groundwater

wisconsin's buried treasure

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wisconsin's buried treasure

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WALKING ON WATER

Groundwater in Wisconsin is indeed a treasure. But like all our natural bounties, it is a treasure whose high value must be sustained not by accident but by purpose.

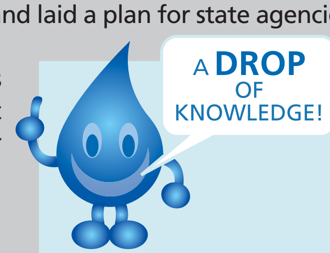
— 1983, "Groundwater: Wisconsin's buried treasure"

Catching trout in crisp clear streams, shooting the rapids in a canoe, lazing around the lake in an inner tube, quenching your thirst on a hot summer day — none of these activities would be possible without **groundwater**. For most of us in Wisconsin, the water we drink, wash with, float on and fish in comes from right below our feet. Groundwater is Wisconsin's invisible resource — our buried treasure. "Groundwater: Wisconsin's buried treasure" was first published in 1983 to educate citizens about the resource we use every day but can't see. Later versions of the publication highlighted actions state agencies and individuals were taking to safeguard groundwater. In 2006, we look back at the progress made and look forward to new challenges in protecting the groundwater resource. It seems fitting that we return to the original title for this new version of "Groundwater: Wisconsin's buried treasure."

Perspectives on groundwater

In 1983, the only option state agencies had for stopping groundwater polluters was litigation under public nuisance laws. The Environmental Protection Agency had set health-based drinking water standards for only 16 harmful substances. State agencies were learning more and more about where and how groundwater occurred and about how vulnerable the resource was. Our state's pioneering "Groundwater Law" was passed in 1984 and laid a plan for state agencies to work together for groundwater protection.

Fast forward to 2006: Wisconsin has limits for over 100 pollutants that threaten groundwater; a new "Water Quantity" law to regulate use; and groundwater flow has been studied in almost every corner of the state. Read on to learn about Wisconsin's groundwater, how state and local government agencies work together to protect this precious resource, and how you can help.



Look for the water drop, your guide to the truth about 10 common groundwater myths!

Using groundwater

Wisconsin is water-rich

When it comes to water, there's no place like Wisconsin. We are water-rich. Between the mighty Mississippi River and the Great Lakes of Michigan and Superior, there are more than 15,000 lakes, 7,000 streams and five million acres of wetland. And that just scratches the surface. Below our feet Wisconsin has a buried treasure — 1.2 quadrillion gallons of groundwater. It's hard to grasp just how much water is stored underground unless you look at how much we use every day:

Municipal drinking water (all uses)	330 million gallons/day
Commercial/ industrial use	256 million gallons/day
Livestock	100 million gallons/day
Irrigation (summer only)	182 million gallons/day
Home use	205 million gallons/day
TOTAL	**1,073 million gallons/day**

– USGS statistics estimates

Each year about 29 trillion gallons of water fall as rain or snow on Wisconsin's 36 million acres. Plants and animals consume some, some returns to the atmosphere through **evaporation** and **transpiration** by plants, and some flows into rivers, lakes and streams. The rest becomes groundwater by seeping through the soil and into groundwater **aquifers**.

If you could somehow pour all the water below ground on top, you'd need to trade in your ranch house for a houseboat: Wisconsin's bountiful groundwater could cover the whole state to a depth of 100 feet!

Getting a clean glass of water isn't as easy as turning on the tap!

In Wisconsin, the quality and quantity of groundwater varies from place to place. The difference is caused by a combination of **geology**, varying precipitation and use. Cities and towns in the north central and northeastern third of Wisconsin receive the most precipitation in the state, but they are underlain by crystalline bedrock, a type of rock formation notorious for yielding only small quantities of water. Even though there may be plenty of rain, finding enough groundwater to supply municipalities in these regions can be difficult.

Groundwater levels have been going down by hundreds of feet around some of Wisconsin's growing metropolitan areas

At last estimate, there were more than 850,000 **private wells** in the state. In areas where water moves through aquifers very slowly, private wells can still yield enough water for residential use. You can drill a hole just about anywhere in Wisconsin and find water. But is this water drinkable? Groundwater can be contaminated in several ways, which you'll read about here. But you'll also read about how you can take action at home to protect Wisconsin's buried treasure.

SUE SWANSON

ANDREW DAHL, COURTESY OF STATE HISTORICAL SOCIETY WHI (D31672

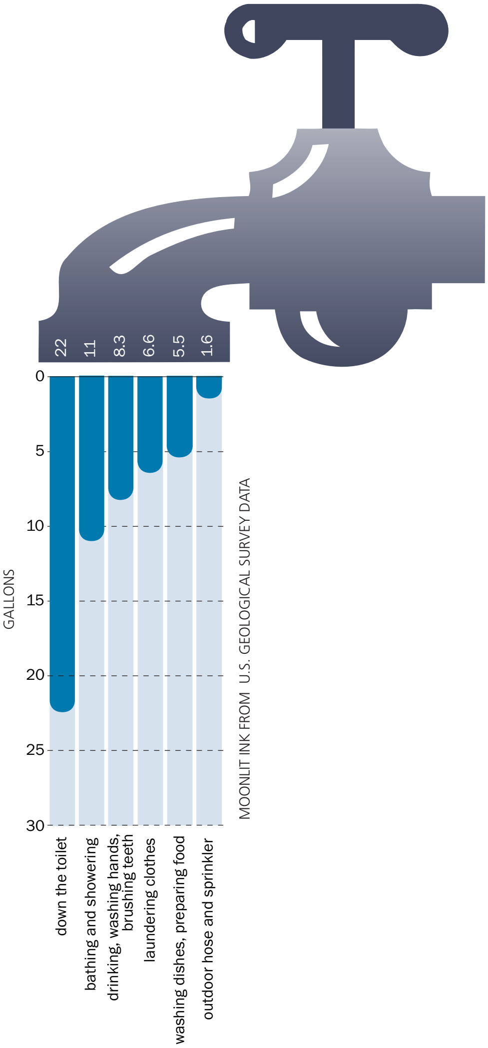
Pure, healthy groundwater is vital to our present, past and future economies. (above) An artesian well at the Nevin Fish Hatchery. (right) A Beloit mineral spring 1873-79.

The worth of water

In Wisconsin, about three-fourths of us draw nearly 205 million gallons of groundwater daily at home to slake thirsts, scrub pots, boil spaghetti and shower. Per person, that's 55 gallons of groundwater per day.

How do you use Wisconsin's ample buried treasure? Take a look at the faucet diagram on page 4.

Fifty-five gallons of groundwater



per person per day may not seem like much, but there are hidden costs for excessive water use. Your community may have to install new wells or water and sewer pipes to accommodate increasing demand. Pumping more water from private or public wells requires more energy, which costs more

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(above) Personal water use averages 55 gallons per day. That does not include groundwater used in water parks or agriculture.
(right) A spring bubbling up in Middleton.

money. Treating used water (referred to as "wastewater") to stringent standards of purity strains every budget.

Thirsty cities

It's used to fight fires, clean streets, fill the local pool, sprinkle golf courses and parks, drench shade trees, supply commercial customers and satisfy the needs of thirsty residents at home or at bubblers (drinking fountains, to non-Wisconsinites) around town. Ninety-seven percent of Wisconsin's cities and villages count on groundwater to provide basic water-related services often taken for granted.

The top counties and main users:

- Dane County (Madison) area, 48 million gallons per day;

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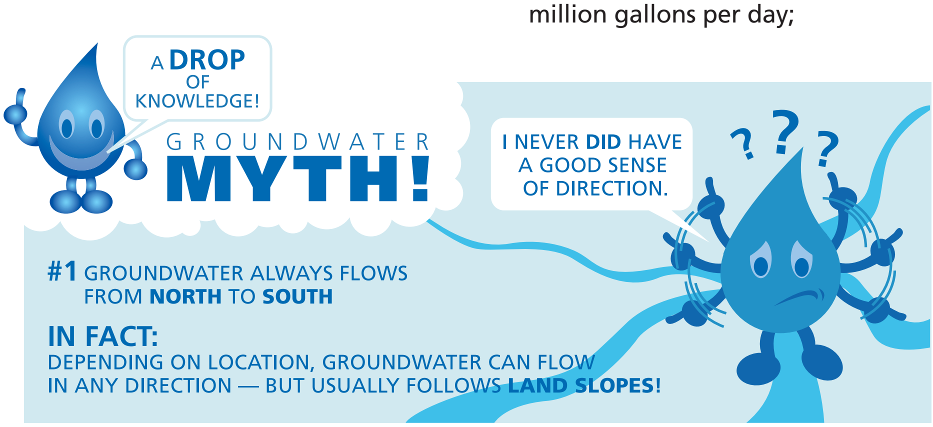
- Waukesha County (City of Waukesha), 27 million gallons per day; and
- Rock County (Janesville and Beloit), 20 million gallons per day.

(USGS statistics estimates)

The average daily cost to a family of four in 2005: between 26 and 35.2 cents — an increase of only a few cents since 1983, when "Groundwater: Wisconsin's buried treasure" was first published.

A fluid economy

Water is vital to Wisconsin's economic health. It's part of countless manufacturing processes, from metal fabrication to paper production to leather tanning. Some of our most important industries — fruit and vegetable processing, cheese-making, dairy farming, meat processing and brewing — need pure, clean groundwater to make the



goods for which Wisconsin is famous.

Big operators aren't the only ones who need this valuable resource. Consider your local laundromat, car wash, water bottlers, restaurants, health clubs, hairdressers...scores of services and products we use daily depend on groundwater.

Food processing soaks it up: processing one can of corn or beans requires nine gallons of water. Cars, fast or slow, also guzzle it up: six gallons of water are needed to produce one gallon of gasoline. And to manufacture that car and put four tires on it takes 39,090 gallons of water!

Commercial and industrial companies draw over 106 million gallons of groundwater each day from their own wells and use about 150 million gallons more provided by municipal water systems, according to the USGS. Groundwater is a silent but important partner in Wisconsin's economy because it provides more than one-third of Wisconsin's business and industrial water needs.

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Wet and wild

Thousands of tourists visit Wisconsin each year to enjoy the state's fabulous water resources. They spent an

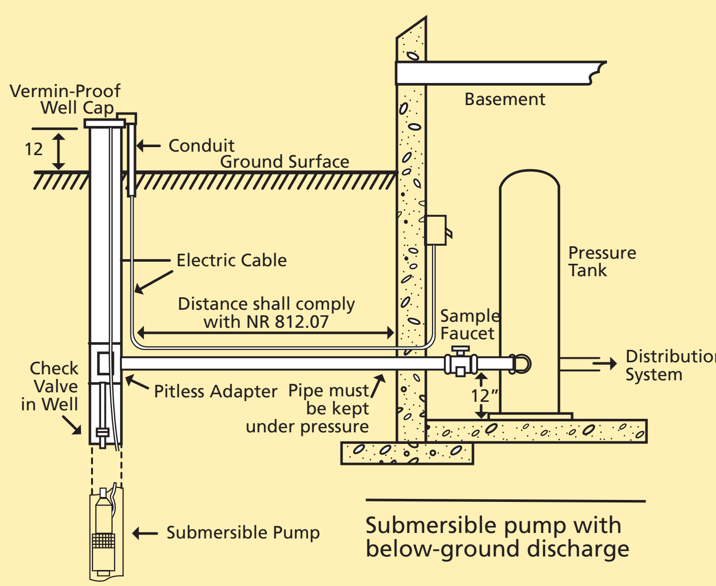
(left) Rain and snowmelt that seep through soil recharge groundwater and are discharged to lakes, streams, rivers and spectacular sights like Amnicon Falls.

How a well works

Wisconsin has had well regulations since 1936 and today is recognized as a national leader in well protection. Well drillers and pump installers must be licensed by the DNR to make sure wells are properly constructed and located.

This figure shows one of many types of private wells constructed in the state. A pump is set inside a drilled and "cased" well at a depth well below the level of groundwater. When the pump turns on, water is drawn through openings in the casing and pushed through pipes to a pressure tank inside a house. The pressure applied by the tank insures pipes will be filled with water when you open the tap. Large **municipal wells** work in a similar manner, but at a much larger scale. Large water towers use gravity to provide the pressure needed to make water flow into distribution pipes and finally to homes.

