Corridors of Exploration: Iowa's Rivers

Iowa Department of Natural Resources
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Introduction

This activity book includes information about the exploration of Iowa via our river corridors and provides opportunities to compare current river conditions/issues to those encountered by early explorers. It contains 11 activities for grades 4-8 which may be easily adapted for older students.

This booklet and supplemental aids were produced as a part of the Iowa Department of Natural Resources' Aquatic Education Program, which is designed to educate the citizenry about Iowa's aquatic resources so they may make informed, responsible decisions about their use.

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How To Use This Booklet

This booklet provides activities that compare/contrast Iowa's current water quality and the quality of water when early explorers visited the state. Some activities are designed to promote problem solving skills, while others are designed for discovery and awareness. Eight rivers are included in this booklet: Mississippi, Missouri, Boyer, Des Moines, Raccoon, Skunk, Cedar, and Big Sioux. The explorers discussed include Marquette and Joliet, Lewis and Clark, Zebulon Pike, Stephen Kearny, surveyors of the General Land Office (GLO), and the Dragoons Albert Lea and Nathan Boone.

These activities may be used together as a unit, or individually. The introductory lesson, "Destination Hydracon," can be used to introduce each of the activities. Each activity includes *time* required for the activity, *vocabulary*, *objectives*, *method*, *materials* needed, *background information*, *procedure*, *evaluatio*n, and possible *extensions*. A list of *reference materials* is provided for more information on the topics covered.

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Iowa's Water

As educators, we often ask questions of our students to help them learn about the world around them. A common question is, "What are the four components of habitat?" It's amazing how quickly some students will answer food, water, shelter, and space. Have you ever wondered how much they know about these? Let's take water. How much do they know about water? Where does it come from? How can it be polluted?

Students may know that all creatures need water to survive. (Without it we could live for just a few days.) They may also know that water is composed of three tiny atoms, one oxygen and two hydrogen, bonded together. Some may even know that Iowa receives 32 inches (over 2½ feet) of precipitation a year. But do students know about the quality of our water? Better yet, do they know about the history of water quality in Iowa?

Iowa's History

Before Euro-American settlement, it is estimated Iowa had 28.6 million acres of prairie, 6.7 million acres of forest, and 4.5 million acres of wetlands. Approximately 22,000 miles of interior rivers and streams meandered through these wild areas. Pre-settlement Iowa was home to many species of wildlife including buffalo, elk, deer, bear, channel catfish, northern pike, passenger pigeons, smallmouth bass, and brook trout. The Native Americans who lived here were predominately descendents of the Woodland Culture (named by Euro-Americans). These people farmed, hunted, played, and died on the land we now call Iowa.

Early Explorers

Early explorers were some of the first Euro-Americans to see Iowa as a diverse, pristine ecosystem. Bohumil Shimek, an early Iowan naturalist, described the pre-settlement forested ravines as having "…beautiful ferns, interspersed with pink and yellow ladies'-slippers and many other wild flowers, all in great profusion." Early explorers saw these ravines and other breathtaking beauties we can hardly imagine.

Many explorers followed rivers and streams as they made their way across Iowa. These explorers wrote of Iowa's rivers and streams in their journals. They described some rivers and streams as being "…relatively clear with a gravel bottom…" (Albert Lea, 1836). Some caught remarkable amounts of fish in the rivers, "…Captain Lewis went out the next day with his party and returned with 709 fish nearly 200 pike amongst them…" (Whitehouse, 1806).

Marquette and Joliet

Euro-American exploration began in 1673 when Father Marquette (a Jesuit priest from France) and Louis Joliet (a French-Canadian fur trader from Quebec) canoed from Fort St. Ignace on Lake Michigan, up the Fox River to the Grande Portage (now Portage, Wisconsin) where they entered the Wisconsin River. They and five other voyagers traveled down the Wisconsin River, entering the Mississippi River at Prairie du Chein, Wisconsin, in June of that same year. It is believed they are the first Europeans to visit Iowa, stepping ashore near the confluence of the Iowa and Mississippi Rivers.

Marquette and Joliet are credited as being some of the first Europeans to ever see the Mississippi River. As they entered the Mississippi they saw a large channel with backwaters, sloughs, and secondary channels. The river was full of life, from bluegill, bass, and catfish to countless birds, beaver, deer, and other wildlife using the river for food, water, or navigation routes. In some places the bottom of the river was paved in mussels, similar to the cobblestone streets Marquette and Joliet had seen in towns. In spring, the river flooded while in summer it was low, allowing many aquatic plants to flourish. The scene they saw must have been incredible. Father Marquette recorded the sights he saw and experiences he encountered in his journal.

At the confluence of the Arkansas and Mississippi Rivers, the group began their return journey up the Mississippi. The area south of this point was under Spanish occupation. Since Spain was France's rival they feared they would encounter trouble if they continued. The party traveled up the Mississippi and Illinois Rivers to Lake Michigan. Unfortunately, Joliet lost both copies of his journal when he tipped his boat in the La Cline Rapids near Montreal. He escaped the rapids, but an Indian boy did not. The only written accounts came from a short diary Marquette wrote during the voyage.

Lewis and Clark

Lewis, Clark, and their crew of forty men (known as the Corps of Discovery) began their journey up the Missouri River on May 14, 1804. Their mission was four fold: 1. Find the Northwest Passage to the Pacific Ocean, 2. Create a good relationship with the Indians to increase trade, 3. Observe and record natural history and ethnology of the area, and 4. Look for resources for future settlers. All members of the Voyage of Discovery were required to keep a journal of their experiences, although not all have been recovered.

Thomas Jefferson selected his personal secretary, Meriwether Lewis, to organize this expedition. Lewis chose William Clark, his friend and former army commander, to share the responsibility of leading this remarkable adventure. Together, Captains Lewis and Clark would lead 40 men across terra incognita – the vast unknown land west of the Mandan Villages (located near present day Bismark, North Dakota).

While both men were comfortable in the wilderness and were excellent hunters, they were very different from each other. Lewis had a more formal education, trained in botany, zoology, geology, and celestial navigation. His personality is often referred to as being withdrawn, moody, and sometimes depressed. Clark was the cartographer for the journey and the better boatman. He is often described as having had a sunnier disposition than Lewis, and proved to have a more level head.

In the latter part of 1803, the crew built their quarters in an area across the river from St. Louis, which they named Camp Wood. Lewis spent much of the winter in St. Louis gathering supplies and making arrangements for their journey. On May 14, 1804, the crew started their journey up the Missouri. Their route would take them up the Missouri River (where they occasionally camped on Iowa shores), to the Mandan Indian village where they stayed the first winter, across the Bitterroot Mountains (in present day Idaho), and down the Snake and Columbia Rivers to the Pacific Ocean.

After reaching the Pacific in the late fall of 1805, they stayed at Fort Clatsop, on the estuary of the Columbia River. They began their journey home in late March of 1806. When the Corps of

Discovery passed the Bitterroot Mountains, they split up, exploring different rivers. Clark went down the Yellowstone while Lewis explored the Marias, both in present day Montana. They later met on the Missouri in present day North Dakota, and continued their journey back to civilization.

In 1806, Lewis, Clark, and the other members of the Corps of Discovery returned to St. Louis. Great celebrations were held in honor of their arrival. The Corps of Discovery traveled 8,000 miles to a land unknown, and (except for the loss of Sgt. Floyd near Sioux City, Iowa, from what is believed to be appendicitis) returned safely. With this journey, a broad path through the Rockies was mapped, the length of the Missouri River and much of the Columbia River were charted, relationships were established with many Indian Tribes, and information about 178 plants and 122 animals were added to the scientific world.

Zebulon Pike

Approximately 132 years after Marquette and Joliet's journey, another explorer traveled the Mississippi. In August 9, 1805, General James Wilkinson assigned Lt. Zebulon Pike on a mission to discover the origin of the Mississippi River, look for potential military sites, and communicate with the native people living in the area. Pike led a crew of 20 men on a 70-foot keel boat (which he later traded for two barges at Prairie du Chein) up the Mississippi with little time to prepare for the journey.

He, like William Clark from the Corps of Discovery, was designated cartographer. However, there were many differences between Pike's expedition and the journey of the Corps of Discovery. Due to Pike's lack of training in the sciences, they did not look for new plants and animals. Pike had no interpreter of Indian languages and no physician. A watch, thermometer, and a theodolite (a device to determine latitude) composed his entire scientific equipment inventory.

On credit, Pike purchased over 155,000 acres where the Minnesota River empties into the Mississippi. Pike agreed to pay the Dakota (Sioux) Indians $200,000 for this land which would be used for a military reservation. Gen. Wilkinson did not agree with the location or the price, and refused to authorize the transaction. Later, army engineers found the land to be the best site for a military base on the Mississippi River. To the Dakota's dismay, the U.S. government paid a mere $2,000 for the land 13 years after the agreement. The post, later named Fort Snelling, was not constructed until 1819.

After the negotiation with the Dakota, the journey continued to run into problems. They ranged from backbreaking winter treks through frozen rivers and lakes and confrontations with British traders unwilling to lower British flags, to a sergeant giving away all of the stored meat, foodstuffs, and Pike's personal belongings at an American stockade.

After traveling close to 5,000 miles Pike returned to St. Louis on April 30, 1806, with disappointing results. He did not find the origins of the Mississippi, stop the illicit fur trade, bring any Indians back to meet with Gen. Wilkinson, nor did he find any new streams, lakes, or rivers. Purchasing the land for Fort Snelling and drawing attention of the activity of British traders in the U.S. (resulting in the Canadian/U.S. border) were his only successes. Despite the inadequate results of the journey, Gen. Wilkinson appointed him to go on another expedition to the southwestern United States, during which he reportedly named Pikes Peak in present day Colorado.

Stephen Kearny

General Stephen Kearny, a soldier, builder, writer, and explorer, commanded the western army during the time of U.S. expansion. Kearny is often referred to as "The Father of U.S. Calvary." He led U.S. forces during the Mexican War where he left his name in many states including Arizona, California, Nebraska, Texas, and Wyoming. Before his military career blossomed, Kearny led explorations through Iowa.

In July of 1820, Kearny and his crew of four officers, 15 soldiers, four servants, and an Indian guide with his wife and baby, went on a government expedition to find a route from Council Bluffs to Camp Cold Water (later named Fort Snelling) in present day Minnesota. They followed the Boyer and Little Sioux Rivers and crossed the prairie pothole region to the northern post. Kearny reported seeing many land animals on his journey. Some of these animals include foxes, wolves, prairie chickens, rattlesnakes, elk, and a herd of 5,000 bison.

Kearny spent sixteen days traveling through Iowa on this expedition. For various reasons, he found this route to be impractical for larger military forces. Troops never followed the path again.

The Dragoons

On March 2, 1833, President Andrew Jackson signed a bill creating a new armed force called the Dragoons. This armed force consisted of groups of uniformed soldiers which patrolled on horseback across the frontier. Some of the Dragoons' duties consisted of keeping peace between Indian tribes, keeping European poachers off Indian lands, building and maintaining paths/roads, and occasionally mapping and exploring uncharted areas of Iowa.

One of these explorations was organized to map the area between the Des Moines and Mississippi Rivers. In 1835, Lieutenant Colonel Stephen Kearny, Captain Nathan Boone (tenth child of Daniel Boone), Lieutenants Albert Lea (whom Albert Lea, Minnesota, is named for), and H.S. Tanner commanded three companies of approximately 170 men across "Indian Country." Lt. Lea (cartographer for the party) drew maps and kept a journal.

This large group of men traveled along many rivers in present day Iowa. Their journey started in the southeastern corner at Fort Des Moines (where Montrose now lies). The group followed the divide between the Des Moines and Skunk Rivers passing Hahawa Lake, present day Swan Lake, in Hamilton County. They crossed wetlands and prairies of north central Iowa. From here they traveled along the Cedar, Shellrock, and Upper Iowa Rivers in Iowa and the Root and Zumbro Rivers in Minnesota. The group of Dragoons saw the Mississippi and then started their journey home. This 1,100-mile trip took them approximately three months to complete.

Along the way, the Dragoons saw very little game, which they credited to the crowding of Indians on small tracts of land. Between hunting and the profit of fur trading many populations of game animals and fur bearers had been greatly reduced. They did notice, however, that every stream was well populated with fish.

The second company of Dragoons to explore Iowa was led by Captain James Allen in 1844. The primary purpose for this journey was to reach the source of the Des Moines River and explore modern day southwestern Minnesota and northwestern Iowa. They, like Albert Lea's group, traveled up the Des Moines River. However, this company left from a different Fort Des

Moines, one founded a year previous by Captain Allen. Present day Des Moines now sits in the location of this fort.

This company followed the Des Moines River until they reached its source. From here they traveled to the Minnesota River and then marched west to the Big Sioux River. While traveling on the Big Sioux River they marveled at a falls that "breaks through a wonderful formation of massive quartz (Sioux Quartzite) that crosses it perpendicularly, and over which the river falls 100 feet in 400 yards."

At the confluence of the Missouri and the Big Sioux, the men started back to Fort Des Moines across country. They noticed the rich prairie, timbered ravines, and the many streams as they crossed the virgin land.

This summer expedition covered 740 miles. Reports written by Kearny and Lea to the Adjunct General in Washington attracted many settlers to Iowa. Some historians consider it the most important exploration of Iowa.

The General Land Office (GLO)

The U.S. General Land Office (GLO) was established in 1812 by the federal government to survey land in the central and western United States. Surveyed land was then "disposed of," sold, or given away. Settlers moving onto the frontier paid for the land. State, counties, schools, war veterans, railroads, and steamboat companies were given land. By surveying, the federal government could raise money and locate and legally describe the parcels purchased by the settlers.

The general survey of Iowa began in the fall of 1836 near the southeastern border, at the Mississippi River. Surveying parties often were composed of five to seven men: a deputy surveyor, two chainmen, a flagman, a marker (axeman), and sometimes one or two mound builders. Groups carried their own flags, shovels, axes, compasses, a 66-foot chain, and personal belongings until their contracts were completed. These men traveled across prairies, rivers, wetlands, and forests without paths or roads. It took 168 deputy surveyors twenty-three years to survey approximately 1,650 townships.

Each deputy surveyor kept field notes as he walked the land. The early field notes contained basic surveying measurements. Later field notes were more detailed and included descriptions of natural and cultural features of the survey lines. Geo(rge?) Stump, while crossing Sioux County, noted the Floyd River as being "…on average about 30 links wide and caused by be[a]ver dams to be about 30 inches deep gentle current good clear water low grassy banks in some places are lined with willow bu[s]hes runs in a gravel bed…." (These field notes currently are being used by Paul Anderson from Iowa State University to make digitized (computer) maps of Iowa's vegetation between 1832-1859.)

If we traveled the routes of early explorers today,
what would we find?

Iowa Today

Iowa has changed greatly from the time of early Euro-American settlement. According to the Iowa Association of Naturalists, we have lost 99.9% of the 30 million acres of prairie to agriculture, urban development, and transportation routes. More than 95% of the original 4.5 million acres of wetlands have been filled or drained to expand agriculture and development. Iowa also has lost 2/3 of the original 6.7 million acres of forests to early logging, fence posts, log buildings, and agriculture. In 1974, only 1.5 million acres of forests remained.

There is potential to reclaim some of our lost natural resources. According to the Iowa DNR, more than 606,000 acres of prairie *could be* restored through roadsides and private gardens. Some 100,000 acres of wetlands and surrounding uplands have been restored or are being reconstructed. In 2002, forest acres expanded to 2.5 million acres due to less grazing and more planting of trees.

Water Quality

How does what happens on the land affect the quality of Iowa's water? Forests anchor soil, provide shade to keep waters cool for certain species of organisms to live in, and provide roots which create habitat for aquatic life. Prairie plants also hold soil in place, promote infiltration of water (decreasing run-off), and are the base of the prairie food chain. Wetlands are diverse habitats that hold water before slowly releasing it to rivers, streams, and lakes.

Water quality can be negatively influenced by human actions. Channelization (straightening) of streams and rivers to create more farmland and drain wet soils more quickly leads to increased soil erosion and loss of aquatic habitats. Fertilizers and chemicals applied to fields and lawns can end up in surface and groundwater. According to Iowa's State Hygienic Laboratory, of ten-thousand private water supply samples voluntarily submitted, 40 percent show unsafe bacterial contentand 15-20 percent exceed the maximum level for nitrate in drinking water (Iowa State University Extension, 1993).

While bacteria and chemicals contaminate underground wells, streams, lakes, and rivers, the leading pollutant in Iowa is silt (very fine soil). Sediment originates from erosion processes within a drainage area (watershed) of a river, marsh, or lake. Soil is carried to bodies of water by surface runoff, wind, or stream bank erosion. Soil erosion is a natural process but is accelerated greatly by human activity. Silt decreases the amount of light that enters the water, hence aquatic plants and algae are decreased. It adds to bottom sediments, clogs the gills of small aquatic animals such as insect larvae, smothers fish eggs, and interferes with sight feeders such as bass, which are unable to locate prey. Damage from erosion exceeds $54 million annually in Iowa.

Humans can have positive impacts on watersheds and water quality as well. Improving soil conservation in watersheds can reduce sediment entering rivers, streams, and lakes. Some examples of conservation farming practices that improve watersheds include buffer strips, grass waterways, terracing, rotational grazing, and minimum tillage. Routine maintenance of vehicles prevents pollutants such as antifreeze and oil from entering the environment through leaks. Disposing of litter and other wastes properly ensures aquatic animals will not be affected.

Research of aquatic systems and water quality has a positive impact on water quality as well. Research is performed by a variety of personnel, from DNR fisheries biologists, geologists, and environmental specialists to college professors and federal agencies, such as the Natural

Resources Conservation Service (NRCS), Fish and Wildlife Service, and Army Corps of Engineers.

Besides performing research, governmental agencies assist citizens in improving water quality. Many counties and towns have hazardous waste drop off sites and recycling centers. Soil and Water Conservation Districts, NRCS, and DNR/county foresters and wildlife and fisheries biologists assist landowners in reducing erosion through the creation of riparian buffers, wetlands, or grasslands. Buffer strips reduce soil loss, improve water quality, and stabilize stream banks. They also improve aesthetics and wildlife habitat. NRCS and DNR personnel help interested landowners evaluate their properties to determine whether they comply for the U.S. Department of Agriculture's Conservation Reserve Program (CRP).

Often biologists monitor resources to assess long-term changes in fish and wildlife populations that result from changes in habitat. The Long Term Resource Monitoring (LTRM) Program on the Mississippi River is an example. This program, authorized by Congress in 1987, was designed to address resource problems such as navigation impacts, sedimentation, water level fluctuations and quality, lack of aquatic vegetation, and reduced fish populations in addition to monitoring invertebrate populations and land cover/use.

Volunteer monitoring has been occurring for decades in Iowa. Early programs include "Save our Streams" and the "Iowa River's Project." In 1996, The DNR began the IOWATER volunteer water quality monitoring program with support of the Izaak Walton League, Iowa Environmental Council, Farm Bureau, Natural Resource Conservation Service (NRCS), and the University of Iowa's Hygienic Laboratory. Since its initiation, IOWATER has registered 1,000 sites for data collection.

Other Materials

Audiovisual Programs (contact your local AEA for availability):
Aging Lakes
A Freshwater Algal Boom
Iowa's Precious Waters
Lakes: Aging and Pollution
The Mississippi River: Ol' Man River and the Twentieth Century
Oxygen Levels during an Algal Bloom
There Once Was a River Called Missouri
Tomorrow will not Wait – Air, Water and Land Conservation
Water Pollution: A First Film
Water Pollution: Soil and Water Conservation

Popular Literature

Mendoza, G. 1990. Were You a Wild Duck Where Would You Go? A wild duck narrator looks at the past when the environment was bountiful, searches through today's polluted environment for a home, and encourages saving and restoring the environment for a home and for the future.

