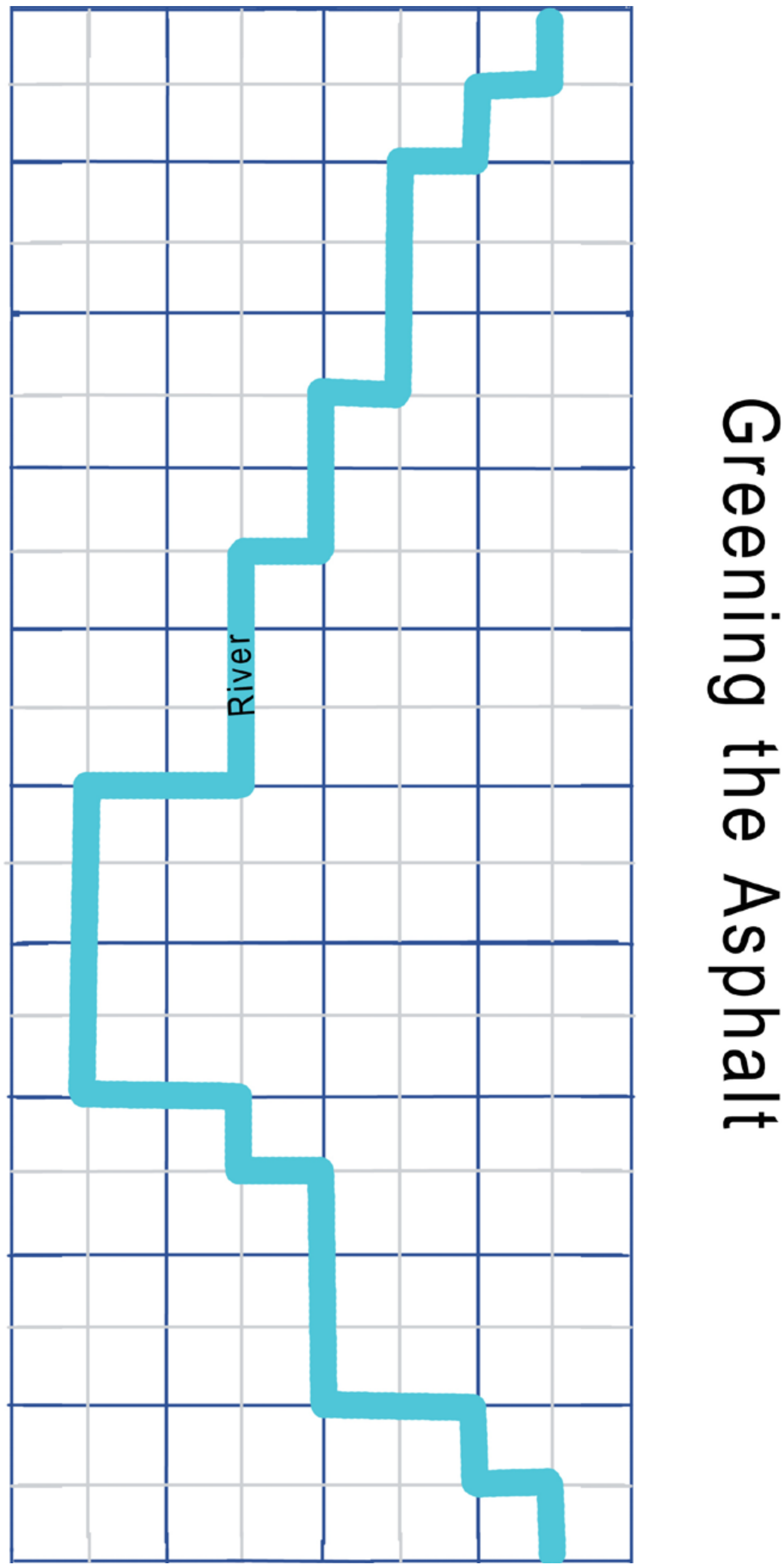
TEAM PROPERTY BOARD



Make an X in squares for impervious development using your own color.

Fill in green space squares completely with GREEN.

Outline your development with black marker.



Green Space Cards
Make 4 copies of this page on cardstock for each set of cards.

Cut apart and shuffle together with Impervious Surface cards to make one set.

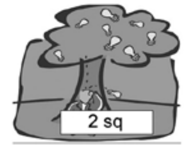
GREEN SPACE | GREEN SPACE

Eco Green Playground
0.25 acres

GREEN SPACE | GREEN SPACE

Eco Green house
1 acre

GREEN SPACE | GREEN SPACE



Neighborhood Park
0.5 acres

POROUS PAVEMENT

BONUS

GREEN SPACE | GREEN SPACE

Botanical Gardens
1 acre

GREEN SPACE | GREEN SPACE

River Walk
1 acre

GREEN SPACE | GREEN SPACE

Trail Park
1 acre

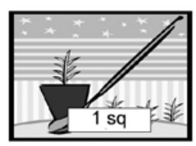
POROUS PAVEMENT

BONUS

GREEN SPACE | GREEN SPACE

Recreation Park
0.75 acres

GREEN SPACE | GREEN SPACE



House Garden
0.25 acres

GREEN SPACE | GREEN SPACE

Urban Park
1.25 acres

GREEN ROOF

BONUS

GREEN SPACE | GREEN SPACE

Preserved Land
1 acre

GREEN SPACE | GREEN SPACE

Landscaped Garden
0.5 acres

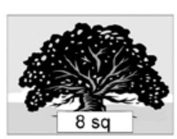
GREEN SPACE | GREEN SPACE

Small Garden
0.25 acres

GREEN ROOF

BONUS

GREEN SPACE | GREEN SPACE



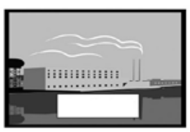
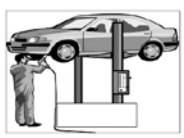
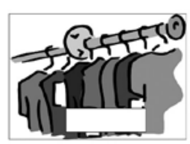
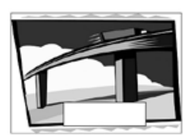
Preserved Forest
2 acres

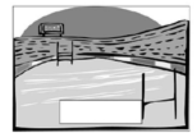
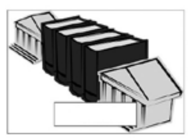
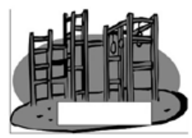
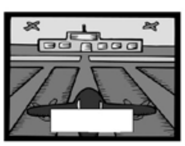
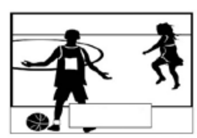
GREEN SPACE | GREEN SPACE

Forest Park
1.5 acres

GREEN SPACE | GREEN SPACE

Conservation Site
1 acre

Impervious Surface Cards Make 3 copies of this page on cardstock for each set of cards. Cut apart and shuffle together with Green Space cards to make one set.	 New Car Dealership 0.75 acres	 Parking Lot 0.75 acres	 Movie Theater 0.75 acres
 Small Industry 1.5 acres	 Swimming Pool 0.25 acres	 Deli 0.5 acres	 Road 2 acres
 Water Treatment 3.25 acres	 Mechanic Shop 0.5 acres	 Gas Station 0.25 acres	 City Sidewalk 0.5 acres
 Large Industry 2.25 acres	 Amusement Park 2 acres	 Retail Store 0.5 acres	 Bridge 2.5 acres
 University 2 acres	 Small Building 0.5 acres	 Used Car Dealer 0.75 acres	 Parking Garage 1 acre

Impervious Surface Cards Part 2 Make 3 copies of this page on cardstock for each set of cards. Cut apart and shuffle together with Green Space cards to make one set.	 Police Station 1 acre	 City Complex 3 acres	 School 1.25 acres
 Large House 2 acres	 Grocery Store 0.5 acres	 Sky scraper 1.75 acres	 Athletic Field 2.5 acres
 Train Station 1.25 acres	 Courthouse 1.25 acres	 Paved Playground 0.25 acres	 Sports Arena 2 acres
 Small Airport 2 acres	 Amphitheater 1.5 acres	 Basketball Court 0.25 acres	 Office Building 1.5 acres
 Large Airport 3 acres	 Library 0.5 acres	 Government Building 0.75 acres	 Office Complex 2.5 acres

Impervious Surface Cards
Part 3
Make 3 copies of this page on cardstock for each set of cards.

Cut apart and shuffle together with Green Space cards to make one set.

 Pharmacy 0.5 acres	 Apartments 2.75 acres	 Medium House 1 acre	 Shopping Mall 2.5 acres
 Highway 4 acres	 Interstate Highway 4.5 acres	 Condos 2.5 acres	 Suburban House 1.5 acres
 Place of Worship 2 acres	 Small House 0.25 acres		

PIPED ON WATER

Students create a model of their city's water and wastewater delivery system in their school community.

Charting the Course

Use the activities *Just Pipe Up!, Greening the Asphalt* and *River to River* before this one so that students have an understanding of the processes and the needs of the city. This activity may be used as an Urban Watershed Stormwater assessment piece.

Objectives

Students will:

- Distinguish between a city's drinking water and wastewater systems.
- Demonstrate knowledge of the sequence of the man-made water cycle.
- Use creativity and prior knowledge to solve one or more problems with stormwater management.

Materials

- Maps of water treatment and wastewater treatment facilities in your area (use Google Maps if necessary)
- Various construction materials for each group: glue, stapler, construction paper, cardboard, markers, straws, scotch tape, toothpicks, markers, crayons, large square piece of paper or cardboard, and paper towel holders to cut for storage tanks, scissors
- Use different colored straws to distinguish between drinking water pipes, stormwater and wastewater pipes
- Copies of the pattern page made on colored construction paper (pg 121)
- Copies of the Inspector's Report (pg. 122)
- A copy of Sewer Systems diagram from page 10 to show students as an example.
- Google Earth access (optional)

Making Connections

Students will use their knowledge of the man-made water cycle in the urban watershed to become city planners and engineers who are responsible for planning and overseeing the delivery of water to homes, schools, and businesses. These planners make sure that the delivery system works and provides the public with clean, potable water and a safe way to clean wastewater.

Background

In most communities in Georgia water for use in homes, businesses, and schools is drawn from a nearby river. A few cities take their drinking water from ground reserves. When water is removed from the river it must be **processed in a drinking water treatment plant** because cities and towns above the takeout point contribute contaminants including bacteria and viruses, pesticides and herbicides, salts and metals, chemicals, oils, and litter to the river. These pollutants must be removed from the water before it is safe to drink. Once the **Drinking Water** is treated, it is transported through a system of storage tanks, pumps, and pipes to the community.

Wastewater is water that has been used in our homes, schools, and businesses and has gone down the drain. This "used" water travels through sewer pipes to the city's **Wastewater Treatment Plant** where it is cleaned before returning to the river. Each day these plants release millions of gallons of treated wastewater into the state's rivers.

Cities have a third water management system to maintain for Stormwater. One hundred or more years ago, cities throughout the eastern U.S. built **Combined Sewer Systems** to take care of wastewater and stormwater. With this system, when the weather was dry, wastewater from homes, schools, and businesses traveled through sewer pipes to wastewater treatment centers for cleaning and was eventually discharged into a waterway. But when it rained, stormwater entered into the combined sewers along with wastewater and together went to the wastewater treatment plant. To prevent the plants from flooding, the combined flow was redirected to a **Combined Sewer Overflow (CSO)** treatment facility, where the water was treated and then released into a river or stream. **The real problem happened during heavy rains, when the water flow exceeded the capacity of the CSO facility and wastewater and stormwater overflowed into the river!**

Nowadays, the last remaining Combined Systems in Georgia cities use large underground tunnels that capture the water from the combined sewer overflows and hold it until it can be treated later at an enhanced CSO treatment facility. **Wastewater should never overflow into a river!**

Most cities in the state (90%) now have Separated Sewer Systems for wastewater and stormwater. Under new laws, cities must construct sewer pipes so that wastewater and stormwater travel in separate paths. The wastewater is piped to a wastewater treatment plant and then discharged into a nearby waterway. Stormwater, on the other hand, is released directly into local waterways from storm drains.