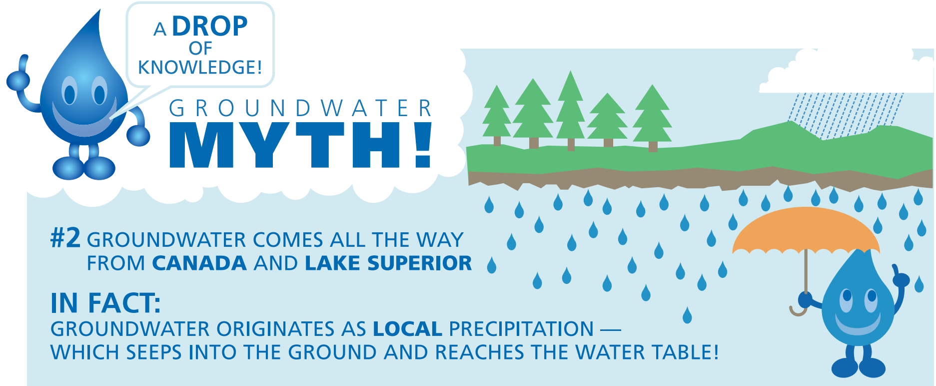
To protect public health, private and public wells must be located far from sources of contamination. For example, a new private well cannot be installed within 250 feet of a wastewater land application site or within 1,200 feet of a landfill. For more information on rules governing wells, check out the DNR Drinking Water and Groundwater webpages at: dnr.wi.gov/org/water/dwg/

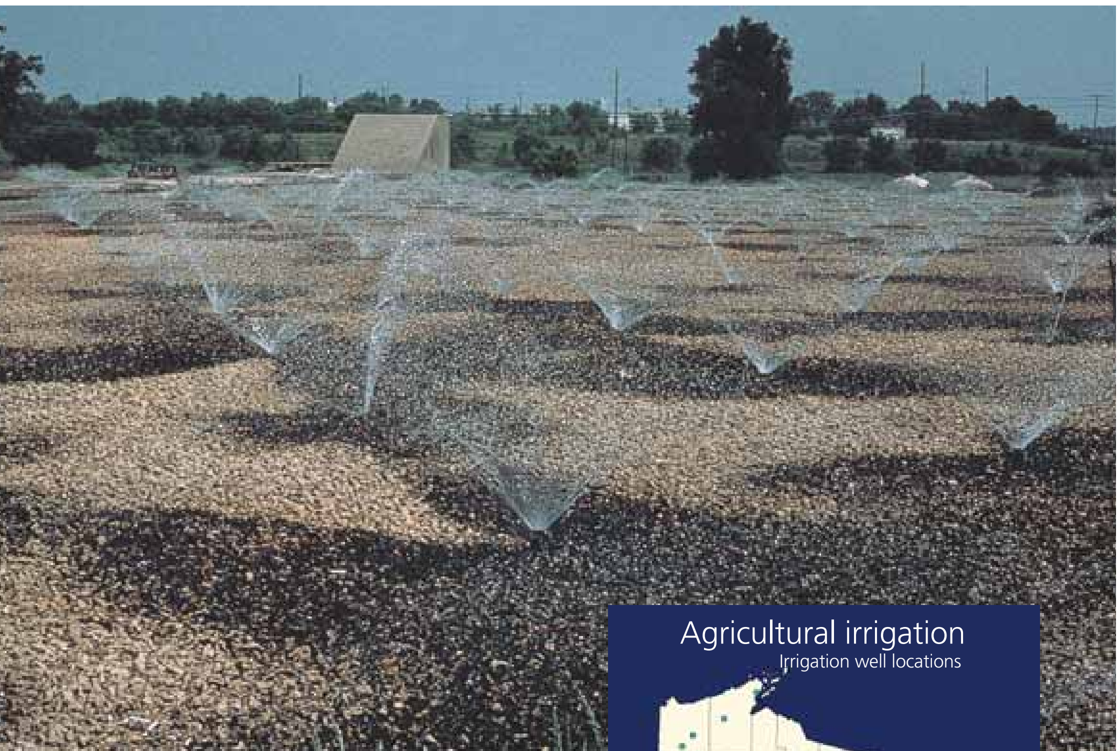


Submersible pump with below-ground discharge

DNR ILLUSTRATION

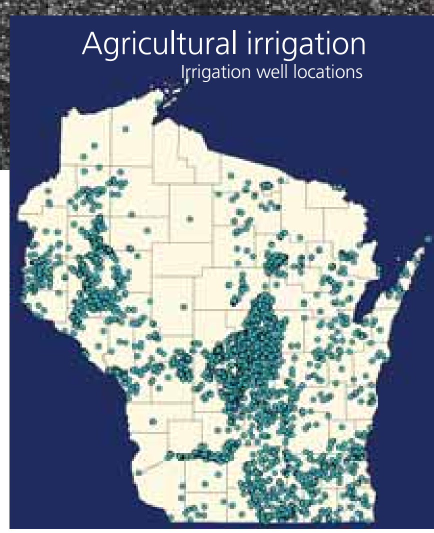
estimated $11.8 billion in 2005 alone. That's a lot of fishing, boating and swimming. What most see is a favorite fishing hole, a secret pond with an expanse of cattails perfect for observing herons, or those wild rapids waiting to devour the raft or roll the kayak. What visitors don't see is the groundwater flowing into those water bodies. After seeping through the soil and rock, groundwater discharges in low places where the water table meets the land surface — streams, lakes and wetlands.





DNR PHOTO

The demand for groundwater rises as farmers install irrigation systems to increase their chances for a strong crop, especially during times of limited rainfall.



AMY IHLENFELDT

Aquaculture?

Take a short test: A dairy cow producing 100 pounds of milk daily slurps 50 gallons of water each day to wet her whistle. There are roughly 1,235,000 dairy cows in the state. On average they each produce 17,800 pounds of milk per year. How much water will they drink in a year?

If you said over 10.9 billion gallons, you pass. For extra credit, how much of that water was groundwater? Ninety-six percent? Good guess!

Wisconsin's farms use about 100 million gallons of groundwater a day to water stock, maintain a high level of sanitation in the milk house and provide all-around cleanliness on the farm. Dairy farmers know that bringing a quality product to market means starting with quality materials — wholesome, nutritious feed and pure, clean water.

The demand for groundwater on the farm continues to rise as increasing numbers of farmers install irrigation systems to make the risky business of farming more certain. In 1969, Wisconsin had an estimated 105,526 acres of irrigated farmland. According to the U.S. Department of Agriculture, that figure now has risen to over 390,000 acres.

Irrigation equipment uses about 182 million gallons of water per day during the growing season, almost all of it groundwater. On average, eighty percent of irrigation water is consumed — it is used by plants and not returned immediately to the soil under the fields.

Much of Wisconsin's irrigated acreage is in the relatively flat 10-county Central Sands area, where the potato is king. The tuber grows well in the sandy, loose soil, which needs less plowing and seedbed preparation than heavier soils and makes for an easy harvest. Water quickly seeps into this permeable soil and drains away almost as fast, allowing the plant roots to breathe and prevent rot. But the sandy soil doesn't hold water well, so irrigation is almost essential to ensure a good crop.

While irrigation has helped formerly marginal lands turn a profit, there is a cost: Excessive irrigation may leach **nutrients**, fertilizers and **pesticides** into groundwater and lower the water table.

Understanding the resource

Recycling water

Water might be called our most recycled resource. The water you drink today contains the same water molecules that flowed in the Nile during the building of the Egyptian pyramids and froze in glaciers when mastodons roamed the earth. Distribution of the earth's total water supply changes in time and space, but the quantity remains constant.

Wisconsin receives an average 30 to 32 inches of precipitation per year. Seventy-five percent evaporates or transpires through plants and never reaches surface water or groundwater. The six to 10 inches that do not evaporate immediately or get used by plants run off into surface waters or soak into the ground, depending on local topography, soil, land use and vegetation. For every inch of water that runs off the land to a stream or lake in gently rolling Dane County, three inches seep to the **water table**. In the sandy plains of Portage County, nine inches seep into the ground for each inch running off the land.

Water distribution is governed by a phenomenon known as the **hydrologic**, or water cycle, which is kept in motion by solar energy and gravity. Start with a spring shower. As the rain falls to earth, some flows downhill as **runoff** into a stream, lake or ocean. Some evaporates; some is taken up by plants. The rest trickles down through surface soil and rock. This water eventually reaches the water table — the top of a **saturated zone** of soil or rock, called an aquifer. The water contained in the aquifer is groundwater. Groundwater is discharged to wetlands, lakes and streams — the low places where the water table meets the land surface. The sun causes evaporation from these surface waters, and, as water vapor accumulates in the atmosphere and clouds begin to form, the water cycle begins anew.

On the move

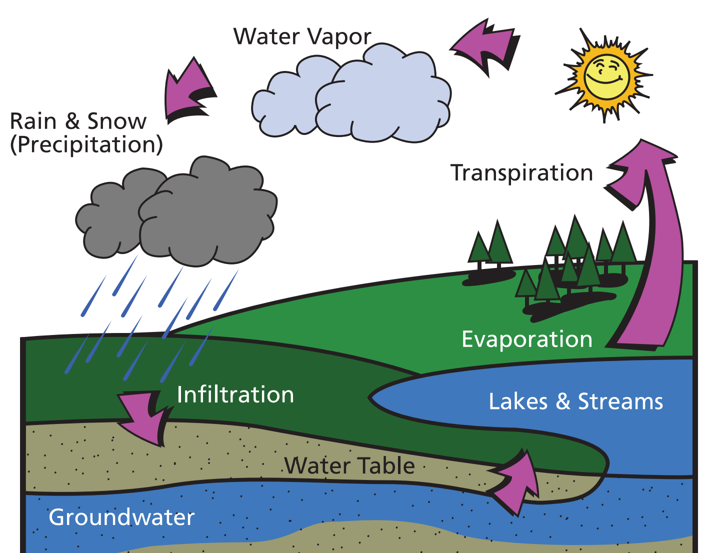
Geology controls the rate of groundwater movement. The size of the cracks in rocks, the size of the pores between soil and rock particles, and whether the pores are connected determine the rate at which water moves into, through and out of the aquifer.

Water generally moves quickly in coarse sand, sometimes as much as several feet per day. Openings between the grains are large and interconnected, resulting in high **permeability**. Very fine-grained material like clay has many pores where water can be stored, but the pores are so small that moving water through or out is difficult. Clay formations are relatively **impermeable** — water may move only a few inches a year. Permeability in **limestone**, on the other hand, primarily depends not on pore spaces, but on the size, frequency and distribution of fractures and cracks.

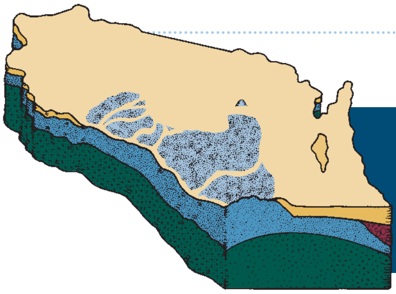
Groundwater is always moving toward a surface outlet or "discharge" area, following the slope of the water table. In Wisconsin, the natural movement is from upland **recharge areas** (places where rain or melt water infiltrates the ground and reaches the water table) to lowland **discharge areas**. Most precipitation seeping into the soil moves only a few miles to the point where it is discharged; in the vast majority of cases, it stays within the same **watershed**.

Perhaps you've wondered why some streams continue to flow during dry periods and in winter, when there's no rainfall. Winter stream flow is largely groundwater discharge (called **baseflow**) that remains at a relatively constant temperature year-round — about 50° F. During the winter, groundwater from the surrounding uplands constantly replenishes streams, and most lakes and wetlands. That same 50° F groundwater baseflow is the reason streams stay icy cold in the summer.

THE WATER CYCLE



DNR ILLUSTRATION



Wisconsin's aquifers

Sand and gravel aquifer

The sand and gravel aquifer is the surface material covering most of the state except for parts of southwest Wisconsin. It is made up mostly of sand and gravel deposited from glacial ice or in river floodplains. The glacial deposits are loose, so they're often referred to as soil — but they include much more than just a few feet of topsoil. These deposits are more than 300 feet thick in some places in Wisconsin.