MacGill, Sheila. 1991. And Still the Turtle Watched. A turtle carved in rock on a bluff over a river by Delaware Indians long ago, watches with sadness the changes humans bring over the years.

Destination Hydracon

Time

two or three 45-minute periods

Vocabulary

natural resources, natural resource management, pollutant, potable water, pristine, water quality, wilderness

Objectives

Students will be able to:

- relate to natural resources early Euro-American explorers discovered in Iowa.
- identify ways people have affected Iowa's natural resources.

Method

Students read a story about exploration and exploitation of an imaginary world. They write a paper describing what they find on the imaginary world and then research the history of settlement of their county/town. They discuss effects people have had on natural resources in their area.

Materials

copies of *Student Handout*
writing materials
paper

Background

The first explorers of Iowa ventured into a world basically unknown to Euro-Americans. Some came as early as 1673, but most came after the Louisiana Purchase in 1803. The United States was only 29 years old when the majority of explorers arrived in Iowa.

A new age was coming. Explorers went to unknown places and returned with tales of their adventures. The journals and letters to President Jefferson from Captain Meriwether Lewis encouraged many people to venture west and start new lives. Lewis and Clark also discovered new plants, animals, people, and navigation routes. Albert Lea's journal perhaps had the most profound effect on the immigration of Euro-Americans to present day Iowa. The following are entries from Clark's and Lea's journals.

- "Both wood-land and prairie, thus far, are exceedingly fertile, the soil being a black loam based upon clay. The trees are usually oak and hickory, and the woods are free from undergrowth; and no stone is to be found, except siliceous pebbles and granitic boulders." – Albert Lea, 1835
- … [the Cedar River] is 45 yds wide, 4½ ft deep, with a current of ¾ mile per hour; and it is fed also by lakes: from these facts it may be inferred with great probability that keelboats may be taken to its very source, during severally months of the year, and that even steamboats of light draught may navigate it advantageously." – Albert Lea, 1835
- "This being my birth day I order'd a Saddle of fat Vennison, an Elk fleece & a Bevertail to be cooked and a Desert of Cheries, Plubs, Raspberries Currents and grapes of a Supr. Quality. …Musquetors verry troublesome, the Praries Contain Cheres, Apple, Grapes, Currents, Rasp burry, Gooseberris Hastlenuts and a great Variety of Plants and flours…What a field for a Botents [botanist] and a natirless [naturalist]" – Clark, Aug 1, 1804

- “we Stoped to Dine under Some high Trees near the high land on the L.S. in a fiew minits Cought three verry large Catfish (3) one nearly white, Those fish are in great plenty on the Sides of the river and verry fat, a quart of Oile Came out of the Surpolous fat of one of those fish” – Clark, July 29, 1804

Since no census was performed in Iowa until the late 1800s, it is difficult to estimate the number of people in Iowa before explorers arrived. For thousands of years, various cultures lived here. Around the time of European exploration, members of the Oneota Culture lived in the Midwest. This culture was traditionally composed of the Winnebago, Ioway-Oto, and Missouri.

Some members of the Oneota Culture lived in villages before and after the first explorations. The largest Oneota village was located along the Big Sioux River in northwest Iowa at the present day Blood Run National Historic Landmark. This village was home to the Ioway and Oto, and possibly the Omaha and Ponca. Other Ioway villages have been located along the Upper Iowa River and in Iowa’s great lakes region.

From the late 1600s to the early 1800s, fur traders and missionaries made various settlements in Iowa. Unfortunately, no journals are found from these people, perhaps due to the loss of journals. The first recorded settlement was by Julien Dubuque in 1788 near the Mesquakie’s lead mines near present day Dubuque. In 1796, Dubuque received a land grant from the Governor of Spain who resided in New Orleans at the time. This land grant gave Dubuque permission to work 189 acres of Spain’s land. While the land was commonly referred to as the “Lead Mines,” Dubuque decided to change the name to “Mines of Spain.” This name is still represented by the Iowa DNR’s *Mines of Spain State Recreation Area*.

In 1860, 187 years after Marquette and Joliet’s expedition, the population of Iowa reached 674,913. The number grew exponentially between 1860 and 1880, reaching 1.6 million. By 1900, 2.2 million people lived in Iowa and greater than 85% of the land was converted from wilderness to agriculture. In 2000, 2.9 million people resided in Iowa, the most biologically altered state in the country.

Procedure

Part I

1. Make copies of the student handout, *Destination Hydracon*. Distribute *Part 1* to students.
2. Have the students read (or read to the students) *Part 1* of *Destination Hydracon*.
3. Discuss the story, asking the following questions:
   - Why do you need to explore Hydracon?
   - What will you take with you?
   - What types of animals do you expect to find?
   - How will you travel?
   - How will you and your crew of 20 map the routes you travel?
4. Have students write a paper on their discoveries covering the above questions.
5. Allow time for students to report to the class as if they are in front of the “President of Earth.”

Part II

1. Distribute *Part 2* of *Destination Hydracon*.
2. Have students read (or read to them) the second part of *Destination Hydracon*.
3. Ask the following questions:
   - What has happened to the animals you “saw” during your exploration of Hydracon?
   - How do you think you would feel if you actually explored Hydracon first? How do you think you would feel if you saw Hydracon 330 years later?

- Why did the people cut down the trees and till the grasslands?
- What has happened to the water of Hydracon? Why?
- Would this affect people who live on Hydracon? If so, how?
- Would this affect wildlife that lives on Hydracon? If so, how?

4. Explain to the students that something similar happened to Iowa. Go over Iowa's history and the status of our water today (refer to ***Iowa's Water***).
5. Have students research what their county/town was like before Euro-American settlement and what it is like now. Possible sources of information include:
   - Historical surveys of counties (visit www.iowater.net/educators/Wetlands/Wetlands.asp for more information and to learn about the General Land Office)
   - Old newspaper articles
   - Dinsmore, J.J. 1994. A Country So Full of Game. Iowa City: University of Iowa Press.
   - County historical societies
   - Iowa Historical Society (visit www.iowahistory.org or write to the State of Iowa Historical Building, 600 East Locust Building, Des Moines, IA 50319-0290 for more information)
6. Have students write a one- or two-page summary of their findings.

Evaluation

How much research did students do for their papers? Check for proper use of grammar and correct spelling. Ask the following questions:

1. What are the similarities between Hydracon and Iowa, specifically the county/town where you live? What are the differences?
2. Have the people of Iowa been affected by actions of early settlers? If so, how?
3. Has wildlife been affected by actions of early settlers? If so, how?
4. In your opinion, do the people of Iowa need to protect their water? Why or why not?

Extensions

Have students make a map, model, or drawing of their counties pre-settlement and post settlement.

Research the status of rivers that run through your county. Do they meet **water quality** (condition of water) standards that have been set for them (look at the Iowa DNR's water quality webpage: www.iowadnr.gov/water/index.html)? If no, why not?

Explore ways students can improve water quality in water bodies in your town/county.

Destination Hydracon
Part 1: Exploring the Water World

It is 300 years in the future. Earth has become overcrowded with people. Many of Earth's **natural resources** (raw materials provided by the Earth and usually processed into useful products) are gone due to improper **natural resource management (**the practice or act of controlling the harvest, protection or restoration, or other use of resources). The most important is the amount of **potable** (drinkable) **water**. The limited fresh water available for human use has been contaminated with a number of **pollutants (**substances that may contaminate air, water, or soil). The people of Earth cannot live in these conditions much longer. People are growing restless and want a better life.

The president of Earth has requested that you do a great favor for her and all civilization. She wants you to explore Hydracon, a newly discovered planet in the middle of the Milky Way. It is reported that this planet has many valuable natural resources that may be harvested and sent back to Earth. Most notable is abundant, clear, unspoiled water, something Earth has been short of for many years.

This **pristine** (unspoiled) planet also may serve as a landing station for future explorations deeper into the Milky Way and become a site for a military base to protect the people of Earth from other troublesome planets. Earth's inhabitants may even establish a settlement on Hydracon.

The president of Earth wants you to map Hydracon, describe the creatures you find, locate potential sites for military bases and settlements, and learn about the local cultures on the planet.

Destination Hydracon
Part 2: The Return Visit

You documented your journey to Hydracon and reported to the president when you returned home. People were very excited about your findings. They held parties and celebrations in your honor. Word spread about your journey. At first, few people moved to Hydracon. Then as tales of the richness of this world were told, more and more people moved.

People are amazed at the **pristine wilderness** (unspoiled natural areas) of the planet: clear running streams, great forests thousands of miles wide, and grasslands as far as the eye can see. People think there is no end to the amount of resources Hydracon has. To survive, they cut down trees to make homes and farms. They mow grasslands and till the soil to plant gardens and fields to feed their families and livestock. They also send natural resources back to Earth for people left behind.

A group of Hydracon historians find documentation of your first exploration of the planet. But, 330 years later there is not one square mile of land that is untouched. Many trees are gone, grasslands have vanished, and worst of all, the water (that everybody came for) is no longer unspoiled. It is dirty with many pollutants in it. Fish species that lived in the rivers when you first arrived are gone. There are few animals left anywhere. The historians begin to search for reasons for the decline of the planet…

What Would You Have Done?*

Time

two to three 45-minute periods

Vocabulary

aquatic, archaeological sites, channel, economic depression, erosion, glochidia, habitat, migration, mussel, non-point source pollution, point source pollution, pollutant, runoff, sediment, sedimentation, snag, terrestrial, water quality, watershed

Objective

Students will be able to evaluate the positive and negative effects of managing the Mississippi River for navigation.

Method

Students portray individuals representing differing perspectives and concerns related to a complex issue at a "public meeting."

Materials

one copy of *Role-Playing Cards*, cut individually
copies of *The Situation at Hand* for each student
writing materials
paper

Background

The Mississippi River is very different now than when Marquette and Joliet traveled its waters. The transformation of the river began in 1866 when the Corps of Engineers created a four-foot navigation channel. Workers dredged, cleared overhanging trees, and removed other obstructions in the main **channel (**deeper part of a moving body of water where the main current flows) of the river. In 1872, the Corps pulled close to 1,300 **snags** (fallen trees) and cut 2,600 overhanging trees. One can only imagine the **habitat** (arrangement of food, water, shelter or cover, and space suitable to animals' needs) those snags provided for the river's **aquatic** (growing, living in, or frequenting water) life.

In 1878, Congress authorized creation of a 4½-foot channel to allow larger boats to travel upstream. This was done with wing dams (rock or wooden structures that come out perpendicular to the shore) and closing dams (dams that run from the shore to an island or from one island to another and eliminate the flow of water to backwaters during low water) to keep the flow of water in the main channel.

River traffic did not increase as was anticipated, so Congress authorized a six-foot navigation channel. More wing and closing dams were built and sand was dredged from the main channel. Even with the six-foot channel, navigation on the river was not up to the potential some people dreamed of.

In 1933, Congress authorized a nine-foot channel. The mandate created a series of locks and dams, acting like stair steps. This huge project was completed between 1934 and 1940. The locks and dams that we see on the Mississippi River today are from this project.

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* Adapted with permission from the activity "The Great Dredging Decision," Exploration of the Mississippi River Activity Guide, Jeff Janvrin, Wisconsin Department of Natural Resources, Wisconsin, 2002.

Many changes have occurred on the Mississippi River since Marquette and Joliet canoed its channel and backwaters. More **sediment** (fine soil and other particles that settle to the bottom of a liquid) travels down the Mississippi River now as compared to 1673 due to the large amount of agricultural and urban development in the river's watershed**.** Dams have slowed the flow of the river causing **sedimentation** (accumulation of sediment) to occur more quickly.

According to the Upper Mississippi River Basin Association, approximately 583 miles (69 percent) of the river has **water quality** (condition of water) problems. These vary from exceeding water quality standards for some **pollutants** (substances that may contaminate air, water, or soil), advisories on fish consumption, contaminated sediment, and state restrictions on swimming or fishing. These problems stem from numerous pollutants from the **watershed** (area of land that drains into a particular body of water) that contaminate the river.

Nonpoint source pollution (pollution which cannot be traced back to its origin) is a major source of water quality problems. This includes **runoff** (water that drains or flows off the surface of the land) from agricultural and urban lands, which can contain soil, pesticides, fertilizers, oil, and grease. Nonpoint source pollution is difficult to control because there is no single location where pollutants enter the river.

Point source pollution (pollution which can be traced back to its origin) can be a source of water quality problems as well. Point source pollution includes industrial discharges, wastewater treatment plant discharges, and overflow of sewer systems. Point source pollution is easier to identify and control. This type of pollution is regulated by a system of permits issued by states to control the concentration of pollutants allowed in the discharge of industries.

Some pollutants may be from a combination of present and past activities. The presence of PCBs in sediment, fish, and mayflies may be from past use of the substance. It also may be from a source not yet determined.

The water quality of the Mississippi River has improved through various methods of preventing pollution. States have created stricter and more comprehensive water quality standards. **Erosion** (removal or wearing away of soil or rock by water, wind, or other forces or processes) control programs like the Conservation Reserve Program (CRP), buffer strips, minimum till farming, terracing, and grassed waterways have reduced sediment entering the river.

While the Mississippi can be considered cleaner than what it was 30 years ago, it needs continuous commitment and expansion of programs to ensure progress continues. Despite the progress we have made, it will never return to the state Marquette and Joliet saw.

For more information on Marquette and Joliet's expedition on the Mississippi River, refer to *Iowa's Water*, page 1.

Procedure

1. Share information about the history of the Mississippi, Marquette and Joliet's expedition, the construction of the locks and dams, and the river's current status (see *background information*).
2. Provide students with *The Situation at Hand* information (either by reading it to them or giving them copies to read).
3. Discuss some of the possible costs and benefits of constructing a lock and dam system on a river from a variety of perspectives.
4. Distribute the cards from the *Role-Playing Cards* to the students. Create any additional roles that illustrate a variety of perspectives and interests.
5. Ask students to research their roles and to develop a short position paper for use in a presentation at the public meeting.

6. Arrange the room to represent a public meeting. Students role-play their positions and make presentations to the elected officials in the United States Congress. Congress will ultimately make a decision on the construction of the locks and dams.
7. After all students have made their presentations, ask the members of Congress to form a consensus plan that attempts to accommodate the various positions.
8. Following Congress's decision, have a brief class discussion to summarize the pros and cons that emerged from student presentations. Identify and list the benefits, if any, and the costs or liabilities, if any, as a result of the decision. Include effects on people, plants, and animals.
9. After the role-play and class discussion, ask each student to write a brief essay describing the student's personal historical recommendation for construction of the locks and dams on the Mississippi River. The students may expand their position papers in writing their essays.

Evaluation

1. What were the characteristics of the Mississippi River when Marquette and Joliet explored it? (flow, water quality, physical appearance, habitats, wildlife)
2. What are the characteristics of the Mississippi River now?
3. Name two or more possible benefits of the construction of locks and dams.
4. Name two or more possible negative consequences of the construction of locks and dams.
5. How has water quality of the Mississippi River been impacted since Marquette and Joliet explored the area?
6. Have fish and wildlife of the Mississippi benefited or been harmed by the changes people have made to the River? Explain. (Some species are more abundant, others are less abundant, some are threatened or endangered.)

Extensions

Attend a public meeting in your community.

Research bodies of water in your community. Were there public works projects done on or around them in the 1930s or 1940s? Why were these projects done? How have they affected the water body? The local community?

Research the Civilian Conservation Corps (CCC). Did CCC members work in your county? If so, what was their project? Has it affected water quality? How?

Teacher Aids

Posters

"Aquatic Life." Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Benthic Macroinvertebrates." Ill. SB Lauterbach. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Fish Iowa! Fish Posters." Ill. Maynard Reese. 1994. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Life in a Stream." Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

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"Biodiversity of Iowa: Aquatic Habitats." 2001. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Canaries of the Deep, The Plight of the Fresh Water Mussel." 2003. Geode Resource Conservation and Development Incorporated.

"Living Landscape." Conservation Technology Information Center.

What Would You have Done: Role-Playing Cards

Bing Button: owner of a local button manufacturing plant – concerned about the impact locks and dams will have on mussel populations	Com R. Us: prominent business person – would like to see the river used as the navigation tool it could be
New Deal: President of the United States – worried about unemployment of many of his citizens	Foss L. Fuel: local coal miner – would like to transport coal down the river
Un M. Ployed: local man without job – seeks employment with the construction of locks and dams	E. Lected: Mayor of area town – hopes the construction of locks and dams will bring jobs and money to the town
T. X. Payer: U.S. citizen – concerned about government spending	Col. C. L. Over: Coast Guard – concerned the channel will be deep enough for safe passage of vessels
Woody Duck: waterfowl hunter – likes current habitat for ducks, geese, and other water birds	O. MacDonald: Iowa farmer – wants more efficient method of transporting grain
Musk E. Lunge: Fish and Wildlife Service – concerned about the lock and dams' impacts to fisheries	I. Ketchum: commercial fisherperson – does not want prime fishing spots to be affected by dredging and construction
Marge Barge: owner of barge company – wants to have the river deep enough for navigation	O.L. Coot : Iowa Conservation Commission Wildlife Biologist – concerned about the impacts flooding will have on waterfowl
Tired O'Wadin: Corps of Engineers Supervisor – wants a more efficient system to assist in navigation	Also E. Lected: U.S. Senator – wants to fund large public construction projects to put citizens to work
Art I. Fact: archaeology buff – concerned the pools created by locks and dams will flood the sites of Native American villages and burial mounds	John Trapper: area trapper – concerned about the dam's impacts to furbearers
T.M. Burr: owner of lumber company – land will be inundated by the pools from the dams	M. O. Mearth: Soil Conservation Service – concerned about erosion during the construction of the dams
Muss Elman: mussel harvester – concerned about effects of sedimentation on mussels	H.M. Owner: owner of house in river bottoms – doesn't want house to be flooded by the dams
E. Conomy: area business person – wants to see transportation on the river to bring more people and supplies to his town	Polly Tishin: U.S. Representative – wants to fund large public construction projects to put Americans at work

The Situation at Hand

It is 1933. The false prosperity of the 1920s has disappeared and the American people are left with the harsh reality of life during an **economic depression** (period of time where there is an economic downturn usually accompanied with high unemployment, loss of value of currency, and lower stock values). More than 10 million Americans are unemployed. Franklin Roosevelt recently took office with a plan to get Americans back to work.

This plan, a.k.a. the "New Deal," will use government money to create jobs for citizens. One of the proposed projects involves the creation of the locks and dams system on the Mississippi River.

Quick Facts

- The locks and dams will create a nine-foot channel from St. Louis, Missouri to St. Paul, Minnesota.
- The Upper Mississippi River has been known for the troublesome snags, sandbars, and rapids that create havoc for river travelers.
- The system will take approximately six years to create and will employ thousands of workers. After construction, hundreds of employees will be needed to operate the facility.
- Some estimates say the project will cost as much as 164 million dollars.
- Many economists project a growth in the local and national economy due to the expansion of trade.
- Water quality will be affected by increased sedimentation due to decreased rate of flow from the dam's blockage of water.
- Wildlife would be affected by:
  - Loss of **terrestrial** (living or growing on land) habitat from flooding the valleys.
  - Blockage of the **migration** (the periodic movement of animals from one area to another and back again as a natural part of their lives) of fish due to the creation of locks and dams.
  - Reduction of migratory fish species (skipjack herring, paddlefish) adapted to free flowing waters.
  - Increase in warmer, nonflowing water habitat resulting in an increase in crappie, bluegill, largemouth bass, and other fish tolerant of these conditions.
  - Great increase in backwater habitat initially due to its expansion.
  - Decrease in the habitat for waterfowl due to the elimination of seasonal flow which allows their food (aquatic plants) to grow.
  - Decrease in the amount of **mussels** (mollusks that have two shells and are collector-filterers) due to increased sedimentation and the loss of migrating fish to transport their **glochidia** (young).
- Other Impacts
  - American Indian **archeological sites** (a place where material remains of past peoples are found) will be flooded.
  - Houses and towns located near the river will be flooded.