Procedure

Warm Up

1. Take a large piece of paper or poster board and divide it in four sections. Draw a picture of the school in the center of the board. Ask students to think about all the homes and businesses around the school that need water. Use Google Earth to view the neighborhood surrounding the school, if possible.

2. Ask the students to name two or three homes or businesses in each quadrant of the map and draw them in and label them. Do this with each quadrant. Ask where the community will get its water. Then tell the students that they need to locate the river or waterway in relation to the school.

3. Using the maps of your city's Water and Wastewater Treatment Plant locations find the nearest intake for drinking water treatment and the nearest wastewater treatment facility. You can draw or stretch a piece of yarn beside the poster board to indicate approximately where the river is. Water leaves the river and is piped to the drinking water treatment facility, then to the homes, schools, and businesses and finally goes to the wastewater treatment facility and back to the river.

4. Discuss the differences between drinking water treatment, and separate and combined sewer systems.

   With students, visit cleanwateratlanta.org web site ->Environmental Education. The site has **Animated Tutorials** showing
   1. What is a Sanitary Sewer System
   2. Combined Sewer System
   3. Separated Sewer System
   4. Typical Sanitary Sewer System Problems
   5. CSO Facility Tour

5. **Invite an engineer to speak about pipes and the delivery system and creative ideas for managing stormwater.** Contact your area's Department of Watershed Management to find out what outreach capacities they have.

6. Discuss the merits and problems with each of the sewer systems (Combined and Separated) and ideas on how to improve the management of stormwater. Teams may use these ideas to develop a creative solution to include in their models.

Activity

1. **Students are about to become city engineers and they must figure out a piping or delivery system to get water from the river to the homes, schools and businesses and back to the river again. They must also consider how stormwater is handled in their part of the community.** What kinds of things will they have to think about *(pumping stations, gravity, cost, pipe material, treatment plant, etc.)*? Where is the river intake and outfall?

2. Use area maps and Google Earth to locate the river and treatment facilities.

3. **Divide the students into four teams and assign each team a quadrant of the community map drawn in the warm up.** Teams may need to see the site on Google Earth and view maps of area before beginning the model construction.

4. **Each team will be responsible for building a representative model of their quadrant onto chart paper or poster board.** Each of these quadrants will fit together later with the school in the center so teams must locate where to place the school in their model. They must generally locate the river and where the nearest drinking water and wastewater treatment facility is in relation to their community.

5. Ask teams to think about the community in the quadrant area around their school and **draw a rough sketch** of the buildings, streets, and pipe systems on scratch paper.

6. **As they are planning their model, remind them of the following:**

- Water is stored prior to sending it on to homes, schools, and businesses and it will need to be pumped so students will need to build storage tanks and pumping stations.
- There are large pipes that get water from the river to the drinking water treatment facility and sometimes a pump is necessary to get water from the river to the drinking water treatment facility.
- **Teams will build two separate waste pipe lines.** One set of pipes will leave homes, schools and businesses and go straight to the wastewater treatment facility. The other set is connected to s**torm drains** in the community that take the stormwater directly to the river.
- In general water moves under pressure to the water treatment plant (students will need to build pumps) and by gravity to the wastewater treatment plant.
- **They should have an idea for a new or proven solution to managing stormwater** and include it in their model. Teams should be prepared to explain it.

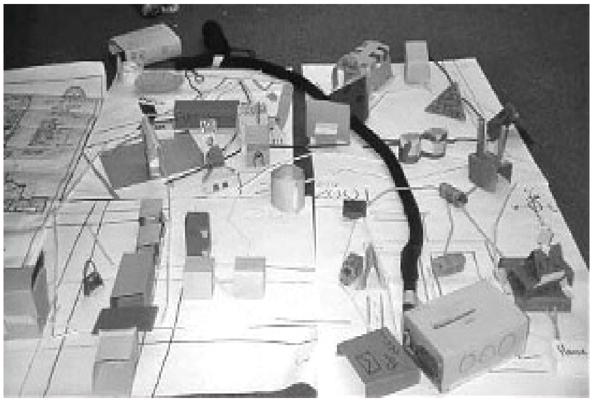
7. **Have each team construct the buildings, streets, and piping out of the materials provided to make a 3-D model of their quadrant.** Students should first transfer their sketch to the larger poster board. The school, river, and treatment facilities should be clearly labeled so that students know where they are located during construction.

Students will construct the piping of drinking water using straws and toothpicks or pipe cleaners from the river to the water treatment plant to their buildings. They will also construct pipes to the wastewater treatment from homes, businesses and schools then back to the river and provide a system for managing Stormwater.

The model does not need to be accurate, just representative of the community. *For example, if a street has 20 houses on it, the group might build only 5.*

8. **After all teams have completed their "piped" community, bring the 4 quadrants back together. Appoint several volunteers to "inspect" the model community using the Inspector's Report.**

9. Give the teams some time to work on their problems and with the others to connect piping to make the community system more efficient.



10. **When the model is completed, ask the teams to brainstorm what occupations are needed to enable the scenario they have designed to take place**. How does the water get from the waterway to the facility or to homes, schools and businesses? What jobs are necessary to make this happen? What kinds of things

would a city engineer have to think about in order to move the water from the river and back to the river again in an urban man-made water cycle? *(Topography, type of soil and rock, gravity, development in place, expenses, materials needed, contractors to do the job).*

Assessment

Invite another class to listen to each team's presentation of its model. They must clearly communicate the following:

- Give an overview of the model and the purpose behind its construction
- Explain the sequence from the river, water treatment, homes, schools, businesses, wastewater treatment and back to the river
- Demonstrate how the water supply and wastewater lines serviced everyone
- Discuss possible problems stormwater brings to the system and share the team's creative ideas for improving the management of stormwater?

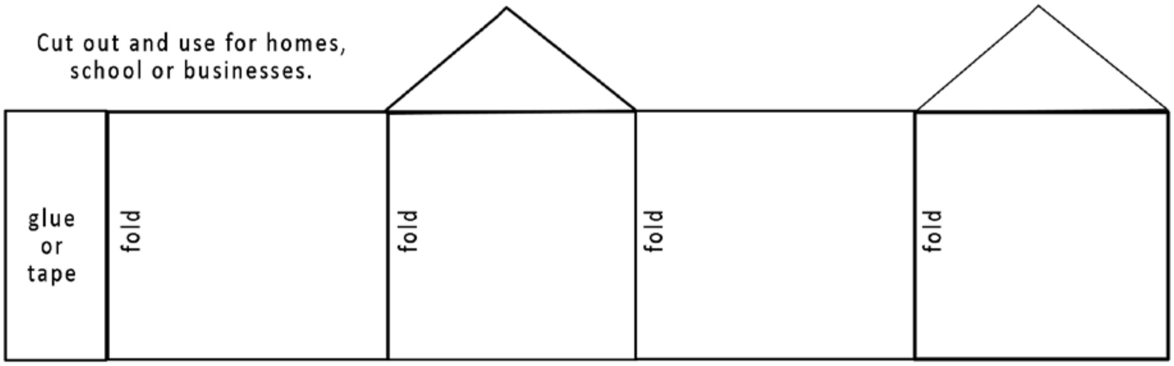
Resources

Georgia's State Water Plan
https://waterplanning.georgia.gov/state-water-plan

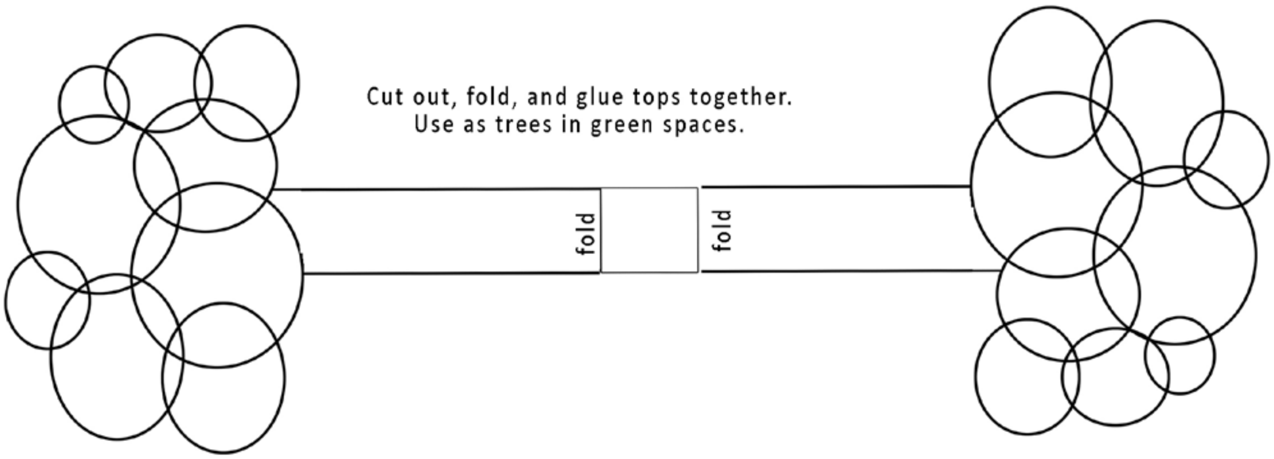
USGS Water Science School
http://water.usgs.gov/edu/wuww.html

Copy this page onto colored construction paper as many times as necessary to provide building materials for students' *Pipedon Water* community constructions.

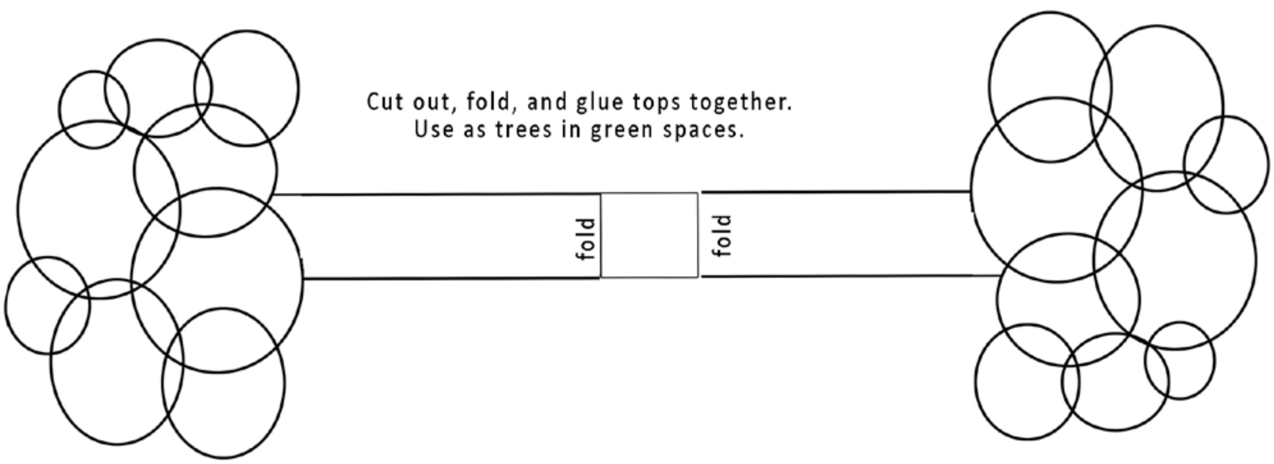
Cut out and use for homes, school or businesses.