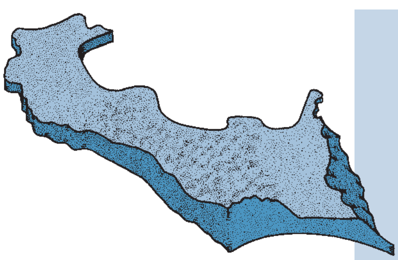
The glaciers, formed by the continuous accumulation of snow, played an interesting role in Wisconsin's geology. The snow turned into ice, which reached a maximum thickness of almost two miles. The ice sheet spread over Canada, and part of it flowed in a general southerly direction toward Wisconsin and neighboring states. This ice sheet transported a great amount of rock debris, called **glacial drift**.

Eastern **dolomite** aquifer

The eastern dolomite aquifer occurs in eastern Wisconsin from Door County to the Wisconsin-Illinois border. It consists of Niagara dolomite underlain by Maquoketa shale.

These rock formations were deposited 400 to 425 million years ago. Dolomite is a rock similar to limestone; it holds groundwater in interconnected cracks and pores. The water yield from a **well** in this aquifer mostly depends on the number of fractures the well intercepts. As a result, it's not unusual for nearby wells to vary greatly in the amount of water they can draw from this layer.

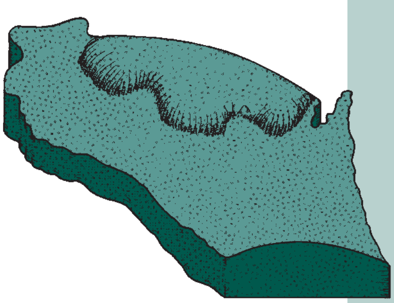
Groundwater in shallow portions of the eastern dolomite aquifer can easily become contaminated in places where



Sandstone and dolomite aquifer

The sandstone and dolomite aquifer consists of layers of sandstone and dolomite bedrock that vary greatly in their water-yielding properties. In dolomite, groundwater mainly occurs in fractures. In sandstone, water occurs in pore spaces between loosely cemented sand grains. These formations can be found over the entire state, except in the north central portion.

In eastern Wisconsin, this aquifer lies below the eastern dolomite aquifer and the Maquoketa shale layer. In other areas, it lies beneath the sand and gravel aquifer. These rock types gently dip



Crystalline bedrock aquifer

The crystalline bedrock aquifer is composed of various rock types formed during the Precambrian Era, which lasted from the time the Earth cooled more than 4,000 million years ago, until about 600 million years ago, when the rocks in the sandstone and dolomite aquifer began to be formed. During this lengthy period, sediments, some of which were rich in

An aquifer is a rock or soil formation that can store or transmit water. Wisconsin's groundwater reserves are held in four principal aquifers: the sand and gravel aquifer, the eastern dolomite aquifer, the sandstone and dolomite aquifer, and the crystalline bedrock aquifer.

THOMAS V. RIEWE

As the ice melted, large amounts of sand and gravel were deposited, forming "outwash plains." Pits formed in the outwash where buried blocks of ice melted; many of these pits are now lakes. The sand and gravel aquifer was deposited within the past million years.

The sand and gravel outwash plains now form some of the best aquifers in Wisconsin. Many of the irrigated agricultural lands in central, southern and northwestern Wisconsin use the glacial outwash aquifer. Other glacial deposits are also useful aquifers, but in some places, large glacial lakes accumulated thick deposits of clay. These old lake beds of clay do not yield or transmit much water.

Because the top of the sand and gravel aquifer is also the land surface for most of Wisconsin, it is highly susceptible to human-induced and naturally occurring pollutants.

the fractured dolomite bedrock occurs at or near the land surface. In those areas (such as parts of Door, Kewaunee and Manitowoc counties), there is little soil to filter pollutants carried or leached by precipitation. Little or no filtration takes place once the water reaches large fractures in the dolomite. This has resulted in some groundwater quality problems, such as bacterial contamination from human and animal wastes. Special care is necessary to prevent pollution.

The Maquoketa shale layer beneath the dolomite was formed from clay that doesn't transmit water easily. Therefore, it is important not as a major water source, but as a barrier or shield between the eastern dolomite aquifer and the sandstone and dolomite aquifer.

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to the east, south and west, away from north central Wisconsin, becoming much thicker and extending to greater depths below the land surface in the southern part of the state.

The rock formations that make up the sandstone and dolomite aquifer were deposited between 425 and 600 million years ago. The sandstone and dolomite aquifer is the principal bedrock aquifer for the southern and western portions of the state. In eastern Wisconsin, most users of substantial quantities of groundwater, such as cities and industries, tap this deep aquifer to obtain a sufficient amount of water.

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iron and now form iron ores, were deposited in ancient oceans; volcanoes spewed forth ash and lava; mountains were built and destroyed, and molten rocks from the earth's core flowed up through cracks in the upper crust.

The rocks that remain today have a granite-type crystalline structure. These are the "basement" rocks that underlie the entire state. In the north central region, they are the only rocks occurring beneath the sand and gravel aquifer.

The cracks and fractures storing and transmitting water in these dense rocks are not spaced uniformly. Some areas contain numerous fractures while others contain very few. To obtain water, a well must intersect some of these cracks; the amount of water available to a well can vary within a single home site. The crystalline bedrock aquifer often cannot provide adequate quantities of water for larger municipalities, large dairy herds, or industries.

Many wells in the crystalline bedrock aquifer have provided good water. However, most of these wells do not penetrate deeply into the rock. Water samples from deep mineral exploration holes near Crandon and deep iron mines near Hurley have yielded brackish water.

Threats to groundwater

You name it — gasoline, fertilizer, paint thinner, antibiotics — if it's used or abused by humans and dissolves in water or soaks through soil, it may show up in Wisconsin's groundwater. New concerns about groundwater are coming to the attention of local citizens and state government. These emerging issues include the potential for pharmaceuticals, pathogens and viruses to contaminate public or private wells. A new area of research examines the combined effects of many contaminants that can occur in an aquifer. For example: What are the health effects of drinking water with very low levels of both pesticides and nitrate?

Activities in urban areas that pose significant threats to groundwater quality include industrial and municipal waste disposal, road salting, and petroleum and hazardous material storage.

In rural areas, different threats to groundwater quality exist; animal waste, **onsite sewage systems**, fertilizers and pesticides are the primary pollution sources.

The "Groundwater and land use in the water cycle" poster on pages 16 and 17 shows how activities on the land interact with the water cycle. Refer to the poster to see how what we do on the ground affects groundwater.

Air pollution is water pollution, too

Particles clouding the air from car exhaust, smokestacks and dust from city streets or farm fields can contribute to groundwater contamination. These particles of hydrocarbons, pesticides and heavy metals settle on the ground, are washed into the soil by rain, and eventually trickle into aquifers. Although a rain shower may disperse the particles from the air, the rains can carry the pollutants down into the ground as the water hits land.

Fertilizer and manure storage and application

Protecting water quality and farm profits is a balancing act the UW-Extension's Nutrient and Pest Management Program is trying to perfect. To produce good yields, farmers need to apply nitrogen, phosphorus and other **nutrients** to their crops. If farmers don't account for the nutrients contained in the manure they spread on their fields, crops may be over-fertilized. Excess nitrate plants can't use will leach into groundwater and excess phosphorus will run off into lakes, streams and wetlands.

Proper measuring of nitrogen and phosphorus in manure saves farmers the cost of purchasing extra commercial fertilizer — and also protects groundwater.

Farmers also must be careful about

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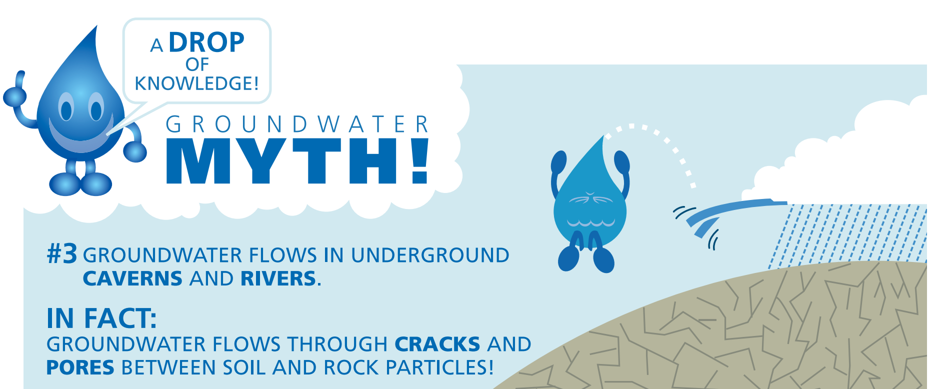
As subdivisions replace cropland, commercial lawn fertilizer use in these areas may threaten groundwater.



where and when they spread manure. Spring snowmelt or excessive rainfall can lead to fish kills and contamination of drinking water wells due to bacteria in manure that has run off from farm fields.

As subdivisions replace farm fields in rural areas, lawns replace crops. Overuse of commercial lawn fertilizer is an additional source of nitrate to groundwater.

Nitrate: a widespread contaminant

Department of Natural Resources scientists looked at nitrate contamination in groundwater and were concerned with some findings. Nitrate occurs in groundwater in every Wisconsin county; both rural and urban populations are exposed. Solving this problem means controlling all sources of nitrate to the environment.

According to a DNR survey, Wisconsin communities have spent more than 24 million dollars to bring nitrate levels down to acceptable levels in municipal wells. That cost has been spread out among 22 municipalities with a combined population of 150,000 or more.

On the private well side, present data indicate that more than 10 percent of the private well samples analyzed for nitrate statewide show groundwater contamination above the federal drinking water and state groundwater standard.

Infants under six months and pregnant women should not drink water with nitrate levels above 10 parts per million — the health-based federal and state standard. Mixing baby formula with high-nitrate water threatens infants under the age of six months, because their stomach acid isn't strong enough to kill certain types of bacteria capable of converting nitrate to harmful nitrite. Nitrite binds hemoglobin in the blood, preventing oxygen from getting to the rest of the body; the baby may lose its healthy color and turn blue. Methemoglobinemia, or "blue baby syndrome" can cause suffocation. Using water with low levels of nitrate can prevent the condition.

A **DROP** OF KNOWLEDGE!

GROUNDWATER **MYTH!**

#4 GROUNDWATER DRAWN FROM HOUSEHOLD WELLS HAS BEEN **UNDERGROUND THOUSANDS OF YEARS**.

IN FACT:
TYPICAL PRIVATE DRINKING WATER WELLS IN WISCONSIN YIELD GROUNDWATER A FEW **YEARS** TO A FEW **DECADES** OLD!

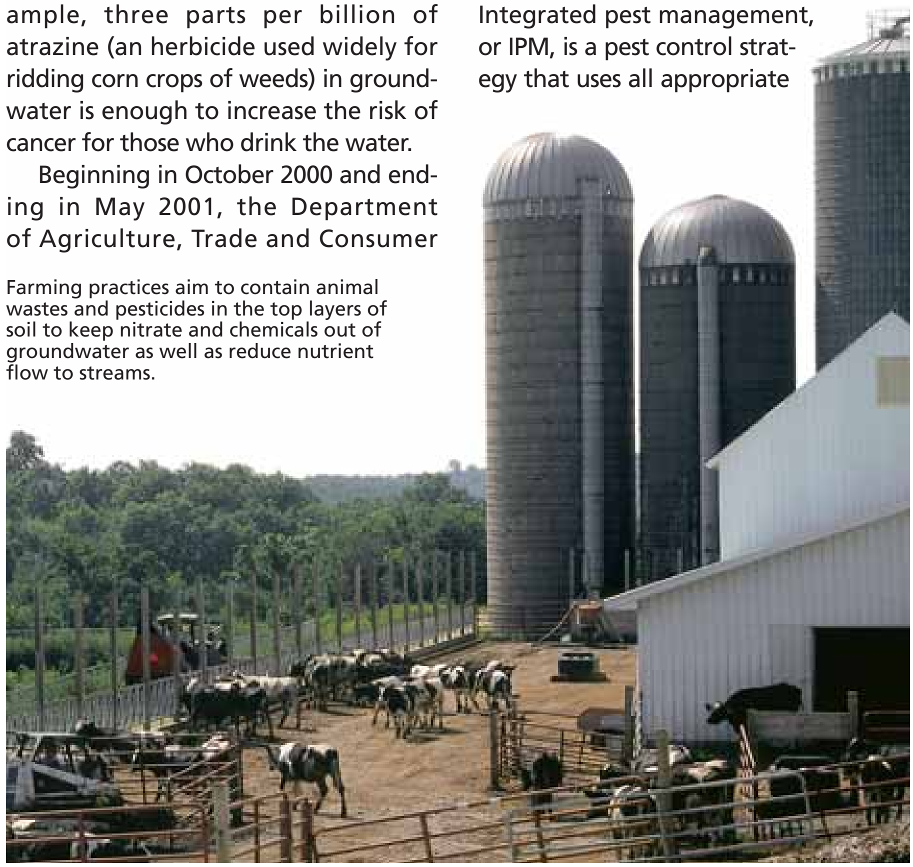
Other health effects linked to nitrate in drinking water include certain types of cancer, thyroid problems and diabetes.

