

## 1. Watersheds

### WHAT'S A WATERSHED?

Not everyone lives next to a stream or pond but all of us live in a watershed. The watershed is the land area that drains into a body of water. You can also think of it as the land area that drains to a common outlet, such as the outflow of a lake, the mouth of a river, or any point along a stream channel. A drop of water falling in a watershed that does not evaporate or become part of a plant or animal will leave the watershed at this outlet.

The path water takes across the land is determined mainly by gravity. High places -- ridges, mountains, and hills -- form divides between adjacent watersheds. Water always flows downhill. The outer boundary of a watershed, therefore, is formed by the ridges and hills surrounding a given waterbody. Precipitation (rain, snow, etc.) falling directly on the watershed boundary will be split between the watersheds on either side.

### PARTS OF A WATERSHED

The watershed of most lakes and rivers consists of a network of streams, wetlands, human-made channels and storm drains, and the surrounding upland. At any point in the watershed, precipitation runs off the land surface and collects in these natural and human-made drainage pathways. As precipitation moves it follows the lay of the land, or topography. Some precipitation seeps into the ground where it moves through the soil and may emerge at a nearby surface waterbody; some penetrates more deeply to replenish regional groundwater supplies.

- **Groundwater**

A groundwater reservoir, or aquifer, is a geologic formation that can store and release large amounts of subsurface water. Groundwater reservoirs have their own watersheds, known as recharge areas, which consist of all the land contributing subsurface flow to a common location. The boundaries of a surface watershed and groundwater recharge area can, but do not always coincide.

In recharge areas, surface waterbodies and groundwater are often interconnected. Occasionally, surface waters can provide a source of flow, or recharge, to the aquifer, especially when water tables are low. When water tables are high, groundwater can flow into lakes and streams and help maintain surface water levels. Lakes which seem to have no major inlet may be fed primarily by groundwater.

- **Wetlands**

Wetlands, such as wooded swamps, marshes and bogs, slow the flow of incoming water and temporarily store this water before releasing it downstream. By retarding flow, wetlands protect downstream areas from flooding. Slow movement of water through wetland vegetation also helps to settle sediments and remove certain pollutants, thereby improving water quality. Wetlands also provide habitat for fish and wildlife. When wetlands are filled or channelized these natural functions are lost.

- **Uplands**

Uplands are the drier, well-drained areas of the watershed. Most streams and lakes receive most

of their water from the upland portions of their watersheds. Upland sites with sandy, coarse-textured soil readily allow precipitation to pass through them and they serve as important groundwater recharge areas. Uplands with fine-textured, less permeable soil may not provide significant groundwater recharge. Precipitation falling on these areas seeps into the shallow soil layers or moves slowly along the soil surface before collecting in small streams and wetlands. When uplands are developed by people, this natural absorption and filtering process is bypassed. Precipitation falling on paved surfaces quickly washes downstream, carrying sediment and other pollutants, eroding streambanks and increasing flooding.

## **THE AQUATIC ECOSYSTEM**

The watershed network makes it possible for pollutants to reach a waterbody located many miles from the pollution source. Groundwater recharge areas also transport pollution, although subsurface water moves much more slowly than surface water.

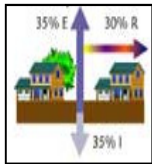
The materials that reach a river or lake through the watershed affect the chemical and physical environment in which a complex association of plants, animals and microorganisms exist. These interrelated organisms and their environment are referred to as the aquatic ecosystem. The watershed is part of this ecosystem. Changes in the watershed will affect other parts of the ecosystem downstream.

## **HOW PEOPLE AFFECT THE AQUATIC ECOSYSTEM**

All of us living within a particular watershed have the ability to make changes in the environment which can intentionally or inadvertently affect aquatic ecosystems, even when activities are far from any shore. These changes include many common activities such as the construction of homes, roads and shopping centers, and the cultivation of crops, lawns and livestock. These activities can change the pattern of water flow in a watershed, increase the amount of water that reaches a waterbody and allow it to get there faster without the opportunity for removal of pollutants by slow filtration through the soil. Inputs of nutrients, sediment, and toxic substances from human sources can seriously impair streams, ponds and groundwater resources.

From: Ruesink, A. 1996. Small Watershed Ecology Assessment Project Handbook. Alan R. Berkowitz and Kathleen Hogan, Project Directors. Institute of Ecosystem Studies, Millbrook, NY.