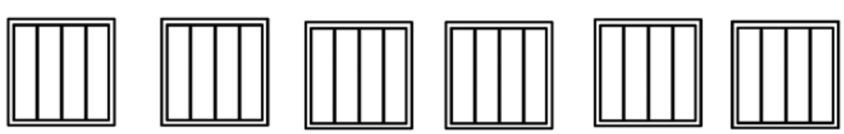
Cut out, fold, and glue tops together.
Use as trees in green spaces.



Cut out, fold, and glue tops together.
Use as trees in green spaces.



Cut out and use the stormdrains.



Inspector's Report

Inspector's name ____________________________ Quadrant: Top Left Top Right Lower Left Lower Right

Inspect this team's model for the following:

- ☐ Are the pipes for each community beginning at the river?
- ☐ Are the pipes going to the drinking water treatment facility, then to the homes, schools and businesses?
- ☐ Do the wastewater pipes leave the homes, schools, and businesses and go to the wastewater treatment facility and back to the river?
- ☐ Can you tell the difference between the drinking water pipes and the wastewater pipes?
- ☐ Does the wastewater treatment plant have an outfall or place where the water is discharged back to the river?
- ☐ Are all the pipes laid correctly?
- ☐ Are they all connected?
- ☐ Do they bring water from the water treatment facility to the homes, school, and businesses and eventually connect to the wastewater treatment facility and finally to the river?
- ☐ Should any of the pipes be connected to pipes from the other sections?
- ☐ Does this team have a creative idea for managing a stormwater system?

Notes:

Use this section to take your students from knowledge to action in their own watershed.

MAKING CHOICES & TAKING ACTION

STEM Connection

SCIENCE • TECHNOLOGY • ENGINEERING • MATHEMATICS

Find these Engineering Connections to

WATERSHED ACTIONS on

www.teachengineering.org

*A Guide to Rain Garden Construction

* Green Infrastructure and Low-Impact Development Technologies

Use ProjectWET.Georgia.gov to find Georgia Science and Mathematics Standards for Project WET and Urban Activities

Through Technology create your Action Posters and Science Notebook on www.discoverwater.org

WALK THE TALK

Students can take actions at home and at school that protect the quality of water in the Urban Watershed.

IN THIS SECTION

WATER AUDIT

Background

The average person in the United States uses approximately 80–100 gallons of water per day with the largest household use being the toilet followed by showers and clothes washers (*EPA WaterSense*)! Before students can change their behavior, they need to know how much water they are using and how they are using it. Changing basic behaviors can reduce water usage.

The following is a list of suggestions for reducing the amount of water used at home:

- Turn off the faucet when you brush your teeth, wash your hands, or do the dishes.
- Don't flush the toilet unnecessarily. Throw tissues and other trash in the wastebasket.
- Turn off the hose and/or use a nozzle that automatically cuts off when you don't hold it down.
- Take shorter showers.
- Fix dripping faucets and running toilets.
- Water your garden only when it needs it – once or twice a week.
- Only wash full loads of laundry and dishes.
- Make sure that your lawn sprinklers don't spray onto sidewalks, streets, or driveways.

The water audit allows the students to calculate their water usage at home so they can discover areas for improvement.

Procedure

1. Hold up the gallon of water to give the students a visual representation of one gallon of water. Then ask them to think about how many gallons of water a day they think their family uses and write that amount down.

2. Give them a clue by telling them that each time they flush the toilet it takes 2- 5 gallons of water. Brainstorm a list with the class of all the different ways they use water at home: for example, baths, dishwashers, toilets, lawn watering, showers, and washing machines.

3. Explain that they will be conducting a water audit and determining the amount of water their family uses throughout the week. Once they have calculated how much water their family uses, have them fill in ways they can reduce the amount of water used at the end of the worksheet and return the form to class for discussion.

Sources

Water Science for School http://water.usgs.gov/edu
EPA WaterSense https://www.epa.gov/watersense
Water Conservation Education South Florida Water Management District https://www.sfwmd.gov/community-residents/water-conservation
Home Water Uses http://home-water-works.org

WATER CONSERVATION AUDIT FOR GEORGIA

How much water does YOUR family use?

Directions: Ask your family to help you answer these questions to find out how much water your family uses.

1. Where do you live? Circle one: house apartment/condo mobile home

2. How many people live in your home including you? Circle one: 2 3 4 5 6 7 8 9 10 more

3. Check your water bill. **Find out how many gallons of water were used in your home during the last billing period:**
__________ **gallons (1 CCF = 750 gallons)**

4. How many days were there in that billing period? ________ **days**

How much water does your family use OUTSIDE?

5. Does your home have a yard? YES or NO If **NO**, skip to question 8.
If **YES**, how big is your yard compared to the other yards on your street?
Circle one: larger the same smaller

6. What type of plants does your yard have?
Circle all that you have: grass ground cover flowers shrubs trees vegetable garden

7. How much water did your family use outside from April to October last year?
Estimate it by answering the questions below:

a. During the growing season, how many minutes do you water your lawn each day?
______ **number of watering minutes per day** (total number of minutes each hose or sprinkler is run every watering day)

b. How many days per week is your lawn watered? ______ **number of watering days per week** (one to seven)

How much water does your family use INSIDE your home?

8. Dishwasher (if you have one)

a. How many times per week is the dishwasher run? _______
b. How full is the dishwasher usually loaded? **Circle one:** full half full less than half

9. Washing machine (if you have one)

a. How many loads per week are usually washed? ______
b. How full is the washing machine usually loaded? full half full less than half
c. Is the setting on the washer set for the correct amount loaded? (For example, small load setting for a small load)
always never sometimes

10. Count them! **How many of each of the following do you have in your home?**

______ sinks ______ showers ______ bathtubs _____ toilets

11. How many showers per week are taken in your home? *Do the Math!*

______ # of family members x ______ # of showers /week = **________ Total # of showers per week**

12. How many baths per week are taken in your home? *Do the Math!*

______ # of family members x ______ # of baths/ week = **________ Total # of baths per week**

13. How many minutes is your family's average shower? Estimate it by answering the questions below.
Time it! Use a stop watch to record he amount of time it takes each of your family members to shower. Add the minutes together and write them in the space below.

Total # of minutes family members spent in the shower in one day _______ ÷ Total # of family members _______ **=**

_______ Average # of minutes for shower in your family

14. Count it! How many times each day is a toilet flushed in your house? _____ times

_______# of toilet flushes x _______ days/week (one to seven) used = **_______ Total # of toilet flushes per week**

15. Are there other places where a lot of water is used in your house? (automatic sprinklers, hottub, swimming pool, etc.)

How much water do YOU ALL use each day?

16. Do the math! **Figure out the AVERAGE water used by each members of your family on a typical day.**

_____ Total gallons/billing period used ÷ _____ # days in billing (average) = _______ Daily Consumption ÷

______ # people in home **= _______ Average Use/person in Gallons/day**

17. Do the math! **Figure out how much water is used OUTSIDE your home.**

a. _____ Watering minutes/day x _____ Watering days/week = ________ Watering Minutes/week ÷ 60 **=**

________ Watering hours/week

b. ______ Watering hours/week x 1800 Gallons/hour **= _______ Gallons/week used Outside**

18. How much do you use?

Activity	**Average GALLONS used in US households/use**	**Multiple by # of uses/week for your Family**	**= Your Family's gallons used/week**
Dishwasher	12	x	=
Washing Machine	30	x	=
Showers	18	x	=
Baths	35	x	=
Toilet Flushes	2	x	=
Outside water use	20	x	=

19. These are the ways I can conserve water at home and at school:

Pharmaceuticals and Personal Care Products

Students will

- Discover the effects Pharmaceuticals and Personal Care Products have on the watershed
- Explore Best Management Practices for the use of PPCPs that they can implement at home and school

Background

Pharmaceuticals and Personal Care Products (PPCPs) are any product used by individuals for personal health or cosmetic reasons or used by agribusiness to enhance growth or health of livestock and farm produce. PPCPs comprise a diverse collection of thousands of chemical substances, including prescription and over-the-counter therapeutic drugs, veterinary drugs, fragrances, lotions, and cosmetics. **The environmental problems begin when these products enter the water system.**

According to the EPA here are some reasons for concern about PPCPs in the water:

- Large quantities of PPCPs can enter the environment after use by individuals or domestic animals.
- Sewage systems are not equipped for PPCP removal.
- The risks posed to aquatic organisms and to humans are unknown, largely because the concentrations are so low. While the major concerns have been the resistance to antibiotics and disruption of aquatic endocrine systems (the system of glands that produce hormones that help control the body's metabolic activity) by natural and synthetic sex steroids, many other PPCPs have unknown consequences. **There are no known human health effects from such low-level exposures in drinking water, but special scenarios (one example being fetal exposure to low levels of medications that a mother would ordinarily be avoiding) require more investigation.**
- The number of PPCPs is growing. In addition to antibiotics and steroids, over 100 individual PPCPs have been identified (as of 2007) in environmental samples and drinking water.

PPCPs usually enter the environment when:

- medication residues pass out of the body and into sewer lines
- externally-applied drugs and personal care products wash down the shower drain
- unused or expired medications are placed in the trash or flushed down the toilet or drain

The discovery of PPCPs in water and soil shows even simple activities like shaving, using lotion, or brushing your teeth affect the environment in which you live.

An important component of protecting the watershed is proper disposal of unused or expired drugs. Below are tips for safe drug disposal.

NEVER flush Rx drugs down the toilet or drain unless specifically instructed on label or by accompanying patient guide. Information on drugs which can be safely flushed can be found on www.fda.gov. However, state regulations vary.

If a drug is not approved for flushing, locate a local Drug Take-back Center through the National Drug Take back program locator:
http://disposemymeds.org/medicine-disposal-locator/

Follow these federal guidelines for proper disposal if no take-back program is in your area.

1. Take Rx drugs out of original containers.
2. Mix drugs with an undesirable substance (i.e. used cat litter or coffee grounds).
3. Put mixture into disposable container with lid or sealable bag.

4. Conceal/remove personal info, including Rx number, on empty container by covering with a permanent marker or duct tape, or scratch off.
5. Place sealed container with mixture and empty drug containers in trash.

Personal Care Choices in a Modern World

Living in the modern world we have many, many choices of products for cleaning ourselves and our homes, including items like soaps with lotion or antibacterial agents, detergents with whiteners and softeners, bodywashes with exfoliating beads. What do we really know about these products and do they actually protect us against disease and infection or improve our skin and clothes?

Some of these products contain pharmaceuticals to control microbial growth. One area of concern is that water treatment plants were built to remove certain wastes, but **they mostly fail to grab the drugs** in soaps, shampoos, toothpastes, perfumes, sunscreen and other skincare products that our daily habits add to wastewater.

The recent infusion of antibacterial and antifungal agents *and more* into these products has raised concern about their place in the environment and in particular their impact on water.

Pharmaceuticals and personal care products (PPCPs) in waterways has caught the attention of the EPA. At present they are being discovered in our Nation's waters at **very low concentrations**. Further research suggests that there may be some ecological harm when certain drugs are present. **To date, no evidence has been found of human health effects from PPCPs in the environment.**

What pharmaceuticals are in our personal care products?

The personal care products that you use in the home and school may make a difference in your health and the health of the environment in the future. Read on:

Antibacterial Soaps and Body Washes

You may have heard that the FDA has asked makers of antibacterial soaps and body washes to prove the products are both safe and effective long-term.

The active ingredients covered under the FDA request include antibacterial agents known as **triclosan in liquid soaps and triclocarban in bar soaps.** (this particular rule does not cover antibacterial cleaning supplies, hand sanitizers or wipes). The makers of these products have to show they are safe for long-term, daily use. They must also prove they work better than soap and water to prevent illness and the spread of certain infections. Meanwhile they are still available for sale.

