Stream Physics Outline

Big Idea

Water is a force that affects landscapes.

Essential Questions

- How do you determine the volume of water flowing past a given point?
- What natural and human factors change the volume of water in a river?
- What affects the velocity of a river?
- In what ways does water shape the land?
- In what ways do the physical properties of water affect the organisms that live there?

Vocabulary

- Acceleration—a change in velocity
- Deposition—the dropping or depositing of natural materials that have been eroded away
- Erosion—the movement of natural materials by wind, water, and gravity
- Force—a push or pull. A force gives energy to an object, sometimes causing it to start moving, stop moving, or change direction.
- Friction—the resistance that one object feels when moving over another
- Hydrology—the study of water's movement and relationship to the land
- Mass—the amount of matter in an object
- Newton's second law of motion—force = mass x acceleration
- Physics—branch of science concerned with the nature and properties of matter and energy
- Speed—the measure of the distance an object moves in a given amount of time
- Velocity—an object's speed in a particular direction
- Volume—the amount of space that a substance or object occupies
- Weathering—the process of breaking down natural materials by chemicals, water, wind, freeze/thaw or friction

Lesson Outline

- Introduction
- Where Is All the Fresh Water?
- Stream Study
- Using Stream Flow Meter to Identify Smoky Madtom Habitat

Stream Physics Outline

- Power of Water Hike
- Erosion Explosion
- Erosion Pans

Optional Activities

- River Mapping/Journaling Activity
- Water Cycle Game
- Watersheds
- Create a River

Stream Physics Activities

INTRODUCTION

What do we mean by physics? (properties of matter/energy—how things work!) When learning about stream physics, are we going to be looking at the living organisms or chemistry of the stream? No. Stream physics looks at how water moves and the impact water has on the landscape. What is a force? (push or pull) Brainstorm forces in nature—wind, water, earth movements, gravity. In the context of water, we are looking at the force of gravity pulling the water, rocks and sediment downstream and the push of water on these elements (stream bank, sediments, rocks, and living organisms).

Today we will be looking at the force of water and how it can shape the land.

Review of metric system: Because we are scientists and the metric system is universal (world-wide), we will be collecting and recording all of our data using centimeters and meters. Using a meter stick, review how many centimeters are in a meter, how many meters are in a kilometer, milliliters in a liter, etc.

WHERE IS ALL THE FRESH WATER?

10 Minutes

Lead In

Why is fresh water important? How much fresh water do we have on our planet?

Procedures

- Use a 1,000 ml bottle of water to represent all the water on Earth. Brainstorm with the students where this water might be found. (oceans, lakes, rivers, icecaps, in the soil, etc.)
- Pour 30 ml of the water (3% of the total) into a 100 ml graduated cylinder. This represents all the freshwater on Earth. Put salt into the remaining 970 ml of water in the bottle to show that this is ocean or saline water that cannot be easily used by plants and animals.
- From the 30 ml of water, pour 6 ml of fresh water into another cylinder and the remaining 24 ml represents frozen water in the polar ice caps (80% of fresh water).
- Of the remaining 6 ml only 1.5 ml of this water is found on the surface of the Earth (lakes, rivers, streams) and the rest is ground water (water too far underground to reach or held in soil).
- Use an eyedropper and remove a single drop of water (.003 ml) and squeeze this out so that all students can see that it is one drop. This one drop represents the clean water (wells, aquifers, clean streams) that is not polluted and is available for use by hu-

mans without treatment.

Wrap Up

Why is it important for scientists (hydrologists, city planners, corps of engineers) to know how much water they have available in local rivers, streams and lakes? Water is a very limited resource. We especially need to know how to manage/conserve water during times of growth and drought. (How do city officials know when to implement water restrictions?) But we also need to manage water resources for aquatic species.

STREAM STUDY

This portion of the lesson is led by the Tremont staff while the second half of the lesson, beginning with the Power of Water Hike, is led by the co-teacher. Groups then switch halfway through the lesson.

1 HR

1 Hour +

Lead In

Since we are part of Great Smoky Mountains National Park and are not managing human water usage, we are going to take a series of measurements to find out how much water is available (volume) and the speed or velocity of the water available for aquatic species. One species in particular is the Smoky Madtom, an endangered species only found in one area of the park.

Procedures

Explain to the students that they are now hydrologists. What is a hydrologist? (a person who studies the physics of water) They have been asked to study re-introduction sites for an endangered species of fish. Have the students read the "Hydrology and the Smoky Madtom" sheet out loud or read it to them.

Velocity

Begin by reviewing velocity and why velocity may be important to the Smoky Madtom. Observe the stream and have students predict what areas would have a high velocity and which would have a low velocity. Have students predict what the substrate in the high and low velocity areas might be composed of and how that might affect the stream life.

Flow has a large impact on water quality and the living organisms and habitats in the stream. Stream speed, which increases as the volume of the water in the stream increases, determines the kinds of organisms that can live in the stream. Some need fast-flowing areas, others need quiet pools. Stream flow also affects the amount of silt and sediment carried by the stream. Sediment introduced to quiet, slow-flowing streams will settle quickly to the stream bottom. Fast-moving streams will keep sediment suspended longer in the water column. Lastly, fast-moving streams generally have higher levels of dissolved oxygen than slow streams because they are better aerated.

Friction

Look at the river. Is it flowing smoothly without any movement of the water within the channel? No! There are rocks, trees, the riverbank, the substrate or bottom of the river channel that has sand, rocks, etc. Rivers are anything but smooth! There is friction everywhere pulling on the water as it flows by. This causes the water to circle and eddy. Observe water moving past a rock. What happens as the water passes the edges of the rock? This means that there are no two points in the river channel that have the same velocity. Some areas are moving very quickly and some are moving very slowly. The sides or riverbanks are pulling on the water as it flows by, as is the bottom of the river channel. One typically finds faster moving (high velocity) water in the center of the river channel and slower moving water along the sides and bottom of the river. The velocity even changes within the water column. For this reason, we will be taking an AVERAGE of all the velocities measured across the stream channel.

Brainstorm with the students how we might determine the velocity of the river. What type of tools might we need to use? (meter measures, stop watch, something that floats, etc.) Discuss why an orange would be better (floats within the water column) than a bowling ball (it will sink and roll along the bottom) or even a hollow plastic ball (it will float on the surface which is affected by air resistance). Using the data sheet, discuss the procedures for calculating velocity. The data sheet has been set up with directions for each step. Please follow directions and record data on your data sheet.

