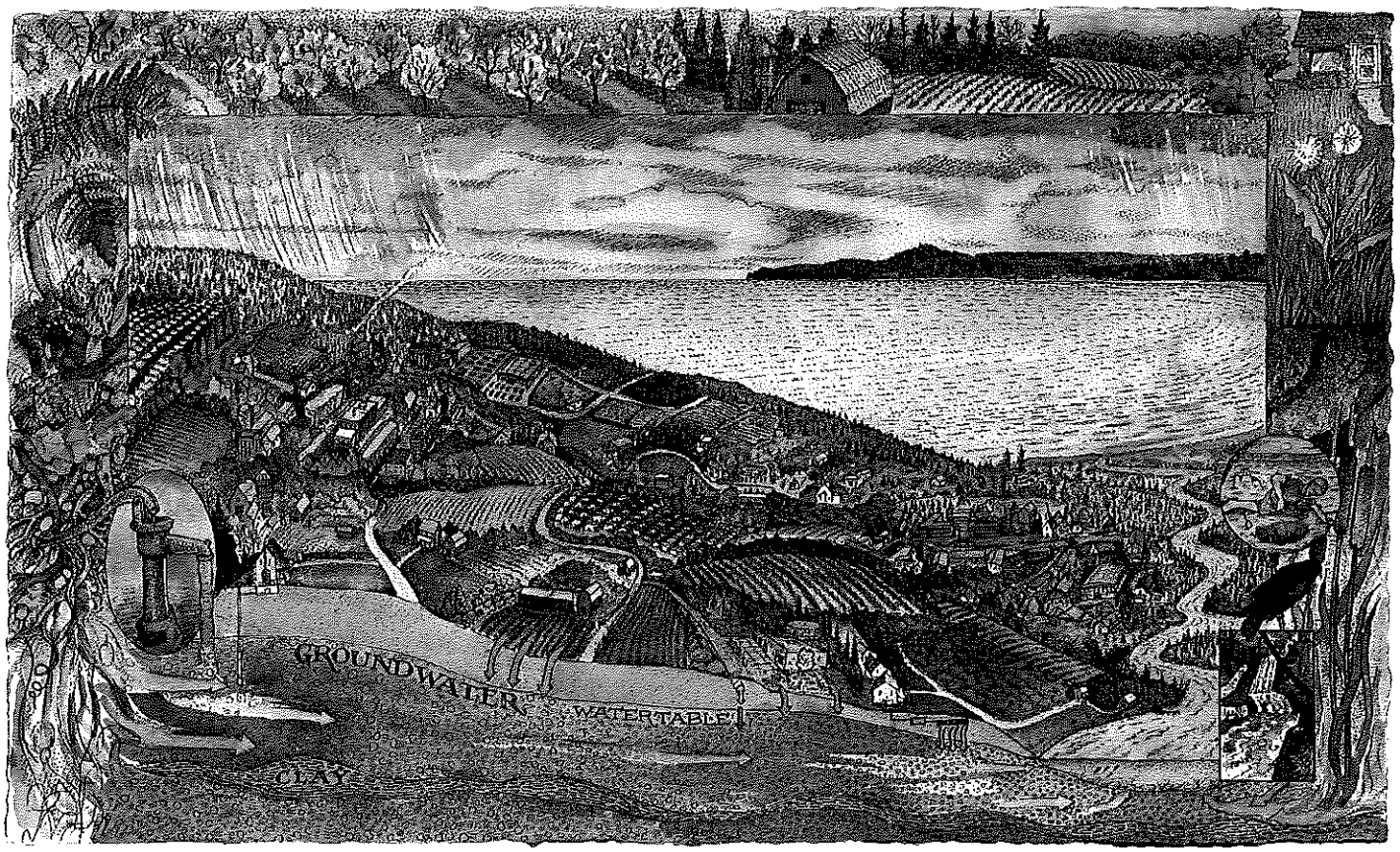
Deep Threats to Our Sixth Great Lake

Spotlighting and Solving Michigan's Groundwater Emergency

FLOW
FOR LOVE OF WATER
MARCH 2021



Art by Glenn Wolff

Groundwater is part of a single hydrological cycle and essential to the quantity and quality of Michigan's wetlands, lakes, and streams, and the Great Lakes. Yet groundwater is the least protected arc of that cycle. While modern laws and policies protecting surface water are well-established, dating to the 1960s and 1970s, the same cannot be said for groundwater. Despite increasing scientific understanding about threats to groundwater and its importance to the healthy sustainability of life, uses, and communities in a watershed, groundwater's out-of-sight character has often left protective policies out of mind.

Groundwater quantity issues have recently generated more policy consideration. The state of Michigan for the first time regulated large-volume withdrawals of groundwater through passage of a new law in 2008. But relatively little attention has been paid to groundwater quality. A patchwork of protections exposes groundwater to continued degradation.