What's the concern?

- Long-term use of soaps and washes with antibacterial chemicals could mean **bacteria become resistant** to these chemicals and are no longer killed or destroyed by them.
- Some research shows that the chemicals may **interfere with hormones** needed for normal brain and reproductive development.
- Studies are showing that they are **no more effective** than regular soap for preventing disease or infections.

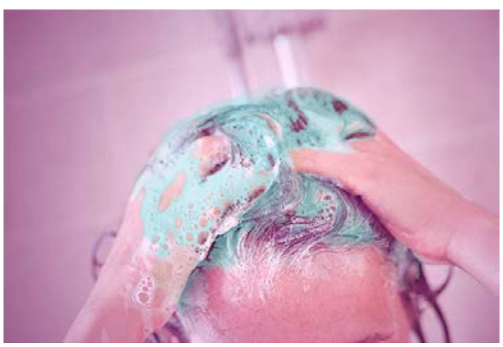
So what happens to the active ingredients when they go down the drain?

Along with your liquid soap or body wash, triclosan journeys to the sewage treatment plant and from there into water supplies. Triclosan was found in approximately 36 U.S. streams.

The good news according to the EPA, is the estimated concentrations of triclosan in surface water do not exceed concentrations of concern for acute risk for aquatic organisms and plants, and chronic aquatic risks are unlikely originating from *consumer* uses of triclosan-treated plastic and textile items.

FYI-- Soaps are not the only use of triclosan. Triclosan is now used in chopping boards, refrigerators, paint, plastic lunchboxes, and mattresses as well as in industrial settings such as the walls, work surfaces and floors of food processing plants to control microbial growth.

Dandruff Shampoo



Medicated shampoos often include a fungicide. Each time we shampoo, a measurable amount of fungicide ends up at the local wastewater treatment plant.

There is a new study in the journal *Environmental Toxicology and Chemistry* about fungicides in the water. It says that even at low concentrations such fungicides can harm many organisms, from tiny algae to big plants and fish.
http://onlinelibrary.wiley.com/doi/10.1002/etc.2367/abstract

More on fungicides in the water
https://toxics.usgs.gov/highlights/fungicide_occurrence.html

Exfoliating Beads

Do you know what a micro-bead is? Reading the labels on teeth whitening toothpaste and exfoliating bodywashes you may see it listed as an ingredient. These plastic particles bypass screens and water treatment processes to enter our waterways. Fish and aquatic birds will often mistake them for food.

Read more here:
CNN Report
http://www.cnn.com/2013/01/07/health/microplastics-soap-unilever/index.html
Newsweek article
https://www.newsweek.com/united-states-just-banned-microbeads-those-tiny-plastic-disasters-your-face-410617

Procedure

1. Take this **Wastewater Treatment Plant Virtual Tour** with Lisa Ellington, Environmental Service Manager, Paragould Light, Water and Cable, Arkansas to discover the functions and limitations in present day technology:. Lead a discussion of the cautions and the concerns about PPCPs heard on the video.
http://www.projectwet.org/resources/on-line-learning/wastewater-treatment-plant-virtual-tour

2. **Hand out the *PPCPs: Group Research* student page to groups of 2-3 students.** Assign each group a number from 1-9. The students will work together through a web search to find the answers to the following questions. They should also record the source of the information:

- What are PPCPs?
- What types of PPCPs are released in your assigned area?
- How are PPCPs released there?
- What happens next to them?

3. They should discover at least the following:

1a. and 1b. Usage by individuals (1a) and pets (1b):

- Released by sweat, vomitus and excretion of unmetabolized drugs which can be exacerbated by disease and slow-dissolving medications
- Disposal of unused/outdated medication flushed to sewage systems
- Underground leakage from sewage system infrastructure

1c. Disposal of euthanized/medicated animal carcasses serving as food for scavengers who eat and release unmetabolized medications through excretion.

2. Release of treated/untreated hospital wastes to domestic sewage systems

- acutely toxic drugs and diagnostic agents are most likely to persist in the environment
- disposal by pharmacies, physicians, humanitarian drug surplus

3a. and 3b. Release to private septic/leach fields

- treated effluent from domestic sewage treatment plants discharged to surface waters, re-injected
- into aquifers (recharge), recycled/reused (irrigation or domestic uses) (3b)
- overflow of untreated sewage from storm events and system failures directly to surface waters (3b)

4. Transfer of sewage solids ("biosolids") to land (e.g., soil amendment/fertilization)

- "straight-piping" from homes (untreated sewage discharged directly to surface waters)
- release from agriculture: spray drift from tree crops (e.g., antibiotics)
- dung from medicated domestic animals (e.g., feed) from CAFOs (confined animal feeding operations)

5. Direct release to open waters via washing, bathing, swimming

- antibiotic soaps
- sunscreen
- medicated shampoos

6. Discharge of regulated/controlled industrial manufacturing waste streams

- disposal/release from clandestine drug labs and illicit drug usage

7. Disposal to landfills via domestic refuse

- leaching from poorly engineered landfills and cemeteries
- medical wastes, and other hazardous wastes

8. Release to open waters from aquaculture (medicated feed and resulting excreta)

- future potential for release from molecular pharming (production of therapeutics in crops)

9. Release of drugs that serve double duty as pest control agents: (examples)

- experimental multiple sclerosis drug used as avicide (agent that kills birds)
- warfarin used as rat poison
- cholesterol medication used as avian/rodent reproductive inhibitors
- certain antibiotics used for orchard pathogens
- acetaminophen (Tylenol) used for brown tree snake control
- caffeine used for coqui frog control

10. What happens next to the PPCPs?

- most PPCPs eventually make their way from the land to water
- the chemistry of the PPCPs might be changed by *phototransformation* (both direct and indirect reactions via UV light)
- PPCPs can be further changed through physicochemical alteration perhaps through interacting with other chemicals in the environment, degradation, and ultimate mineralization
- PPCPs can become airborne through volatilization (mainly certain anesthetics, fragrances)
- some are taken up by plants and aquatic animals
- medicated-feed dusts released are inhaled

4. Students will share the information they have researched with the class and generate a list Best Management Practices for PPCPs that can be followed at school and at home. Students then will prepare public information posters for display in the public areas of the school.

Resources

Pharmaceuticals and personal care products in water:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5459316/

https://www.sciencedirect.com/science/article/pii/S2405665016300488

https://www.epa.gov/sites/production/files/2018-11/documents/cecs-ppcps-factsheet.pdf

PPCPs : Group Research

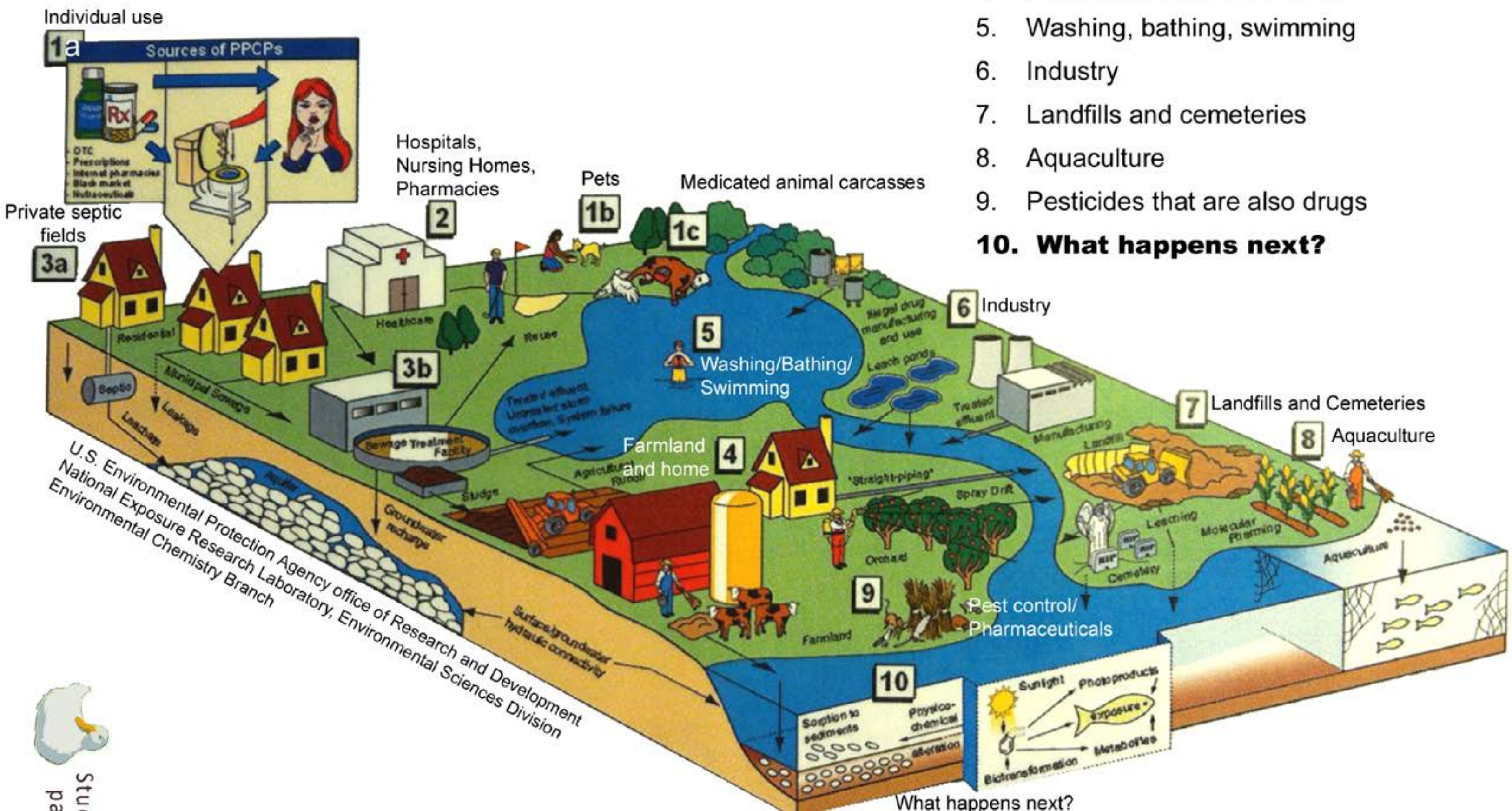
What are PPCPs?

What type of PPCPs are released in your assigned area?

How are they released into the environment there?

What happens next to the PPCPs?

1a. Individual Use
1b. Pets
1c. Medicated animal carcasses
2. Hospitals, Nursing Homes, Pharmacies
3. Private septic fields
4. Farmland and Farm houses
5. Washing, bathing, swimming
6. Industry
7. Landfills and cemeteries
8. Aquaculture
9. Pesticides that are also drugs
10. What happens next?



Student page

Storm Drain Stenciling

Materials

- Storm drain stencils or adhesive curb markers
- Adhesive spray to keep stencil securely in place while using ink roller or spray can and Duct tape
- Marking paints or ink and rollers. Marking paints should be fast-drying, acrylic and used inverted (spray with can upside down). Some brands are Krylon, Rust-Oleum, Emedco
- Bags or cardboard pieces to put stencil patterns in once wet
- Tools to clean the drain area before stenciling, like wire brushes, brooms, etc.
- Safety vests, traffic cones
- Rubber or latex gloves
- Student-made Informational brochures to hand out in the neighborhood

Background

Storm drain stenciling projects are an easy way to inform the community that stormwater and contaminants flow Inform the community that stormwater and contaminants flow through storm drains to the nearest waterway. Several states have guidance documents available (including Texas, New Jersey, and Massachusetts).

