Chapter 2: Minnesota Waters—Atmosphere, Rivers, Lakes

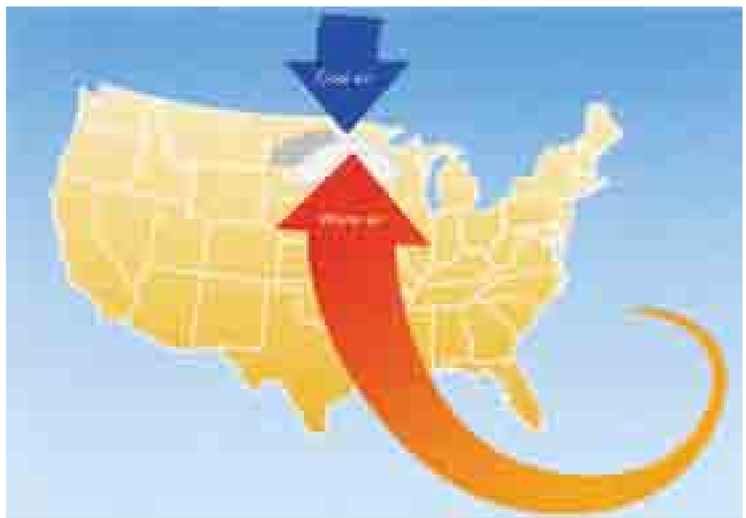
Key Concepts:

- Minnesota has bountiful supplies of water, but it's not equally distributed
- Water in Minnesota exists in many forms and locations
- The abundance of water in various locations varies with time and place
- Minnesota's lakes and rivers are many and varied
- By studying lakes and rivers, we can learn things that help us keep them healthy

MINNESOTA IS A WATER-FULL STATE. One out of every five square miles of surface area in Minnesota is covered by lakes, streams, or wetlands. Of all of the states, the U.S. Census Bureau ranks Minnesota eighth in the amount of surface area covered by water—and that's not counting numerous wetlands, bogs, and lakes smaller than 40 acres. Let's take a trip around the water cycle to see where and how water permeates our state.

Water in the Air

Where does Minnesota water come from? Most of the water that enters Minnesota is water vapor that is carried on the wind from the Gulf of Mexico.



Rob Blair, University of Minnesota

Even on days when there is not a cloud in the sky, there is water in the air. Water molecules float around among the nitrogen, oxygen, carbon dioxide, and other gas molecules that make up the atmosphere around us.

How does water get out of the air? One way is through a process called **condensation**—turning from a gas into a liquid. The trigger for doing so is a combination of temperature and the presence of a surface on which the water molecules can gather.

Minnesota Water Facts

Number of lakes 10 acres or larger: 11,842

Miles of natural streams and rivers: 69,200

Acres of wetlands: 9.2 million

Amount of water that falls on Minnesota each year: 38,000,000,000,000 gallons

Sometimes this surface is a big one—a windowpane on which fog forms, or a blade of grass that gathers dew. Other times the gathering place may be very small. Rain droplets and snowflakes form when water molecules condense around tiny specks of dust or other matter, called **condensation nuclei,** floating in the sky. Eventually enough water may accumulate into clouds that it falls from the sky as rain.

Another way water leaves the gaseous state is when it turns from a gas into a solid—a process known as deposition. Snowflakes, window frost, and *hoarfrost* are all products of deposition.

Because of its crystalline structure, snow takes up more space than liquid water. As a result, an inch of snow contains less water than an inch of rain. The amount of water in snow varies, depending on weather conditions. It takes about 20 inches of the light, fluffy new snow that falls at 14° F to equal 1 inch of rain. About 5 inches of the heavy, wet snow that falls right around freezing temperature would equal 1 inch of rain. A general rule many people use is that 10 inches of snow equals 1 inch of rain.

On average, precipitation equal to 27 inches of rain falls on Minnesota each year. This is three times as much as Nevada, which receives only 9 inches annually—but only a fraction of Hawaii's hefty 70 inches.

Because southeastern Minnesota is closer to the Gulf of Mexico than northwestern Minnesota is, it tends to receive more precipitation. Average annual rainfall equivalent in Minnesota ranges from 32 inches in the southeastern part of the state to 19 inches in the northwest. Most of the precipitation our state receives falls during May through September. Only 8 percent falls in the winter months of December through February.

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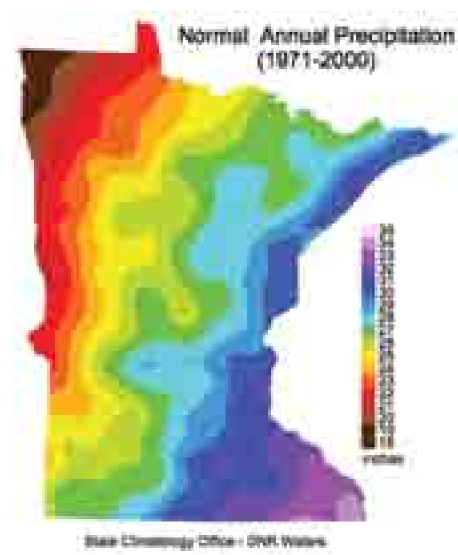
Hoarfrost on trees.



Weather vs. Climate. What's the difference between weather and climate?

Weather is what happens in a specific place at a specific time. Today the weather may be rainy, or windy, or cloudy, or cold. In addition to using words, we describe weather with specific numbers, such as temperature, atmospheric pressure, wind speed, and relative humidity. Weather can change quickly.

Climate, on the other hand, is the characteristics of the weather at a particular location based on many observations of weather over many years. The words we use to describe climate can be similar to the ones we use to describe weather—humid, or mild, or cold, or wet. The numbers we use to describe climate, however, are likely to be ranges or averages rather than "here and now" quantities.

So, if we say we have snowy weather, that means it's snowing. If we say we have a snowy climate, I may not need a shovel right this moment, but chances are good I will at some point!

Clouds. A cloud is a collection of water droplets clinging to condensation nuclei. As the water droplets gather, they create an opaque area in the atmosphere that we call a cloud.

Some clouds are big and billowy. Others are light and wispy. What makes clouds different? The answer has to do with the conditions under which they were formed.

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Clouds that are formed high in the sky—20,000 feet or more above the surface of the earth—are made of ice crystals and tend to be thin and feathery.

