2001: a water odyssey

The Special Educational Exhibition of the 2001 Kentucky State Fair

KENTUCKY STATE FAIR

teacher packet

KY STATE FAIR
The Ultimate Field Trip

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Contents

Acknowledgments

The Kentucky State Fair Board is pleased to celebrate its tenth annual special exhibition with *2001: A Water Odyssey*. One individual is solely responsible for this new environmental education focus at the State Fair and for eliciting the participation of many agencies and organizations: Dr. David Wicks, Director of Jefferson County Public Schools Office for Environmental Education. We are grateful for his leadership.

This curriculum resource grows from work to develop the *Water Odyssey* exhibition. The purpose of the exhibit was to teach the 650,000+ visitors to the Kentucky State Fair about the concept of a watershed and to demonstrate to these visitors how they can actively improve water quality in their own watershed. Many individuals participated in this process, first teaching me about watersheds then strategizing with me about how to teach others. They include: Jennifer Turner of the Ky. Division of Forestry, R. C. Story of the Ky. Department for Surface Mining Reclamation & Enforcement, Dr. Allan Dittmer of the University of Louisville Department of Teaching and Learning, Mac Stone of Kentucky State University Research Farm, Pennie DuBarry of U. S. Geological Survey, Rayetta Boone of the Ky. Department of Agriculture, Judith Petersen and Clark Dorman of Kentucky Waterways Alliance, Susan Hamilton of the Louisville Development Authority, Kurt Mason of the Jefferson County Conservation District, and Lonnie Nelson of the Ky. Department of Fish & Wildlife Resources, who each had a role in this interpretation. Many others were involved with the exhibition as well.

Thanks, too, to Danny Fitzgerald and Ben Rodman for creating the watershed drawing and to Rita Hockensmith for developing the Kentucky Watershed Map. Russ Barnett of the Kentucky Institute for the Environment and Sustainable Development, Jim Kipp of the Kentucky Water Resources Research Institute, and Chuck Parrish of the U. S. Army Corps of Engineers, Louisville District, were particularly helpful editing the Milestones Timeline. Kim Henken and Jennifer Cocanougher of the University of Kentucky Cooperative Extension Service shared their extensive knowledge of existing teaching resources related to water. Heartfelt appreciation is extended to all of the professionals in water-related careers who shared their enthusiasm and experiences with us through interviews and on-the-job photos.

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We hope teachers will utilize these resources in their classrooms for years to come and will provide feedback on this publication's successes and shortcomings. Mark your calendars for the next major Kentucky State Fair educational exhibit, *2002: A Land Odyssey*.

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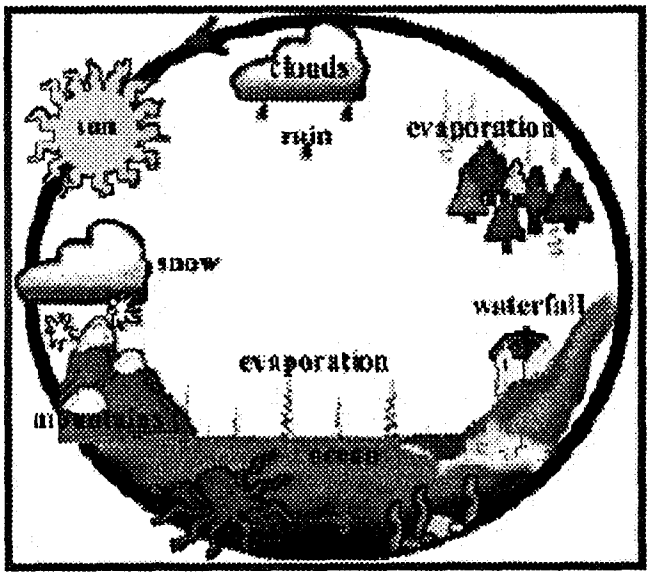
wa|ter·shed

Have you ever wanted to *really* influence the world—have an impact on the *entire* planet? Well, you *do* everyday, by making choices in your watershed. Many of the things you do each day affect the soil, air, water, plants, and animals, and when you affect the soil, air, water, plants, and animals, you affect the water quality in your watershed. So what is a ***watershed*** anyway, and how can *you* stop water pollution?

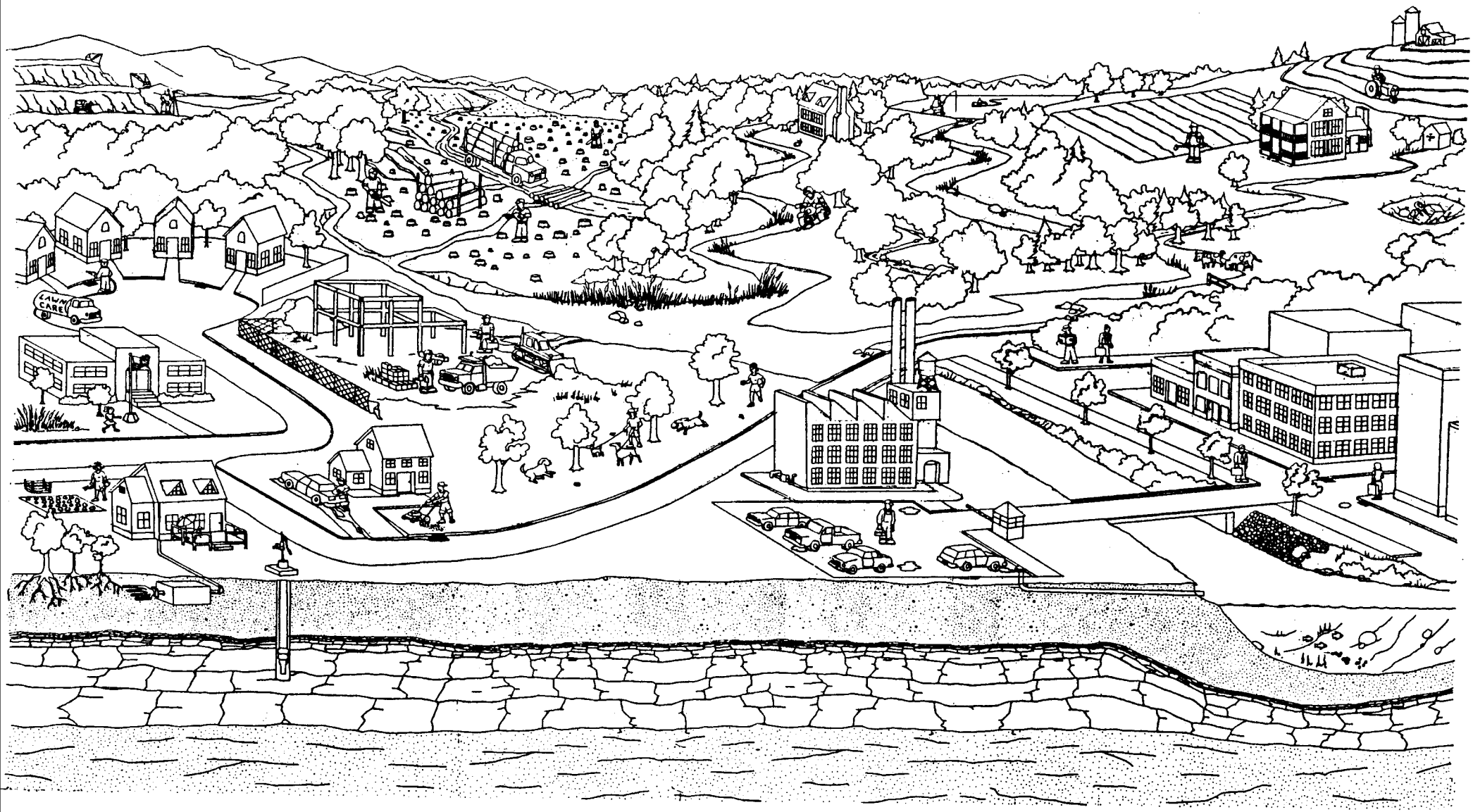
A **watershed** is the land that water flows across or under on its way to a stream, river, or lake. More specifically, it is a given area of land that drains into one particular body of water. The land around us—our back yard, neighborhood, our town, our county—is made up of interconnecting watersheds, also called **basins**.

Precipitation (rain, sleet, snow) brings water from the clouds back to the land. Within each watershed, water runs to the lowest point, which may be a stream, river, lake, or underground cave. The water can move in two main ways. On the **surface** of the ground, water runs across everything from farmlands, to forests, golf courses, parking lots, backyards, and downtown streets. But some water also soaks into the ground, and underground the water travels as **groundwater**.

Water in a watershed is always on the move. As surface runoff and as groundwater, the water is carried from small waterways such as creeks to small streams, and on to larger streams and eventually on to rivers. Before the journey is done, the water in major rivers is emptied into the oceans. All along the way, the water cycle begins and ends and begins again.



graphic from www.epa.gov/safewater/kids/cycle.html



A WATERSHED----WHERE EVERY PROPERTY IS CREEKSIDE PROPERTY

A Watershed—Where Every Property is Creekside Property

Classroom Discussion Using the Watershed Foldout Picture

Create transparencies of the backside of the large, loose-leaf version of the watershed picture (they will copy onto two 8-½"x 11" pages) and lay the transparencies over the watershed picture, matching up the title at the bottom. The information written on these overlays will help interpret the picture, so the picture may be used as a tool to teach about Nonpoint Source (NPS) Pollution and our responsibilities for water quality within our own watershed.

This picture shows how surface water and groundwater flow in a watershed as well as a variety of land uses that impact water quality within a watershed. Remember, all activities in the watershed—not just those that take place near bodies of surface water—impact water quality. Our model watershed shows streams and activities close to one another, but in reality these things would be spread across many miles. Because water is on the move in the watershed, all parts of the watershed are interconnected—even if they are far apart. The arrows represent the direction the surface water is flowing. The dotted line arrows remind us that water also soaks into the ground throughout the watershed, and that groundwater (also called the aquifer) is in a layer beneath the surface.

Questions for the classroom:

What is a watershed? What is nonpoint source (NPS) pollution? Find at least four possible types of NPS pollution in this watershed. Find an example of NPS pollution that *you* can take some responsibility for—some way *you* can change your actions to improve water quality.

Find at least three ways the community uses water in this watershed, as illustrated in the picture.

Find at least two *natural resources* pictured that help improve water quality.

Locate the body of water in the surface coal mining area of the watershed. What do you think it is? Research coal slurry impoundments. What does it mean to "reclaim" an old mine site?

How do activities such as logging and construction impact water quality?

Find two examples of wastewater treatment systems in homes. Which one is always harmful to water quality? How do we make certain the other is not harmful to water quality?

Name three ways farmers can help contribute to healthy water in the watershed.

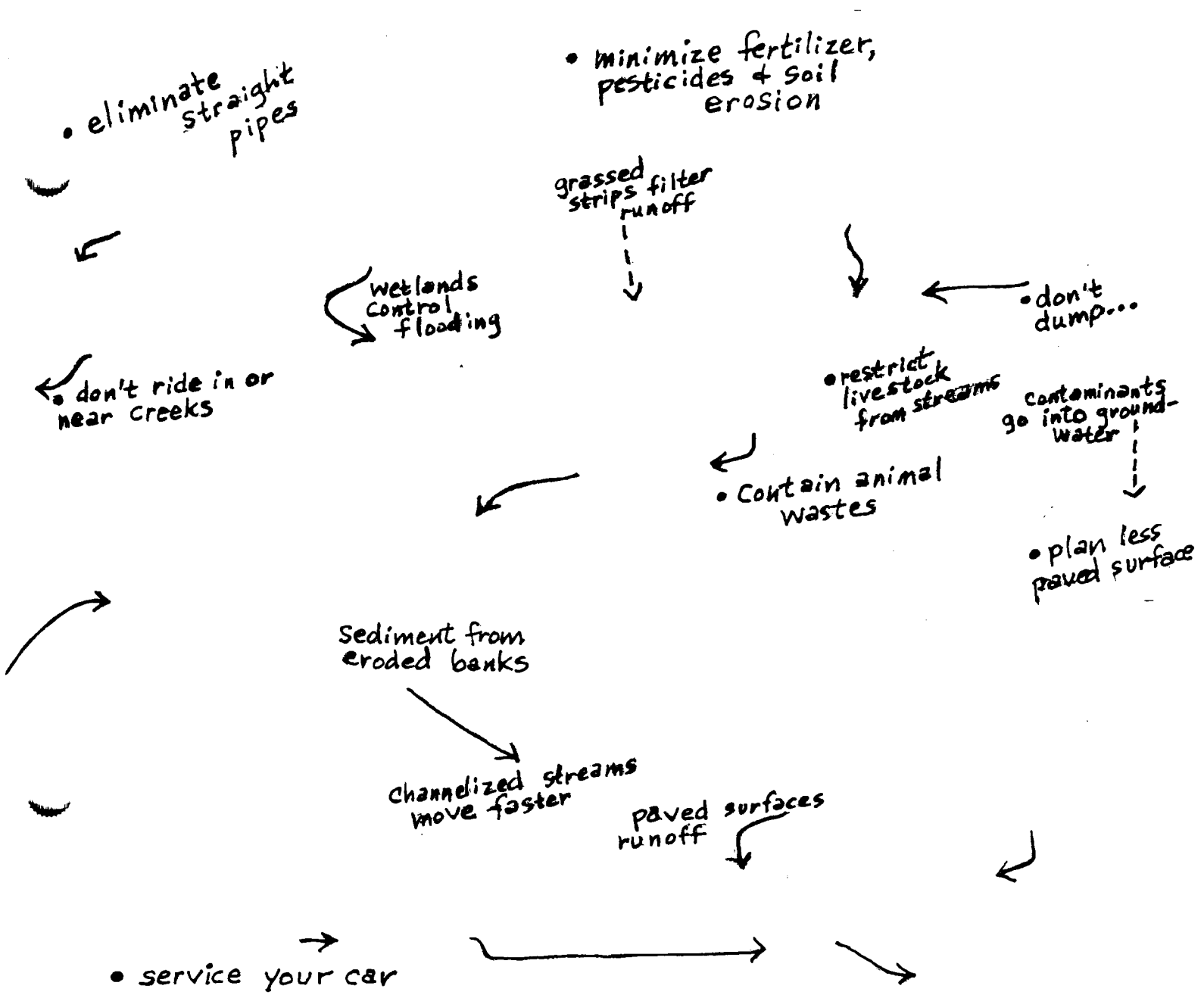
Find a sinkhole dump. Why is this a water quality problem? How do sinkholes form?

How can recreation—having fun in and around the water—impact water quality?

How much of the surface in this watershed is natural (soil, trees, water) and how much is manmade (buildings, roads, parking lots, etc.)? Is it like this in *your* watershed?

Why do we say, "every property is creekside property" in the watershed?

• reclaim old mine sites
• minimize soil erosion in logging
forests filter water
• minimize lawn chemicals
sediment fences reduce soil in runoff
• preserve wetlands
• support low-impact development
• dispose of household chemicals properly
• compost yard wastes & use a mulching mower
• clean-up pet wastes
storm drain leads to creek
wells tap groundwater
• maintain septic systems
Contaminants can enter groundwater through the soil, too
All activities in the watershed can impact water quality, even if the creek is far away.
A WATERSH



55% of Kentucky is karst - cracks and caves in these limestone rocks reduce the filtering of contaminants (sediment, pesticides, etc.)

--/HERE EVERY PROPERTY IS CREEKSIDE PROPERTY

KENTUCKY RIVER BASIN PROFILES

Brief descriptions of Kentucky's major watersheds.

Major watersheds or basins that drain into major rivers can be very large. Most of Kentucky is in the large Ohio River watershed that, in turn, is part of the larger Mississippi River watershed. However, these large watersheds may be subdivided into smaller and smaller watersheds, too--land that drains into smaller streams. Our map identifies 13 watersheds in the state: Kentucky, Salt, Licking, Upper Cumberland, Lower Cumberland, Lower Tennessee, Green, Tradewater, Big Sandy, Little Sandy, Tygarts, plus the Ohio Tributaries and Mississippi Tributaries. The seven watersheds described below represent the key basin management areas; all but one of these include more than one of the thirteen denoted on the map.

For more information, see the Web sites listed below or request a report from your Basin Coordinator.

KENTUCKY RIVER BASIN

http://www.nr.state.ky.us/nrepc/kra/status1.htm

Special Features:

- Cities: Lexington, Frankfort, Hazard, Richmond.
- Eastern Kentucky mountains, Bluegrass countryside, the Knobs, karst and cave geology.
- Daniel Boone National Forest, Red River Gorge, Kentucky River Palisades.
- Fishing lakes and streams.

Issues of Concern:

- Water supply and demand.
- Flooding from stormwater and contaminated city stormwater.
- Managing city and rural sewage and livestock manure.
- Lack of streamside trees and plants.
- Erosion from farming, logging, and construction.
- Effects of mining.

SALT RIVER BASIN and MINOR OHIO RIVER TRIBUTARIES

http://water.nr.state.ky.us/dow/salt.html

Special Features:

- Major population centers: Louisville, Jefferson County, Fort Knox.
- Karst geology and Ohio River alluvium floodplain.
- Taylorsville Lake, Otter Creek Park, Bernheim Forest, E. P. Tom Sawyer State Park.
- Tourism and recreation.

Issues of Concern:

- Population density and growth; urban sprawl and loss of agricultural farm land.
- Nonpoint source pollution from urban areas and agricultural activities.
- Sewage treatment-package plants, in-stream plants, and septic systems.
- Landfill areas (including Superfund Sites).
- Loss of wetlands and other protected lands.

LICKING RIVER BASIN and MINOR OHIO RIVER TRIBUTARIES

http://water.nr.state.ky.us/dow/salt.html

Special Features:

- Cities include Covington, Maysville, Morehead, Winchester.
- Forested hills in upper reaches, rolling farmland along middle regions, urban/industrial development near the confluence with the Ohio River.
- Big Bone Lick and Blue Licks State Parks as well as many nature preserves and wildlife management areas; Cave Run Lake.
- Diverse fish and mussel species, including some that are rare or endangered.

Issues of Concern:

- Flooding is common in some places.
- Straight pipes/treated sewage discharges.
- Sediment concerns due to logging, heavy use by animals, construction, and stream erosion.
- Littering and illegal dumping.
- Brine from extraction of oil and gas reserves.
- Loss of habitat because of human activity and animal agriculture.
- Increase in impermeable surfaces which increases flooding and streambank erosion.

CUMBERLAND RIVER BASIN

http://water.nr.state.ky.us/dow/c4.htm

In Kentucky, this basin includes the Upper Cumberland River Basin in Eastern Kentucky and the Lower Cumberland River Basin in Western Kentucky.

Special Features:

- Cities: Harlan, Hopkinsville, Somerset.
- Eastern Coal Field to Pennyrile Plateau; karst topography.
- Many of the state's largest forests and parks; Big South Fork National River and Recreation Area, Cumberland Falls, and the state's largest lake: Cumberland.
- Mostly rural with few industrial areas.
- Many Outstanding State Resource Waters designated to protect federally threatened and endangered aquatic species.

Issues of Concern:

- Open dumping.
- Nonpoint source pollution as a result of strip mining; improper logging practices; urban and agricultural runoff; runoff from oil and gas drilling roads; ATV use on steep terrain and riparian areas.
- Loss of riparian habitat.
- Straightening and dredging of stream channels.
- Straight pipes.

FOUR RIVERS REGION

http://water.nr.state.ky.us/dow/c4.htm

This region includes the Lower Tennessee River Basin and tributaries in the Jackson Purchase area of Kentucky that drain into the Ohio and Mississippi River Basins.

Special Features:

- City: Paducah.
- Gently rolling terrain underlain mainly by loose sediments such as sand and silt.

- Western waterlands that surround Land Between the Lakes.
- Extensive wetland areas.
- Outstanding resource waters: Bayou de Chien supports the endangered Darter fish, and the Lower Tennessee River supports the most diverse natural freshwater mussels in the U.S.

Issues of Concern:
- Open dumping.
- Loss of riparian habitat. Loss of river habitat due to dredging and stream channelization.
- Nonpoint source pollution from stormwater drainage of soil, fertilizer, livestock waste, and chemicals; urban runoff from roads, parking lots, and rooftops.
- Wetland function loss due to drainage, development, and farming.
- Failing septic systems.
- Recreational boat discharges from houseboats and other boats into recreational water.

GREEN and TRADEWATER RIVER BASINS

http://water.nr.state.ky.us/dow/green.htm

Special Features:
- Cities: Bowling Green, Henderson, Owensboro.
- Karst geology/caves (from small crevices to the largest cave system in the world), Western Kentucky Coal Field, oil and gas reserves.
- Pennyrile State Forest, seven state parks and one national park.
- Expansive wildlife management areas; extensive wetlands; numerous man-made reservoirs for public water supply, flooding mitigation, and recreation.
- Many unique species (mussels, cave shrimp, etc.).

Issues of Concern:
- Development in groundwater recharge areas.
- Straight pipes and poorly treated sewage discharges.
- Concentrated animal feeding operations (CAFOs) in karst terrain.
- Habitat changes within streams and invasive exotic species.
- Illegal open dumps and sinkhole dumps.
- Poor forest harvesting practices and mining reclamation.
- Urban/development runoff (pollutants, sediment, surging flow patterns).

BIG and LITTLE SANDY RIVER and TYGARTS CREEK BASINS

Special Features:
- Cities: Ashland, Prestonsburg.
- Part of the largest deciduous forest in the world.
- Mining is a major natural resource and part of the economy.
- Seven state parks.
- Rare cold water habitats: Caney and Laurel creeks. Bat Cave and Cascade Cave: Kentucky's largest wintering site for endangered Indiana bat.

Issues of Concern:
- Nonpoint source pollution primarily from acid mine drainage and failing septic systems.
- Habitat destruction resulting in four species listed as endangered or threatened.
- Resource extraction.
- 541 miles of streams not supporting uses.

WATERSHED DECISIONS: TAKING ACTION FOR BETTER WATER QUALITY

This section of text is drawn from a series of key exhibit panels on Nonpoint Source Pollution that will premiere at the 2001 Kentucky State Fair, then tour as a traveling exhibit thereafter.

non·point source pol·lu·tion -- Also called **runoff** pollution, nonpoint source pollution occurs when water flowing over the surface of the ground or under the ground picks up pollutants from diffuse (widely scattered) sources and carries them into surface waters and groundwater. This **pollution** is called "nonpoint" because it doesn't come from a single source or *point*.

Although you may not commonly hear the term, nonpoint source pollution is ***the nation's largest water quality problem***. In fact, three times as many miles of Kentucky streams and rivers are contaminated from nonpoint sources as from point sources.

When many people think of major causes of water pollution, they think of big industries and city sewage plants with polluted water coming out of pipes—identifiable *points*. Years ago we learned more about pollution from these *point sources* and, as a result, created better laws that improved many industrial and wastewater treatment pollution problems. Understanding nonpoint source (NPS) pollution will be another major step toward improving our water quality. We should be aware that many of our regular, daily activities can contribute to NPS pollution.