The piecemeal approach is inadequate to meet the needs of the 21st century. The lack of emphasis on pollution prevention and current provisions of law that allow groundwater to become and remain contaminated instead of being cleaned up pose serious current and future health risks. The result is Michigan's groundwater emergency.

Virtually every city and township in Michigan contains multiple sites of groundwater contamination, and some communities are riddled with them. Some contamination reaches as far back as the early 1900s, while contemporary pollution continues to create new or continuing problems. This cannot continue if Michigan's public and ecological health and economic prosperity are to be assured for future generations. Vig-

orously protecting the entire water cycle is all-important.

The lack of urgency in strengthening protection of Michigan's groundwater is short-sighted. When rivers burned, lawmakers passed the Clean Water Act. When the Exxon Valdez spilled 11 million gallons of crude oil into Prince William Sound, lawmakers toughened safety requirements for shipping of petroleum products. Yet spill after spill of hazardous materials into groundwater has happened for decades in Michigan, and the policy response has been incremental.

While groundwater is an often overlooked and poorly protected Michigan resource, it is vitally needed and serves critical natural and human uses in many ways.

Deep Threats to Our Sixth Great Lake builds on our 2018 groundwater report, and documents additional dangers to groundwater. It also proposes an overarching, comprehensive solution in state law and policy: a Michigan Groundwater Protection Act to prevent groundwater contamination while holding accountable those who pollute this shared public resource. Such a solution is critical now and will become increasingly so in this century. Michigan's water, including groundwater, will face new demands as population grows and industries relocate here in the face of water shortages and climate change pressures elsewhere.

Just as importantly, groundwater protection and conservation are fundamental tenets of good environmental stewardship. Michigan cannot fulfill its responsibilities as the Great Lakes State if its groundwater is widely polluted, nor can our people, drinking water, trout streams, tourism, agriculture, and businesses thrive unless Michigan practices such stewardship.

While groundwater is an often overlooked and poorly protected Michigan resource, it is vitally needed and serves critical natural and human uses in many ways. In FLOW's 2018 report, *The Sixth Great Lake: The Emergency Threatening Michigan's Overlooked Groundwater Resource*, we highlighted its critical nature:

- Groundwater is the source of drinking water for approximately 45 percent of Michigan's residents.
- Between 20 and 40 percent of the volume of the Great Lakes originates as groundwater.
- Manufacturing, agriculture, and other uses withdraw an average of 766 million gallons of groundwater per day in Michigan, supporting hundreds of thousands of Michigan jobs.

This *Deep Threats* report charts a path to a robust and lasting defense of Michigan's all-important groundwater resource as part of the public trust by revamping standards and rules to prevent further contamination. If Michigan treats groundwater as priceless instead of worthless, as a vulnerable resource in state policy, law, and practice, the state can assure an economically and environmentally sustainable future for all its people, communities, and businesses.

We recommend that the state of Michigan:

- Develop and enact a state groundwater policy built on the principle that groundwater must be fully and aggressively protected through a combination of prevention and rigorous cleanup measures.
- Ban or strictly limit use in Michigan of chemicals that frequently contaminate groundwater.
- Reinstate the polluter pay principle in law both to assure polluters are held accountable and to deter future groundwater contamination.
- Assess fines, penalties, and damages for impairment of the groundwater resource, and require full cleanup by polluters unless technically infeasible.
- Establish a fund to assist homeowners, largely in rural areas, in obtaining water water testing.
- Publish an annual report, based on a comprehensive public database, that identifies and ranks by hazard all sites of contaminated groundwater or connected overlying land or downgradient groundwater, creeks, streams, lakes, and wetlands.
- Direct additional public funding to accelerate the cleanup of Michigan's groundwater contamination.

This report first provides updates on matters discussed in FLOW's 2018 report. Succeeding chapters cover groundwater problem chemicals, Michigan's continued failure to act on septic system pollution, the need for a groundwater protection act, and recommendations.