Talking Points:

- How and why we take an average
- Why replication is important and how our results would be more accurate with more measurements
- Stream velocity variability across the stream as observed by the orange's velocity
- Velocity is a measure of distance over a given amount of time

Volume

Now we know how fast our river is moving (velocity) but we want to know how MUCH water (volume) is in our river. Why would we want to know how much water is in the river (Smoky Madtom requirements, how long will it take a lake to fill, recreational kayaking/rafting, support for a communities water needs, etc.) You have probably taken volume measurements in your classroom. How do you find the volume of a solid? (length by width by height) How do you find the volume of a liquid? (graduated cylinders) How would we find the volume of the river? It isn't square like our PVC model! We can find the depth and the width of the river, but what about length? Velocity is the measure of distance over time. The distance we used for our velocity measurement was 10 meters so we will be using our velocity average for our length. To find the width, we will stretch a meter tape from water's edge to water's edge. Our depth measurement will need to be an average depth. Again, the more depth measurements we take, the more accurate our final stream discharge rate will be. We will be taking a depth measurement every 100 centimeters or 1 meter (see Directions for Using the Stream Flow Meter sheet).

Talking Points:

- Why take an average depth in a stream? (is the water all the same depth?)
- Importance of keeping the tape measure perpendicular to the flow of the stream

Stream Flow

Stream flow, or discharge, is the volume of water that moves over a given point over a fixed period of time. The flow of a stream is directly related to the amount of water moving off the watershed into the stream channel. It is affected by weather, increasing during rainstorms and decreasing during dry periods. It also changes during the different seasons of the year. Using the data sheet ask the students to find the stream flow of the Middle Prong. Remember our initial question—Can this river support the Smoky Madtom?

Wrap Up

What controls the rate of flow in a river channel? Two things affect the rate of flow or the momentum of the water: the amount of water flowing, or volume, and the shape and size of the channel–capacity of the channel. For example, a river channel that is 10 meters across and has 100 cubic feet of water passing through will have less velocity compared to a river channel that is only 5 meters wide with 100 cubic feet of water. If a channel becomes narrower or shallower, then the water will increase in velocity; and if a channel is wider or deeper, the velocity will decrease. Now, remember Newton's second law of motion which states that a force is equal to mass x acceleration. If you have a high volume of water moving with a lot of velocity then you will have increased force;

and conversely, if you have a little volume of water with decreased velocity then you will have less force.

USING STREAM FLOW METER TO IDENTIFY SMOKY MADTOM HABITAT

10 Minutes

Lead In

The Smoky Madtom needs shallow riffle habitat with water velocities 0.5-0.7 m/sec to breed and lay its eggs. Have the students point out areas in the Middle Prong where they think suitable Smoky Madtom habitat might exist. Tell the students that they will use a Stream Flow Meter to determine the velocity in different areas of the Middle Prong to see if their predictions are correct.

Teacher's Note: This activity is usually performed after the students take the measurements to determine stream flow, i.e., finding velocity of the orange and measuring stream width and depths.

Procedures

Prior to this activity, the students estimated velocity of the Middle Prong by floating oranges in a 10-m section of the Middle Prong. Ask the students if they think hydrologists and engineers use oranges to measure velocity. Most of the students will tell you that hydrologists and engineers use special equipment to measure water velocity. Introduce the stream flow meter to the students. This is the same instrument hydrologists use when they need to measure precise water velocities. Show how the impeller turns when in the water or when you blow on it and describe how it determines velocity by the number of times the impeller turns—the higher the velocity, the faster the impeller spins. Demonstrate how the stream flow meter works by taking measurements at the top of the water column and at the bottom of the water column. Where is the velocity the highest? Where is it lowest? Explain that the velocity is lowest at the bottom of the stream because of friction and turbulence. Lower water velocity is the reason why most fish and other aquatic organisms are found at the bottom of the water column, because they don't have to expend as much energy fighting the current. Now ask them where the stream flow meter impeller should be placed in the water column to measure the average velocity. It should be placed in the middle of the water column (actually 6/10 from the bottom of the stream).

Now that the students understand how the stream flow meter works, pick three or four students to choose sections of the Middle Prong where they think suitable Smoky Madtom breeding habitat exists. Go with the students to their chosen site. Move the impeller up or down the pole so that it rests in the middle of the water column. Have the student call out the velocity readings. (Make sure that you and the student are far enough behind the impeller not to interfere with the stream flow.) Which sites were suitable breeding grounds for the Smoky Madtom?

Wrap Up

Ask the students if they think measuring the velocity of these sites just one time provides enough data to assess whether suitable Smoky Madtom breeding habitat exists or not? How could the stream flow meter be used to determine the stream discharge (volume of water moving past a given point)? (Instead of using oranges to measure velocity, they could use the stream flow meter.)

POWER OF WATER HIKE

30 minutes

Lead In

The purpose of this hike is to find examples of water doing work (past or present), to illustrate the power of water. Moving water has force and can pick up small pieces of sand, sticks, leaves, and even large rocks and boulders. As you are hiking, have the students try to find examples of spots where water may have done work (caused weathering and erosion) in the past.

Remind the students that weathering is the process of breaking down natural materials by chemicals, water, wind, freeze/thaw or friction; erosion is the movement of weathered natural materials by wind, water, and gravity; and deposition is the dropping or depositing of natural materials that have been eroded away from the source they were weathered from.

Procedures

Below are a few areas you might want to visit during the Power of Water Hike. Encourage students to find evidence of water doing work in other areas.

- We record rainfall data with weather station equipment, so stop by the weather station. Some students may have already collected data before breakfast, so give these students the opportunity to talk about what they learned and the measurements they took. Ask the students when they would expect the river to be at its highest in a rain event—is it during, immediately after, or a short time after the rain event? (The river peaks a short time after a rain event, because water runs off the surrounding land and enters through smaller creeks as well.)
- Walk to the river by the bridge and follow the path that leads down to the water's edge on the right-hand side of the bridge. At the river level, there is a depth gauge. (see photos of flood) During the flood of 2003, the water level rose to within 8 inches of

the bottom of the bridge. Staff members who were here during the flood say that they could hear the rocks and boulders at the bottom of the river knocking and hitting one another. It sounded like thunder! If you go to the ford by the River House, you can observe the rocks that have been pushed by the water over the paved ford. This is a great opportunity to talk about Newton's second law of motion: force = mass x acceleration. The more water there is, the more mass that water has. The greater mass will create a greater pull of gravity on that water, which creates more force to move objects in the water. For example, use the illustration of a semi truck and a small car traveling at the same velocity—the semi truck has a lot more force because it has greater mass than the small car.