Fish in the Seine

Time
Part I – two 45-minute periods, Part II – one or two 45-minute period(s), Part III – two 45-minute periods

Vocabulary
aquatic, benthic trawl, channel, channelization, dam, dissolved oxygen, electrofishing, flood, floodplain, habitat, habitat generalist, habitat specialist, ichthyologist, niche, pool, population, pristine, riffle, run, sediment, seine, snag, species, species richness, turbidity, water quality

Objectives
Students will:

- identify fish according to their characteristics.
- recognize correlations between habitat quality and animals present.
- identify changes in the Missouri River.
- describe methods biologists use to gather data on the Missouri River.

Method
Students will research fish characteristics, diet, and habitat and graph data on charts. *Part III* allows students to sample a local fish population, collect data, graph the results, and compare them to the Corps of Discovery's results.

Materials
graphing paper
pictures or drawings of different fish and fish anatomy
writing materials
copies of *Student Worksheet I* for each small group
copies of *Student Worksheet II* for each student
Part III:
(materials for making a seine)

- two 6, 8, or 10-foot long by 3 or 4-foot wide fiberglass window screening or ¼-inch netting
- four 4-inch wide strips of canvas (6, 8, or 10 feet long)
- four 4-inch wide strips of canvas (3–4 feet long)
- 4 broom handles or wooden dowels (4–6 feet, both need to be same size)
- thread
- sewing machine

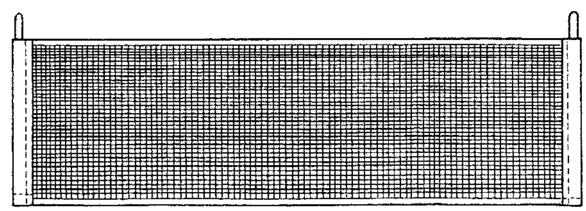

Illustration from the Homemade Sampling Equipment, Water Quality Series Booklet 2, Tennesse Valley Authority

Directions
1. Sew 6, 8, or 10 foot long (depending on your net size) strips of canvas to top and bottom of the net.
2. Make two 1-inch castings at either end of net with the 3 or 4-foot strips of canvas making sure to sew bottom end of casting shut as shown.
3. Insert broom handle or wooden dowel.

Background

Nicknamed the Big Muddy, the Missouri River is the longest river in the United States, covering 2,341 miles. It drains one-sixth of the continental United States. Historically, it had floodplain forests, turbid water, braided streams, and numerous **snags** (underwater structures that may be manmade – stake piles, cedar trees or natural – fallen trees), sandbars, rapids, and varying flow patterns that made travel difficult. The Corps of Discovery encountered these navigation problems on their long journey.

While the Missouri was treacherous for navigation, it contained excellent **habitat** (arrangement of food, water, shelter or cover, and space suitable to animals' needs) for wildlife including deer, mallards, plovers, mussels, mosquitoes, and catfish, often noted in journals of the Corps of Discovery.

On August 15, 1804, Lewis, Sgt. Floyd, and nine other men sampled the fish **population** (number of a particular species in a defined area at a given time) in a small tributary northeast of present day Macy, Nebraska. The men used a type of brush net made of willow and bark as a seine. Lewis noted their first attempts to sample the fish populations to be successful, catching 308 fish. He identified the species as pike, salmon, bass, perch, redhorse, catfish, and silverfish. The next day Lewis went out with a dozen men and sampled the fish community again. This time they caught about 800 fish. Lewis recorded pike, brook trout, white bass, catfish, buffalo, red horse, bass, channel catfish, and many minnows.

The Missouri River has undergone many changes since Lewis and Clark traveled it. Steamboat traffic began in 1819 and peaked in 1869. People started removing snags in 1832. This activity peaked during 1885-1910. In 1901, 17,676 snags, 69 drift piles, and 6,073 overhanging trees were removed (Pierce, 2003).

While the Upper River (in Montana) still is **pristine** (unspoiled), the Middle River (through eastern Montana and North and South Dakota) and Lower River (along Iowa and through Missouri) has been altered. From 1937-1963 the Corps of Engineers impounded the Middle River for navigation, flood control, hydro power, irrigation, and recreation. In 1912, the **channelization** (straightening) of the Lower River began. In 1945, Congress mandated construction of a nine-foot channel from the confluence of the Missouri and Mississippi to Sioux City, Iowa. This **channel** (deeper part of a moving body of water where the main current flows) has been maintained ever since.

Historically, the Missouri had a main channel with a large **floodplain** (land near a stream/river which flood water spills onto) and many braided streams, sloughs, and varying water flow. The alteration of the river has increased its depth, **turbidity** (the amount of light that can get through the water column due to the amount of suspended sediments in water that make the water muddy or cloudy) from channelization, and summer flow from upstream **dams** (impoundments). Since dams upstream control water flow, variation in the river's flow is greatly reduced. The stable water flow allows navigation on the river, but decreases backwater habitat during spring **floods** (the abnormally high stream/river flow that overtops the banks of a stream/river) and **aquatic** (growing, living in, or frequenting water) plant growth in the summer's dry season. Channelization also has resulted in the loss of secondary channels, sloughs, and backwater, which in turn resulted in a loss of habitat for fish.

Today, biologists study fish communities through various methods including **electrofishing** (using an electric current to temporarily stun the fish so they can be identified, weighed, and measured), **benthic trawls** (dragging a net on the river bottom to gather fish), and **seining** (dragging long nets through the shallows to capture fish) to name a few. The Corps of Discovery's brush net was a crude seine.

Scientists may look for **species richness** (number of species present in an environment) when studying a fish community. Typically a higher quality environment has greater species richness. Different **species** (individuals that are more or less alike and are able to breed and produce fertile offspring under natural conditions) occupy different **niches** (function of an organism or population within an ecological community). A more diverse community has more niches available, so more species are present. Species may be **habitat generalists** (may live in a variety of habitats) or **specialists** (require specific conditions to live).

One habitat specialist is the brook trout. It needs cool water with lots of **dissolved oxygen** (molecules of oxygen gas dissolved in water). Largemouth bass can live in many different types of habitats. They are generalists.

The results of a recent study performed by the Iowa Cooperative Fish and Wildlife Research Unit and Iowa State University shows species richness is higher in the channelized Lower River than the upper and middle sections, but there are more exotic (non-native) fish. Populations of native fish are declining.

A second study by the US Geological Services Bureau and Environmental Protection Agency determined that the Missouri River along the channelized section is actually less turbid than it was historically. They cited many explorers' quotes on the fast current of the main channel and the large amounts of **sediment** (fine soil and other particles that settle to the bottom of a liquid) in their drinking water. These explorers reportedly saw sandbars form in front of their eyes.

For more information on Lewis and Clark's journey up the Missouri River, refer to *Iowa's Water,* page 2.

Procedure

Part 1

1. Share *background information* on the Corps of Discovery and the Missouri River.
2. Initiate a discussion of former habitats of the Missouri River and animals that lived there.
3. Divide the class into small groups. Make and distribute copies of *Student Worksheet I* to each group. Assign one fish from the *Student Worksheet I* to each group.
4. Have students research characteristics of the fish, ways to identify it, its habitat, and its diet.
5. Allow time for students to share their results in class and to complete the missing sections of *Student Worksheet I*.

Part II

1. Make copies of *Student Worksheet II* and distribute to students.
2. Discuss the Corps of Discovery's population sampling of the Missouri River. Initiate a classroom discussion of the results.
3. Have students calculate species richness from the Corps of Discovery's population sampling.
4. Have students graph data from the table.
5. Allow time for students to complete the worksheet.

Part III

1. Obtain (or create – see the *Materials section* for directions) two seines.
2. Select a small, fairly shallow, slow-moving stream with a fish population near your school as the sampling site for this activity. Be sensitive to the impact you may have on stream banks and beds, spawning and nesting sites, and vegetation. Have students establish ethical guidelines for their sampling activities. If the stream is not a public site, obtain permission to visit it. Advise students in advance to dress for the setting – old (sturdy) shoes and shorts or jeans are best.
3. At the sampling site, brief students on habitat courtesies, working from their own list of ethical guidelines for sampling activities. Instruct them on how to minimize damaging the habitat and encourage care in their collecting techniques. Emphasize that all wildlife is to be returned to its habitat unharmed. Designate two to three people as recorders. These students will write down the species of fish collected. The remaining students will assist in seining the stream.

4. Have students identify different habitats in the stream. **Pools** are deeper than adjacent areas. Water flow is slowed and the bottom is usually made of very small particles. **Runs** are sections of a stream or river with moderate current and fairly uniform water flow. **Riffles** have fast current and are typically shallower than a run or pool. The water surface is broken up due to flowing over rocks.
5. Have one group of students take one seine and stand in the water, extending the seine across the width of the stream if possible.
6. The second group should walk on the shore, entering the stream a small distance from the stationary seine. Have the second group walk the seine to the first group. It is important to keep the bottom of the seine on the bottom of the stream to prevent fish from escaping.
7. After the second group meets the stationary group, have students bring the bottom of their nets to the surface to see what fish they caught.
8. Have all students assist in identification using fish identification guides. A guide is available on the web (www.iowadnr.gov/education/index.html). If small fish are difficult to identify, group them into minnows, darters, or a combination. The Topeka shiner, a federally endangered fish, may be found in the Raccoon, Boone, and Rock drainages in Boone, Calhoun, Dallas, Hamilton, Green, Lyon, Osceola, Sac, Webster, and Wright counties. Teachers that can identify the Topeka Shiner should note the location, date, number and any other information and send to Daryl Howell, Iowa DNR, 502 E. Ninth Street, Des Moines, IA 50319-0034, 515/281-8524. Recorders should record the data and note where fish were collected (pool, riffle, run). Immediately release all fish after identification. Following the ethical guidelines established by the group, seine in different locations and different directions (upstream, downstream).
9. Have students figure species richness and graph results from their population sampling. Compare their results to the Corps of Discovery's.

Evaluation

Part I
1. What are some differences between fish? (shape of mouth, body shape, etc.)
2. What do fish eat? (answers should vary depending upon fish)
3. Where do fish live?
4. What is a habitat generalist? What is a habitat specialist? What are examples of both of these?

Part II
1. What is the species richness of the fish community in the Corps of Discovery's study?
2. How many habitat generalists did the Corps of Discovery find? How many habitat specialists? Does this tell us anything about the quality of the river? Why or why not?
3. How has the Missouri River changed since the Corps of Discovery traveled it?
4. What are some ways to improve the quality of the Missouri River for fish and other aquatic animals? (practice soil conservation, allow some of the flood plain to return to it's natural state, reduce activities that cause non-point source pollution)

Part III
1. What was the species richness of your sample? How does this compare to the species richness of the Corps of Discovery sample? What are some possible reasons for differences? (different nets, different streams, changes in water quality)
2. What species of fish did you collect? How does your list compare with the Corps of Discovery's?
3. Did you find any exotic species? (carp, zebra mussels, etc.)
4. Did you find more fish in pools, runs, or riffles?
5. What types of fish did you find in pools (habitat specialists or generalists)? Why?
6. What types of fish did you find in runs (habitat specialists or generalists)? Why?
7. What types of fish did you find in riffles (habitat specialists or generalists)? Why?

8. Can you create any hypotheses about this stream's **water quality** (condition of water) from this study? What are they? How could you prove them? (more studies, collect data from different areas, etc.)

Extensions

Invite a local DNR fisheries biologist or county conservation board naturalist to bring fish for a demonstration and discuss ways to identify fish and sample populations.

Adopt the stream where you seined fish.

Collect other data (pH, dissolved oxygen, nitrates, and phosphates) and see if there are correlations between these and the species present. Measure these in other streams and compare the results.

Make this activity a bi-annual event for your class. Note differences in species found at different times of year.

Research more about the Corps of Discovery's journey. Numerous websites and books are available on the subject. Visit www.pbs.org/lewisandclark for additional lesson plans regarding their travels.

Teacher Aids

Posters

"Aquatic Life." Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Benthic Macroinvertebrates." Ill. SB Lauterbach. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Fish Iowa! Fish Posters." Ill. Maynard Reese. 1994. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Life in a Stream." Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

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"Biodiversity of Iowa: Aquatic Habitats." 2001. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Canaries of the Deep, The Plight of the Fresh Water Mussel." 2003. Geode Resource Conservation and Development Incorporated.

"Living Landscape." Conservation Technology Information Center.

Books

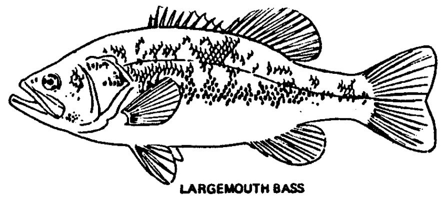
Clark, W. and M. Lewis. 2002. The Definitive Journals of Lewis and Clark Up the Missouri to Fort Mandan. Edited by G. Moulton. Lincoln: University of Nebraska Press.

Iowa Department of Natural Resources. 1987. Iowa Fish and Fishing. Des Moines.

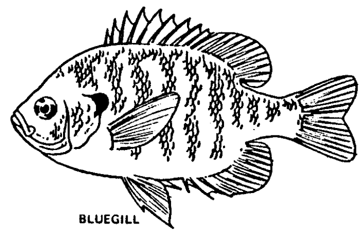
Zim, H.C. and A.C. Martin. 1987. A Golden Guide to Pond Life. New York: Golden Press.

Student Worksheet I: Fish in the Seine

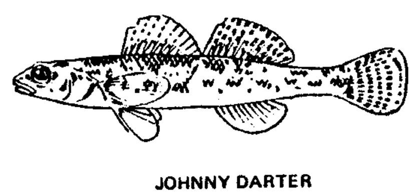
Common Name:
Scientific Name:
Habitat:
Description:
Food:
Importance:



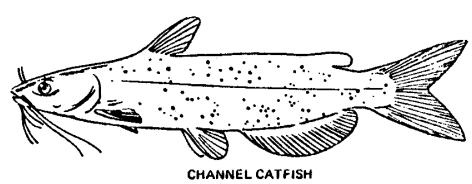
Common Name:
Scientific Name:
Habitat:
Description:
Food:
Importance:



Common Name:
Scientific Name:
Habitat:
Description:
Food:
Importance:



Common Name:
Scientific Name:
Habitat:
Description:
Food:
Importance:



(Illustrations courtesy of the Illinois Department of Natural Resources)

Student Worksheet II: Fish in the Seine

Lewis and Clark recorded 31 species of fishes in their journals and notebooks during their journey up the Missouri River and down the Snake and Columbia Rivers. On August 15, 1804, Clark and 10 men used a seine and caught "318 fish of different kinds, i.e., pike, bass, salmon, perch, red horse, small cat, and a kind of perch called silverfish on the Ohio" (*The Definitive Journals of Lewis and Clark Up the Missouri to Fort Mandan*, 2002).

The next day Lewis and 12 men caught the fish listed in the following table. Some of the fish were misidentified. Through their drawings and descriptions, **icthyologists** (people that study fish) can identify the fish more correctly. However, not all identifications came with descriptions and drawings. The possible current names included in the table, are guesses from fisheries biologists, historians, and water quality specialists. Study the table and answer the questions.

Species Collected	Possible current name	# Collected
pike	walleye – *Stizostedion vitreum,* northern pike – *Esox lucius*	79
salmon resembling trout	mooneye – *Hiodon tergisus,* goldeye – *Hiodon alosoides,* brook trout – *Salvenlinus fontinalis**	8
salmon trout	mooneye – *Hiodon tergisus,* goldeye – *Hiodon alosoides* brook trout – *Salvenlinus fontinalis**	18
rock	northern rock bass – *Ambloplites rupestris,* warmouth – *Lepomis glulosus*	1
flat back	flathead catfish – *Pylodictus olivaris,* blue catfish – *Ictalurus furcatus*	1
buffalo	bigmouth buffalo – *Ictiobus cyprinellus,* smallmouth buffalo – *Ictiobus bubalus,* black buffalo – *Ictiobus niger*	approximately 64
red horse	black redhorse – *Moxostoma duquesnei,* golden redhorse – *Moxostoma erythurum,* silver redhorse – *Moxostoma anisurum,* shorthead redhorse – *Moxostoma macrolepidotum,* river redhorse – *Moxostoma carinatum,* greater redhorse – *Moxostoma valenciennesi*	approximately 65
bass	smallmouth bass – *Micropterus dolomieui,* largemouth bass – *Micropterus salmoides*	4
cat	channel catfish – *Ictalurus punctatus,* bullhead (yellow, black, brown) – *Ictalurus* sp.	490
silver fish	golden shiner – *Notemigonus crysoleucas*	71**
shrimp	crayfish – Family *Cambaridae*	1

* the brook trout is not believed to be the correct species
** No amount was given for silver fish. This number was calculated by adding the total number of species caught and subtracting that number from 800 (the number of fish Lewis stated catching).

Student Worksheet II: Fish in the Seine

1. Species richness is figured by adding the number of different species in an environment. For example, if there were 68 bluegill, 49 channel catfish, and 25 largemouth bass in a pond, the species richness would be 3 (bluegill, channel catfish, and largemouth bass.) What is the species richness of Lewis' sample from above?

2. Which of these animals are habitat specialists (animals that must have a habitat with certain conditions)? Which of these animals are habitat generalists (animals that can live in almost any habitat)? HINT: Research where animals live…trout are habitat specialists because they must live in cold water streams, catfish are habitat generalists because they can live in many types of habitats: rivers, lakes, or ponds.

3. Graph the number of habitat generalists and habitat specialists. Label the x-axis, "Type of Species." Label the y-axis, "Number of Species."

Messin' in the Mud*

Time
one 45-minute session

Vocabulary
Cesium 137, erosion, floodplain, pollutant, radio-isotope, sediment, sedimentation, water quality, watershed

Objectives
Students will be able to:

- determine how sediment samples are gathered.
- determine how sedimentation rate values are calculated.

Method
Students graph and interpret actual Mississippi River data of sediment accumulations and perform an activity looking at sedimentation in a stream/river/pond.

Materials
graph paper
smooth, clear plastic water bottle or container
Table 1

Background
At the time of Zebulon Pike's Mississippi River expedition, the North American fur trade was underway. Euro-Americans had been traveling the Mississippi's tributaries trading with Native Americans for many years. Iowa's first Euro-American settler, Julien Dubuque, mined lead with Mesquakie Indians near present day Dubuque for 17 years. Besides the occasional settlement, the Mississippi River had changed little from when Marquette and Joliet had first seen it, 132 years prior to Pike's expedition.

Only 128 years after Pike's journey, people began to construct locks and dams on the Mississippi. The purpose of the locks and dams was to create a series of pools to provide adequate depth for navigation. These pools act like a stair step of water between Minneapolis, Minnesota and St. Louis, Missouri. Construction of the locks and dams permanently flooded lowland **floodplains** (land near a stream/river which flood water spills onto) and transformed seasonal wetlands into large pools of water.

The stabilization of water levels also reduced its rate of flow (speed), hence its ability to transport **sediment** (fine soil and other particles that settle to the bottom of a liquid). The decrease in water speed has accelerated **sedimentation** (accumulation of sediment) along the river. Sediment is now one of the most damaging **pollutants** (substances that may contaminate air, water, or soil) in the river. The constant **erosion** (removal or wearing away of soil or rock by water, wind, or other forces or processes) of upland areas in its **watershed** (land that drains into a particular body of water) threatens to fill in backwaters of the Mississippi within the next 50 to 100 years. So, monitoring sedimentation in the river corridor is very important.

