

Illinois Department of Natural Resources

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ENTICE – Environment and Nature Training Institute for Conservation Education *Illinois Aquatics 101*

Part I

SURFACE WATER AND GROUND WATER

Hydrology is the study of the movement and distribution of waters. Water may be found in the ground (aquifers), on the surface (lakes, rivers, ponds, streams, wetlands) and in the atmosphere (precipitation, clouds and airborne toxins). Water is also found in all organisms and is essential to life. Water is a renewable natural resource and changes forms through the water cycle.

About 97 percent of the earth's water is salt water, with most of it in the oceans. The remaining three percent is found in freshwater rivers, ponds, lakes, icecaps, water vapor, ground water and in organisms. The two most available sources of fresh water are surface water and ground water. The other main source of fresh water is the ice in the polar regions.

Illinois is a very water-rich state. Water practically surrounds Illinois, as it is bordered by three major rivers and one Great Lake. Illinois receives an average of 35 to 42 inches of rainfall each year and has vast groundwater supplies. The citizens of Illinois use a tremendous amount of water annually with a 1985 study ranking Illinois fourth in the United States for the amount of average fresh water withdrawals per day (U.S.G.S. 1987).

Surface Water

Surface water includes permanent, open bodies of water 0.1 acre or larger. They are separated from wetlands by their permanence and by their general lack of emergent woody vegetation. There are four subclasses of surface water in Illinois: Lake Michigan; flowing waters; impoundments; and reservoirs. Combined, these four categories total more than 1.6 million acres of surface water.

Only about seven percent (976,640 acres) of Lake Michigan is within the state of Illinois' jurisdiction and only that portion will be referred to here. This amount accounts for about 61 percent of the surface water of Illinois. Lake Michigan borders Cook and Lake counties.

The flowing water classification includes streams, canals, creeks (small streams) and rivers. Streams make up about 20 percent (325,000 acres) of Illinois surface water with the majority of the streams found in southern and western Illinois. Henderson (21,388 acres), Calhoun (20,838 acres), Rock Island (14,359 acres), Hancock (12,899 acres) and Carroll (12,514 acres) are the five counties with the most stream acreage (IDNR 1996).

Impoundments are standing bodies of water constructed by artificial means or formed by nature, excluding Lake Michigan and the three reservoirs mentioned in the next paragraph. About 16 percent (259,400 acres) of Illinois' surface water is contained in impoundments. The majority of the impoundments are found in the southern and western regions of the state. Forty-three percent of the impoundments are privately owned, followed by 32 percent that are publicly owned, 15 percent state owned, 9 percent organization owned and 1 percent commercially owned. The top five counties in regard to impoundment acreage are Lake (14,739 acres), Mason (14,246 acres), Williamson (12,615 acres), Fulton (12,052 acres) and Cook (7,858 acres).

The reservoir classification in Illinois covers only the three reservoirs constructed by the U.S. Army Corps of Engineers. They total 54,580 acres, or three percent of the surface water in Illinois. Lake Carlyle covers 24,580 acres in Fayette, Bond and Clinton counties. Rend Lake occupies 18,900 acres in Jefferson and Franklin counties. Lake Shelbyville covers 11,100 acres in Shelby and Moultrie counties.

Ground Water

Ground water results from precipitation. This precipitation percolates under the surface of the earth and fills the cracks, crevices and tiny pores between soil and rock particles much like water saturates a sponge. It may remain undisturbed for years, even centuries, or it may flow into wells drilled into the ground or flow out of the ground as springs. Ground water moves an average of three inches per day, depending on the porosity of the rock. Ground water is affected by the type of soil in the area. Permeability ranges from 0.06 inches per hour in some clay soils to more than 20 inches per hour in some sandy soils.

The major uses of ground water in Illinois are public water supply (47 percent), industry (21 percent), agriculture (21 percent) and private water supply (11 percent). About 50 percent of Illinois' population uses ground water from wells for drinking. Almost all of the people (98 percent) who live in rural areas draw their drinking water from wells. About 75 percent of Illinois' community water systems use ground water. More than 410,000 wells are used to tap the ground water in Illinois. Almost all Illinois ground water is recharged, or replenished, locally. About 15 percent of the potential ground water supply is presently being used. Water wells range in depth from 20 feet to more than 2,800 feet.

Although less than eight percent of the tested Illinois community water wells show measurable levels of contamination, ground water may be contaminated. In some areas of Illinois, the ground water is contaminated with naturally occurring minerals, like calcium and magnesium, which makes the water "hard." In parts of northern and western Illinois, radium in deep, bedrock aquifers exceeds the drinking water standard.