- Have students look at the pictures of the flood again. What else do they notice about the river, besides that it looks very high? The color of the water is different. The amount of sediment stirred up in suspension in the water column is called turbidity. Why would fast-moving water have higher turbidity than slow?
- Find areas where soil has been eroded away or debris has been pushed by moving water (usually has a rippled appearance). Examine these areas and have the students try and determine why erosion occurred in this spot and not in other areas close by. (softer or loose rock/soil, steep incline, etc.)
- Rocks that are rounded and smooth as if they have been polished may have been in a river or stream. When rocks tumble over each other and bits of sand wash by them, small pieces of rock break off, giving the rock a smooth or rounded appearance.
- On the West Prong Trail just before the Cemetery Trail branches off to the right, you cross over a water bar, a ditch dug across the trail. Ask students how the water bar can help prevent erosion of the trail. The water bar is used to divert the fast moving water off of the trail into the leaves, slowing the velocity and the ability of the water to do work.
- Just past the cemetery there is a small stream. Observe how the stream has cut into the ground. The fast-moving water (high energy) flows through the valley after a rain event down this steep hillside. Have the students observe the difference in slope between this site and the larger river. This water has eroded the banks and has moved the sediment downstream. Why aren't the rocks as smooth as those in the larger river? (There is not enough constant flow to weather the rocks—in larger streams the rocks are constantly being weathered by the moving water and sedi-

ment.)

- Find an area where the stream is flowing quickly and forming a small channel. This is called a run. An area where the water is barely moving at all is called a pool. Collect some sediment from the bottom of a run and from the bottom of a pool. You should observe fine, silty sediments from the pool and coarse, rocky sediments from the run. Why does this occur? (Small sediments continue to be carried downstream in fast water and heavier sediments fall out, whereas the small sediments have the opportunity to settle out in still or slow moving water.) What animals do you think would be found in each area? (Animals adapted for fast moving water have small claws to hold onto the rocks and are very streamlined so the current washes over them instead of pushing them downstream—stoneflies, mayflies, water pennies. Animals that are not adapted for fast moving water tend to congregate in the pools—dragonfly nymphs, salamanders, crayfish.)

Evidence of water erosion is all around us and not just in the mountains. You can find examples of the power of water around your homes and schoolyard. At home look at the downspout from your gutters and observe how the water may have eroded the soil. At your school, observe areas around the playground or places where people walk and there are no sidewalks. You can also observe rivers and streams around your home and school. Do they have a lot of sediment or are they clear? The decisions we make when building houses and shops, cutting down trees and other plants, and covering soil with pavement or concrete, can all change the way water flows and the amount of work that water can do in an environment.

ERosion Explosion

15 Minutes

Lead In

Ask the students what term describes the washing away of soil. (erosion) What is the relationship between soil and plants? (Plants prevent erosion by trapping soil with their roots.) Tell the students they will now play a game demonstrating the importance of plants in preventing soil erosion. In this game they will play the role of plants or grains of soil; the object of the game is to not be eroded. A good place to play this active game is in the field area near the blacktop.

Procedures

Hand out cards labeled with the various roles. Most of the students will be grains of soil, but the teacher will need to choose three or four students to be plants. The job of the plants is to provide a safe refuge for the grains of soil, who do not want to be eroded.

Assign one of the plants to be an old oak tree, another to be a pine tree, and the remaining plants should be smaller shrubs (mountain laurel, rhododendron). Larger trees have the ability to hold more soil because of their deeper root systems and more extensive shallow feeder roots, while the smaller shrubs can protect fewer grains. This is expressed by the number of grains indicated on the cards. For example, the oak tree's card has the number three. This means that the tree can hold three grains of soil. The pine tree will have a number two and the shrubs will each have a number one.

Another student will play the role of water. His or her job is to run and tag the grains of soil before they can attach themselves to one of the plants.

On the teacher's call, the grains of soil are to run and try to latch onto one of the plants before they are tagged by the water and before the plants are filled to their capacity with other grains of soil. If a grain of soil is tagged, it has been eroded and must return to the established starting point. A grain of soil must also return to the starting point if it runs to a plant which is full.

In the first round, expect only a couple of grains of soil to be eroded. Ask the students if the erosion of a few grains of soil is a serious problem. (No, erosion is a natural process that is not necessarily problematic.) Before starting the second round, explain that you need to cut down the old oak tree for firewood and that you need to cut down the pine tree for notebook paper. Tell the trees that they are now dead and consequently cannot hold any grains of soil. Then play again and watch what happens. In the second round there will be a marked increase in the number of grains of soil who get eroded.

Wrap Up

Ask the students why there was such a dramatic increase in the amount of soil erosion. Have them explain the relationship between plants and soil erosion. (When trees are stripped from the land, the amount of soil erosion increases.) Ask the students how or why this is a problem.

Has there been a time in the past when erosion along these hillsides was greater than it is today? (Yes, when this area as logged in the first half of the 20th century.)

What would happen if the trees died from a lightning strike and were left in the forest? (They would decompose and turn into soil.)

Have students name some other things that are eroded. (mountains, rocks, river beds, etc.) Make certain they understand that this is a much slower process than soil erosion. It may occur over many millions of years.

EROSION PANS

20 Minutes

Teacher's Note: Before this activity begins, you'll need some dirt to put in the paint pans. The Tremont teacher/naturalist may have gathered this for you prior to the lesson, or you might collect some while on your Power of Water Hike.

Lead In

Gather students together in an open area, preferably with forest nearby (the grassy area near the River House works well). Tell the students that Tremont is in the process of restructuring the Tremont campus. We may be building a new dormitory, dining hall and classrooms in the area that is now the field. The older buildings will be torn down, allowing these areas of campus to return to a natural state.

As a hydrologist, you have been asked to come up with a plan of how you would prevent erosion from occurring during the construction of these new buildings. It is your job to protect the Middle Prong of the Little River from sedimentation. Sedimentation can harm fish and macro-invertebrates in the river by choking their gills with fine silt and filling in the areas between rocks where the lay their eggs and find shelter.

Procedures

Water flows downhill and often carries sediment and litter with it. Water erosion is a natural process but humans have accelerated the rates of erosion by disturbing the plants living in the topsoil. In this activity students will use objects found on the ground to illustrate the need for cover in preventing erosion.

Give each small group a paint tray. The leader needs to place about 2 or 3 cups of soil at the top of each paint tray. Explain to students that with their team, they will use dead materials (leaves, sticks, and small rocks) found on the ground to protect the soil in the construction area (located at the top of your pan). In about 10 minutes a large storm with torrential rains will reach the Smoky Mountains and wash out the construction site. The students should be prepared to explain to the rest of the teams what they have done to prevent erosion—their strategy! The design with the least amount of sedimentation in the Middle Prong (the water collecting at the bottom of the pan) will have their design chosen by the construction company.

While students are working, the leader can prepare another paint tray with soil for a demonstration without any erosion control measures. When students are ready, gather the whole group around the paint tray without erosion measures and ask them to predict what they think will happen. Hold the water can a few feet above the soil and pour while the students count to ten. The water that collects at the bottom of the pan should be dark with sediment. You may also observe rills or "gullies" forming in the soil. Now have the whole group go to the first students' pan. Have the students explain their strategy for controlling erosion. After the group has presented their pan, pour the water for ten seconds. Discuss what happened and move on to the next pan, until all of the construction sites have been "rained on."