CHAPTER 1

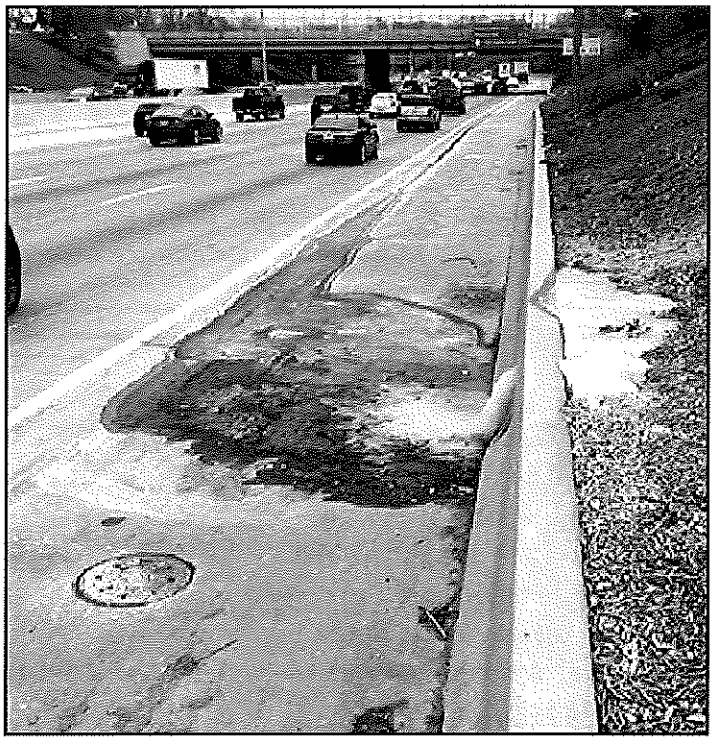
Developments since FLOW's 2018 Groundwater Report

Since FLOW's initial groundwater report, *The Sixth Great Lake: The Emergency Threatening Michigan's Overlooked Groundwater Resource*, new developments have exposed troubling gaps in the state's groundwater protection framework.

GREEN OOZE

In December 2019, drivers noticed a mysterious green substance seeping onto the shoulder of I-696 in Madison Heights[1]. Environmental investigators quickly identified the source of what the news media called "green ooze." It was the inevitable result of state policies that have treated Michigan's groundwater, in some locations, as an essentially worthless resource.

The source of the green ooze, which contained the toxic chemicals hexavalent chromium, trichloroethylene (TCE), cyanide, and perfluorooctanoic substances, or PFAS, was the former Electro-Plating Services business located beside the freeway. Cited in numerous state and federal enforcement actions for sloppy handling of toxic waste, Electro-Plating Services filed for bankrupt-



Green ooze that flowed onto the shoulder of I-696 in Madison Heights dramatized the problems associated with leaving contaminants in the ground rather than cleaning them up. (Credit: US EPA)

What Is Groundwater?

Running over the land or percolating downward after rainfall or snowmelt, groundwater is held in tiny pore spaces in the rock and soil. In Michigan on average about one-third of precipitation reaches groundwater, known as recharge. After water is absorbed into the ground, gravity pulls the water down through the unsaturated zone. This area of the earth's crust is where tiny gaps between sediment grains, called pore spaces, are filled with either air or water. Water here can be trapped and used by plant roots or percolate downward into the saturated zone, where water exclusively fills the pore spaces. The division between the unsaturated and saturated zone is called the water table.

Groundwater in the saturated zone moves both vertically and horizontally, flowing through soils and rock toward a lower elevation discharge point like a spring, stream, lake, or wetland. As groundwater moves through the surface of the earth, it often travels through an aquifer. Aquifers are underground formations that contain water at high enough concentrations that we can sustainably pump groundwater from them for freshwater use.

Almost all groundwater will discharge into surface water, unless captured by root uptake or extracted first. As a result, large-volume withdrawals can affect the flow and water levels of surface waters, and in some instances affect water quality because of the reduction in flow volume of a lake or a stream. Similarly, contaminated groundwater can degrade inland lakes, streams, and the Great Lakes. Typically, groundwater moves much more slowly than a stream or river, often traveling less than one foot per day. Between 80% and 90% of available freshwater in the United States is groundwater[7]. Groundwater makes up about 25% of the world's freshwater, with nearly all of the remaining freshwater stored in ice.

cy. Improper waste management allowed the chemicals to seep into the ground below the facility and eventually exited onto I-696.

Records revealed that the Michigan Department of Environmental Quality, now the Department of Environment, Great Lakes, and Energy (EGLE), and the U.S. Environmental Protection Agency (U.S. EPA) had warned the business to comply with hazardous waste regulations since 2010, but the facility didn't shut down for another six years. More immediate enforcement action might have prevented some of the groundwater contamination.

Initially, government agencies dealt primarily with containers of waste at the facility. But the chemical wastes had penetrated the soil and reached groundwater. By January 2021, state and federal agencies had spent $4.1 million on cleanup. The company's owner paid a different kind of price, a one-year jail sentence for criminal violations and restitution of $1.4 million.

As of January 2021, EGLE had identified 153 groundwater sites in the state that exceeded the new PFAS drinking water standards.