[Adapted from Joubert, L & Gold, AJ, 1990, **What is a Watershed?**, The University of Rhode Island, College of Resource Development, Department of Natural Resources Science, Cooperative Extension, Kingston, RI.]



## 2. The Water Cycle and Land Use

Water is probably the natural resource we all know best. All of us have had firsthand experience with it in its many forms -- rain, hail, snow, ice, steam, fog, dew.

Yet although we use it daily, water is probably the natural resource we least understand. How does water get into the clouds, and what happens to it when it reaches the earth? Why is there sometimes too much and sometimes too little? And is there enough water for all the world's plants and animals, including people?

Water covers nearly 75% of the earth; most is sea water. But sea water contains minerals and other substances, including those that make it salty, that are harmful to most land plants and animals. Still, it is from the vast salty reservoirs of seas and oceans that most of our precipitation comes -- no longer salty or mineral laden. Water moves from clouds to land and back to the ocean in a never-ending cycle. We call this the water cycle, or the hydrologic cycle.

Ocean water evaporates into the atmosphere, leaving impurities behind, and moves across the earth as water vapor. Water in lakes, ponds, rivers and streams also evaporates and joins the moisture in the atmosphere. Soil, people, and other animals contribute moisture to the atmosphere, as do factories, automobiles, and planes.

Plants contribute large amounts of moisture to the atmosphere through transpiration. Plants pull water from the soil through their roots and into their stems and leaves where it keeps cells alive and rigid. Some water is used in photosynthesis, but most is lost to transpiration through the leaves as water vapor. In the summer months when trees are actively photosynthesizing, transpiration is a major component of the water cycle. Since many trees are dormant during the winter months, transpiration plays a smaller role then. Some of the water vapor in the atmosphere is visible to us as fog, mist, or clouds. Water vapor condenses and falls to earth as rain, snow, sleet, or hail depending on region, climate, season, and topography. Global precipitation over land surfaces averages 26 inches per year, but it is not evenly distributed. Some places get less than 1 inch and others more than 400 inches each year.

The United States receives about 30 inches of precipitation each year, or about 4.3 trillion gallons a day. Total streamflow from surface and underground sources is about 1.2 trillion gallons a day. This is the amount available for human use -- homes, industry, irrigation, recreation. The difference between precipitation and streamflow -- 3.1 trillion gallons a day -- is the amount returned to the atmosphere as water vapor via evaporation or plant transpiration. It is roughly 70 percent of the total input of water.

When water hits the ground some soaks into the soil and the rest runs off over the surface. The water that soaks into the soil sustains plant and animal life in the soil. Some seeps to underground reservoirs called groundwater. Almost all of this water eventually enters the cycle once more.

Humans can do little to alter the input side of the water cycle, so our primary supply of water is firmly fixed.

But our land use activities can alter the quality and quantity of the water that is available to us.

Because much of our water supply comes to us as precipitation falling on the land, the fate of each drop of rain, each snowflake, each hailstone depends largely on where it falls -- on the kind of soil and its cover.

Surface runoff from rain or melting snow can carry away huge amounts of soil via erosion. Freshly plowed farmland, cleared areas in new housing developments, and highway fills and banks are especially vulnerable. The water loosens soil particles and carries them away. Soil erosion by surface runoff is the source of sediment that fills streams, polluting water and killing aquatic life. It also shortens the useful life of dams by filling the reservoirs behind them.

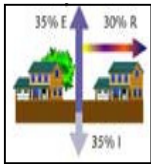
In cities and suburbs, where much of the land is paved or covered with streets, buildings, parking lots, and airport runways, water runs off as much as 10 times faster than on unpaved land. Since this water cannot soak into the soil, it flows rapidly down storm drains or through sewer systems, contributing to floods and often carrying debris and other pollutants to streams.

Throughout the world the need for water continues to increase. Per capita use of water, especially in industrialized countries, is increasing rapidly. Population growth also brings demands for more water.

Our land use activities and our management of the water available to us determines whether or not we have both the quantity and quality of water to meet our needs. It is our obligation to return water to streams, lakes and oceans as clean as possible and with the least waste.

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[Adapted from **Conservation and the Water Cycle**, 1983, USDA Soil Conservation Service, Agriculture Information Bulletin No. 326.]



### 3. Maps and Messages

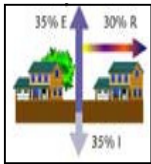
Maps are simplified, symbolic representations of the world that call attention to key features of the landscape. Many of them are also quite beautiful.