Use and misuse of pesticides

All types of pesticides (insecticides, herbicides and fungicides) have been used in Wisconsin agriculture for a long time. These pesticides can reach groundwater when spilled at storage, mixing and loading sites, or when overapplied to fields. "Empty" pesticide containers not properly disposed of are another source of trouble. Just a little spill of most pesticides can have a big impact on groundwater quality. For example, three parts per billion of atrazine (an herbicide used widely for ridding corn crops of weeds) in groundwater is enough to increase the risk of cancer for those who drink the water.

Beginning in October 2000 and ending in May 2001, the Department of Agriculture, Trade and Consumer Protection (DATCP) collected and tested 336 samples from rural private drinking water wells to determine the impact of agricultural pesticides on groundwater resources. DATCP analyzed the samples for commonly used herbicides. Results from the study showed over 35 percent of wells tested contained detectable levels of herbicides or their metabolites (compounds created when herbicides and other chemicals deteriorate in soils).

Protecting groundwater from pesticide contamination while maintaining farm profitability isn't easy — too much pesticide and the environment suffers; too little and crop yield goes down. Integrated pest management, or IPM, is a pest control strategy that uses all appropriate



Farming practices aim to contain animal wastes and pesticides in the top layers of soil to keep nitrate and chemicals out of groundwater as well as reduce nutrient flow to streams.

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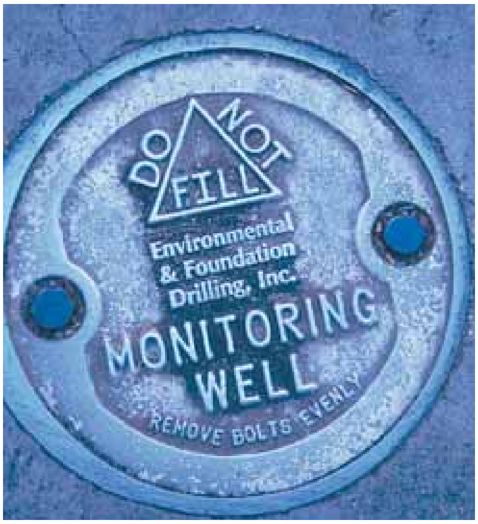

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Monitoring is one way to identify groundwater threats.

ROBERT QUEEN

Recycling efforts and properly constructed landfills are preventing much of the groundwater contamination that was seen 35 years ago at landfills.

control methods (chemical and non-chemical) to keep pest populations below economically damaging levels while minimizing harm to the environment. Here's how it works: farmers "scout" fields for weeds and pests. After identifying what is present, the farmer purchases and applies the minimum amount of herbicides and insecticides only in the areas where weeds and bugs are a problem. Farmers using IPM find they spend less on pesticides. It's a bargain for the environment, too.

Landfills

Thanks to recycling efforts since 1995, each year we divert about 40 percent of the Wisconsin-generated solid waste from Wisconsin's landfills. The wastes we can't divert are disposed of in properly sited, designed, constructed and maintained landfills, which prevent **leachate** (the foul liquid that forms when water percolates through solid waste) from polluting groundwater. There are 72 highly engineered licensed landfills accepting solid waste in Wisconsin that do a good job of protecting groundwater.

We weren't always so fortunate. In the early 1970s about 2,000 dumps were identified by the DNR. Those located near navigable waters, within floodplains, wetlands or critical habitat were ordered closed. Remaining landfills posing a threat to the environment due to hydrogeologic setting or poor operation were required to monitor groundwater and surface water. The monitoring data indicated some landfills and open dumps were causing groundwater pollution.

Based on the data and current state and federal regulations, all landfills are now required to have a composite liner system (a plastic membrane on top of four feet of compacted clay) and a leachate collection system to keep liquid waste out of the groundwater. Municipal dumps not meeting these design standards were closed prior to 1993.

Wastewater

Wastewater generated by municipalities, industries and farms may be treated or stored in ponds or lagoons. Many small communities operate lagoon systems for treating sanitary sewage through bacterial degradation of organic material in the wastewater. A manure lagoon on a dairy farm can hold waste until conditions are right for field application.

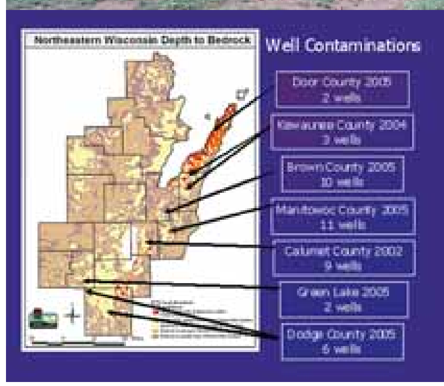
Lagoons are sealed with compacted clay or plastic liners. Nevertheless, burrowing animals or soil movement can cause leaks. Routine inspections and maintenance are necessary to keep lagoons operating properly and to prevent contamination of groundwater.

Some industries dispose of their wastewater by applying it to farm fields or to land specifically operated as a disposal system. Most municipalities and some industries also apply **sludge** produced in their treatment systems to cropland as a nutrient and soil conditioner. The waste is applied according to how much water, solids and nutrients soil and crops can absorb. If the system isn't managed properly, and too much waste and water are applied to the land, or if the operator fails to adjust the amount applied to account for rainfall, groundwater and wells can be contaminated or the material may run off to surface waters.

Onsite sewage systems

There are more than 750,000 **onsite sewage systems** (private onsite wastewater treatment systems) in Wisconsin — serving approximately 30 percent of all households in the state. Most of these systems are located in unincorporated areas. Here's how onsite sewage systems work: wastewater flows from the house to a settling tank where solids settle out. The liquid continues out to an absorption field consisting of a series of perforated pipes that drain away from the house. The liquid is then absorbed into the soil. Bacteria in the settling tank break down solid waste, leaving a sludge that needs to be removed periodically by a licensed septage hauler or "honey wagon."

When systems don't work properly, bacteria, nitrate, viruses, detergents, household chemicals and chloride may contaminate groundwater, nearby wells and surface water. Even properly installed systems may pollute groundwater if they are not located, used and maintained correctly. (For tips on maintaining onsite sewage systems, see page 27.)



LIZ HEINEN

DEAN TVEDT

Quickly containing and removing pollutants are key to successful spill response efforts. (left) Northeastern Wisconsin manure contaminated wells 2002-05.

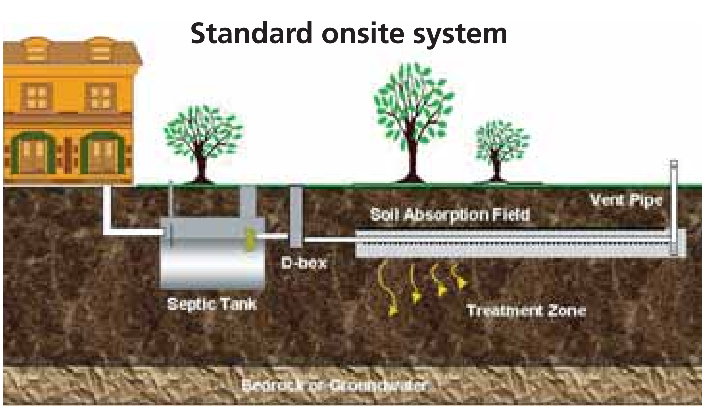
Spills and illegal dumping of industrial and commercial chemicals

When paint thinners, degreasers, pesticides, dry cleaning chemicals, used oil, fertilizers, manure and a host of other hazardous materials trickle into the groundwater, they create a potential danger to the public and the environment.

Accidents happen — over 1,000 spills of toxic or hazardous materials are reported each year in Wisconsin. **Volatile organic compounds** (VOCs) such as petroleum products account for many of the spills in the state. Topping the list is diesel fuel. Other substances such as pesticides, paint and ammonia, make up the rest. Most spills occur at industrial facilities or during transport of hazardous substances. Response efforts focus on containing and removing the hazardous material to a proper disposal facility. This protects groundwater and surface waters.

An undetermined number of spills go unreported, their presence a secret until area wells become polluted. Although there are strict regulations governing transport, storage and disposal of toxic and hazardous wastes, illegal dumping continues. Problems from past practices that occurred before regulations were in place surface periodically.

The threat to groundwater from these toxic products is real. That's why state and federal resources are devoted to finding these sites and cleaning them up. Many programs exist to clean up sites, from the federal Superfund program to address the worst sites in the nation, to the state cleanup program that includes spill response, leaking underground storage tanks, the state Superfund program, and a focus on cleaning up "brownfields" (properties that have been abandoned or are underutilized because of actual or perceived contamination).



LEROY JANSKE

Have your onsite sewage system inspected once a year and go easy on the system by minimizing water use.

Leaking underground storage tanks

People in the environmental cleanup business call them LUSTs; for all of us, it spells trouble. Over the years, many old leaking underground storage tanks that used to hold gasoline, diesel and fuel oil have slowly corroded and released their contents into the soil and groundwater. About 18,000 of Wisconsin's older tank systems have leaked as rust and other factors took a toll on the tanks and dispensing lines. Even small leaks caused significant groundwater contamination; it takes only a little gasoline in water to make it undrinkable. Property owners and their environmental consultants have cleaned up contamination at over 16,000 sites during the past 20 years. New regulations require existing tank systems to be upgraded. This will help prevent future problems.

Unused wells

What happens to the old well can determine how the new well functions. If old wells are not filled properly with such impermeable materials as cement or bentonite clay, they provide a direct channel for pollutants from the surface to groundwater and other nearby wells. Thousands of old wells no longer used but still open at the soil surface threaten Wisconsin's groundwater. Whenever you see an old windmill in the country, it's likely there's an unused well underneath. Licensed well drillers and pump installers are routinely hired to properly abandon or fill old wells.

Drainage wells draw water off a section of wet ground by piercing a clay layer and allowing surface water to run directly into groundwater. Drainage wells have been prohibited in Wisconsin since 1936, but they do turn up occasionally.

Stormwater

When development occurs, recharge to groundwater can be short-circuited. Rainfall, instead of infiltrating, runs off pavement and collects in lakes, rivers and streams. Stream levels become more variable or "flashy," floods and channel erosion are more common, and groundwater recharge decreases. To put the hydrologic cycle right and prevent stream banks from washing out, Wisconsin requires new developments to infiltrate most of the stormwater falling on their sites.

Because stormwater from roofs, driveways, parking lots and streets contains contaminants such as gasoline, metals and bacteria, it must be cleaned up or pretreated before it is put back in the ground using engineered stormwater infiltration devices.

Sources of natural contamination

Minerals found naturally in soils and rocks dissolve in groundwater, giving it a particular taste, odor or color. Some elements, such as calcium and magnesium, are beneficial to health. Radium, radon gas, uranium, arsenic, barium, fluoride, lead, zinc, iron, manganese and sulfur are undesirable ingredients found in Wisconsin groundwater. The levels of the contaminants depend on their concentrations in the aquifer and the amount of time the water or air has been in contact with them. Radioactivity in groundwater from naturally occurring uranium, radium and radon is a concern in Wisconsin. Radioactive contaminants expose those drinking the water to the risk of cancer. Public water systems are required to test groundwater for radioactivity. Recent sampling has detected **radionuclides** in some Wisconsin groundwater. **Gross alpha activity** and radium also have been found in Wisconsin water supplies. The EPA has drinking water standards for radium and radon.

Most natural contaminants aren't harmful; the problem is aesthetics rather than safety. Iron and manganese are found throughout the state. They stain plumbing and laundry, and can give drinking water an unpleasant taste and odor.

Excess fluoride, sulfur, lead and arsenic are less common and more localized. Changes in the aquifer system, such as declining water levels, can cause chemical reactions that release contaminants into groundwater. In northeastern and western Wisconsin declining water levels have caused the release of arsenic and heavy metals. Arsenic is a known carcinogen and has been found at very high levels (up to 15,000 parts per billion). Special well construction methods have proven effective in avoiding the problem, but add greatly to the cost of getting a water supply. In some parts of Wisconsin the groundwater is naturally acidic and can corrode pipes and plumbing, leading to elevated levels of lead and copper in drinking water. Well owners should test their water periodically to assure the water quality is acceptable.