Ground water may be contaminated by other sources, too. Gasoline and other harmful liquids have leaked from underground storage tanks into ground water. Pollutants can seep into ground water from poorly constructed landfills or septic systems. Ground water may be polluted by runoff from fertilized fields, livestock areas, abandoned mines, salted roads and industrial areas. People can contribute to contamination by dumping household chemicals down the drain or pouring them on the ground. Also, because ground water moves so slowly, the contamination is likely to remain concentrated and close to the point where the pollution occurred.

Ground water contaminated with bacteria, chemicals, pesticides, gas or oil can result in serious health problems. Overuse of farm chemicals can pollute ground water with nitrates, and people and/or animals that drink the water can be poisoned. Contaminated ground water can be cleaned up, but it is very expensive and time-consuming to do so.

Legislation

Illinois has tried to reduce the threat to its ground water by expanding and unifying the state's ground water protection programs. In 1987, the General Assembly passed the Illinois Ground Water Protection Act. The Ground Water Protection Act is a comprehensive law that deals with three types of potentially contaminating land uses. Potential primary sources of contamination include disposal and storage sites that handle large amounts of hazardous materials and any amount of hazardous waste. Potential secondary sources of contamination include facilities that store smaller amounts of hazardous materials, for example, agricultural chemical facilities, storage sites for salt used in de-icing, wastewater treatment plants and above- and below-ground petroleum storage tanks. Potential routes of contamination are possible pathways for contaminants and include abandoned wells, drainage wells and sand- and gravel-mining operations. Several agencies assist in making sure that the provisions of the act are being carried out. Those agencies include the

Illinois Environmental Protection Agency, Illinois Department of Natural Resources, Illinois Department of Public Health, Illinois Pollution Control Board and the Office of the State Fire Marshal.

WATER AS A RESOURCE

Water is one of the most common substances on earth, but it is also one of the most precious. Life cannot exist without it. It has been referred to as the "liquid of life." Water is the only substance on earth which can be found naturally in three separate forms--solid, liquid and gas. A single molecule of water can float as a vapor (gas) then fall to earth as rain (liquid) and then freeze into ice, sleet or snow (solid). Water is a finite resource--all the water we are ever going to have on earth is here now.

Who uses water?

Humans use water for many activities including cooking, bathing, washing clothes and dishes and brushing teeth. Factories and industries use water to manufacture things that people use, like clothes, paper, gasoline, electricity, plastic and glass. Water is also used in the mining process. Farmers use water to grow crops and raise animals for food. It takes about 15 gallons of water to grow the wheat to make one loaf of bread, about 120 gallons for a chicken to lay one egg and about 4,000 gallons to produce a pound of beef. People use water for recreational purposes such as swimming, boating and fishing. Barges carry people and goods on rivers and lakes. Water provides food and shelter for many organisms.

Every living thing on earth must have water. Even though it is a reusable resource, it must be shared by all water users and managed to ensure future supplies. Drinkable water is not free. Water treatment facilities and the distribution of drinking water are costly. Customers are charged according to the amount of water they use. A water meter is used to measure how many gallons or cubic feet a household or business uses. Because users pay for water and because there is a finite amount of fresh water available for use, we must conserve our supplies, using them as wisely and efficiently as possible.

It is important to keep data related to water usage for governmental agencies, public-supply operators, water-resource managers and researchers for assessing current water-use patterns and anticipating future water demands. State water use data are collected and compiled by the Illinois State Water Survey in cooperation with the U.S. Geological Survey.

Where is Illinois' Water?

Illinois is a water-rich state and most of those riches flow through its streams and rivers (see Figure 1). The state is bordered by three major rivers: the Mississippi to the west and the Ohio and the Wabash to the south and east. Sixty-three shoreline miles (976,640 acres) of Lake Michigan, one of the five great freshwater lakes between the United States and Canada, create Illinois' northeast border. According to Illinois Environmental Protection Agency statistics, Illinois' 14 major river basins are drained by more than 106,900 miles of flowing water. This stream miles measurement figure constantly changes due to erosion, siltation and stream diversion. There are nearly 88,000 inland lakes and ponds (313,980 acres). Also, there are one million acres of wetlands and marshes, a tiny remnant of the original eight million acres that existed in the state. This system of streams, rivers, lakes and creeks is called surface water. Much of the water we use exists out of sight – underground. Ground water is the supply of water under the earth's surface that forms natural reservoirs. Although ground water accounts for only a fraction of the earth's supply of water, it is widely used for human consumption. Actually, it is more abundant than the water found in rivers, lakes and streams. Ground water accounts for 99 percent of the world's freshwater supply. Forty-seven percent of the public water supply in Illinois comes from ground water; industry extracts 21 percent, another 21 percent is used for agricultural purposes and those who have private water supplies use 11 percent.