Maps reflect the cartographer's (map maker's) knowledge, biases, and view-of-the-world. In medieval times, for example, map makers often wrote "Here there be dragons" on portions of the map that were unexplored or dangerous. Before the voyages of Christopher Columbus, European cartographers drew maps of a flat world because they didn't know or believe that the world was round.

Most modern maps do not reflect such extreme attitudes or misinformation. But map makers still choose what to depict on their maps and how to depict it, based on how and by whom they hope the map will be used. For example, to attract tourists to Dutchess County's many antique dealers, a map maker might produce a coarse scale map that depicts the county's major roadways and antique shop locations, ignoring other features like cemeteries and ballparks and lakes that might add too much confusing detail to the map. Coarse scale maps depict a few major landscape features. Fine scale maps include much more detail. For example, when a school considers building additional classroom space they need a fine scale map showing the locations of all existing buildings, parking lots, sidewalks, fire hydrants, playing fields, power lines, underground sewage and gas lines, trees, and streams on the school property.

The next time you look at a map, observe the different techniques the map makers used. Notice how plants, paths, roads, and other features are represented on the map, and whether or not symbols and a key are used. Notice what features have been included on the map and what features have been left off. What is the map telling you about the world and about the map maker?

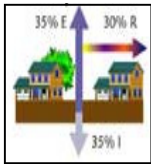
From: Ruesink, A. 1996. Small Watershed Ecology Assessment Project Handbook. Alan R. Berkowitz and Kathleen Hogan, Project Directors. Institute of Ecosystem Studies, Millbrook, NY.



## 4. Water Quality At-A-Glance

	Unpolluted Stream or Pond
Chlorides	<ul style="list-style-type: none"> <li>Clean water has 8-12 mg/l chloride.</li> </ul>
Nitrates	<ul style="list-style-type: none"> <li>Aquatic organisms need nitrates in small quantities.</li> <li>Clean water has less than 3 mg/l nitrate.</li> </ul>
Phosphates	<ul style="list-style-type: none"> <li>Clean water has low phosphates, usually between 0.01 and 0.03 mg/l.</li> </ul>
pH	<ul style="list-style-type: none"> <li>Water with a pH range from 6.5 to 8.6 is the best condition for fish and almost all invertebrates.</li> </ul>
Aquatic Organisms	<ul style="list-style-type: none"> <li>Clean water has a large number of different kinds of aquatic organisms, including those that cannot tolerate pollution.</li> </ul>

	Polluted Stream or Pond
Chlorides	<ul style="list-style-type: none"> <li>Water with more than 250 mg/l chloride is considered not drinkable.</li> <li>Chlorides can enter water from road salt, soil leaching, and industrial and animal wastes.</li> </ul>
Nitrates	<ul style="list-style-type: none"> <li>High readings indicate pollution from fertilizer, sewage, industrial waste or detergents and may accelerate the eutrophication process.</li> <li>Federal law requires that nitrate levels in public water supplies be less than 10 mg/l.</li> </ul>
Phosphates	<ul style="list-style-type: none"> <li>Readings higher than 0.03 mg/l indicate pollution from fertilizer, sewage, industrial waste or detergents and may accelerate the eutrophication process.</li> <li>Waste water is 5 to 30 mg/l phosphate.</li> <li>drinking water must have less than 0.5 mg/l phosphate, according to federal law.</li> </ul>
pH	<ul style="list-style-type: none"> <li>Water with pH less than 5 or greater than 9 is harmful for aquatic life.</li> <li>Below pH 4.5, few fish and invertebrates can survive.</li> <li>pH can be influenced by soil leaching, industrial pollution, and acid rain.</li> </ul>
Aquatic Organisms	<ul style="list-style-type: none"> <li>There may be many organisms in the stream, but there will be little variety. All of the organisms will belong to a few species that can survive in polluted water.</li> </ul>



## 5. What's the Big Deal About Dirt?

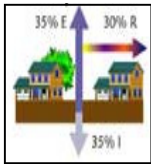
To different people the word "soil" has different meanings. To you, perhaps, soil is the lumps in your garden, the material under the grass in your schoolyard, or the furrows in a farmer's field. To the farmer, soil is a medium for plant growth. To a real estate developer, soil is a surface that can be sculpted to make an attractive landscape. To some contractors, soil is something to be scraped off the land and sold to other contractors. For us in our study of small watersheds, soil is a dynamic layer in which many complex chemical, physical and biological activities are going on constantly. Since virtually all of the landscape -- and thus all of every watershed -- is covered by soil, all water falling onto the land must pass over and/or through this dynamic layer. What happens to the water as it passes through the soil is key to how much water will come out the other end and what will be in it.