At least 50 percent of water quality problems in the United States are due to NPS pollution. NPS pollution is the main reason why about 40 percent of U. S. rivers and lakes are considered unsafe for basic uses such as fishing or swimming. Of the monitored rivers, lakes, and streams in Kentucky, ***88 percent*** are impacted by nonpoint source pollution.

When you look for possible sources of water pollution, you can't just look at activities that take place in or directly around a body of water. You must be concerned with the entire area that drains into it. Understanding your watershed is the key. A **watershed** is the land that water flows across or under on its way to a stream, river, or lake. More specifically, it is a given area of land that drains into one particular body of water. The land around us—our backyard, neighborhood, our town, our county—is made up of interconnecting watersheds, also called **basins**.

As water moves through the watershed, it picks up pollutants and carries them on, eventually depositing them into the oceans. The most common nonpoint source pollutants are sediment and nutrients.

Sediment is another word for soil particles. Wherever the soil is disturbed—when soil is dug up to build a house or plant a crop, for example—small particles of the soil are washed into the water. Too much sediment can reduce the sunlight that reaches aquatic plants by clouding the water. Sediment can even clog the gills of fish and suffocate other aquatic life. When **nutrients** (fertilizers, livestock and pet wastes) and other substances such as pesticides, pathogens, salts, oil, grease, toxic chemicals, and heavy metals enter the water they destroy habitats and kill fish and other creatures that live in and depend on water. Not only can excessive sediment and

nutrients be harmful to wildlife; they can make drinking water unsafe, and prevent us from fishing, swimming, and even wading in the lakes, rivers, and streams of our community.

Causes of NPS pollution may be found on the farm and in the city and suburbs. They may be found on lands harvested for timber and mined for coal and in lands devoted to our recreation and pleasure. And most certainly, NPS pollution may be found in our own backyards.

The Clean Water Act was enacted in 1972 with the goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters—making the nation's waters "fishable" and "swimmable." To reach that goal, streams, rivers and lakes are classified according to their uses: aquatic habitat ("fishable") or recreation ("swimmable"). There is also a classification for domestic (drinking) water supply. Each state must monitor and evaluate its rivers, streams, and lakes and send a report to Congress every two years. The Kentucky Report to Congress on Water Quality for 1998 shows that 67 percent of assessed waters fully supported their uses, 12 percent partially supported their uses, and 21 percent did not support their uses.

To address NPS pollution as the number one problem, the Nonpoint Source Management Program was established as an amendment to the Clean Water Act in 1987. Read on to learn more about the causes of NPS pollution and how *you* can have a true impact on Kentucky waters.

Growing Crops & Growing an Understanding of BMPs

The United States has over 330 million acres of agricultural land, and the crops and livestock raised on this land feed our nation and other parts of the world. Farmers are often called the original **stewards** or caretakers of the land, because they understand how important it is to have healthy land and water. But if a farm is not carefully managed, sediments, nutrients (from fertilizers and animal wastes), pathogens (bacteria and viruses), and pesticides from farming activities can affect both the surface and groundwater in the watershed. Methods to reduce the impact of NPS pollution are called **Best Management Practices** or **BMPs**.

One of the common causes of nonpoint source (NPS) pollution in surveyed groundwater, rivers, and lakes is agriculture. When farmers plow to loosen the soil for planting and apply fertilizers and pesticides, some of the soil particles (sediment) and chemicals can make their way into the water. **Sediment** from all sources is the largest single pollutant that affects water quality.

Fertilizers, animal wastes (manure), and crop residues can improve production, but they can add too many nutrients, such as phosphorus, nitrogen, and potassium, to the soil. The crops can't absorb the excess nutrients, and this excess can be carried into the water by storm runoff. Knowing the amount of nutrients already present in the soil and animal waste, along with the seasonal nutritional needs of the crops, can help determine when and how much fertilizer is "just enough."

When just the right amount of **insecticides**, herbicides, and fungicides are used—to kill pests and limit the growth of weeds and fungi—*and* when these chemicals are stored and spray equipment is filled properly, the water is not threatened. But applying chemicals only when they are needed

is not the only way that farmers can improve water quality. Planting techniques, such as **strip cropping, filter strips** and **grassed waterways**, slow down water runoff and direct it to areas where it can soak in and be naturally filtered. **Conservation tillage** methods disturb the soil less, thereby reducing erosion and sedimentation. The crop residue left behind helps the soil retain moisture, too.

Raising Livestock & Raising Water Quality

By October 2001, all Kentucky farms must implement an **Agriculture Water Quality Plan**—a written plan to use **Best Management Practices (BMPs)** to protect surface and groundwater. The Agriculture Water Quality Act legislation applies to any landowner who operates 10 or more acres for agriculture or silviculture (forestry) or who qualifies for payments from agricultural programs. Resources are available to help farmers design and pay for BMPs.

Kentucky has a wealth of pastureland excellent for raising livestock. Farmers need to properly maintain these pastures by preventing livestock from overgrazing. Important BMPs for livestock farmers include rotating grazing areas, supplying alternate sources of water and shade away from streams, providing stream crossings, and replanting grasses when the soil becomes exposed. Riparian zones (stream banks planted with trees, shrubs and grasses), wetlands, and buffer strips are all features that are important to agricultural land. These features can filter soil particles and animal wastes from the water as well as slow and collect runoff.

In confined animal facilities or feedlots, high concentrations of waste (manure) are produced in a small area. By properly managing wastewater and runoff in these areas, the nutrients and pathogens (bacteria and viruses) in the animal waste will not enter the water in harmful quantities.

If a Tree Falls in the Forest...Does It Disturb the Water?

Kentucky has 12.7 million acres of forestland, covering an estimated 48 percent of Kentucky's land base. About 93 percent of the state's forests are privately owned, and there are approximately 306,000 forest owners in Kentucky. The average woodland tract is small—only 30 acres, but these forested areas are important to maintaining water quality.

Harvesting trees and creating and using roads to transport timber can lead to increased sediment entering water. Removing trees near streams can destabilize stream banks and eliminate shade. Reduced shade causes warmer water temperatures that can kill fish and other aquatic life. Dragging logs along **skid trails** can cause erosion, compact the soil, and disturb the forest **litter**—the layer of decomposing leaves and other plant material on the forest floor. Forest litter is important to water quality, for it naturally filters the water that passes through it.

Best Management Practices (BMPs) for forestry include setting aside protected areas where trees will not be harvested, for example, on steep slopes where erosion is more likely to occur or alongside streams. **Streamside Management Zones** (SMZs) are protected areas where

vegetation grows along the stream. To eliminate excess erosion, logging roads should be built to follow the natural contours of the land and away from streams, whenever possible. Logging operators can schedule harvesting to avoid the rainy season and times when fish are migrating or spawning. Replanting new vegetation after the harvest is also an important BMP.

The Kentucky Forest Conservation Act (KFCA), enacted in July 1998, defines the minimum BMPs that are required by law, but landowners may choose from many approved practices to protect and restore our precious forestlands. Commercial loggers are required to have a **Master Logger** on site at all times. The Kentucky Division of Forestry has designated over 4,000 Master Loggers to date and conducts timber-harvesting inspections to ensure that timber harvesting operations are using the appropriate BMPs, as mandated by the KFCA.

It's My Watershed. What Do *I* Contribute?

NPS pollution is *everyone's* problem, and there are many ways you and your family can prevent nonpoint source pollution at home. Think of your yard as a mini watershed, remembering that anything that goes into the soil can eventually wind up in the water. When the rains come, whatever is on the ground may go to a **storm drain** that eventually goes to a river or stream, it may go directly to a stream or river, or it may soak into the ground and make its way into groundwater.

Some ways that you can prevent nonpoint source pollution at home may surprise you...

Top Ten Ways *You* Can Reduce or Prevent NPS Pollution at Home:

1) **Landscape with nature in mind.** Plant grasses, trees, and other plants, especially ones that will tolerate pests and drought such as native plants. Vegetation will slow and absorb runoff, keeping pollutants, especially sediment, from reaching streams. **Mulch** around your landscaping to keep the soil moist. When planning your landscaping, maintain the natural contours of the land; if necessary, terrace your garden to help water soak into ground.
2) **Use fertilizers and pesticides only when necessary**. On average, homeowners use 10 times more chemicals on their lawn per acre than the farmer uses to grow crops. Read product labels carefully to learn how to dispose of old or unused fertilizers and pesticides appropriately. Many can be taken to a drop off center in your county for disposal.
3) **Aerate your lawn** regularly and **use a mulching mower**, as clippings naturally fertilize the grass. Never blow grass clipping or leaves into the street—they'll enter a storm drain and decompose, polluting the water and depleting the oxygen needed for aquatic life to thrive. Capture extra leaf and grass clippings and other yard wastes and compost them. **Create a compost pile** or bin for your yard wastes and vegetable and fruit scraps from the kitchen. Locate the compost at least 50 feet from a well, lake, or stream and aerate it regularly. Finished compost is a great natural fertilizer for your lawn and garden!
4) Don't put pet wastes in the compost bin, though. Regularly **collect pet wastes** from the lawn and dispose of them in the trash can.
5) **Plan for less paved surfaces**. Think about pavers, crushed rock, mulch, wood decking, and grass as alternatives to concrete or asphalt driveways and patios and plan for proper drainage.

6) **Dispose of chemicals and motor oil at a recycling center**. Never, never dump these on the ground or into a storm sewer or at roadside dumps or in your garbage.
7) **Keep your car in tiptop shape**, so oil, brake fluid and antifreeze won't leak into the ground and extra exhaust won't pollute the air. When you wash your car or change the oil, don't allow soapy water or oil to wash into the storm drains. Water from storm drains is often emptied directly into rivers and streams without being treated. Wash the car when its parked in the grass, so the water can slowly be filtered and seep into the ground.
8) If you have a **septic system**, install the best type and maintain it properly.
9) **Watch what you flush**. Oil, grease, cleaners and other chemicals, feminine hygiene products, and certain foods should not go down drains or toilets. They can erode pipes, interfere with the breakdown of wastes in the septic tank, and linger even after the water has been filtered for reuse.
10) **Conserve water**. One simple way to conserve is to stop dripping faucets, as they can waste as much as 20 gallons of water a day. Another way of looking at it: If every house in America had a drippy faucet, we would waste 928 million gallons of water each day!

Urban Runoff: The Price of Progress

If you have ever noticed water rushing down the street toward the nearest storm drain or observed water puddling on your lawn after a hard rain, you have seen examples of what happens when water cannot find enough places to soak into the ground. Roads, parking lots, roofs, and compacted soil are **impervious** or non-porous surfaces. Because cities have large expanses of impervious surfaces, a typical city block generates nine to ten times more runoff than a woodland area of the same size, and that runoff moves ten times faster across paved surfaces into storm drains and then into streams.

Fast-moving runoff carries more debris and pollutants and causes erosion and streamside damage. It can also cause flooding. Water running over paved surfaces and buildings becomes warmer, too, since these surfaces radiate heat. When this warmer water enter streams, it can kill fish and other aquatic life.

If we think about how the water in our watershed eventually flows into larger watersheds and, ultimately, to the oceans, we can see how important it is to understand the big picture. Just as many of Kentucky's major cities were built along rivers, many of the nation's major cities were built along rivers and coastal areas. But urban areas are not the only danger zones; suburban development threatens water quality as well.

We cannot eliminate all of the impervious surfaces, but there are many things we can do to reduce nonpoint source pollution in developed areas. For example, builders can plant grass and set up barriers called **sediment fences** to reduce the soil that washes away from the building site. Sediment and solids from construction sites are the top pollutants in urban areas. Developers can protect sensitive natural areas near the development, minimize the land disturbance, and retain natural drainage and vegetation, preserving areas such as wetlands and riparian zones. Planned **greenspace** (using plants that require minimal chemicals and irrigation) can be effective, too.

In lands that have not been developed, land contours, native vegetation, and free-flowing streams demonstrate natural strategies for protecting water quality. When we change the land to meet our growing needs, we must follow nature's example.

Reclaiming Our Natural Landscapes

Mining companies in the coalfields of eastern and western Kentucky have a responsibility to help maintain clean water, too. Erosion is the biggest nonpoint source pollution concern in coal mining areas. Best Management Practices for coal mining operations include protecting exposed soil, controlling dust, maintaining coal waste impoundments, and restoring contours and vegetation at abandoned sites.

Abandoned mine lands are coal mining sites that were poorly or never reclaimed. The water at these sites is either acidic with high concentrations of metals or overloaded with sediment. **Acid mine drainage**, caused when iron pyrites in the ground are exposed during mining, contains harmful sulfuric acid which can kill living organisms and also pollute drinking water.

The Ketchup Lake reclamation project—dramatically illustrated below—is one example of the work managed by the Division of Abandoned Mines in the Kentucky Department for Surface Mining and Reclamation. Coal operators are assessed a fee on each ton of coal produced, and the Division of Abandoned Mines uses these funds to purchase and restore old mining sites closed prior to the enactment of the Surface Mine Reclamation Act in 1977.

Although You May Not Want to Think About It...

One of the most important ways individuals can reduce nonpoint source pollution is to install the proper type of **on-site wastewater treatment system (OWWTS)** and maintain it regularly. Septic systems or on-site wastewater treatment systems are installed to collect and process wastewater in homes that do not have access to city sewer systems. Approximately forty percent of all Kentucky homes utilize septic systems. Conventional septic systems are not adequate in many places, and advanced water treatment systems are needed. All new homes built in Kentucky since 1998 must have an approved sewage disposal system if they are not connected to a municipal sewer system; in fact, new homes must have an approved OWWTS in place before electricity can be hooked up.

Prior to the purchase of a home or property, homeowners should arrange an inspection of the land and seek expert advice regarding the best site for the system and the best type of OWWTS to install. Wastewater systems should be constructed away from wells, surface waters, wetlands, and floodplains. Locating cars and heavy equipment or construction projects above the proposed disposal area should be limited because these activities can cause irreversible damage to the soil, rendering it unable to support a wastewater treatment system.

Once your OWWTS is in place, here are some guidelines to follow to protect water quality around the site:

- Inspect your system annually and pump the tank out regularly—every three-to-five years.
- Keep the system in good repair and keep complete maintenance records.
- Follow guidelines inside the house to prevent excessive discharge. Take care not to flush oil, grease, cleaners, paint, feminine hygiene products, and food down drains or toilets; they can interfere with the breakdown of wastes in the tank.
- Avoid doing several full loads of laundry back to back—an OWWTS can only handle so much at a time!
- Do not use a garbage disposal.
- Select and maintain efficient water fixtures, fix all drips immediately, and conserve water to reduce the possibility of overflow.

Wastewater can contain: organisms such as bacteria and protozoa; pathogens such as parasites and viruses; organic matter including food, paper, detergents, oil, and grease; inorganics (metals, minerals, etc.); nutrients (nitrogen and phosphorus); and solids. A properly installed and maintained OWWTS is the solution for NPS pollution caused by wastewater.

Support Our Candidate: Mother Nature for Water Quality!

Contact with contaminated water can make us sick—really sick—from harmful bacteria, viruses, heavy metals, or chemicals. Our drinking water can make us ill, but so can plants grown in contaminated soil or fish living in unhealthy water. We can get sick from swimming in lakes or even wading in creeks. Contaminated water is harmful to humans, but it can be devastating—even deadly—to wildlife. More than half of Kentucky's threatened, endangered, or rapidly declining species depend on **aquatic ecosystems**. Certain species—many mussels and insect larvae such as caddisfly, stonefly, and mayfly—can only live in *clean* water. The steps we must take to clean polluted water are expensive, so *preventing* nonpoint source pollution is the best strategy for water quality.

Since it is not possible to completely eliminate all causes of NPS pollution, another strategy is important: protecting the natural features that promote water quality, such as forests, riparian zones, natural stream channels, and wetlands.

The tree canopy in **streamside forests** provides cover for fish, crayfish, and aquatic insects, and the extensive root system of the trees draws in and uses much of the nutrients from the water, so excess nutrients don't enter nearby surface and groundwater. Forested **riparian zones** or **buffer strips** along streams, rivers, and lakes actually contribute to cleaner water, as the trees and shrubs filter and trap sediments and absorb pollutants from runoff and shallow groundwater zones.

Physical changes to the natural stream channels—called **hydromodification**—also threaten water quality. Straightening streams and damming rivers may benefit some human activities, but it can increase NPS pollution and impact aquatic ecosystems.

Wetlands are the areas where the soil is inundated or saturated by surface or groundwater for periods long enough to support plants and animals that thrive in saturated soil conditions. They

are the link between land and water in the watershed. The next panel tells how these environments uniquely support water quality.

By preserving and restoring the natural features that promote water quality, you will make a major impact on the reduction of nonpoint source pollution.

Wetlands—There's More to the Marsh than Meets the Eye

More than half of all wetlands in the United States were lost between the late 1700s and mid-1980s. In Kentucky, wetlands have been even more endangered. As we have developed farmland and built cities over the last 200 years, we have destroyed more than ***80 percent*** of Kentucky's native wetlands. Only five other states surpass this unenviable record. Education is key to saving what remains of these precious natural habitats.

A **wetland** is an area where the level of water is at or near the soil surface. Wetlands are often a transitional zone located between a body of water and dry land or in low-lying areas of land. The term "wetland" refers to swamps, marshes, bogs, sloughs, and other environments characterized by a unique type of soil, called **hydric soil**, and a unique type of plant life, called **hydrophytes**. Hydrophytic plants, such as cattails, bulrushes, and cypress trees, are well adapted to wet conditions. Some wetlands are not covered with water 100 percent of the time; in fact, some wetlands—such as bottomland hardwood forests—are dry for periods of the year.

Because wetlands are often the lowest points on the landscape, runoff carries pollutants to these areas. This is important because wetlands are an incredibly efficient filtration system; they can greatly reduce the affects of nonpoint source pollution in the watershed. Wetlands serve as a **natural filter**, trapping and storing sediment, transforming nutrients and certain heavy metals, and even detoxifying chemicals found in runoff *without* being degraded.

Wetlands also act like a sponge, absorbing large amounts of water and thereby protecting communities from flooding. In fact, in watersheds with large wetland areas, flooding can be reduced as much as 95 percent during its peak. The wetlands hold the floodwaters temporarily, then slowly release them into the stream channel. This gradual and even distribution of runoff energy prevents the erosion of stream banks and channels.

The United States Army Corps of Engineers regulates land use in wetland areas threatened by agricultural and development activities. The Corps issues permits for land uses that may compromise or fill in wetlands and oversees wetlands **mitigation**—efforts to replace those wetlands functions lost through development. Although no manmade feature can fully duplicate the benefits of a native wetland area, constructed wetlands can greatly reduce nonpoint source pollution and provide habitat to numerous wildlife species.

Milestones in Kentucky Watershed History

An illustrated version of this timeline is a component of the exhibition, *2001: A Water Odyssey.*

400 Million Years Ago (MYA)
The area that would become Kentucky was part of an **ancient sea**, and the seas continued to rise and fall for 75 million years. Remains of marine life were deposited on the ocean floor and covered by sediment that would transform into **limestone** rock millions of years later. During the Pennsylvanian Period (330-290 MYA) various water features covered the area, from alluvial valleys to coastal plains to swamps. These water features deposited sand and rich sediment that in time would become Kentucky's **sandstone, coal, and shale**. Later erosion of the resistant Pennsylvanian sandstone created **natural arches** such as Natural Bridge in Powell County. Rain carrying carbon dioxide from the soil seeped into tiny cracks in the limestone over the ages and as more water drained through the limestone, **caves** began to form, including the longest cave in the world, Mammoth Cave.

1 Million-10,000 Years Ago
During the Pleistocene Epoch (also called the **Great Ice Age**) major advances and retreats of continental glaciers altered the land and affected the river courses. The Kentucky River was then a tributary of the ancient Teays River. At the end of this period, the last major glaciers dammed the Teays and when they melted, they created the **Ohio River Valley**, diverting waters toward the Mississippi River. Water eroded the layers of rock to expose limestone rich with **fossilized marine life** at the Falls of the Ohio. The deciduous forests we know today began to form as the climate warmed.

12,000 Years Ago
Native Americans began arriving in the Ohio Valley. Initially, these peoples were nomadic hunter-gatherers, but around 1,000 years ago, they began to establish permanent farming villages here. The rivers influenced their settlement, transportation, and trade. **Salt springs** in the area attracted animals, and therefore, hunters; these same salt licks drew early Euro-American settlers, who extracted the mineral for food seasoning and preservation.

1750s
Some evidence indicates that a Shawnee settlement called Eskippakithiki may have existed on Upper Howard Creek (Clark County). What is likely Kentucky's last permanent Native American settlement, the trade village called **Lower Shawneetown**, moved from the banks of the Ohio River opposite the confluence of the Scioto River in 1758.

1774
The first permanent Euro-American settlement was established in the area that would become Kentucky: **Fort Harrod**. The site was selected due to the presence of a large natural spring and the proximity to the Salt River. The following year, **Boonesborough** was settled on the Kentucky River. Accessibility to water resources was a major factor in community development throughout the state's history. Fifty-one of the state's 120 county seats are situated on rivers, and eight of the state's ten largest cities are located on major rivers. Countless smaller communities,

farms, and businesses have been built near creeks and springs throughout the commonwealth. The first licensed **ferryboat**—one of nine authorized when the area was still a part of Virginia--began operation at Boonesborough in 1779.

1778
Because the rapids stopped river traffic at the **Falls of the Ohio**, two early settlements were established there—Corn Island and Louisville—both founded by General George Rogers Clark.

In its natural, unimproved state, the Ohio River was littered with fallen trees, gravel bars, and rocks. The river ranged from shallow, stagnant pools that could be crossed by foot in times of drought to raging torrents rising 100 feet in times of flood.

1788
Regular passenger and freight service was initiated on the Ohio River between Pittsburgh, Cincinnati, and Louisville, using the new mode of transportation: **keelboats**. An improvement over the flatboat, keelboats made it possible to travel *upstream* for the first time.

Around this time, communities such as Lexington and Frankfort began establishing some of the first public **waterworks** in Kentucky, digging area springs and sometimes damming up the water, then delivering it to town through hollowed-out cedar log pipes.

1803
Meriwether Lewis and William Clark met at the Falls of the Ohio in October and assembled recruits for the **Corps of Discovery** from applicants in the Louisville area, including Clark's slave York. More men (and one woman, Sacagawea, who served as translator and symbol of a peaceful mission) were recruited further west, and the team set out on the greatest exploring venture in American history.

1811
The first **steamboat** on western waters, the *New Orleans*, arrived in Louisville on its way from Pittsburgh to New Orleans. Throughout the first half of the century, this new method of transportation would expand commerce, speed travel, and develop river towns.

1811-12
The New Madrid earthquakes created **Reelfoot Lake** in the Jackson Purchase. It is one of three large natural lakes in the state. About 2,500 acres of the 27,000-acre lake, which serves as a vital habitat for migratory birds, are in Fulton County, Kentucky.