Unfortunately, the green ooze site is far from unique. "As visually dramatic as this is, it really draws attention to the fact that there are thousands and thousands of sites across the state where soil and groundwater is contaminated," Tracy Kecskemeti, EGLE district supervisor said, "and we only have the resources to address a small number."[2]

PROTECTIVE DRINKING WATER STANDARDS FOR PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

A major step forward was the state's adoption on August 3, 2020, of some of the most protective drinking water standards in the country for seven chemicals from the family of compounds known as PFAS.[3] Michigan Governor Gretchen Whitmer called for development of the rules in early 2019. Chemicals in this class of more than 5,000 substances are bioaccumulative and persistent, meaning they build up in the food chain and do not easily break down.[4] These "forever chemicals" are intended to repel water, grease, and stains in products like carpets, nonstick pans, waterproof jackets, and fast food and other food packaging. They are also used in firefighting foam often used on military bases and at commercial airports.

Mounting research links PFAS to a wide range of health problems. Studies of the best-known PFAS, called PFOA and PFOS, show links to kidney cancer and testicular cancer, as well as endocrine disruption in humans. Scientists have also discovered unusual clusters of serious medical effects in communities with heavily PFAS-contaminated water. As of January 2021, EGLE had identified 153 groundwater sites in the state that exceeded the new PFAS drinking water standards.

An example was the discovery in summer 2020 of groundwater contamination in East Bay Township, just east of the City of Traverse City.[5] A state sampling team found PFAS in groundwater downgradient from a facility shared by Cherry Capital Airport and a U.S. Coast Guard Air Station. Either or both may have contributed to the contamination as a result of firefighting drills using PFAS foams. Citizens in the 15 homes whose well water has been found to be contaminated by PFAS chemicals (seven homes above health-based drinking water standards) are receiving bottled water as a temporary solution. Plans are developing to extend the City of Traverse City's municipal drinking water supply to the affected homes. It is unknown how long those in the affected neighborhood have been drinking PFAS-contaminated water, although state and local officials were aware of potential contamination approximately eight months before alerting residents.

FUNDING FOR CLEANUP

Some new taxpayer funding for environmental cleanup has materialized. In December 2018, the Michigan Legislature approved $69 million in annual state income tax revenue for the Renew Michigan Fund. Some of that funding is dedicated to environmental cleanup and redevelopment. This comes on top of cleanup funding from unredeemed deposits generat-

Groundwater and the Public Trust

Although laws like the U.S. Clean Water Act primarily protect surface water, in the real world of hydrology, groundwater and surface water are virtually inseparable. In most Michigan locations, groundwater flows to surface water and provides a substantial share of the base flow of rivers and the volume of the Great Lakes. Similarly, contaminated groundwater often vents into lakes and streams.

Legislatures and courts have begun to recognize that groundwater and navigable lakes and streams[8] are inseparable[9]; what happens to one, happens to the other. Further, public trust law already sets forth several basic, established principles or standards, which, in turn, provide an overarching framework to govern all decisions, rights, and duties regarding navigable waters and tributaries of the Great Lakes Basin[10]:

1. Public trust waters and protected public uses cannot be alienated by government, and, in any event, may never be transferred or controlled for private purposes. A public purpose is required. (Public protected uses include navigation, commerce, fishing, swimming, recreation, and drinking water).

2. The proposed diversion or use cannot materially impair the flow, level, integrity, or quality of public trust water and tributary water. It cannot materially impair public trust resources or protected public issues.

3. A duty is imposed on the government to account for its actions or approvals of a diversion or use by making duly recorded findings based on adequate information concerning the effects of a proposed use to assure that there is no unlawful alienation or transfer for private purpose and no material impairment of public trust waters or uses.

More and more frequently, courts are perceiving a nexus between the use, diversion, or impact to groundwater and hydrologically connected public surface water that is protected by the public trust doctrine. In 2020, the United States Supreme Court ruled that a discharge of toxic chemicals to groundwater that was directly connected to nearby surface waters constituted a discharge to the surface waters of the United States.[11]

If the public trust is applied to the entirety of the water cycle, including groundwater, then the impacts of pollution, as well as withdrawal of groundwater, cannot materially impair public uses of that groundwater. No one owns or has a right to diminish or impair the quality of groundwater that connects to surface water. This should be the bedrock principle of groundwater law and policy. But in fact, current Michigan law condones the continued impairment of groundwater quality.

ed by Michigan's beverage container law. Although an important step forward, this revenue falls well short of what is needed to clean up so-called "orphan sites" where no responsible private party exists to pay the bill. EGLE has estimated there are more than 14,000 cleanup sites that are unfunded, inadequately funded or on hold.

FUNDING TO REPLACE FAILING SEPTIC SYSTEMS

On October 1, 2020, Governor Whitmer proposed $500 million in additional funding for clean water.[6] Her $500 million package includes $35 million for a program to replace failing septic systems that contaminate groundwater and surface water, the first such allocation in state history. The legislature must approve the funding before the program can proceed.