Soil is made up of substances in three states -- solid, liquid and gas. The solid portion is both inorganic (rock fragments) and organic (plant, animal, and microbe materials, both living and dead). The liquid portion is a complex solution of chemical compounds necessary for many important activities in the soil. The gases are basically those found in the atmosphere, together with gases liberated by biological and chemical activity in the soil. They are found in the open pore spaces of the soil.

The soil in Dutchess County is not the same as that in other parts of North America. Soils differ from country to country and even from town to town. Soils are classified according to their composition of organic material, inorganic material, soil solution and soil air. They are also classified based on their profiles, which can be easily observed by digging a trench in the ground. Soil type is affected by the underlying parent material (rocks) from which it was formed as well as topography, age, climate, vegetation, and soil organisms.

The soil classification system is a useful way to learn about differences in soils. For example, Bernardston silt loam soils (abbreviated BeB on the Dutchess County Soil Map series) are deep, well-drained soils that were formed in glacial till. Water moves through these soils at a moderate pace. Prime farmland can be found where these soils occur on flat to gently-sloping terrain. In contrast, Carlisle muck soils (designated Cc) are deep and poorly-drained with a large amount of organic (once-living) material. Carlisle muck soils retain water and they are often found in wetland areas. Carlisle muck soils are unsuitable for human agricultural and residential uses and they provide a rich habitat for wetland plants and animals.

From: Ruesink, A. 1996. Small Watershed Ecology Assessment Project Handbook. Alan R. Berkowitz and Kathleen Hogan, Project Directors. Institute of Ecosystem Studies, Millbrook, NY.



## 6. Glossary

**ABIOTIC:** Something that was never alive (water, rocks, air); the physical environment.

**AERIAL PHOTOGRAPHS:** Photographs taken from an airplane high above the land surface; used for mapping and reconnaissance.

**ALGAE:** Simple one-celled or many-celled plants that are the most basic type of plant life in aquatic environments.

**ALGAL BLOOM:** A huge growth of algae that can change the water color to green, brown, or yellow. May occur due to nutrient additions or naturally, such as in the fall when leaves drop from streamside trees, increasing the amount of sunlight that reaches algae in the stream.

**AQUATIC:** In or near water.

**BASE FLOW:** The normal volume of water that passes through a stream or river which can increase due to storm events or decrease during drought conditions.

**BIOTIC:** Something that is alive, or used to be alive.

**BUFFER ZONE:** A strip of vegetation along a stream or pond that intercepts pollutants, sediments, and fast-moving runoff before they enter the stream or pond water.

**CARNIVORE:** A flesh-eating animal. Examples include dragonfly nymphs, spiders and foxes.

**CHLORIDE:** One of the chemical constituents of salt (sodium chloride); high chloride readings in streams may indicate contamination from road salts.

**COMMUNITY:** All the organisms living in a given area.

**CONTOUR LINES:** The lines connecting all points of the same elevation on a part of the earth's surface as shown on topographic maps.

**DETRITIVORE:** An animal that eats dead plant and animal material ("detritus"). Examples include aquatic sowbugs and scuds.

**ECOLOGY:** The study of how living things interact with each other and their physical environment.

**ECOSYSTEM:** All the living things and their physical environment as they interact in a given area.

**EROSION:** The removal or wearing away of soil or rock by water, wind, or other processes. Erosion can occur naturally and by land use activities such as development, road building, farming and clearing for timber.

**EUTROPHICATION:** Over-enrichment of a water body with nutrients. Can cause excessive plant growth whose decomposition depletes the oxygen supply in water, thus killing animal life and making the water unfit for human consumption.

**FERTILIZER:** Chemical mixtures rich in plant nutrients like nitrate and phosphate that are applied to farmland and lawns to promote plant growth.

**FLOODPLAIN:** Low, flat areas adjacent to rivers, ponds, and streams that are subject to flooding.

**GROUNDWATER:** Water found underground, in the zones of soil and bedrock.

**HEADWATERS:** Place of origin (where water first surfaces) of a creek, stream, or river.

**HERBIVORE:** A plant-eating animal. Examples include mayfly nymphs, white-tailed deer and caterpillars.

**HYDROLOGY:** The area of science dealing with the study of the waters of the earth and its atmosphere.

**INTERMITTENT STREAM:** A stream that flows during the wettest part of the year (normally the spring, winter, and fall) but often becomes dry in the summer.