During this activity, students will paint messages, such as "Keep Clean-Drains to the Stream", on storm drains or curbs that educate the local community about storm drains. It lets the public know that everything that goes down a storm drain, such as antifreeze, motor oil, paint, trash, pesticides, fertilizers, dirt, leaves, and grass flows, untreated into a nearby stream.

Stormwater runoff is rainwater that runs off rooftops, lawns, driveways, and streets in our neighborhoods. As the water flows, it picks up grass clippings, oil, grease, leaves, dirt, harmful bacteria, toxic chemicals, litter, and other contaminants. Polluted stormwater runoff is also called "nonpoint" source pollution because the pollution comes from many different sources, as opposed to "point" source pollution which comes from one identifiable source such as a factory pipe that dumps contaminants straight into the stream. Instead of dumping contaminants down the neighborhood storm drain, people can recycle used oil, avoid chemical fertilizers and pesticides, properly dispose of pet waste in garbage cans, and wash cars on lawns instead of pavement.

There are many web-based sources for stencils and curb markers, as well as the other materials needed but you don't have to spend a lot of money. Try to get donations and ask parents to contribute to this project with materials and time.

Procedure

Here are some simple steps and instructions for storm drain stenciling:

1. Get permission from your city public works office, town officials or business owners in private parking lots before stenciling storm drains. There may be restrictions in some areas.

2. Have students create door-hangers or brochures on the importance of storm drain stenciling. Allow them time to distribute the information in the neighborhood and to speak with residents.

3. Gather all supplies needed for the project. Use pieces of cardboard to practice stenciling on before application. This will ensure that you are applying the right amount of paint. Many first time stencilers will use too much ink or paint on the roller (the same with spray paints). Less paint/ink is better and will look better overall. You are much better off with one light coat, let it dry and then apply a second coat to darken paint or ink if needed.

4. Make sure you do the stenciling project on a sunny, dry day between 40 and 80 degrees Fahrenheit. Clean the surface you are stenciling with a brush or broom or even with a wire brush for hard to remove dirt, oils, tars, etc. Pick up any trash in the area around the drain.

4. Place stencil on surface (you may want to use the adhesive spray on the back of the stencil first and make sure this is where you want the lettering and image to go). Apply spray paint or ink roller. Remember Less paint/ink is better and will look better overall.

5. After storm drain stencil is completed, lift it off surface and place wet stencil in between two sheets of cardboard to carry to next drain. It is OK to let the paint or ink dry completely on the stencil. Most paints can flake off by rolling the stencil after they have completely dried. The inks will not build up on the stencil as thick as acrylic paints and can handle more applications. If you still wish to clean the stencil after multiple ink applications, try anything from simple green to solvent-based cleaners.

Further Sources:

Clean Water Campaign – http://www.cleanwatercampaign.com

Das Curb Markers – www.dasmanufacturing.com

RAIN GARDENS

Materials

- Expert to help your students locate the proper placement for a rain garden and conduct soil testing
- Wet tolerant, drought tolerant, hardy plants
- Mulch
- Gardening tools

Background

In the larger cities of Georgia there are plenty of hard surfaces from development such as, rooftops, streets, driveways, sidewalks, and parking areas. These impervious surfaces become roller coasters for stormwater by transporting it quickly to the nearest drain, stream, or lake. Stormwater is rainwater that moves quickly over hard surfaces carrying pollutants and sediment to our streams, lakes, and rivers instead of percolating into the soil.

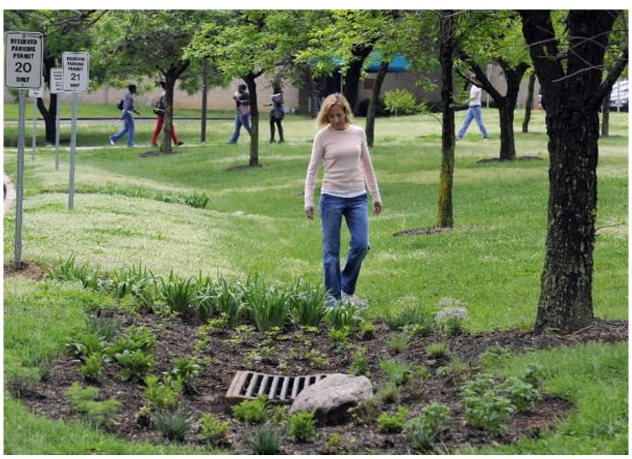
An excellent solution to stormwater pollution is an attractive rain garden. A rain garden is a natural landscape feature that requires less maintenance and fewer chemicals than lawns. The rain garden receives runoff water from roofs or other hard surfaces and holds the water on the landscape thereby reducing stormwater flows. About thirty percent more water will soak into a rain garden as compared to an equal amount of landscape elsewhere. Beyond reducing the amount of stormwater, rain gardens also reduce the amount of stormwater pollution. Many pollutants are filtered out and broken down over time because the plants, mulch, and soil combine natural physical, biological, and chemical processes to remove pollutants from runoff.

Procedure

Ask students to define stormwater runoff and why it is a problem. Then ask the students to brainstorm ways that a home landscape can reduce the amount of stormwater entering the waterways.

Rain gardens are usually located in natural depressions at least 10 feet away from a house or building. Rain gardens should not be placed on steep slopes, near septic systems, over utility lines, or areas with a seasonal high water table.

To build a Rain Garden, take a good look at your school campus and determine where runoff collects after rain. You may need to consult with an expert, who can walk the school campus with you and help you discover the best location for your rain garden. The size of a rain garden is determined by the amount of impervious surface and the type of soil. After the location and size are laid out, dig up the area, replace the soil with a blend of planting soil, mulch and sandy soil, and then plant with water tolerant plants, such as iris and reeds.

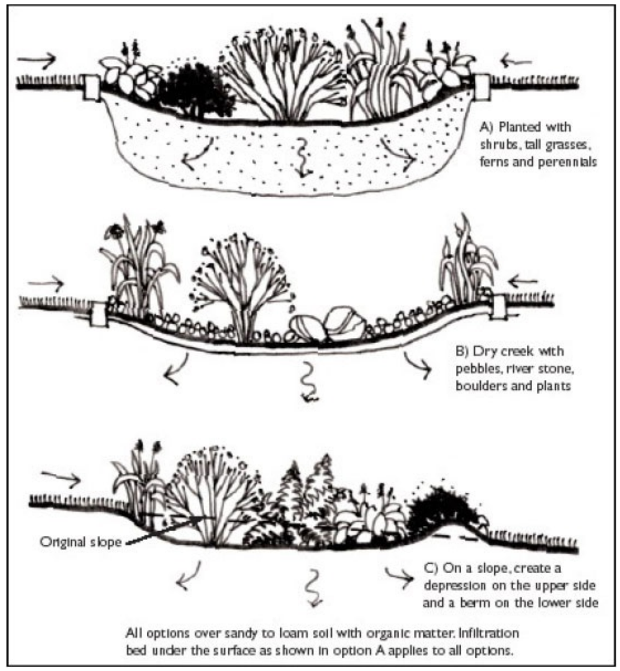


Use these sources to guide you

Adopt-A-Stream – www.adoptastream.ga.gov

Clean Water Campaign – www.cleanwatercampaign.com

City of Atlanta Watershed Management
www.cleanwateratlanta.org



RAIN BARRELS

Materials

- New 55 gallon food grade plastic drum
- Tube of sealant/adhesive caulk
- Mesh screen
- Mosquito brick
- ½ inch faucet
- Down spout flex elbow

- 3 bricks or concrete block
- Optional: 1 inch plug

Background

The idea of capturing rainwater in cisterns is generations old. Landowners have used cisterns as a way to collect water for water gardens, plants, washing clothes and even drinking. A rain barrel is a great way to save water and energy by reducing water use and an excellent tool to teach students about stormwater runoff and water conservation.

A rain barrel is a rainwater harvesting system that is connected to a downspout from a house or building. It collects rainwater from a roof and gutters, which can then be used to water gardens or lawns. "The average US household uses 146,000 gallons of water per year with up to 50 % of that water going towards landscaping during the summer months" (Rainwater Harvesting). A sprinkler uses 480 gallons an hour, a hose uses about 600 gallons an hour and a drip hose uses 1 gallon an hour for every 100 feet of hosing. It rains about 50 inches yearly in Georgia and rainwater runoff from the roof and gutters can be reused through rain barrels. By collecting rainwater, one can save energy, water, and money to the tune of $600 a year.

Rain barrels also help reduce erosion and stormwater runoff and increase water quality. Stormwater runoff picks up contaminants from driveways, roads and lawns, such as yard debris, oil, pesticides, and fertilizers. Capturing stormwater in rain barrels and reusing it for lawn and garden care reduces the amount of stormwater runoff from your property and the possibility of local contamination.

Procedure

1. You and your students may purchase pre-made rain barrels through your local garden store, Amazon or other online source.

2. Rain barrels can also be created from store bought materials. Follow these directions:

a. Drill two ½" diameter holes near the top of the trashcan/drum for overflow.

b. Cut two-pieces of mesh screen slightly larger than 1 inch.

c. Using the sealant/adhesive caulk, attach the mesh screen to the overflow holes drilled at the top of the barrel/ trash can.

d. If you are using a plastic drum, it is recommended that you drill the third hole at the very bottom so that you will be able to completely drain the drum. Put a plug in the third hole.

e. Drill another hole 6 inches from the bottom in the side, which should be the same size as your faucet opening (for a ½ inch faucet use a 7/16 drill). Screw the faucet into the opening and secure with sealant/adhesive on both sides.

f. In the trash can cover, cut a 6 x 6 inch opening (the hole can be either circular or a square). Cover the opening with mesh screen. Secure using the sealant/adhesive caulk.

g. Cut an opening that is approximately 1/3 the size of top in the top. Cover the opening with mesh screen. Secure using the sealant/adhesive caulk. Attach the trash can cover to the can.

h. Place the rain barrel on 3 bricks next to the downspout you wish to capture the water from. This is so you can put a bucket/water pail under the faucet. Cut the downspout to just above the rain barrel. Attach the downspout flex elbow to the downspout.

i. Slide the rain barrel under the spout lining up the mesh screen opening with the flex elbow. Spray water on the roof and check to make sure the rain barrel and mesh opening are in the right location.

j. Add a mosquito brick monthly and enjoy your new rain barrel.

Students may consider holding a workshop to teach others how to construct their own Rain Barrels.

Sources

Southface Energy Institute www.southface.org
Rain Barrel FAQ's
https://www.mmsd.com/what-we-do/green-infrastructure/rain-barrels/rain-barrel-faq
Rain Barrel Guide: How to use rain barrels for water collection http://rainbarrelguide.com

COMMUNITY INVOLVEMENT

Students can take action to improve water quality in their own community.

GEORGIA ADOPT-A-STREAM

Georgia Adopt-A-Stream
Volunteer Water Quality Monitoring

Georgia Department of Natural Resources

Georgia's Volunteer Water Quality Monitoring Program

The goals of Georgia Adopt-A-Stream are to (1) increase public awareness of the State's nonpoint source pollution and water quality issues, (2) provide citizens with the tools and training to evaluate and protect their local waterways, (3) encourage partnerships between citizens and their local government, and (4) to collect quality baseline water quality data. To accomplish these goals, Georgia Adopt-A-Stream encourages individuals and communities to adopt sections of streams, wetlands, lakes or rivers. Manuals, training, and technical support are provided through Georgia EPD, Adopt-A-Stream Regional Training Centers and community/watershed Adopt-A-Stream organizers throughout the state.