CLEAN, SAFE, AND AFFORDABLE WATER

The continuing COVID-19 pandemic underscores the need for clean, safe, and affordable water for sanitary purposes, whether from groundwater or surface waters. Yet water utilities continue to shut off residential water services. Governor Whitmer imposed a shutoff moratorium in the spring, using emergency powers that the Michigan Supreme Court struck down later in the year fall. Left with no safety net, Detroit residents and frontline activists pressured Mayor Mike Duggan to impose a moratorium on all water shutoffs within the city limits until the end of 2022. Meanwhile, Governor Whitmer signed legislation sponsored by State Senator Stephanie Chang that implements a temporary moratorium on water shutoffs statewide through March 31, 2021.

PFAS-tainted Groundwater Hits Home

One day in March 2016, Tony Spaniola picked up the *Detroit Free Press*. What he saw surprised him. A front-page article about what might be Michigan's biggest water problem was accompanied by a photograph of Van Etten Lake—the same lake on whose shores he owned a cottage.[12] The article detailed extensive chemical contamination flowing underground from the former Wurtsmith Air Force Base to the lake. The pollution turned out to be one of many PFAS chemical compounds, used at the base in firefighting foams for training exercises.

"At first I was assured there was no problem on our side of the lake. But in October 2016, the local health department cautioned against drinking from my well," Spaniola says.

A few years earlier, two of his dogs had died of internal cancers, a year or two apart. At the time, he wondered whether this might be related to the water they drank from the lake.

"The water at our kitchen sink was filtered pretty well through a system provided by the State, but not the rest of the place. We were told we could shower in it, but now there are studies suggesting otherwise. The skin issue is a big issue. Inhalation is a big issue." The cottage is now being supplied by safe, clean municipal water instead of by his well.

"It changes your whole outlook on being in that place. It's a real game changer in terms of daily living," he says.

Then illnesses in people in the area began to add up. There was no way of knowing whether these were related to PFAS, and government agencies chose not to conduct any human health studies despite repeated requests from the community. A "Do Not Eat" fish advisory for the Au Sable River had been issued in 2012, four years before the drinking water advisory. A "do not eat" advisory for venison from area deer was issued in 2018. These were additional blows to the community.

"When you think about Michigan, hunting and fishing are a big part of life," Spaniola says. It is not just a matter of sport. Some area residents depend on fish and game as part of their subsistence.

What began for Spaniola in 2016 and for others in the community in 2010, when contamination was found at the former Air Force base, has become

PFAS contaminants from the former Wurtsmith Air Force Base near Oscoda have contaminated drinking water, a lake, fish and wildlife. (Credit: Anthony Spaniola)

an often-frustrating battle to demand cleanup of the contamination and full-blown studies of the impact of the chemical exposure on the health of area residents. The U.S. Department of Defense, responsible for the contamination, has dragged its feet.

Spaniola worries about the impact of the contamination on nearby Lake Huron. "Everything that gets into my lake and then the Au Sable River ends up in Lake Huron within a matter of days."

Prevention in the first place would have been the wise course, according to Spaniola. "I think we really have to change the way we regulate chemicals like PFAS," he says. "We've gone from 4,000 to 7,000 PFAS chemicals in recent years. The impact is still happening."

CHAPTER 2

Groundwater Problem Pollutants

The many chemical contaminants in Michigan's groundwater, combined with the lack of environmentally sustainable federal and state chemical policies, continue to put Michigan's groundwater and other resources at risk. An example is trichloroethylene (TCE), a manufactured chemical that has contaminated groundwater at more than 300 locations in Michigan.

Two recent policy developments have underscored the need and opportunity for Michigan to act by passing a state law to control TCE. In 2020, Minnesota became the first state in the country to outlaw many remaining uses of TCE,[13] and the U.S. EPA found 52 of 54 current TCE uses pose an unreasonable risk to human health.[14]

When spilled on the ground, TCE can travel through soil and water and contaminate drinking water supplies, including public and private wells.

Commonly used as a solvent to remove grease from metal parts during manufacturing processes or to make additional chemicals, TCE has also been used to extract greases, oils, fats, waxes, and tars; in dry cleaning operations; and in consumer products such as adhesives, paint removers, stain removers, lubricants, paints, varnishes, pesticides, and cold metal cleaners.