Self-supplied vs. Public Water Supplies

Self-supplied, or private, water is water withdrawn from a surface or ground water source by a user rather than being obtained from a public supply. There are nearly 400,000 private wells in Illinois which serve approximately 1.3 million people. A public water supply is water withdrawn by public and private water suppliers and delivered to groups of users. Public suppliers provide water for a variety of uses, such as domestic, commercial, hydroelectric power generation, industrial and public water use. Water provided by public water suppliers or water that is self-supplied can come from surface water or ground water.

The self-supplied population is the difference between the total county population and the population served by public water supply. Eighty percent of the population of Illinois is served by public-supply facilities. In 1990 the largest supplies of surface water withdrawals for public supply were from Lake Michigan, the Mississippi River and the Sangamon River. The largest withdrawals of ground water for public supply were in Champaign, Cook, Du Page, Kane, Lake, La Salle, McHenry, Madison, Peoria, Tazewell, Will and Winnebago counties. Although many commercial and industrial water users purchase water from public water supplies, a number of large users develop their own water supplies. This process creates competition between industry and domestic users for the same water supplies. Nearly all the self-supplied industry in Illinois can be divided into four major classifications: thermoelectric power generation; hydroelectric power generation; manufacturing; and mineral extraction.

Uses of Water in Illinois

Drinking Water: There are several sources of drinking water in Illinois. One source is surface water from rivers and lakes. Almost half of Illinois residents rely on a second source, ground water, to meet their daily water needs. Lake Michigan supports drinking water uses for the northeastern portion of the state.

Agricultural: Although irrigation uses relatively small amounts of water in terms of total withdrawal, it is a major water use in some areas of the state. Water for irrigation is applied during the growing season of May-August, but the total water used is averaged over the entire year. The source of most irrigation water is ground water.

Water use for livestock purposes is determined by multiplying the county population of each major type of farm animal by the estimated water directly consumed by the animal and other water used in association with the animal (Kirk 1987).

Personal Hygiene and Other Uses: People use water for bathing, washing clothes and dishes and brushing teeth, as well as cooking and other uses. The average water user in the United States uses 80 to 100 gallons of water per day.

The largest public water system is the Chicago Department of Water which services more than 5 million people within Chicago and the outlying areas. The largest area served by a public water supply system is the Rend Lake Conservancy District in southern Illinois. Reaching into parts of nine counties (Franklin, Jackson, Jefferson, Hamilton, Marion, Perry, Saline, Washington and Williamson), this conservancy district serves an area of more than 1,800 square miles.

Industrial: Many industrial processes require water.

Mining: Water is an important part of the mining process. Coal mining in southern Illinois consists of both surface and underground operations that utilize little to no ground water for a consumptive purpose. Water is used to keep coal dust down in the mines during coal extraction. Water is also used to wash coal after it is extracted. Coal mine use in Illinois is approximately 200,000 gallons per day per mine, some of which can be recycled. Varied amounts of ground water must be removed in both types of mining. It is typically pumped out

of the mine and discharged off the site through a regularly monitored discharge point which must meet state and federal regulations. The coal mining operator is required to replace any drinking water supply that is interrupted as a result of the mining operations. Surface and ground water discharge are closely monitored by the Illinois Department of Natural Resources.

Transportation: The Mississippi, Illinois, Ohio and Kaskaskia rivers are equipped with locks, dams and maintained channels. They serve as important transportation routes for commercial navigation in and through Illinois and add to Illinois' rich aquatic history.

Recreation: Recreation and leisure are important parts of the day-to-day lives of most people. Swimming, fishing, hunting, trapping, boating, skiing, snowmobiling and observing wildlife are the major water-related activities. They provide the opportunity to enjoy the outdoors and contribute to our state's economy, bringing in millions of dollars from licenses, permits and registrations. They also contribute to local economies in the form of hotels, restaurants and gasoline.

Illinois has 63 miles of Lake Michigan shoreline, 40 miles of which is publicly owned and devoted to open space and recreation. Ranging from Chicago's public beaches, parks, marinas and museums to sand dunes, marshes and miles of natural beach, the Lake Michigan shoreline offers a rare mixture of active and passive recreational and scenic opportunities. In the midst of the Midwest's largest concentration of people, the Lake Michigan shoreline has the potential to impact the most people – both Illinois residents and tourists – of any of Illinois' recreational and scenic sites.

Education: Bodies of water and wetland areas provide field laboratories for students in the natural or physical sciences.