**LAND USE:** How humans use the land and its resources.

**MACROINVERTEBRATES:** Small aquatic organisms that can provide an index of stream water quality. Clean water has a high number of different kinds of macroinvertebrates.

**NITRATE:** A nutrient containing the element nitrogen. High nitrate readings in a stream may indicate pollution from fertilizer, industrial waste, sewage, or detergents.

**NONPOINT SOURCE POLLUTION:** Pollution that comes from numerous and diffuse sources, such as highway storm drains, septic systems, and runoff from agricultural or developed land.

**NUTRIENT CYCLE:** The pathway of nutrients moving back and forth between living things and the non-living environment (soil, water, and air).

**NUTRIENT:** A substance that does not provide energy, but supplies minerals that living things need in reasonable amounts to stay healthy. These are the building blocks of organisms' bodies.

**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.

**PERENNIAL STREAM:** A stream that flows during all seasons of the year.

**PHOSPHATE:** A nutrient containing the element phosphorous. High phosphate readings in streams may indicate pollution from fertilizer, industrial waste, sewage, or detergents.

**POINT SOURCE POLLUTION:** Pollution that enters a water body from a single identifiable source, such as an industrial drain pipe, a mine pit, or a ship.

**RIPARIAN AREA:** The area on either side of a stream. Vegetated riparian areas can buffer the stream from land

use that would otherwise send toxins, nutrients, or sediments into the water.

**RUNOFF:** Water that drains or flows off the surface of the land.

**SEDIMENT:** Soil, sand, and minerals which are washed from land into water, usually after rain, and settle to the bottom as new material.

**SEPTIC SYSTEM:** A means of sewage disposal in which waste material is stored in an underground tank or released into an underground leach field.

**STORMWATER:** Water that runs off paved surfaces after a heavy rain; stormwater may carry sediments and pollutants into streams, erode streambanks, and increase flooding.

**STREAM:** The type of runoff where water flows in a channel downhill because of the pull of gravity. Streams include rivers, brooks, and creeks.

**SUCCESSION:** A change in the kinds of plants and animals living in an area over time. In the northeast, succession on land often proceeds from abandoned fields to shrubs to forest.

**TOPOGRAPHY:** All natural and human-made surface features of a geographical area.

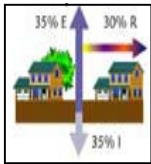
**TRIBUTARY:** A stream that flows into a larger stream, river or lake.

**WATER QUALITY:** A term that refers to how clean and healthy a waterbody is; a stream with good water quality has little or no pollution and supports a healthy diversity of aquatic life.

**WATERSHED:** The land area that drains into a body of water; also called a drainage basin.

**WETLANDS:** Any land area that tends to be regularly wet or flooded. Characterized by special soil types and specialized plants.

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## Resources for Teachers and Students

### CURRICULUM GUIDES:

**Always a River: Supplemental Environmental Education Curriculum on the Ohio River and Water.** 1991. US Environmental Protection Agency, Office of Research and Development, Cincinnati, OH. Publication AWBERC-91-09.

*Four units are presented: the Ohio River and the total ecosystem; physical, chemical, and biological aspects of water; human use, influence, and impact on the Ohio River; and historic influence and implications of the Ohio River.*

**Aquatic Field and Classroom Activities.** Green, R.J. 1990. Education Section, Missouri Department of Conservation, PO Box 180, Jefferson City, MO 65102-0180.

*Seven aquatic exercises can be used in the field and laboratory.*

**A Curriculum Activities Guide to Watershed Investigations and Environmental Studies.** 1980.

Institute for Environmental Education, 32000 Chagrin Boulevard, Cleveland, OH 44124. [Phone: (216) 464-1775]

*Major sections include Why Study Watersheds?, Teaching Resources Within a Watershed, and Some Operational and Technical Skills Needed in Watershed Studies. IEE also publishes a two-volume interdisciplinary guide to Water Pollution.*

**Earth: The Water Planet.** Gantrell, JE, Crowder, J, & Callister, JC. 1989. National Science Teachers Association Special Publications, 1742 Connecticut Avenue NW, Washington, DC 20009.

*Materials for middle-grade teachers in Earth science, organized in five modules on different aspects of water.*

**Groundwater: A Vital Resource.** Compiled by Cedar Creek Learning Center in cooperation with the Tennessee Valley Authority, Office of Natural Resources and Economic Development, Environmental/Energy Education Program, Knoxville, TN 37902.