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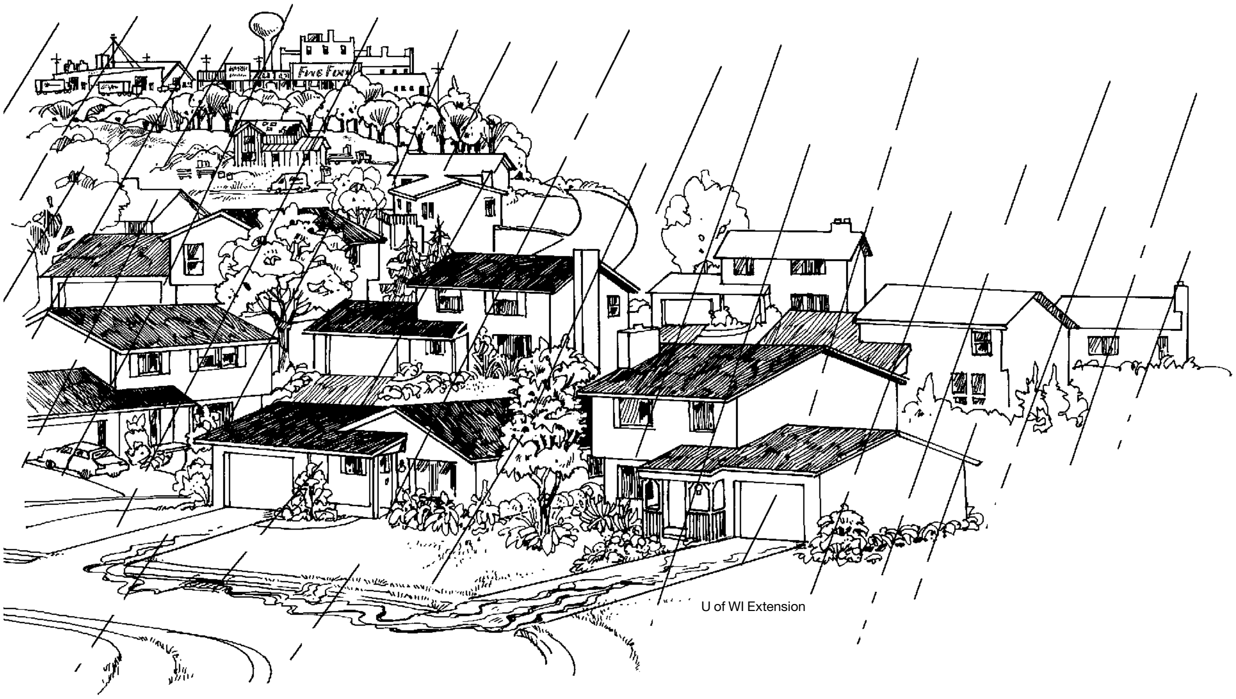
Clouds that are formed closer to earth are mainly water and have a more solid appearance.

Hydrology is the science of water and how it is distributed and moves in the air, on land, and in the ground.

Water in Transition

What happens to water when it leaves the air as rain or snow? Often it doesn't immediately soak deep into the ground or flow toward surface waters (and eventually the sea), but stops temporarily at a place in between—a snow bank, a puddle, a plant, or a person.

On land, variations in the Earth's surface can slow water's journey downstream. These variations give the water time to soak into the soil and supply moisture to the soil itself and to the groundwater system. Some of these features are natural, while others were built by people. Natural low points in fields and forests and manmade reservoirs and retention ponds gather water during storms and as snow melts.



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Benefits of Shoreland Vegetation.

Riparian zones, or buffers, along the banks naturally consist of deep-rooting, flood-tolerant plants and trees that provide multiple benefits:

Bank stabilization

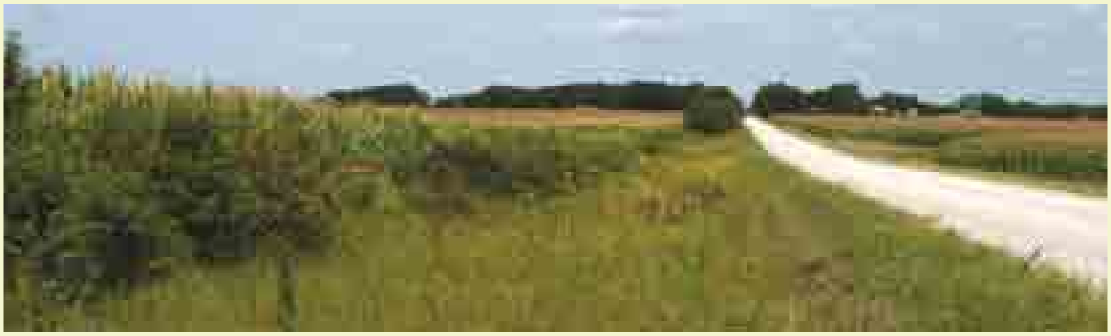
- Native riparian vegetation has dense, deep, intertwined root systems that physically strengthen soils.
- Riparian root systems remove excess moisture from the soil, making banks more resistant to erosion or slumping.
- Exposed root systems provide roughness that dissipates the water's erosive energy along the banks while the plant stems and leaves provide roughness during flood flows.

Water quality protection

- Vegetated buffers intercept and filter out much of the overland flow of water, nutrients, sediment, and pollutants; accordingly, wider corridors are more effective at protecting water quality and promoting ground-water recharge.

Riparian habitat benefits

- Diverse riparian vegetation provides shade, shelter, leafy or woody debris, and other nutrients needed by fish and other aquatic organisms.
- Wide, continuous, vegetated floodplains help dissipate flood flows, provide storage for floodwaters, retain sediment and nutrients, and provide shelter, forage, and migration corridors for wildlife.



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Links to Land. Where water travels once it hits the surface of Minnesota depends on the kind of surface it meets. Forests, wetlands, and vegetated croplands tend to absorb water. Impervious surfaces like roads, sidewalks, rooftops, compacted soils and bare rock shed water.

The amount of precipitation that soaks into the soil also depends on the time of year. Precipitation in July and August is more likely to be used by plants than to infiltrate into the soil. In the fall, after plants have stopped growing, more precipitation will soak into the ground rather than be pulled into the roots of plants. Precipitation that falls on frozen ground, snow, or ice, is not as likely to soak in as precipitation that falls on warm, permeable soil. As a result, a larger proportion of water that falls in winter is likely to run off into lakes and streams rather than soaking into the soil.

Living things can also slow water's journey downstream. In living things water performs many functions. It provides the hydrogen atoms that plants need to make carbohydrates during photosynthesis. It carries substances, like nutrients, from one place to another. It provides lubrication to help body parts move smoothly. It dissolves biological chemicals and helps them interact with each other. It moderates fluctuations in body temperature and dilutes waste products. Some water that enters living things is transformed into other kinds of molecules, and living things make some water out of other molecules.

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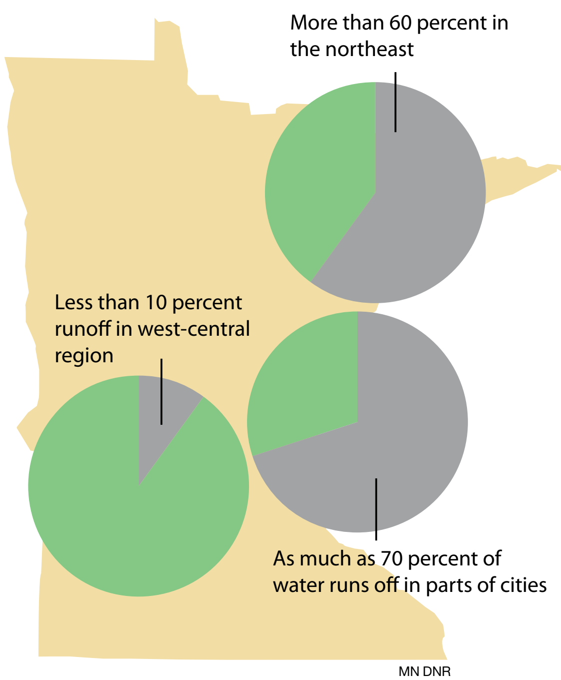
Eventually water leaves living things. It might move on as molecules that evaporate from the surface of a plant or from the sweat of an animal—a process called **transpiration.** It might be part of the organism's fluids—sap, saliva, sweat, tears, and so on. One way or the other, it ends up in the atmosphere or as part of a body of water continuing the journey toward the sea.

On average, 76 out of every 100 drops of water that fall on Minnesota find their way back into the atmosphere, either evaporated or sublimated from the surface or transpired by trees, grass, and other plants.