Habitat: The land/water connection is an extremely rich wildlife habitat due to the abundance of water, nutrients from plant decay and diverse vegetation providing both food and cover for hundreds of species of fish and wildlife. Many valuable plant and animal species are either located in wetlands or dependent upon them. The Illinois Wetlands Inventory (IDNR 1996) identified 617 types of wetlands and deepwater habitats in our state. They provide food and shelter for 40 percent of the state's endangered or threatened species and serve as spawning grounds for many fish and shellfish. Wetlands are breeding, feeding and resting areas for waterfowl and shorebirds and also provide habitat for many species of insects, amphibians, reptiles, bacteria and other living organisms.

Utility Plants: The largest use of water in Illinois is for electric power generation – 94.9 percent of total water usage. Most of the water is for cooling, which is a nonconsumptive use. For example, a large power plant that can generate enough electricity for a city of 500,000 people would use up to a billion gallons of cooling water per day. Drinking water and other consumptive uses in that city would amount to about 50 million gallons per day.

ADAPTATIONS

There is an amazing diversity of life on earth. Illinois has about 54,000 identified species. A quick review of any one particular group of organisms reveals a wide array of subtle differences within the group. For instance, there are more than 200 fish species in Illinois, each with a distinct body shape, coloration, feeding habits and reproductive strategy.

These subtle differences are adaptations. An adaptation is an adjustment, often hereditary, that an organism goes through to live in a particular environment. Adaptations to the environment allow different organisms to fill different niches, or roles, in the environment. This partitioning minimizes competition for the same habitat requirements (food, water, cover, space). Adaptations develop over long periods of time and may be either physical features or specialized behaviors.

Because water covers about 75 percent of earth's surface, many adaptations are directly related to water. Most water is in motion. The movement of water and the changes that occur, either through natural or human processes, can make water a very difficult habitat to live in: gravity, the sun's energy and earth's rotation cause rivers to rush downstream or plunge over ledges to create spectacular waterfalls; they induce lakes and ponds to swirl below their surfaces and draw the ocean waves to shore. Gravity causes all free-running water to flow downhill. Wind also contributes to the movement of water. Currents can be weak or strong, water volume fluctuates, streams can dry up or flood, oxygen levels in water change with temperature changes, water density near the surface is different than at greater depths, water temperatures fluctuate according to depth, water freezes and pollution is easily spread. Not all organisms can live in water. Only those that have developed the special adaptations that enable them to withstand the inconsistency of water will survive.

Animal Adaptations

Adaptations increase an animal's chances of surviving in a particular environment and with a particular lifestyle. Animal adaptations may be a body shape to allow them to swim faster, a mouth shape to permit eating a particular type of food, a shape of the feet or legs to permit standing in a watery area or the manner of reproduction to insure increased survival of their young.

Plant Adaptations

Plants adapted for life in the aquatic environment can live in water-saturated soil that has low oxygen levels. While most plants absorb some oxygen from the soil through the roots, aquatic plants have developed adaptations to increase oxygen absorption. Cattails get oxygen to the roots through hollows in the stem and leaves. One way to kill cattails is to mow them very short and then flood them above the mowed stems, suffocating the plants. Baldcypress trees have developed "knees" to aid in oxygen absorption by the roots. Duckweeds have adapted to the aquatic environment by floating on the water's surface, with their roots dangling in the water to absorb nutrients and minerals.

Annual plants that live on mud flats have developed adaptations to allow survival in conditions where water levels fluctuate. Seed production is tied to day length, and plants rush to produce seeds before winter sets in. Some plants have delayed seed germination which allows them to build up seed banks in the soil until sufficient moisture is present.

Changing to Survive

Some species develop very specific adaptations to a habitat or feeding style. When changes occur in an organism's environment it must move or adapt, or it will die. Sudden changes (flood, earthquake, water quality change) do not allow sufficient time for organisms to adapt. Those organisms that have developed very narrow ranges of habitat requirements are extremely vulnerable to changes and probably will not survive.

RIVERS AND STREAMS

Running water is essential in supporting aquatic organisms because the constant movement aerates the water, providing oxygen. The movement of water also keeps nutrients available and flushes wastes further downstream. Running water can cause some loss of life, such as experienced during a flood, with organisms moved downstream, into flood plains and away from flowing water or unable to survive the increased flow and dying.

Illinois is bordered by 880 miles of rivers and has 106,900 miles of rivers and streams within its borders. It is estimated that the surface area of Illinois' interior rivers and streams is 325,000 acres.

Definition

Rivers and streams are deep-water habitats contained within a channel. If water flows through the channel throughout the year, the river or stream is called a perennial stream. An intermittent stream has water flowing only part of the year. The smaller streams that feed into larger rivers and streams are tributaries. The land adjacent to a river or stream that is periodically flooded is the flood plain.

Young or immature streams are short and flow swiftly, thus the rate of erosion is great. The channels of these streams are usually straight, with a v-shaped bottom. Older or mature streams have wide, flat-bottomed, or u-shaped channels. The water flows slower, and the rate of erosion is less. It is a natural process for bodies of water to evolve. Water is dynamic, not static.