DNR DRINKING WATER AND GROUNDWATER PROGRAM

An aggressive program aims to locate, replace or remove buried tanks that can leak stored fuels. Few tanks leak this badly, but even small amounts of gasoline make water unfit for use in residences, businesses and for animals. Cleanups are expensive.

Groundwater cleanup

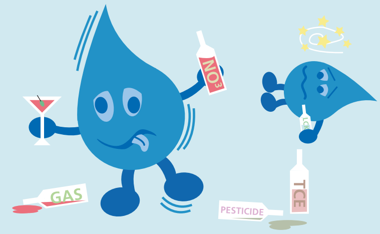
Groundwater contamination can be linked to land use. What goes on the ground can seep through the soil and turn up in drinking water, lakes, rivers, streams and wetlands. Tracking down and stopping sources of pollution is a lengthy and expensive process. It's usually impossible to completely remove all traces of a pollutant. Conducting a partial cleanup of an aquifer to a usable condition can cost a substantial amount of money.

Who pays the enormous cost of groundwater cleanup? The owner or facility operator causing the pollution should shoulder the cost. But what happens when the owner is bankrupt, out of business or dead? Taxpayers must step in. Federal and state money is used for cleaning up sites and enforcing laws governing waste disposal and hazardous material spills.

When it comes to groundwater, prevention is the best strategy. This means looking at the many ways we pollute groundwater and finding methods to keep those pollutants at bay. Landfills and wastewater lagoons need to be sited, designed and operated to prevent **infiltration** to groundwater. Pesticides must be applied according to need and label instructions, and fertilizers and manure should be applied in carefully calibrated amounts to enhance crops without damaging the environment. With vigilance and care, we can protect our buried treasure.

A **DROP** OF KNOWLEDGE!

GROUNDWATER **MYTH!**



#5 GROUNDWATER IS **ALWAYS** PURE BECAUSE SOIL **FILTERS** OUT ALL IMPURITIES.

IN FACT:
HARMFUL BACTERIA IN WATER **CAN** BE FILTERED OUT BY SOIL, BUT MANY CHEMICAL POLLUTANTS ARE **NOT CHANGED** AND **REMAIN** IN THE WATER!

Groundwater quantity — enough for all

With 1.2 million billion gallons of groundwater, the Mississippi River and two Great Lakes, there is no other state that comes close to having the water resources we have in Wisconsin. Yet Wisconsin has a growing thirst for groundwater. There are areas in the state where streams aren't running and **springs** aren't flowing because the groundwater that feeds them is being pumped dry. In a growing number of places we are pumping groundwater faster than it can be replenished.

In the past century, groundwater has been drawn down several hundred feet around Waukesha and Brown counties. In water-rich Dane County, groundwater levels have dropped 60 feet and are expected to drop more as the population continues to grow. These long-term drops in groundwater levels affect fish, wildlife and people from farmers to factory owners. Local scarcity sometimes pits communities against one another and the natural resources we all enjoy.

When a proposed water bottling plant in Adams County was opposed by citizen groups in1999, the interest of policymakers and the public in water quantity issues bubbled to the surface. It became clear that state laws didn't address the effect of high-capacity wells on nearby springs, wetlands or trout streams. The Big Springs case made people much more aware of the connection between groundwater, surface water and human activities.

(left) Portions of the Little Plover River, a Class I trout stream, dried up during the summer of 2005 likely due to increased water use and a lack of rain.

(right) The effect on wildlife and fish will be felt for a long time.

BOTH PHOTOS: BY BRYANT BROWNE

The Great Lakes Charter

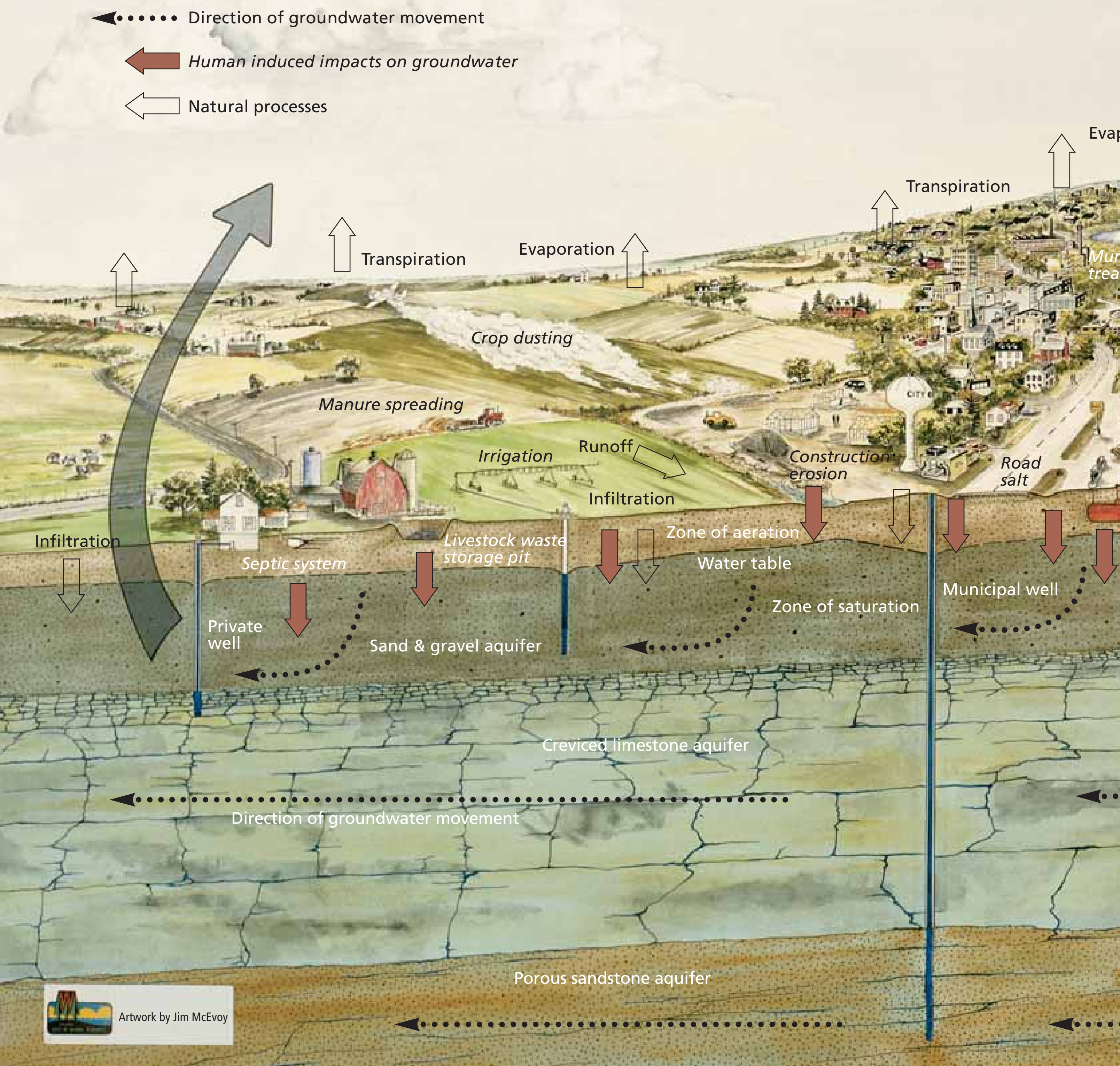
The Great Lakes constitute the largest volume of unfrozen fresh surface water in the world — about 5,440 cubic miles. There has been a great push in recent years to protect these waters. Much of the effort has been focused on updating the Great Lakes Charter, an agreement signed in 1985 by the eight Great Lakes governors and the premiers of Ontario and Quebec outlining principles for managing Great Lakes water resources.

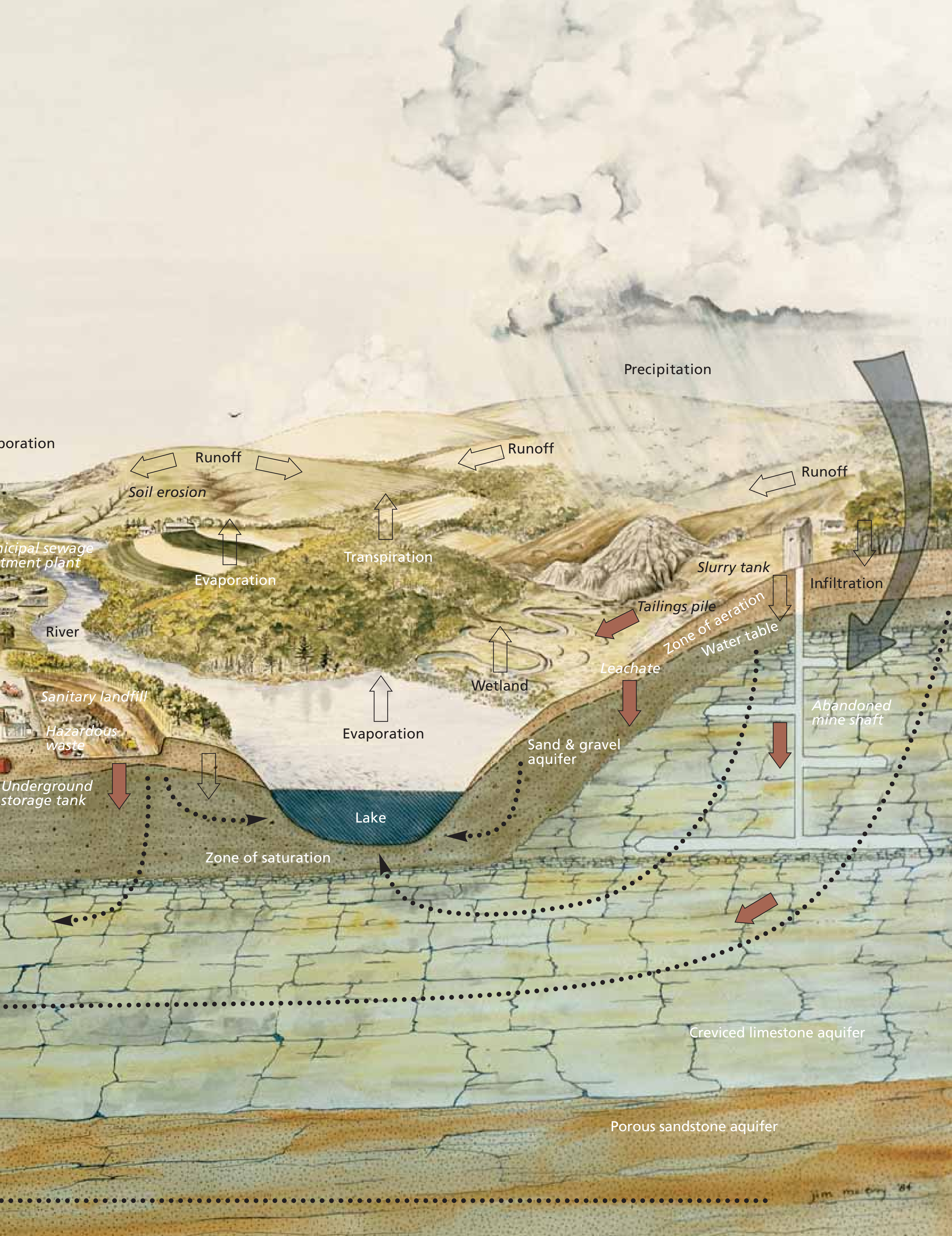
A 1998 proposal to export bulk quantities of Lake Superior water to Asia raised concerns that existing agreements were inadequate to protect these waters. It spurred action in 2000-2001 to develop an annex to the charter, which would strengthen it by establishing clear procedures for deciding whether to approve any proposed withdrawal of Great Lakes waters.