Running Water

Another 22 out of 100 drops of water that fall on Minnesota end up traversing the land in a pattern that is determined by rock, soil, and landforms. Statewide, the amount of annual precipitation that ends up running off the surface rather than soaking in ranges from more than 70 percent in parts of cities, to more than 60 percent in the steep, rocky, river-etched northeastern part of the state, to less than 10 percent in the flat, porous-soiled west-central region.



Some people brag about sports teams. Others take pride in cars or clothes. What gives Minnesota hydrologists big heads is our abundance of running water. All together, Minnesota has 69,200 miles of streams and rivers. End to end, they would stretch around the earth two and a half times!

When rain falls or snow melts, whatever doesn't soak into the soil or evaporate back into the atmosphere eventually moves to lower ground, drawn by the force of gravity. What starts as a drip turns into a trickle. As more water flows from across the landscape, the trickle grows into a small stream. Two streams may join to form a larger one. Eventually a major river is formed.

The Nature of Rivers

In the same way you might describe other people by their gender, the color of their hair, what they are wearing, their height, and so on, scientists describe streams and rivers by traits that vary from one to another. Traits used to describe rivers include:

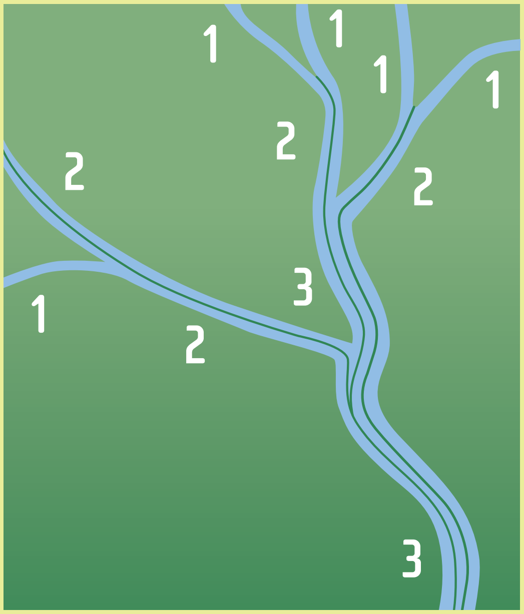
- size, shape (sinuosity) and slope of the channel
- channel material (sand, cobble, boulders, bedrock)
- stream order (see side bar *2+1=2)*
- amount of dissolved oxygen and water temperature
- amount of nutrients and sediment being carried along or deposited
- discharge rate—the volume of water that moves through it in a specified amount of time.

Depending on where you are in Minnesota, you may use different terms to describe the streams. For example, in a "flashy system" such as those found in southeastern and northeastern Minnesota (due to exposed bedrock and steep bluffs), water runs off the land and into the nearby stream quickly. The water rises and velocity increases rapidly and also retreats very quickly. This can cause flash flooding and erosion issues. Southwestern Minnesota, on the other hand, tends to have systems that are slower to respond, with gently rolling hills with deep glacial tills and more wetlands that store the water longer and recharge groundwater.

2 + 1 = 2. Streams and rivers are assigned a ranking called an "order" that describes their relationship to other streams and rivers flowing into them. Different things live in different stretches. The biggest rivers in Minnesota—the Red, Minnesota, lower Mississippi, lower St. Croix—tend to have stream orders on the range of 7 to 10. They move slowly.

To calculate stream order, follow these two simple rules:

1. If two streams of the same order meet, the stream they form together is one order higher (2+2=3)
2. If two streams of different orders meet, the stream they form together takes on the order of the higher of the two (2+1=2)



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Anatomy of a Stream

A body of flowing water is called a stream. Think of a stream you know. What is it like?

Your answer probably depends on which stream and even which part of the stream you are thinking of. The characteristics of Minnesota streams vary from one region of the state to another. In addition, the source of a stream, where water first gurgles from a spring or seeps from the side of a hill, is far different from the wide, mature river it becomes downstream. Not surprisingly, seasons and weather make a big difference, too. Most Minnesota rivers, for example, experience peak flows in spring as snow and ice melt into liquid water. Because of the timing of spring thaw, such peaks tend to occur in April for the southern half of the state and May in the north.

The science of lakes, rivers, wetlands, and other freshwater bodies is called **limnology.** By studying bodies of water, we can learn what conditions they need to stay healthy, and what we can do to help them.

What's In a Name? What's the difference between a stream and a river? How about a brook or a creek? Though the exact usage may vary from place to place, in general a **stream** is any natural waterway that contains flowing water at least some of the time. A *brook* or a *creek* is a small stream. A *river* is a large stream. Other names for running water used around the country include *kills, rills, cricks,* and *sloughs.*

Minnesota Rivers

Minnesota rivers are rushing and lazy, shallow and deep, clear and muddy, narrow and broad. Some are just a foot or two wide. Waters at the head of a river tend to be cool, fast flowing and clear. Those downstream tend to be warmer, slower and generally contain more sediment. In other words, different rivers—and even different stretches of the same river—have their own unique characteristics. The nature of those characteristics is related to many factors, including geology, biology, land use, topography, and time of year.

Along the Minnesota portion of the north shore of Lake Superior, where the state's highest point (Eagle Mountain, elevation 2,301 feet) is less than 15 miles from its lowest point (Lake Superior, elevation 602 feet), sharp drops and unyielding rock create narrow, steep slopes for water rushing toward the big lake and eventually the Atlantic Ocean via the Great Lakes. Exposed bedrock provides hard surfaces over which waters flow. As a result, features like rapids and waterfalls are common in rivers like the Cascade River and Baptism River on the North Shore of Lake Superior. Trout can be abundant in these steep, fast, channels with their cool water and high oxygen levels derived from the aeration effect of turbulence.

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Baptism River

To the west, on the border with North Dakota, the Red River of the North flows out of Lake Traverse and Mud Lake. This flat river runs along the Minnesota–North Dakota border with a vertical drop of just over 6 inches per mile. Ancient glacial Lake Agassiz created this extremely flat area that floods regularly. Floods provide the benefit of leaving behind rich, black soil for crops, but also create big challenges for those who live there, too.

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Spring flooding in Grand Marais Creek, 1 mile upstream of confluence with Red River.

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Dry August conditions in Grand Marais Creek.


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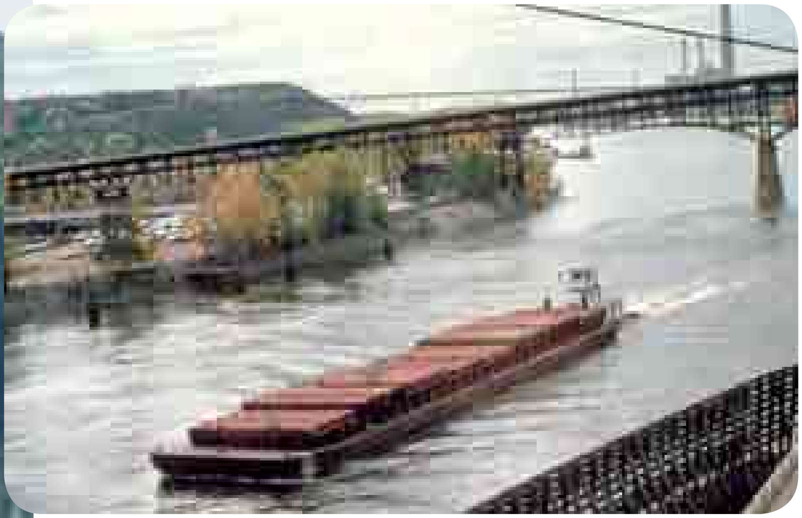
Minnesota River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Mississippi River

In southwestern Minnesota, rivers often drain relatively flat land (rolling hills, glacial terrain), much of it agricultural fields with exposed soil. Four major rivers in this area, the Cottonwood, Redwood, Yellow Medicine, and Lac qui Parle, all drain into the Minnesota River, which in turn drains into the Mississippi. These waters tend to transport sediment and nutrients (such as nitrogen and phosphorus from fertilizer) into the Minnesota River and then into the Mississippi River. Many glacial advances and retreats left behind deep deposits of soil, called glacial till, good for farming. The streams can meander in a sinuous water course and down cut through this till, eroding banks and taking sediment downstream to the Minnesota River.