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* Adapted with permission from Exploration of the Mississippi River Activity Guide, Jeff Janvrin, Wisconsin Department of Natural Resources, Wisconsin, 2002.

One way to determine sedimentation rates is to obtain bottom samples from the river and determine the depth at which the **radio-isotope Cesium 137** (^{137}Cs) appears. A radio isotope is a radioactive isotope (one of two or more species of atoms of the same chemical element that have the same atomic number and occupy the same position in the periodic table and are nearly identical in chemical behavior, but differ in atomic mass or mass number and so behave differently in the mass spectrograph, radioactive transformations, and physical properties). ^{137}Cs is a radioactive product of explosions from nuclear bomb tests.

Nuclear fallout first entered our environment in 1954. Peak nuclear testing by Americans occurred during 1957 and 1958. Heavy Russian testing occurred from 1962-1964. In 1971, the French and Chinese engaged in some limited nuclear testing. ^{137}Cs binds strongly to small particles such as clay and organic matter, so tends to retain its position in the soil column. As soil erodes, some particles that have ^{137}Cs bonded to them are deposited downstream as sediment. Provided that sediment is undisturbed, and that the sediment regularly erodes, the amount of sediment deposited during a given time period can be determined by the amount of ^{137}Cs present in that layer of river sediment.

Sedimentation rates have decreased in recent years, but are still a threat to the Upper Mississippi River valley. Some backwater lakes will become marshes within the next century. Since much of the Upper Mississippi River watershed is cultivated, maximum conservation of upland soils is crucial to maintaining the Upper Mississippi River.

To learn more about Zebulon Pike's journey up the Mississippi River, refer to *Iowa's Water,* page 3.

Procedure

1. Share and discuss the *background information* regarding the history of the Mississippi River and how construction of the locks and other factors has contributed to accelerated sedimentation in the Mississippi.
2. Describe to students how ^{137}Cs is used to determine sedimentation rates in the Mississippi River.
3. Provide students with the sedimentation rates data from *Table 1*. Have them graph "pool number" (x-axis) versus "sedimentation rate" (y-axis) for the 1954-64 and 1965-75 time blocks. Students should include a legend with their graph.
4. Have students generate possible explanations for differences in the amounts of deposited sediment for the different pools as well as the different time blocks (i.e., quantities of suspended sediments increase as you go downstream, levees in the upper river prevent erosion, farmland contributes to greater degrees of erosion).
5. Have students speculate on the reasons behind the decreased sedimentation rates in more recent years (i.e., soil loss reduction techniques such as contouring, grassed waterways, conservation tillage).

Evaluation

1. How has the Mississippi River changed since Zebulon Pike explored the area?
2. Where does ^{137}Cs in the environment come from?
3. How is ^{137}Cs used to determine sedimentation rates?
4. List three things (human induced or natural) that contribute sediments to the Mississippi River.
5. How does sediment impact Mississippi River habitats and critters?
6. What are some ways to reduce the amount of sediment that reaches the Mississippi River?

Extensions

Remove the top and bottom of a smooth, clear plastic water bottle or container to form an eight-inch (or longer) "tube." In a wadable stream, push the tube gently into the bottom with a slight twisting motion. When you have pushed the tube in as far as you can, dig down to the bottom of the tube and lift it out of the water. Wipe any mud off the outside of the tube. You should be able to see layers of sediment that have been deposited over time. This is similar to how core samples are done to calculate sedimentation rates.

Research information about soil erosion and conservation in Iowa. Visit the NRCS web site (www.nrcs.usda.gov/technical/land) to view maps on soil erosion rates and learn about factors affecting **water quality** (condition of water).

Go to the photo gallery on the NRCS' home page (www.nrcs.usda.gov) to look at examples of good soil conservation techniques – buffers, contour farming, etc. How many techniques are used in your county?

Teacher Aids

Posters

"Aquatic Life." Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Benthic Macroinvertebrates." Ill. SB Lauterbach. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Life in a Stream." Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

CD Rom

"Biodiversity of Iowa: Aquatic Habitats." 2001. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

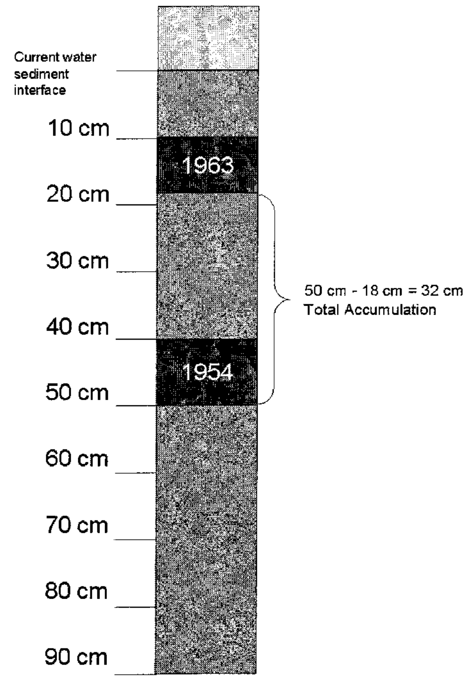
"Canaries of the Deep, The Plight of the Fresh Water Mussel." 2003. Geode Resource Conservation and Development Incorporated.

Books

Iowa Department of Natural Resources. 1987. Iowa Fish and Fishing. Des Moines.

Zim, H.C. and A.C. Martin. 1987. A Golden Guide to Pond Life. New York: Golden Press.

Figure 1: Example of a sediment core using Cesium 137 to determine sedimentation rates



The diagram shows the bottom of the first peak (1954) at approximately 50 cm. Cesium 137 was absent prior to 1954, so, in this area of the Mississippi River, the maximum depth of the bottom of the first peak would be 50 cm.

The bottom of the second peak (1963) is at 18 cm., this represents the second of two main peaks (1954-58 and 1963-64). This suggests the bottom line of the first peak occurred in 1954, and the bottom line of the second peak occurred in 1963. If we consider these to be inclusive years, we can say that 32 cm of sediment accumulated over this 10-year time period.

Table 1: Comparison of selected sedimentation rates for Pools 4 through 10, Upper Mississippi River

Pool	Principal Tributary Stream	Number of Profiles Sampled	Maximum Depth 137Cs (cm)	Estimated Rate of Sedimentation (cm/yr) 1954-64 1965-75 (Average Values)
4	Chippewa	5	60	3.4 1.2
5	Zumbro	5	60	3.1 1.1
5A	(None)	4	70	4.1 2.0
6	Trempealeau	6	90	3.0 3.3
7	Black	7	60	3.2 0.9
8	Root	6	80	2.8 2.0
9	Upper Iowa	8	70	4.3 1.2
10	Wisconsin	6	90	3.6 2.5
			Mean	3.4 1.8

Source: Wiener, James G., Richard V. Anderson, and David R. McConville. (ed.) 1984. Contaminants in the Upper Mississippi River. Boston: Butterworth Publisher.

Who Polluted the Missouri?*

Time
one 45-minute session

Vocabulary
aquatic, channelization, dam, flood, floodplain, habitat, meander, non-point source pollution, pollutant, pollution, sediment, terrestrial, turbidity, water quality, watershed

Objectives
Students will:

- ☐ become aware of the many different ways pollutants can enter water.
- ☐ discuss positive actions they can take to help prevent pollution.
- ☐ realize that protecting the environment requires ongoing changes in some of their daily habits.

Method
Students participate in a story conveyed about the Missouri River, while answering questions regarding water quality of the river.

Materials
2 clear, gallon jars of water (one jar is needed for 15 students)
1 labeled film canister per student (see *List of Characters*)

Background
The Missouri River is the longest river in the United States. It flows through the Rocky Mountains, Great Plains, Central Lowlands, and the Interior Highlands. The climatic zones differ from alpine, dry plains to humid forests with rainfall ranges from eight to 40 inches a year. Human alterations also have affected different portions of the river. The Missouri often is thought to be composed of three different rivers: the Upper, Middle, and Lower.

The Upper River, in western Montana, is very similar to what Lewis and Clark saw in 1804. Very little of it has been altered by humans. It **meanders** (turns or winds) and contains **habitat** (arrangement of food, water, shelter or cover, and space suitable to animals' needs) for **aquatic** (growing, living in, or frequenting water) and **terrestrial** (living or growing on land) animals and plants.

Six large **dams** (impoundments) have been built on the Middle River (in eastern Montana and North and South Dakota). The Corps of Engineers built the dams between 1937 and 1967, primarily for navigation and **flood** (abnormally high stream/river flow that overtops the banks of a stream/river) control, but also for hydropower, irrigation, and recreation. These dams control the release of water, so have reduced the river's flow variability. They also have reduced **turbidity** (the amount of light that can get through the water column due to the amount of suspended sediments in water that make the water muddy or cloudy) since the water drops **sediment** (fine soil and other particles that settle to the bottom of a liquid) when it is slowed by the dams. The Lower River's channel (bordering Iowa and Nebraska and through Missouri) has been narrowed and constrained to allow navigation. **Channelization** (straightening a river or stream) began in 1912 and has since resulted in increased depth and turbidity (although a recent study by the Environmental Protection Agency and the U.S. Geological Survey

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* Adapted from "Who Polluted the Potomac," WETA, 2000.

Bureau shows that since the explorers' era, turbidity has still decreased due to the presence of upstream dams). Secondary channels, sloughs, and backwaters that provide critical habitat for aquatic life also were lost. Since channelization began, the **floodplain** (land near a stream/river which flood water spills onto) of the Lower River has been converted to agriculture and urban areas, increasing the amount of **pollutants** (substances that may contaminate the air, water, or soil) entering the river. Sections of the Lower River are on the federal list of impaired waterways due to arsenic and fecal coliform bacteria.

For more information on Lewis and Clark, refer to *Iowa's Water*, page 2.

Procedure

1. Prepare and label film canisters as described in the ***List of Characters*** for each student.
2. Fill two clear, gallon jars with water nearly to the top.
3. Divide the class into two groups and seat each group around one of the gallon jars of clean water. (Note: The activity is designed for up to15 students per jar.)
4. Distribute one set of canisters to each group of students. Ask them to keep them closed and to not reveal identities of their character or contents.
5. Explain that you will tell a story about the Missouri River and that each of them will play a part in the story. When they hear the name of their character mentioned in the story their job is to open the canister and empty its contents into the "river" (represented by the jar of clean water in the middle of their group).
6. Read the story, pausing after questions, and allowing students time to think and respond.
7. Research **pollution** (contamination of soil, water, or atmosphere by the discharge of harmful substances) problems in Iowa rivers, including the Missouri – which drains the western part of Iowa. What contributes the most pollution? (Agriculture – why? Agriculture has the greatest percent of land use). Discuss that the Mississippi drains the remainder of the state. Find the Divide on a map. Discuss **non-point source pollution** (pollution that enters water through runoff from land).

Evaluation

1. How has the Missouri River changed since Lewis, Clark, and the Corps of Discovery traveled its shores?
2. What is pollution?
3. How does pollution affect **water quality** (condition of water)? The Missouri River? People?
4. What can be done to prevent pollution?
5. What is the number one pollutant in Iowa's waters? (Refer to ***Iowa's Water,* page 6**.)

Extensions

Travel to a local stream/river and look for sources of pollution.

Visit the Iowa Geographic Image Map Server (ortho.gis.iastate.edu/) to view land use maps. Discuss possible pollutants generated by different types of land use in the Missouri River watershed or the **watershed** (land that drains into a particular body of water) of a river or stream near your school.

Change the story to symbolize a stream or river near your school.

Adopt a local stream/river.

Explore the world of point source and non-point source pollution with the EnviroScape™. To see a brochure for the EnviroScape™ and a list of loander locations, visit www.iowadnr.gov/education/index.html.

Teacher Aids

Posters:

“Aquatic Life.” Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources’ Aquatic Education Program.

“Benthic Macroinvertebrates.” Ill. SB Lauterbach. Des Moines: Iowa Department of Natural Resources’ Aquatic Education Program.

“Life in a Stream.” Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources’ Aquatic Education Program.

CD Rom

“Biodiversity of Iowa: Aquatic Habitats.” 2001. Des Moines: Iowa Department of Natural Resources’ Aquatic Education Program.

“Living Landscape.” Conservation Technology Information Center.

Books

Clark, W. and M. Lewis. 2002. The Definitive Journals of Lewis and Clark Up the Missouri to Fort Mandan. Edited by G. Moulton. Lincoln: University of Nebraska Press.

Zim, H.C. and A.C. Martin. 1987. A Golden Guide to Pond Life. New York: Golden Press.

List of Characters

Character	Substance in Canister
Construction site	1/2 tsp dry clay soil (not sand)
Trees	Dry leaves crumbled
Motorboat	1/8 tsp vegetable oil
Family picnic	Assorted litter (pull-tabs, Styrofoam, etc.)
People fishing	Tangle of nylon fishing line
Farmer	1/4 tsp baking powder
Farmer	1/2 tsp dry clay soil (not sand)
Barnyard	1/2 tsp brown liquid
Homeowner	Yellow food color + water + toilet paper (a full canister is most effective)
Coal mine	1/4 canister vinegar
Commuters	1/8 tsp vegetable oil
Gardeners	1/4 tsp baking soda
Antifreeze	1 tsp of blue/green food color + water
Washing the car	1/2 canister of soapy water
Mysterious liquid	1/8 tsp diluted red food color + water

There are 15 characters in the story, so you will need to prepare two sets of canisters for a group of 30. The above is a description of substances necessary for the canisters. All substances are safe for students to handle.

Note: It is best to use small amounts of each substance for a realistic effect.

Story: Who Polluted the Missouri?

For many thousands of years people have lived on the banks of the Missouri River. They hunted in forests and prairies, harvested food from wetlands and floodplains, and fished the river.

Question:

Imagine the jar of water in front of you was taken from the Missouri River by a Native American child about 200 years ago. Describe how it looks to you. Would you drink this water? Eat fish that came from it? Swim in it?

In 1804-1806 Lewis, Clark, and their crew of 40 men explored the Missouri to find the Northwest Passage to the Pacific Ocean, create a good relationship with the Native Americans to increase trade, observe and record natural history of the area, and look for resources for future settlers. All members kept a journal of their experiences and discoveries. In them, they wrote of Native American villages, prairie, and the river itself. They described the abundance of wildlife including large catfish that weighed an average of 33 pounds.

Soon pioneers began to arrive. They found the world's most fertile land for farming, forests and prairies teeming with game, and a river that provided ample food and water. The river was an outstanding environment for settlement and the pioneers prospered.

Question:

How do you think pioneers used the river? Do we use the river in the same ways today?

The Missouri River has changed a lot in the past 200 years. This is the story of the changes. Listen for the name of the character printed on your canister. When you hear your character named, open the canister and dump its contents into the river.

Imagine now that everything in the story is happening in the present – maybe even while we're sitting here today.

A sudden downpour drenches the area. The pounding rain is washing loose soil from a nearby ***construction site*** into the river. High winds whip through ***trees*** and blow leaves into the water too.

Question:

Is this water safe to drink? (If the response is "no," ask if the river had leaves or soil in it when Lewis and Clark drank from it?) Would you swim in it? Boat on it? Is it safe for wildlife?

In a short while, the storm passes over and the sun comes out again. People head for the river to have fun. Some zoom up and down the river in ***motorboats*** and don't notice that a little engine oil leaks into the water. Lots of ***families*** are ***picnicking*** in the parks too. Some people have left trash on the shore. During the next storm that trash will wash into the river. A ***person fishing*** on the dock snags the hook on a log and breaks the nylon fishing line.

Question:

Would you drink this water now? Would you swim in it? Go boating? Is it safe for wildlife? What litter is most dangerous for wildlife? Why?

Not everyone is out playing today. A ***farmer*** has been fertilizing cornfields in the Loess Hills. The rain washed some of the fertilizer off the land and into the nearby river. Another ***farmer*** tilled the field before it rained. Soil (sediment) washed into the river. This farmer also keeps pigs and other animals in the ***barnyard***. As rainwater drains out of the barnyard it carries some manure into a little creek behind the farm. The creek flows to the Missouri.

Out in the country, high on a hill, overlooking the river is a big old house. The ***homeowner*** has not maintained the septic tank. It is full and it is outdated. Untreated wastewater flows from the tank to a nearby ditch. It then flows to a small creek and into the Missouri.

Question:

Would you drink this river water now? Would you swim in it? Go boating?
Is it safe for wildlife?

Along the Middle River (upstream in Montana) is a ***coal mine***. Rain water drained down into the shaft and soaked piles of wastes and scraps from mining. This made the water acidic – sort of like strong vinegar. The acidic water trickled into the Missouri. By the time it reaches Iowa's basic soils, it poses no problems for fish.

Many ***commuters*** drive their cars to and from work. If a car is not kept in good repair it might leak oil or other fluids that are washed off the pavement and into the river with the next rain.

Question:

Would you drink this water now? Swim in it? Go boating? Could fish or other wildlife live in water that was like vinegar?

Let's look in on some typical activities around the neighborhood. Lots of ***gardeners*** are out working in their yards today. Many of them are using weed killers and insect sprays to keep lawns pretty. The next rainfall will wash these into a little creek nearby and then into the Missouri.

There's a father teaching his daughter how to change ***antifreeze*** in their truck. They pour used antifreeze on the driveway. Antifreeze is sweet tasting and can poison an animal that licks it. It also can get into the nearby creek and poison fish. Later, father and daughter ***wash the car***. The soapy water rushed down the driveway into the storm drain; the storm drain empties into the local creek, which empties into a tributary of the Missouri. Phosphates in detergents used to be a pollution problem because they acted like fertilizer, making too much algae grow in the river. Laws were passed to stop the use of phosphate soaps in order to help solve the algae problems. But grease and grime on a car contain asphalt from roads, asbestos from brakes, rubber particles from tires, heavy metals, and rust. If the father and daughter had gone to the local car wash, the water would have been treated before it was returned to the river.

Next door a family is cleaning out their garage. They find an old rusty can with a tattered skull and crossbones label still stuck on it. What could it be? It looks dangerous and they want to get rid of it before someone gets hurt. But how? Junior gets the idea: "Let's pour it down the drain out by the curb. Hurry up!" So the ***mysterious liquid*** goes down the storm drain. The poison is out of sight – but it is headed for the Missouri?

Question:

Who polluted the Missouri?

The Course of a River

Time

one or two 45-minute sessions

Vocabulary

aquatic, channel, channelization, erosion, flood, floodplain, habitat, meander, pool, riffle, sediment, water quality, watershed

Objectives

Students will:

- discover how rivers are formed.
- collaborate to create their own river.
- apply forces of nature to alter a river.
- apply human techniques to alter a river.

Method

Students discuss the Boyer River's history using historical and present day maps and aerial photos. Students explore the natural processes and human alterations of a river through an activity using a stream table.

Materials

Harrison, Crawford, Sac, and Buena Vista counties' historic vegetation maps from www.public.iastate.edu/~fridolph/dnrglo.html

current land cover maps from http://ortho.gis.iastate.edu/

Boyer River watershed boundary map obtained by calling the Geological Survey Bureau at 319/335-1575 and asking for its watershed map

stream table for class demonstration. This may be borrowed by contacting the DNR Aquatic Education Program (641/747-2200) for a list of sites with stream tables for loan, or visit www.iowadnr.gov/education/index.html. Directions for building and drawings of a stream table are available at www.iowadnr.gov/education/index.html.

Background

In 1820, Stephen Kearny and company traveled along the Boyer River in present day western Iowa. The river was a slow, meandering stream, breaking up the vast tall grass prairie. The Boyer provided **habitat** (arrangement of food, water, shelter or cover, and space suitable to animals' needs) for **aquatic** (growing, living in, or frequenting water) animals in its pools and riffles. The crew celebrated the Fourth of July along this river by drinking whiskey, toasting their forefathers with a mint julep, and eating pork and biscuits.