TCE released into the environment can pollute soil, groundwater, and the air. TCE's high mobility in soil often results in groundwater contamination.[15] The molecular and chemical properties of TCE make it slow to degrade and time-consuming to mitigate the effects of its contamination in the soil and groundwater. When spilled on the ground, TCE can travel through the soil and water and contaminate drinking water supplies, including public and private wells; moreover, it can move underground into lakes and rivers and evaporate into the air. These TCE vapors can enter buildings through cracks in the foundation, pipes, and sump and drain systems, thus contaminating indoor air. This phenomenon is known as vapor intrusion. At several Michigan locations where housing and office structures were built on contamination sites, TCE was left in soils rather than being excavated and removed, and has vaporized into these buildings through foundations and basements. In some cases, EGLE has temporarily evacuated occupants of the buildings because of the danger of air inhalation of TCE.[16]

TCE has been characterized as carcinogenic to humans through all routes of exposure and poses a significant human health hazard.[17] People who are exposed to moderate levels of TCE may experience headaches, dizziness, and sleepiness. Large amounts of this chemical may lead to coma, nerve damage, or death. TCE is known to interfere with early life development and lead to developmental toxicity, immunotoxicity, and neurotoxicity. This chemical has also been linked to damage to eyesight, hearing, the liver, the kidney, balance, heartbeat, blood, nervous system, and respiratory system. In the workplace, exposure to TCE may cause scleroderma, a systemic autoimmune disease, and, in men, it has been observed to result in decreases to sex drive, sperm quality, and reproductive hormone levels. In addition, prolonged exposure to TCE has led to kidney cancer and is associated with an elevated risk of non-Hodgkin's lymphoma and liver cancer.

The U.S. Food and Drug Administration (FDA) in 1977 banned the use of TCE in food, cosmetic, and drug products in the United States.[18] In Canada, TCE is no longer manufactured, and the Canadian Environmental Protection Act of 1999 is intended to significantly reduce the use and release of TCE as a solvent degreaser into the environment. Several other countries have regulations to control the use, and subsequent risks, of TCE (e.g. Sweden and Germany).

In 2016, the U.S. EPA proposed a ban of TCE for aerosol degreasing use and spot cleaning in dry cleaning facilities.[19] However, in December 2017, the EPA—guided by the Trump Administration—shifted

the proposed bans from "active" to "long-term action" status. The EPA conducted a risk evaluation and, despite the known health risks posed by trichloroethylene and the potential savings of millions of dollars from the reduction of those risks, the EPA sided with the chemical industry's opposition and has avoided finalizing the ban of TCE in the United States. In November 2020, however, EPA again reversed course. Its scientific study found that 52 of 54 uses of TCE still permitted present unreasonable risk to worker and consumer health. The EPA has two years to finalize a rule to reduce the risks posed by the 52 uses.

State action also has a place in efforts to protect human health from TCE. On May 16, 2020, Minnesota became the first state in the U.S. to ban high-risk uses of TCE. In effect, beginning June 1, 2022, any facility that is required to have an air emissions permit by the Minnesota Pollution Control Agency (MPCA) may not use TCE.[20] This includes manufacturing, processing, and cleaning operations. Additionally, the legislation defines conditions under which exemptions may be granted by the commissioner of the MPCA. The legislation sets forth processes for facilities to apply for extensions or exceptions from the TCE ban and allows up to $250,000 worth of zero-interest loans to assist small businesses in their transition away from TCE use.

This ban was enacted largely due to the work of the Neighborhood Concerned Citizens Group (NCCG) of White Bear Township, Minnesota, who lobbied for a ban on this toxic chemical after the local Water Gremlin, a fishing sinker manufacturer, had admitted to leaking elevated levels of TCE for nearly 17 years.

TCE is the pollutant in one of the largest plumes of contaminated groundwater in the United States. It has caused widespread contamination and cost millions of taxpayer dollars in Michigan. Dumped in shallow, sandy pits decades ago, TCE has contaminated 13 *trillion* gallons of groundwater in Mancelona, Michigan, making the Wickes Manufacturing plume the largest TCE plume in the United States.

TCE contamination of groundwater has impacted over 500 residential drinking water wells and several community drinking water supply wells across Michigan, including municipal wells near Battle Creek and Petoskey, and private wells near Albion and Brighton. The Oakland County Health Division has reported vapor intrusion of TCE from multiple potential sources: dry cleaning facilities, gas stations, and metal degreasing operations. Franklin, Michigan also has reported vapor intrusion in a series of small downtown businesses after health inspectors found an aging and toxic TCE storage container buried underneath a local shop. Elevated levels of TCE in groundwater have been detected in southeast Grand Rapids, Detroit, and Sturgis.

Several case studies have been performed to analyze the effectiveness of TCE alternatives in the United States.[21] One example is a Schick facility in Verona, Virginia, that manufactures a variety of steel blades and uses TCE in both cleaning and degreasing operations. The company made TCE elimination a priority due to its role as a potential environmental contaminant and increasing costs associated with regulations for its distillation and waste disposal. Upon eliminating their TCE-based cleaning processes, Schick installed aqueous wash boxes on the production lines and began using an alcohol-based vapor degreaser. These modifications reduced occupational and public risk and resulted in an approximate cost reduction of $250,000 from reduced energy use and material and hazardous waste disposal costs.