Land in southeastern Minnesota has been etched by rivers into hills and valleys. Along the Mississippi River, some bluffs stand hundreds of feet above the surface of the river. This part of the state is famous for its karst topography—landforms shaped by underground water etching through limestone and creating caves, sinkholes, springs, disappearing streams, and other irregularities above and below ground.

Karst topography is why this area has few lakes, but plenty of springs and beautiful, cold-water trout streams. It's also why water pollution is a particularly powerful threat in this area: Contaminants reaching surface or groundwater in one area can travel rapidly through the interconnected mazes of surface and groundwater to harm other waters far away.

Southeast Minnesota is famous for its karst topography.


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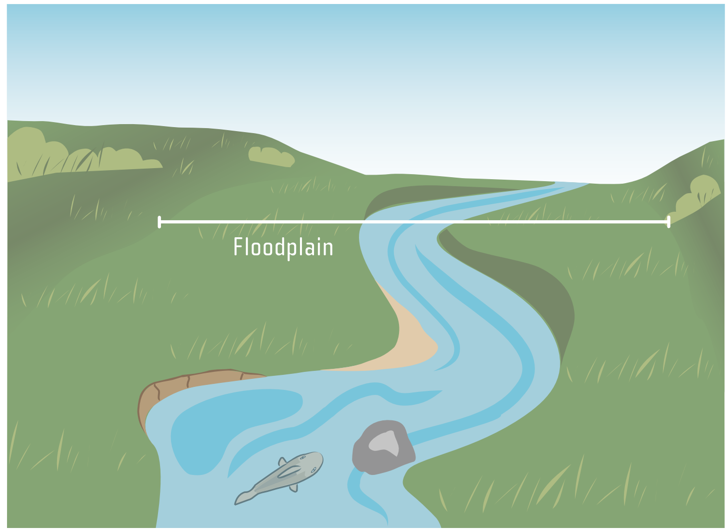
Trout Waters. Northeastern and southeastern Minnesota streams tend to have cool water with lots of dissolved oxygen, perfect conditions for trout. High oxygen content is due to two factors: the water temperature (cold water holds more oxygen than warm water) and the turbulence of the fast-flowing streams, which gives the oxygen in air opportunity to mix in with the water.

Overflow Lot



An important component of streams and rivers, but one we don't always think of, is the part they use only part of the year. Known as the **floodplain,** this area is the "overflow parking lot" for water rushing downstream during snowmelt or in times of heavy rain.

Floodplains are flat areas of land along the side of a river and vary in width depending on the geology of the area. They tend to have rich soil because of the nutrients deposited by floodwaters. They not only hold large quantities of water during flooding events, but also are home for many plants and animals. Their backwaters act as nursery areas for river fish. Rivers and their floodplains have a critical ecological relationship, and many plants and animals depend on the seasonal "pulse" of both flooded and low-water conditions.

Floodplains are often used as farmland and parklands. This land use allows the area to still flood and provide water storage when needed without causing damage to buildings and other structures. In drier times, floodplains can provide other benefits such as food production or recreation. For example, after the flood of 1997 many homes along the Red and Red Lake rivers in East Grand Forks were replaced with a greenway called the Red River State Recreation Area. As a result, flooding was transformed from a major property and safety threat in an inhabited neighborhood, to a natural regeneration of health and life to the riverside habitat whose inhabitants include river otters, bald eagles, and an abundance of warblers and other songbirds.

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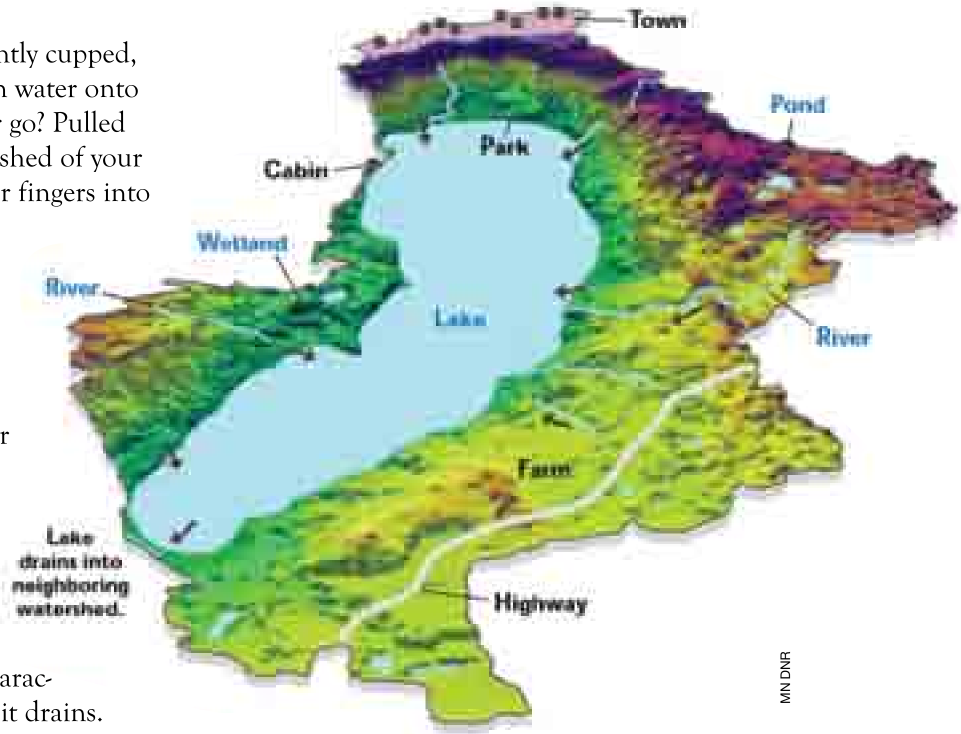
Red River Blues. One of the reasons the Red River in western Minnesota is so susceptible to flooding is that it flows north. When spring arrives, the more southerly upstream watershed thaws first, sending ice chunks and meltwater rushing into the still-frozen portions to the north. The result is a backlog of water and ice that disrupts the normal downstream flow of water, sending it out into the floodplain instead. Another major reason for the "Red River Blues" is the loss of wetlands due to agricultural drainage. This not only reduces the landscape's capacity to hold water in wetlands, but delivers runoff water more quickly through ditches and underground drainage. Minnesota is unusual in that very little water flows into the state. This means that our lakes and rivers for the most part are not recipients of water pollution from other states.

What Is a Watershed?

Hold out your hand palm up, slightly cupped, with your fingers tightly together. Run water onto your fingertips. Where does the water go? Pulled by gravity, it travels through the watershed of your hand, down the valleys shaped by your fingers into the "lake" of your palm.