*Activity topics include the water cycle, water distribution in soils, water quality, and community impacts.*

**Investigating Streams and Rivers.** 1992. GREEN, 2050 Delaware Avenue, Ann Arbor MI, 48103.

*An interdisciplinary curriculum guide for use with Mitchell and Stapp's Field Manual for Water Quality Monitoring.*

**Living in Water: An Aquatic Science Curriculum for Grades 4-6.** 1987. National Aquarium in Baltimore, Department of Education and Interpretation, National Aquarium in Baltimore, Pier 3, 501 East Pratt Street, Baltimore, MD 21202.  
*Activities are scientific studies of water, aquatic environments, and the plants and animals that live in marine and freshwater habitats. Many are suitable for use with older students.*

**The Official Captain Hydro Water Conservation Workbook.** Johnson, B. 1975. East Bay Municipal Utility District, PO Box 24055, Oakland, CA 94623. [Phone: (415) 835-3000.]  
*Whimsical yet thought-provoking comic book curriculum discusses water cycles and wastewater treatment with many pages of student exercises.*

**Pond and Stream Safari: A Guide to the Ecology of Aquatic Invertebrates.** 4-H Leader's Guide 147L-24. Cornell Cooperative Extension. Distributed by Cornell University Resource Center, Business & Technology Park, Ithaca, NY 14850. [Phone: (607) 255-2080.]  
*Seven activities help students explore the habitats and features of stream dwellers.*

**Project Water Science.** Water Education Foundation, 717 K Street, Suite 517, Sacramento, CA 95814. [Phone: (916) 444-6240.]  
*A series of 10 laboratory exercises teaches students about the chemical nature of water and how water relates to the environment.*

**Science Demonstration Projects in Drinking Water.** 1990. US Environmental Protection Agency, Office of Water, Washington, DC 20460. Publication 570/9-90-007.  
*Brief pamphlet includes a selection of science demonstration projects related to drinking water.*

**The Story of Drinking Water.** 1984. American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235. [Phone: (303) 794-7711.]  
*Designed to show children (K-12) the value of water; includes a teacher's guide.*

**Teachers Guide to World Resources: Watershed Pollution.** 1994. World Resources Institute, 1709 New York Avenue, N.W., Washington, DC 20006. [Phone: (202) 638-6300.]  
*Lessons cover environment and development both globally and locally, drawing on skills and knowledge from the biological sciences, social studies, history, economics, and global studies.*

**Teaching Soil and Water Conservation: A Classroom and Field Guide.** 1988. USDA Soil Conservation Service. [Available from district offices.]  
*Contents include 22 conservation activities, with a how-to-do-it section and an interpretation section.*

**Two H's and an O: A teaching resource packet on water education.** Heimlich, JE, Oberst, MC, & Spittler, L. 1993. ERIC Clearinghouse for Science, Mathematics, and Environmental Education, The Ohio State University, 1929 Kenny Road, Columbus, OH 43210.  
*Five activity-packed sections include the science of water, the hydrologic cycle, using water, water conservation, and water pollution.*

**Water, Water Everywhere.** Jacobson, C. 1991. Hach Company, PO Box 389, Loveland, CO 80539.  
[Phone: (800) 227-4224.]

*Activities integrate reading, discussion, and hands-on environmental science.*

**Wow! The Wonders of Wetlands.** Slattery, B. 1991. Environmental Concern, Inc., PO Box P, St. Michaels, MD 21663. [Phone: (410) 745-9620.]

*Section topics include wetland plants and animals, water, soil, and wetland issues.*

**Wading Into Wetlands.** 1992. Ranger Rick's Nature Scope, National Wildlife Federation, 1400 16th Street, NW, Washington, DC 20036-2266. [Phone: (800) 432-6564.]

*Activities focus on the characteristics of wetlands and the ways people have used and abused them.*

**Water: Can We Keep It Fit For Life?: Problem-Solving Activities for Middle-Level Science.** NY Science, Technology, & Society Education Project, 89 Washington Avenue, Room 228, Albany, NY 12234. [Phone: (518) 486-1726.]

*This 4-8 week module is designed to help students realize that water problems deserve their attention and water resources deserve their stewardship.*

**Water Precious Water. Project AIMS: A Collection of Elementary Water Activities, Book A.** AIMS Education Foundation, PO Box 7766, 5629 East Westover Street, Fresno, CA 93747.