Several companies in Michigan have also made the switch to TCE-free degreasing products. After reports of TCE contamination in the air and groundwater, a Howell, Michigan, company, Diamond Chrome Plating, opted for an aerospace cleaning fluid called Next 5408.

The most efficient and sustainable way to limit the release of TCE and other harmful alternatives into the environment may be for the state of Michigan to regulate TCE by permits. There is no one-size-fits-all approach to regulating TCE across a variety of industries and applications. There are, however, an array of safety precautions and considerations that regulatory agencies must put in place to prevent TCE from becoming a public health hazard. Among these is the necessity to regulate and monitor storage and containment requirements of TCE and ensure effective waste disposal protocols. Additionally, it is imperative that regulations define limits on the amount of TCE that may be used by a company. To ensure the health of Michigan residents, it is also necessary to increase the frequency of state and private testing and moni-

Technology and Remediation Strategies for Contaminated Groundwater

Preventing groundwater contamination will always be the most responsible, protective, and cost-effective course of action, but many remediation strategies have recently emerged as options for already polluted sites. Technological advancements in groundwater remediation have increased effectiveness in addressing contaminated sites; however, many strategies remain costly, intrusive, or a combination of the two, making prevention all the more imperative.

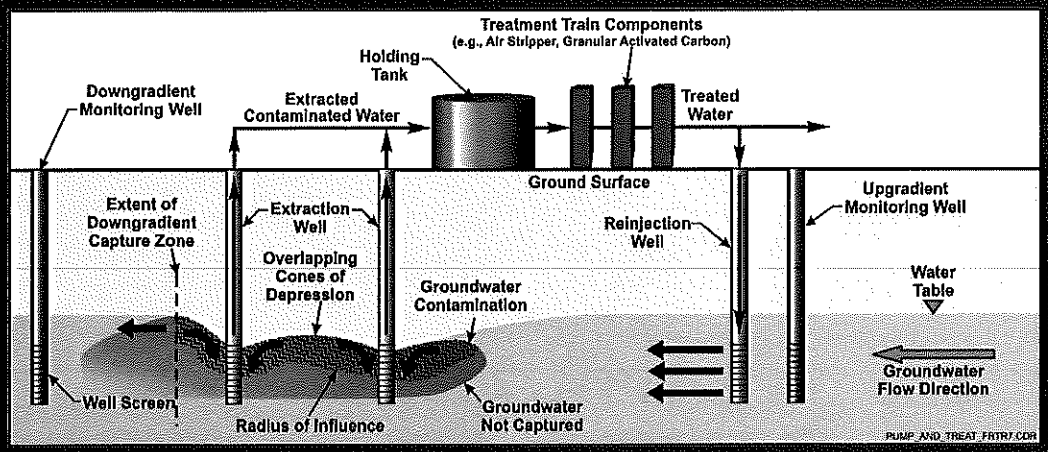
An array of onsite, or *in situ*, groundwater remediation methods have been developed in recent decades, presenting options for contamination types and variations in groundwater ecosystems. For these onsite remediation methods to have an impact, contaminated groundwater plumes first must be contained. Typically operating with the goal of a stable groundwater ecosystem, the most effective onsite remediation methods involve the introduction of a reactive element as well as sometimes incorporating a physical barrier or mixing process.[22]

The most widely used method of treating contaminated groundwater is "pump and treat" (P&T), where groundwater is removed and then treated above ground, often with chemical reactants.[23]

Permeable Reactive Barriers (PRBs) offer the beginnings of an effective remediation strategy, but often must be joined with other methods to provide the best results.[24] Barriers can be helpful in cases that involve large migrating groundwater contamination plumes, as they are comparatively low cost and require limited maintenance.[25] The residence time of the groundwater moving through the chemically enhanced remediation barrier must be long enough for contamination levels to reach an acceptable level; otherwise, the process must go one step further.[26] The resulting strategy, commonly referred to as a bio-PRB, can help stop the progress of a moving contaminated groundwater plume while simultaneously introducing reactive material to decrease toxicity levels in the groundwater source.[27]

Monitored Natural Attenuation (MNA) is another process that aims to have minimal negative impact in remediation practices, while, of course, correcting as much as possible. While PRBs are effective in treating migrating contaminants, MNA is most efficient in combating stable contaminated groundwater plumes.[28] However, MNA must involve thorough testing, as well as an EPA-recommended process of monitoring groundwater extracted from no fewer than three wells and measured at least 10 total times throughout the process to ensure the long-term isolation of the contaminated groundwater source.[29]

Bioelectrochemical Systems (BES), as a whole, are promising options for onsite groundwater remediation. Other strategies often need to be incorporated with one or more additional treatments, or are only effective on certain contamination types.[30] These systems aim to facilitate remediation through chemical reactions within the contaminated water, introducing the electrically charged chemical variant that best applies to the contamination at hand. BES practices are also more impactful in most circumstances in which the simple addition of treatment chemicals, as the BES method promotes much greater levels of reaction potential in remedying groundwater.[31]



Pump & Treat Contamination Treatment System.

toring for TCE contamination. Finally, information of efforts taken by facilities and regulatory agencies to control TCE contamination must be transparent and readily available. If there are inherently safer products and technologies available to facilities than reliance on TCE, then a TCE-alternative should be used.