1818
Martin Beatty contracted for the drilling of a well on his property along the South Fork in what is now McCreary County. The original purpose of the well was to locate a new source for salt water, but oil was struck at a depth of 200 feet and Beatty No. 1 became the first commercial **oil well** in Kentucky.

1824
President James Monroe enacted the Inland Waterways Improvement Act, placing the **U. S. Army Corps of Engineers** in charge of managing and maintaining inland waters. The Corps'

early efforts in Kentucky included building the first wing dam to improve navigation near Henderson and implementing snagboats and dredges to remove fallen trees, sandbars, and other obstructions.

1830
The **Louisville & Portland Canal,** under construction since 1825, opened to bypass the Falls of the Ohio. The "Falls" are actually rapids that stretch over a two mile section of river, causing a drop of as much as 26-feet in low water and limiting navigation over them to periods of high water (usually late October or November and February-April only). Prior to the completion of the canal, a drayage industry flourished between Louisville and Shippingport, transporting goods around the Falls by land.

1833
Kentucky's first **lock and dam** project was begun along the Green River. The project was completed to Bowling Green in 1842, contributing to the growth of this interior city.

In the first of four major **cholera epidemics** in Kentucky, residents of Lexington and Russellville suffered the greatest losses of life. Steamboat crews and passengers carried the disease into and through the state. After the final epidemic in 1872, people began to understand that the disease was caused and spread by drinking water contaminated by sewage disposal.

1836
The Corps of Engineers began a dam project for slackwater navigation on the **Kentucky River,** completing the first five dams by 1842. Without the improvements, commercial navigation was usually not possible during the low water season of July-October.

1841
Canalization of the **Green and Barren Rivers** was completed, making this major western and central Kentucky waterway navigable.

1857
L&N Railroad engineer Albert Fink designed the second largest **iron bridge** in the nation, to span the Green River near Munfordville.

1860
Kentucky's first **potable (drinkable) water service** began serving 512 subscribers (mostly businesses), in Louisville. The idea was slow to catch on in much of the state, as citizens continued to haul water indoors from wells, springs, and rainwater collectors such as rain barrels and cisterns.

1861-65
Rivers played an important role during the **Civil War,** transporting goods and soldiers. War strategies on both sides of the conflict included sabotaging bridges and dams and stretching a giant chain across the Mississippi River at Columbus, Kentucky, to control river traffic.

1867
The Covington and Cincinnati **suspension bridge**, designed by John August Roebling (who later engineered the Brooklyn Bridge), opened as the longest suspension bridge in the world.

1870
Albert Fink designed the one-mile-long railroad bridge at Louisville, at the time the longest **iron bridge** in the U. S.

1876
A Kentucky **fish commission** was created in response to stream depletion. The following year, the commission began stocking the Kentucky River with fish, including non-native species. In 1912, the state became one of the first to establish a resident hunting and fishing license.

1877
High Bridge opened as the **tallest bridge** in North America and was dedicated by President Rutherford B. Hayes in 1879. The 275-foot-tall railroad bridge was constructed on the Kentucky River in Jessamine County.

1884
Louisville's **Mary Miller** became the first American woman to receive a steamboat master's license.

1895
Using a technology recently introduced from England—structural concrete—the first **concrete river navigation lock** in the U. S. was built on western Kentucky's Rough River. Prior to this new technology, locks had been built of stone masonry and dams of timbercrib framing filled in with loose rock.

1896
The Louisville Water Company became the first water utility to use disinfectant to clean the water when it began adding **chlorine** to combat diseases such as typhoid and cholera.

1909
Following a 1905 **logging** disaster, floating loose logs down river was prohibited on the Kentucky River where it had thrived at timber centers such as Ford, Kentucky. Still a major commercial enterprise, logs were thereafter transported down river on rafts.

1917
The **final dam on the Kentucky River** (No. 14) was completed. Unfortunately, by this time the lock and dam system was virtually obsolete. Only two steamboat packets and two towboats were still in operation on the river, as most cargo had been shifted to rail transportation. Coal, crude oil, fluorspar, and calcite continued to be river cargo, and by the 1920s **showboats** began to travel the rivers to entertain.

1920

The **Water Power Act** was established to regulate the generation of electricity from waterways on public land and from navigable streams. Dix River Dam on the Kentucky River was one of the state's earliest hydroelectric power plants.

The first **diesel towboats** appeared, introducing the technology that fuels most river traffic today.

1929

President Herbert Hoover attended a reception on Louisville's riverfront to celebrate the completion of the **Ohio River canalization**. All 981 miles had been made navigable to a depth of nine feet by 51 movable dams (25 along Kentucky's borders) that created slack-water pools.

This same year, the Municipal Bridge (later the Clark Memorial Bridge) was completed as the **first bridge designed for automobiles** over the Ohio River at Louisville.

1930

Kentuckians experienced the worst **drought** in the state's history. Extreme drought throughout the U. S. caused the Dust Bowl in the Great Plains during the early 1930s, and the federal **Soil Erosion Service**, predecessor to the Soil Conservation Service and Natural Resources Conservation Service, was established in 1933 to address these erosion problems. Kentucky began to establish county conservation districts in 1940.

1937

Heavy rains caused the worst **flood** in Kentucky history. River towns, such as Ashland, Louisville, and Paducah were particularly hard-hit by record-high waters. This devastating event led to the construction of levees and floodwalls in Frankfort and, eventually, a series of 17 major impoundments (manmade lakes) throughout the state for flood control.

Also this year, the first **federal studies of water quality** were conducted and as a result, the U. S. Public Health Service began to recognize problems such as industrial contamination from whiskey distillery discharge and acid mine drainage as well as urban contamination from sanitary sewers.

1942

Losses of aquatic habitats and water quality problems have affected some of Kentucky's native species. Efforts to restore populations of one such species began this year, when Fish and Wildlife officials began providing nesting boxes for **wood ducks** to meet a need caused by the loss of tree cavity nesting sites in wooded wetlands. A more recent species restoration project began at 14 sites in 1991, for the **river otter**.

1943

The first **manmade lake** to address flood problems, Dale Hollow Lake, was completed on the Tennessee border. The following year, the Kentucky Dam was completed on the Tennessee River creating Kentucky Lake, at that time the largest manmade lake in the world with over 160,000 acres (almost 50,000 in Kentucky). The last flood control lakes opened in the early 1980s at Paintsville and Taylorsville.

1948
The Ohio River Valley Water Sanitation Commission (ORSANCO) was established to control and abate pollution in the Ohio River Basin. It is an interstate commission representing eight states, including Kentucky, and the federal government.

1950
The **Ohio River Navigation Modernization Program** was initiated to replace old wooden wicket dams and small locks with concrete and steel structures and 1,200-foot-long chambers, allowing towboats with 15 barges to pass at one time. This modernization program continues today, and replacement of the last old wicket dam (the Olmsted Locks and Dam at Ballard County) began in 1993.

1952
Lake Cumberland was formed by an impoundment of the river of that name, creating the largest lake in Kentucky at 50,250 acres.

1958
Louisville began treating its wastewater. Prior to this time, the city disposed of its wastewater directly into the Ohio River, without treatment.

1968
The **Wild & Scenic Rivers Act** was established to select certain rivers of the nation that possess remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values and preserve them in a free-flowing condition, while protecting their local environments. The Red River is Kentucky's only National Wild and Scenic River.

1970
The **Environmental Protection Agency** (EPA) was created and charged with the establishment and enforcement of environmental protection standards consistent with national environmental goals, such as the **Clean Air Act**.

1972
The national goals of the 1948 Federal Water Pollution Control Act were expanded by the **Clean Water Act** to restore and maintain the chemical, physical, and biological integrity of the nation's waters—to make the nation's waters "fishable" and "swimmable." Under the Act, each state must monitor and evaluate its rivers, streams, and lakes and send a report to Congress every two years. The laws were focused on effluent pollution from point sources, that is, pollution emptied directly into waterways, particularly from industrial pipes.

1973
The **Endangered Species Act** was enacted to conserve and restore endangered and threatened species and the ecosystems upon which they depend. In 2001, 1,244 U. S. species were named to this list, and 38 of those were Kentucky species, including 14 species of mussels, 5 species of fish, the copperbelly water snake, and the Mammoth Cave shrimp.

1974
The **Safe Drinking Water Act** was enacted to minimize contaminants in drinking water, investigate the health effects of chemicals in the water, monitor public water supply systems, and protect groundwater sources. After studying the nation's water supplies, national safe drinking water standards were announced in 1977.

1976
The Kentucky State **Nature Preserves** Commission was created to legally designate naturally significant areas as protected by law for scientific and educational purposes. By 2001, the Commission managed forty state nature preserves to protect and preserve rare species and the natural environment.

1977
The Federal **Surface Mining Control and Reclamation Act** was passed. The act established national laws and standards intended to minimize and eliminate the negative impacts of mining on the environment and the public. Under one section, coal operators are assessed a fee on each ton of coal produced, and the Division of Abandoned Mine Lands uses these funds to purchase and restore old mining sites closed prior to the enactment of the law.

1981
Federal legislation was passed to locate, investigate, and clean up emergency hazardous waste sites, and Valley of the Drums in Bullitt County, Kentucky, was named one of 114 priority **Superfund** sites in the country. It took ten years to clean up this site where more than 4,000 drums of hazardous waste were found to be polluting the soil, groundwater, and creeks.

1986
The EPA established the Office of **Wetlands Protection**, recognizing that all but 95 million acres of the 215 million acres that were once wetlands in the continental U. S. had been destroyed.

1988
The worst **drought** in 50 years affected at least 35 states, including Kentucky. Soon thereafter, legislation was passed to require all counties to have water supply plans.

Zebra mussels introduced by a European ship into the Great Lakes began to invade inland North American waters where they have multiplied and spread quickly. The alien bivalves pose a growing threat to the Ohio, Kentucky, Tennessee, and Cumberland Rivers in the commonwealth impacting native freshwater mussels, public water supplies, and attaching to virtually all underwater surfaces as well as destroying microscopic life.

1990
The Kentucky legislature passed a **source water assessment and protection program** to evaluate each county's ability to provide an adequate supply of clean water.

1994

The Kentucky legislature passed the **Agriculture Water Quality Act**, whereby farmers must develop and implement a written plan to use **Best Management Practices (BMPs)** to protect surface and groundwater by October 2001.

Beginning this year, anyone in Kentucky who engages in activity with the potential to impact groundwater, including owners of domestic wells and onsite wastewater treatment systems, was required to have a **groundwater protection plan.**

1997

After assessing U. S. **watersheds**, the EPA published its finding on the Internet, allowing citizens to view data on local water quality. Nonpoint source pollution—runoff from urban and rural sources—was identified as the main source of water pollution.

1998

The **Kentucky Forest Conservation Act** was enacted to implement methods for preventing and reducing soil erosion and water contamination for all commercial timber harvesting operations.

The **Kentucky Aquaculture Plan** was developed to encourage statewide participation in one of the world's fastest growing food production industries. Freshwater shrimp, trout, catfish, and paddlefish were key species in the state's aquaculture plan.

The Louisville Water Company became the first drinking water utility in the nation to employ a **riverbank infiltration (RBI) well** to filter water from the Ohio River through the natural sand and gravel in the riverbank. The well produces water that is almost as clear as water leaving the treatment plant, so fewer chemicals are needed. RBI technology eliminates the need for water intake pipes along the river that are often clogged by populations of invading zebra mussels.

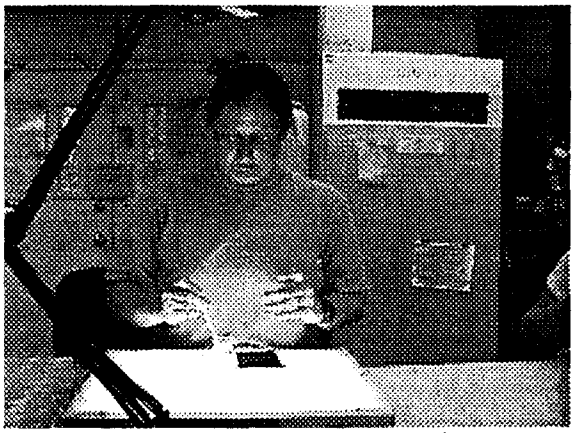
2000

Work was begun on a nine-year project to add a second 1,200-foot lock chamber at **McAlpine Locks and Dam** on the Ohio River at Louisville. Over 240 million tons of cargo (70% of which was coal, oil, gas, and other energy products) were shipped on the Ohio River system in 1999—more than on the Panama Canal.

A fire and whiskey spill at the Wild Turkey Distillery warehouse in Lawrenceburg resulted in the killing of over 227,000 fish in the Kentucky River near Frankfort.

A coal waste containment pond failed in Martin County, sending 250 million gallons of **coal slurry** into the Tug Fork of the Big Sandy River and killing most of the aquatic life in 75 miles of surrounding streams. The EPA recognized the accident as one of the worst environmental disasters in the history of the southeastern United States.

Water Related Careers:
Interviews with Kentuckians Who Make a Difference for Water Quality



Susan is in the lab performing a toxicity test on water samples from a wastewater treatment plant. The test will determine if this treated wastewater will be safe for fish when returned to the stream.

Susan Cohn, Environmental Biologist III
Kentucky Division of Water, Frankfort, KY

Exactly what is your job? The Bioassay Section. I raise fish (fathead minnows) and daphnids (an invertebrate water organism) for testing sewage treatment plant effluent. We collect samples that are returning to the streams of Kentucky and put baby fish and daphnids into the water and see if they can live and grow. The Water Quality Branch collects fish, macroinvertebrates (bugs, crayfish, mussels, etc.) and algae to determine aquatic community health. I often help them, too.

How did you get into this field? Sort of fell into the job that was available. I had an interest in community ecology and liked the idea of protecting the entire aquatic system by testing token organisms to see if we humans were cleaning up our mess before sending it back to the creeks.

What training did you have/need to prepare for this career? I have a Masters of Science in biology. You don't specifically need the MS but is helpful. You can train specifically in aquatic toxicology, but my background is more general than that...Lots of on-the-job training.

Where do you work? I work in Frankfort, in an office and in a culture room. Our room/lab is where we raise fish and daphnids and other organisms to test stream sediments. The room is kept at 25 degrees Celsius. We also have a mobile laboratory that we take to state parks to run tests at facilities in the surrounding areas. I also help other people in our Water Quality Branch collect bugs, fish and algae in streams all over the state

With whom do you work? I work with a variety of people: other biologists, biologists from other states, interim biologists, secretaries, engineers, technologists, management. Sometimes, I meet with elected officials, sewage treatment plant operators and superintendents.

What do you like best about your job? I like seeing different parts of the state. I like to be able to tell people that most of the sewage treatment plants in our state are doing a pretty good job. I like getting out in the streams and picking up rocks and seeing what is there.

How does your work impact water quality/make a difference? Our work very directly makes a difference. We can tell if the effluent (water going back to the creek) is clean enough for the plants and animals that live there. We can show, by looking at the aquatic community, if the test is correctly predicting stream quality. We can tell a facility they need to upgrade treatment to meet requirements for these organisms.

To learn more...http://water.nr.state.ky.us/wq/bioassay/index.html. It may be too technical for some, but I may be contacted directly as well. I'm the web developer, so my info is in there. We can show our lab, or do a few school visits with our test organisms to do a talk each year. (There are not very many of us in the section, so we are kind of limited on this kind of thing).

Susan is holding a bug seine, or screen, to catch all the bugs that wash downstream while Skip kicks the rocks and sediment in a creek riffle. The bugs, or macroinvertebrates, are brought back to the lab and identified. Based on the species present, they can determine the biological health of the creek. They collect fish and algae too.

Dave Wilson, Registered Geologist
KY Dept. for Surface Mining Reclamation and Enforcement (DSMRE), Frankfort, KY

Exactly what is your job? I conduct investigations regarding coal mine water problems.

How did you get into this field? I had an early interest in earth and water science (hydrology and geology).

What training did you have/need to prepare for this career? BS/MS college degree in Geology.

Where and with whom do you work? I work at coal mines gathering information or data, and in an office compiling the data for reports. I work with coal mine operators and other geologist and engineers.

What do you like best about your job? I like solving scientific and engineering problems.

Describe a fun or major project you have worked on. Due to a groundwater complaint alleging damage from a coalmine, I was tasked with scientifically determining whom the mine affected.

How does your work impact water quality/make a difference? My work is based on enforcing Federal and State mining law to protect the public and environment.

To learn more, visit...www.nr.state.ky.us/nrepc/dsmre

Michael Unthank, Hydrologist
U. S. Geological Survey, Water Resources Division, Louisville, KY

USGS hydrologist Mike Unthank and technician Doug Zettwoch prepare to install an observation well beneath the Ohio River to measure groundwater levels in the riverbed.

Exactly what is your job? I am a groundwater hydrologist. I investigate the quantity and quality of groundwater resources in Kentucky. My job can involve everything from drilling wells to water quality sampling to mapping to identifying contaminant sources.

How did you become interested in this subject? I have always wanted to work outside in an environmental profession. Civil engineering gave me the basics to consider a couple of different opportunities.

What training did you have/need for this career? I have a Bachelors of Science degree in Civil Engineering from the Speed Scientific School, University of Louisville. I am provided with additional training opportunities through the USGS.

Where do you work? Our area of responsibility is the state of Kentucky; I generally focus on groundwater systems adjacent to the Ohio River.

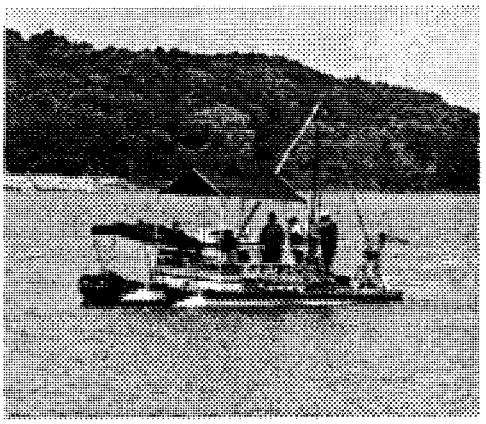
With whom do you work? I work with a varied group of cooperators (or clients) that have particular concerns or issues related to groundwater in their area.

What do you like best about your job? What I like best is being able to help people solve their problems as they relate to water resources or provide them with information or data that they would not be able to get themselves so they can make better-informed decisions about water pollution, drinking water supplies, etc.

Describe a fun or major project you have worked on. I have recently been working with the Louisville Water Company as they explore ways to serve better drinking water. This works covers all of the bases from quantity to quality and best management practices. Plus, I get to work outside during quite a bit of the project.

How does your work make a difference? I believe the information and services we provide allow water resource managers to make more informed and technically sound decisions that, in turn, help protect and preserve our natural water resources.

For more information, visit...http://water.usgs.gov



The USGS crew uses a 75-lb. drop-weight hammer to 'drive' an observation well into the bed of the Ohio River to measure drawdowns in the groundwater table due to nearby pumping.

Lonnie Nelson, Aquatic Education Administrator
Kentucky Department of Fish and Wildlife Resources, Frankfort, KY

Exactly what is your job? I work to establish educational programs concerning the aquatic environment. The primary focus is helping the students understand the importance of clean water and the health of aquatic organisms for all aspects of human actions including recreation.

How did you get into this field? I have always been interested in working in the fish and wildlife field. When I received my masters degree in Fish and Wildlife Biology, I concentrated on educational programs that could be adapted into schools. I applied for my current job in Kentucky and was fortunate to be selected.

What training did you have/need to prepare for this career? I have a bachelor's degree in education and a masters degree in Fish and Wildlife biology.

With whom do you work? I work with schools, youth groups such as 4H, scouts, church groups, parks and recreation, police departments, civic groups, professional educators and biologists all over the state.

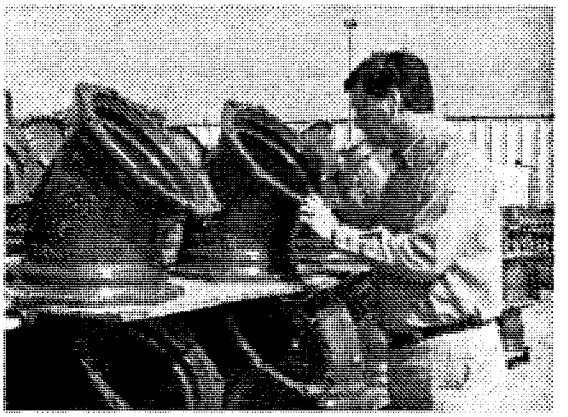
What is most satisfying about your job? The most satisfying aspect of my job is working with young people in hands-on investigation of streams. When they see the organisms and realize the importance of each toward the biodiversity of the ecosystem, it provides a great deal of personal reward for me.

Describe a fun or major project you have worked on. In 1995, we produced the Stream Ecosystem poster for Kentucky. That poster was so well received that we decided to produce a complete set of posters. Five other states now participate in this endeavor. At this writing, three posters are available and a fourth is at the printer. When the most recent poster has been distributed to all states, there will be approximately 450,000 posters printed.

How does your work impact water quality/make a difference? When students see the diversity of life in stream studies or in the posters, they take the message home to their parents. They also receive information that will be valuable for them when they are adult voters. When we provide fishing opportunities, we stress to participants that fishing, boating, swimming, etc., are not available unless a healthy environment supports those activities.

To learn more... Teachers should call (800) 858-1549 to receive personal attention to their needs. Also, visit the department Web site at **www.kdfwr.state.ky.us.**

Keith Coombs, Project Manager—Main Replacement Program
Louisville Water Company



Exactly what is your job? I design water main replacement projects for the Louisville Water Company. The design effort includes gathering data about existing water mains, other utilities, customers, and existing conditions at the project site. The information is then compiled into a set of project drawings. Specifications are then written to explain the procedures and outcomes desired on the project. During construction, I also monitor the progress of the project.

How did you become interested in this field? I have always enjoyed problem solving and technical challenges. I became interested in the Civil Engineering field while in college. Civil engineering is a "people" serving profession.

What training did you have/need to prepare for this career? Math and science classes, leading to a degree in Engineering.

Where do you work? I work primarily in an office and do much of my work on a computer. I also spend much of my time in meetings with engineers and other professional people to discuss projects, policies, and procedures. I also try to get out into the field as much as possible to see the work. It is important to maintain a link with the physical side of the business.

With whom do you work? I work with many types of people—professional, union labor, contractors, and government representatives, to name a few. Within the Water Company I work with my Team that is comprised of two project managers, a drafter, four inspectors, and a clerk.

What do you like best about your job? The thing I like most about my job is taking ideas, turning them into plans and specifications, and then watching them grow into something concrete. The most satisfying part of my job is helping customers with either problems or concerns.

Describe a fun or major project you have worked on. A group of employees from the Water Company worked at the Louisville Science Center to construct a water exhibit for the new KidZone area that opened in October 1999. Although the work was difficult and time-

consuming, it was very rewarding when the exhibit opened and children of all ages began to enjoy the exhibit.