Wrap Up

After all of the pans have been "rained on," ask students what worked the best? Worst? Ask students to think of ways they have seen construction crews deal with erosion issues on construction sites (hay bales, silt fences, rock burms, cloth with grass imbedded, etc.). Ask students to think why plants are such good erosion controllers (roots hold soil). Ask students why the Middle Prong is so clear? What are some ways that the water quality is changed as the water leaves the park?

OPTIONAL ACTIVITIES

RIVER MAPPING/JOURNALING ACTIVITY

At least 10 minutes. (Up to 30 minutes or more if time allows.)

Teacher's Note: Due to time constraints, this activity is often not included in the lesson. It can make a great free-time activity, as it requires very few materials and little effort on the instructor's part to conduct it.

Lead In

Now that the students have had an opportunity to discuss the power of water and the effect water has on the landscape, we'll take some time to look at a section of the river in a little more detail. Gather the students near the river. Ask the students: does the whole river look the same? What are some differences between areas of the river? (Some areas, like riffles and runs, have faster moving water; others, like pools, have slower moving water. Some areas are in sun, while others are shaded. There are large boulders in some sections, fallen trees in others.) Why is this important for the living creatures in the stream? (Critters have different habitat requirements; a diversity of potential habitats typically means a diversity of stream life.) Explain to students that they'll be taking a closer look at the diversity of elements that make up the river.

Procedures

Tell students that you'd like each of them to find a quiet spot along the banks of the river (not too close to the water's edge) where they'll sit and draw a map of a section of the river. The maps shouldn't extend all the way up and down to the furthest extent of the river they can see, but should just be the approximately 20' wide section directly in front of them. Reintroduce the vocabulary words of pool, riffle, and run. Students should map their section of the river, labeling the important features of each section. They should also include the different characteristics they brainstormed earlier—prominent boulders, fallen trees, undercut banks, etc.—whatever they feel is important.

Wrap Up

Once they've completed their maps, you may ask them to write a paragraph or two about why all of these different areas of the river are important. You might also discuss this as a group, once everyone has finished and gathered back together. Discuss the following questions with the students:

- How has water as a force shaped this landscape? (Water has carved out this valley; in the river itself, water has moved rocks into and around the river channel to form riffles, eroded the river bottom or washed rocks downstream to form pools and runs.)
- Why is the diversity of physical features important? (It provides habitat for a greater diversity of stream critters; different types of fish, insects, and even mammals prefer different habitats within the stream.)
- How will the river change in the future? (The river will continue to erode the riverbed, cutting the valley deeper.)
- Can we have an impact on these habitats within the river? (Deforestation leads to soil erosion, which can deposit sediment in pools. Dam building has a huge impact, essentially creating one large pool behind the dam, eliminating other habitat types.)

20 MINS

WATER CYCLE GAME

20 Minutes

Lead In

Gather students into a circle and hand out water cycle cards randomly to the students. Review the stages in the water cycle (evaporation, transpiration, respiration, precipitation, condensation). Discuss with the students: What is a cycle? How do the processes on the cards come together to form a cycle? Can they think of other cycles in nature? (rock cycle, nutrient cycle, lots of different life cycles) Explain to students that they'll play a game to explore how the processes on the cards come together to form a cycle.

Procedures

Start with a single ball in play. Give the ball to a student, and explain that they can only pass the ball to a student whose card represents a potential next stage in the cycle. For example, rain could precipitate into a river or stream, water from the river or stream could evaporate into the clouds or be consumed by an animal and respired. Rain that precipitates on the ground could be used up by a plant and then transpired into the clouds, or evaporate from the ground directly into the clouds, and so on. After tossing the ball around the circle a few times, introduce additional balls to illustrate that the water cycle is continuous—the plants are transpiring at the same time water is evaporating from the ground and rain is falling as precipitation, etc.

As the students get better, add in the other two balls, one at a time, until all three balls are in play at once.

After a few minutes of play, collect the balls but have the students continue to hold their water cycle cards. Introduce a scenario where a coal plant is pumping pollution into the atmosphere. How can this affect the water cycle? First, it would affect the clouds by polluting the water vapor (collect the cloud cards). This in turn causes acid rain or polluted rain (collect rain/snow cards). This can cause damage to plants and contaminate the ground (collect plant and ground cards). Runoff will contaminate the rivers and streams (collect river and stream cards) and this will affect the animals that depend on the plants and clean water such as fish and macroinvertebrates that live in the rivers and streams (collect final animal cards). Add in a fourth ball of a different color (Optional: Dip squishy water balls into a bucket of water to simulate pollution. Anyone who gets wet now has been affected by that pollution.) Have the students keep track of whether they've received the "pollution" ball. How long did it take for the pollution to spread throughout the cycle?

Wrap Up

When the pollution was added into the game, the water cycle was disrupted by human impacts. Do humans have an affect on our environment? Brainstorm some other ways that humans have an effect on our environment? What are some things that we can do to alleviate our impacts on the environment?

WATERSHEDS

15 Minutes

Lead In

Where does the water in our river come from? (rain or other precipitation both here and at higher elevations, springs, and feeder springs) Where does this water end up? (Little River, Tennessee River, Ohio River, Mississippi River, Gulf of Mexico) Now everyone is going to get to make their own mountain range and have a "rain storm" come along.

Procedures

Each student or group of students will build their own mountainous area, including valleys, using one sheet of tinfoil or freezer paper. Crumple up the foil or paper and loosely straighten the paper back out. Make sure the waxed side is up. Ask the students to trace the mountain or ridgetops using a wet erase or washable marker. Have students predict where the water will flow when sprayed with water. After listening to their predications, use a small spray bottle to “rain” on the “mountains” and observe where the water flows. Use this illustration to explain that as water flows over the surface of the land as runoff, the water collects in streams and rivers. The pattern of streams and rivers that collect water into a basin is called a watershed. An extra challenge would be to have students create multiple watersheds that join to form one large watershed.

OPTIONAL: Now give students the ARC/GIS diagram of the rivers and streams in Great Smoky Mountains National Park. Have the students work together to try and circle the different watersheds found in the park. Using the key, help students check and correct their maps so they will begin to see the patterns stream channels make in a watershed.

Wrap Up

Ask students what geologic feature might be found running through the middle of the Smoky Mountains? Why is it important to know what is found in your watershed? Will this affect water quality?

CREATE A RIVER

20 Minutes

Lead In

Tell students that they are each to draw a river on a sheet of paper. The only requirement is that there be at least two human-made structures and at least one natural feature on the river or on the banks. Tell them also to orient their river so that it flows across the page horizontally. The area around their rivers will represent the watershed, which is the land area drained by a river.