Getting Started

1. Locate a stream, wetland or lake you would like to monitor.
2. Obtain the introductory manual, ***Getting To Know Your Watershed*** from the Georgia Adopt-A-Stream office.
3. Read the manual and follow the directions to register your stream, wetland or lake.
4. Conduct a Watershed Assessment using the data forms and directions in the manual.
5. Plan one cleanup event and one outreach activity for the year.
6. Call Georgia Adopt-A-Stream to find out about additional manuals and workshops for visual, biological and chemical monitoring.

Free Resources Available from Georgia Adopt-A-Stream

Getting To Know Your Watershed Manual

Visual Stream Survey Manual

Biological and Chemical Stream Monitoring Manual

Wetland Monitoring Manual

Adopt-A-Lake Manual

Adopt-A-Stream Educator's Guide

Georgia Adopt-A-Stream: It All Begins with You video

Georgia Outdoor: Georgia Adopt-A-Stream & Rivers Alive video

You're the Solution To Water Pollution brochure and poster

Georgia Adopt-A-Stream Newsletter

Water Quality Data on Google Earth

Training Workshops

Professional Learning Hours/Continuing Education

Visual Stream Survey

What

- A visual & physical evaluation of stream conditions

Why

- Most of the critical water pollutants and habitat damage (sedimentation, erosion, excessive nutrients) can be detected through the visual survey

When

- Monitor quarterly or once every season

Chemical Monitoring

What

- The basic tests are pH, dissolved oxygen, temperature and settleable solids
- Advanced tests include phosphates, nitrates, ammonia, alkalinity and conductivity

Why

- Oxygen is needed for respiration
- Temperature is directly related to biological activity
- pH measures the acidity or alkalinity of the water
- Phosphates and nitrates are nutrients that cause algal blooms when present in excess

When

- Monitor once a month

Biological Monitoring

What

- An inventory of Macroinvertebrates in the stream

Why

- The overall health of the stream can be determined by the diversity of macroinvertebrates found. The presence of macroinvertebrates indicate the quality of both water and habitat

When

- Monitor quarterly or once every season

Contact:

Georgia Adopt-A-Stream
2 Martin Luther King Jr Dr SE
Suite 1462
Atlanta, GA 30334
aas@dnr.ga.gov
(470) 524-5791
(470) 938-3341

ADOPTASTREAM.GEORGIA.GOV

GEORGIA PROJECT WET

What is Project WET?

The Project WET (Water Education Today) is an international, interdisciplinary water science and education program for educators of K-12 students with the mission to reach the world with water education. The 64 activities in the Curriculum and Activity Guide are correlated to national and state standards in every discipline.

GEORGIA
project WET
WATER EDUCATION TODAY

How can I become a WET Educator?

Be a part of a network committed to teaching young people the vital connections between water resources and our lives through interactive, fun workshops. Participants of WET Educator Workshops (6-10 hours) receive training to teach children, the Project WET Curriculum and Activity Guide, as well as additional water education resources. Facilitator Workshops (10-16 hours) are also available for those educators wanting to provide training to other adults through their own Project WET Educator Workshops. Check the calendar page on ProjectWET.Georgia.gov or eeingeorgia.org for the latest workshop schedule.

For more information contact:

GA PROJECT WET

2 Martin Luther King Jr Dr SE
Suite 1462
Atlanta, GA 30334
(470) 524-0617

PROJECTWET.GEORGIA.GOV

GEORGIA RIVER OF WORDS

What is River of Words?

River of Words is an environmental poetry and art project for K-12 students. It connects kids to their watersheds and their imaginations through poetry and art.

- Free national K-12 student contest each year, Gerogai deadline Feb. 1
- Free resources for educators
- Integrated environmental education

Complete rules on projectWET.georgia.gov/ga-river-words

How can students get involved?

Students begin by learning their "ecological address" through development of their observational and descriptive skills in the exploration of their watershed. Then they create poetry or art reflecting this experience which may be entered into a FREE national contest. The full contest rules are available on the ProjectWET.Georgia.gov website under River of Words. A FREE Educator's Guide offers information on Georgia's watersheds and ways to incorporate science, poetry, art and service learning into the classroom. The guide includes tons of activities to support the program through journaling, observation, poetry writing, and artistic exercises. Download or request a hardcopy through the website.

Georgia River of Words is sponsored by Georgia Project WET and the Georgia Center for the Book. Winning students are featured in an exhibit which travels for a year to the libraries of the state. Their work is also published in a full-color journal distributed throughout Georgia.

Take your students' learning further!

GEORGIA'S ANNUAL WATERWAY CLEANUP

What is Rivers Alive?

Rivers Alive is a volunteer cleanup event that targets all waterways in the state of Georgia including streams, rivers, lakes, beaches, and wetlands. The mission of **Rivers Alive** is to create awareness and involvement in the preservation of Georgia's water resources through waterway cleanups. **Rivers Alive** is held year round and is sponsored by the Georgia Department of Natural Resources' Georgia Adopt-A-Stream Program.

Why should you get involved?

Georgia's 70,150 miles of streams and rivers need your help! Our waterways provide us with fresh drinking water, great recreational opportunities like canoeing and fishing, and they serve as a pleasant respite from our busy day to day lives. This is your opportunity to help protect on of our most precious resources. Help us clean our rivers, streams, lakes, beaches and wetlands by joining and supporting **Rivers Alive**!

How you can get involved:

- For those of you who would like to join an existing cleanup, please visit our website (RiversAlive.Georgia.gov) to search our maps and find a cleanup near you and contact information.
- If you are considering organizing a local **Rivers Alive** cleanup event, go to the **Rivers Alive** website (RiversAlive.Georgia.gov) and register your event to receive free t-shirts for your volunteers (event must be registered by July 31 in order to receive t-shirts).
- On the website, you will find a River Cleanup Guide with ideas to make your event more successful, sample press releases, waivers, maps, and detailed contact information so volunteers can find your event, and links to your local **Rivers Alive** cleanup web pages!
- Become a sponsor! Contributions enable **Rivers Alive** to provide promotional material such as posters, banners, educational materials and Rivers Alive t-shirts to volunteers all over the state.

For more information contact:
Georgia Environmental Protection Division, NonPoint Source Program

riversalive@dnr.ga.gov

RIVERSALIVE.GEORGIA.GOV

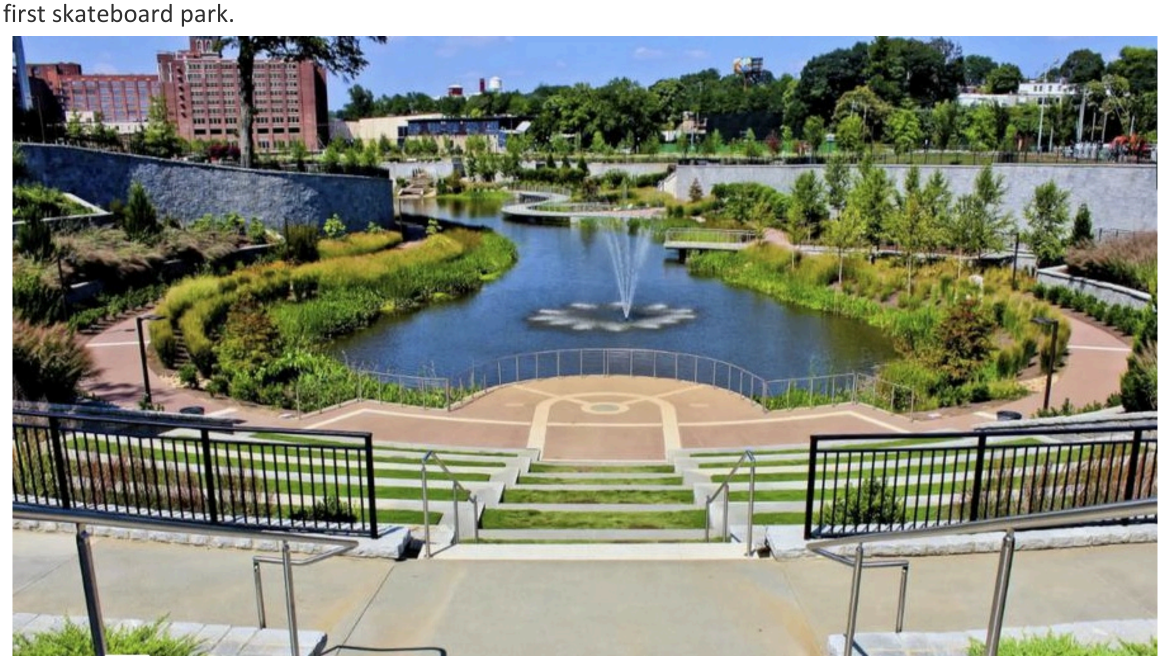
470-524-5791

STORMWATER SPOTLIGHT

Every once in a while a project is developed that so dazzles us by its beauty and design that we don't even notice that it is a fully functioning urban stormwater engineering feat. This is such a site.

Atlanta's historic Old Fourth Ward neighborhood (best known as the location of the Martin Luther King, Jr. historic site) with its growing population and one of the city's highest rates of children living in poverty, was in desperate need of a large public park. It also had an area that suffered serious flooding after storms. **The city was considering costly underground piping when a better solution emerged from the community.**

Why not channel the storm water into a manmade lake that would become the central feature of a new park? The Trust for Public Land purchased several properties to help the city create the 35-acre park, which broke ground in October 2008. In June 2010, the park opened the first 17 acres including a playground and water-play feature, an outdoor theater, and the city's first skateboard park.



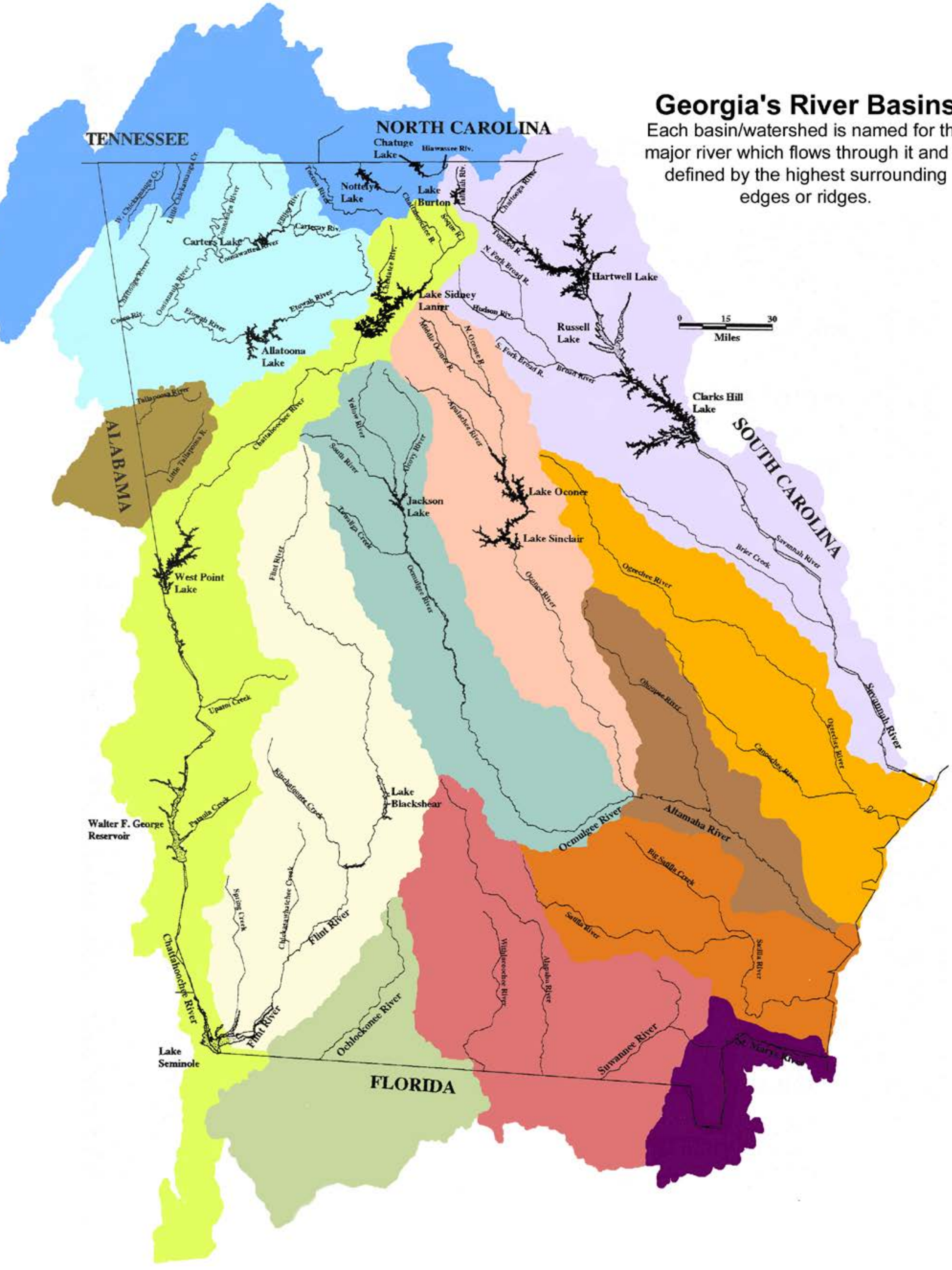
Today the Old Fourth Ward Park has a 2-acre lake that provides beauty and nature in an urban setting and also functions as a storm water detention basin which increases the area's sewer capacity, reduces the burden on aging city infrastructure, and minimizes downstream flooding and property damage.