How does your work make a difference? My primary function is to replace old water lines that have exhibited maintenance problems (breaks or leaks) or water quality problems (discolored water). Replacement of these old mains with new mains provides a more consistent supply of better quality water.

For more information, check out...www.louisvillewater.com

Darren Garrison, Plant Manager
Maysville Water Plant

Exactly what do you do? I oversee daily operations of the water treatment plant and lab and order parts for the plant as well as the distribution department.

How did you get into this field? While in college studying business management, I learned that Maysville Community College was going to be getting an Environmental Science Program. After two years of business management, I dropped it and pursued the Environmental Science degree. I wasn't disappointed.

What training did you have/need to prepare for this career? The college program actually prepared me more than I realized. I already knew how to run most of the tests associated with the lab and also knew a lot about the process of a water treatment plant.

Where do you work? At first—five years ago—I was mainly operating the plant, but now I'm more on the management end of things.

With whom do you work? I work with two other operators on days and have two more operators on the night shift. Occasionally, I work with the distribution crew (I also have a Distribution License).

What do you like best about your job? The thing I like most is having a sense of pride, because we are providing a service that impacts the welfare of the whole population of Maysville.

Describe a fun project you have worked on. I went to an elementary school one time to run jar tests for students and show them exactly how a water treatment plant works.

How does your work make a difference? Our work impacts water quality, because if you don't do your job correctly, the public's health is at risk.

Jennifer Lynn, Project WET State Coordinator
University of Kentucky Cooperative Extension Service, Carlisle, KY

Exactly what is your job? I am the state coordinator for an internationally known water education program for teachers, called Project WET (Water Education for Teachers). I am also the director of a residential Environmental Education 4-H Camping Program.

How did you become interested in this subject? Nature was always an interest to me, and I went to college to become a teacher.

What training did you have/need for this career? B. S. in Education, plus study in the field of environmental education.

Where and with whom do you work? I work statewide and at N.C. 4-H Camp in Nicholas County. I work with teachers, kids, cooperative extension agents and specialists, college students, state agency personnel, and others.

Describe a fun project you have worked on. I enjoyed working with a teen group on planting a Native American garden one weekend.

How does your work make a difference? It makes a difference by providing educators with the best water education materials to teach about all aspects of water, including water quality and watersheds.

Billy Fudge, District Forester
Kentucky Division of Forestry, Campbellsville, KY

Exactly what is your job? I manage the fire suppression activities and the timber harvest inspections. I also assist private woodland owners with managing their timber resources in six counties of south central Kentucky.

How did you get into this field? I started as a County Ranger and worked my way into this job.

What training did you have/need to prepare for this career? I have an associate degree, but a B. S. in Forestry would be preferable.

Where and with whom do you work? I've fought fires in California, Montana, Wyoming, and Kentucky. My normal activities are in south central Kentucky. I work with many facets of government, environmental groups, and the general public.

What do you like best about your job? It has been an adventure. We do something different almost on a daily basis. Being able to work outdoors and travel the backcountry is a plus.

Describe a fun or major project you have worked on. Fighting fires among jagged Rocky Mountain peaks...Working on changing the way the U. S. government uses incentives to help woodland owners manage their woodlands.

How does your work impact water quality? There are about 13,000,000 acres of forest in Kentucky. The health of that ecosystem is directly related to the quality of Kentucky's springs, wells, streams, and rivers.

For more information, check out the University of Kentucky School of Forestry, the Kentucky Division of Forestry, and the U. S. Forest Service.

George Antonious, Water Quality Researcher
Kentucky State University

Exactly what is your job? I determine the movement of pesticides in soil, water, and air. The goal of my research is to reduce the impact of pesticides and nutrients on the quality of runoff water.

How did you get into this field? Studying, searching, and taking environmental science classes.

What training did you have to prepare for this career? I studied soil chemistry, physics, and biology.

Where and with whom do you work? I work generally in the lab and sometimes in agricultural fields. I work with the United States Department of Agriculture.

Describe a major project you have worked on. The use of plant extracts prepared from wild tomato species to kill insects on other vegetable crops.

How does your work make a difference? It determines ways to reduce pesticide residues in soil and water.

Pam Snyder, Stewardship Program Specialist
Kentucky Division of Forestry, Frankfort, KY

Pam in her fire fighting gear.

Exactly what is your job? I coordinate the forest stewardship program and forest management programs at the state level and review the implementation of these programs at our district field offices. Other duties are Kentucky Tree Farm Administrator, federal cost share programs, and Situational Unit Leader for wildland fire fighting.

How did you become interested in this subject? I completed a forestry internship program at Land Between the Lakes National Recreation Area while in college. That led me to completing a graduate degree in forest ecology at Southern Illinois University at Carbondale.

What training did you have/need to prepare for this career? I have a B.S. in ecology and environmental biology and a master's degree in forestry. I also have completed numerous KDF trainings in the following areas: Best Management Practices, water quality, silviculture, forest products utilization, and wildland fire training.

Where and with whom do you work? I work out of the KDF Central Office in Frankfort. I work with private landowners, KDF service forester, Tree Farm Committee, Ky. Forest Stewardship Committee, and U. S. Forest Service.

How does your work make a difference? Using Best Management Practices (BMPs) during tree harvesting can prevent pollution to our rivers, lakes, and streams. The Division of Forestry provides landowners with technical assistance in using appropriate BMPs. The Agriculture Water Quality Act encourages the use of BMPs for silviculture activities.

For more information, visit...www.nr.state.ky.us/nrepc/dnr/forestry/dnrdof.html

Judith Petersen, Executive Director
Kentucky Waterways Alliance, Munfordville, KY

Exactly what is your job? I direct a statewide non-profit organization that works to protect and restore Kentucky's waterways and their watersheds. In doing so, I help direct our group's policy on issues and regulations that affect Kentucky's waters.

How did you get into this field? I have always been interested in protecting the environment.

What training did you have/need to prepare for this career? I had a strong science and engineering background and a number of years of experience in environmental fields prior to becoming the Executive Director for Kentucky Waterways Alliance. Other useful training for this career would be biology, geology, hydrology or environmental sciences.

With whom do you work? I work with local groups all across Kentucky who want to protect their watershed. I also work with the state Department for Environmental Protection and the U. S. Environmental Protection Agency on water quality issues and public policy and regulations. Finally, I work with other national, regional and state groups who are also working on water related issues.

What do you like best about your job? The people I work with are great. They care about the environment. However, the most satisfying part of my work is knowing that through my work for Kentucky Waterways Alliance, we helped to protect or restore the water quality in an area.

Describe a fun or major project you have worked on. Sometimes I get to go canoeing to help people better appreciate and understand why it's so important to clean up or protect the water in their community. That's always fun. I also helped to plan and organize a project in Cherokee Park in Louisville where we taught volunteers how to restore and stabilize the streambank along Beargrass Creek. I get to meet and work with the best people, and I am so lucky to get paid for a job that I love—doing work that I believe in.

How does your work impact water quality/make a difference? I help empower other groups and individuals to protect their rivers and streams in addition to working on these issues directly. I help guide policy and regulations that make the protection of water quality the law in our state.

For more information, visit...www.KWAlliance.org

Chad Wagner, Hydraulic Engineer
U. S. Geological Survey, Louisville, KY

Exactly what is your job? I am a hydraulic engineer. My work focuses on surface water and the processes behind how water moves and how materials such as sediment and pollutants are transported by water.

How did you get into this field? I have always been interested in the environment and helping conserve it, especially our water resources. In addition, I enjoy working outdoors, and this profession provides a balance between office and field work.

What training did you have/need to prepare for this career? I have a Bachelor of Science degree in Civil Engineering and a Master of Science degree in Environmental Engineering from the University of Tennessee. The USGS has also provided me with many training courses to understand the equipment we use.

Where do you work? My main area of responsibility is in the state of Kentucky, but one project requires us to travel across the nation to collect data on flooding rivers.

With whom do you work? I work mainly with other federal and state agencies, such as the Federal Highway Administration, Environmental Protection Agency, and Corps of Engineers.

What do you like best about your job? It is exciting to actually be able to go into the field and collect information that most people are unable to gather and interpret the data in order to provide the information necessary to manage our earth's vital water resources.

Describe a fun or major project you have worked on. I recently returned from collecting real-time data around bridges in the upper Midwest floods. The data we collected helped the state determine if the bridges were safe for people to drive across. We had to battle very rough floodwaters in our boat, which was quite exciting.

How does your work make a difference? The information we provide allows water managers to assure that everyone has water when they turn on their faucets. We also determine/predict how severe and to what extent floods will affect people along rivers and streams. By understanding how pollutants move through water, we can more efficiently sample for pollutants and determine what measures are needed to improve water quality.

To learn more, go to...www.water.usgs.gov

Suggested Water-Related Themes & Activities across the Curriculum

Core Content for Assessment Areas Covered by The Following Activities:
Science: Properties of Matter; Characteristics of Organisms; Organisms and Their Environments; Organisms' Basic Needs; Populations and Ecosystems; Earth's Components.
Social Studies: Physical Characteristics of Regions; Human Settlement Patterns; Physical Environment and Human Activity; Historical Perspective.

Key Concept: Water is essential to life.

Reading Connections:
- Read *Drinking Water: Refreshing Answers to All of Your Questions* by James M. Symons (1995).
- Read *The Magic School Bus at the Waterworks* by Joanna Cole (1986).

Writing Connections:
- Write a short story describing a community somewhere in the world (or under certain circumstances in your hometown) without water.
- Write a story related to finding water on Mars or another planet.

Science Connections:
- Create an illustrated handbook of native animal species in Kentucky, classifying animals as terrestrial or aquatic. Briefly describe each species and list the ways each animal is dependent upon water and to what extent.
- Investigate ways that scientists classify characteristics of other planets and the methods they use when searching for water in the universe.

Social Studies Connections:
- Study Kentucky maps to locate major cities and historic towns in relation to water. Identify place names that refer to water.
- Research and compare the various sources of drinking water (wells, cisterns, municipal systems) and where they are used.

Math Connections:
- Predict your daily water usage. Complete the Daily Water Use Calculator worksheet (in this packet). Survey family/friends/classmates on water use. Chart results, figure averages, find patterns.
- Analyze a water company bill. How much water is used in your community annually? What's the average use per person?

Arts & Humanities Connections:
- Design a poster, brochure, or advertisement to promote water conservation.

Technology Connections:
- Go to www.ca.uky.edu/enri/dropgame.htm and play the water trivia Drop Game. Search the Internet to create new answers/questions for the game.

Field Trip Connections:
- Visit your community water company.

Key Concept: Soils have various properties and are found in layers.

Reading Connections:
- Read *Dirty Rotten Dead* by Jerry Emory (1996).
- Read *The Magic School Bus Meets the Rot Squad* by Linda Beech Ward (1995).

Writing Connections:
- Write a step-by-step guide teaching others one way to build a compost bin. Combine the methods into a technical manual or handbook for compost bin construction.

Science Connections:
- Create illustrations and a summary chart comparing the filtration processes at work in earth layers, wastewater treatment plants, and septic tanks.
- Research how wetlands, forests, and certain soils naturally filter runoff. Compare filtration in karst and non-karst areas.

Social Studies Connections:
- Read *Atlas of the Environment* by Geoffrey Lenn and Don Hinricksen (1992) to learn about drinking water and sanitation problems throughout the world.

Math Connections:
- Calculate the wastewater created in a neighborhood. Investigate and categorize wastewater generated at local factories and other businesses.

Arts & Humanities Connections:
- Design a wetland garden or create a wetland mural for your school.

Technology Connections:
- Search the Internet to locate the most current worldwide data on disease and death statistics, water use, sanitation and drinking water supplies.

Field Trip Connections:
- Visit the wastewater treatment plant in your community.

Key concept: All organisms cause changes in the environments in which they live.

Reading Connections:
- Read the Water Career Profiles (in this packet).

Writing Connections:
- Write an acrostic for "Watersheds" using words or phrases that express the interconnectivity of parts of the watershed and activities within it.
- Discuss water-related careers in your community, write and conduct interviews of workers. Write biographies of local water heroes in your community.

Science Connections:
- Build a terrarium or pan model of a watershed or wetland (see "Wetland Model" in this packet).
- Use an EnviroScape® model to study runoff.
- Compare the water cycle to the way water moves through the watershed.
- Discuss the Watershed drawing with transparency overlays (in this packet).

Social Studies Connections:
- Plan a new development for your community considering water quality issues. Include science by designing an experiment to test your development plan.

- Meet with developers to ask about their plans to protect water quality.
- Connect NPS pollution problems to geographic factors across the state (populations, land uses, etc.)

Math Connections:

- Participate in stream monitoring and water quality testing to collect data.

Arts & Humanities Connections:

- Create a multi-layered drawing of a watershed on transparency pages with layers representing gradual development/building in the watershed. Include a water flow layer.
- Perform the "Hear Ye! Hear Ye!" play (in this packet).
- Create public service videos teaching others how to make a difference for water quality.

Technology Connections:

- Use the Web to locate your watershed and reports about it. See www.epa.gov/surf.
- See also http://adopt-a-watershed.org, www.state.ky.us/nrepc/water/wwhomepg.htm.

Field Trip Connections:

- Visit a stream, taking photographs, making sketches, observing features & human activities.
- Observe runoff that occurs on school property during a rain.

Key Concept: History is a series of connected events (cause and effect).

Reading Connections:

- Read the Milestones of Kentucky Water History Timeline.
- Read *Who Came Down That Road?* By George Ella Lyon (1992).
- Create a clippings scrapbook with newspaper and magazine articles related to water for your school library. Summarize and categorize the contents.

Writing Connections:

- Write a newspaper article about one event on the timeline, as if the event just occurred.
- Write a new story called *Who Came Down That River?*

Science Connections:

- Investigate how water impacts/causes the formation of certain land features (rock bridges and arches, caves, oxbow lakes, valleys, etc.).

Social Studies Connections:

- Create index cards for each timeline event and use the cards for games to order events chronologically, match cause-and-effect events, categorize events.

Math Connections:

- Interpret the Milestones Timeline in mathematical terms, using bars of proportional length. Compare the measurements of prehistoric and historic events.

Art & Humanities Connections:

- Create landscapes depicting Kentucky water scenes at various times in history.

Technology Connections:

- Use the Internet to further research events of the timeline.

Field Trip Connections:

- Visit a water-related site or feature that has been significant to your community, investigating its significance and impact (dam, lake, spring, falls, etc.).

Daily Water Use Calculator

Do you know how much water you use? Use this tally to add up all of the water you usually use in one day. List the amount of water used for one time in the first column (see the list below) and the number of times you do this each day in the second column. Multiply the two numbers and enter the total in the last column. For a grand total of your daily water usage, add all of the numbers in the far right column.

Flushing the toilet:	____gallons X	____	=	____gallons
Brushing your teeth:	____gallons X	____	=	____gallons
Washing your hands:	____gallons X	____	=	____gallons
Taking a bath:	____gallons X	____	=	____gallons
Taking a shower:	____gallons X	____	=	____gallons
Washing dishes by hand:	____gallons X	____	=	____gallons
Washing dishes by automatic dishwasher:	____gallons X	____	=	____gallons

GRAND TOTAL: ____gallons

flushing toilet: 5 gallons
washing hands: 4 gallons
brushing teeth: 3 gallons
taking shower: 35 gallons
taking bath: 20 gallons
automatic dishwasher: 15 gallons
washing dishes by hand: 20 gallons

So, how much water will you use today? This chart doesn't include many activities such as doing laundry or watering your lawn. The average American uses 80-100 gallons each day, and that's too much!

Teach your family ways to use less water, such as:

- Install low-flow toilets & showerheads
- Take 5-minute showers
- Fix leaky faucets and toilets
- Don't leave the water running
- Wash only full loads

Think of one more way you can conserve water and write it below.

Recommended Watershed Web Sites

The Top Ten:

Kentucky Division of Water http://water.nr.state.ky.us/dow/

Teachers will find the publication, "Guidelines for Stream and Wetlands Protection in Kentucky" and the most recent Kentucky Reports to Congress on Water Quality helpful. Reports and information on all Kentucky river basins is linked here, on the Kentucky Watershed Management page, http://water.nr.state.ky.us/dow/watrshd.htm.
Link to the Natural Resources & Environmental Protection Cabinet (www.nr.state.ky.us) for the quarterly magazine, "Land, Air and Water," Kentucky Water Watch (volunteer monitoring projects), and an extensive list of Web sites for student research.

United States Environmental Protection Agency www.epa.gov/students/water.htm

This comprehensive site features the water cycle, a useful water treatment diagram, Surf Your Watershed (a great way to learn about your local watershed), and loads of experiments (see the "Darby Duck" link and also www.epa.gov/students/water_treatment_process_us.htm).

Kentucky Geological Survey www.uky.edu/KGS

This site includes information on Kentucky groundwater resources. Watch for new information on karsts.

United States Geological Survey http://water.usgs.gov/education.html

"Water Science for Schools" includes information on the Earth's water, water properties and chemistry, and urbanization. For primary grades, check out Water Science Storytime.
Order the water poster series: Wetlands, Water Use, Wastewater, Navigation, Ground Water, and Water Quality.

Natural Resources Conservation Service, U. S. Department of Agriculture

www.nhq.ncrs.usda.gov

Backyard Conservation offers how-to instructions for creating backyard (schoolyard) wetlands, ponds, wildlife habitats, compost bins, and more.

Adopt-a-Watershed http://adopt-a-watershed.org/

Adopt-A-Watershed is a K-12 school-community learning experience using a local watershed as a living laboratory for hands-on activities which make science applicable and relevant to the students' lives. Extensive, creative curriculum units.

University of Kentucky College of Agriculture Cooperative Extension Service, Environmental & Natural Resource Issues Task Force

www.ca.uky.edu/enri/index.htm

Access the Task Force's extensive publications and resources lists.
For a fun water game (à la *Jeopardy*), see www.ca.uky.edu/enri/dropgame.htm

U. S. Army Corps of Engineers, Louisville District www.lrl.usacre.army.mil/optm
View Ohio and Kentucky River navigation maps and read daily river reports
Visit www.lrl.usacre.army.mil/cd/mcalpine.htm for photos of McAlpine Lock & Dam as well as history and lock replacement project details.
Visit www.wes.army.mil/el/wetlands/ysi.html for "The Young Scientist's Introduction to Wetlands," a well-illustrated, printable publication.

Kentucky Department of Fish & Wildlife Resources www.kdfwr.state.ky.us/teacher.htm
Extensive teacher's guides (PDF files) may be found on this site. Some are companions to the department's aquatic ecosystem posters. Contents range from life cycles and food chains of aquatic species to the interconnectivity of streams in the watershed and the human impacts on major rivers. Classroom activities and glossaries are included. Other guides profile topics such as Wetlands & Waterfowl and Kentucky fish.

National Geographic Rivers 2001 www.nationalgeographic.com/geographyaction
Features lesson plans and student activities for using, changing, and saving our rivers, plus an interactive rivers system graphic.

Other Web sites to check out:

American Rivers www.amrivers.org
Blackacre State Nature Preserve
www.jefferson.k12.ky.us/Programs/BlackAcre/welcome.html
Center for Global Environmental Education, Hamline University, "Rivers of Life"
http://cgee.hamline.edu/rivers/index.htm
Center for Watershed Protection www.cwp.org
Give Water A Hand www.uwex.edu/erc/
The Global Rivers Environmental Education Network (GREEN)
http://www.earthforce.org/green/
Kentucky Association for Environmental Education www.kaee.org
Kentucky Coal Council Coal Education page www.coaleducation.org/resource/sources.htm
Kentucky Department of Agriculture, Division of Agriculture & Environmental Education
www.kyagr.com/enviro_out/education/index.htm
Ky. Dept. for Surface Mining Reclamation & Enforcement www.nr.state.ky.us/nrepc/dsmre
Kentucky Environmental Education Council www.state.ky.us/agencies/enved/
Kentucky Institute for the Environment & Sustainable Development (KIESD)
www.louisville.edu/org/kiesd/
Kentucky Waterways Alliance www.KWAlliance.org
Louisville Water Company www.lwcky.com
Metropolitan Sewer District (MSD) www.msdlouky.org
Ohio River Valley Water Sanitation Commission (ORSANCO) www.orsanco.org
River Network www.rivernetwork.org
U. S. Fish & Wildlife Service Endangered Species page http://endangered.fws.gov/education

Additional Recommended Resources

Receive the most current **status report of your basin** by calling the Division of Water at (502) 564-3410 or visiting http://water.nr.state.ky.us/dow/watrshd.htm. Basin reports include such components as descriptions of physiography, land uses, and watershed quality, as well as assessments of individual streams.

The Courier-Journal publishes a newspaper in print and on the Web related to its annual Conservation Contest. The theme for 2001 is "Water Odyssey" to compliment the Fair exhibit. Visit www.courier-journal.com

Guidelines for Stream and Wetland Protection in Kentucky from the Kentucky Division of Water, 1997. This illustrated guide describes stream dynamics, erosion, restoration of in-stream habitats, riparian buffer zones, and wetlands. It may be downloaded on the Web at http://water.nr.state.ky.us/dow/dwwqe/guide.htm or contact the DOW at (502) 564-3410 for a printed copy.

Kentucky Agricultural Statistics, an annual publication available from the Kentucky Department of Agriculture, (502) 564-5293 or 1-800-928-5277. Includes weather, climatological, and precipitation summaries, as relevant to crop and livestock production in the state.

Kentucky Alive! Report of the Kentucky Biodiversity Task Force, Commonwealth of Kentucky, 1995. Summarizes issues affecting biodiversity, from native plant and animal communities to fragile ecosystems to human influences. The historical perspective on biodiversity is given, and strategies for the future are also included. Available from the Kentucky Department for Natural Resources, (502) 564-2184, www.nr.state.ky.us.

Kentucky River Development: The Commonwealth's Waterway by Leland R. Johnson and Charles E. Parrish, U. S. Army Corps of Engineers, Louisville District, 1999. An extensive illustrated history of the Kentucky River, with an emphasis on navigation. www.lrl.usacre.army.mil/optm

Kentucky's Threatened and Endangered Species, Kentucky Department for Fish and Wildlife Resources, 1998. Illustrated descriptions of all plant and animal species on the state's at-risk lists. Contact (502) 564-4336 or www.kdfwr.state.ky.us/

Leopold Education Project, curriculum for grades 6-12 designed to instill a land ethic among tomorrow's stewards by providing direct experience with the natural world. The LEP is interdisciplinary in nature, combining Aldo Leopold's classic literary work, *A Sand County Almanac* with an ecologically sound understanding of science. For more information contact Laura Lang, KY Dept of Fish & Wildlife Resources, #1 Game Farm Rd, Frankfort, KY 40601.