All of the land area that drains into a particular river or lake is called its **watershed.** The watershed creates a common connection among places on the landscape—the connection of contributing water to a specific lake or stream. Watersheds can be as small as the area around a pond or as large as hundreds of square miles that drain to a major river. Whether the land is bare or full of plants, flat or steep, rocky or boggy or something entirely different determines many characteristics of the water body into which it drains. If a lake's watershed includes peat bogs, the water entering into it will be stained with acids, giving it a rich brown color. If the watershed contains a lot of bare land, the lake at the bottom of the watershed may take in silt and soil, clouding the waters with suspended solids. If the soils in the watershed are rich in phosphorus, the runoff will act as a fertilizer for aquatic vegetation, and the lake will grow lush with plants and algae.



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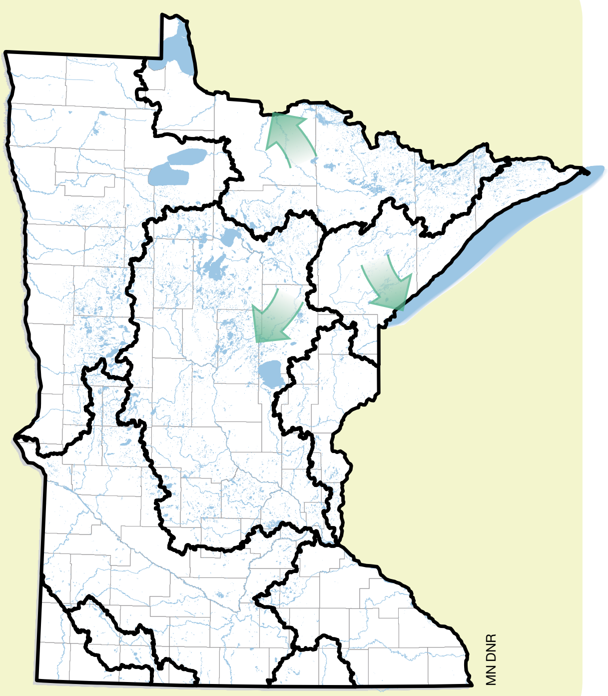
On a big-picture basis, water that falls in Minnesota flows through one of three large watersheds: north via the Red River to Hudson Bay, east via the Great Lakes and St. Lawrence Seaway to the Atlantic Ocean, or south via the Mississippi River to the Gulf of Mexico.

Hill of Three Waters. Minnesota is home to a rare water feature known as a triple divide where three major watersheds diverge. At a spot near Hibbing in the northeastern part of the state (Section 26, Township 58, Range 21), two major watershed divides, the Northern Divide and the St. Lawrence Seaway Divide, intersect. As a result, water runs in three directions—toward the Gulf of Mexico, the Gulf of St. Lawrence, and Hudson Bay. Ojibwe Indians are said to have called the site "Hill of Three Waters" and used it for council meetings. The site is now part of the Hull Rust Mahoning Mine—one of the largest operating open pit iron ore mines in the world. A sign at the Anchor Lake rest area, about 33 miles southeast of the site, describes the triple divide. In addition to being a notable landmark, it is now also an example of how human actions can alter the location and movement of water across the landscape on a large scale.



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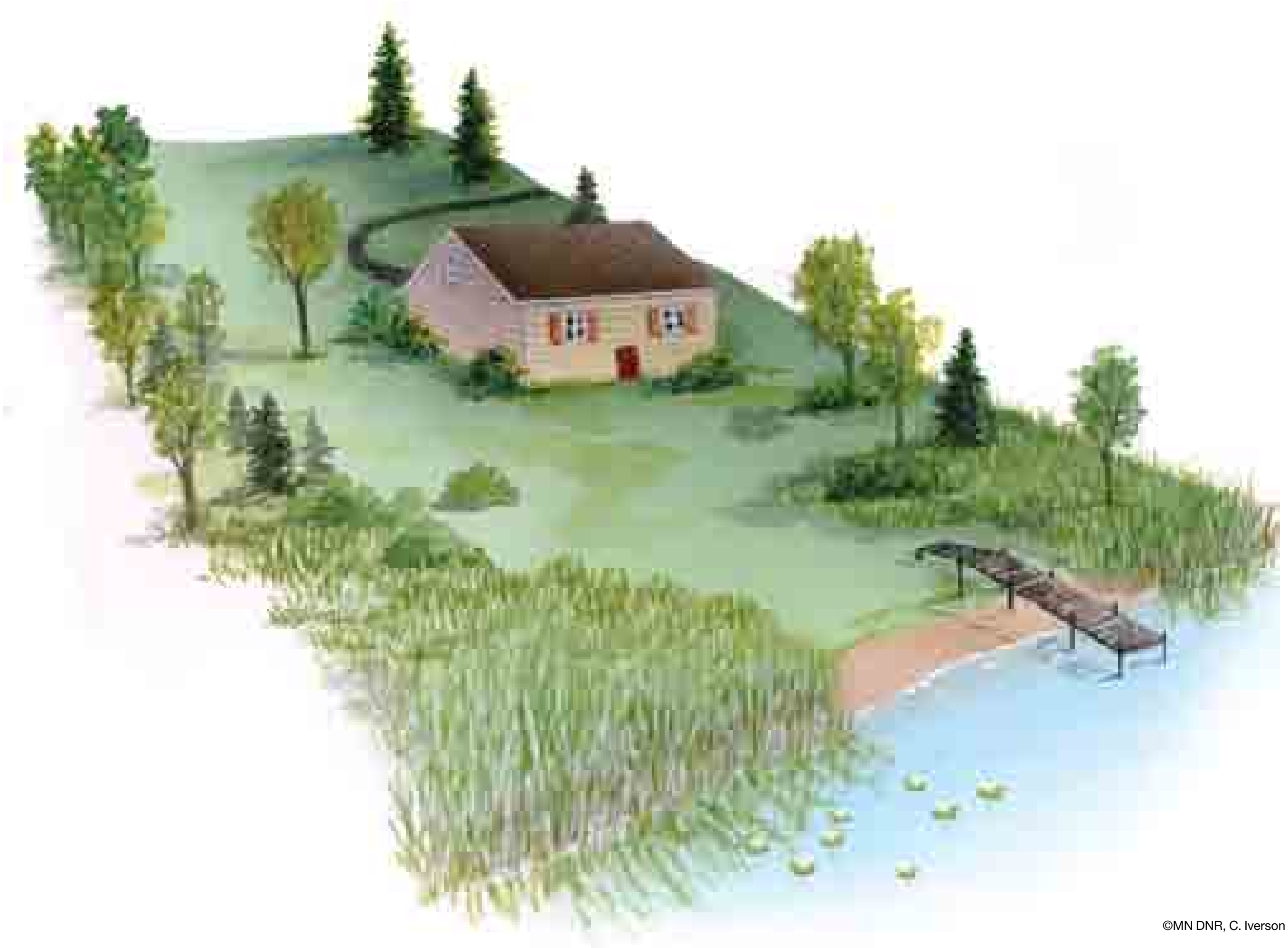
The Minnesota Department of Natural Resources (DNR) categorizes Minnesota watersheds at different scales—the three large watersheds are subdivided into progressively smaller watersheds to define areas of the landscape where water runs downhill, forming creeks and rivers. There are 81 major watersheds in the state, defined by the river into which they drain. Each of these major watersheds can be divided into minor watersheds that feed water to a particular **tributary** of that major river.