*Classroom activities integrate science, math, and language arts.*

**Water: The Basis of Life.** 1979. Soil Conservation Society of America, 7515 Northeast Ankeny Road, Ankeny, IA 50021.

*A cartoon book that introduces students to water quality concepts.*

**Water Watchers.** 1987. Massachusetts Water Resources Authority. Charlestown Navy Yard, 100 First Avenue, Boston, MA 02129. [Phone: (617) 242-6000.]

*A 5-lesson water conservation curriculum for junior high school science and social studies classes.*

**Water Wisdom.** Massachusetts Water Resources Authority, 100 First Avenue, Charlestown, MA 02129. [Phone: (617) 242-7110.]

*Contents include 24 stand-alone activities on water supply and water conservation for high school students.*

**Water Wisdom.** 1990. A Supplement to the California State Environmental Education Guide, Alameda County Office of Education, 313 West Winton Avenue, Hayward, CA 94544-1198.

*Three instructional units aimed at grades 4 through 8 include Water Nurturing Nature (a science unit), Water Rights and Responsibilities (a social science unit), and Water Symbolism (a literature unit).*

**Water Worlds.** 4-H Leader's Guide L-5-18. Cornell Cooperative Extension. Distributed by Cornell

University Resource Center, Business & Technology Park, Ithaca, NY 14850. [Phone: (607) 255-2080.]

*Activities help students learn about the physical and biological features of the worlds of water.*

**The Ways of the Watersheds. An Educator's Guide to the Environmental and Cultural Dynamics of New York City's Water Supplies.** Haskin, K.M. 1995. Frost Valley YMCA. 2000 Frost Valley Road, Claryville, NY 12725. [Phone: (914) 985-2291]

*Curricular activities about watershed hydrology, geology, ecology, pollution, development issues, and water conservation*

## **MONITORING GUIDES:**

**Adopt-A-Stream Teacher's Handbook.** 1987. Delta Laboratories, Inc., 34 Elton Street, Rochester, NY 14607.

*The Handbook contains detailed instructions for a variety of environmental quality tests that can be carried out by students as well as extensive chapters on safety, sampling, physical parameters, chemistry, aquatic biology, and microbiology.*

**Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools.**

Mitchell, MK & Stapp, WB. 1991. Thomson-Shore Printers, Dexter, MI. Distributed by WB Stapp, 2050 Delaware Avenue, Ann Arbor, MI 48103.

*Nine water quality tests are presented, and the Manual encourages the integration of ecological, economic, social and political disciplines essential to resolving critical water quality issues.*

**The Monitor's Handbook.** Campbell, G & Wildberger, S. 1992. LaMotte Company, PO Box 329, Chestertown, MD 21620. [Phone: (800) 344-3100]

*The Handbook provides useful background on how and why to monitor the quality of natural waters.*

**Project Mayfly: Guide to the Determination of Water Pollution in Local Waterways.** Widmer, K.

Washington Crossing Audubon Society, Pennington, NJ. Distributed by the Mid-Atlantic Regional Office, National Audubon Society, 1104 Fernwood Avenue #300, Camp Hill, PA 17011. [Phone: (717) 763-4985.]

*Educational study units help high school students monitor the health of streams, rivers, and lakes in their own area.*

**Save Our Streams: A Citizen Action Program.** The Izaak Walton League of America, 1401 Wilson Blvd., Level B, Arlington, VA 22209. [Phone: (703) 528-1818.]

*Various resources provide information about beginning and maintaining a stream monitoring and protection program.*

**The Streamkeeper's Field Guide to Watershed Inventory and Stream Monitoring Methods.** Murdoch, T. and Cheo, M. Adopt-A-Stream Foundation, P.O. Box 5558, Everett, WA 98206. [Phone: (206) 388-3487.]

## Hydrology and Ecology BACKGROUND INFORMATION SOURCES:

**Adopting A Stream, A Northwest Handbook.** Yates, S. 1988. Adopt-A-Stream Foundation, P.O. Box 5558, Everett, WA 98206. [Phone: (206) 388-3487.]

*Background information on stream ecology, watersheds, and activities to protect, monitor, and restore streams.*

**America's Water: Current Trends and Emerging Issues.** The Conservation Foundation, 1250 24th Street, NW, Washington, DC 20037. [Phone: (202) 778-9575.]

*Explores the shift in US water policy from resource development to resource management.*

**Answers to Common Lake Questions.** New Hampshire Department of Environmental Services, Hazen Drive PO Box 95, Concord, NH 03301.