Ohio River Navigation: Past, Present, Future, U. S. Army Corps of Engineers, Ohio River Division, 1979. www.lrl.usacre.army.mil/optm

Project Food, Land & People provides educational resources and over 38 lesson plans that help educators and students in grades PreK-12 to better understand the interrelationships among agriculture, the environment and people of the world. For more information contact Rayetta Boone (rboone@mail.state.ky.us), KY Department of Agriculture, Mero St, 7th Floor, Frankfort, KY 40601 or phone (502) 564-4696.

Project Learning Tree (PLT), uses the forest as a "window to the world," to increase students' awareness of our complex environment; to stimulate critical thinking; to develop the ability to make informed decisions on environmental issues; and to instill confidence and commitment to take responsible action on behalf of the environment. For more information, contact Doug McLaren (dmclaren@ca.uky.edu), Cooperative Extension, Department of Forestry, University of Kentucky, 205 Thomas Poe Cooper Building, Lexington, KY 40546-0073 or phone (859) 257-2703.

Understanding Blackacre State Nature Preserve, Jefferson County Public Schools, 2000. Multidisciplinary lesson plans tied to Performance Standards, utilizing Blackacre in Jefferson County as a teaching site. Lesson plans include pond and stream studies. Contact the JCPS Center for Environmental Education at (502) 485-3295 or www.jefferson.k12.ky.us/Programs/BlackAcre/welcome.html.

Water Quality Report, Louisville and Jefferson County, may be requested from the Metropolitan Sewer District, (502) 587-0603, www.msdlouky.org

Waterfront Park: A Curriculum Guide, Jefferson County Public Schools, 2000. Multidisciplinary lesson plans tied to Performance Standards, utilizing Louisville's Waterfront Park as a teaching site. www.jefferson.k12.ky.us

Several new water education resources will continue to be available after the 2001 Kentucky State Fair, as a result of the U. S. Environmental Protection Agency and Kentucky Division of Water grant to this project. To inquire about the availability of the following items, please contact those listed below:

"Watershed Decisions" (NPS pollution) Traveling Exhibit, Water Use Display, Watersheds Graphic, and Runoff Models
Contact: Rosetta Fackler, Kentucky Division of Water, 14 Reilly Road, Frankfort, KY 40601; Telephone: 502-564-3410; email: Rosetta.Fackler@mail.state.ky.us

16' x 32' Floormap: "Step Up To the State: Kentucky Watersheds Edition"
Contact: Kentucky Waterways Alliance, 854 Horton Lane, Munfordville, KY 42765-8135; Telephone: 270-524-1774; email: Director@KWAlliance.org.

EnviroScapes® Wetlands and Nonpoint Source Models
Contact: Dr. David Wicks, Jefferson County Public Schools Center for Environmental Education, 9600 Old Six Mile Lane, Room C146, Louisville, KY 40299; Telephone: 502-485-3295; email: dwicks1@jefferson.k12.ky.us

Previously Released Open-Response Items Related to Water

How can water-related units of study help improve student test scores? Water-related questions do appear on the CATS test, particularly in Science and Social Studies, but occasionally in other assessment areas as well. The list below identifies some sample Released Open-Response Items that may help plan water units. The questions demonstrate the value of integrating water-related issues into the curriculum across disciplines.

Five sample Open-Response Questions are included on the following pages. (Sample student responses and a scoring rubric are available on the Web for all but one of these questions.)

To view the additional released items listed below, go to the CATS link on the Kentucky Department of Education Website at www.kde.state.ky.us/comm/commre/cats and select from the options listed under "Assessment." Some more recently released questions include associated Academic Expectations, scoring guides, and samples of student responses. Additional (older) questions are archived under "Released Items from Prior Years."

Spring 1999 Release Item, Grade 4 Science
"Changing States." Students are asked to show their understanding of different states of water (i.e, solid, liquid, and gas) and of how these states may change. Students are also asked to show their understanding of how these changes that are present in the water cycle relate to the context of a "real-life" situation.

Spring 1999 Release Item, Grade 4 Science
"Earth Materials." Students are asked to show their understanding of the basic needs of living organisms and how organisms use Earth materials (soil, water, gases) to fulfill these basic needs.

Spring 1999 Release Item, Grade 4 Science
"Joe's Soil Experiment." Students are asked to demonstrate their knowledge of scientific content when assessing a soil permeability experiment. They are then asked to demonstrate recognition of appropriate scientific design procedures, identify mistakes in scientific procedure, and propose solutions to correct the identified mistakes.

Spring 1999 Release Item, Grade 7 Science
"Acid Rain." In addition to the basic concept of scientific inquiry, students are asked to show their understanding of water as a solvent, of how substances react chemically with other substances, of how substances are often placed in categories or groups if they react in similar ways, and of the effect of a chemical substance on living organisms or non-living structures.

1998-99 Release Item, Grade 8 Practical Living
"Water-Quality Regulations." Students are asked to explain reasons for specific government regulations to ensure the quality of public water. They are also asked to identify and describe the scope of resources that could help citizens who believe their water supply may be unsafe.

1998-99 Release Item, Grade 11 Arts & Humanities
"River Music." Students are asked to imagine that they have been chosen to compose a piece of music celebrating a community's relationship to its river. They are asked to consider how a river might impact a community, as well as how factors such as time, place, and belief systems are reflected in music.

1998-99 Release Item, Grade 11 Social Studies
"Ocean Waste." Students are asked to show their understanding of how human modification of the physical environment (releasing industrial and human wastes into the ocean) might affect human life (have possible global effects). They are also asked to develop strategies to help solve the problems associated with the contamination of oceanic ecosystems.

The first two pages of each of the Released Open Response Items below are reproduced, with permission, on the following pages.

1995-96 Release Item, Grade 4 Science
"Weather in a Bottle." Students are asked to use the sealed bottle as a model to explain evaporation and condensation in the water cycle and to tell what would happen on Earth if water did not go through these changes.

1995-96 Release Item, Grade 4 Social Studies
"Kentucky River Cities." Students are asked to show their understanding of why location near a large river offers advantages to a community and explain why these advantages are important.

1996-97 Release Item, Grade 8 Social Studies
"Widespread Drought." Students are asked to show their understanding of the economic cause and effect of drought on farmers, consumers, bankers, and merchants.

1997-98 Release Item, Grade 7 Science
"Results of Damming a River." Students are asked to demonstrate an understanding of environmental change over time by describing the changes and resulting long-term effects of damming a river.

Spring 1999 Release Item, Grade 11 Science
"Soil Erosion Protection Methods." In addition to the general concept of scientific inquiry, students are asked to show their understanding of demonstrations and explanatory models in Earth Science and of changes in the Earth's surface. To do so, they may draw upon their experiences and knowledge of soil composition, erosion, and erosion prevention.

1995-96 KIRIS OPEN-RESPONSE ITEM SCORING WORKSHEET

Grade 4 — Science Question 5

The academic expectations applied in this item include:

2.1 Students understand scientific ways of thinking and working and use those methods to solve real-life problems.

2.4 Students use the concept of scale and scientific models to explain the organization and functioning of living and nonliving things and predict other characteristics that might be observed.

The core content assessed by this item includes:

Process

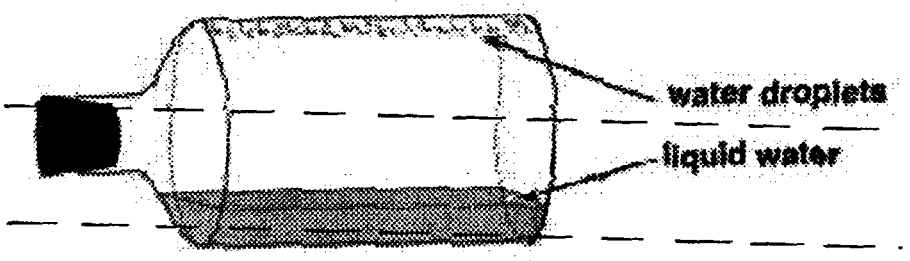
- Data is used to construct a reasonable explanation.
- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.

Content

- Properties of Objects and Materials
  - * Materials can exist in different states - solid, liquid, and gas. Some common materials can be changed from one state to another by heating or cooling.
- Earth's Components
  - * Water on the earth can be a solid, liquid, or gas and can go back and forth from one state to the other. If water is changed from one state to another, the amount (mass) of water remains constant.

5. Weather in a Bottle

The picture below shows a large, sealed, glass bottle. The bottle had some water in it and was left on a warm surface. This bottle is a model of the water cycle.



a. Use what happens in the bottle to explain the water cycle.

b. Tell what would be different on Earth if water did not go through the changes that are happening in the bottle. Include two or more differences in your answer.

SCORING GUIDE

Score	Description
4	Student response contains no misconceptions. A. Student correctly uses the bottle system as a model to clearly explain evaporation and condensation of water as it relates to the water cycle. B. Student tells two or more acceptable differences that would be seen if water did not evaporate and condense.
3	Student response contains minor misconceptions. A. Student implies or weakly uses the bottle system as a model to explain evaporation and condensation of water as it relates to the water cycle. The use of the model and the explanation has limited detail. B. Student tells one or more acceptable differences that would be seen if water did not evaporate and condense.
2	Student response is vague or unclear and includes errors, but the response shows some pertinent science. A. Student attempts to explain the water cycle without using the bottle system as a model, OR A. Student tells what happens in the bottle without referring to the water cycle, OR B. Student attempts to tell the difference that would occur on Earth without the changes in the bottle, OR Student succeeds on either A. or B.
1	Student shows minimal understanding or makes a weak attempt to respond. Student response attempts to explain the water cycle, but is mostly wrong or confused.
0	Response is incorrect or irrelevant.
BLANK	Blank/no response.

1995-96 KIRIS OPEN-RESPONSE ITEM SCORING WORKSHEET

Grade 4 — Social Studies Question 4

The academic expectation addressed by this item is:

2.19 Students recognize and understand the relationship between people and geography and apply their knowledge in real-life situations.

The core content assessed by this item includes:

- Every place is unique and can be described by its human and physical characteristics.
- Physical characteristics of a place include its landforms, climate, water, plants, and animals.
- The physical environment both promotes and limits human activities (e.g., moun tains as barriers or protection; rivers used as boundaries or transportation routes).

4. Kentucky River Cities

Many Kentucky cities are located near large rivers. What are three or more important advantages that the rivers provide these cities? Explain why each advantage you name is important.

SCORING GUIDE

Score	Description
4	Student describes at least three important advantages a river provides and explains in detail why each one is important. Explanations are clear and informed.
3	Student describes at least three important advantages a river provides but explanation of why the advantages are important is weak and lacks detail. OR Student describes two advantages with detailed explanation of why they are important.
2	Student describes two advantages but explanations are weak and lack detail. OR Student describes one advantage and gives a good explanation of why it is important.
1	Student lists advantages; explanations, if included, are unclear or misinformed. OR Student indicates minimal understanding of the benefits of being near a body of water.
0	Response is incorrect or irrelevant.
Blank	Blank/no response.

Some advantages of being located on a river:

- transportation
- shipping
- power (including electricity)
- irrigation
- source of water
- fishing
- recreation
- beauty

1996-97 KIRIS ASSESSMENT
Open-Response Item Scoring Worksheet

Grade 8—Social Studies Question A

The **academic expectation** addressed by "Widespread Drought" (Question A) is

2.18 Students understand economic principles and are able to make economic decisions that have consequences in daily living.

The **core content** assessed by this item is

- Governments, societies, and individuals experience scarcity because productive resources are limited and wants are unlimited.

Widespread Drought

Kentucky has had summertime droughts. These droughts impact the total economy in this state. Explain how each of the following groups could be affected by a drought. Give an example of an economic impact on each group.

Farmers

Consumers

Bankers

Merchants

SCORING GUIDE
Grade 8 Social Studies

Score	Description
4	Student clearly explains how each of the four groups could be affected by a drought. Explanation includes accurate example(s) for each group. Response shows a thorough understanding of economic cause-and-effect to farmers, consumers, bankers, and merchants.
3	Student explains how three (or more) of the four groups could be affected by a drought. Explanation includes accurate example(s) for three of the groups discussed. Response shows a general understanding of economic cause-and-effect to farmers, consumers, bankers, and merchants.
2	Student explains how two (or more) of the four groups could be affected by a drought. Explanation includes an example for two of the groups discussed. Response shows limited understanding of economic cause-and-effect.
1	Student minimally explains how one (or more) of the four groups could be affected by a drought. Explanation may be weak with no accurate example(s). OR Student explains non-economic impact(s) of drought on one or more groups.
0	Response is totally incorrect or irrelevant.
Blank	No response.

1997-98 KIRIS ASSESSMENT
Open-Response Item Scoring Worksheet

Grade 7—Science Question 10

The **academic expectations** addressed by "Results of Damming a River" (Question 10) include

2.1 Students understand scientific ways of thinking and working and use those methods to solve real-life problems.

2.6 Students understand how living and nonliving things change over time and the factors that influence the changes.

The **core content** assessed by this item includes

Content

- Earth's Subsystems – Human activities change the earth's land, water, and atmosphere. Some of these changes decrease the capacity of the environment to support life forms.

Inquiry

- Developing descriptions, explanations, predictions, and models using evidence.

Results of Damming a River

The water level in many Kentucky rivers continually changes. As a result, many rivers in Kentucky have been channeled and dammed to control unpredictable water levels.

a. Describe **two** environmental changes that could occur from the damming of a river.

b. Briefly describe **one** long-term effect that could result from one of the environmental changes you described in **part a**. Explain your answer.

SCORING GUIDE
Grade 7 Science

Score	Description
4	The response is complete and demonstrates a strong understanding of environmental change over time. A thorough and accurate description of two changes from damming a river is given and a resulting long-term effect from one of those changes is described and explained.
3	The response addresses the question and demonstrates an understanding of environmental change over time, although minor errors and omissions may be present. An accurate description of one environmental change from damming a river is given and a resulting long-term effect from the change is described and explained.
2	The response addresses the question but demonstrates a limited understanding of environmental change over time. A description and/or explanation of at least one change from damming a river is included. The description of a resulting long-term effect may reveal misconceptions. The response may contain errors or omissions.
1	The response is incomplete and demonstrates a minimal understanding of environmental change over time. An attempt to describe change from damming a river or a resulting long-term effect is included; however, the response may contain major errors, misconceptions, and omissions.
0	Response is totally incorrect or irrelevant.
Blank	No response.

Sample Student Responses

Environmental changes: loss of life, erosion, flooding, change in sources of food or water

Long-term effects: habitat destruction/change; permanent change in water level; changes in predator/prey relationships; change in the food chain; migration; change in land use; flood control

Science Behind the Question

Environmental changes could include reduction of nutrients from less flooding, change in habitat in flooded areas, less loss of life due to flooding, etc. Results on the ecosystem could include change in habitat leading to migration, adaptation, or death; redistribution of water; interference with migration patterns; etc.

SPRING 1999 RELEASE ITEM
Grade 11 Science

SAMPLE OPEN-RESPONSE QUESTION

How do students provide evidence of what they know and can do in science?

The following is an example of an open-response question designed to provide an opportunity for students to show what they know and can do in the area of science:

Soil Erosion Protection Methods

Soil erosion can cause problems during road construction, housing development, and farming.

a. Propose **two** models that would demonstrate different ways to prevent soil erosion and explain how each model works.

b. Describe a test to evaluate the effectiveness of **one** of your models.

SCIENCE CONTENT

What is the relationship of the assessment to the curriculum?

The content of the open-response question "Soil Erosion Protection Methods" addresses the following Science Academic Expectations: "Students understand scientific ways of thinking and working and use those methods to solve real-life problems" (2.1: Nature of Scientific Activity), and "Students use the concept of scale and scientific models to explain the organization and functioning of living and non-living things and characteristics that might be observed" (2.4: Models and Scale).

This question provides a way for students to show their understanding of several concepts from the *Core Content for Science Assessment.* In addition to the general concept of scientific inquiry (i.e., the methodology of scientific thinking and investigation), students are asked to show their understanding of demonstrations and explanatory models in Earth Science and of changes in Earth's surface. In answering this question, students may draw upon their experiences and knowledge of soil composition, soil erosion, and methods of preventing erosion.

SPRING 1999 RELEASE ITEM
Grade 11 Science

PERFORMANCE EXPECTATIONS

How good is good enough?

An appropriate student response should provide evidence of the student's in-depth understanding of how to design appropriately scaled demonstration models, and how to test a model's response to simulated erosion conditions.

For example, an appropriate response to this question would show that the student can

- identify two different models that would demonstrate different ways to prevent soil erosion;
- clearly explain how each model works; and
- clearly describe a test that could be used to evaluate the effectiveness of one of the identified models (i.e., describe a test with enough detail so that the validity of the conclusions about the effectiveness of the model could be determined).

Successful student work should provide convincing evidence that the student can use scientific content and inquiry skills to address the relevant issue(s), although the response may not address all details and may contain some minor flaws.

APPLICATIONS

How is this relevant?

This question addresses the fundamental aspects of scientific inquiry, as well as of scale modeling. By successfully answering this question, students demonstrate an ability to propose practical models and valid tests for the evaluation of those models. Students who demonstrate this ability are better able to use the techniques of scientific inquiry to investigate situations and to propose and test solutions to problems encountered in everyday life. This ability will also help students to recognize the importance and practicality of applying scientific methodology to make inferences about the characteristics of systems where full-scale experiments cannot be conducted.

Selected Lesson Plans from Water-Related Curriculum Publications

The following pages contain recommended lesson plans from the resources listed below. To obtain the complete publication, contact information is given on the first page of each unit. *Project WET* and *Project WILD Aquatic* are available through teacher workshops, so contact the Kentucky coordinators below for further information.

All lesson plans are reproduced with permission of the publishers.

Splashing in Kentucky!, "Nonpoint Source Pollution Walking Tour," Kentucky Waterways Alliance, THE EARTH MOBILE, and the Kentucky Division of Water, 1988. To learn how to obtain this publication through a teacher workshop, contact Cathy Neeley (neeley@se-tel.com), East Kentucky Science Center, 207 W. Court St., Suite 201, Prestonsburg, KY 41653, call toll free at (877) 889-0303.

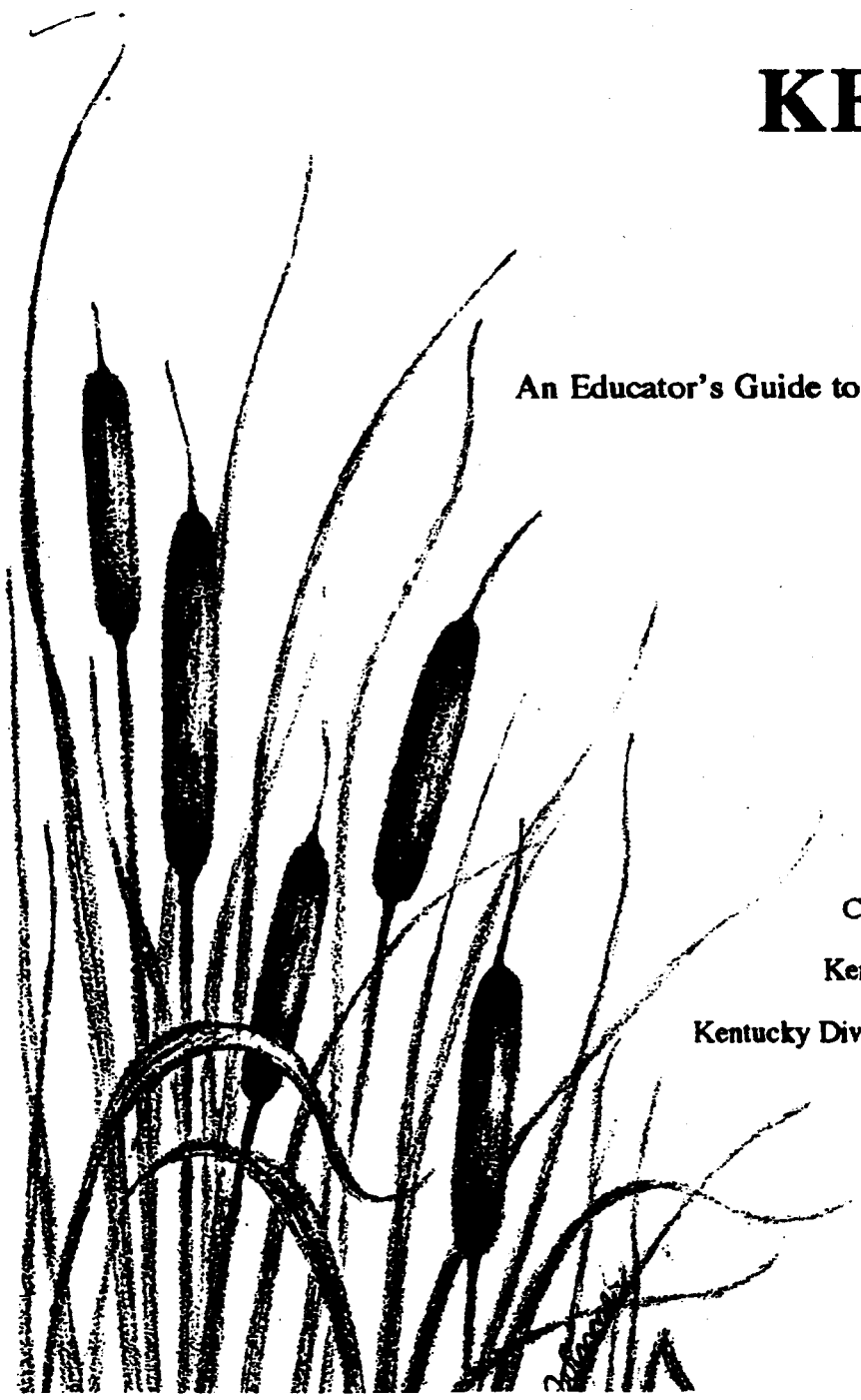
Project WET, "Sum of the Parts," Montana State University. Focusing on the theme of the relationship between people and water, activities also address water's chemical and physical properties, quantity and quality issues, aquatic wildlife, ecosystems and management strategies. For more information about teacher training and Project WET, contact Jennifer Lynn (jlynn@ca.uky.edu), North Central Environmental Education Center, 260 Camp Drive, Carlisle, KY 40311 or (859) 289-5308.

Project WILD Aquatic, "Riparian Retreat," Council for Environmental Education (publisher of Project WILD as well). Interdisciplinary conservation and environmental education programs emphasizing wildlife. Designed for educators K-12. These educational materials are provided to educators through practical, interactive workshops. For more information on Project WILD and Aquatic WILD in Kentucky, contact Jay Webb, Kentucky Department of Fish and Wildlife Resources, #1 Game Farm Rd., Frankfort, KY 40601 or (502) 564-4762.

WOW! The Wonders of Wetlands, "Hear Ye! Hear Ye!," Environmental Concern, Inc. See first page of the lesson plan for contact information.

Ranger Rick's NatureScope—Wading into Wetlands, "Wetland Models," McGraw-Hill. See first page of the lesson plan for contact information.