Procedures

After they have completed their drawings, collect them and then tell the students that what they have done is create a river by each drawing a section. Place all of the drawings end to end so that the water “flows” down the river. Discuss what happens to the quality of the water as the river progresses. Ask individual students what human-made structure they have placed on or near the river. There are negative side effects to virtually all types of development on or near a river.

- Houses, stores, shopping centers, roads: run-off from urban areas includes gasoline, oil, synthetic chemicals, and sewage
- Factories, power plants: dumping of chemicals, thermal pollution in dumping of wastewater
- Farms and rural areas: run-off of pesticides and fertilizers, illegal dumping of garbage in river, animal wastes

- Increased run-off from paved or other impermeable surfaces (roof-tops, pavement, etc.) can cause an increase in flow (flooding). Many large shopping developments have to have a holding pond to hold the excess water to prevent flooding/surges of water in rivers/streams.

Wrap Up

By watching the "river" get polluted and how many impermeable surfaces humans create, the students will see that water pollution and increased water volume is a complex process that involves many people. End the activity by mentioning that the adaptations of stream inhabitants generally will not help them survive if human-caused changes occur within the environment. The adaptations of stream animals have taken millions of years to develop, and the rapid changes that people bring to stream habitats are negatively affecting the diversity of aquatic life.

Ask students for some ideas of ways they can protect streams and rivers. Emphasize that all life depends on water, and that it is up to us, as individuals and as members of society, to ensure that we have an adequate supply of water for ourselves and our fellow earth dwellers.

THE METRIC SYSTEM

Length – the distance from one point to another
Meter (m) A meter is slightly longer than a yard.
1 meter = 1000 millimeters (mm)
1 meter = 100 centimeters (cm)
1000 meters = 1 kilometer (km)

Volume – the amount of space an object take up
Liter (L) A liter is slightly more than a quart
1 liter = 1000 milliliters (mL)

Mass – the amount of matter in an object
Gram (g) A gram has a mass equal to about one paperclip
1000 grams = 1 kilogram (kg)

Temperature – The measure of hotness or coldness
Degrees Celsius (C) 0°C = freezing point of water
100°C = boiling point of water

Metric – English Equivalents
2.54 centimeters = 1 inch
1 meter = 39.37 inches
1 kilometer = 0.62 miles
1 liter = 1.06 quarts
250 milliliters = 1 cup
1 kilogram = 2.2 pounds
28.3 grams = 1 ounce
°C = 5/9 x (°F – 32)

Prefix	Symbol		Meaning
Kilo-	k	1000	thousand
Hecto-	h	100	hundred
Deka-	da	10	ten
Deci-	d	0.1	tenth
Centi-	c	0.01	hundredth
Milli-	m	0.001	thousandth

Stream Physics Resources

WHERE IS ALL THE FRESH WATER?

All the water on Earth!

1,000 ml

Pour 30 ml into another beaker

Oceans and salty seas

970 ml that is left

All freshwater on Earth

30 ml in beaker

Pour 6 ml into another beaker from 30 ml

Frozen water in the polar ice caps

24 ml that is left

Using an eye dropper take out 1.5 ml (one full pipette)

Surface water (lakes, rivers, streams)

1.5 ml in eyedropper

Groundwater that is too far to reach or held in soil

Clean water–wells, clean streams, aquifers–Water available to humans and animals

4.5 ml that is left

ONE DROP

HYDROLOGY AND THE SMOKY MADTOM

The Smoky Madtom (*Noturus baileyi*) is a federally endangered fish endemic (native only to one small area) to the southern Appalachian Mountains. The Smoky Madtom is in the catfish family, but grows to only about 2.9 inches in length. Today the fish is found only in a 6.5 mile section of Citico Creek in nearby Cherokee National Forest, TN, and in the lower sections of Abrams Creek in the western side of Great Smoky Mountains National Park.

The Smoky Madtom was extirpated (made locally extinct) from Abrams Creek in the 1957. In perhaps one of the most foolish management decisions in the park's history, it was decided that Abrams Creek should be poisoned to remove native "trash" fish to make it more suitable for exotic Rainbow Trout, a popular game fish. During the poisoning of the stream, scientists gathered the dead fish to put in jars for museums. One fish stood out as a new species – the Smoky Madtom. It almost became one of the first species to simultaneously be discovered as a new species and made extinct all within the same day. Fortunately, it was later found in Citico Creek in the 1980s. It was probably found in other tributaries of the Little Tennessee River, including the main channel of the Little Tennessee River; however, dams, sedimentation, and other human activities probably extirpated these populations. At existing locations of the Smoky Madtom, small dams built by children and adults threaten Smoky Madtom populations by slowing down the velocity of stream flow in shallow riffles, the primary habitat of the small fish.

The Smoky Madtom was re-introduced to Abrams Creek in the late 1990s. The fish needs clean, cold water, but is only found in streams with abundant shallow riffles. Because the fish is currently found in only two streams, the U.S. Fish and Wildlife Service is attempting to find new sites for the Smoky Madtom to be re-introduced. One of these sites is the Middle Prong.

The U.S. Fish and Wildlife Service and Great Smoky Mountains National Park has hired you to determine the flow of the Middle Prong and to assess whether or not it is a large enough stream for the Smoky Madtom. The most recent research suggests that the Smoky Madtom requires streams with a minimum flow, or discharge, of 1.9 m3/sec. This fish also needs shallow riffles with a velocity of 0.5 – 0.7 m/sec for breeding. Using scientific techniques, your job is to determine whether or not the Middle Prong would be a suitable site for re-introduction of the federally endangered Smoky Madtom.

Stream Physics Resources

DATA SHEET

1. Measure a 10 meter length along the bank of the river.
2. Predict the time it will take an orange to travel this distance.
3. Measure the time it takes the orange to cover 10 meters with a stopwatch and record.
4. Use the average time to compute the velocity.

Velocity

Trial 1 [ ] sec.

Trial 2 [ ] sec.

Trial 3 [ ] sec.

Trial 4 [ ] sec.

Trial 5 [ ] sec.

+

[ ] ÷ 5 = [ ] AVG. SEC.

1000 (cm traveled) ÷ [ ] AVG. SEC. = [ ] cm/sec. (Velocity)

Describe what happens each time the orange floats down the 10 meter segment of river.

5. Did the velocity change each time? Why or why not? Next, extend a tape measure across the width of the river. Be sure that you measure from water's edge to water's edge and record in centimeters.

[ ] = Width of river in cm

6. To find the average depth of the river, have all the students participating (with the exception of one recorder) spread themselves out across the width of the river. they should be evenly spaced. each student will take a depth measurement at the upstream section of the concrete ford pad. Record these depths below in centimeters.