Every Minnesotan has a watershed "address." Your watershed address is defined by where the water that falls on you eventually flows. For example, the watershed address of a person living in Ely might be Burntside Lake, Lac La Croix, Rainy River, Red River, Hudson Bay. The address of a person living in Northfield might be Cannon River, Mississippi River, Gulf of Mexico.

Lakes

When you think of water, what do you think of? Many Minnesotans think of lakes. Lakes get their water from different a variety of sources. Some comes from rain, snow, and other forms of precipitation. Some runs off from the land surrounding the lake. Some enters from other bodies of water: streams, wetlands, or groundwater. Lakes whose main water source is surface water are called *drainage lakes.* Lakes whose main source is groundwater are known as *seepage lakes.*

With more than 10,000 lakes, it's not surprising that a few might have to share a name. The most common lake names in Minnesota, along with the number listed under that name on DNR's Lake Finder : Long (119), Twin (89), Mud (87), Island (87), Bass (85), Rice (84), Round (50), Spring (39), Horseshoe (33), and Johnson (21) .



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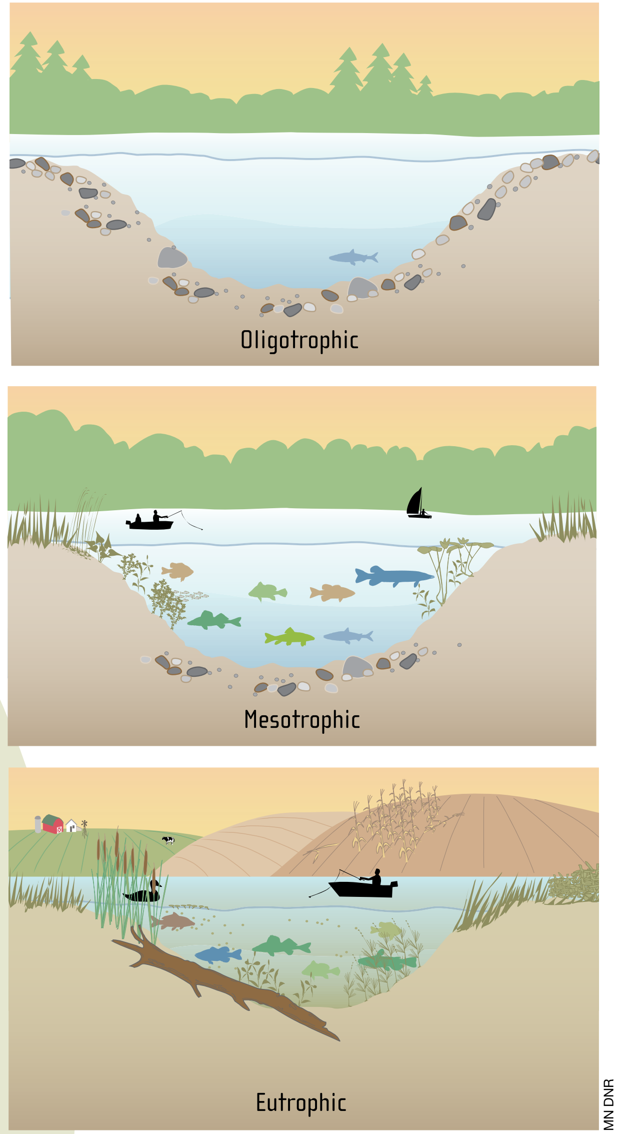
How We Describe Lakes

Like people and puppies, lakes come in many different varieties. Some are large, deep, and clear. Others are shallow and full of algae. Many are some combination of the two.

The character of a lake depends on many things, beginning with how the lake was originally formed and the kinds of rocks and soils that surround and underlie it. Some of the many factors that affect the character of lakes are: its size and shape, the climate, the plants and animals that live in the lake, and the extent to which human activity influences the lake.

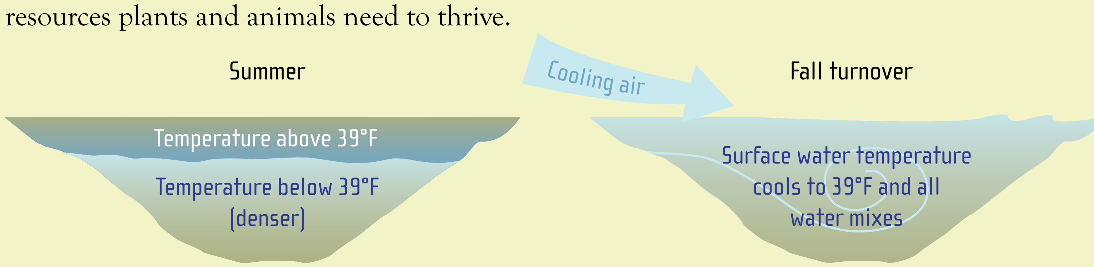
One way limnologists (freshwater scientists) classify lakes is by how nutrient rich they are. Lakes with few plant-supporting nutrients are called **oligotrophic.** Those moderate in nutrients are called **mesotrophic.** Those rich in nutrients are called **eutrophic.** The nutrient status of a lake depends on many factors: including the age of the lake, the size of the watershed, size and shape of the lake, characteristics of the surrounding land, and the amount and nature of runoff and other human-generated inputs it receives.



Layered Lakes. The fact that liquid water has different densities at different temperatures creates a fascinating phenomenon in many Minnesota lakes known as stratification. During the summer, the surface of the lake heats up. Because water above 39° F is less dense than water below 39° F, it tends to remain near the surface, mixed by the wind only with the water immediately below it. In the fall, cooling air causes the surface water to cool, too. As it does, it becomes heavier than the water below it and starts to sink. The water in the lake eventually mixes until it is all more or less 39° F, a process called the fall turnover.

During winter the water just under the ice is at freezing point—32° F. In spring, when the air warms, the ice melts and the surface water warms too. It eventually reaches 39° F and mixes with the water below it—creating a second (spring) turnover.

Spring and fall turnover help mix oxygen and nutrients through the lake, providing the resources plants and animals need to thrive.

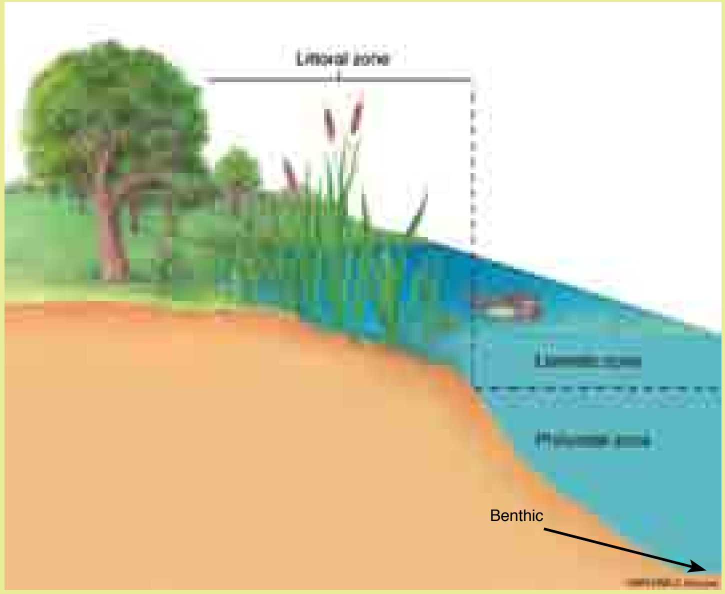


Anatomy of a Lake. Just as lakes can be classified, parts of lakes are classified, too. One example is classifying by biological communities. The portion of the lake where light reaches all the way to the bottom is called the littoral zone. Rooted plants like wild rice and bulrush grow here, as do newly hatched fish, called fry.