The rate water flows within a channel is called velocity. Many factors can influence the velocity of water. The gradient (pitch) of the channel, volume of water flowing and amount of area the stream drains (watershed) influence the flow of water. Recent precipitation, or the lack of, will contribute to the stream's velocity. Stream flow is also affected by the composition or type of material in the stream bed (sand, silt, mud, gravel, bedrock).

Every river and stream has a watershed, or drainage basin, the total land area that provides water to the river or stream. Along with the surface water runoff, these bodies of water receive sedimentation and other materials from the watershed. Many rivers flood regularly, increasing productivity and enriching flood plains with rich sediment and nutrients. Changes to the Mississippi and Illinois rivers, such as levees and locks and dams, have diminished natural flooding cycles and reduced productivity of these systems. So while flooding may be a problem for humans, it is an important natural process for rivers.

The vegetation growing adjacent to flowing water is called riparian vegetation. This plant zone provides shade to the water body, slows the rate of erosion and decreases the amount of silt flowing into the water. Characteristic plants growing in riparian zones in Illinois include willows, cottonwood, sycamore, box elder, sedges, bulrushes, cattails, buttonbush and touch-me-not.

Meanders (curves) form in older, slower flowing streams as their channels migrate along the path of least resistance. During floods, the additional volume and velocity of water will often cut off the meander, forming a chute. As the flood subsides and the water loses velocity, sediment drops out of the water column. Sediments may form a sandbar, creating a natural dike between the chute and the old meander. Thus, an oxbow lake is formed where the meander used to be. The sediment that is left behind during these natural stream migrations is called alluvium.

With the constant flow of water, temperatures in rivers and streams vary. Stream velocity, the amount of water directly exposed to sunlight and volume of water can alter water temperature.

As water flows over structures in the channel, aeration occurs. The amount of oxygen in water is dissolved oxygen, or "DO." The addition of oxygen to a water body is important in providing the oxygen needed for many

aquatic organisms. In some instances you can determine the general quantity of dissolved oxygen in the water by the presence or absence of certain organisms. Pike and trout require medium to high levels of dissolved oxygen, while carp and catfish survive in waters having low dissolved oxygen. Waters with high dissolved oxygen support a large variety of aquatic creatures including mayfly nymphs, stonefly nymphs, caddisfly larvae and beetle larvae. As dissolved oxygen levels drop, these species disappear and are replaced with aquatic worms, fly larvae and outbreaks of algae populations.

Life in a Stream

Aquatic organisms are often categorized by where they live in the water column: benthic; pelagic; and surface. Benthic organisms live on the stream substrate and feed on plant and animal materials that collect on the bottom. Crayfish, mussels, and stonefly and mayfly larvae are examples of benthic organisms. Pelagic organisms live within the water column. These organisms may float or swim and include fishes, frogs, turtles, water lilies and a variety of insects. The final category is the surface dwelling organisms, such as water striders, duckweeds and adult dragonflies and damselflies.

The place organisms live within a stream or river is primarily determined by how well they can deal with water currents. Some organisms that live in swift water have adaptations that allow them to anchor to the substrate (stonefly and mayfly nymphs). Others seek out more protected areas in the water, like behind large rocks or in pools (water strider, fish). Life in swift water provides abundant food supplies flowing downstream and highly oxygenated water.

Historical Perspective

Illinois has been part of the central lowland of the North American continent for at least the last 300 million years. The Ice Age had major impacts on Illinois and its rivers. Glaciers blocked and buried some rivers and created new ones. Ancient rivers, such as the Teays, Cumberland, Paw Paw and Ticona, no longer exist. The Missouri River once flowed in much of what is now the Mississippi River bed but was blocked and filled during the Kansas (second) glacier and diverted to a new channel. The Teays River was diverted south of the glacier and became the Ohio River. The Ohio River was where the Cache River is now.

Ecological Importance

Many of the river backwaters, deep glacial lakes and wet prairies historically found in Illinois have been drained or seriously disturbed. More than 106,900 miles of streams exist in Illinois. More than half have been degraded in some manner – dredging, damming, pollution, siltation or presence of exotic plants, fishes or mussels.

Many rivers rely on flooding to increase productivity and enrich flood plains with sediment and nutrients. Changes to the Illinois and Mississippi rivers through construction of levees and locks and dams have diminished the natural flooding cycle and reduced productivity of these systems.

Economic Importance

Water is the cornerstone of much of our recreation – from boating, canoeing and fishing to skiing, scuba diving and swimming. Fishing, hunting and trapping of aquatic life provide recreational opportunities and supplement the table with food and may provide fur for clothing. Many rivers, streams and lakes attract tourists and support area businesses.