*29-page book on lake environment issues and nonpoint source pollution.*

**Brown Water Green Weeds.** University of Wisconsin, Green Bay, ES-317, Green Bay, WI 54311-7001. [Phone: (414) 465-2317.]

*Fact sheet illustrated with cartoons, providing an introduction to nonpoint source pollution.*

**A Citizen's Guide to Community Water Conservation.** National Wildlife Foundation Water Resources Program, 1400 16th Street, NW, Washington, DC 20036. [Phone (800) 666-0206.]

*Manual provides background information, guidelines and water conservation tips.*

**Clean Lakes Program.** Terrene Institute, 1700 K Street, NW, Suite 1005, Washington, DC 20006. [Phone: (202) 833-8317.]

*10-page brochure explains EPA's Clean Lakes Program and how it works.*

**Clean Water In Your Watershed: A Citizen's Guide to Watershed Protection.** Alexander, S. 1994. Terrene Institute, 1717 K Street, NW, Suite 801, Washington, DC 20006-1504. [Phone: (202) 833-8317.]

*Practical guide demonstrates how to identify problems that threaten a watershed and helps generate possible solutions.*

**The Creek in Your Backyard.** Coyote Hills Interpretive Center, 8000 Patterson Ranch Road, Fremont, CA 94536. [Phone: (415) 795-9385.]

*6-panel brochure on how to preserve urban creeks.*

**Down By the River.** Hunt, CE & Huser, V. National Wildlife Federation Water Resources Program, 1400 16th Street, NW, Washington, DC 20036. [Phone: (202) 797-6800.]

*260-page book describes the impact of federal water quality projects and policies on biological diversity.*

**Freshwater Studies.** Gee, JHR. 1986. George Allen & Unwin LTD., 40 Museum Street, London WC1A 1LU, UK.

*23 lab and field exercises for high school students explore many ecological concepts from the abiotic environment to community structure.*

**Guide to the Study of Freshwater Ecology.** Andrews, WA, ed. 1972. Prentice-Hall, Inc., Englewood Cliffs, NJ.

*Includes extensive background information as well as 30 field and laboratory studies.*

**Guide to the Study of Soil Ecology.** Andrews, WA, ed. 1973. Prentice-Hall, Inc., Englewood Cliffs, NJ.

*Includes extensive background information as well as 43 field and laboratory studies.*

**How to Teach With Topographic Maps.** Van Burgh, D, Lyons, EN, & Boyington, M. 1994. National Science Teachers Association, 1840 Wilson Boulevard, Arlington, VA 22201. [Phone: (800) 722-6782.]

*Student activities explore latitude and longitude, the concept of scale, terrain changes and how to use topographic maps for environmental studies.*

**Lake Smarts: The First Lake Maintenance Handbook - A Do-It-Yourself Guide to Solving Lake Problems.** McComas, S. 1994. Terrene Institute, 1700 K Street, NW, Suite 1005, Washington, DC 20006. [Phone: (202) 833-8317.]

*This how-to manual contains field-tested, easy and affordable projects to help citizens clean up, improve and maintain the lakes and ponds in their community.*

**The Land Use Connection.** Minnesota Pollution Control Agency, Public Information Office, 520 Lafayette Road, St. Paul, MN 55155. [Phone: (612) 296-6300.]

*28-page introductory booklet on nonpoint source pollution with companion slide or video show.*

**A Primer on Water Quality.** USGS Books and Open-File Services, Box 25425, Federal Center, Denver, CO 80225.

*27-page booklet defining water quality, the water cycle and how nature affects water quality.*

**The Role of Land Use and Geology in the Water Cycle.** Iowa State University, 133 South Main Street, Elkader, IA 52043. [Phone: (319) 245-1457.]

*Fold-out poster with information on the back side addressing nonpoint source pollution.*

**A Stream Becomes an Ocean.** Virginia Tech Cooperative Extension Service, Distribution Center, 1120 Landsdowne Street, Blacksburg, VA 24060. [Phone: (703) 961-6192.]

*15-page activity book on surface water addresses nonpoint source pollution.*

**Volunteer Lake Monitoring Program.** Indiana University Department of Environmental Management, SPEA 340, Bloomington, IN 47415. [Phone: (812) 855-4556.]

*6-panel brochure on volunteer lake monitoring and nonpoint source pollution.*

From: Ruesink, A. 1996. Small Watershed Ecology Assessment Project Handbook. Alan R. Berkowitz and Kathleen Hogan, Project Directors. Institute of Ecosystem Studies, Millbrook, NY.