On December 13, 2005 the eight states and two Canadian provinces announced the Great Lakes Water Management Strategy, called Annex 2001. The agreement to manage water quantity in the Great Lakes basin and, with just a few limited exceptions, ban diversions of Great Lakes basin water, is the first multi-jurisdictional agreement of this magnitude in the world. All 10 governments have agreed to collectively manage water

continued on page 18

Groundwater and land use in the water cycle





Precipitation
poration
Runoff
Runoff
Runoff
Soil erosion
nicipal sewage
tment plant
Evaporation
Transpiration
Slurry tank
Infiltration
Tailings pile
Zone of aeration
Water table
River
Leachate
Wetland
Sanitary landfill
Hazardous
waste
Evaporation
Abandoned
mine shaft
Sand & gravel
aquifer
Underground
storage tank
Lake
Zone of saturation
Creviced limestone aquifer
Porous sandstone aquifer

USGS PHOTO

For each new well drilled, a report detailing soil types, depths to bedrock and groundwater elevation is sent to the DNR. This information helps map subsoil geology and groundwater movement.

continued from page 15

usage according to the shared goals expressed in this agreement. The fundamental principle is that the most significant fresh water resource in the Western Hemisphere must be treated as one ecosystem. Procedures also address pumping from wells outside the basin that alter groundwater flow and capture groundwater originating within the basin.

The United States Geological Survey is exploring the connection between groundwater and the Great Lakes in southeastern Wisconsin.

The distribution and the amount of water pumped from shallow and deep rock formations in southeastern Wisconsin has changed significantly over time. Groundwater that once flowed toward Lake Michigan is now intercepted by pumping and diverted west, where it is discharged after use to surface waters flowing into the Mississippi River Basin. This may reduce inflows to the Great Lakes.

Groundwater is important to ecosystems in the Great Lakes Region because it is, in effect, a large, subsurface reservoir from which water is released slowly to provide a reliable minimum level of water flow to streams, lakes, and wetlands that feed into the Great Lakes. Groundwater discharge to streams generally provides good quality water, which promotes habitat for aquatic animals and sustains aquatic plants during periods of low precipitation.

Quality is quantity

It isn't just the amount of water at stake, but the quality, too. In southeastern Wisconsin, the resulting drop in the groundwater level means water is now drawn from deeper rock layers that have naturally occurring radium. The concentration of radium in drinking water is high, and the water must be treated to protect the health of citizens. The cost of treatment is borne by the ratepayers.

We're beginning to realize that stewardship of groundwater involves more than just keeping it clean. We have to conserve. The Groundwater Protection Act, passed in 2003, attempts to control well location and pumping rates to protect trout streams and other sensitive surface water bodies in the state. Regional efforts to assess and manage drinking water supplies are underway in southeastern Wisconsin, where use has resulted in the most severe drop in groundwater levels.

Our great-grandparents may have used hand pumps and buckets, but they knew how deep their wells were and they thought about how to protect their drinking water. Today, community wells are located far from our homes, and we take it for granted that water will pour out of the tap when we turn it on. It's time to ask ourselves, can we have it all — green lawns, swimming pools and quality springs, streams and drinking water?

Protecting the resource

Wisconsin's groundwater law

Groundwater protection emerged as a major concern in the late 1970s as interest groups — spurred on by events like Love Canal in New York and the detection of the pesticide aldicarb in some Wisconsin private wells — debated how to protect groundwater in an industrial and agricultural society.

On May 4, 1984, Chapter 160 of the Wisconsin Statutes was signed into law. Dubbed the "groundwater law," Chapter 160 has been called the most comprehensive regulatory program for groundwater in the country. All state agencies involved in groundwater protection must adhere to numerical standards that define the level at which regulatory agencies must act to clean up pollutants in groundwater. These standards are defined not only by public health, but also by the effect a pollutant can have on the environment and public welfare.

One of the most important features of Wisconsin's groundwater law is something that is not in it — aquifer classification. Aquifer classification involves looking at the use, value or vulnerability of each aquifer and allowing some to be "written off" as industrial aquifers not fit for human consumption. Wisconsin said "no" to aquifer classification. The philosophical underpinning of Wisconsin's groundwater law is the belief that our groundwater is capable of being used for citizens to drink, and must be protected to assure that it can be.

The Groundwater Coordinating Council (GCC)

When you think about the diverse activities and events affecting groundwater, it's no surprise the responsibility for managing our buried treasure is delegated to many governmental agencies. Cooperation is key — and the GCC is the group turning the key. Since 1984, the GCC has served as a model for interagency coordination among state government officials, the governor, and local and federal governments.

Representatives from the Departments of Natural Resources; Commerce; Agriculture, Trade and Consumer Protection; Health and Family Services; Transportation; the University of Wisconsin System; Wisconsin Geological and Natural History Survey and the governor's office serve on the council. The GCC advises and assists state agencies in coordinating non-regulatory programs and sharing groundwater information. Increasing public knowledge of the groundwater resource through public outreach efforts and educational materials is an important GCC function.

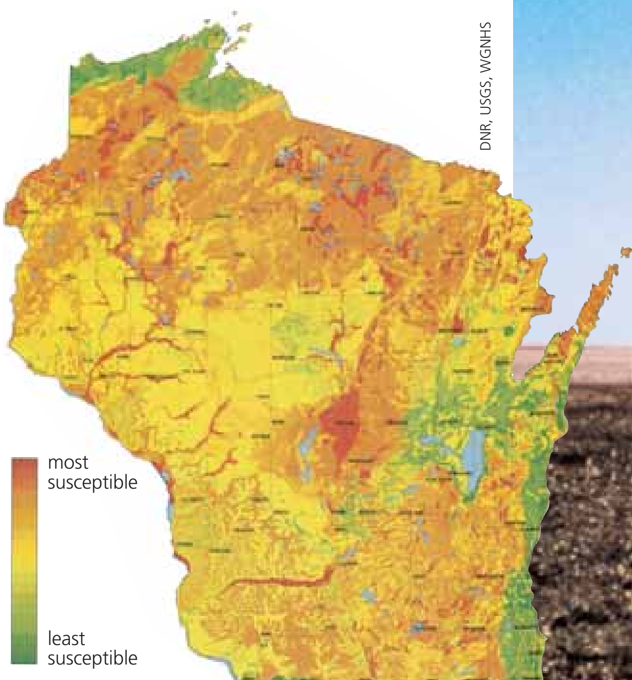
Department of Natural Resources (DNR)

It's only natural that a resource like

Trained lab technicians analyze groundwater for bacteria and chemicals.

DNR PHOTO

Groundwater contamination susceptibility in Wisconsin



Soil, rock and groundwater characteristics were used to make this map. Other important factors needed to determine groundwater susceptibility include land use, groundwater flow and location of nearby lakes, streams and wetlands.

University of Wisconsin-Extension and DATCP provide farms with information and skills training necessary to maintain farm profitability with an eye on protecting the environment.

groundwater receives a lot of attention from the Department of Natural Resources. From insuring the water you drink is clean to making sure new landfills are properly sited and constructed, DNR staff is there. DNR's groundwater activities include protecting the resource, cleaning it up and making sure public health and environmental standards are set and met.

Protecting groundwater means preventing what goes on the ground from going into groundwater. By looking at soil and rock types, thickness of soil and rock layers, and depth to groundwater, DNR hydrogeologists, engineers and specialists can make decisions about where waste can be spread, or if a landfill can be safely installed at a particular site.

But looking at the natural environment isn't enough to predict how contaminants will move in the subsurface. The map of groundwater contamination susceptibility in Wisconsin shown above is only one piece of a very complex groundwater protection puzzle. Land use, groundwater recharge and proximity to surface water are also important considerations when trying to site landfills or large farm operations.

One way to help protect public health is to protect the area around water supply wells from sources of contamination. Wellhead protection programs require municipalities to restrict land use around new public water supply wells and encourage planning around older wells. Under the DNR's Source Water Assessment Program, land areas that contribute water to public wells were identified, potential contaminant sources were inventoried, and the susceptibility for each public water supply was evaluated. The assessments assist water system operators in preparing wellhead protection plans.

New rules for siting large livestock operations, stormwater infiltration devices and farm nutrient management require separation distances between contamination sources affecting private and public wells and direct conduits to groundwater.

In addition, starting in 2010, Wisconsin's smart growth laws require that local government programs and actions affecting land use must be guided by and consistent with a locally adopted comprehensive plan to address community water supplies.

At sites with contaminated groundwater, the responsible party must find and remove the source of pollution and determine how far contamination has spread. Groundwater monitoring wells are sunk to collect samples for chemical analysis. When the contamination boundaries are known, the difficult job of cleaning up the groundwater begins. Some sites take years and millions of dollars to clean

DNR PHOTO

Groundwater research verified how quickly nearby contaminants washed pollution through a sinkhole into groundwater and seeped out to a discharge area. Pollution spreads wide, deep and quickly where the rock is fractured near the surface.

up. In the case of groundwater, a drop of prevention is truly worth a gallon of cure.

Wisconsin Geological and Natural History Survey (WGNHS)

Since 1854, the WGNHS has cataloged Wisconsin's geology, **hydrogeology**, soils, biology and other natural resources. The state survey is the principal source for maps and records about Wisconsin groundwater and related geology. It supplies counties and regional planning agencies with information to make land use and wellhead protection decisions. Research conducted at the survey helps state agencies more effectively manage Wisconsin's groundwater. A collection of well cuttings and rock samples from about 300 wells per year are housed and described by the survey — "hard" evidence of what's hidden below ground. This collection from 44,000 wells has been cataloged in a database and can be viewed at the survey's Research Collections and Education Center in Mount Horeb. County and regional studies of geology and groundwater are produced for use by anyone interested in the **hydrology** of a specific area.

Department of Transportation (DOT)

Salt keeps Wisconsin's highways safe but can be a source of groundwater pollution. Because salt is bad for the environment and the roads, DOT is always looking for alternatives and ways to minimize salt use. Temperature sensors in pavement and remote weather stations along state highways help keep county highway crews prepared to do battle with winter storms and predict when pavement conditions will require applications of chemical agents or salt.

The Department of Transportation has construction standards for storing road salt to contain runoff that could contaminate groundwater. DOT works with DNR and Commerce staff to clean up groundwater pollution from petroleum storage tanks and other hazardous waste sites along DOT rights-of-way, and where new roads and bridges are planned. DOT also tests wayside wells for thirsty travelers.

Department of Health and Family Services (DHFS)

Who do you call to find out if pollutants in your well or drinking water supply are a health risk to you and your family? Start with your local health department. If they don't have the answer, the health experts at the DHFS can help you. The DHFS provides health information and advice on contaminants to individuals, and to state, county and local government agencies. When groundwater pollutants affect a community, DHFS staffers work with residents and participate in public meetings to let citizens know the risks associated with contaminants in the water supply.

#6 IF WELL WATER IS STAINED — IT MUST BE POLLUTED.

IN FACT:
STAINED WATER DOESN'T NECESSARILY MEAN THAT IT'S UNSAFE TO DRINK!

ROBERT QUEEN

ROBERT QUEEN

Manure control in barnyards, careful fertilizer and pesticide applications, and tilling methods that minimize exposed soil can reduce chemical, nutrient and bacterial flow from farms to groundwater.

They advise how to best protect families and drinking water.

DHFS protects groundwater and the people who drink it by recommending standards to DNR for substances in groundwater that can cause health problems. DHFS conducts studies on the harmful effects of chemicals to determine "how much is too much." It also works with DATCP to determine how new pesticides will break down in groundwater and what health risks are associated with these compounds.

A **DROP** OF KNOWLEDGE!

GROUNDWATER **MYTH!**

#7 IF WATER **TASTES GOOD** — IT'S SAFE TO DRINK.

IN FACT:

YOU CAN'T JUDGE GROUNDWATER BY ITS TASTE OR SMELL **ALONE**! A SUDDEN CHANGE IN FLAVOR OR ODOR SHOULD BE INVESTIGATED.

Department of Commerce (Commerce)

Commerce ensures underground and above-ground storage tanks don't leak. The agency keeps records on over 72,000 tanks used to store gasoline, fuel oil and other products. The Petroleum Environmental Cleanup Fund or PECFA, is used to reimburse owners for the cost of removing older tanks and cleaning up petroleum contaminated sites. Commerce regulates installation, maintenance and abandonment of new tanks.

Commerce helps individuals, businesses, local development organizations and municipalities revive abandoned industrial sites or "brownfields" by providing grant money for site assessment and cleanup. Since the program's 1997 inception, 1,240 acres have been revitalized. This translates into about 4,600 new jobs at over 100 different locations throughout the state.

Commerce regulates onsite sewage treatment systems and stormwater infiltration practices as part of the plumbing code. Restrictions on where and how onsite sewage systems are installed protect private and public wells and groundwater from contamination.