SPLASHING IN KENTUCKY!



An Educator's Guide to Nonpoint Source Water Pollution

Cathy L. Neeley, compiler

Kentucky Waterways Alliance
THE EARTH MOBILE
Kentucky Division of Water, Nonpoint Source Section
1998

NONPOINT SOURCE POLLUTION

Point source pollution has a well defined point of entry into the waterway such as a pipe from an industry. Nonpoint source pollution does not enter the waterway from a single point or originate from a single location. It occurs from many widespread activities within the watershed including agriculture, timber harvesting, construction, development of urban areas, mining, failing septic systems, urban runoff, etc. Thus, any chemical or waste product on the ground can become nonpoint source pollution. Some specific pollutants include:

- acid rain
- acid mine drainage
- fertilizers
- pesticides
- animal waste runoff
- automotive fluids such as oil and antifreeze
- road salts
- soil erosion
- raw sewage

Nonpoint source pollution occurs when surface runoff picks up these pollutants as it flows over the ground and transports them to nearby bodies of water. When the runoff reaches less saturated areas it soaks into soil to the groundwater carrying the pollution with it (Mississippi Department of Environmental Quality, 1993).

In Kentucky, the greatest and most widespread source of water pollution comes from contaminated runoff from farms, coal mines, and urban areas as well as:

- poorly operated sewage treatment plants
- malfunctioning septic systems
- soil erosion
- illegal straight pipes (Kentucky Environmental Quality Commission, 1994)

Nonpoint source pollution affects Kentuckians by increasing the cost of treating drinking water and wastewater, the loss of recreational activities such as swimming and fishing, the incidence of flooding, and the risk of exposure to contaminants and pathogens (Wisconsin Department of Natural Resources, 1989).

The amount of nonpoint source pollution could be reduced by:

- limiting surface runoff
- keeping surface runoff clean
- maintaining or restoring native vegetation in buffer zones next to ponds, sinkholes, streams, etc.

Also, Kentucky farmers are now required to have a water quality protection plan for their land to reduce the incidence of nonpoint source pollution from agricultural areas.

The activities in the following sections illustrate nonpoint source pollution.

NONPOINT SOURCE POLLUTION WALKING TOUR

GRADES: K-A
SUBJECT: Geography, Science, Social Studies
SKILLS: Analyzing, applying, classifying, describing, discussing, identifying, listing, mapping, observing, recognizing, visualizing.
DURATION: 1 to 2 hours
SETTING: Outdoors
KERA ACADEMIC EXPECTATIONS: 1.3, 1.10, 2.19, 3.6, 5.3, 6.1, 6.2

OBJECTIVE: To define and identify local problems of nonpoint source pollution.

METHOD: Take a walking tour of neighborhood looking for examples of nonpoint source pollution.

MATERIALS NEEDED:

- Paper
- Pencils
- Clipboards
- Topographic or road maps

PROCEDURE:

- Take a walking tour of neighborhood looking for nonpoint source pollution.
- List pollution seen and plot locations on map.
  ex.: automotive fluid spills on roadways, gas stations, parking lots, etc.
  decayed organic material
  trash in gutters, storm drains, or roadside ditches
  evidence of lawn treatment: flags, fertilizer pellets on sidewalks or in gutters
  soil erosion
  road salt
  trash in sinkholes
  crop fields or livestock next to waterways
- Determine from maps what watershed would be affected by this pollution.

EVALUATION: This activity demonstrates that nonpoint source pollution can be found everywhere.

- What is the land use in the area of the walking tour? (farms, urban, residential, etc.)
- What types of pollution were found?
- Where was the most amount of pollution found? Why?
- Where was the least amount of pollution found? Why?
- What watersheds are affected by this pollution?
- What could be done to minimize these effects?

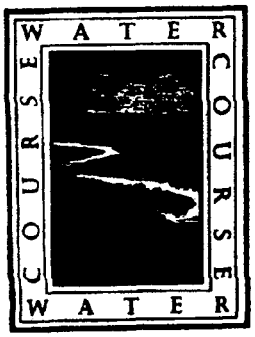
EXTENSIONS:

- Write a report on what was found and present it to concerned citizens.
- Write a newspaper article or letter to the editor.
- Join an existing environmental group or start one in order to clean up some of the pollution.

(activity designed by Cathy L. Neeley)

Project WET

Curriculum & Activity Guide



The Watercourse
201 Culbertson Hall
Montana State University
Bozeman, Montana 59717-0570

Council for Environmental Education
5555 Morningside, Suite 212
Houston, Texas 77005-3216

Sum of the Parts

Grade Level:
Upper Elementary, Middle School

Subject Areas:
Environmental Science, Government

Duration:
Preparation time: 50 minutes
Activity time: 50 minutes

Setting: Classroom

Skills:
Gathering information (observing); Organizing (arranging); Analyzing (identifying components); Interpreting (identifying cause and effect); Applying (proposing solutions)

Charting the Course
Supplement this activity with activities on runoff ("Just Passing Through," "A-maze-ing Water," and "Rainy-Day Hike") and water use practices ("Common Water"). Aspects of water quality monitoring are introduced in "Macroinvertebrate Mayhem."

Vocabulary
point source pollution, nonpoint source pollution, Best Management Practices

You have just inherited valuable riverfront property with a new house and a resort on it. On the day you move in, you discover the beach polluted with oil and littered with construction materials and animal waste! Where did all this stuff come from?

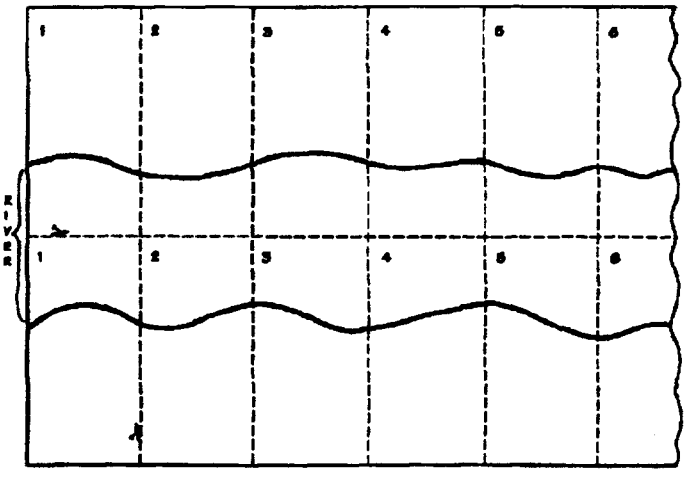
Objectives

Students will:

- distinguish between point and nonpoint source pollution.
- recognize that everyone contributes to and is responsible for a river or lake's water quality.
- identify Best Management Practices to reduce pollution.

Materials

- *Large piece of poster board or newsprint* (Using blue marker, draw and color a river on poster board, as shown below. Divide the stream in half down the middle and crosswise into sections. Each section should include a bit of river and blank space to allow room for students' drawings. The number of sections should correspond with the number of students or groups of students working together. Number the sections on one side of the river in sequential order, placing numbers in upper left-hand corners and repeat for the other side. Cut out the sections of stream. For durability, sections can be laminated.)
- *Drawing pens and pencils*
- *Items from students' desks (e.g., pencil, paper clip, book)*



Making Connections

In math class, students add a list of figures to obtain the total or "sum" (of the parts). Most students have attended a large gathering (concert, sporting event) and have been amazed at the amount of garbage left behind. Each person in attendance probably did not leave much on the ground, but with 500, 1,000, or more people doing the same, the total amount was large. Taking a closer look at how students can positively or negatively contribute to water quality helps them appreciate their role in water quality management.

Background

The quality of water in a river (or lake) is, to a large extent, a reflection of land uses and natural factors found in its watershed. If soil near a river or lake naturally erodes, chances are the river has sediment and turbidity problems. If

the land has stable vegetative cover, erosion is kept in check. When humans settle and develop land, water quality is affected. Breaking sod, cutting forests, building cities, mining, and other land uses make an impact upon water quality.

Everyone bears responsibility for the health of a watershed and the water systems (rivers, lakes, wetlands, etc.) within a drainage basin. Individual actions, both negative and positive, add up. Understanding a river or lake's water quality and quantity involves investigating the condition of the contributing watershed. If the watershed is polluted, the river will likely be polluted.

Watershed investigations are conducted for many reasons. Some investigations monitor changes in river and stream flows over time, to protect fisheries, to regulate floods, or to meet seasonal demands. Other studies determine the best method of protecting a river or lake from pollutants. One aim of a researcher might be to determine which areas of a watershed contribute the highest percentage of contaminants. This information is vital to policymakers and water managers when determining how best to spend money for improvements. For example, most lake improvement projects address problems in the watershed as well as those of the lake. It would prove fruitless to spend thousands (or even millions) of dollars to clean up a lake, if problems in the watershed will only pollute the lake again.

When watershed managers investigate land use practices that might affect the quality of water, they are concerned with two general sources of pollutants: point and nonpoint.

Point source pollution involves pollutants that are discharged from, and can be traced back to, an identifiable point or source, such as a

Major Sources of NPS Pollution and BMPs

Source	Best Management Practices:
Roads and Streets	• dispose of paints, solvents, and petroleum products at approved disposal sites, not in storm drains or street gutters • fix automobile oil and fuel leaks • stop oil dumping on rural roads • use nonchemical deicers (sand and ash) on roads, sidewalks, and driveways • construct a sediment catch basin to collect storm water runoff • reduce road construction runoff by building terraces and catch basins, and by planting cover crops
Agriculture	• read and follow all labels and ask for application directions before using chemicals, fertilizers, and pesticides • use conservation tillage • use contour farming • use strip cropping • leave filter strips and field borders along wetlands and streams • use a cover crop to protect exposed soil • rotate crops • plant shelter belts and windbreaks • institute pasture management • terrace areas prone to erosion • construct livestock waste collection and treatment ponds for confined livestock • use grassed waterways • seal abandoned or waste disposal wells • fence waterways to reduce riparian zone impact by livestock
Logging	• monitor water entering and leaving cut areas • prevent sediments from reaching streams and lakes by building terraces, catch basins, and natural filters • leave a vegetative buffer zone in riparian areas • maintain and restore effective watersheds • implement a plan to reduce erosion from roads
Mining	• monitor all water entering and leaving mine sites • intercept and reroute uncontaminated water away from contaminated areas (keep clean water clean!) • construct catch basins and terraces, and plant cover crops, to catch sediment and prevent erosion • catch and treat contaminated water (clean contaminated water!) • stabilize stream channels • stabilize mining waste areas to prevent release of materials to streams • maintain buffer strips along streams
Construction	• implement a sediment control plan • plant ground cover to reduce erosion • dispose of solvent, paint, and other wastes at approved disposal sites • build temporary, small dikes to slow and catch runoff • build sediment catch basins to collect construction runoff • build earth berms and filter runoff before water enters stream
Residential	• use nonchemical deicers (sand and ash) on residential driveways and sidewalks • read labels prior to using pesticides and fertilizers • consider xeriscaping • use nonchemical fertilizers (compost) on gardens • dispose of household hazardous waste at approved disposal sites • maintain septic tanks if sewers are not available

factory's discharge pipe or a sewage ditch. Nonpoint source (NPS) pollution occurs when the source of a contaminant is unidentifiable; that is, the pollutant can come from one of many places. Examples of nonpoint source pollution include runoff from agricultural fields containing fertilizers and pesticides, motor oil filtering from urban areas, and sediments from eroded stream banks.

Surface runoff and ground water can transport both point and nonpoint source pollutants. Since point source pollutants are identifiable, they are easier to monitor.

The protection of surface and ground water resources from NPS pollution presents an enormous challenge because of the widespread and diverse nature of the problem. Land and water managers rely on methods called *Best Management Practices*, or BMPs, to describe land use measures designed to reduce or eliminate NPS pollution problems. A list of nonpoint source pollution sources and suggested BMPs can be found in the side bar on the previous page.

Procedure

▼ *Warm Up*

Determine student knowledge about watersheds by asking them to name several major North American rivers (e.g., Mississippi, Columbia, Missouri, Hudson, and Rio Grande). Where do these rivers originate (where are the headwaters) and end? How many states does each cross or touch?

Discuss some of the predominant types of land uses found along one river as it flows through a single state. Do students think these practices could affect the river? What do students think the attitude of downstream state residents might be about the water received from their upstream neighbors?

▼ *The Activity*

1. **Inform students that they have just inherited a piece of riverfront property and a million dollars. Have them list ways they could use the land and the money.**

2. **Pass out "pieces" of property and drawing pens and pencils. Explain that the blue is water and the blank space is land they own. They have one million dollars to develop their land as they wish.** They can farm or ranch; build resorts, homes, factories, or parks; plant forests, log, mine—whatever they like.

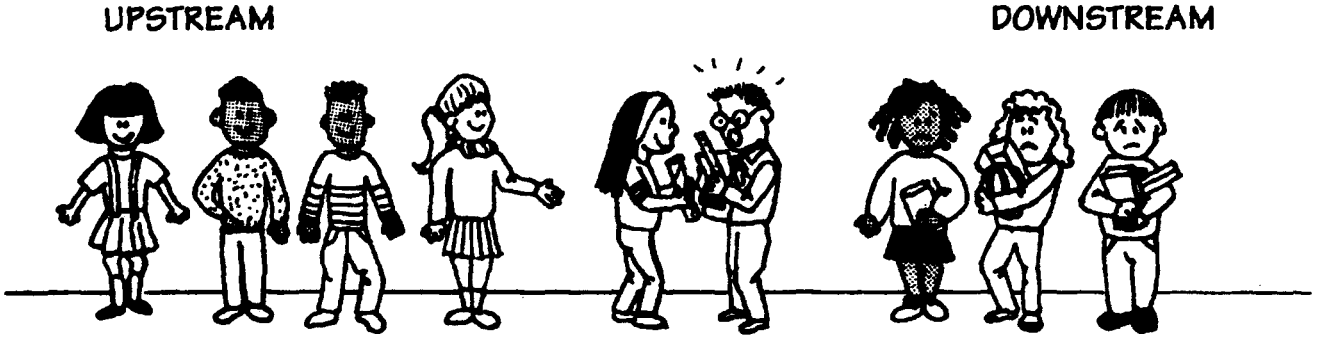
3. **When students have completed their drawings, ask them to look in the upper left-hand corner of their property for a number. Explain that each piece is actually a part of a puzzle. Starting with number one, have students assemble their pieces.** They will construct the stream pathway and adjacent land area in proper order. (The ones should face each other, with the twos next to them, and so forth.)

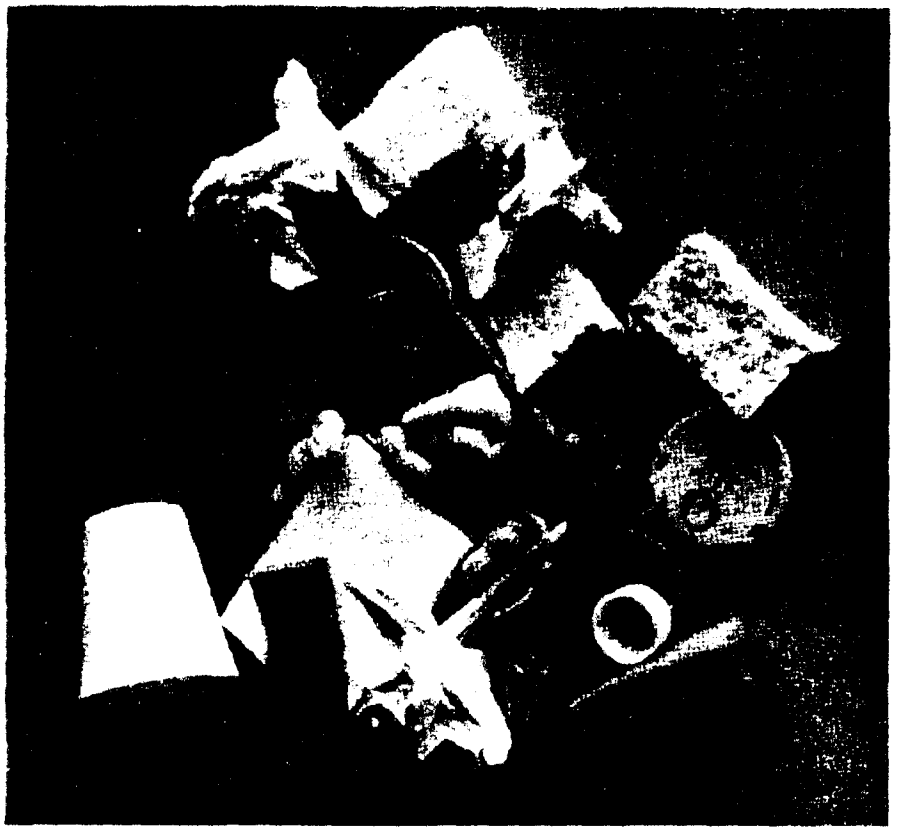
4. **Have students describe how they developed their land and how they used water. They should identify any of their actions that polluted or added materials to the waterway. Have students represent each of their contributions to the river with an item from their desks (e.g., book, piece of paper, pen, pencil).**

5. **Tell students to take their item(s) and line up in the same order as their pieces of river front property. They are going to pass their pollution pieces downstream. Have them announce what kind of pollutant they are holding before they pass it on.** The ones will pass their item(s) to the twos, the twos will pass everything to the threes, and so on, until the last students are holding all the items.

▼ *Wrap Up and Action*

After all the items have reached the final students, discuss the activity. How did those students toward the middle or at the end of the river feel? What about their property use plans? Could a student downstream be affected by the actions of a student upstream? Could upstream users





Simulated point and nonpoint source pollution collected during "Sum of the Parts."

alter the water quality of those downstream?

Tell students to reclaim their items. Explain that the items easily identifiable as their own simulate point source pollution. Other items (e.g., pencils, paper clips, notebook paper) may be more difficult to claim, because these kinds of pollutants originated from multiple sources. Tell students these represent nonpoint source pollution.

As a follow-up, have each student write one paragraph detailing ways to reduce the amount of pollution he or she contributed. (Share the *Major Sources of NPS Pollution and BMPs* from **Background**.) Students can research the regulations governing waterfront property in their communities. If they believe their waterways are poorly treated, they may want to write letters to local government officials supporting environmentally sound land use legislation.

Assessment

Have students:

- express their opinions about individual contributions to total water quality (***Wrap Up***).
- write a paragraph identifying what they can do to protect water quality (***Wrap Up***).
- discriminate between point and nonpoint source pollutants (***Wrap Up***).

Upon completing the activity, for further assessment have students:

- design a community that uses Best Management Practices that allow for minimum contribution of pollutants.

Extensions

Instead of a river, have students represent a lake system. One student represents a lake. A group of students encircle the student representing the lake; they are houses around the lake. Other students, standing in lines extending from the lake, can be streams flowing to the lake. Students pass their item(s) downstream and into the lake until all the items are held by the person in the middle who represents the lake.

Have students adapt the activity to represent a river system that includes tributaries flowing into a main channel.

Complete the main activity using real water users within the watershed where students live. Or assign roles (farmers, suburban dwellers, etc.) to students and have them develop their land accordingly. How would they manage their land to protect water resources?

Resources

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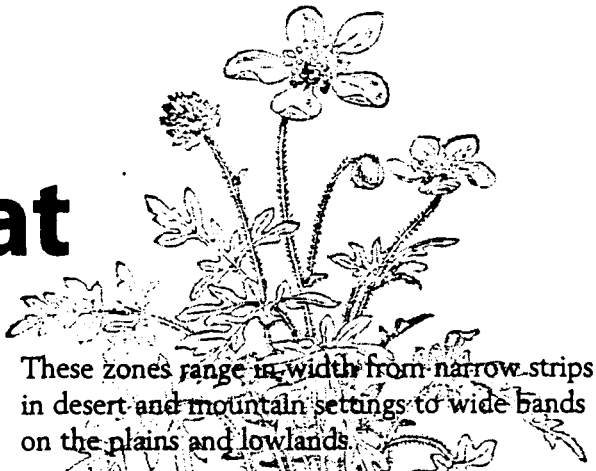
Riparian Retreat



Objectives

Students will: 1) describe habitat characteristics of riparian areas; 2) identify animals that inhabit them; and 3) state the importance of riparian areas to wildlife and humans.

Method

Awareness of a riparian zone is created through the use of a simulated field trip and art work.

Materials

Art materials: water colors, acrylics, poster paints, crayons

Background

Riparian areas or zones are important and valuable in many ways, including hosting whole communities of life. Riparian zones are the green ribbons of life found on the edges of watercourses (streams, lakes, ponds, etc.) Conditions within the zones support plant communities that grow best when their root systems are near the level of high ground water.

Grade Level: 5-8

Subject Areas: Language Arts, Environmental Education

Duration: one 30- to 45-minute session

Group Size: any

Setting: outdoors or indoors

Conceptual Framework Topic Reference: AAIA, AAIB, AAIIA

Key Terms: riparian, ecology, habitat, value, buffer

Appendices: Simulated Field Trips

These zones range in width from narrow strips in desert and mountain settings to wide bands on the plains and lowlands.

Riparian areas provide space, shelter and food for the plant and animal communities with which they are associated. For example, leaf litter and terrestrial insects falling from vegetation into a stream are a source of detritus, providing nourishment for some aquatic life. Vegetation may also provide shade from the sun for aquatic plants and animals and land-dwelling creatures at the water's edge. Riparian areas are also transportation corridors for animals that depend on water bodies for food and shelter. The riparian plant community, especially shrubs and trees, provides shelter and food for many animals. Trees and marshy areas provide shelter for nesting birds and the banks provide homes for burrowing animals.

The riparian zone may serve as a buffer between the uplands and the water. For example, rainfall dropping on uplands and flowing downhill can be cleansed as it flows through a riparian zone. The banks of riparian areas store water during periods of high flow such as rainstorms or snow melt and release this water to the stream during low-flow times. Riparian vegetation strengthens the stream banks. This tends to prevent erosion and maintains the stream channel, keeping the water clear.

Riparian areas also have aesthetic and recreational values for humans. They are used for fishing, hiking, camping, picnicking and resting.

Procedure

1. Ask the students if they have ever been to a stream or riverbank. What was it like? Were plants growing there? What did the area look like? Was it hot or cool? Encourage the students to talk and share descriptions of any area by a stream or riverbank they may have been to, or at least have seen pictures of.
2. Next, tell the students that the kind of area they have been describing has a special name. In some parts of the country it is called a "riparian area." Riparian areas are important natural areas for people and wildlife. In order to learn more about these kinds of areas, the students will need to close their eyes and picture the things you will be describing. Invite the students to get in a comfortable position, close their eyes and do their best to picture what they hear.

NOTE: Educators may want to read the section about simulated field trips that appears in the appendices to this activity guide for additional suggestions concerning use of this instructional strategy with students.