River corridors continue to be used for shipping produce and manufactured goods downstream. Rivers and streams dammed to create a reservoir may provide recreational opportunities, generate electricity, supply homes and agricultural lands with water and store flood waters. Damming of rivers and streams does, however, result in the loss of almost all the habitat features and amenities which depend upon and are produced by flowing water.

Soils can be eroded and moved downstream by wind, rain or glaciers. Though erosion is a natural process, many human practices accelerate the erosion process. Soil particles can be picked up by wind or water when trees are cleared or prairie grasses or other terrestrial herbaceous vegetation is removed, either by people or when cattle over-graze the site. Soil particles in water can kill bottom-dwelling organisms, clog the gills of fishes and mussels and destroy spawning habitat. Herbicides, pesticides and other chemicals attached to soil particles can kill or severely injure populations of aquatic organisms.

Removal of sediment is a costly process. Navigational channels must be periodically dredged to maintain an area for travel and for barges transporting products. Destruction of vegetation in a watershed may result in erosion and the filling of a lake or reservoir. As a result, the water body may have diminished appeal for recreation. A decreased capacity for water storage provides less water for human, agricultural or industrial use or for flood storage.

Management Practices

Management of streams and rivers requires protecting habitat essential to the aquatic organisms. Activities within the watershed greatly affect the quality of water. Controlling erosion includes minimizing the amount of soil that is exposed to air and water. Projects and activities should be designed to minimize the amount of soil disturbed. Conservation farm practices may include covering the soil, leaving a crop residue or planting vegetation in the area.

Protection of aquatic resources may require zoning to prevent construction along the banks of the water body. Water pollution is categorized as nonpoint (from a land practice such as agriculture or construction), municipal (wastewater and storm runoff), industrial (chemical discharge from industry) and dredged (removal which also stirs up sediment). Water quality can be improved by minimizing the amount of activity leading to any and all of these types of pollution.

Aquatic resources may also be managed by enhancing the resource. In streams, wing dams may be built from the bank. Water flowing across the wing dam cuts a deep pool for fish on the downstream side of the dam. Other structures are placed in the bank to provide overhangs for shade and spawning (catfish and smallmouth bass).

Issues

Illinois' agricultural landscape impacts aquatic habitats. The chemicals used to increase crop production and decrease crop pests wash into lakes and streams. Contaminants that enter the water column eventually enter fish flesh. These contaminants may make fishes unfit to eat. Bottom feeders and large predatory gamefish often concentrate large quantities of contaminants in their flesh due to their food habits and longevity. Invasive species cause serious threats to native aquatic life.

LAKES, PONDS, RESERVOIRS

More than 2,900 lakes, 84,000 ponds and three large reservoirs are found across Illinois. Lakes are generally considered to be nonfree-flowing (lentic) bodies of water 20 or more acres in size, while ponds are nonfree-flowing bodies of water smaller than lakes (IDNR 1988). Illinois contains a variety of lake types. Northern Illinois is home to glacial lakes which were created thousands of years ago as glaciers advanced and receded. Oxbow lakes are formed when a meandering stream cuts a new and straighter channel. The old bend in the stream, now cut off from the main channel, becomes a lake.

Impoundments and reservoirs are created by obstructing the flow of a river with a dam or berm. These water bodies are often used for public water supplies. Ponds and stormwater detention basins are built by excavation or by expansion of an existing lowland area.

Lake ecosystems are complex and varied. Oligotrophic lakes tend to be unproductive in terms of organisms present, have high levels of dissolved oxygen and contain very clear water. Lakes that have many particulates present, low dissolved oxygen and are highly productive with large populations of plants, animals and plankton are eutrophic. Mesotrophic lakes fall between the two extremes found in oligotrophic and eutrophic lakes. Within the lake there are specifically adapted organisms. Bottom dwellers are known as benthic organisms. Free-swimming organisms are called nekton. Plankton are small, free-floating organisms. Neuston are organisms that live on the surface film of water, like water striders, duckweeds, mosquito larvae and whirligig beetles. Those lakes with the greatest diversity of species tend to be the most stable. However, changing or disturbing even one component of the ecosystem affects all of the other components. Although the effects may not be seen immediately, they will occur.