Department of Agriculture, Trade and Consumer Protection (DATCP)

Pesticides, fertilizers and nutrients can leach to groundwater, causing human health and environmental risks. DATCP is responsible for regulating most aspects of agrichemical application, storage and cleanup in Wisconsin. To promote the proper handling, storage and safe use of farm chemicals, pesticide applicators and sellers must complete a certification program and be licensed by DATCP. Field staff regularly inspect if storage and mixing facilities comply with groundwater protection regulations. If a spill occurs, money and staff are available to help with the cleanup. The Nutrient Management Program helps prevent groundwater pollution by providing funding to counties to help farmers write nutrient management plans. The Clean Sweep program provides farmers and homeowners with safe options to dispose of pesticides and other hazardous chemicals for free. Businesses pay a portion of disposal costs for these substances.

University of Wisconsin-Extension

Wise groundwater use is a priority for the University of Wisconsin-Extension. Traditionally, extension agents and specialists provided farm families with agricultural tools, information and skills training. Today their role has evolved into promoting community development, maintaining farm profitability while protecting the environment, and conserving natural resources. Extension educators provide outreach to citizens, farmers, school children and public officials on water testing, water treatment devices, wise land use policy such as wellhead protection, and other groundwater topics. With offices located in each county, outreach activities can be tailored to local needs. Basin educators, located in each of the state's major river basins, provide land and water resources outreach to local communities. Extension promotes and assists private and public partnerships to conserve and protect our water resources.

The Nutrient and Pest Management Program's crop plots on working farms promote the careful use of manure and pesticides. The Farm*A*Syst program helps farmers identify and correct risks to groundwater around farmsteads. Community Drinking Water Programs help private well owners to identify individual water quality concerns and community-wide groundwater issues.

Educational institutions

From university classes on hydrogeology to state fair displays, education is the most important tool we can use to safeguard groundwater. Colleges and universities offer courses that prepare students for careers in hydrogeology, wastewater management, soil science and other disciplines vital to groundwater protection. They also conduct research on groundwater development, movement and cleanup technologies. Vocational and technical colleges offer associate degrees in fields related to agriculture and water resources management. Environmentally safe methods of farming are taught in UW agricultural "short courses."

United States Geological Survey — Water Resources Division (USGS)

The USGS Water Division's job is to keep tabs on groundwater quantity in Wisconsin. Starting in 1946 with just

ROBERT QUEEN

According to the U.S. Department of Agriculture, Wisconsin has over 390,000 acres of irrigated farmland.

KEN BRADBURY

DNR PHOTO

(above) Research can benefit both surface waters and groundwater. (below) State well codes dictate how to drill and install wells to protect both water supply and groundwater.

Well water should be tested periodically for signs of bacteria, nitrate and any chemicals that may be used in your area.

ROBERT QUEEN

a few wells, the USGS, with the Wisconsin Geological and Natural History Survey, now collects water level measurements in over 170 Wisconsin wells. Some of the wells are measured daily using electronic recorders; others are measured weekly, monthly or quarterly. The data serves as a starting point for evaluating the effect new wells and land development will have on groundwater levels, wetlands, streams and lakes. For example, a study in the Great Lakes Basin showed groundwater that once flowed toward Lake Michigan is now pumped, used and discharged as treated wastewater to surface waters within the Mississippi Basin. This may affect surface water flow and fish habitat in tributaries feeding Lake Michigan.

Wisconsin State Laboratory of Hygiene (SLH)

The Wisconsin Laboratory of Hygiene is the main environmental testing laboratory for the DNR, DHFS and other state agencies. (See pages 28 and 30 for information on well testing.) The Laboratory performs a variety of chemical and biological drinking water tests, ranging from exotic pathogenic bacteria to potentially cancer-causing chemical contaminants. In addition to extensive testing of Wisconsin's public water supplies, the laboratory also offers private well owners basic drinking water tests such as an analysis for *E. coli*. The presence of *E. coli* indicates a water supply may be contaminated with fecal material and thus presents a health threat. Local commercial laboratories can also provide some well water tests, and the Laboratory of Hygiene partners with them so high-quality testing is readily available throughout the state.

How to protect the groundwater you drink and use

It's your turn

You've read about what government and industry are doing to guard groundwater. Now, here's what you can do to help.

Examine your own habits

Everyday activities affect groundwater quality. Think about the ways you use water at home. If you've always considered pure, clean water to be a cheap, unlimited resource, chances are you're accustomed to wasting water and haven't been concerned about what you pour down the drain.

Common sense goes a long way toward keeping Wisconsin's groundwater clean and plentiful. Here are some ways to cut back on water use and protect groundwater:

Conservation is wise use

Use water-saving devices and appliances: Since 1992, new toilets manufactured in the U.S. use only 1.6 gallons of water — much less than the six gallons each flush used to consume. If you have an older toilet, toilet dams or inserts placed in the toilet tank retain water during flushing and can save up to three gallons per flush. A plastic bottle weighted with washed pebbles makes a good insert. Low-flow faucet aerators (for either inside- or outside-threaded faucets) mix water with air and can reduce the amount of water flowing from your sinks.

Look for and fix leaks: A dripping faucet can waste 20 or more gallons of water a day; a leaking toilet, several thousand gallons a year. An inexpensive washer is usually all you need to fix a leaky faucet. Adjusting or replacing the inexpensive float arm or plunger ball can often stop toilet leaks.

Drinking water: Keep a pitcher of drinking water in the refrigerator to quench your thirst without running the tap.

Bathing and showering: A water-saving showerhead can cut the amount of water used to about three gallons per minute without sacrificing the feeling of a good drenching. Turn off the water while soaping up during a shower to save extra gallons. New water-saving showerheads come with a button to shut off the flow without changing the mix of hot and cold water. Bathers should put the stopper in the drain before running the water, then mix cold and hot for the right temperature. Turn off the tap while shaving or brushing your teeth.

Dish washing: If you wash dishes by hand, don't leave the water running while washing them. Make sure the dishwasher is full before you turn it on; it takes as much water and energy to wash a half-load as it does to wash a full load. And scrape dishes

DAVE JOHNSON

TRACEY TEODECKI

DNR PHOTO

Homeowners can protect groundwater too. Take unwanted cleaners, paints and pesticides to Clean Sweep hazardous waste collection sites.

rather than rinse before loading the dishwasher.

Laundry: Always set the fill level to match the size load you are washing. Remember: Full loads save water because fewer loads are necessary. Front-loading washers use less detergent, electricity and water.

Lawn care: A rain barrel is a great way to save on water and it's not chlorinated, fluoridated or loaded with dissolved salt, so it's better for your grass and plants. Consider reducing the size of your lawn by planting trees, shrubs and ground covers. Rain gardens are attractive, low maintenance, and reduce runoff to lakes and streams.

Waste minimization

Household toxic wastes: Don't use household drains as ashtrays, wastebaskets or garbage disposals! Toilets (and kitchen sinks, garage drains and basement washtubs) are not places to discard varnish, paint stripper, fats, oil, antifreeze, leftover crabgrass killer or any other household chemicals. Just because it's down the drain doesn't mean it's gone! These products may end up in your water supply, especially if you have an onsite sewage systems. Store your toxic products in tightly sealed containers in a safe, dry spot, share them with others who can use them, or bring them to Clean Sweep events in your community; call your County Extension office or DATCP for details.

Lawns: Reduce or eliminate the use of lawn pesticides and fertilizers. A significant amount of these chemicals can leach into groundwater. Test your soil first to determine if it needs additional nutrients. If you do apply fertilizer, do it in the first week of May or after September 15.

Recycle! Reuse or recycle plastic bags and containers, aluminum cans, tin cans, glass, cardboard, newspaper, paper bags and other paper products. Don't dump waste oil down the drain or on the ground — bring it to community collection tanks where it will be picked up and reprocessed. Recycling conserves landfill space. Less garbage in the landfill means less harmful leachate that could contaminate groundwater.

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Pesticides and fertilizers can leach to groundwater and cause health and environmental risks.

Biodegradable soaps and cleansers: Go easy on groundwater! Use nontoxic and biodegradable soaps and household cleansers. Or try environmentally friendly alternatives: Baking soda on a damp cloth to scrub sinks, appliances and toilet bowls; a mixture of white vinegar and water for cleaning ceramic tile, doors, windows and other glass surfaces; pure soap flakes and borax for washing clothes.

Dishwashing: Use the minimum amount of detergent needed to clean plates, glasses and silverware satisfactorily. Choose a non-phosphate automatic dishwashing detergent.

Garbage disposals: They're noisy, use a lot of water and electricity, and increase the amount of waste in the water going to the wastewater treatment plant or your sewage system. Compost your kitchen waste and use it to mulch yard plants and hold moisture in the soil. For more ideas, look for the pamphlet "Better Homes and Groundwater" (publication number DG-070-2004) on the DNR website at: dnr.wi.gov/org/water/dwg/gw/ and select "Publications."

Take care of your onsite sewage system

Even a properly sited, permitted, constructed and maintained onsite sewage system can pollute groundwater, especially if the soil is highly permeable or the water table is close to the surface. You can keep your system in good working order by following these four tips:

1. Be cautious about what you put in. Ordinary amounts of bleaches, lye, soaps and detergents will not harm the system, but household chemicals like paint thinner, drain cleaner, solvents, gasoline, oil and pesticides should NEVER go into an onsite sewage system. Once released in the absorption field, these toxic products can leach into groundwater.

Never flush bones, coffee grounds, vegetable peelings, fruit rinds, disposable diapers, sanitary napkins, tampons, bath oils, cigarette butts or other materials that do not break down easily into a septic tank. Avoid dumping grease down the drain. It can build up in the tank and clog the inlet or the soil absorption field.

2. Have your onsite sewage system inspected once a year. A licensed septage hauler can measure the level of scum and sludge that has built up. The tank should be pumped when the sludge and scum occupy one-third of the tank's liquid capacity. NEVER go into a sewage tank — it may be full of toxic gases. Hire only licensed septic tank haulers to clean out your tank. They should pump through the manhole, inspect inlet and outlet baffles for damage, and service any outlet filters that may be installed. County sanitarians will have the names of licensed septage haulers in your area.

3. There are no known chemicals, yeasts, bacterial preparations, enzymes or other additives for sewage tanks that will eliminate the need for periodic cleaning.

4. Go easy on your system. Don't do more than three loads of laundry per day (a dishwasher cycle equals one load). Minimize garbage disposal use.

Properly locate and construct wells

Wells can be safe, dependable sources of water if sited wisely and built correctly. Here are five points to remember:

1. Ask questions if you plan to drill a new well or intend to purchase property with an existing well. Talk to your neighbors: Do they have any problems with their wells? How deep are wells in the area? Were there contaminated wells in the area? How was the contamination taken care of? How was the land where you want to drill the well used in the past? What is its **Wisconsin Unique Well Number**?

Talk to local government officials: What laws govern private water supplies? Are housing densities low enough to ensure enough water for everyone's needs? Are there zoning restrictions limiting certain types of land use? What current land and water uses — irrigation, a quarry — in the area might affect your water quality or quantity?

2. Consult the Wisconsin Well Code. Established in 1936, the Wisconsin Well Code is administered by the Department of Natural Resources, which sets standards for well construc-

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Teach children early to build lifelong habits that protect resources. (left) A school project shows how food wastes, leaves and grass settle down into rich compost. (below left) A lot of household grime can be cleaned up with less toxic products.

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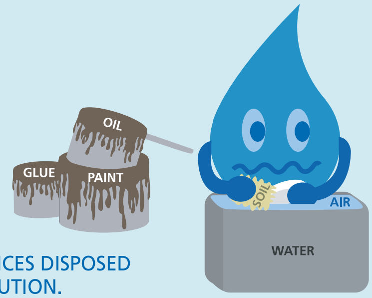

#9 POURING A **SMALL AMOUNT** OF WASTE ON THE GROUND WON'T CAUSE A PROBLEM.

IN FACT:
EVEN SMALL AMOUNTS OF HAZARDOUS SUBSTANCES DISPOSED OF **IMPROPERLY** CAN CAUSE GROUNDWATER POLLUTION.

DNR PHOTO

DNR maintains a list of licensed well drillers and pump installers.

tion. The code lists the distances required between the well and sewage drain fields or dry wells, sewer lines, farm feedlots, animal yards, manure pits, buried fuel tanks, fertilizer and pesticide storage sites, lakes, streams, sludge disposal and other potential contamination sources. Wells should always be located up the groundwater gradient and as far from these potential sources of contamination as possible.

3. Hire reputable, experienced, licensed installers. Only people licensed with the Department of Natural Resources should drill wells. Only people holding DNR pump installer licenses may install pumps. No license is required if you construct your own well or install your own pump. However, state law requires that the work be done according to state well code.