[ ] + [ ] + [ ] + [ ] +

[ ] + [ ] + [ ] + [ ] +

[ ] + [ ] + [ ] + [ ] +

+ + + +

+ + + +

+ + + +

7. Add all of the depths together and divide by the number of depths recorded.

   ____ = average depth in cm

8. To find the area, multiply the width times the average depth.

   ____ cm x ____ cm = ____ cm^2

   Width x Depth = Area

9. Multiply these numbers by the velocity you found earlier to find the volume of water flowing through the river at this given time.

VOLUME OF FLOW

____ cm^2 x ____ cm/sec = ____ cm^3/sec

Area (width x depth) x Velocity (length) = Volume of flow

10. Finally, let's convert this measurement into cubic meters per second by dividing cubic centimeters/sec by 1,000,000 (Why 1,000,000? Remember CUBIC is 100 x 100 x 100 = 1,000,000).

    ____ cm^3/sec ÷ 1,000,000 = ____ m^3/sec

    How does the Middle Prong of the Little River compare with other rivers in the world?

Name of River	Discharge
Amazon River, Brazil	212,400 m^3sec
Congo River, Zaire	39,650 m^3sec
Yangtze River, China	21,800 m^3sec
Mississippi River, USA	17,300 m^3sec

Stream Physics Resources

2003 Flood Photos

Tremont Road under water

Under Tremont bridge

Stream Physics Resources

EROSION EXPLOSION CARDS

Oak Tree (3 grains)	Water
Pine Tree (2 grains)	Water
Shrub (1 grain)	Shrub (1 grain)
Grain of Soil	Grain of Soil
Grain of Soil	Grain of Soil
Grain of Soil	Grain of Soil
Grain of Soil	Grain of Soil

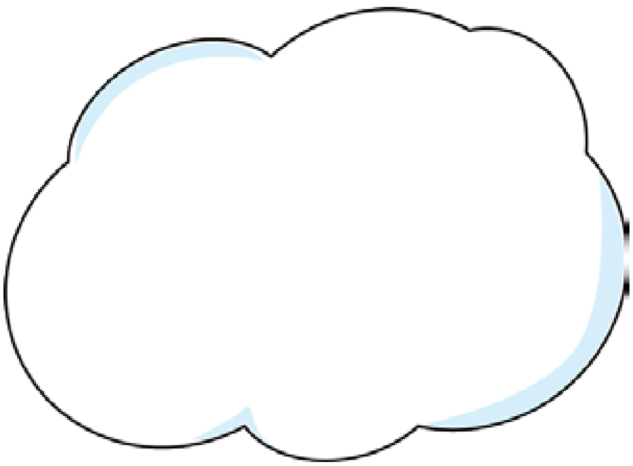
EROSION PANS

Great Smoky Mountains Institute at Tremont is in the process of restructuring the Tremont campus. We may be building a new dormitory, dining hall and classrooms in the area that is now the field. The older buildings will be torn down, allowing these areas of campus to return to a natural state.

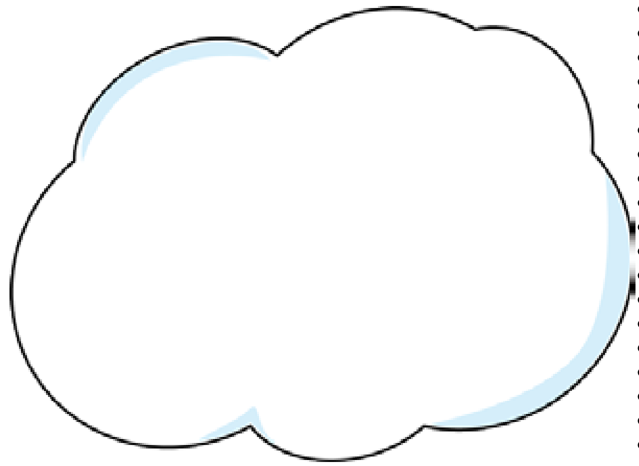
As a hydrologist, you have been asked to come up with a plan of how you would prevent erosion from occurring during the construction of these new buildings. It is your job to protect the Middle Prong of the Little River from sedimentation. Sedimentation can harm fish and macroinvertebrates in the river by choking their gills with fine silt and filling in the areas between rocks where the lay their eggs and find shelter.

With your team, use dead materials (leaves, sticks, and small rocks) found on the ground to protect the soil in the construction area (located at the top of your pan). Please do not use large rocks (this would represent paving over the top of the construction site). You will have about 10 minutes before a large storm with torrential rains reaches the Smoky Mountains and our construction site. Be prepared to explain to the rest of the teams what you have done to prevent erosion – your strategy! The design with the least amount of sedimentation in the Middle Prong (the water collecting at the bottom of the pan) will have their design chosen by the construction company.

WATER CYCLE GAME CARDS



CLOUD



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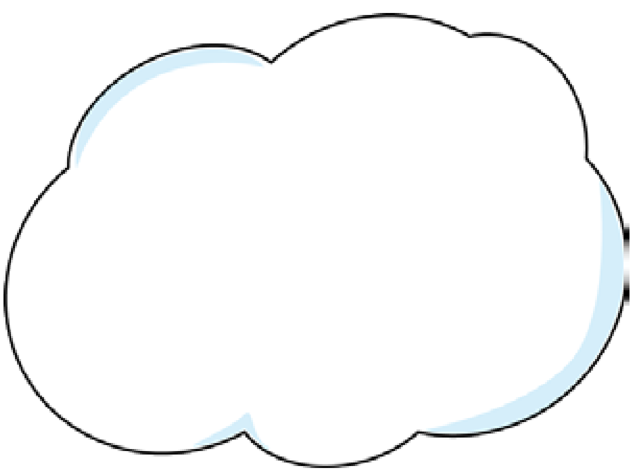

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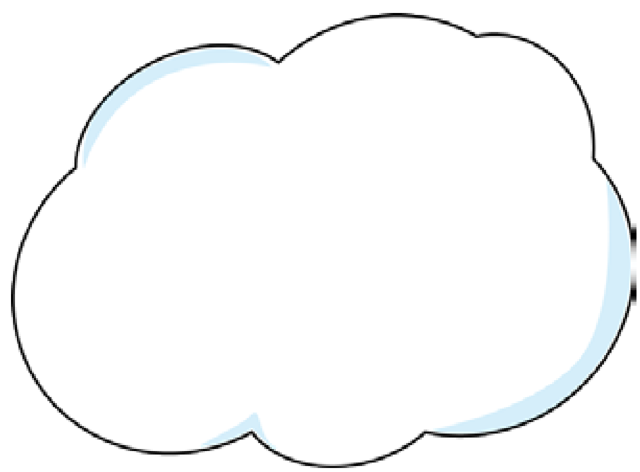