This park was designed and built by The Georgia Conservancy's *Blueprints for Successful Communities*, under a new research project combining traditional stormwater engineering and urban design. This project partnered with graduate students from the College of Architecture at Georgia Tech who examined four different sites within metro Atlanta and focused on holistic, low impact development policies that could be adopted and implemented to greatly benefit the community. The idea was to identify creative ways to solve water issues on site after understanding the site's placement within a watershed.

Each site had specific challenges with managing water providing opportunities for creative design problem-solving. The design team's efforts involved multiple site visits, presentations, collected information and maps, hydrological analysis, and calculations to help develop a set of draft recommendations for consideration.

Please visit The Georgia Conservancy's complete report here:
http://www.georgiaconservancy.org/blueprints/stormwater.html

RESOURCES


Georgia's River Basins
Each basin/watershed is named for the major river which flows through it and is defined by the highest surrounding edges or ridges.
NORTH CAROLINA
TENNESSEE
ALABAMA
SOUTH CAROLINA
FLORIDA
Chatuge Lake
Nottely Lake
Lake Burton
Carters Lake
Lake Sidney Lanier
Hartwell Lake
Russell Lake
Allatoona Lake
Clarks Hill Lake
Jackson Lake
Lake Oconee
Lake Sinclair
West Point Lake
Lake Blackshear
Walter F. George Reservoir
Lake Seminole
Miles
0
15
30
Ocmulgee River
Altamaha River
Flint River
Chattahoochee River
Ochlockonee River
Suwannee River
Savannah River

These web resources + much more can be found on ProjectWET.Georgia.gov/Stormwater

WATER EDUCATION

Project WET is a national K-12 interdisciplinary water education program intended to supplement a school's existing curriculum. Coordinated in Georgia through the Environmental Protection Division, Project WET nurtures the awareness, appreciation, knowledge, and stewardship of water resources using classroom ready teaching aids through Educator and Facilitator Certification Workshops.
In Georgia: www.ProjectWET.Georgia.gov
National Project WET Foundation: www.projectwet.org; Discover Water: discoverwater.org

Environmental Education in Georgia site is the clearinghouse for environmental education events and opportunities in the state: www.eeingeorgia.org

Environmental Education Alliance (EEA) of Georgia is a nonprofit organization that promotes communication and education among professionals in the field of environmental education in Georgia. EEA is an affiliate of the North American Association for Environmental Education: www.eealliance.org

Georgia Adopt-A-Stream (AAS) program site has information on various program, participants, monitoring results, public education, training and more: adoptastream.georgia.gov

The Clean Water Campaign is a cooperative, multi-agency education and outreach effort coordinated by the Metropolitan North Georgia Water Planning District for the 15-county Metro Atlanta area: cleanwatercampaign.org

EPA Office of Ground Water and Drinking Water Kid's Stuff has information and resources especially for kids to learn more about drinking water: http://water.epa.gov/learn/kids/drinkingwater/index.cfm

USGS Water Science For Schools site has extensive water basics and water use information, interactive displays, resources, data, picture gallery, glossary, and more: water.usgs.gov/edu/

EPA Water Drop Patch Project has information to help Girl Scouts use their skills and knowledge to educate others in their community about the need to protect the nation's valuable water resources: https://www.gscm.org/content/dam/girlscouts-gscm/documents/Volunteer%20Resources/Program%20Resources/WaterDropPatchProjectManual_March2009.pdf

EPA Explorer's Club has fun and interesting activities about air, water, garbage and recycling, plants, animal and other environmental topics: www.epa.gov/kids/

EPA Environmental Education Grants: www2.epa.gov/education/environmental-education-ee-grants

American Rivers: https://www.americanrivers.org/

WATER CONSERVATION

Georgia Water Wise Council: www.gawp.org/group/GWWC

25 easy tips for saving water at home: http://www.eartheasy.com/live_water_saving.htm

Education and tips for conservation: http://wateruseitwisely.com/

Waterwise site has educational information, WaterWise tests and more: http://www.getwise.org/

Tips for saving water inside and outside plus links and educational information: http://www.watereducation.org/post/water-conservation-tips

WATER PROTECTION

Center for Watershed Protection: http://www.cwp.org/

Life at the Water's Edge - A Guide to Stream Care in Georgia
This publication reviews simple stream care practices targeted at homeowners: https://adoptastream.georgia.gov/sites/adoptastream.georgia.gov/files/LATWE2016_web.tiff%20%281%29.pdf

Riparian Buffer Publications from UGA: https://rivercenter.uga.edu/wp-content/uploads/2021/01/Protecting-Riparian-Buffers-in-Coastal-Georgia.pdf

USEPA River Corridor and Wetland Restoration: https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=OW&dirEntryID=23817

USDA Stream Corridor Restoration: Principles, Processes and Practices: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?cid=stelprdb1043244

EPA Office of Water Concerned Citizens site has information to raise public awareness and encourage involvement in water quality issues: https://19january2017snapshot.epa.gov/www3/epahome/citizen.htm

EPA Nonpoint Source Program: https://www.epa.gov/nps

Georgia Department of Community Affairs *Water Resources Toolkit for Local Governments:* https://www.dca.ga.gov/local-government-assistance/planning/local-planning/water-resources-technical-assistance

STORMWATER

Storm drain marking or stenciling is a great way to increase community awareness about nonpoint source pollution and prevent dumping of pollutants. Examples of storm drain markers and storm drain stenciling kits may be found at: http://www.dasmanufacturing.com

US EPA: Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices: http://water.epa.gov/polwaste/green/costs07_index.cfm

NRDC: Stormwater Strategies: https://www.nrdc.org/issues/water-smart-cities

Stormwater Coalition: Increase compliance with BMP maintenance requirements, and can help garner public support for a local stormwater management program: http://www.stormwatercoalition.org/

Stormwater Outreach Materials: http://water.epa.gov/polwaste/npdes/stormwater/Stormwater-Outreach-Materials-and-Reference-Documents.cfm

Low Impact Development Center: http://www.lowimpactdevelopment.org/

Georgia Stormwater Management Manual: http://www.georgiastormwater.com/

Stormwater Manager's Resource Center: https://www.stormwatercenter.net/

Stormwater Coalition educational materials: http://www.stormwatercoalition.org/

HABITAT IMPACT

Wetlands: https://www.epa.gov/system/files/documents/2021-11/bmp-stormwater-wetland.pdf

Wildlife: https://www.atlantawatershed.org/the-city-of-atlanta-department-of-watershed-management-joins-atlanta-audubon-society-for-a-special-honor/

GEORGIA RESOURCES

Georgia River Network: http://www.garivers.org

Georgia Center for Urban Agriculture: https://ugaurbanag.com/

Georgia Native Plant Society: http://www.gnps.org/

Coastal Plain Native Plant Society: https://gnps.org/chapters/coastal-plains-chapter/page/2/

UGA Pesticide Safety for the Homeowner: extension.uga.edu/publications/detail.cfm?number=C998

Georgia Department of Community Affairs: https://www.dca.ga.gov/

Clean Water Campaign: http://www.cleanwatercampaign.org/

Georgia Environmental Protection Division: http://epd.georgia.gov/

UGA Cooperative Extension Service: http://extension.uga.edu/

WATERSHEDS

EPA Watersheds Webcast: http://www.epa.gov/watershedwebcasts

Office of Oceans, Wetlands and Watersheds: https://www.epa.gov/aboutepa/about-office-water#wetlands

Surf Your Watershed: http://www.epa.gov/surf/

WATER POLLUTANTS

Water Pollutants http://www.explainthatstuff.com/waterpollution.html

USEPA Pesticides site: http://www.epa.gov/pesticides

NOAA Marine Debris: http://marinedebris.noaa.gov/

Nonpoint Source Pollution Resources and Students and Teachers: https://www.epa.gov/nps/resources-students-and-educators-about-nonpoint-source-nps-pollution

CLIMATE CHANGE AND WEATHER

Project WET Foundation Climate Resources: https://www.projectwet.org/programs/climate

National Environmental Education Week: https://www.neefusa.org/education/eeweek

Climate Impacts in the Southeast: https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-southeast_.html

EPA Climate Research: https://www.epa.gov/climate-research

WeatherBug Schools: https://www.weatherbug.com/education/

Rainfall statistics: http://www.ncdc.noaa.gov/

EPA Climate Change Impact to Ecosystems: https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-ecosystems

National Agencies

United States Fish and Wildlife Service: www.fws.gov

National Oceanic & Atmospheric Administration (NOAA): www.noaa.gov

Severe Weather: https://www.nssl.noaa.gov/education/svrwx101/floods/

NOAA Education site: http://www.education.noaa.gov/

National Park Service: www.nps.gov

Natural Resources Conservation Service Programs: www.nrcs.usda.gov

Farm Service Agency: www.fsa.usda.gov

Federal Emergency Management Agency (FEMA): www.fema.gov

Media

Water Treatment workers: http://www.youtube.com/watch?v=S1wUOad-0ag

Stormwater Videos

- http://www.youtube.com/watch?v=SByymar3bds is to a video about Volkswagen's initiative called "The Fun Theory" which proposes that it is possible to encourage people to change their behavior by making it fun and easy for them. This particular clip covers an experiment done in Stockholm where they created a set of Piano Stairs in the underground train system to encourage people to take the stairs rather than using the escalator. How can your students use fun to create something for stormwater problems?
- Stormwater Pollution Prevention Basics: https://www.youtube.com/watch?v=6XT0VwmPo_U
- PSAs and videos about preventing stormwater pollution. http://www2.erie.gov/environment/index.php?q=how-can-you-prevent-stormwater-pollution#PSA
- Water Research Foundation Youtube Channel: https://www.youtube.com/channel/UCfvzfNtMkLT_4kvTg6kEmlA

Water Related Games

http://discoverwater.org

https://thewaterproject.org/resources/water_related_games

https://wateruseitwisely.com/kids/games/

https://games4sustainability.org/water-games/

https://www3.epa.gov/safewater/kids/gamesandactivies.html

https://www.epa.gov/nps/resources-students-and-educators-about-nonpoint-source-nps-pollution