Lakes are the least permanent and probably the most fragile part of Illinois' surface water system. All lakes are considered to be temporary because over time they fill in through the process of eutrophication. Because water moves much more slowly through a lake than it does through a stream, lakes act as settling basins. Inflowing solid and dissolved substances, natural and synthetic, may drop out of the water and build up on the bottom. Seepage lakes are fed primarily by ground water, while drainage lakes are fed by surface runoff and tributary streams. Drainage lakes tend to show immediate responses to dramatic precipitation changes. However, seepage lakes may show little change in water levels during prolonged dry periods because the ground water supplying them tends to remain fairly constant. If a seepage lake is affected by a severe drought, it may take several years for water levels to return to normal. Changes in the watershed may also affect the lake's water balance. Undeveloped land tends to absorb rainfall and release it slowly. Yet when land is covered with impervious structures like roads and parking lots, precipitation runs off quickly and may change water levels in lakes drastically.

Physical Properties

Many Illinois lakes are deep enough to stratify, or form layers of water with different temperatures. Stratification occurs because water's density changes with its temperature. Water is densest at 39°F. Above and below that point, water becomes lighter. In very shallow lakes, stratification does not occur

because wind and wave action keep the water molecules mixed throughout.

In the fall, air temperatures cool the surface waters of a lake to 39°F. When the water reaches this point, it sinks (fall turnover). As the lake continues to cool, the colder water (32°F) is pushed to the top and may form ice. When spring arrives, the surface waters begin to warm. As they reach 39°F they sink and mix with the deeper water (spring turnover). As the season progresses, the temperature differences between the upper and lower regions of the lake increase. In lakes deeper than about 10 to 12 feet, the lake stratifies into three layers. The upper layer, or epilimnion, extends down about eight to 15 feet from the surface and is the warmest layer. The middle layer, also known as the metalimnion or thermocline, is narrow and exhibits falling temperatures with increasing depth. Below the thermocline to the lake bottom exists the hypolimnion which has the coolest lake waters.

Temperature is one of the key factors that regulate the kind of species that can live in our lakes. The amount of dissolved gases that water holds varies with the temperature. Warm water, for instance, holds much less oxygen than cold water. Temperature also affects feeding, growth and reproduction of many aquatic organisms.

Biological Properties

Lakes may be divided into three biological zones. The littoral zone extends into the lake from the shoreline. Macroinvertebrates, bacteria, rooted aquatic plants, algae, aquatic vertebrates and other organisms are numerous here. Wetlands often border at least part of the lake's shore. Light penetrates to the bottom of this zone.

The open water part of a lake is the limnetic zone. Phytoplankton, zooplankton and fish are found here. Since photosynthesis can only occur where light is present, the transparency of the limnetic zone affects the productivity of the phytoplankton and therefore the amount of oxygen produced.

Deep lakes may have a profundal zone. This zone receives little or no sunlight. Bacteria, fungi and other decomposing organisms thrive on the organic matter that falls from the upper layers of the lake. Large amounts of oxygen are used in decomposition, and the profundal zone is known for being deficient in oxygen.

Chemical Properties

Dissolved Oxygen (DO)

The amount of oxygen dissolved in a lake's water has a dramatic effect on the organisms present. Under normal conditions water contains 30 times less oxygen per given volume than air. Oxygen may enter a lake by diffusion from the atmosphere and by photosynthesis. Factors affecting dissolved oxygen levels include photosynthetic activity, wind and wave action, the amount of decomposing organic matter, time of day, salinity, atmospheric pressure, volume of water and temperature. Winter can be particularly stressful for a lake's aquatic life. Ice may seal off atmospheric oxygen. A layer of snow may block sunlight penetration through the ice. If these conditions persist for a lengthy period, oxygen-producing organisms may die while decomposition and respiration for other organisms continues. Oxygen levels may fall so low that a winter kill occurs.

Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand measures the amount of oxygen used by microscopic organisms as they decompose organic materials. Increased quantities of plant life in a water body usually lead to increased levels of BOD. Increased levels of organic wastes also lead to increased BOD. Sources include natural

waste material, such as leaves, factories/processing plants, agricultural runoff and wastewater treatment plants.

In water bodies with high BOD levels, most of the available oxygen is used in the process of decomposition. Aquatic life must be tolerant of low oxygen levels, move or die. When this condition occurs, organisms that thrive in low oxygen may flourish.

Total Solids

The total solids category includes both dissolved solids (pass through a filter) and suspended solids (trapped by a filter). The category includes living and nonliving items. Typical inorganic components are the result of weathering and soil erosion in the watershed and resuspension of sediments. Suspended solids may contain excess nutrients, pesticides and toxins. Organic suspended solids are mainly algae and decaying organic matter. High concentrations of total solids may lead to the following problems: a laxative effect in drinking water; an unpleasant taste in drinking water; reduced water clarity; decreased photosynthesis; and an increase in water temperature. Low concentrations of total solids may limit growth of aquatic life.