"It is a hot summer day. You are walking in a meadow filled with knee-high grasses. Here and there are masses of tiny blue wildflowers... The ground beneath your feet is uneven, but you are in no hurry as you walk slowly toward a grove of trees. As you near the trees, you notice the changing colors of green... A breeze whispers through, showing first a shiny green, then a dull green underside of the leaves...As you step into the grove of trees, you are surrounded with a welcome coolness...You immediately feel the protection of the canopy of green above your head...A tap-tap-tapping sound breaks into your thoughts. Searching about among the rough-barked trunks, your eyes finally spot a bird, black and white with a touch of red on its head, clinging to a vertical tree trunk and bobbing its head in time to the rhythmic tapping...Your eyes fill with the beauty of the setting...Your skin welcomes the cool...As you breathe deeply, the very scent of green comes to you....The aroma of earth and growing things is strong and you detect here and there almost a memory of the sweet perfume of the flowers... Once in a while the pungent but not unpleasant odor of wet soil and last season's decaying leaves and grasses catches your attention.

As you explore further, you notice that the tree trunks are not as crowded and close as before... Grass, which earlier reached to your knees, is being overshadowed by chest-high bushes. Although these bushes have no thorns, they nevertheless snag your clothing...Your arms are lightly scratched by the twig ends. Several of the bushes are covered with small berries, pink and pale green, ripening into red in the warm sun. The bushes become taller...You find yourself pulling aside thick, tangled willows taller than your head...You carefully choose a safe path along the precarious trail beneath your feet. Suddenly your left foot drops six inches and, looking down to examine the terrain more closely, you notice that, where you stepped, the tunnel of a burrowing animal collapsed from your weight. Moving on again you feel the whisper of an abandoned spider web touch the side of your face...Brushing it aside, you notice the slope of the land is steeper...You pause, listening...listening. You can hear the high drone of insects...It has come upon you so gradually, you are surprised that you didn't hear it before...Now it seems almost frighteningly loud. And beneath the buzzing drone, and lower in pitch and volume, is the sound of water gently spilling over rocks. Above the place where the water must be, you see thousands of tiny spots milling before your eyes, the creators of that high buzzing sound...The spots are hundreds of swarming insects in a cloud too thick to picture...A dragonfly flashes by with its iridescent pinks and greens, darting here, pausing, darting there, pausing, snatching dozens of the dots, relishing a meal in an unending insect buffet. You step aside, ducking beneath the swarming insects...You smile as your eyes come to rest on the splashing waters of the stream a few feet below. As you proceed, you use your arms to open a space to walk between the graceful tan and green willows that bounce back undisturbed

continued

in your wake. As your eyes comb the scene for a place to rest, you notice a hip-high rock ahead of you—gray, warm, and not yet water-smoothed...You pause before reaching the rock and bend toward the water, gathering a handful of pebbles from the stream bed. One leg anchors itself on the ground between two willows while the other reaches over the water. With the pebbles in your hand, you swing up onto the dry perch of the rock. You settle down and look at the still wet pebbles...gray, pink, tan and cool in your warm hand. After you examine them carefully, you toss the stones one at a time into the stream, listening to the pleasing plop of stone on water. Then your eyes drift downward to the waters of the stream near the base of your rock...In an eddy you see a fish, hidden like an illusion in the stone and silt, waiting, waiting, unblinking and still, only the faint wave of a gill, a tail fin, showing any evidence of life at all.

As you continue to look downstream you notice all kinds of small insects are now dancing across and above the water...A small ripple occurs in the water, then another and another... You realize that fish are rising up from below and feeding on the surface insects....Birds dart in and out of the tangle of vegetation...Some fly through. Downstream a frog begins to croak... Much nearer, another frog offers a reply. You look around quickly to see if you can find the nearer frog. For a moment you think you spot it, but then realize that, unless it sings again, you may never find it. Your eyes search for a moment as more frogs telegraph their messages back and forth. But then it seems time to leave...You take one last sweeping look all around this beautiful setting...You slowly get up from your rock along the streamside and head back home."

3. Ask the students to continue to sit quietly with their eyes closed and review the whole experience. Ask them to pay particular attention to their favorite images. Tell them they are going to be asked to describe this setting as they saw it. Invite them to open their eyes.
4. Ask students to describe their favorite images. Once each student has done this, invite all of the students to select art materials. Each student should draw or paint his or her favorite images on the paper provided. Once they are finished, have the students tape up their artwork on a display area.
5. Ask the students to identify some of the characteristics of riparian areas. What kinds of plants did they see? What kinds of animals? Was the environment different near the water than it was farther away from the water? If yes, what were some of the similarities and some of the differences? Ask the students to list, describe and discuss some of the many reasons that riparian areas are important and have intrinsic value, as well as value to wildlife and humans.

Extensions

1. Visit a riparian habitat. Look for things that you encountered in your visualization. List things that you did not picture in your mind would be there.
2. Develop a list of ways that would make it possible for people to visit a riparian area without damaging it.
3. Put your descriptions in writing. Combine words and pictures to convey some of the diversity in riparian areas.
4. Is a different word used in your region to describe these kinds of areas? If not riparian zone, what are they called?

Evaluation

1. What is a riparian zone?
2. Identify four animals found in a riparian zone.
3. Why are riparian zones important to wildlife? To humans? Why are riparian zones intrinsically valuable? Write a poem to explain your response.
4. Describe your position on a plan to develop a riparian habitat for recreational use by hikers, birdwatchers and other "low-impact" users. A parking area, restrooms, walkways, garbage removal and other needs must be considered.

WOW!
The Wonders Of Wetlands

Produced through a partnership between

Environmental Concern Inc. and The Watercourse

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Environmental Concern Inc.

The Watercourse

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Hear Ye! Hear Ye!

[illegible]
3-4 with modifications
5-12

[illegible]
Language Arts, English, Social Studies

[illegible]
One hour

[illegible]
Classroom

[illegible]
Gathering and applying information

[illegible]
Try "Hydropoly!" or "Regulation Runway" for other approaches to studying wetland regulations

[illegible]
public hearing

Summary

Hear Ye! Hear Ye! Who has a say about what your community does with wetlands? You do!

Students conduct a mock public hearing to make a group decision on an important project.

Objectives

Students will:

- describe the process of a public hearing.
- analyze some effects of a development on an adjacent wetland.
- weigh factors in a proposed building project and decide whether or not to proceed.

Materials

- *copy of the script for each student*
- *an enlarged copy of the project proposal sketches*
- *any desired props or costumes*

Making Connections

Though the legal process for regulating wetlands accommodates public participation, many citizens are unaware of the importance of their role in environmental decision-making. This introduction to the goings-on at a public hearing may encourage students to attend and participate in this part of the democratic process at some time in their lives. Students will learn that every voice makes a difference.

Background

When someone wants to build on or alter wetland areas, he or she must first apply to both the state and the federal governments for a permit to do the work. Representatives of government agencies will visit the proposed project site, determine where the wetland boundaries lie, and assess the ecological functions and social and wildlife values of the wetland.

Before each agency makes its final decision on whether or not to issue a permit, the project will go out on public notice. Public notices may be posted in the local newspaper and will be sent to individuals who have placed their names on a mailing list (see chapter 6). If any individual requests it, a hearing will be held to discuss all relevant issues surrounding the project.

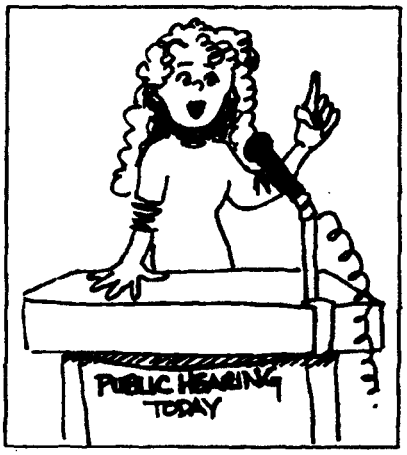
At the hearing, involved agencies are represented and their testimonies presented. Citizens may sign up to testify or give their views on the project as well. Citizens' statements really matter and will become part of the public record! Points brought out during the hearing will be used by the agencies in decision-making.

Procedure

Warm Up

Give the class a brief background on public hearings. The play in this activity depicts a public hearing on a proposed building project in a wetland. Although the case is fictional, the process of the hearing and the nature of the testimonies are realistic.

Decisions are normally not made at the hearings, but at the end of this hypothetical scenario, students will discuss the issues and reach a group decision on the project's fate. Although the names of state agencies and their permit requirements differ from state to state, but the ones depicted here are fairly representative.



The Activity

1. Review the proposal, then assign the roles in the play. Students who do not play a part will represent the hearing audience and take the lead in the final decision-making process as a "hearing committee."

2. Have the class perform the hearing as described on the student pages.

Wrap Up and Action

After the performance, give students time to discuss the case as a group or in small groups, or lead a class discussion. Have students present decisions to the class, including revisions to the proposed project (see Suggested Solutions, below).

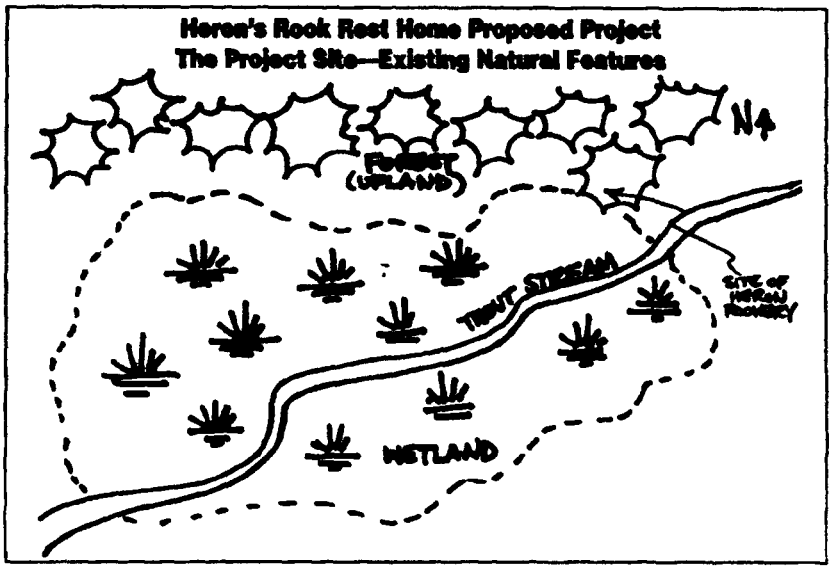
Have students attend an actual public hearing. How does it compare to the one they enacted in the classroom?

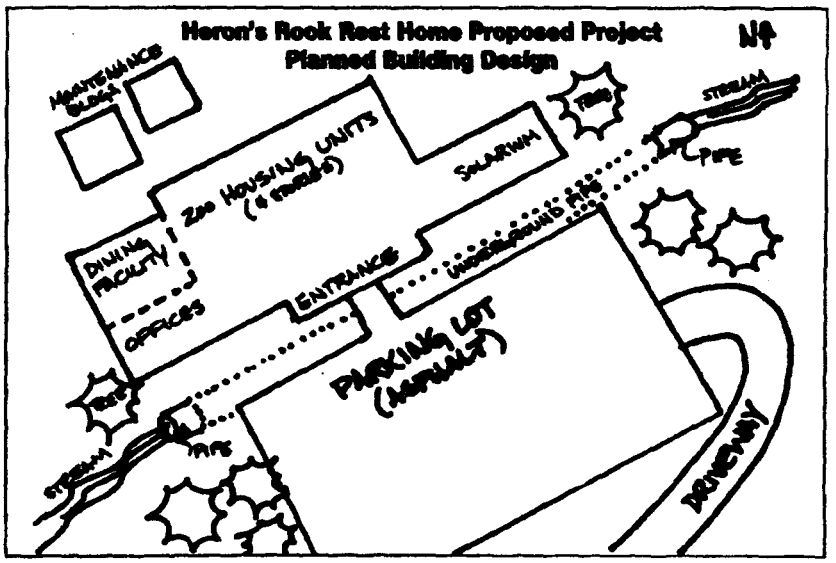
Suggested Solutions:

Here are some suggested revisions and solutions that will make the project more environmentally sensitive and reduce impacts to the wetland. Most are brought forth in the play, but review them as the final discussion and decision-making process proceeds. Students should be encouraged to make their own recommendations, and there are certainly no right or wrong answers to this activity. However, the goal is to come up with a building plan that does the most good for the greatest number of people *and* the environment—a compromise plan to meet everyone's objectives as fully as possible.

1. *Whenever possible, avoid building in the wetland itself.* For example, move the building and parking lot back from the stream area (see diagram). This would make the walk from the building to the parking lot longer, but it would also save most of the wetland area, protect the stream, and give residents a nice view of wildlife. The building may also need to be a bit smaller. This entire plan would cost less.

2. *Follow agency recommendations to reduce the effects of runoff and erosion.* Install and maintain silt fences during construction; install infiltration trenches to cool and





filter runoff before it enters the stream; landscape the area to blend it into the surrounding environment and help filter and slow runoff; to reduce runoff in the parking lot, use gravel or oyster shells instead of pavement (crushed gravel surfaces can be made wheelchair-accessible).

3. *After the building has been completed, develop an interpretive trail around the wetland for community use.* This would allow citizens continued access for fishing, bird-watching, etc. Involve residents of the facility in on-site wetland education programs for area youngsters.

4. *Make the long walk from the parking lot to the building pleasant and educational (see #1).* Landscape it to make it attractive, and build a bridge and boardwalk over the stream and wetland. Install a sign or two along the way to point out natural features such as wildlife habitat.

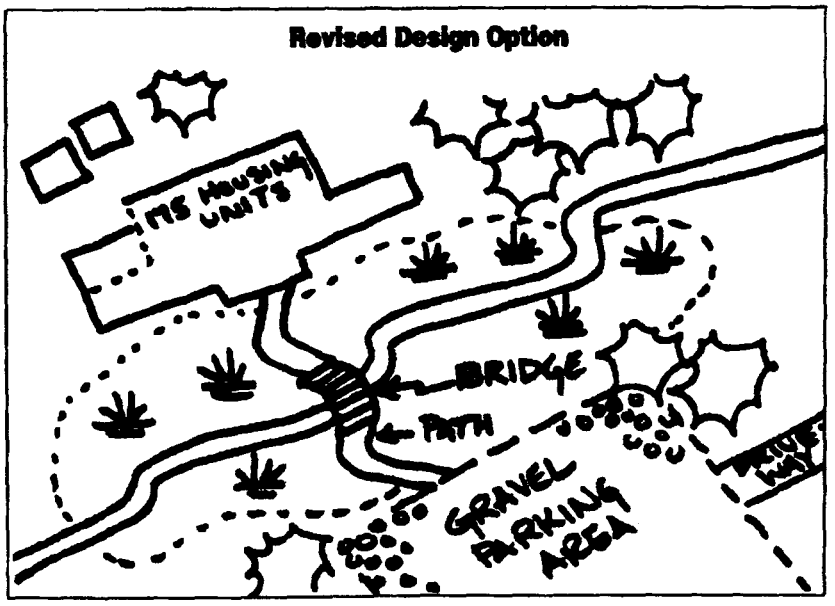
Assessment

Have students:

- perform character roles in a mock public hearing.
- decide on a solution to an environmental issue based on the proceedings of a public hearing.
- critique the process of the mock public hearing.

Extensions

Place your class on a public notice mailing list by writing to your local U.S. Army Corps of Engineers district office. Look in the government listings (blue pages) of the phone book under "United States Government, Department: Army, Corps of Engineers." You may need to check the book for the nearest large city to find a district office. You must specify the watershed (the area surrounding a particular body of water) in which you are interested.



Hear Ye! Hear Ye!

The Characters:

- A Hearings Officer:

  Ms. Samantha Keep M. Inline, a highly skilled lawyer who will preside over the hearing.

- Resource and Regulatory Agency Representatives:

  Mr. Reggie U. Lator of the state's Department of Natural Resources (DNR)

  Ms. I. M. Cleanwater of the state's Department of Environmental Quality (DEQ)

  Mr. Chuck Finnenfeather of the U.S. Fish and Wildlife Service (FWS)

  Mr. Phil N. Waters of the U.S. Army Corps of Engineers (the Corps)

  Ms. Vee Toh Powers of the U.S. Environmental Protection Agency (EPA)

  Mr. George Fishismylife of the National Marine Fisheries Service (NMFS), an agency of the National Oceanic and Atmospheric Administration (NOAA)

- Citizens and Other Interested Parties:

  Mr. Ronald P. Gotbucks, the permit applicant (the would-be owner of the rest home to be built)

  Mr. Harry Nailenhammer, a builder (has been contracted by Mr. Gotbucks to build the rest home)

  Mr. and Mrs. Ace R. Sellers, the current owners of the land in question

  Ms. Louise B. Socialcause from the state's Bureau of Economic Development

  Mrs. Bun E. Hugger of the local chapter of the We Protect Nature and Wildlife Society (otherwise known by the acronym, "WeePNoW")

  Mr. Pierpont Pospistle, an elderly man and potential resident of the rest home

  Mrs. Helen Nimby, a resident of the neighborhood near the project site

  Mr. Arthur Nicerman and his nine-year-old granddaughter Sally-Jane, area residents

  Ms. Marcia Planwell, an interested citizen who is trained and employed as a wetland/environmental consultant

The Scene:

A large, plain-looking meeting room. There is a long table at the front of the room with several chairs behind it. The rest of the room holds rows of folding chairs for an audience. A table near the doorway holds a sign that instructs people to enter their names in a notebook as they arrive, to record the hearing's attendants. Anyone who wishes to speak at the hearing must also place his or her name on a list posted on the wall.

[Several people are beginning to file into the room. They stop to read the sign and dutifully scribble their names in the book and on the list. Many are quiet and serious-looking; others are chattering to each other in near whispers, hurriedly fitting in last-minute instructions. All take their seats as a stately, impressively-dressed woman enters and sits at the table in the center chair (she is the Hearings Officer, Ms. Keep M. Inline). The agency representatives seat themselves beside her at the table. The Hearing Officer speaks:]

The Script:

Hearings Officer (H.O.): If everyone is ready, I will open the meeting. We are here this evening to hear testimony on the proposed Heron's Rook Rest Home building project. This hearing was requested by a member of the community in response to public notice number 5362-477K. The applicant, Mr. Ronald P. Gotbucks, has submitted permit applications to the Corps Of Engineers and the state Department of Natural Resources and Department of Environmental Quality. The agencies have indicated that the applications are complete and correct and that their project managers have visited the site. We will hear their assessments this evening, and testimony from the applicant, involved parties, and interested citizens.

[She holds up the drawings of the project site and building plan and points to the described features.]

The project site in question is a 7-acre parcel of land containing 3.75 acres of wetland with a trout stream running through it. The application states that six of the seven acres are to be cleared of vegetation and the wetland and stream are to be filled in with clean fill-dirt. A pipe would be installed below ground to carry water from the stream through the property, so as not to interrupt the flow. The building is a rest home with 200 units (living quarters for 200 individuals or couples, maximum occupancy 300 people). Included is a general dining facility and a solarium/recreation room. A paved parking lot and access drive are to be

placed to the southwest of the building. The main building and maintenance buildings would cover approximately two acres. The parking lot is another 1 acre, and the access road traverses .83 acres on the parcel.

Are there any questions on the project as explained?

[Waits. There are no questions.]

Then I will now invite the resource agencies, seated here at the table, to present their testimonies on the case. I will remind the audience that no decisions have been made on the permit applications. The agency representatives are merely stating how they currently stand on the proposed project and why. May we have the first speaker, please?

Mr. Lator: I'm Reg Lator from the state's Department of Natural Resources. I'm the project manager on this case and I'll be making the decision on whether to issue the permit. Our first inclination is to deny the permit as applied for, BUT we feel that alternatives exist that would make the project more environmentally sensitive. We would be more likely to approve the permit if efforts were made to reduce the wetland damage. One way is by moving the building back away from the stream and into the upland area. Some wetlands would still be affected, but not as many. The parking lot should also be set back farther away from the wetland area. This would mean a longer walk from the parking area to the building, but it would save substantial wetland area.

H.O.: Thank you, Mr. Lator. Could we hear from the other state agency now?

Ms. Cleanwater: Yes! I represent the Department of Environmental Quality. We will be deciding whether to issue the applicant the necessary Water Quality Certificate.

We also have some reservations about the project as proposed, because of the effects it will have on the quality of the waterway. The construction and clearing of plants from the site would destroy the filtering ability of the existing wetland, and would send more sediment and pollutants into the stream. This will dirty the water, smother fish eggs, and kill aquatic insects.

The paved parking lot and the building's rooftop would cause a lot of runoff to enter the stream. Without the plants to slow down the flow of water from the land, the rate of flow of the stream would be greatly increased. The lack of vegetation would also mean that the stream would no longer be shaded. With direct sunlight hitting it, the water's temperature will increase. Both the temperature change and the flow increase will be harmful to the trout that live and spawn in that stream. We can't afford to lose valuable trout habitat.

H.O.: Thank you, Ms. Cleanwater. As long as we're hearing about wildlife resources, let's hear what the U.S. Fish and Wildlife Service thinks about the project.

Mr. Finnenfeather: Hi. I'm Chuck Finnenfeather. Basically, the Service agrees with Ms. Cleanwater about the trout population. In addition, several other valuable wildlife species have been observed using the site as both a feeding and nesting area. Those animals include the black duck, wood duck, American bittern, great blue heron (there is a large rookery or nesting area there), spotted and box turtle, spotted salamander, and others. In the last year, two bald eagles were seen in the area. This type of habitat is becoming scarce in our region, due mostly to development. We need to protect what is left of wetlands like this one. All efforts should be made to minimize disturbance to the wetland. I think that there are ways to do that, and Mr. Lator of DNR has mentioned some of those.

H.O.: The National Marine Fisheries Service is another federal agency reviewing the case.

Mr. Fishismylife: Uh, yes. I'm George Fishismylife from National Marine Fisheries. The assessments of the other agencies have been stated very well, particularly that of the DEQ (uh, that was Ms. Cleanwater, I believe). One of our main interests is what happens to commercially important fish and shellfish. It is true that the trout population would be threatened by the project as proposed. Our agency does not predict much of an effect on commercial fisheries, except that the increased sediment load from construction could eventually reach the fishing areas downstream. If the water-quality issue is addressed by means of sediment control, then we would not object to the project.

Mr. Nailenhammer: Excuse me, please. May I ask a question?

H.O.: Yes, please do, but only a question—you must register to speak.

Mr. Nailenhammer: Yes, thank you, and I believe I will be testifying later. Mr. Fishismylife, what sort of sediment control measures would help keep the stream clean?

Mr. Fishismylife: Well, normally, in construction projects, a

stormwater management pond is called for. This would be a basin that collects runoff and allows sediment to settle to the bottom. The sediment would be trapped in the basin, while the cleaner water would flow out through a pipe near the pond's surface.