The majority of the Boyer River and its **watershed** (land that drains into a particular body of water) were "settled" by Euro-Americans within 12 years of Kearny's journey. Pioneers and their descendents began tilling the prairie sod to create farmsteads and build houses, churches, schools, and businesses in. Sometime after settlement, humans began channelizing the river.

In its natural state, streams and rivers **meander** (turn or wind), changing their course over time. **Pools** (areas of a stream or river which is deeper than adjacent areas, water flow may be slowed, and the bottom usually is made of very small particles) and **riffles** (area of a stream or river with faster current; usually more shallow than a run or pool; the water surface is broken up due to flowing over rocks) located between meanders support a diversity of aquatic life. **Channelization** (straightening) accompanied with replacing the surrounding natural vegetation with row crops, eliminates much of the habitat so much of the aquatic life disappears from the area. This modification results in faster moving water, which increases **erosion** (removal or wearing away of soil or rock by water, wind, or other forces or processes) and deepens **channels** (deeper part of a moving body of water where the main current flows). This chain reaction initiated by stream channelization destroys the natural integrity of stream channels and often results in major damage to bridges. **Floods** (abnormally high stream/river flow that overtops the banks of a stream/river) also are more severe.

Most of Iowa's interior rivers and streams have channelized stretches – some 3,000 miles of Iowa rivers have been lost to channelization. The Boyer River is one of the more heavily channelized rivers in the state.

The Boyer River empties into the Missouri River. According to the Missouri River Natural Resources Committee and the U.S. Geological Survey-Biological Resources Division, 735 miles of the Missouri River have been channelized or stabilized, shortening the river by 72 miles and eliminating 127 miles of river shoreline habitat. 168,000 acres of former river disappeared as **sediment** (fine soil and other particles that settle to the bottom of a liquid) accumulated behind the wing dikes, forming new land. Over 35,000 acres of river channel were lost along Iowa alone. Development for agriculture and urban areas replaced nearly 354,000 acres of floodplain habitats. Levees, built to protect against flooding, encouraged development of the **floodplain** (land near a stream/river which flood water spills onto). They also isolated aquatic habitats off the main channel and wetlands from the river.

For more information on Stephen Kearny's exploration refer to *Iowa's Water*, page 4.

Procedure

1. Share with students the *background information* of Stephen Kearny's journey. Discuss historical conditions of the Boyer River. Look at the Boyer River's watershed map from the Geological Survey Bureau. Note where the boundaries are.
2. Show students historical vegetation maps of Harrison, Crawford, Sac, and Buena Vista counties. Find the Boyer River on each map and look at the vegetation surrounding it. Note that the river on the map is where it was in 1999. Look for wetlands and forested areas away from the river. Does the river look like it is accurately marked?
3. Look at current land use patterns in the Boyer River's watershed by looking at the land cover maps on the website listed earlier. Compare and contrast the historical vegetation and present land cover maps of Harrison, Crawford, Sac, and Buena Vista counties. Again, find the Boyer River on each map. Ask students how the river has changed. Initiate a discussion on changes of the Boyer and the effects of channelization on the natural processes of a river. Include vocabulary from above.
4. Inform students they will be creating their own rivers. If using a borrowed stream table, follow the directions below.
5. Using a scoop or cupped hands, create a meandered (S-shaped) channel. Watch water flow through the stream's channel. Note the erosion of banks and creation of sandbars. If left to flow for a short period of time, the stream may create multiple channels. Discuss where aquatic wildlife lives in streams. Locate pools and riffles. Take a small, floating object, and time how long it takes it to reach the end of the stream from any given point. Record the results. Increase the flow of water to allow the stream to flow outside of its banks. Note what happens.

streams. Locate pools and riffles. Take a small, floating object, and time how long it takes it to reach the end of the stream from any given point. Record the results. Increase the flow of water to allow the stream to flow outside of its banks. Note what happens.

6. Have students make a channelized (straight) stream. Watch water flow through the stream's channel. Ask students where aquatic wildlife would live. If left to flow for a short period of time, the channelized stream will begin to meander. Straighten the channel and take the floating object from before. Again, time how long it takes to reach the end of the stream from the designated point. Increase the flow of water again to allow the stream to flow outside its banks. Note differences between the channelized and meandering streams' floods.
7. Allow time for students to explore the stream table. Observe and comment on natural processes they discover.

Evaluation

1. What was the Boyer River like when Stephen Kearny and company traveled along its shores? What is the Boyer River like today?
2. Does a river tend to flow in a straight line, or curve like an "S"?
3. Where does aquatic wildlife live in a meandering stream? Where does aquatic wildlife live in a channelized stream? What happens to the diversity within a stream when it is channelized? (Diversity decreases due to the absence/reduction in habitat.)
4. What happens to the velocity of water when a stream/river is channelized?
5. What happens when a meandering stream floods? What happens when a channelized stream floods? Does this affect the floodplain differently?
6. Why do people channelize streams/rivers? What are benefits to channelization? What are drawbacks?
7. How does channelization affect **water quality** (condition of water)?

Extensions

Take a field trip to a meandering and channelized stream. Look for aquatic wildlife (insects, fish, crustaceans, etc) at both streams. Record and compare results.

Look at different rivers in Iowa. What similarities do they have with the Boyer River? What differences?

Research other explorations in western Iowa.

Research what life was like in your county when the Boyer River was being explored in 1820.

Teacher Aids

CD Rom

"Biodiversity of Iowa: Aquatic Habitats." 2001. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Living Landscape." Conservation Technology Information Center.

Planning a Plenty*

Time

one to three 45- to 60-minute periods

Vocabulary

aquatic, channel, channelization, floodplain, habitat, healthy, land-use planning, lifestyle, pollutant, pollution, population, watershed

Objectives

Students will be able to:

- evaluate the effects of different kinds of land use on riverine habitats.
- discuss and evaluate **lifestyle** (individual's way of life) changes to minimize damaging effects on rivers.

Method

Students create a collage of human land-use activities around an image of a river.

Materials

For each team:
scissors
masking tape
paper
list of land uses
1 *Map of the Cedar River*
large piece of paper (18" x 24") for each small group

Background

The Dragoons crossed many rivers during their expedition in the summer of 1835. While crossing the Cedar River (near present day Osage), Lieutenant Albert Lea noticed the river to be about 35 yards wide, 2½ feet deep, swift, clear, and having a gravelly bottom. Albert Lea noticed limestone bluffs located periodically on the river. He also noted that there were "(n)o falls or rapids…on the river." Boats were reported to have ascended the river annually and Lea thought the river to be navigable to its sources several months out of the year. There was not a permanent human settlement at this location.

The Cedar River originates in southwestern Minnesota, travels east/southeast through central Iowa, and empties into the Iowa River in Louisa County. At the time of the Dragoon's crossing, few recorded Euro-Americans lived in its 6,720 square mile watershed. As of 2000, over 261,000 people live along the Cedar River alone.

Since the earliest times, humans have planned the arrangement of housing in regular, rectangular patterns. Civic and religious buildings are placed in prominent locations. These patterns not only give structure to American cities, but they also affect wildlife **habitat** (arrangement of food, water, shelter or cover, and space suitable to animals' needs) and **populations** (number of a particular species in a defined area at a given time). Some people perceive undeveloped areas as raw material for human use, while others believe natural environments are to be preserved without regard for human needs. Still

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*Based on the activity *"Dragonfly Pond,"* Project WILD Aquatic K-12 Curriculum & Activity Guide, Council for Environmental Education, Houston, Texas, 2001.

others feel there should be a balance, maintaining a **healthy** (supports the diversity of life) natural environment should be incorporated into development to meet human needs.

Growth in natural systems is limited by the available energy in the system. Energy in natural systems is translated into food, water, shelter, space, and continued survival. The microbes in the soil are just as necessary to a habitat as plants and predators.

Human land use can disturb the natural balance of our ecosystems. Growth in human activities often can go beyond the natural limits of a setting. Humans can import energy sources and other resources or they can remove energy sources from a system.

Rivers and their **floodplain** (land near a stream/river which flood water spills onto) forests, wetlands, sloughs, and backwaters provide habitat for a variety of plants and animals. Wetlands play a very special role in filtering **pollutants** (substances that may contaminate air, water, or soil) out of the water. River and stream systems often are altered to accommodate human wants or needs. Hundreds of miles of river and stream shoreline and thousands of acres of wetlands and floodplain forests are lost each year to channelization, draining, dredging, filling, **pollution** (contamination of soil, water, or atmosphere by the discharge of harmful substances), and development. Iowa has lost more than 3,000 miles of interior rivers to **channelization** (straightening). Engineering work for navigation on the Missouri River reduced the **channel** (deeper part of a moving body of water where the main current flows) area by more than 35,000 acres along Iowa alone.

One of the major challenges facing our society is how to regulate growth and conserve open spaces. Students will struggle with the arrangement of land uses in an effort to preserve a section of the Cedar River's habitat. When students reach some kind of agreement about local issues, the activity shifts to how their consensus affects riverine habitat and people downstream. The activity ends with consideration of the idea that everyone lives downstream.

For more information on the Albert Lea or the Dragoons, refer to *Iowa's Water,* page 4.

Procedure

1. Discuss the Dragoon's 1835 journey through Iowa and southeastern Minnesota. Share the *background information* from above.
2. Explain to students that during this activity they will use the Cedar River as a microcosm of environmental concerns involved in making **land-use planning** (planning of how the land will be used by people) decisions. Copy the *Map of the Cedar River* on the board or overhead.
3. Ask students how the land in the river's **watershed** (land that drains to the river) might be used. Compile a list of their ideas on the board or an overhead. Some land uses include: farm fields, factories (can list specific types in your area), houses, apartments, roads, shopping centers/stores, natural areas, wetlands, prairies, forests, schools, gravel pit, animal feed lot.
4. Divide the class into teams of four or five, with each student representing one of the interest groups described below. Students will stay in these groups until the end of the activity. Possible interest groups to include are:
   - Residents – want to live in the area
   - Farmers – want to use the land to raise food and livestock
   - Conservationists – want to maintain the land as wildlife habitat
   - Business interests – want to use the land for commerce and economic growth
   - Gas station owners – want to make a living in servicing and repairing vehicles
   - Parks and recreation department personnel – want people to have a place for recreation
   - Water treatment personnel – want to sell clean water to residents
   - Highway department personnel – want to maintain access in the area
   - Factory representatives – want to preserve jobs and commerce

NOTE: Add other interest groups that may be important locally

5. Distribute 18” x 24” pieces of paper that will serve as the base map for each team’s river and its associated land uses. Have students copy the *Map of the Cedar River* and the list of land uses from the board. All land uses must be incorporated in their maps. Students can make the land use larger or smaller in their map of the area or they may include additional land uses. When finished, the maps should be completely covered in land uses, no blank areas. Suggest to students that they may want to create a working map first, then create the final map of land uses after they have reached agreement about location and size of each land use.
6. When students are ready to begin the process of making land-use decisions, have them create a list of benefits and costs for each land use. Guide the class discussion so that they consider the consequences of each land use. Record these lists on the chalkboard. Following are a few examples:

Farms

Benefit

- produce food
- add economic value
- provide jobs through seasonal employment

Cost

- use pesticides (herbicides, insecticides) that may damage people and the environment
- become source of soil erosion
- sometimes drain wetlands for farm land

Businesses

Benefit

- provide employment
- provide commerce
- create economic stability

Cost

- produce wastes and sewages
- may contaminate water (detergents, pesticides)
- use chemical fertilizers (lawns, etc.

7. Have students work in the teams for 30 to 45 minutes.
8. Have each team display its base map and report on the work in progress. Encourage discussion of the students’ choices emphasizing that:
   - no land use can be excluded, and
   - consensus (an agreement among all parties) must be built around each decision.

   Discuss consequences of the students’ proposed land-use plan. Be firm about the issues, but fair about this being a very difficult set of choices.
9. Continue the discussion by asking more teams to share their proposed plans. What would happen if the factory and businesses were to close? Abandoning the farm would have what effects? Do farmlands provide habitat for some wildlife? What happens if wetlands are drained to create farmland?
10. Give students additional time working in their teams to decide on the best possible land-use plan under the circumstances. Being sensitive to their frustrations, display all final land-use plans. Analyze and discuss the merits of each approach. Point out that although their solutions may not be perfect, they can minimize the damage to the Cedar River.
11. Choose one of the team’s base maps and continue the Cedar River downstream. The students may have dumped effluent below their section of the river and let it flow downstream. Show the route the stream might travel. On the drawing, have the Cedar River flow into the Iowa River. Continue drawing to the Mississippi River and finally to the Gulf of Mexico. You may also connect several of the teams’ maps together, one above another, to indicate the flow downstream.

12. Ask students to brainstorm possible problems in each of these **aquatic** (growing, living in, or frequenting water) systems as a result of human activities on the Cedar River. What might be potential consequences of such activities? For example, you could emphasize the effluent from the factory. How will it be treated? Where? By whom? Where will it go? With what effects?
13. Ask the students to examine all of the land uses in this activity. What could people who are actually in charge of various land uses do to minimize damage to the Cedar River? End with an emphasis on solutions rather than problems. Point out, for example, they could "mine" industrial effluents through "scrubbers" to extract wastes as profitable resources. Farmers may employ conservation tillage practices. ... Petroleum wastes could be recycled.

Evaluation

1. How has the Cedar River changed since the Dragoons traveled it?
2. What are three ways people can reduce or prevent damage to rivers?
3. Under what conditions, if any, do you think these actions to reduce damage to rivers would be appropriate? Inappropriate? Select any action that you think would be appropriate and that you could take to reduce or prevent damage to floodplain wetlands. Write a one-page paper about your plan.

Extensions

Visit the ortho map server (ortho.gis.iastate.edu/) and print aerial photographs of the land near the Cedar River (or a local river) and research actual land use in the watershed. How might land uses negatively impact the quality of the water? What are some ways impacts might be minimized?

Perform this activity using a local stream or river instead of the Cedar River.

Locate a river or stream in your community. Determine the overall quality of the river, stream, forests, or wetlands with which it is connected.

Trace any stream or river system that passes through your community from its source to its entrance into the ocean. List all sites you can identify that lower the quality of the waters in their journey and suggest how to reverse or minimize the process.

Research the history of your county through local historical societies and the state historical society. How have land-use practices changed since 1835?

Learn more about environmental impact statements. Obtain actual copies of statements about rivers in your area. What concerns are addressed in those documents?

Research zoning laws and land-use regulations in your area. Would the plan your group proposed be allowed in your community?

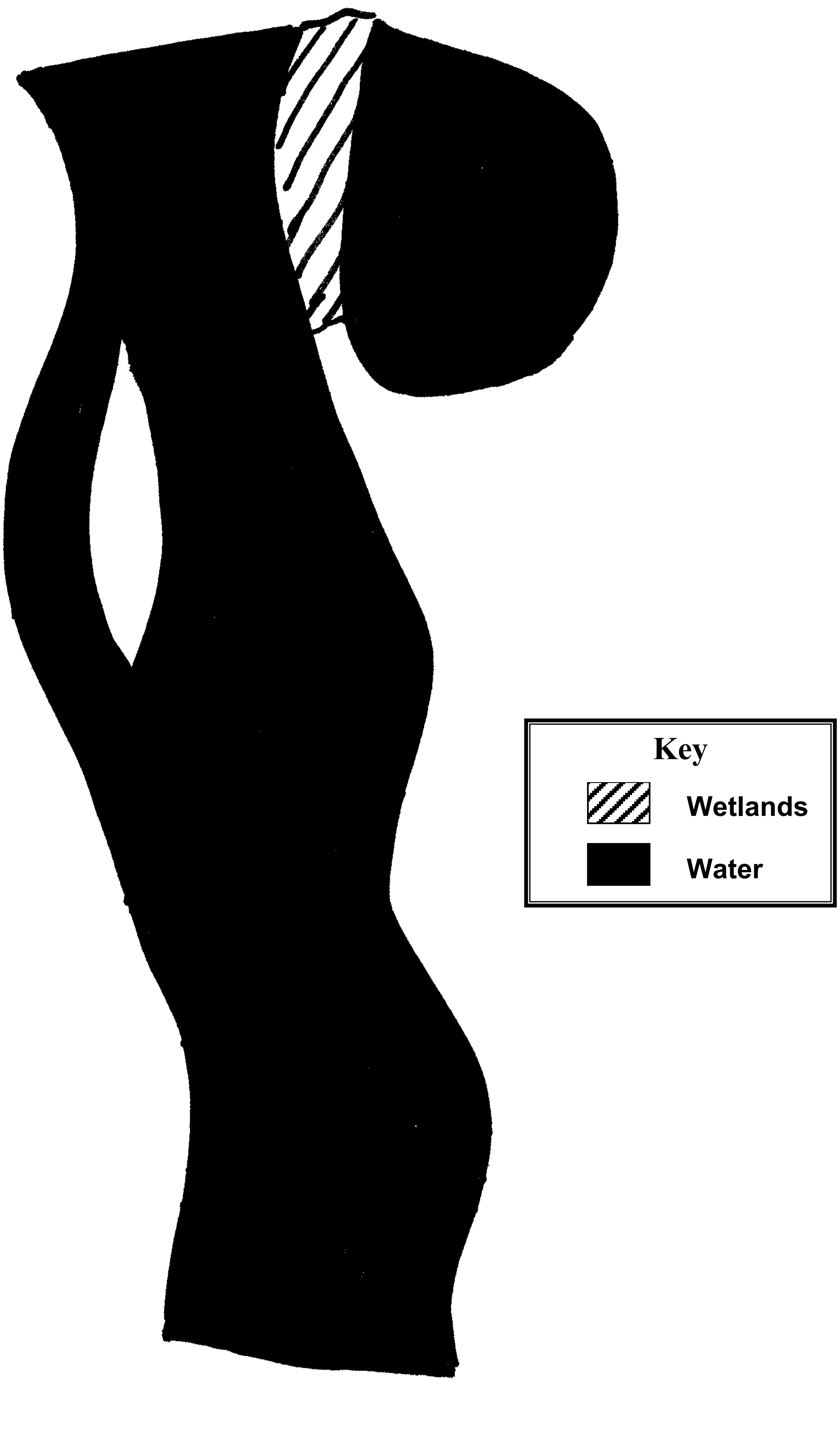
Teacher Aids

CD Rom

"Biodiversity of Iowa: Aquatic Habitats." 2001. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Living Landscape." Conservation Technology Information Center.

Planning a Plenty: Map of the Cedar River



Putting Water in the Shed*

Time

two or more 30- to 60-minute periods

Vocabulary

aquatic, dam, erode, habitat, pollutant, pollution, precipitation, runoff, sediment, tradeoffs, turbidity, water quality, watershed

Objectives

Students will:

- describe the characteristics of watersheds.
- discuss the role of watersheds in providing wildlife habitat as well as human habitats.
- give examples of how watersheds can be conserved and protected.

Method

Students measure the area of a small watershed and calculate the amount of water it receives each year, compare and contrast their findings to the Raccoon River, and discuss changes in the Raccoon River watershed since the Dragoons traveled its shores and the varied roles watersheds play in human and wildlife habitat.

Materials

six stakes or markers
hammer
two 50-foot measuring tapes
two 100-foot measuring tapes (or twine or heavy string)
writing materials
clipboards
large pad of paper for display
access to the internet
graphing paper
local topographic maps

Background

The Dragoons explored the courses of many of Iowa's rivers, including the Raccoon. Riding their horses, the men also traveled across land through various **watersheds**. A watershed is an area of land that drains into a particular body of water. Boundaries of a watershed are determined by the land surface surrounding that stream, river, or lake. Because **runoff** (water that drains or flows off the surface of the land) must flow somewhere, all land areas are a part of some watershed.