Turbidity

Turbidity (cloudiness) measures the clarity of water. The more suspended solids in the water, the higher the turbidity. Some turbidity is normal from dissolved organic matter, sediment and minerals. Increases above normal levels may be caused by soil erosion, waste discharge, runoff and other factors. High turbidity leads to warmer water, lower oxygen levels and less photosynthesis. It can clog fish gills, reduce growth, reduce disease resistance, cover eggs and larvae and eliminate habitat.

Total Phosphorus

In many lakes the amount of phosphorus present controls the amount of plants present. This essential nutrient can also cause problems if it is present in significant quantities. Phosphorus added from sewage treatment plants, lawn and farm fertilizers, poor septic systems or other sources leads to increased growth of algae and aquatic plants, sometimes to detrimental effect. Lakes are referred to as "young," "middle-aged" or "old." High levels of phosphorus continually being added to a lake, or phosphorus loading, can cause eutrophication, in which the lake ages before its time.

Phosphorus is measured in parts per billion (PPB). To give you an idea of the dimensions of this measurement, one part per billion would be like one pinch of salt for every 10 tons of potato chips or one second in 32 years or one drop of water in 500 barrels of soft drink.

Nitrogen

Nitrogen is used by organisms to build proteins. It is very abundant in its molecular form, but most organisms cannot use it in this form. Some species of blue-green algae are able to use nitrogen directly from the atmosphere. They also convert it into forms that aquatic plants can use: ammonia and nitrate. Nitrogen is then passed to aquatic animals as they eat the plants or organisms that have eaten the plants. Decomposition of organic matter and waste excretions of aquatic animals may contribute large amounts of nitrogen compounds into the water, leading to eutrophication. Ammonia, a nitrogen compound formed during organic decomposition, can be toxic to aquatic life in significant quantities.

pH

The pH scale measures the hydrogen ion concentration of substances and ranges from 0-14. Neutral solutions have equal amounts of hydrogen ions and hydroxide ions, with a pH of 7. If a substance has

more hydrogen ions than hydroxide ions, its pH is between 0 and 7 and is considered acidic. If a substance has more hydroxide ions than hydrogen ions, its pH is between 7 and 14, and it is considered basic. For every one unit change in pH, there is a ten-fold change in the acidic or basic content of the sample. Many factors can affect pH, including acid rain or snow and the types of rocks and minerals found in the area.

Under normal conditions most Illinois lakes have a pH between 6.5 and 9. Although rainwater in Illinois is slightly acidic (about 4.4), most lakes are able to offset this acidity by naturally occurring buffering compounds in the water. A pH reading of below 5 is considered critical and damage to the gills of aquatic organisms may occur. Readings of 5 to 6 are rated as endangering because this level of acidity is toxic to some organisms. Readings between 6 and 8 are considered satisfactory.

Fecal Coliform

Fecal coliform bacteria are found in the solid wastes of humans and other warm-blooded animals. These bacteria can enter water bodies through direct release by animals, from runoff carrying animal wastes and from human sewage. Fecal coliform bacteria naturally occur in the digestive tracts of warm-blooded animals. Pathogenic bacteria may be present along with the fecal coliform bacteria. If fecal coliform counts are high for an area, there is an increased chance that pathogenic organisms are present, too. Pathogenic organisms are usually not sampled directly because they are few in number and difficult to count. Fecal coliform results are stated as number of colony forming units (CFU) per 100 ml of water.

No fecal coliforms should be present in drinking water. A range of 200-1,000 CFU per 100 ml of water is safe for swimming, although people often swallow water when swimming and chances of infection are great. CFU readings of 1,000-5,000 per 100 ml of water are considered safe for activities like boating and fishing. Ear infections, dysentery and hepatitis may be contracted in areas with high fecal coliform counts.

Temperature

Temperature of the water directly affects the amount of dissolved oxygen present, chemical concentrations, rate of photosynthesis, metabolic rate of aquatic organisms and sensitivity to diseases and parasites. Water has a high heat capacity and resists temperature change. Cool water holds more oxygen than warm water. Thermal pollution occurs when warm water is added to a natural body of water, generally by industries, dams and runoff. Actions such as clearing shoreline vegetation may cause an increase in water temperature. Soil erosion contributes to warmer water because the suspended soil particles absorb heat.

Most aquatic species are acclimated to specific ranges of water temperatures. As the temperature changes, those species that are adapted to one range of temperatures will be replaced by those that are tolerant of the new temperature. At temperatures greater than 68°F, many plants and fish diseases thrive, as do most bass, crappie, bluegill, carp, catfish and caddisflies. Temperatures in the range of 55-68°F support some plants and some fish diseases along with salmon, trout, stoneflies, mayflies, caddisflies and water beetles. Water temperatures below 55°F are habitable for trout, caddisflies, stoneflies and mayflies. Rapidly changing water temperatures can cause thermal stress to aquatic organisms.