NONPOINT SOURCE POLLUTION: CAUSES, SOURCES, & IMPACTS

Causes (pollutant or stressor)	Possible Sources	Potential Adverse Impacts
Sediment and Siltation **(sand, silt, clay)**	Cropland Forestry activities Pasture Stream banks Construction Roads Mining operations Gullies Livestock operations Other land-disturbing activities	Sediment may destroy fish habitat by: (1) blanketing spawning and feeding areas; (2) eliminating certain food organisms; (3) causing gill abrasion and fin rot; and (4) reducing sunlight penetration, thereby impairing photosynthesis. Suspended sediment decreases recreational values, reduces fishery habitat, adds to mechanical wear of water supply pumps and distribution systems, and adds treatment costs for water supplies. Nutrients and toxic substances attached to sediment particles may enter aquatic food chains, cause fish toxicity problems, impair recreational uses or degrade the water as a drinking water source.
Nutrients **(phosphorus, nitrogen)**	Erosion and runoff from fertilized fields Urban runoff Wastewater plants Industrial discharges Septic systems Animal production operations Cropland or pasture where manure is spread	Nutrients are essential for the growth and survival of aquatic plants and animals. Excess nutrients may cause excessive algae and aquatic plant growth, which may choke open waters and consume oxygen (primarily from decomposition of dead plants and algae). These conditions will adversely affect fish and aquatic organisms, fishing and boating, and the taste and odor of finished drinking water. Nitrogen contaminants in drinking water significantly above the drinking water standard may cause methoglobinemia (blood disease) in infants, and have forced the closure of many water supplies.
Pathogens **(bacteria and viruses)**	Human and animal excretions Animal operations Cropland or pasture Wastewater treatment Septic systems Urban runoff Wildlife	Waterborne diseases may be transmitted to humans through drinking or contact with pathogen-laden water. Eating shellfish uncooked or taken from crops irrigated with pathogen-laden waters may also transmit waterborne diseases. The principal concern in both surface and ground waters is the potential degradation of public water supply sources. Pathogens reaching a lake or other surface water may limit primary contact recreation, such as swimming.

Pesticides	All land where pesticides are used: (forest, pastures, urban/suburban areas, golf courses, waste disposal sites) Sites of historical usage (chlorinated pesticides) Urban runoff Irrigation return flows	Pesticides may enter surface waters either dissolved in runoff or attached to sediment or organic materials, and may enter ground water through soil infiltration. The principal concerns in surface water are their entry into the food chain, bioaccumulation, toxic effects on fish, wildlife and microorganisms, habitat degradation and potential degradation of public water supply sources. Ground water impacts are primarily related to water supply sources.
Toxic Substances **(heavy metals, oil, and petroleum products)**	Urban runoff Wastewater treatment Industrial discharges	Toxic substances may enter surface waters either dissolved in runoff or attached to sediment or organic materials and may enter ground waters through soil infiltration. Principal concerns in surface water include entry into the food chain, bioaccumulations, toxic effects on aquatic organisms, other wildlife and microorganisms, habitat degradation and degradation of water supplies. Ground water impacts are primarily related to degradation of water supply sources.
Organic Enrichment **(depletion of dissolved oxygen)**	Human and animal excretions Decaying plant & animal matter Discarded litter and food waste	Organic materials (natural or synthetic) may enter surface waters dissolved or suspended in runoff. Natural decomposition of these materials may deplete oxygen supplies in surface waters. Dissolved oxygen may be reduced to below the threshold necessary to maintain aquatic life.
Thermal Stress & Sunlight	Riparian corridor destruction Bank destruction Urban runoff Hydromodifications Industrial dischargers	Direct exposure of sunlight to streams may elevate stream temperatures, which can exceed fish tolerance limits, reduce dissolved oxygen and promote the growth of nuisance algae. The lack of trees along a stream bank contributes to thermal stress and excessive sunlight. Thermal stress may also be the result of storm water runoff, which is heated as it flows over urban streets. Hydromodifications that create wider, shallower channels create more surface area and allow for quicker temperature changes. Modifications that create pools and increase the storage time of water may also contribute to thermal stress by increasing surface area and not allowing the warmed water to wash out of the watershed. Coldwater fish may be eliminated or only marginally supported in streams affected by thermal stress.

pH **(acidic and alkaline waters)**	Mine drainage Mine tailings runoff Atmospheric deposition Industrial point source discharges	Acidic or alkaline waters will adversely affect many biological processes. Low pH or acidic conditions adversely affect the reproduction and development of fish and amphibians, and can decrease microbial activity important to nutrient cycling. An extremely low pH will kill all aquatic life. Acidic conditions can also cause the release of toxic metals that were adsorbed to sediments into the water column. High pH, or alkaline conditions, can cause ammonia toxicity in aquatic organisms.
Flow Alterations **(hydrologic modifications)**	Channeling Dams Dredging Stream bank modifications	Hydrologic modifications alter the flow of water through the stream. Structures or activities in the water body that alter stream flow may in turn be the source of stressors, such as habitat modifications, or exacerbate others, such as thermal stress. Dams may also act as a barrier to the upstream migration of aquatic organisms. Stream flow alterations may result from a stressor such as sedimentation, which may change a streambed from narrow with deep pools to broad and shallow.
Habitat Modifications	Channeling Construction Changing land uses in the watershed Stream burial Dredging Removal of riparian vegetation Stream bank modifications	Habitat modifications include activities in the landscape or in the water body that alter the physical structure of the aquatic and riparian ecosystem. Some examples include: removal of stream side vegetation that stabilizes the stream bank and provides shade; excavation in the stream and removal of cobbles from the stream bed that provide nesting habitat for fish; stream burial; and development that alters the natural drainage pattern by increasing the intensity, magnitude, and energy of runoff waters.
Refuse, Litter and Other Debris	Litter Illegal dumping of solid wastes	Refuse and litter in a stream can clog fish spawning areas; stress aquatic organisms; reduce water clarity; impede water treatment plant operations; and impair recreational uses of the water body, such as swimming, fishing and boating.

From the Georgia Adopt-A-Stream Teacher's Manual
Visit www.adoptastream.ga.gov for more information about this program.

STORMWATER GLOSSARY

Additive: a term used generally to indicate special chemicals that may be added to products to improve their characteristics

Advanced Treatment: the level of water treatment that requires an 85% reduction in pollutant concentration; also known as tertiary treatment

Aeration: the addition of oxygen to water

Bacteria: tiny, single-celled organisms which may encourage decomposition of wastes or cause disease in animals and plants

Best management practice (BMP): methods adopted by resource users designed to mitigate harm to the environment that might result

Biosolids: nutrient-rich organic byproducts of the treatment of domestic sewage in a treatment facility; when treated and processed, they can be recycled and applied as fertilizer to improve soils and stimulate plant growth.

Chemical: typically a human-made substance; some types are harmful if swallowed and others help in water treatment

Clean Water Act: a federal law enacted in 1977 which gives rules for discharging pollutants into public water and gives quality standards for drinking water

Clear well: storage area for drinking water after being treated

Coagulation: a step in the water treatment process which causes contaminants to clump together for easy removal

Combined sewer overflow (CSO): stormwater may travel through the same pipes as wastewater does, and in a heavy rain the water in these pipes may be more than can be handled by the water treatment plant; in this case, waters in combined pipes bypass water treatment and move through the CSO control station before entering a river or stream

Disinfection: the process designed to kill most microorganisms in wastewater, including essentially all pathogenic (disease-causing) bacteria; there are several ways to disinfect, with chlorine being the most frequently used in water and wastewater treatment plants

Effluent: water that has been treated and cleaned through filtration

Environmental Protection Agency (EPA): a federal agency which seeks to ensure natural resources such as water are safe and are used responsibly

Evaporation: The conversion of a liquid (e.g. water) into a vapor (gas) usually through the application of heat energy

Filtration: A process for removing particulate matter from water by passage through porous media

Finished water: water which has been treated and is acceptable for drinking

Greenspace: land that allows water to pass through the soil on its way to underground aquifers

Hydrologic Cycle: See *Water Cycle*

Impervious surface: a hard surface, such as asphalt, through which water cannot pass

Infrastructure: the system of buildings, pipes, and roads which make up a town or city

Inorganic: materials which do not come from living things and do not contain carbon; an example is metal

Integrated pest management: a method of pest control in which chemical and non-chemical means are used to control pest populations, including natural enemies, weather, and crop management in addition to chemical pesticides; IMP is meant to be less expensive and more environmentally responsible than pesticide use alone

Man-made Water Cycle: the cycle through which water travels as it is removed from a natural source, cleaned, disinfected, transported to homes, schools, and businesses, treated, and returned to a river; the man-made cycle mimics the natural cycle in which rainwater filters through soil, sand, and rock

Nonpoint source pollution: pollutants that come from an unidentified source, such as pesticides, fertilizers, detergents, sediment, oil, grease, and animal waste for example

Nutrient: provides nourishment; nutrients that are in fertilizers may cause harm to aquatic ecosystems when found in large quantities

Organic: materials which come from living things such as plants or animals and which contain carbon

Parts per billion (ppb): a unit of measurement used to describe the amount of a pollutant, chemical, or nutrient in a substance such as water; for example, if you put one microliter of ink in a liter of water, the concentration of ink in the water would be 1 ppb

Parts per million (ppm): a unit of measurement used to describe the amount of a pollutant, chemical, or nutrient in a substance such as water; for example, if you put one milliliter of ink in a liter of water, the concentration of ink in the water would be 1 ppm

Percolate: to pass through a porous substance

Point source pollution: pollution that comes from an identifiable source, such as a pipe that drains into a stream

pH: potential of hydrogen; a measure of the acidity or alkalinity of a solution

Pollution: an undesirable state of the natural environment being contaminated with harmful substances as a consequence of human activities

Primary treatment: the treatment stage of wastewater in which solids and impurities are removed

Porous pavement: a special type of pavement that allows water to pass through instead of running off

Potable water: water that is suitable for drinking

Pumping station: where water is transported from a river or stream into a treatment plant

Raw water: untreated water which comes from a river, stream, or lake

Regulator: equipment in the wastewater system that directs flow to the CSO and tunnel when the wastewater treatment plant is at capacity

Rooftop Garden: gardening on the roof of a building; commonly done in cities where garden space is at a premium; rooftop gardens provide greenspace in the city, reducing impervious surface

Safe Drinking Water Act: a Georgia State law which requires regular water monitoring in order to ensure that the water is healthy and safe to drink

Secondary treatment: the treatment stage which employs biological and chemical processes

Sedimentation: the process by which particles in water settle to the bottom of a container and collect there

Separated sewer system: a system in which wastewater goes through water treatment and storm water goes directly into a stream without any treatment

Stormwater: water that is generated by rainfall and is often routed into drain systems in order to prevent flooding

Transpiration: The process by which water absorbed by plants is evaporated into the atmosphere from the plant surface (usually leaves)

Urban heat island effect: the effect of impervious surfaces in urban areas; impervious surfaces absorb heat during the day and release it at night when the temperatures drop, causing it to feel warmer than expected in urban areas

Virus: a tiny parasite which may cause disease

Water Cycle: The paths water takes through its various states (vapor, liquid and solid) as it moves throughout Earth's systems

Water pollution: anything that is put into a water source and is not naturally found there, such as fertilizers, soaps, and animal waste

Water quality standard: rules for water quality and treatment which help ensure that water is safe to drink and use

Watershed: The land area from which surface runoff drains into a common body of water; also called a drainage basin

Wastewater: water that contains unwanted materials from homes, schools, and businesses and is a mixture of water and suspended solids.