Captain James Allen and his men saw tall grass prairie with occasional wetlands, or "potholes," as they traveled through the Raccoon River watershed on their return to Fort Des Moines from the Big Sioux. The wetlands and prairies served as filters and sponges and were vital components of the Raccoon River's watershed. Today, over 95% of original wetlands and 99.9% of original prairies are gone from our watersheds.

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* Based on the activity "Watershed," Project WILD Aquatic K-12 Curriculum & Activity Guide, Council for Environmental Education, Houston Texas, 2001.

The watershed is a complex system of soil and topography linking all living things within its boundaries. Plant and animal life depend on the water within each watershed. Watercourses also transport water, organisms, nutrients, and other materials. What affects one watershed eventually affects other sites downstream.

One material moving through the watershed is soil. Because rivers constantly **erode** (remove or wear away) the lands that contain it, suspended **sediments** (fine soil and other particles that settle to the bottom of a liquid) are part of the natural dynamics. However, human activities such as clearing land, building dams, farming, and industrial development accelerate this process. Runoff carries loose soil into the water system, which may increase **turbidity** (cloudiness) of water. Turbidity can interfere with light reaching plants to make food or with fish receiving oxygen.

Contaminants in the water are of particular concern. Contaminants include excessive nutrients (such as nitrates and phosphates) that overload natural systems and harmful chemicals introduced into the water. Fertilizers, pesticides, and bacteria are major agricultural contaminants. Industrial wastewater can contain a myriad of contaminants from oil to heavy metals.

Contamination of watersheds is a serious problem for humans. It also is a problem for wildlife. Most often it is wildlife – particularly **aquatic** (growing, living in, or frequenting water) wildlife – that suffers most directly and immediately from contaminated water. Silt buries crucial **habitat** (arrangement of food, water, shelter or cover, and space suitable to animals' needs). Ammonia can kill all aquatic life in a stream immediately. Nutrients cause profuse growth of algae that die and deplete oxygen.

Watersheds feed and are fed by groundwater. Surface contamination can penetrate into the earth and contaminate groundwater supplies. Water can move so rapidly across the surface it is often expressed in cubic feet (or cubic meters) per second. Below the ground's surface, water movement might be expressed in *inches* (or centimeters) per *year*. Therefore, groundwater can remain contaminated for centuries.

Another human activity that affects watersheds is diverting water from its natural flow. We often divert water or modify its flow to meet human needs. In Iowa, **dams** (impoundments) have been built to provide a constant water supply for towns or industries, to create lakes for recreation, and to maintain water levels for navigation and provide hydropower (Mississippi River). While dams provide predictable water supplies, they also may radically alter the habitats in and near a river.

Past efforts to improve **water quality** (condition of water) focused on specific sources of **pollution** (contamination of soil, water, or atmosphere by the discharge of harmful substances), such as sewage discharges or on specific water resources, such as a segment of a river or wetland. This approach may address specific problems, but it often does not address subtle, chronic problems in the watershed. For example, pollution from a sewage treatment plant might be reduced significantly after new technology is installed, but habitat destruction or other sources of polluted runoff in the watershed may still impact water quality. Managing the watershed unit as an integrated system helps resource managers determine what factors impact water quality and actions needed to protect or restore a water body.

The Raccoon River drains all or part of 17 Iowa counties before reaching the Des Moines River in Des Moines. More than 370,000 people – 13% of Iowa's population – rely on water sources within the watershed for drinking. Sections of the Raccoon River have been identified by the Environmental Protection Agency as being impaired from fecal coliform bacteria and nitrates.

The watershed's high concentration of nitrates have exceeded the federal maximum contaminant level (MCL) standard with enough frequency since the late 1980s that Des Moines Water Works (DMWW) installed and currently operates the world's largest nitrate removal facility. The DMWW can produce 10 million gallons of processed water per day. In 2000 the facility was operated almost one out of three days. Since it costs $3,000/day to operate the facility, almost $330,000 was spent that year to remove nitrates from the Des Moines drinking water supply. (Nitrates are returned to the river downstream of Des Moines.) Most scientists feel it is far more economical to prevent contaminants from entering water systems than to clean up pollution after it takes place.

Several factors contribute to pollution problems in the river. Almost ¾ of the 2.3 million acres of the Raccoon's watershed are in agriculture (corn, soybeans, livestock, poultry). Some 850,000 are in corn with an estimate over 55,000 tons, or 3,900 dump trucks, of fertilizer applied every year. Much of what was wetland has been converted to cropland. Wetlands were drained by tiles to remove water from the area. Tiles are direct pipelines into the river, so speed up drainage, but also reduce or eliminate absorption of chemicals into the soil.

Urban issues also affect water quality. Development, impermeable surfaces (such as parking lots), and storm water systems speed the rate water flows and eliminate any filtration of **pollutants** (substances that may contaminate air, water, or soil).

In the early 1990s, the state associations of corn and soybean growers and cattle, pork, and poultry producers partnered with the Iowa Agribusiness Association and Iowa Farm Bureau to form the Iowa Nutrient Management Task Force. This task force recommended numerous ways to improve water quality. The Agriculture's Clean Water Alliance (formerly known as the Raccoon River Watershed Project) was organized to keep nutrients out of the Raccoon River and its tributaries using these recommendations.

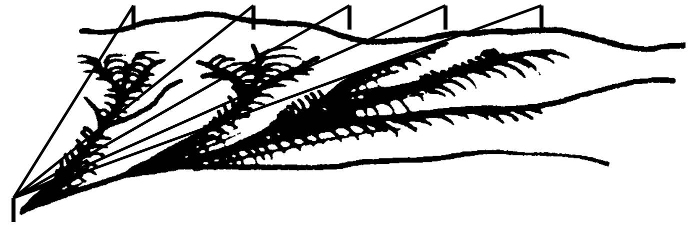
The Agriculture's Clean Water Alliance is composed of 11 agribusiness retailers in the watershed. One of the initiatives adopted by the group is to support an "Environmental Code of Practice." The Code establishes reasonable and practicable guidelines that all members stand behind. For example, Iowa State University recommends farmers not apply anhydrous ammonia until soil temperatures fall below 50 degrees. The Alliance made this recommendation into a policy and agreed not to sell anhydrous until soil temperatures dropped. People in the Raccoon watershed are working to reduce the amount of pollution entering the river.

To learn more about the Dragoons, refer to *Iowa's Water,* page 4.

Procedure

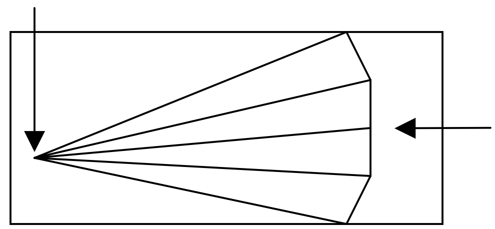
1. Discuss the concept of a watershed. Use local maps and local stream systems as examples. Topographical maps or raised relief maps are valuable tools. (You can get watershed boundary maps of local streams or lakes by calling the Geological Survey Bureau at 319/335-1575 and asking for watershed maps.) Emphasize that watersheds range in size from those of tiny tributaries (like the stream near your school) to total river systems like the Raccoon and Mississippi Rivers.
2. Introduce the concept that a ridgeline is the border between two designated watersheds. Use topographical maps of local areas to show how the boundaries of a watershed can be determined by tracing ridgelines between adjacent watersheds. Trace a watershed on a transparent overlay over a topographical map. Introduce the notion of the ridgeline (highest contour line in an area) being the border between two designated watersheds.
3. Select a site (approximately 100 feet square) that resembles a small watershed. If possible, there should be a visible drainage pattern. There needs to be enough slope so students can visualize the watershed concept. Explain to students that they will be going to a small watershed and will be measuring its area in much the same way large watersheds are measured.
4. Show students the equipment that you will be taking along and explain how five stakes will be used to mark the top of the ridgeline of the watershed. Indicate the "control" stake that will represent the bottom of the drainage system (e.g. pond, river, lake). Illustrate the process of measuring a watershed on the chalkboard or overhead before going to the site. You also can use a large pad and markers to review the procedures visually at the site.

5. At the site, divide students into teams of three to five. Determine the ridgeline of the watershed. Drive stakes or markers along the upper boundary of the watershed (ridgeline). Stakes should be 20 to 40 feet apart.



6. As a group, have students determine the location for the control stake at the “bottom” of the watershed. Students will measure from the control stake to each of the stakes along the ridgeline. The control stake should be 60 to 100 feet from the ridge stakes.
7. Measure from the control stake to each ridge stake and between ridge stakes. Sketch the stakes on a large piece of paper and note the distance between each stake. Convert the sketch to a scale drawing of the “watershed” by transferring it to a piece of graphing paper (see Diagram A).

Diagram A

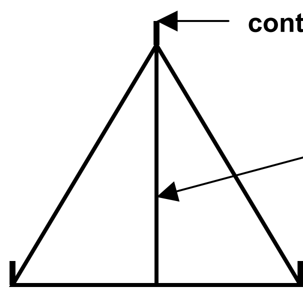


8. Have each team determine the area of the watershed, following these procedures (see Diagram B):
   - Determine the area of each triangle using the following formula

   ½ Base x Height = Area of a triangle (in square feet)

   - Repeat for each triangle.
   - Add the areas of all five triangles together to get the area of the watershed (in square feet).

Diagram B



9. Calculate the volume of **precipitation** (any form of water falling from the sky) that falls on the miniature watershed each year. You will need to know the annual precipitation in your area. Convert the amount to feet:

number of inches / 12 = number of feet

Multiply the annual precipitation by the area of the watershed to calculate the annual volume of precipitation.

Precipitation x Area = Volume of Precipitation (cubic feet)

10. Have students visit the orthomap server site (http://ortho.gis.iastate.edu/), find the Raccoon River and determine its watershed.
11. Discuss the *background information* on the Dragoon's expeditions. Have students look at maps of the 1832-1859 vegetation in Iowa (www.public.iastate.edu/~fridolph/dnrglo.html) to see what Iowa was like around the time the Dragoons explored it. Have students locate the Raccoon River and its watershed. Explore the site further, looking at different maps of counties the Raccoon River flows through.
12. Visit the following websites to look at modern land use maps of the counties the Raccoon River flows through: http://ortho.gis.iastate.edu/.
Ask students how land cover has changed.
How do they think these changes have impacted the watershed?

Evaluation

1. How does a watershed work? How does it affect humans? How does it affect wildlife?
2. How is groundwater affected by conditions in your watershed?
3. How do humans affect watersheds?
4. What kinds of things can be done to protect, conserve, and improve watershed quality? What are some reasons, if any, to protect and conserve watersheds? What are some **tradeoffs** (to use alternately; to exchange places with another involved)? When, if ever, might it seem inappropriate to protect and conserve a watershed?
5. How does the size of the Raccoon River watershed compare with the small watershed you mapped?
6. What changes have taken place since the Dragoons traveled the shores of the Raccoon River? How have these changes impacted the quality of the Raccoon River's water?
7. What are some things that have been done to protect the Raccoon River? What are some additional ways to enhance the river? What are some things that can be done to protect a river or stream near your school?
8. Develop a plan to protect, conserve, or restore a nearby watershed.
9. How are wildlife habitats related to watersheds? Why are watersheds important to people? Write a short essay in response to these questions.

Extensions

Calculate the total area of an actual watershed in your area using topographic maps.

Calculate the total water that falls annually on your watershed.

Simulate a watershed. Have students stand in a circle with quart (liter) containers of water and empty the containers on cue toward the center of the circle. Have students trace the "natural" paths taken by the water and see if they can trace the watersheds indicated by the diverse flow pattern.

Incorporate the use of the EnviroScape™ watershed model to demonstrate possible sources of pollution and "best management practices" such as terraces, buffer strips, and silt dams to help reduce pollution entering the water. Visit the following websites for more information:

www.iowadnr.gov/education/index.html - EnviroScape™ brochure
www.iowadnr.gov/education/index.html - lists agencies with EnviroScape™ models

Learn more about the Agriculture's Clean Water Alliance by visiting the following websites:

www.iptv.org/mtom/archivedfeature.cfm?Fid=74%20
www.acwa-rrws.org/

Adopt a local watershed and work to conserve, protect, or restore it.

Borrow a stream table to demonstrate what a stream looks like before and after a dam is built. Contact the DNR Aquatic Education Program (641/747-2200) for a list of sites with stream tables for loan, or visit www.iowadnr.gov/education/index.html.

Teacher Aids

Posters

“Aquatic Life.” Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources’ Aquatic Education Program.

“Benthic Macroinvertebrates.” Ill. SB Lauterbach. Des Moines: Iowa Department of Natural Resources’ Aquatic Education Program.

“Life in a Stream.” Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources’ Aquatic Education Program.

CD Rom

“Biodiversity of Iowa: Aquatic Habitats.” 2001. Des Moines: Iowa Department of Natural Resources’ Aquatic Education Program.

“Living Landscape.” Conservation Technology Information Center.

Do You Have a Reservoir?

Time
one or two 60-minute sessions

Vocabulary
aquatic, channel, dam, flood, habitat, municipal water storage, reservoir, sediment, watershed

Objectives
Students will:

- research and map the Des Moines River and its dams.
- predict effects of a dam on an area.
- suggest reasons a dam would be built.
- identify consequences of dams to humans and wildlife.

Method
Students will examine the Des Moines River system and determine effects of dams along it.

Materials
copies of an Iowa political or road map (two per student)
copies of student handout *Iowa's Major Reservoirs*
colored markers or pencils
one or more atlases with state maps for the United States
wall map of the United States
reference materials

Background
In 1843, Fort Des Moines was built near the confluence of the Raccoon and Des Moines Rivers. The Dragoons stationed there mostly radiated out to trouble spots on horseback, many times following the Des Moines River north. Hundreds of men would explore and patrol the area now known as Iowa from this fort. The men also used the Des Moines River to receive heavy shipments of supplies by steamboat. Fort Des Moines was closed after three years.

The Des Moines River is the largest interior river in Iowa; flowing 535 miles and draining 9.4 million acres of land. Humans have dealt with **floods** (abnormally high stream/river flow that overtops the banks of a stream/river) since they have lived near its banks. A series of floods took place in 1851, 1859, 1903, 1944, 1947, and 1954. In 1938 and 1944, Flood Control Acts were passed that allowed a study of nine sites along the river for potential flood control structures. In the 1960's, the U.S. Army Corps of Engineers began construction of **dams** (impoundments) at two of these sites, Saylorville and Red Rock. Unlike navigation dams on the Mississippi, these dams were built to control flooding.

Many other streams and rivers were dammed in Iowa. There used to be over 540 water-powered mills in Iowa. Most of these mills required a dam on a river or stream to provide the water power. The first dam in Iowa was built on the Yellow River in northeast Iowa by Jefferson Davis (the later Confederate President) while he was a soldier at Fort Crawford in Prairie du Chein.

People construct dams across rivers for many reasons: to protect land from floods, store water, generate power, redirect river **channels** (deeper part of a moving body of water where the main current flows), create artificial lakes (reservoirs), and keep water levels high so boats can travel without bottoming out. All dams, no matter why they are built, must be strong enough to contain huge volumes of water without leaking or breaking.

A new body of water is created behind the dam. It may be used for fishing, swimming, waterskiing, and boating. But, thousands of acres of **habitat** (arrangement of food, water, shelter or cover, and space suitable to animals' need) as well as people's homes may be lost when the river valley above the dam floods. Below the dam, the river level drops. The lowered water levels may hinder the migration of **aquatic** (growing, living in, or frequenting water) animals, while the dam itself may become a barrier. The remaining flow may not be enough water to sustain communities downstream.

A placid **reservoir** (natural or manmade body of water) may cover thousands of acres upstream of a dam. Saylorville Lake has a normal water surface area of 5,950 acres. Lake Red Rock covers 19,000 acres. As water entering the reservoir slows down, it drops the **sediment** (fine soil and other particles that settle to the bottom of a liquid) it carries. After many years, accumulating sediment can fill some reservoirs.

Iowa streams and rivers have been dammed at more than 200 locations to provide water for a variety of purposes. Many are used for **municipal water storage** (water stored for public consumption or use) while some are used for flood control and others for recreation. These range in size from 15-acre Mitchell Lake to the large reservoirs. Over 100 lakes have been constructed for recreation throughout Iowa. They are generally small; only one in four is over 100 acres.

For more information on the Dragoons, refer to *Iowa's Water,* page 4.

Procedure

1. Share *background information* on the Dragoons and Fort Des Moines.
2. Have students brainstorm reasons for building a dam.
3. Explain the three main reasons in Iowa: flood control, recreation, and municipal water storage.
4. Locate the Des Moines River watershed on a map of Iowa. Inform students that the Des Moines River is more than 535 miles long and its watershed includes 9.4 million acres of land. Find the Des Moines River watershed (http://ortho.gis.iastate.edu/).
5. Discuss building of dams in Iowa, including *vocabulary words* from above. Ask students to list some potential effects (negative and positive) of dams. Write their responses on a chalkboard.
6. Divide students into pairs. Give each pair a set of colored markers or pencils and a copy of the Iowa map.
7. Students should use one color to trace the Des Moines River from its source to its mouth.
8. Use a second color to highlight the tributaries that flow into the Des Moines River.
9. Consult the map and *Iowa's Major Reservoirs*. Locate dams on the river and use a third color to mark their locations.
10. Have students use a fourth color to outline regions drained by the Des Moines River.
11. Have students label towns and cities in the Des Moines River **watershed** (area of land that drains into a particular body of water): Fort Dodge, Boone, Carroll, Des Moines, Indianola, and Ottumwa.
12. Have students predict which communities depend on the Des Moines River for drinking water.
13. Using maps of the United States compare and contrast the Des Moines River to the Colorado River in western U.S. Are dams located on both rivers? Research why dams are used on the Colorado. How are they different from dams on the Des Moines? Similar?
14. Have students create a drawing of an area before and after a dam is built.

Evaluation

1. How has the Des Moines River changed since the Dragoons traveled its shores? How has this affected water quality?
2. Why were dams built on the Des Moines River? What do you think would happen if there were no dams on the Des Moines River?
3. What is a difference between Saylorville dam and Lock and Dam 10 on the Mississippi River?
4. Could a steamboat float up the Des Moines River to Des Moines today? Why or why not?
5. What happens to water as it reaches a reservoir? What happens to the sediment in the water?
6. How does the Des Moines River compare with the Colorado River? See above.
7. What are some benefits of dams?
8. What are some negative impacts of dams?
9. Have pairs of students display their maps of the dams, watersheds, and cities along the Des Moines River.

Extensions

Find a stream or river near your school. Follow it along its course. Have students pick a location where they can imagine a dam. How wide would it be and how high? Have students imagine the reservoir created by the dam. Use a topographical map to determine the extent of the reservoir created. To get a sense of its size, decide how deep the water should be in the reservoir, and then climb up one of the banks until you are that far above the present surface of the stream or river. Have students walk upstream, staying as much as possible at the same level. The surface of a reservoir is nearly flat, so if you stay at the same elevation while you walk, you'll actually trace the shoreline of your imaginary reservoir. Explore your imaginary reservoir, asking students: What effects would the dam have on the land upstream? What happens to the people and animals upstream? What happens to the water while the dam is being built? What would happen if there was a leak in the dam? What happens to the river or stream below the dam?

Borrow a stream table to demonstrate what a stream looks like before and after a dam is built. Contact the DNR Aquatic Education Program (641/747-2200) for a list of sites with stream tables for loan, or visit www.iowadnr.gov/education/index.html.

Teacher Aids

Posters

"Aquatic Life." Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Benthic Macroinvertebrates." Ill. SB Lauterbach. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Life in a Stream." Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

CD Rom

"Biodiversity of Iowa: Aquatic Habitats." 2001. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Canaries of the Deep, The Plight of the Fresh Water Mussel." 2003. Geode Resource Conservation and Development Incorporated.

"Living Landscape." Conservation Technology Information Center.