DNR maintains a list of licensed well drillers and pump installers (see it on-line at dnr.wi.gov/permitprimer/water/pumps/). Be cautious of very low bids that appear, in comparison to others, to have a low per bag grout cost, or no grout listed. Make sure the successful bidder knows that notification is required as part of the contract to drill the well. Ask to be notified before grouting, and be at the site when the well is grouted. While the grouting is taking place, watch to ensure the cement is pumped into the space between the casing and the drill hole, with the grout filled from the bottom of the casing.

The well driller is responsible for flushing the well, test pumping it, disinfecting it, collecting a water sample for bacteriological tests, sending a well constructor's report to the Department of Natural Resources, and providing the owner with a copy. This document contains a record of the soil and rock layers penetrated by the well; lists the work performed and materials used; and the unique well number assigned to your well so the DNR can keep a record over time of your well water quality. This is important information to have if your well is ever contaminated. Reports collected over time in an area give researchers an idea of what's going on underground.

A pump installer, if different from the driller, must disinfect the well and collect a water sample to check for bacteria.

4. How often should I have my well tested? Annually test your well for bacteria and nitrate, and again at any time a change in odor, taste, color or clarity causes you to suspect contamination. Check for nitrate when infants or pregnant women use the water. (See page 30, "How safe is my drinking water?")

5. How do I fill in an old unused well? Fill and seal unused wells with concrete or bentonite, a type of clay. Licensed well drillers or pump installers can help you close off the old well to prevent groundwater pollution. For a copy of the pamphlet "Well Abandonment" (publication number DG-016-2001) go to dnr.wi.gov/org/water/dwg/gw/ and select "publications."

What else can you do?

Report illegal or abandoned waste sites. Call (800) 943-0003.

Keep up with local land use and waste disposal issues. Housing, commercial development, highway construction and landfills may have an adverse effect on groundwater quality if not carefully planned and constructed. City, town or county governments may need to institute zoning regulations or prohibit or restrict activities that could endanger groundwater. Find out what the land use issues are in your community and encourage your neighbors to do the same. Attend community meetings and let your elected officials and utility operators know provisions to protect groundwater must be the first step in any local land use or waste disposal proposal.

Where can I get answers to my questions about groundwater?

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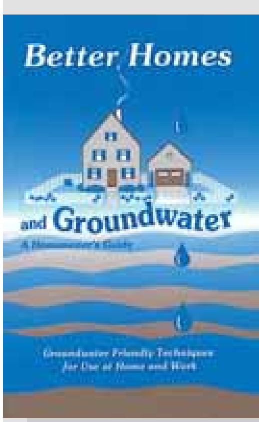
Public water system owners face many distinct challenges in managing a public water supply, among them, providing adequate supplies to all users, preventing contamination, and planning for a system's future needs.

1. **The DNR website** at dnr.wi.gov/org/water/dwg/gw/ provides answers to many groundwater questions. Need more information? Contact the DNR regional office or service center nearest you. Visit dnr.wi.gov/org/caer/cs/ServiceCenter/locations.htm for a complete list.
2. **The Wisconsin Geological and Natural History Survey** has maps, well construction reports and other information on aquifers and geology. For a list of WGNHS publications, write Wisconsin Geological and Natural History Survey, 3817 Mineral Point Rd., Madison, WI 53705-5121. (608) 262-1705. Visit the survey's website at www.uwex.edu/wgnhs/
3. **Your county University of Wisconsin-Extension office** can help plan safe, functional farmyards and rural homes. Call or write your extension office for booklets on safe drinking water, groundwater protection, best management practices for pesticide and fertilizer use and other topics. Look for the address and phone number under the "county" listing in the phone book white pages, or visit www.uwex.edu/
4. **The Department of Commerce** has the details on proper onsite sewage system operation. Write Department of Commerce, Division of Safety and Buildings, 201 W. Washington Ave., P.O. Box 7969, Madison, WI 53707-7969 and ask for publication SBD-7009, "Is the grass greener over your septic system?" Visit their website at www.commerce.state.wi.us/
5. **The Department of Agriculture, Trade and Consumer Protection** offers information on best management practices and Clean Sweep Program for farms and atrazine prohibition areas. Write DATCP, 2811 Agriculture Dr., Madison, WI 53708-8911. (608) 224-5002. On the web: datcp.state.wi.us/index.jsp
6. **The Central Wisconsin Groundwater Center** is a clearinghouse for information on groundwater issues statewide, with a strong focus on Wisconsin's Central Sands area. The center maintains a database of private wells tested through the UW-Stevens Point Water and Environmental Analysis Laboratory, conducts applied research, and offers educational materials and programs. Write CWGC, College of Natural Resources Room 224, University of Wisconsin-Stevens Point, Stevens Point, WI 54481-3897. (715) 346-4270. Visit the center's website at www.uwsp.edu/cnr/gndwater



Better homes and groundwater

To request a copy of "Better Homes and Groundwater: A Homeowner's Guide," a booklet which provides groundwater friendly techniques for use at home and work, look online at the DNR website at: dnr.wi.gov/org/water/dwg/gw/ and select "publications" or call 608-266-6669 and ask for publication number PUB-DG-070-2004.

Visit the DNR website at dnr.wi.gov for more information about drinking and groundwater protection; choose "drinking and groundwater" from the drop-down program menu. Also check the UW-Extension website at cecommerce.uwex.edu and click on "water quality" under the natural resources drop-down menu.

How safe is my drinking water?

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Many Wisconsinites, urban and rural, are concerned about the quality of the water they drink, with good reason. Threats to a safe water supply exist everywhere, the result of our daily activities. How do you know if your water is safe to drink?

If your water is supplied by a community public water system, your water utility will mail a **Consumer Confidence Report** to you each fall. The report will include information on the source of the utility's drinking water, the treatment used to purify water, any contaminants that have been found in drinking water, and the potential health effects of those contaminants. Reports will also identify where additional information about the water supply can be found and how citizens can become involved in protecting water sources. Utilities must annually provide updated reports for their consumers.

Private well owners should have their wells tested periodically. Private laboratories do tests for chemical contaminants, such as volatile organic compounds or pesticides. Check the Yellow Pages under "laboratories" or "water analysis" or check the website dnr.wi.gov/org/es/science/lc/INFO/Lablists.htm for a certified lab in your area. Cost ranges from $30 to $1,000 depending on the number and type of chemicals analyzed and the test methods.

For a small fee, the State Laboratory of Hygiene will test your drinking water for several pollutants including bacteria, nitrate or fluoride. For a test kit, call the lab at (800) 442-4618 or write the State Laboratory of Hygiene, Environmental Health Division, 2601 Agriculture Dr., P.O. Box 7996, Madison, WI 53707-7996. Private labs will also do these tests.

Wells can be disinfected by displacing all the water in the well with a mixture of bleach (containing at least five percent chlorine) and water or by dropping chlorine tablets or powder down the well. Contact the DNR Bureau of Drinking Water and Groundwater, at P.O. Box 7921, Madison, WI 53707-7921 or call (608) 266-6669 for literature on private well operation.

If high nitrate is the problem, the well construction and location should be checked.

Wells can sometimes be deepened to get past contamination. Inadequate well installations may be upgraded. Wells located in pits, for example can be extended above ground and the pit filled in. These are costly options, however; it's best to have the work done properly in the beginning to avoid problems later. Your DNR private water supply specialist can give you advice on obtaining a safe

Installing a sewage drainage field.

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Both private labs and the State Lab of Hygiene analyze well water samples.

drinking water supply.

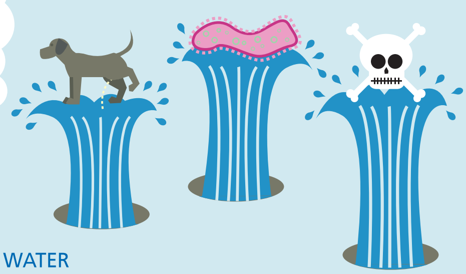
If your water utility or a lab test alerts you to the presence of high levels of chemicals in your drinking water, you may be advised to drink bottled water or drill a new well. But what about low levels of contaminants? Will small quantities of benzene, a major component of gasoline, or perchloroethylene, a chemical used in dry-cleaning solvents, make your water undrinkable?

The answer is, No. That's not to say, however, that the water is totally safe to drink. For instance, the Environmental Protection Agency estimates that one part per billion of perchloroethylene in drinking water could lead to one or two additional cases of cancer in a population of one million people who drink such water over a 70-year lifetime.

Drinking water contamination, even at very low levels, should not be taken lightly, nor should the risks be exaggerated. To keep the risk of contamination as low as possible, public agencies and private citizens must continue to make tough decisions on what's worth the risk and what's not.

A **DROP** OF KNOWLEDGE!

GROUNDWATER **MYTH!**



#10 ARTESIAN WATER IS THE **PUREST** WATER AVAILABLE.

IN FACT:
ARTESIAN SUPPLY IS **NO GUARANTEE** THAT WATER IS SAFE! ARTESIAN WATER CAN BE CONTAMINATED.

groundwater glossary

Aquifer: A rock or soil layer capable of storing, transmitting and yielding water to wells.

Baseflow: That part of stream discharge from groundwater seeping into the stream.

Consumer Confidence Report: A report, required under the amendments to the Safe Drinking Water Act, which lists contaminants found in community public well water systems, water treatment methods, devices used and potential health effects.

Discharge area: An area in which groundwater reaches the surface. Examples are springs, seeps, lakes or rivers, or by evaporation and transpiration.

Dolomite: Calcium magnesium carbonate, a common rock-forming mineral. Many rocks in Wisconsin referred to as limestone are actually dolomite.

Evaporation: The process by which water is changed from a liquid into vapor.

Geology: The science dealing with the origin, history, materials and structure of the earth, together with the forces and processes operating to produce change within and on the earth.

Glacial drift: Sediment transported or deposited by glaciers or the water melting from a glacier.

Gross alpha activity: Decay of radionuclides in natural deposits. Can be either radium or uranium.

Groundwater: Water beneath the surface of the ground in a saturated zone.

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Hydrogeology: The study of groundwater and its relationship to the geologic environment.

Hydrologic cycle: The complete cycle through which water passes from the atmosphere to the earth and back to the atmosphere.

Hydrology: The science encompassing the behavior of water as it occurs in the atmosphere, on the land surface and underground.

Impermeable: Having a texture that does not permit water to move through quickly.

Infiltration: The movement of water into and through a soil.

Leachate: A liquid formed by water percolating through soluble waste material. Leachate from a landfill has a high content of organic substances and dissolved minerals.

Limestone: A sedimentary rock consisting chiefly of the mineral calcite (calcium carbonate).

Municipal well: A well, owned and operated by a municipality, serving more than 25 people for at least 60 days of the year.

Nutrients: Compounds of nitrogen, phosphorus and potassium that promote plant growth.

Onsite sewage system: Used to treat household sewage and wastewater by allowing the solids to decompose and settle in a tank, then letting the liquid be absorbed by the soil in a drainage field.

Permeability: The capacity of rock or soil to transmit a fluid, usually water.

Pesticides: A general term for insecticides, herbicides and fungicides.

Private well: A well serving one home maintained by the owner.

Radionuclides: Any manmade or natural element that emits radiation in the form of alpha or beta particles or as gamma rays.

Recharge area: An area in which water infiltrates and moves downward into the saturated zone of an aquifer.

Runoff: Precipitation not absorbed by the soil.

Saturated zone: The part of a water-bearing layer of rock or soil in which all spaces, large or small, are filled with water.

Sludge: Sediment remaining after wastewater has been treated.

Spring: A flow or natural discharge of groundwater at the surface.

Transpiration: The process by which plants give off water vapor through their leaves.

Volatile Organic Compounds: A group of common industrial and household chemicals that evaporate or volatilize when exposed to air. Includes gasoline and solvents.

Water table: The level below which the soil or rock is saturated with water, sometimes referred to as the upper surface of the saturated zone.

Watershed: The land area from which surface runoff drains into a stream system.

DNR PHOTO

Well: A vertical excavation that taps an underground liquid-bearing rock formation. In Wisconsin, wells are drilled to obtain water, to monitor the quality of groundwater, or to determine the depth of the water table.

Wisconsin Unique Well Number: A number assigned to individual wells, which allows state agencies and the public to track groundwater quality through time. New wells drilled since January 1, 1988 are assigned unique well numbers.