Toward the middle of the lake, beyond the littoral zone, is the limnetic zone—the area of open water. Here fish and zooplankton such as daphnia and copepods thrive. Algae such as spyrogyra and cryptomonas capture the energy from sunlight. Below the limnetic zone, where insufficient sunlight penetrates for photosynthesis to occur, is the profundal zone.

The cold, dark bottom surface beneath the profundal zone is called the benthic zone. Invertebrates such as mussels and crayfish live here, nourished by detritus that floats down from above.

You can learn more about these zones of life in Chapter 4.



Another way lakes are classified is by how often the water within them turns over (see "Layered Lakes" sidebar). Some lakes, like Minnetonka in Hennepin County, turn over twice a year. These are known as **dimictic** lakes. Some, such as Mille Lacs, are **polymictic**—they mix many times over the course of a year. **Monomictic** lakes, including Lake Superior, mix one time per year. A few lakes are **meromictic**—they never mix completely. Deming Lake in Itasca State Park is an example of a meromictic lake. Relatively deep, with a small surface area and sheltered from the wind, it doesn't experience the conditions needed to mix all the way to the bottom.

Lakes also can be categorized by the kinds of substances that are dissolved in their water—which in turn is characteristic of the terrain that surrounds and underlies them. Lakes with a lot of calcium and magnesium are called *hardwater* lakes. Lakes with little of these minerals are known as *softwater* lakes. The hardness of a lake's water affects the impact pollutants have on it, as well as its ability to keep nutrients in solution where they can be used by plants.

Lakes Over Time

Minnesota lakes change markedly from season to season. In summer the water at the surface warms, plants are photosynthesizing rapidly. In winter the water cools and ice forms. The ice floats on top of the colder, denser water, reducing the exchange of gasses and heat between the water and the atmosphere. The ice provides a platform to hold snow, which covers and darkens the waters. With the changes in the environment, the location and proportions of living things changes, too. For example, in early spring and fall, **diatoms** are a prominent part of the phytoplankton. In early summer, green algae peak, and blue-green algae increase their populations in late summer. And, as every angler knows, where in the lake fish can be found varies from season to season as well.

Like people, lakes tend to change and grow old over time. Lakes tend to become shallower as soil and organic material wash in from the surrounding watershed. As the lake fills in, plants begin to take root beneath its surface, speeding the process. Under some conditions sphagnum moss creeps out over the water, and the open water surface shrinks. Eventually a lake may become a wetland and, ultimately, solid ground.

Minnesota's Lakes

Minnesota is widely known as the Land of 10,000 Lakes. But it's even better than that: According to the Minnesota Department of Natural Resources, the state is home to 11,842 lakes 10 acres or larger.

Why is Minnesota so rich in lakes?

Part of the reason is the amount of precipitation that falls here. Another reason is our state's geologic history.

Most of Minnesota's lakes formed as a result of the action of giant glaciers that shaped its surface tens of thousands of years ago. Some lakes were formed when a ridge of glacier-deposited material, called a moraine, blocked the flow of water. Others were created when water filled bowl-shaped depressions created by the melting of giant chunks of ice. An example of Minnesota lakes formed in this way is the Minneapolis chain of lakes (including Calhoun, Harriet, Lake of the Isles, and Cedar).

A few lakes were formed instead by the action of rivers. One example is Lake Pepin, a large bulge in the Mississippi River that formed when deposits of the Chippewa River partially blocked its flow downstream from its confluence with the St. Croix River. Other lakes are known as oxbow lakes. These lakes form when a river changes its course and leaves behind a pinched-off meander of

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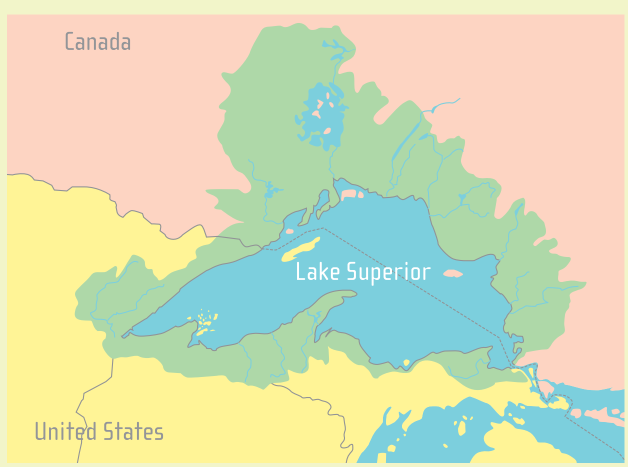
Satellite view of Minneapolis chain of lakes.

A Great Lake. Lake Superior, which forms part of Minnesota's eastern border, has the largest surface area of all freshwater lakes in the world at 31,820 square miles. Its volume is 2,900 cubic miles, and its shoreline covers 2,726 miles. Lake Superior holds 10 percent of all Earth's surface freshwater.




Explore Minnesota Tourism

Lake Pepin

itself. Big Logan, Little Logan, and Oxbow lakes in Aitkin County are all oxbow lakes, formed as the Mississippi River adjusted its course.

Some Minnesota lakes are formed by human action. Lake of the Isles in Minneapolis was just a shallow lake and wetland until engineers turned it into a 120-acre lake in the early 1900s. Pokegama Lake in Grand Rapids was created by a dam built across the Mississippi in the 1880s to control flooding. The Iron Range has lakes formed from water filling the pits left behind by iron miners. One of these, Portsmouth Mine Pit in Crow Wing County, is Minnesota's deepest lake, at 450 feet.

Ever since Minnesota lakes were formed, they have been slowly filling in with soil carried into them from the surrounding watershed. Some lakes are lined with 40 feet or more of sediment. Scientists use these layers of sediment to learn about the history of the area.

What Are Lakes Like?

Minnesota lakes are shallow and deep, large and small, nutrient rich and nutrient poor. In other words, our lakes vary a lot!

In northern Minnesota lakes tend to be relatively clear, with few nutrients. Lakes in the southern part of the state, where there is more nutrient-rich soil, more agriculture, and more human settlement, tend to have more nutrient inputs and thus more plant growth.

In northern Minnesota, lakes tend to be relatively clear, with few nutrients.

The color of the water in Minnesota lakes varies depending on other lake traits. Lakes with a lot of nutrients may be green from the algae that grow in them. Lakes with marl (a combination of clay, sand, and limestone) may appear turquoise. Some northern Minnesota lakes have brownish water. This color, called tannin, comes from materials produced when plants decompose in bogs. Also known as bog stain, the color is not harmful and is not an indication of poor water quality. It usually means there is a wetland in the lake's watershed.

Slice of Life. Do you enjoy a good story? Few are as detailed and fascinating as the ones the mud at the bottom of a lake has to tell. Scientists interested in learning the environmental history of an area extract long, cylindrical samples of sediment from the bottoms of lakes. By studying the physical and chemical properties and the remains of microscopic organisms and pollen embedded there, they can learn much about changes in the climate, pollutants, and other conditions through the millennia. Their science, called paleolimnology, is helping us to understand how Minnesota has changed in the past, how it is changing today, and how it is expected to change in the future as greenhouse gases and other human impacts alter the balance of nature.