Impoundment	Location	Costs	Benefits
Lake Red Rock	60 miles downstream from Des Moines on the Des Moines River	$88,000,000 in federal funds to construct 19,000 acres of land permanently flooded 70,000 acres flooded at "full pool" level	Provides recreation in the form of fishing, camping, and water skiing Prevents flooding in the cities of Ottumwa, Eldon, Eddyville, Keosaqua, and Farmington Prevents flooding of 36,000 acres of farmland Prevented estimated $449 million from 1969-1999
Lake Rathbun	7 miles N of Centerville on the Chariton River	$28,894,210 in federal funds to construct 11,000 acres flooded permanently 21,000 acres flooded at "full pool"	Water from reservoir allows operation of Rathbun Hatchery Provides flood control to 148,000 acres in the Chariton River Basin Provides recreation in the form of boating, fishing, swimming, hiking, and camping
Coralville Lake	Upstream from Iowa City on the Des Moines River	$1,465,000 for construction of a bridge over the reservoir 4,900 acres permanently flooded Lands and roads in "flood pool" are flooded for longer periods of time than were expected forcing government acquisition of them	Est. $23,853,400 saved in flood control between 1958-1986 (No acreage figures) Provides recreation in the form of boating, camping, hiking, fishing, picnicking, and swimming
Saylorville Lake	11 miles upstream from the city of Des Moines on the Des Moines River	5,950 acres permanently flooded 16,700 acres flooded at "full pool" Necessitated construction of three additional dams to protect Polk City during times of high water levels Estimated cost of $130,100,000 Possible damage to Ledges State Park	Provides recreation in the form of fishing, swimming,. and boating Provides water to the city of Des Moines and Southern Iowa Utilities (which pays $512,600 annually for 25 years for the water) Provides flood protection to the City of Des Moines

Information derived from "Water Resources Development in Iowa 1987": U.S. Army Corps of Engineers, North-central Division; www.mvr.usace.army.mil/redrock/flooddamage.htm.
June 2003

Water Neighborhood*

Time
one to three 45-minute sessions

Vocabulary
aquatic, biomass, biotic index, dissolved oxygen, diversity, erosion, habitat, healthy, indicator species, meander, mussel, pH, pollutant, pollution, pool, population, riffle, temperature, turbidity, water quality, watershed

Objectives
Students will:

- identify several aquatic organisms.
- assess the relative environmental quality of a stream or pond using indicators of pH, water temperature, and the presence of a diversity of organisms.

Method
Students investigate a stream or pond using sampling techniques.

Materials
identification books (i.e., A Golden Guide to Pond Life)
Student Worksheets I and *II*
sampling equipment (seine nets, sieves, assorted containers, white trays, magnifying lenses, eye droppers, forceps, thermometer, meter sticks or tape measure, microscopes)
water quality test kit (with tests for pH and dissolved oxygen) (Note: A simple water quality test kit can be obtained from scientific supply houses dealing with high school biology supplies. Kits may be available from a high school biology teacher, county conservation board, certain state parks, wildlife agencies, or local universities.)

Background
The General Land Office (GLO) in 1812 sent surveyors to the "new frontier" to survey the land for disposal. The surveyors of Iowa noted vast prairies, troublesome wetlands, and rich forests as they made their way across the land. In some areas, they were the first Euro-Americans to record the vegetation and wildlife in what would become townships. In their notes, they described numerous beavers, muskrats, and minks living along bodies of water.

The South and North Skunk Rivers begin in central Iowa, join in southeastern Keokuk County, and flow to the Mississippi River. Surveyors' maps show that the Skunk River was a forested river, in contrast to the surrounding tallgrass prairie. Historically, its **watershed** (land that drains into a particular body of water) consisted of prairie and wetlands near its source and forests near its confluence with the Mississippi.

Since Euro-American settlement, the majority of the Skunk River's watershed has been changed for agriculture and urbanization. For example, in Story County, approximately 92% of the land is either cropland or urban, and in Jasper County it was straightened and the **meanders** (turns or winding of a

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* Adapted from "A Lesson Plan for Some Water Investigations," Investigating Your Environment Series, U.S. Forest Service, Revised 1977.

stream) were cut through. In this county it is sometimes referred to as the "Skunk River Ditch." Some portions of the Skunk River Greenbelt (riparian area) are publicly owned and remain forested. Others are developed for farming or urban areas. In 2002, the Environmental Protection Agency declared a portion of the Skunk River impaired from pesticides. Pesticides affect **aquatic** (growing, living in, or frequenting water) life in the river.

In 1998, Dr. Jim Colbet, a professor at Iowa State University (ISU), began a community service activity entitled the "Skunk River Navy." ISU freshman biology students monitor water quality and **populations** (number of a particular species in a defined area at a given time) of native fresh water **mussels** (mollusks that have two shells and are collector-filterers), work to reduce **erosion** (removal or wearing away of soil or rock by water, wind, or other forces or processes), and improve the aesthetic quality of the Skunk River in Story County. This project allows students to learn about the biology of Iowa, while making a positive contribution to their community.

All organisms of an ecosystem are dependent upon each other. A large aquatic animal, such as a river otter, cannot survive if it has few fish, crayfish, and mussels to eat. Fish, crayfish, and mussels cannot survive without smaller fish, insects, and plankton to eat, and so on. In streams and ponds, the presence or absence of certain organisms, called **indicator species**, reveals much about **water quality** (condition of water). The absence or presence of organisms that are sensitive to **pollutants** (substances that may contaminate air, water, or soil) is an indicator of water quality.

The **biotic index** (number of kinds of living organisms found in an ecosystem) also is related to water quality. The presence of numerous aquatic species usually indicates a **healthy** (able to support life) environment. A water body with just a few different species usually means conditions are less healthy. **Pollution** (contamination of soil, water, or atmosphere by the discharge of harmful substances) generally reduces the quality of the environment and, in turn, the diversity of life forms. In some cases, the actual **biomass** (amount of living organisms) will increase because of pollution, but the **diversity** (variety) inevitably goes down.

For more information on the Skunk River Navy visit www.biology.iastate.edu/SRN/SRN.html. **For more information on the General Land Office (GLO) project, refer to *Iowa's Water*, page 5.**

Procedure

Before the Activity

1. Select a small, fairly shallow, slow-moving stream or pond near your school as the sampling site for this activity. Be sensitive to the impact you may have on stream banks and beds, spawning and nesting sites, and vegetation. Have students establish ethical guidelines for their sampling activities. If the stream is not a public site, obtain permission to visit it. Advise students in advance to dress for the setting – old (sturdy) shoes and shorts or jeans are best.
   NOTE: If a site visit is not possible, modify the activity to be conducted in the classroom.
2. Share the *background information* on the GLO project, conditions of Iowa after settlement, and settlement's impact on the Skunk River.
3. At the sampling site, brief students on habitat courtesies, working from their own list of ethical guidelines for sampling activities. Instruct them on how to minimize damaging the **habitat** (arrangement of food, water, shelter or cover, and space suitable to animals' needs) and encourage care in their collecting techniques. Emphasize that all wildlife is to be returned to its habitat unharmed. Decide whether you will take some of the organisms back to school for further study.
4. Begin the activity by observing the water. Identify organisms on the surface and in the depths. Use sampling equipment (nets, trays, sieves, etc.) to collect as many different forms of animal life as possible. Sample different microhabitats near rocks, in **riffles** (area of a stream with faster current; usually more shallow with the water surface broken up due to flowing over rocks) and in **pools**

(area of a stream which is deeper than adjacent areas, water flow is slower and the bottom is usually made of very small particles). Place animals in white trays for viewing and drawing so you can see the animals in detail. Keep adequate water in the trays and place them in a cool, shady spot. Change the water as often as needed to keep the animals cool. This is a good time to use the microscopes, if available.

5. On *Student Worksheet I*, have students identify and draw animals they observed (either in the water or in collection containers). Ask them to fill in the number of each kind found and to describe the location where the animal was found. Once these observations are completed, carefully return animals to their natural habitat.
   NOTE: If you choose to take some of the animals to the classroom, be sure you have adequate water as cool as in the natural setting. You may place organisms in Petri dishes or any shallow transparent dish and use an overhead projector to project images onto a screen or wall.
6. Encourage students to discuss their observations. How many kinds of organisms did they find? Explain that a variety of different kinds of plants and animals (diversity) usually indicates a healthy ecosystem.
7. Test the water at the field site for other indicators of quality. Using the water quality test kit, have students determine **dissolved oxygen** (molecules of oxygen gas dissolved in water) and **temperature** of the water as well as **pH** (a measure that indicates the relative acidity or alkalinity of a substance) and air temperature.
8. Note the color of the water. A cloudy, black/brown indicates sediment (**turbidity**); cloudy green indicates one-celled algae. Are other kinds of algae present? Are stream banks eroded? What is the cover of the riparian area (forested, grass, bare)? Is the stream straight or meandering? What is on the bottom of the stream – silt, sand, or rock? Is there anything else that might affect water quality (look for tile lines, trash, spilled oil, etc.)? These items can indicate soil erosion, channelization, removal of bank vegetation, nitrates, etc.
   NOTE: Students may also measure stream velocity, which can be accomplished by timing a floating object (i.e. a ping pong ball) as it travels a known distance (i.e. 10 feet).
9. Discuss how pH, water and air temperature, turbidity, and dissolved oxygen (DO) affect the diversity of life forms found in aquatic environments. Would you expect the same variety of life in other locations? Predictions of animal diversity can be made from measurements of dissolved oxygen, water temperature, turbidity, and pH. Likewise, certain indicator species also can disclose information about DO and water temperature. The latter measurements have the greatest impact in Iowa.
10. Ideally, you could repeat this activity at other sites with different characteristics. Biologists examine hundreds of sites in order to try to understand and predict what is happening in natural systems. If you visit another site, it might be useful to divide the class into two groups with one half doing *Student Worksheet I* and the other half doing *Student Worksheet II*. When each group is finished, students could come together and mutually predict what the other group found.
11. Re-emphasize the fact that diversity of animals is a useful indicator of habitat quality as well as an overall indicator of environmental quality.

Evaluation

1. Draw a simple illustration of one or more of the collected organisms. Identify each organism and write the correct name beside the picture.
2. How can water quality be determined?
3. Is water quality important? Why or why not?
4. Scenario: You found a trout in a stream with a large variety of other organisms. Predict ranges you would expect to find for DO and water temperature.

5. Based on the data you gathered, is this body of water healthy? Does it contain a diverse community of species?
6. Did you find any indicator species? If so what were they? What does this tell us about the stream?
7. How has Iowa changed since the surveyors surveyed Iowa? How has it stayed the same?
8. Do the actions of people living on the land affect water quality? Why or why not?

Extensions

Sample the stream above and below the local water supply.

Find the most diverse and least diverse streams in the area.

Monitor a local stream. Contact IOWATER, www.iowater.net, for details on training.
Adopt a local stream.

Research what your county was like before settlement. Go to www.public.iastate.edu/~fridolph/dnrglo.html for more information on the General Land Office project.

Teacher Aids

Posters

"Aquatic Life." Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.
"Benthic Macroinvertebrates." Ill. SB Lauterbach. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.
"Fish Iowa! Fish Posters." Ill. Maynard Reese. 1994. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.
"Life in a Stream." Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

CD Rom

"Biodiversity of Iowa: Aquatic Habitats." 2001. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.
"Canaries of the Deep, The Plight of the Fresh Water Mussel." 2003. Geode Resource Conservation and Development Incorporated.

Books

Iowa Department of Natural Resources. 1987. Iowa Fish and Fishing. Des Moines.
Zim, H.C. and A.C. Martin. 1987. A Golden Guide to Pond Life. New York: Golden Press.

Dissolved Oxygen (DO) Requirements for Native Fish and Other Aquatic Life (DO in parts per million [ppm])

(Below 68 °F)	(Above 68 °F)
Cold-water organisms including trout	Warm-water organisms including fish such as bass, crappie, catfish, and carp
6 ppm	5 ppm

6 ppm -- 5 ppm

Temperature Ranges (Approximate) Required for Certain Organisms

Temperature	
Greater than 68 °F 920 °C) = Warm water	Much plant life, many fish diseases
	Most bass, crappie, bluegill, carp, catfish, caddisfly, dragonfly, mayfly, mussels
55 – 68 °F (12.8 – 20 °C) = Cool water	Plant life, some fish diseases
	Salmon, trout, stonefly, mayfly, caddisfly, water beetles, small-mouth and rock bass, various minnows and darters, mussels
Less than 55 F (12.8 °C) = Cold water	Trout, caddisfly, stonefly, mayfly, various minnows, darters, sculpins

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pH Ranges That Support Aquatic Life

Most Acidic----------------------------- Neutral-------------------------------------- Most Basic
1 2 3 4 5 6 7 8 9 10 11 12 13 14

Bacteria
1.0 -- 13.0
Plants (algae, rooted, etc.) 6.5-- 13.0
Carps, suckers, catfish, some insects
6.0 ------------ 8.5
Bass, crappie 6.0 ------------ 8.5
Snails, clams, mussels 6.5 --------------- 9.0
Largest variety of animals 6.0 --------------- 8.5
(trout, mayfly, stonefly, caddisfly)

Student Worksheet I

Where Organism Was Found	Sketch of Organism	Number Found

Student Worksheet II

	Observations	Predictions
Water Temperature		
Dissolved O_2		
Air Temperature		
pH		
Comments:		

What's in Your Floodplain?

Time

one to two 60-minute period(s)

Vocabulary

100-year flood, channel, dam, erosion, flood, floodplain, habitat, meander, non-point source pollution, point source pollution, pollutant, pollution, reservoir, runoff, sediment, water quality

Objectives

Students will be able to:

- recognize changes in a river from its natural to altered state.
- identify ways pollutants can enter a river through flooding.
- recognize differences between point source and non-point source pollution.

Method

Students will participate in an active game, acting like water molecules and soil particles during a flood.

Materials

colored construction paper (7 colors) cut into small pieces (1- to 2-inch squares work well) or poker chips
large playing area
plastic or paper bags
string, line chalk, or other ways to mark boundaries
Pollutant Information Sheet (one for each student)
Student Directions cut into pieces
paper
writing materials

Background

A year before Captain James Allen's expedition with the Dragoons into northwest Iowa and southwest Minnesota, heavy rains fell. These rains caused rivers to swell out of their banks, onto the surrounding land. This land is referred to as a river's **floodplain**. The Big Sioux, like many of the Missouri River's tributaries, often leaves its typical **channel** (deeper part of a moving body of water where the main current flows) and envelopes its floodplain.

Flooding is any abnormally high stream flow that overtops the banks of a stream. Flooding is a natural process in a river. It creates new channels, wetlands, and oxbow lakes. A floodplain is an integral part of a river system that acts as a **reservoir** (a natural or manmade body of water) and temporary channel for flood waters.

Captain Allen and his crew noted large trees uprooted from the great rains. His report notes the Big Sioux River had "…risen about 17 feet, covering all of its bottom lands five or six feet. Great masses of drift wood had been deposited on its low grounds and timbered bottoms…we followed this river down 159 miles to its mouth, and the rise had been everywhere greater as the stream increased in size. Near its mouth it had partaken of the great rise of the Missouri. And here I noticed water-marks four miles from the Missouri, which I estimated to be at least 25 feet above the ordinary level of that river…" Through various observations, Allen concluded that the greatest rainfall occurred further north than where his crew had traveled.

People have been attracted to floodplains throughout history. The land is fertile (from deposited topsoil), flat, and near water so agriculture, development, and transportation require less effort. Prior to Captain Allen's expedition in 1844, the largest community of people living along the Big Sioux was a village of Native Americans at a site now named Blood Run. Between 1300 and 1750, this site was a major trading location for members of the Oneota Culture including the Omaha, Ioway, Oto, and Yankton Sioux tribes. Approximately 5,000 people lived at this site from 1700-1725, making it the largest known Oneota village in the Midwest. This area encompasses 650-1,250 acres in Iowa, and possibly 1,000 acres in South Dakota.

Today the largest city on the Big Sioux River is Sioux Falls, South Dakota, with about 124,000 people. This city lies in the Big Sioux's floodplain. Despite a flood control system constructed by the Army Corps of Engineers in the 1950s, it has flooded several times in the past 40 years. Its flood control system does not protect the city from a **100-year flood** (a flood having a one in 100 chance of being equaled or exceeded in any given year). Since the system does not protect the city to the Federal Emergency Management Administration's (FEMA) standards, the city is working with the Corps to upgrade its system of levees, spillway, diversion channel, and diversion dam.

Floods are dangerous when they occur and even after the waters have receded. When modern towns flood, numerous chemicals, petroleum products, and effluent may become **pollutants** (substances that may contaminate air, water, or soil). **Pollution** (contamination of soil, water, or air by harmful substances) can be divided into two groups: point source and non-point source. **Point source pollution** occurs when a pollutant can be traced back to the point of origin. For example, when a sewage treatment plant has a leak the sewage can be traced back to the plant. **Non-point source pollution** occurs when a pollutant cannot be traced back to its point of origin. Many times we see the results before we know there is a problem. An example of this would be **runoff** (water that drains or flows off the surface of the land) full of silt from a field or construction area.

While flooding is a natural process, there are ways to reduce the magnitude of floods and the amount of pollution entering waterways. Wetlands act as natural sponges, absorbing water and filtering out pollutants before reaching a body of water, so wetlands reduce the amount of water and pollutants that reach rivers and streams. Grass waterways slow runoff and absorb water before it reaches a stream or river. Levees, dikes, and **dams** (barriers preventing flow of water) may keep the water in the main channel, but they are costly to construct, remove **habitat** (arrangement of food, water, shelter or cover, and space suitable to animals' needs) for wildlife, and increase the risk of downstream flooding.

We also can reduce the amount of pollutants entering bodies of water. Good conservation practices in fields and developed areas keep soil, fertilizers, pesticides, and other chemicals out of our waters. Reducing or eliminating construction in the 100-year floodplain reduces damage from floods and prevents pollutants from these areas from entering rivers and streams.

For more information on Captain James Allen's journey, refer to *Iowa's Water,* page 4.

Procedure

1. Share *background information* on floodplains, pollutants, and Captain James Allen's journey through northwest Iowa.
2. Assign a pollutant from the *Pollution Information Sheet* to each color of construction paper. Make sure you have a lot of "**sediment**" (fine soil and other particles that settle to the bottom of a liquid) and an increased number of "fertilizer" and "manure."