CLOUD

WATER CYCLE GAME CARDS

RAIN

RAIN

RAIN

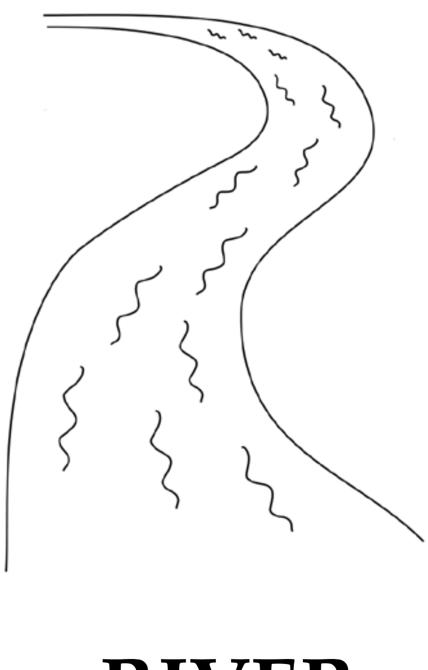
RAIN

Stream Physics Resources

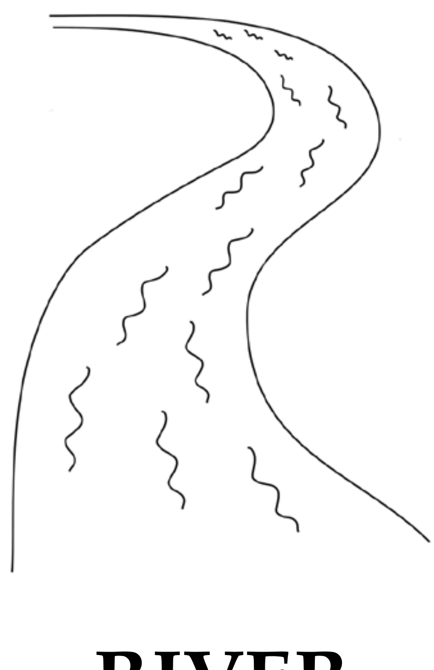
WATER CYCLE GAME CARDS

SNOW

SNOW



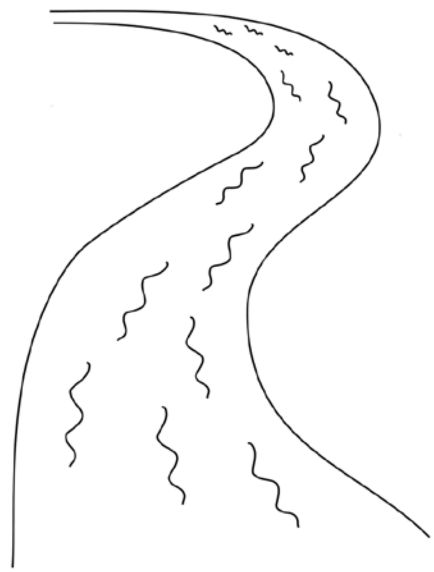
RIVER



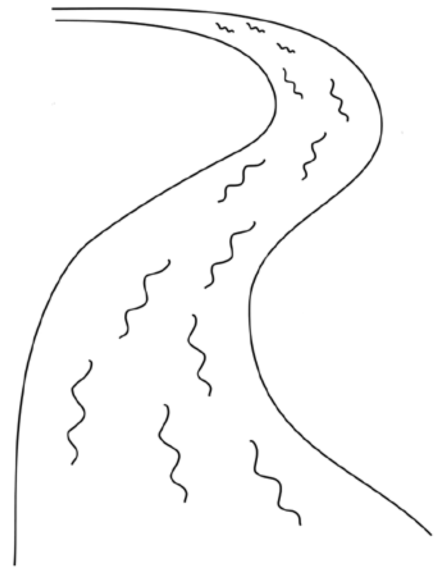
RIVER

Stream Physics Resources

WATER CYCLE GAME CARDS



RIVER



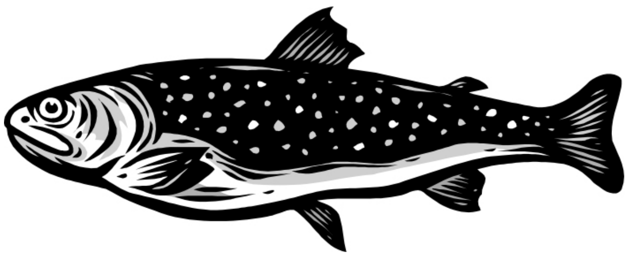
RIVER

OCEAN

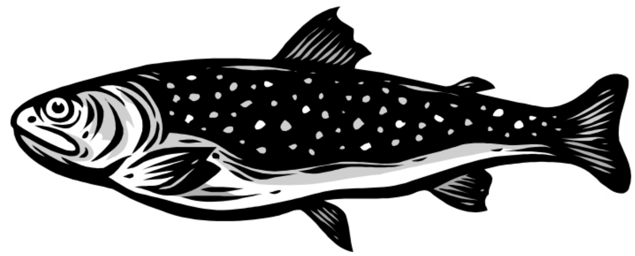
OCEAN

Stream Physics Resources

WATER CYCLE GAME CARDS



FISH

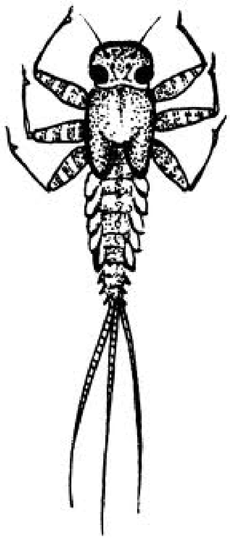


FISH

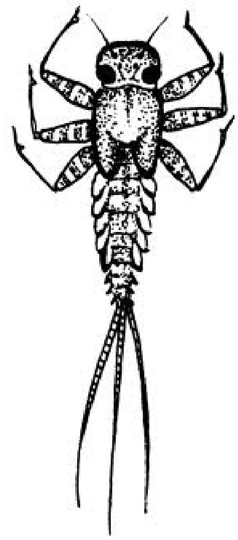
OTTER

OTTER

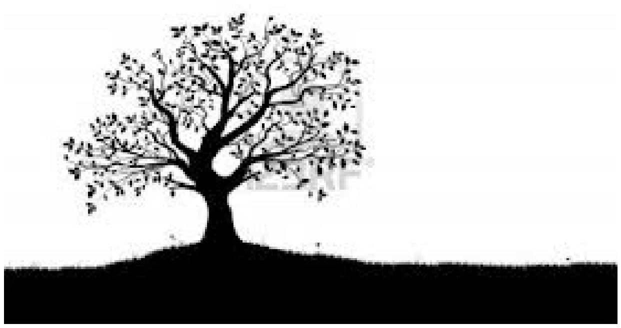
WATER CYCLE GAME CARDS



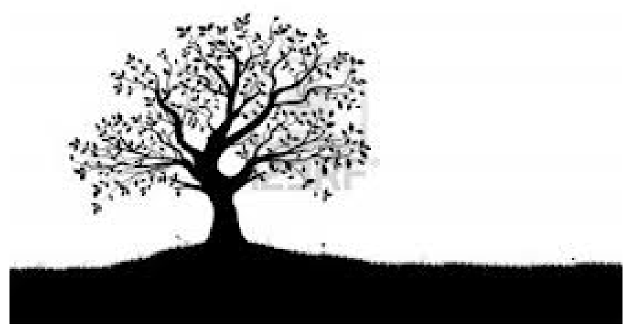
MAYFLY LARVA



MAYFLY LARVA



TREE

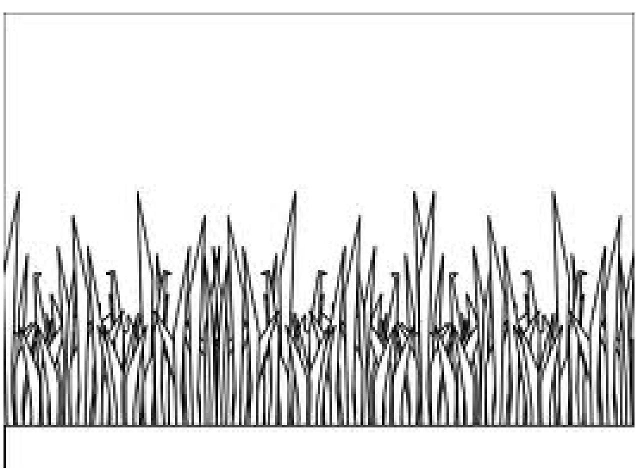


TREE

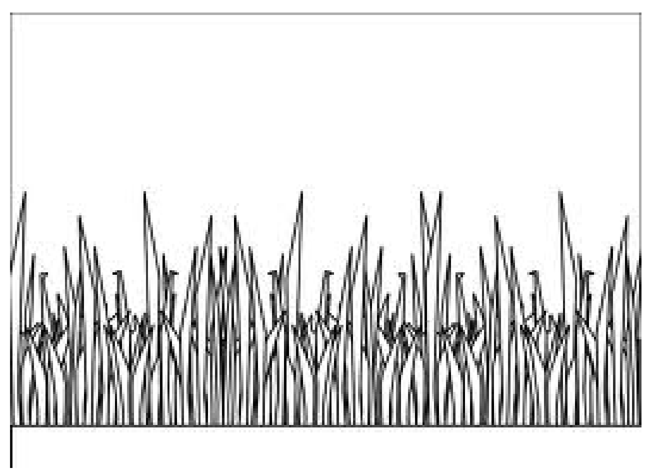
WATER CYCLE GAME CARDS

FLOWER

FLOWER



GRASS

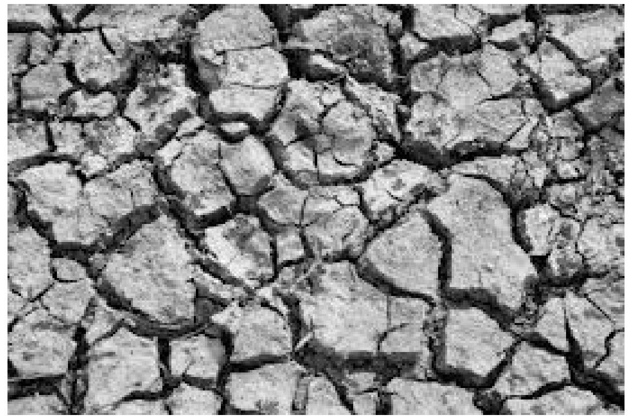


GRASS

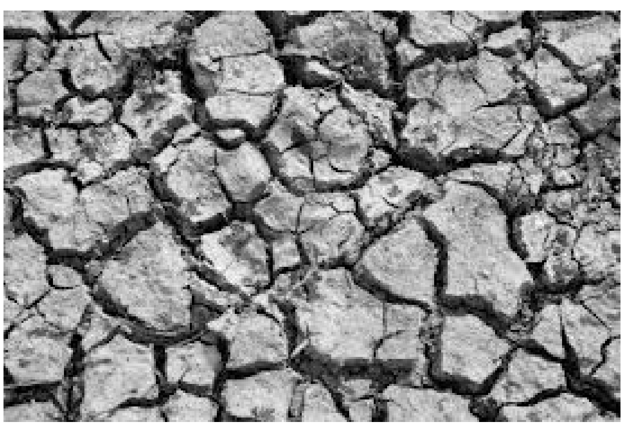
Stream Physics Resources

WATER CYCLE GAME CARDS

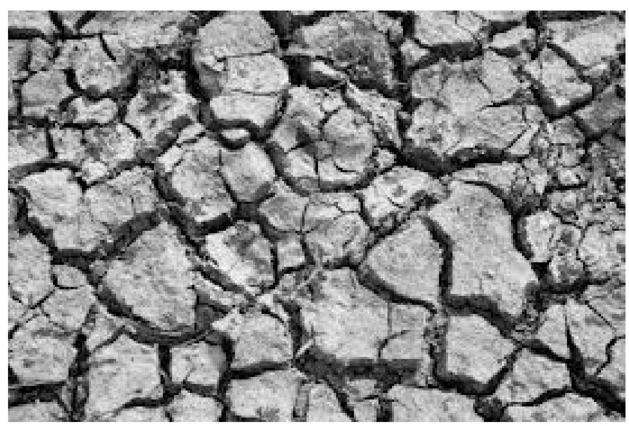
GROUND



GROUND



GROUND



GROUND

HOW MANY PEOPLE IS THIS RIVER ABLE TO SUPPORT?

Key Question: How many people is this stream able to support?

To live in the fashion to which we are accustomed, it has been estimated that each person needs 150 gallons of water each day.

The following section will allow you to calculate how many people this stream will support. Supply the missing information, complete each step in turn, and you will have the answer to the question!

Equivalents: One cubic foot of water (1 ft^3)= 7.48 gallons
One cubic foot of water (1 ft^3)= 62.4 pounds

Multiply cubic feet per second by 7.48 to find gallons of water per second.

[ ] ft^3/sec X 7.48 = [ ] gal/sec
(volume of flow) (volume of flow)

2. Multiply gallons per second by 60 to determine gallons per minute.

[ ] gal/sec X 60 sec/min = [ ] gal/min
(volume of flow) (volume of flow)

3. Multiply gallons per minute by 60 to determine gallons per hour.

[ ] gal/min X 60 min/hour = [ ] gal/hour
(volume of flow) (volume of flow)

4. Multiply gallons per hour by 24 to determine gallons per day.

[ ] gal/hour X 24 hrs/day = [ ] gal/day
(volume of flow) (volume of flow)

5. Divide the gallons per day by 150 (the number of gallons each person needs per day). This will answer the question "How many people is this stream able to support?"

[ ] gal/day ÷150 = [ ] people
(volume of flow)