CAREER PROFILE

Erika Rivers
Lakes Planner,
Minnesota DNR
Grand Rapids

Erika Rivers likes lakes, and she likes talking to people. As a DNR lakes planner, she spends a lot of time talking to people about how they can protect Minnesota's lakes by keeping the shoreline as natural as possible. Her work ranges from speaking at lake association meetings, to conducting research by surveying both people and lakeshores, and helping DNR revise shoreland rules.

"Minnesota is losing native habitat in and around our lakes and rivers at an alarming rate," Rivers says. "I encourage private shoreland homeowners, lake associations, and local government units to keep shorelands as natural as possible; to restore shorelands that have been altered by past development practices; and to enact shoreland ordinance protections that encourage native vegetation and minimize human impacts."

Rivers first became interested in shoreland protection after seeing native species disappear at the lake cabin she visited as a child. She encourages students who are interested in a career like hers to take lots of science and math classes in high school and both communication and science classes in college. She says a graduate degree is usually necessary for a natural resources career today.

Related careers:
community liaison,
extension educator,
natural resources specialist

Suggested Project WET Activities and Minnesota Connections

EL = elementary	MS= middle school	HS=high school

Water connects all earth systems

Branching Out* (watersheds) MS – Maps of major MN watersheds.

Just Passing Through (erosion) EL, MS

Rainy Day Hike (stormwater pollution) EL, MS

Poetic Precipitation (condensation, precipitation) EL, MS

Stream Sense (stream study, inquiry, sensory observation) EL, MS

Water is a natural resource

Color Me a Watershed* (watersheds, mapping) HS – Aerial photos of MN major watersheds over time.

A Drop in the Bucket (global water distribution) EL, MS, HS

Great Water Journeys* (water ways) MS, HS – MN Water journey cards

Sum of the Parts (nonpoint source pollution) EL, MS

Water resources are managed

Back to the Future (analyzing streamflow data & floodplain planning) EL, MS, HS

Water resources exist within social constructs

Water Crossings* (rivers & history) EL, MS, HS – MN water crossings stories, maps.

* Some Project WET Activities have Minnesota adaptations posted online for Minnesota Project WET Educators in the trained teacher page at www.mndnr.gov/projectwet. Additional adaptations will be added when possible.

Classroom Connections

Watershed Address: Use a map to figure out your watershed address—starting at your school, show the path that a drop of rain would take on its way to the ocean. If it makes it all the way, how far does it travel? Invite students to think about what might happen to that drop of water along the way. In the spirit of *Paddle-to-the-Sea,* invite them to write stories describing the droplet's imaginary adventures as it journeys to the ocean.

Wet Calculations: Use water as a way to explore the application of mathematics concepts you are teaching. Are students practicing multiplication? Ask them to figure out how many water molecules are in a teaspoon, Converting units of measurement? Have them figure out how many liters of water are in Lake Superior.

Water Moving Mountains: Give younger students a chance to play with water and sand. If you pour a little bit of water onto of a mountain of sand, where does it go? If you pour a LOT of water onto a mountain of sand, then where does it go? With enough water and sand you can make rivers, lakes, groundwater, and even oceans of your own!

What's in a Name? Research the origin of the name of a lake or river near you. When did it get its name? Who named it, and why did they give it that name? Has it had other names?

Map Investigation: Distribute road maps of Minnesota to pairs of students. Ask each pair to think of a question about Minnesota's lakes or rivers they could answer using the map. Then have them use the map to find the answer to the question. Examples: Are there more lakes in northeastern Minnesota or in southwestern Minnesota? In which direction does the Mississippi River flow? How many cities and towns have the word "Lake" or "River" in their names? What proportion of the state's border is formed by water?

Roots of Water Words: Explore the ancient Latin and Greek roots of water-related terms and how those roots link them to other English, French, or Spanish words. What is the common connection between sinuosity, sinus, and sine? How about agua and aquifer? Hydrology and hydrant? Sediment and sedentary? Lac, laguna, and lagoon?

Out and About

Follow the Drop: Follow the water from your school roof as far as you can, then use maps and sources to find out the name of the major river through which it will travel.

Snow Gage: In winter months, keep a "snow gage" outside your classroom window. When it snows, measure the snowfall. Then bring the gage indoors and let the snow melt. Compare the ratio of snow volume to water volume for snowfalls at different temperatures. Is there a correlation?

Label Your Lake! If there is a lake within walking distance, visit it as a class. Use observation to learn as much as you can about it. Based on what they can see from shore, do students think it is oligotrophic, mesotrophic, or eutrophic? Can you characterize it and its watershed? Check the DNR website's Lake Finder or your local watershed district to learn more. Be sure to talk about water safety ahead of time and enforce water safety rules during your visit.

A few excellent resources:

1. Lake Finder Website, MN DNR. http://www.dnr.state.mn.us/lakefind/index.html The Lake Finder contains data for more than 4,500 lakes and rivers throughout Minnesota, including: lake surveys, lake depth maps, lake water quality data and lake water clarity data, satellite-based water clarity information, lake notes, invasive species information, and fish consumption advice.

2. Cooperative Stream Gaging Website, MN DNR & MPCA. http://www.dnr.state.mn.us/waters/csg/index.html This water data resource site provides access to near real-time and historical streamflow and water quality data.

3. Interactive map of Minnesota watersheds, United States Geological Survey. http://gisdmnspl.cr.usgs.gov/watershed/index.htm. This interactive web application displays the 84 major watersheds in Minnesota and allows users to zoom in and out to search minor watersheds and see maps and sizes of each.

4. Surf your watershed website, United States Environmental Protection Agency. http://cfpub.epa.gov/surf/locate/index.cfm This site allows you to look up any watershed in the nation to find community information like lists of local citizen based groups, water monitoring data, information on impaired waters, streamflow data, political boundaries, etc.

5. Google Earth, Google. http://earth.google.com/. Google Earth is a powerful web tool that lets students view any place on Earth via satellite imagery, maps, terrain. An excellent resource for watershed, land use and geography lessons.

6. Minnesota Lake Browser, University of Minnesota. http://water.umn.edu/lakebrows.html. This online, interactive lake water clarity mapping tool is based on satellite data from 1990, 1995, 2000 and 2005. Once you have found a particular lake, you can retrieve more detailed lake water information from the MPCA and DNR.

7. *Waters to the Sea CD-ROM,* Hamline University's Center for Global Environmental Education. http://www.hamline.edu/cgee/waters2thesea/. Virtual river journeys, led by historic guides, take you from prehistoric times up to the present. Videos, QuickTime VR movies, and engaging multimedia activities examine a variety of land-use themes in each watershed. Visits to a virtual water quality lab correlate land uses with water quality.

8. Healthy Rivers: A Watercourse, MN DNR. http://files.dnr.state.mn.us/assistance/backyard/healthyrivers/course/index.html An online interactive program designed to help students understand the ecology, management, and stewardship of river and stream systems. This multimedia tool includes photos, maps, animations, audio interviews, video clips, and excellent resources.

9. Watershed Assessment Tool, MN DNR. http://www.dnr.state.mn.us/watershed_tool/index.html. An online tool where students can access a large number of watershed data layers in a single mapping application and find summaries for the local watershed. Includes information on the ecological health of Minnesota's watersheds including scores and grades based on broad data inputs and models.

10. *Rivers: Make It Work* by Andrew Haslam (1997). This elementary level book explores rivers including diagrams, experiments, landscapes, maps, models, and projects.

Want More? See www.mndnr.gov/projectwet for resources and information:

Academic standards correlations to Project WET activities
Educational materials/classroom resources for Project WET teachers
Out and About—field trip ideas
Citizen science/service learning opportunities
Useful websites
Suggested books