3. Mark off a 10-foot wide section across the playing area. This will be the Big Sioux River. Make the river **meander** (S-shaped). Mark off 10 feet on both sides of the river. This will be the 100-year floodplain. Mark two smaller "tributaries" at one end of the river. The water will flow away from the tributaries into the Missouri River (the end of the Big Sioux). Place half of the "sediment," and a small amount of "sewage" on and near the river and tributaries' banks and floodplain.
4. Inform students they will be acting like water molecules. Explain the playing area and the areas marked.
5. Handout the cut *Student Directions* (one per student), make additional copies if needed.
6. Have students read their directions and move to their designated starting places. When you say "River Flow!" the game starts with the students, designated as water molecules in the river or tributary, walking through their respective channel. When all river/tributary molecules have made it to the Missouri River, explain to the students this is what the Big Sioux was like when Captain James Allen explored the area. The River meandered and was within its banks. Ask how many people picked up pieces of construction paper. Record the number of pieces picked up on a sheet of paper. Inform students what the two different colors represent. **Erosion** (removal or wearing away of soil or rock by water, wind, or other forces or processes) and sewage (animal & human waste) occurred long before Allen explored the area.
7. Gather the pieces of construction paper from the students and place throughout the playing area.
8. Have the river/tributary water molecules resume their starting positions. When you say "Flood!" students should follow the directions on their piece of paper. There should not be enough pieces of construction paper for everyone. When all molecules have reached the Missouri River, part one of the game is finished. Explain to the students this is what the Big Sioux used to look like (when Allen explored the area) when it flooded. The river expanded out of its banks enveloping the floodplain. Ask how many people picked up pieces of construction paper. Record the number of pieces picked up on the sheet of paper. Review the representation of the different colors. There were not enough pieces of construction paper, because the vegetation throughout the floodplain held the soil in place, animal wastes decomposed, and nutrients were used by the plants.
9. Gather all pieces of construction paper and have students trade their directions. Explain to them that they will represent what the Big Sioux looks like today. Straighten the boundaries of the Big Sioux River and the tributaries. Add the remaining pieces of construction paper in the floodplain. Be creative; place pollutants in "clusters" to represent contaminants that might come from cities and/or farms, etc. Describe what you are doing, while you are doing it.
10. Have students read their directions and move to their designated starting places. When you say "River Flow!" the game resumes with the students designated as river or tributary water molecules moving through their respective channel. When all molecules are in the Missouri River, explain to the students this is what the Big Sioux River looks like now with normal water flow. Ask how many students picked up pieces of construction paper. Record the number of pieces picked up on the sheet of paper. Explain the representation of each color. Define point source and non-point source pollution and list which pollutants are which.
11. Have the river/tributary water molecules return to their starting positions. When you say "Flood!" students should follow directions on their piece of paper. When all water molecules have reached the Missouri River, part two of the game is finished. Explain to the students that this is what happens when the Big Sioux floods today. The River expands its banks and envelops the floodplain. Ask how many people picked up pieces of construction paper. Record the number on the sheet of paper. Review the representation of each color. Review point source and non-point source pollution and list which pollutants are which.

12. Hand out *Pollutant Information Sheet*.
13. Have students brainstorm or research ways to prevent pollution and reduce the impacts of floods.

Evaluation

Discuss the following:

1. What was the Big Sioux like when Captain Allen traveled it? (meandering, braided streams, backwaters, sloughs)
2. What is the Big Sioux like now? (portions are channelized, one channel, flood control structures, development of the floodplain for cities, farming, etc.)
3. What happens as water flows downstream? (Water picks up sediment and other pollutants)
4. What happens when a river floods?
5. Did more pollutants enter the river during the flood or during normal flow? Why?
6. What is point source pollution? What is non-point source pollution?
7. What are some types of pollutants?
8. How have people impacted the **water quality** (condition of water) of the Big Sioux River?
9. What are some ways to prevent pollutants from entering waterways?
10. What are some ways to reduce flooding?

Extensions

Demonstrate non-point source pollution and point source pollution by borrowing an EnviroScape® model. For a list of places that have an EnviroScape® for loan, or for more information, check out the DNR web site (www.iowadnr.gov/education/index.html), or call the Aquatic Education Program (641/747-2200).

Borrow a stream table to demonstrate floods, watersheds and channelized and meandering streams. Contact the DNR Aquatic Education Program for a list of sites with stream tables for loan, or visit www.iowadnr.gov/education/index.html.

Research what explorers visited your area and modify the activity to represent a local river.

Teacher Aids

Posters:

"Aquatic Life." Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Life in a Stream." Ill. Brian Wignall. 1989. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

CD Rom

"Biodiversity of Iowa: Aquatic Habitats." 2001. Des Moines: Iowa Department of Natural Resources' Aquatic Education Program.

"Canaries of the Deep, The Plight of the Fresh Water Mussel." 2003. Geode Resource Conservation and Development Incorporated.

Tributary Water Molecule
Begin at the top of a tributary.
When you hear "Water Flow!" walk ***within*** the banks of your tributary and the Big Sioux River to the Missouri River.
When you hear "Flood!" walk quickly ***within*** the banks of your tributary and the Big Sioux River to the Missouri River.

Tributary Water Molecule
Begin at the top of a tributary.
When you hear "Water Flow!" walk ***within*** the banks of your tributary and the Big Sioux River to the Missouri River. Collect 3 pieces of construction paper on your way.
When you hear "Flood!" walk quickly ***within*** the banks of your tributary and the Big Sioux River to the Missouri River. Collect 5 pieces of construction paper on your way.

Tributary Water Molecule
Begin at the top of a tributary.
When you hear "Water Flow!" walk ***within*** the banks of your tributary and the Big Sioux River to the Missouri River. Collect 1 piece of construction paper on your way.
When you hear "Flood!" walk quickly ***inside*** the banks of your tributary and ***outside*** the banks of the Big Sioux River to the Missouri River. Collect 4 pieces of construction paper on your way.

Tributary Water Molecule
Begin at the top of a tributary.
When you hear "Water Flow!" walk ***within*** the banks of your tributary and the Big Sioux River to the Missouri River. Collect 1 piece of construction paper on your way.
When you hear "Flood!" walk quickly ***inside*** the banks of your tributary and ***outside*** the banks of the Big Sioux River to the Missouri River. Collect 2 pieces of construction paper on your way.

River Water Molecule
Begin at the start of the Big Sioux River.
When you hear "Water Flow!" walk ***inside*** the banks of the Big Sioux River to the Missouri River.
When you hear "Flood!" walk quickly ***inside*** the banks of the Big Sioux River to the Missouri River. Collect 5 pieces of construction paper.

River Water Molecule
Begin at the start of the Big Sioux River.
When you hear "Water Flow!" walk ***inside*** the banks of the Big Sioux River to the Missouri River.
When you hear "Flood!" walk quickly ***inside*** the banks of the Big Sioux River to the Missouri River. Collect 2 pieces of construction paper.

River Water Molecule
Begin at the start of the Big Sioux River.
When you hear “Water Flow!” walk ***inside*** the banks of the Big Sioux River to the Missouri River.
Collect 1 piece of construction paper.
When you hear “Flood!” walk quickly ***inside*** the banks of the Big Sioux River to the Missouri River.

River Water Molecule
Begin at the start of the Big Sioux River.
When you hear “Water Flow!” walk ***inside*** the banks of the Big Sioux River to the Missouri River.
Collect 1 piece of construction paper.
When you hear “Flood!” walk quickly ***outside*** the banks of the Big Sioux River to the Missouri River.

River Water Molecule
Begin at the start of the Big Sioux River.
When you hear “Water Flow!” walk ***inside*** the banks of the Big Sioux River to the Missouri River.
Collect 2 pieces of construction paper.
When you hear “Flood!” walk quickly ***outside*** the banks of the Big Sioux River to the Missouri River. Collect 4 pieces of construction paper.

River Water Molecule
Start at the beginning of the Big Sioux River.
When you hear “Water Flow!” walk ***inside*** the banks of the Big Sioux River to the Missouri River.
When you hear “Flood!” walk ***outside*** the banks of the Big Sioux River to the Missouri River.

River Water Molecule
Start at the beginning of the Big Sioux River.
When you hear “Water Flow!” walk ***inside*** the banks of the Big Sioux River to the Missouri River.
When you hear “Flood!” walk ***outside*** the banks of the Big Sioux River to the Missouri River.

Rain Molecule
Begin at the top of the Big Sioux River.
When you hear “Water Flow!” do nothing.
When you hear “Flood!” walk quickly ***inside*** the banks of the Big Sioux River to the Missouri River.
Collect 2 pieces of construction paper on your way.

Rain Molecule
Begin at the top of the Big Sioux River.
When you hear “Water Flow!” do nothing.
When you hear “Flood!” walk quickly ***outside*** the banks of the Big Sioux River to the Missouri River. Collect 2 pieces of construction paper on your way.

Rain Molecule
Begin at the top of the Big Sioux River.
When you hear “Water Flow!” do nothing.
When you hear “Flood!” walk quickly ***outside*** the banks of the Big Sioux River to the Missouri River.

Rain Molecule
Begin at the top of a tributary.
When you hear “Water Flow!” do nothing.
When you hear “Flood!” walk quickly ***inside*** the banks of your tributary and ***outside*** the banks of the Big Sioux River to the Missouri River. Collect 3 pieces of construction paper on your way.

Rain Molecule
Begin at the top of a tributary.
When you hear “Water Flow!” do nothing.
When you hear “Flood!” walk quickly ***inside*** the banks of your tributary and ***outside*** the banks of the Big Sioux River to the Missouri River. Collect 2 pieces of construction paper on your way.

Rain Molecule
Begin 2 paces from the middle of the Big Sioux River.
When you hear “Water Flow!” do nothing.
When you hear “Flood!” walk quickly ***outside*** the banks of the Big Sioux River to the Missouri River. Collect 2 pieces of construction paper on your way.

Rain Molecule
Begin 2 paces from the middle of the Big Sioux River.
When you hear “Water Flow!” do nothing.
When you hear “Flood!” walk quickly ***outside*** the banks of the Big Sioux River to the Missouri River. Collect 1 piece of construction paper on your way.

Sediments

Particles of soils, sand, silt, clay, and minerals wash from land and paved areas into creeks and tributaries. In large unnatural quantities, these natural materials can be considered pollutants. Construction projects often contribute large amounts of sediment. Sediments may fill stream channels that later require dredging. Sediments suffocate fish and shellfish populations by covering fish nests and clogging the gills of bottom fish and shellfish. This is often a non-point source pollutant.

Human and Animal Waste

Human waste that is not properly treated at a waste treatment plant and then released into water may contain harmful bacteria and viruses. Typhoid fever, polio, cholera, dysentery, hepatitis, flu, and common cold germs are examples of diseases caused by bacteria and viruses in contaminated water. The main source of the problem is sewage getting into the water. People can come into contact with these micro-organisms by drinking the polluted water or through swimming, fishing, or eating shellfish living in polluted waters. Often unexpected flooding of barnyards, stock pens, or holding tanks can suddenly increase the toxic effects of animal waste in water. Animal waste can also act as a fertilizer and create damage by increasing nutrients. This is commonly a non-point source pollutant.

Detergents and Fertilizers

Many of these substances are toxic to fish and harmful to humans. They cause taste and odor problems and often cannot be treated effectively. Some are very poisonous at low concentrations. The major source of pollution from agriculture comes from surplus fertilizers in the runoff. Fertilizers contain nitrogen and phosphorus that can cause large amounts of algae to grow. The large algae blooms cover the water's surface. Once dead, they sink to the bottom where bacteria feed on them. The bacterial populations increase and use up most of the oxygen in the water. Once the free oxygen is gone, many aquatic animals die. This process is called "eutrophication." This is typically non-point source pollution.

Pesticides, Herbicides, and Fungicides

Chemicals that are designed to limit the growth of or kill life forms are a common form of pollution. This pollution results from the attempts to limit the negative effects of undesirable species on agricultural crop production. Irrigation, ground-water flow, and natural runoff bring such toxic substances to rivers, streams, and lakes. This is typically non-point source pollution.

Organic Waste

Domestic sewage treatment plants, food-processing plants, paper mill plants, and leather tanning factories release organic wastes that bacteria consume. If too much waste is released, the bacterial populations increase and use up the oxygen in the water. Fish die if too much oxygen is consumed by decomposing matter. This is commonly a point-source pollutant.

Inorganic Chemicals

Inorganic chemicals and mineral substances, solid matter, and metal salts commonly dissolve in water. They often come from mining and manufacturing industries, oil field operations, agriculture, and natural sources. Those chemicals interfere with natural stream purification; they destroy fish and other aquatic life. They also corrode expensive water treatment equipment and increase the amount of boat maintenance. This is commonly a point-source pollutant.

Petroleum Products

Oil and other petroleum products such as gasoline and kerosene can enter water from boats, automobile service stations, and streets. Oil spills kill aquatic life (fish, birds, shellfish, vegetation). Birds are unable to fly when oil loads their feathers. Shellfish and small fish are poisoned. If it is washed on the beach, oil requires much labor to clean up. Fuel oil, gasoline, and kerosene may leak into ground water through damaged underground storage tanks. This is often a non-point source pollutant, but may be a point source if in the form of a large oil spill.

Glossary

100-year flood: a flood having one in 100 chance of being equaled or exceeded in any given year

aquatic: growing, living in, or frequenting water

archaeological sites: a place where material remains of past peoples are found

benthic trawl: dragging a net on the river bottom to sample aquatic populations

biomass: amount of living organisms

biotic index: number of kinds of living organisms found in an ecosystem

Cesium-137: a radioactive product of the explosions from nuclear bomb tests carried out in the 1950s and early 1960s

channel: the deeper part of a moving body of water where the main current flows

channelization: describes a stream or river that has been straightened

dam: a barrier preventing flow of water

dissolved oxygen: molecules of oxygen gas dissolved in water

diversity: variety

economic depression: period of time where there is an economic downturn usually accompanied with high unemployment, loss of value of currency, and lower stock values

electrofishing: using an electric current to temporarily stun fish so they can be identified, weighed, and measured

erosion: the removal or wearing away of soil or rock by water, wind, or other forces or processes

flood: the abnormally high stream/river flow that overtops the banks of a stream/river

floodplain: the land near a stream/river which flood water spills onto

glochidium: the larva of a freshwater mussel (Superfamily *Unionoidea*) that generally lives as a temporary parasite on a host fish; a mussel larva that is microscopic, many species require a fish as a host for development to a juvenile

habitat: the arrangement of food, water, shelter or cover, and space suitable to animals' needs

habitat generalist: an animal that may live in a variety of habitats

habitat specialist: an animal that must have specific conditions present to survive

healthy: a habitat which supports the diversity of life

ichthyologist: a person that studies fish, their classification, structure, habits, and life history

indicator species: a particular plant or animal species used as a general measure of the health of an ecosystem

isotope: one of two or more species of atoms of the same chemical element that have the same atomic number and occupy the same position in the periodic table and are nearly identical in chemical behavior, but differ in atomic mass or mass number and so behave differently in the mass spectrograph, radio transformations, and physical properties

land-use planning: usually refers to the planning of how the land will be used by people

lifestyle: individual's way of life

meander: a turn or winding of a stream

migration: the periodic movement of animals from one area to another and back again as a natural part of their lives

municipal water storage: water stored for public consumption or use

mussel: mollusks that have two shells and are collector-filterers

natural resources: raw materials provided by the Earth and usually processed into useful products; some natural resources are renewable (e.g., trees, crops, wildlife); other natural resources are non renewable (e.g., oil, coal, metals)

natural resource management: the practice or act of controlling the harvest, protection or restoration, or other use of resources

niche: the function or position of an organism or a population within an ecological community

non-point source pollution: pollution that enters water through runoff from land

pH: a measure that indicates the relative acidity or alkalinity of a substance (The pH scale ranges from 0 (most acid) to 14 (most basic), with a pH of 7 being neutral)

point-source pollution: pollution that can be traced back to the point of origin

pollutant: substance that may contaminate air, water, or soil

pollution: contamination of soil, water, or atmosphere by the discharge of harmful substances

pool: area of a stream or river which is deeper than adjacent areas; water flow may be slowed and the bottom usually is made of very small particles

population: the number of a particular species in a defined area at a given time

potable water: water suitable for drinking

precipitation: any form of water falling from the sky (e.g. rain, snow, hail)

pristine: uncorrupted by civilization or world

radio-isotope: a radioactive isotope

reservoir: a natural or manmade body of water

riffle: area of a stream or river with faster current; usually more shallow than a run or pool; the water surface is broken up due to flowing over rocks, etc.

run: area of a stream or river with moderate current and fairly uniform water flow

runoff: water that drains or flows off the surface of the land

sediment: the matter that settles to the bottom of a liquid such as water

sedimentation: the accumulation of sediment

seine: a net that hangs vertically in the water, typically with floats at the upper edge and weights at the lower edge that can be moved through the water to trap and/or catch fish

snag: an underwater structure that may be manmade (stake piles, cedar trees) or natural (fallen trees)

species: a population of individuals that are more or less alike and are able to breed and produce fertile offspring under natural conditions; a category of biological classification immediately below the genus or subgenus

species richness: the number of different species present

temperature: degree of hotness or coldness measured on a scale

terrestrial: living or growing on land

trade off: to use alternately; to exchange places with another

turbidity: subjective term used to measure the amount of light that can get through the water column due to the amount of suspended sediments in water that make the water muddy or cloudy

water quality: term referring to the condition of water (can it support life or be consumed)

watershed: area of land that drains into a particular body of water

wilderness: a place uncultivated and uninhabited by human beings

Web Sites

This listing is just to get you started. There are thousands of sites which deal with early explorers, Iowa's rivers, and water quality.

Early Explorers

Dragoons

showcase.netins.net/web/marjned/nathan.html
Nathan Boone and the 1835 march

www.campsilos.org/mod1/teachers/r3.shtml
Excerpts from records of the Dragoons march in 1835

www.jlindquist.com/allen.html
Summarizes Captain Allen's journey through Iowa, including his report on the expedition

General Land Office Surveyors

www.public.iastate.edu/~fridolph/glo/pinfo/timeline.html
Notes, maps, and information on the GLO surveys and Iowa State University project

Lewis, Clark, and the Corps of Discovery

lewisandclark.org/
Lewis and Clark Trail Heritage Foundation homepage

www.pbs.org/lewisandclark/
Journal entries, maps, and information on the expedition

Marquette & Joliet

www.americanjourneys.org/aj-051/summary/index.asp
Summary of voyage

Stephen Kearny

www.absoluteastronomy.com/topics/Stephen_W._Kearny
Kearny's military career

Zebulon Pike

www.artsci.wustl.edu/~landc/html/pike_b.html
Pike's journal

Agencies & Organizations

Agriculture Clean Water Alliance
www.acwa-rrws.org/
Information on Raccoon River watershed project

Iowa Association of Naturalists
www.iowanaturalists.org/
Home page to the Iowa Association of Naturalists

Iowa Conservation Education Coalition
www.extension.iastate.edu/iowaee/ICEC.html
Home page to the Iowa Conservation Education Coalition

Iowa Department of Natural Resources
www.iowadnr.gov
Home page to the Iowa Department of Natural Resources

Skunk River Navy
www.biology.iastate.edu/SRN/SRN.html
Information on Iowa State University's community service activity and the Skunk River

Home Pages by Topic

Clean Water Act
www.epa.gov/r5water/cwa.htm
A brief history of the Clean Water Act

Fishes (Iowa)
www.iowadnr.gov/education/index.html
Guide to fish species in Iowa

Floods
www.mvr.usace.army.mil/redrock/flooddamage.htm
Des Moines River flood control – Red Rock Reservoir

www.mvr.usace.army.mil/Brochures/SaylorvilleLake.asp
Information on Saylorville Lake

www.siouxfalls.org/PublicWorks/water_conservation/flood_control.aspx
Sioux Falls flood control

Missouri River

infolink.cr.usgs.gov/
Various Missouri River information including maps and the history of the river

www.sdstate.edu/wfs/research-unit/missouri-river-benthic-fish-study.cfm
Missouri River Benthic Fish Study

Rivers and Streams

octopus.gma.org/streams/edge.html
Living on the edge describes the natural buffers of streams, its riparian zone

octopus.gma.org/streams/streams.html
(Maine) What is a stream? Life along a stream, living on the edge, and the role everyone can play to help keep it healthy and full of life

www.history.com/topics/mississippi-river
Information about the history of the upper and lower Mississippi River, maps,

www.greatriver.com
Mississippi River Homepage

www.scetv.org/ntti/lessons/2000_lessons/oxbow.cfm
Lesson plan on the natural processes that shape rivers and form lakes

Settlement of Iowa

biology.usgs.gov/luhna/chap2.html

Maps and charts on the interrelationships of expansion of settlers and creation of farms across the U.S.

www.npg.org/states/ia.htm
Shows the historical resident population of Iowa from 1860 to 2000

Water Quality

water.usgs.gov/
Home page for the USGS water resources information

www.cdc.gov/healthywater/drinking/private/wells/
fact sheets on keeping the water quality in private wells safe

http://www.igsb.uiowa.edu/service/wateres.htm
Iowa ground water resources