Ms. Cleanwater: Yes, that's true, but remember that in this case we're talking about a trout stream. Water sitting in a shallow pond like that would heat up quickly. Then we'd have more problems for the fish. A better idea would be to install infiltration trenches. These are basically boxes that are built into the ground. They allow the runoff to filter down into the ground before it gets into the stream. This actually cools the water off and filters out the sediment and pollutants. If the area around the trenches is planted with vegetation to add more filtering ability, then the problem would be well taken care of.

H.O.: Thank you. We should move on now. There are two more federal agencies here tonight.

Mr. Waters: I'm Phil Waters from the Army Corps of Engineers *[clears his throat loudly]*. The Corps is actually the deciding factor, here, for the federal government. We will be issuing or denying the permit under the Clean Water Act. We have not made our decision, as yet, but are taking all of these issues into account, including comments from the public. We will balance the public benefits against the natural resource losses and try to arrive at a fair decision. That's all I have to say for now.

H.O.: And finally, Ms. Powers...

Ms. Powers: Good evening. I am Vee Toh Powers from the U.S. Environmental Protection Agency, or EPA. For those of you who are not familiar with our role in this process, I will explain. EPA relies on the reports from the Fish and Wildlife Service and National Marine Fisheries for information about the project's impacts on natural resources. We have the ability to override the Corp's decision on the application, and I feel that we would not allow the Corps to issue the permit as it stands. I recommend that the applicant pay careful attention to the recommendations made here tonight. The rest home would be a valuable asset to the community, if the project is managed well with respect to the environment.

H.O.: Thank you, all agency representatives. Now I would like to open the floor to those members of the public who have signed up to speak. May we have the first speaker?

Mr. Gotbucks: I am Ron Gotbucks, the applicant. I felt I should make my presence known. I think everyone knows where I stand on this project. I have a lot of money at stake here. The project was designed this way because I felt that it would remove the hazards posed by the wetland—you know, mosquitoes, bad odor, and so on. But if you all think the marsh has some value, I'm willing to listen to suggestions to improve the project. I have to, or I won't get my permit.

[The crowd chuckles.]

Mr. Nailenhammer: Harry Nailenhammer, here. I'm the builder, hired by Mr. Gotbucks. I need to know what I'm supposed to be responsible for in this project. These safeguards you're talking about could cost a lot of money and time. I need to keep costs down for my client. I already counted on putting up silt fences to catch the eroding soil—that's common practice for my people. I need to know where it's okay to cut down trees and where I can and can't drive my equipment.

Mr. and Mrs. Sellers: We're the current owners of the property in question. We've agreed to sell the land to Mr. Gotbucks. We were going to give the property to our daughter, but she was transferred to another state for her work. We can't afford to pay taxes on the land, and we need the money from the sale for our retirement. If Mr. Gotbucks doesn't get his permits, he won't buy the land, and we'll be stuck!

Ms. Socialcause: I'm Louise Socialcause and I work for the state's Bureau of Economic Development. Frankly, I think we can't afford not to have this rest home built! The housing situation for the elderly in this area is poor. With this new facility, we'll have a better draw for more types of people to the area, which also means more consumers and a better economy. And think of all the visitors who will come here to see their loved ones and spend some money while they're here! It's something we've needed for a long time.

Mrs. Nimby: I'm Helen Nimby. I live in the adjoining community. I have two small children. The traffic in our area is bad enough as it is. Bringing more people to the area will worsen the situation. I moved here to give my kids a nice, quiet lifestyle. Now I'm worried about them getting hit by a car! And I know how long these construction projects take. We'll have noisy tractors and such disturbing us for months! What do I say to this project? Not in MY backyard!

Mrs. Hugger: Hello, everyone.

I'm Bun E. Hugger. I represent the We Protect Nature and Wildlife Society. We at WeePNoW are very disturbed at the prospect of destroying such valuable wildlife habitat. The home should be built in another location, and the area sold as reserve land. Keep it protected, for the wildlife. Wetlands are critical to maintaining clean air and water. Our children need a healthy environment! I say, stop the project altogether!

Mr. Nicerman: I'm Arthur Nicerman. This little girl here with me is my granddaughter, Sally-Jane. She's nine.

[Sally-Jane waves, beaming at her grandfather proudly.]

Every Sunday Sally-Jane and I go to the marsh there and go fishing and birdwatching. It's a nice, quiet place to spend some quality time with the little one—you should all go there some time! Well, I understand that everybody's got their reasons for wanting to use the land more profitably, but isn't there some way that they can do that and still keep a nice place for me and Sally and the critters? Maybe they could build around the marsh. That's all I wanted to say.

Mr. Pierpont Pospistle:

[He moves very slowly and takes a while to reach the front of the room.]

My name is Pierpont Pospistle. I'm 82 years old. My hearing is lousy and my eyesight is going. They don't let me drive anymore. I've been living with my son and his family but we can't stand each other anymore, not in the same house, anyway. I've already got my place in line for one of those apartments in Heron's Rook. That would give me back some feeling of independence. I like the project just as it is. I don't need to be walking a long way from the parking lot to the building. It'd make me not want to go places when my son comes to visit and take me out. Other than that, just build the danged place so I have somewhere to live!

Ms. Planwell: I am Marcia Planwell. I'm here this evening as an interested citizen, but I am employed as a wetland and environmental consultant. I'd like to make a few comments. First, Mr. Pospistle. There is a solarium (a sun room) planned for the east wing of Heron's Rook. Would you be happy looking out at a parking lot? Wouldn't you rather have a view of a natural area? If the building is set back as the gentleman from DNR suggested, this could be incorporated into the plan. Mr. Gotbucks, if you want to save money on construction, do not choose to fill in the wetland! This is very expensive, and the ground will not be very stable over the long term. It could sink! If you make the building a bit smaller, say 175 units instead of 200, you would harm a bit less wetland area. You might not make as much money on the housing, but it's a small price to pay. Certainly, the best alternative would be to put the building somewhere else completely, but a compromise on all sides is not impossible.

H.O.: Since Ms. Planwell was the last speaker, I will remind everyone that all testimony presented here is now part of the public record and will be used in deciding this case. After the permitting deadline, the public may contact the agencies to find out about the outcome of the case. I thank you all for coming. The hearing is adjourned.

THE END

"Wade into Wetlands"

WETLANDS AREN'T WASTELANDS

GOAL

Ranger Rick's* NatureScope *is a creative education series dedicated to inspiring in children an understanding and appreciation of the natural world while developing the skills they will need to make responsible decisions about the environment.

Most people never really think much about wetlands, and if they do, their thoughts often focus on how to change a wetland to make it more "productive." In fact, if you look back on the history of people's relationships with wetlands, we seem to have been following a policy of "the only good wetland is a filled-in, dredged, or channelized one." But wetlands are tremendously productive habitats and are most valuable in their natural state.

Although many people's negative attitudes about wetlands are slowly changing, the old "wetlands are wastelands" mindset is tough to get rid of. Unfortunately we are losing thousands of acres of wetlands every year because many people never got a good "wetland education."

We hope that *Wading Into Wetlands* and other wetland educational materials will help kids develop a positive attitude about wetlands. By exploring bogs, swamps, and marshes, your kids can see firsthand why these natural areas are so important to wildlife—and to people. And even if you don't live near a wetland, it won't be hard to get your group excited about such wetland wonders as meat-eating plants, gator holes, and quakin' and shakin' bogs.

As you read through the issue, you'll see we've divided wetlands into two general groups: freshwater wetlands and saltwater wetlands. Although we covered many of the major types of fresh and saltwater wetlands, we didn't have space to cover them all. For example, in the chapter on saltwater wetlands, we talk about mangrove swamps and coastal salt marshes, but not inland saltwater wetlands. But even though we couldn't squeeze in every type of wetland in the world, we know there's enough here to keep you and your group "swamped" with ideas.

Judy Braus

"Ahhhh . . . life!"

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NATIONAL WILDLIFE FEDERATION
"Working for the Nature of Tomorrow"

Wetland Models

Make a clay model of a wetland and discover how a wetland works.

Objectives:
Discuss what a wetland is. Describe several functions of a wetland

Ages:
Intermediate and Advanced

Materials:
- *chalkboard or easel paper*
- *modeling clay*
- *Oasis (florist foam)*
- *roasting pans*
- *small piece of indoor-outdoor carpeting*
- *sponges*
- *pine needles, twigs, grass, weeds, soil and other natural materials*
- *cotton swabs (optional)*
- *toothpicks (optional)*
- *cardboard*
- *glue*
- *scissors*
- *paper and pencils*
- *crayons or markers*
- *pictures of wetlands and wetland plants and animals*
- *jar of muddy water*
- *water*
- *reference books*
- *poster paints*

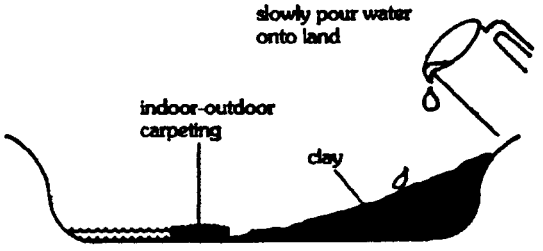
Subject:
Science

It's hard to tell, just by looking at wetlands, that they help filter silt and pollutants from water, help prevent soil erosion, and often reduce flood damage. But by building a simplified wetland model, you can demonstrate some of these important wetland functions.

Before you begin the activity, make a demonstration model. Here's how to do it:

1. Spread a layer of modeling clay in half of the roasting pan to represent land. Leave the other half of the pan empty to represent a lake or other body of water, such as a river or ocean.
2. Shape the clay so that it gradually slopes down to the body of water (see diagram).

3. Smooth the clay along the sides of the pan to seal the edges. You can also form meandering streams in the clay that lead into the body of water.
4. Cut a piece of indoor-outdoor carpeting to completely fill the space across the pan along the edge of the clay (see diagram). The carpeting represents the wetland buffer between dry land and open water.



Begin the activity by asking the kids to list the characteristics of a wetland. Write their answers on a chalkboard or large sheet of easel paper. Take a group survey to decide which of the characteristics might apply to all wetlands. (See the background information on pages 3-4.)

Next show the group some pictures of different types of wetlands, including freshwater and salt marshes, freshwater swamps, mangrove swamps, and bogs. Have the kids think about the animals and plants that might live in each kind of wetland. (For examples, see the background information on pages 18-20 and 33-35.)

Now demonstrate some of the functions of a wetland using the model. Explain that wetlands, like all habitats, are very complicated natural systems. And scientists are still learning more about how they work. Scientists already know that wetlands perform some very important functions, such as filtering pollutants, reducing flood damage, and preventing soil erosion. (Scientists also think that some wetlands, at times, might help to recharge underground water supplies.) Explain that your model will demonstrate some of these functions in a very simplified way. Here are a couple of the functions you can demonstrate with the model:

Flood Control: Fit the piece of carpeting into the wetland area. Pour some water slowly on the land, as shown. Have the kids describe what happens. (Some of the water is slowed down by the wetland [carpeting]. The excess slowly flows into the body of water.)

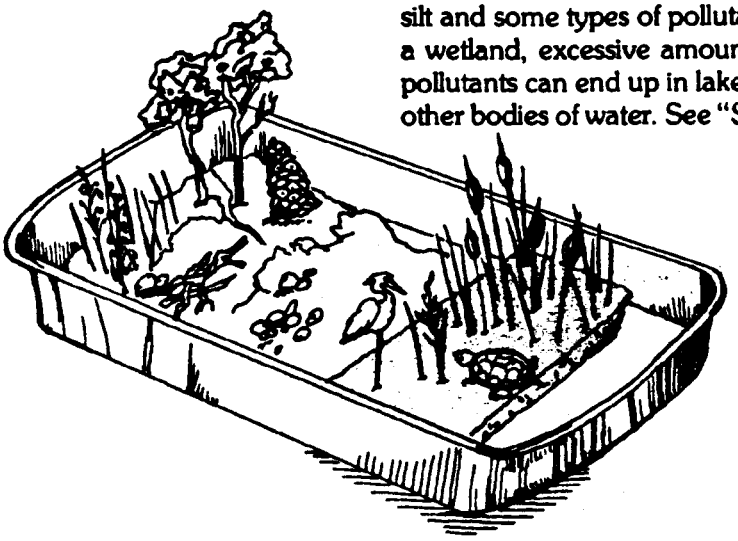
Now remove the carpeting and water. This time pour the same amount of water on the model at the same spot and rate as before. Have the kids note any differences. (The water should fill the body of water much more quickly than before. That's because it's no longer buffered by the wetland. Explain that most wetlands are shallow basins that collect water and slow its rate of flow. This slowing process helps reduce flooding and also helps prevent soil erosion.)

In many coastal areas wetlands are drained and filled in, and houses or

marinas are built right along the water. Without a wetland buffer, these developed areas are often subjected to severe flooding and erosion, especially during violent storms.

Water Purification: Pour the water out of the model and replace the piece of carpeting in the wetland. Pour some muddy water from the jar onto the land. Ask the kids to compare the water that ends up in the body of water with the water in the jar. (Explain that the soil particles are trapped by the carpeting, making the water in the body of water much clearer.)

Remove the carpeting, pour out the water, and try the experiment again. What happens without the wetland in place? Ask the kids why all the dirt particles end up in the body of water now. (The thick mat of plant roots in a wetland helps trap silt and some types of pollutants. Without a wetland, excessive amounts of silt and pollutants can end up in lakes, rivers, and other bodies of water. See "Silt Trappers" on page 4 to find out more about how wetlands act as natural filters.)



After demonstrating some wetland functions, discuss how wetlands are important wildlife habitats, as well as important recreation sites for people. (See the background information on pages 46-48 for more about how wetlands are important to people and wildlife.)

Now divide your group into smaller groups of about five each. Tell each group they will be making their own wetland models out of clay, using your model as an example. (Instead of using indoor-outdoor carpeting to represent a wetland, have them use Oasis [florist foam] molded into a very shallow basin. Then the kids can attach plants and animals to the model with toothpicks.) They can make a freshwater marsh, a salt marsh, a freshwater swamp, a mangrove swamp, or a bog. Provide reference books so the kids can see pictures of the different types of wetlands. Then have them decorate the models according to the types of wetlands they are making. Here are some ideas:

- For cattails, use cotton swabs painted brown, pieces of grass, or toothpicks painted green with bits of brown clay stuck on the tops.
- Use long pine needles for reeds.
- Shape wetland creatures from clay or cut them from paper and glue onto toothpicks.
- Make trees by gluing pieces of green sponge onto twigs.

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2001: a water odyssey

Teachers' Key/Student Worksheet 1 **Recommended Grades: 4 and up**

The following worksheets may be photocopied and distributed to your students if you wish them to complete a structured activity while touring the exhibit, *2001: A Water Odyssey.* You may wish to assign the Open-ended response pages *after* the tour, when the students have returned to the classroom. If you do this, you may wish to let them know the questions *before* the field trip, so they can think about possible answers as they tour.

Please instruct all students using these worksheets or other written assignments to follow these guidelines:

1) Do not prop your papers up on exhibits when filling in your answers. Use clipboards, notebooks, or your partner's back to provide a rigid surface behind your paper.
2) Please handle the hands-on exhibits gently and try not to touch the text panels.
3) Do not walk along the stream edges, cross into the landscaped areas, or touch the plants.
4) Be on your best museum behavior: respect the displays and the other visitors to the Fair.
5) If you must sit down on the floor to work on your paper, please find an out-of-the-way spot to do so.

Some questions have many possible answers, but here are some possible answers you may find on tour:

1. Activities that can impact water quality in this watershed include: coal mining, construction/development, lawn fertilizer, pet waste, logging, crop fertilizer, cattle in the stream, ATV in the stream, sinkhole dumping, paved surfaces, car oil leaks, eroded streambanks, channelized stream...Natural features that can improve water quality include wetlands, forests, and riparian zones.
2. basin
3. The Mississippi River watershed covers about 1.2 million square miles.
5. Marine fossils are found in the limestone, since seas covered the land that is now Kentucky 400 million years ago.
6. Native Americans and Euro-Americans were both drawn to Kentucky's water resources and settlements were often located near rivers, streams, springs, and other water features. See 1750s, 1774, 1778, and 1788.

7. 1981, Valley of the Drums in Bullitt County and 2000 Martin County coal slurry spill.
8. Wetlands—they reduce flooding, naturally filter water, and provide a vital environment for certain plant and animal species.
9. Riffles, shoals, pools, vegetated banks, riparian zones, meanders are all features of a healthy stream. Allowing the water to flow naturally and keeping trees, shrubs, and groundcover along the streambank are just two examples of ways to maintain stream health.
10. Ohio River species such as paddlefish, carp, spotted bass, river darter, and bluegill may be found on the Big River Ecosystems poster and in the 4,000 gallon fish tank.
11. Aquatic ecosystems are communities of plants, animals, and bacteria and their water habitats—the environments where they live, feed, and reproduce. Small creatures such as crayfish, beetle larva, dobsonfly, and mayfly may be studied to find out how clean a stream, river, or lake is. They are called bio-indicators or indicators of the life the water is able to support.
12. Urban and suburban development—expansion of cities and surrounding neighborhoods—often changes the natural features of the land and water. Streams may be straightened, narrowed, or dammed and wetlands may be filled in so that homes, businesses, roads, parking lots, and other structures may be built. Construction causes increased sediment to enter streams. Paved surfaces increase and speed runoff and prevent natural filtration of contaminants.

Name_____

2001: a water odyssey

Student Worksheet 1

Find the answers to these questions in the exhibit, *2001: A Water Odyssey*. Answers will be found in and around the stream landscape. We'll give you clues where to look.

Begin in the Introduction area, where a giant triangle covered with huge pictures is found beneath the *2001: A Water Odyssey* banner.

1. Check out the watershed model and giant matching picture. List at least three activities shown here that could impact water quality.
   a.

   b.

   c.

2. What's another word for watershed?

3. Find the Kentucky Watersheds map here (or use the floor map version). Write the name of the watershed in which you live here:
   What is the really big watershed that all of Kentucky empties into?
   How big is it?

4. Read about water related jobs on the Careers Kiosk. Which one sounds interesting to you? Why?

Look for answers to these questions along the timeline, "Milestones in Kentucky Watershed History."

5. What kinds of fossils can you see at the Falls of the Ohio and at other exposed limestone sites in Kentucky? How old are these fossils and why are they here?

6. Find one example of how water has influenced settlement in Kentucky and write about it.

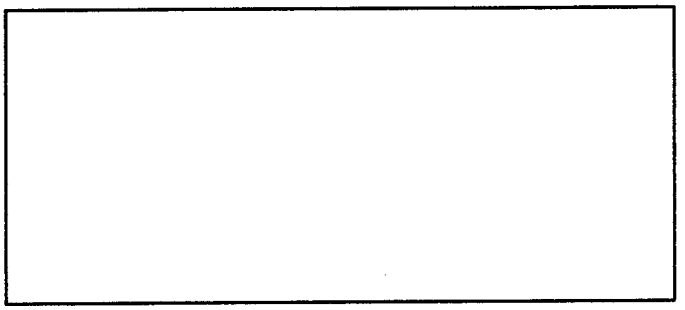
7. Find one example of water pollution in Kentucky on the timeline. When and where did it occur?

Tour the stream area to locate the following answers.

8. What is an area that has water on the land surface all or part of the time? Why is this water environment so important?

9. Name at least one feature of a healthy stream and write about one way to keep a stream healthy.

10. Name a fish species of the Ohio River and draw a sketch of it here.



11. What is an aquatic ecosystem? Name an aquatic species that helps determine the health of the water.

12. What is urban and suburban development, and how does it affect water quality?

Name_____

2001: a water odyssey

Student Worksheet/Open-Ended Response

1. In the space below, write a definition for the word "watershed," using your own words.

2. In the space below, make a sketch of something you found to be interesting in the exhibit. Beneath it, write a brief "label" or description to teach something about your picture.

3. In the space below write a definition of "nonpoint source pollution," then give three examples of nonpoint source pollution.

4. Hopefully, you learned some new things on your tour, including how *you* can take actions for better water quality each day. Use the space below to write about ways that you can impact Kentucky waters.

2001: a water odyssey

Student Worksheet 2—Discussion Questions for Adult Leaders to Ask Younger Students While Touring Recommended Grades: K-4

Find the answers to these questions in the exhibit, *2001: A Water Odyssey*. Answers will be found in and around the stream landscape. We'll give you clues where to look.

Begin in the Introduction area, where a giant triangle covered with huge pictures is found beneath the *2001: A Water Odyssey* banner.

1. Check out the watershed model and giant matching picture. What kinds of things are going on here? Many of these activities can pollute the water—make it too dirty for swimming or fishing. Do you see some things that might pollute the water?

2. Look at the giant pictures that surround the Introduction. What kinds of water features do you see here (lakes, waterfalls, streams, wetlands, ponds, rivers)? How are we using water in these pictures (drinking, swimming, fishing, boating, transporting goods...)?

3. A watershed is the land that water flows across or under on its way to a stream, river, or lake. It's an area of land that drains into one particular body of water. The land around us—our back yard, neighborhood, our town, our county—is made up of watersheds or basins that are all connected together. Let's go to the giant floor map and find the watershed where *we* live. Next, let's count all of the big watersheds in Kentucky. How can we find the name of each watershed? What are the wavy, dark blue lines on the map? What is the wavy line along the north edge of Kentucky? Where is the capital of Kentucky? How do you know it's the capital?

Next, visit the timeline, "Milestones in Kentucky Watershed History."

4. Let's compare the pictures of boats and bridges and dams. How do these things help us use the waterways in our community? What is a flood? Can you find pictures of the biggest flood in Kentucky history? When was this flood?

Now, it's time to walk along the stream.

5. Who would like to push the button to operate this lock and dam model? How does it work? How would a lock and dam help a boat move down the falls of a river?

6. Find a section of the stream that curves and has rocky areas (called riffles) and a marshy wetland. These are all parts of a healthy stream. One of the signs shows a drawing of the parts of a healthy stream. Remember this drawing and the way the flowing stream here looks. We're going to make drawings of a healthy stream when we get back to school.

7. Along the stream, we see things that show that coal mining, farming, and logging are all activities in the watershed. How can these activities affect the water?

8. How do you use water every day? Do your parents or neighbors use water in other ways? At the water calculator display, "How Much Water Do You Use Each Day at Home?," let's figure our daily water usage. [do the math based on consensus figures from the group] How do we use the most water at home? What can we do to use less?

9. Let's visit the Home lawn area to learn something new we can do for cleaner water. What do we want to go home and teach our families?

10. Can you find the place where the stream begins? Does the water seem to come from under the ground? This is called groundwater, and groundwater flows under layers of soil, sometimes coming to the surface to flow into streams and lakes.

11. There's a 4,000 gallon fish tank here. What kind of fish do you see? Where do you think these fish came from? Are they from a small stream or a big stream? What's another word for a really big stream?

12. Nearby is a picture of some strange looking aquatic or water creatures. Why do you think the picture is so dark? Where can you find underground streams like this? Have you ever been in a cave?

13. Before we leave, can you tell me ways *you* can help Kentucky waters be clean and healthy? Why is this so important?