Given the uncertainty of federal policy, Michigan should not wait to take action to limit most TCE uses, just as Michigan did not wait for the EPA to set enforceable standards for PFAS in drinking water. Because it has a paramount interest in protecting the health of its residents, Michigan should act with urgency to pass a state law to control TCE.

PROBLEM GROUNDWATER POLLUTANT: NITRATE

One of the least-publicized groundwater contamination threats is nitrate. Nitrate pollution of groundwater in Michigan is largely caused by the overapplication of nitrogen from agricultural fertilizers and animal waste, although failing septic systems also contribute nitrogen pollution to the state's groundwater. Nitrate has been linked to numerous, negative human health effects.

Infants below the age of 6 months who drink water containing nitrate in excess of the health-based standard are especially at risk, and could become seriously ill with a condition called methemoglobinemia or "blue-baby syndrome." This condition deprives the infant of oxygen and, in extreme cases, can cause death. In children, there is also growing evidence of a correlation between nitrate and diabetes. Birth defects have also been linked to nitrate exposure. Several epidemiological studies over the past decade have examined statistical links between nitrate exposure and neural tube birth defects. In the human body, nitrate can convert to nitrite (NO2) and then to N-nitroso compounds (NOCs), which are some of the strongest known carcinogens. As a result, additional human health concerns related to nitrate-contaminated drinking water include increased risk of non-Hodgkin's lymphoma, gastric cancer, and bladder and ovarian cancer in older women.

Michigan

Although the state of Michigan does not estimate the percentage of wells statewide containing high levels of nitrate, there is strong reason to believe the extent of groundwater contamination by nitrate approaches that of nearby states, given similar hydrogeology and agricultural practices. Nitrate contamination in Wisconsin and Minnesota is widespread at about 10% of private wells, and therefore Michigan likely bears a similar burden on its 1.25 million private wells.

Thousands of private drinking water wells across Michigan are believed to contain nitrate at detectable levels, and many contain nitrate in excess of drinking water standards. The U.S. EPA estimated that 3,254 square miles of groundwater area in Michigan are contaminated with nitrate concentrations that are at least half the level of the drinking water safety standard.[32] This is 6% of the state's land area. Nitrates not only contaminate groundwater, but also run off or discharge to lakes and streams, causing blooms of algae in down-

Agricultural fertilizers, animal waste, and failing septic systems all contribute nitrate to groundwater. Nitrate is associated with numerous human health impacts.

stream reaches and lakes. This, in turn, depletes oxygen levels, decreases fish populations, decreases the value of riparian property, and diminishes uses for public and private recreation and drinking water supplies.

Because nitrate is colorless, odorless, and tasteless, many Michigan residents may unknowingly be consuming it. The state should make testing easily accessible at low cost or no cost to owners of residential properties with private wells and educate the public on the value of such testing.

Wisconsin

About 1.7 million people in Wisconsin rely on private wells for drinking water, and the state Department of Health Services estimates at least 1-in-10 private Wisconsin wells has high levels of nitrate.[33] An estimated 42,000 private wells exceed the drinking water health standard for nitrate, with a total cost estimate for abandoning the contaminated wells and replacing each with a new, safe water supply exceeding $440 million. One village in Portage County replaced a public water supply well due to high nitrate concentrations at a cost of $1,128,000. A study found that nitrate pollution in drinking water is linked to negative health outcomes that are costing people in Wisconsin anywhere between $23 million and $80 million each year in medical expenses from adverse birth outcomes and cancer.[34]

The state estimated that in 2007, over 200 million pounds of nitrogen were applied to agricultural lands in excess of University of Wisconsin recommendations, a number that could be substantially reduced with broader adoption of nutrient management plans. Even in the best managed agricultural systems, over the long term (seven years), nearly 20% of nitrogen fertilizer bypasses plants and leaches to groundwater.

Minnesota

The Minnesota Department of Health has found that over 10 percent of the private wells sampled in some townships in southwestern, southeastern, central, and north-central Minnesota have nitrate levels above the drinking water health standard.[35] To address the problem, the state in 2020 implemented a new rule governing agricultural nitrate.

The rule bars farmers from applying nitrogen fertilizer in certain seasons in certain parts of the state and regulates application in 30 areas, such as Hastings, where community water supplies show high nitrate levels. In 2007, as nitrate levels were reaching the state's health risk limit, the city of Hastings spent $3.5 million to install a denitrification system.

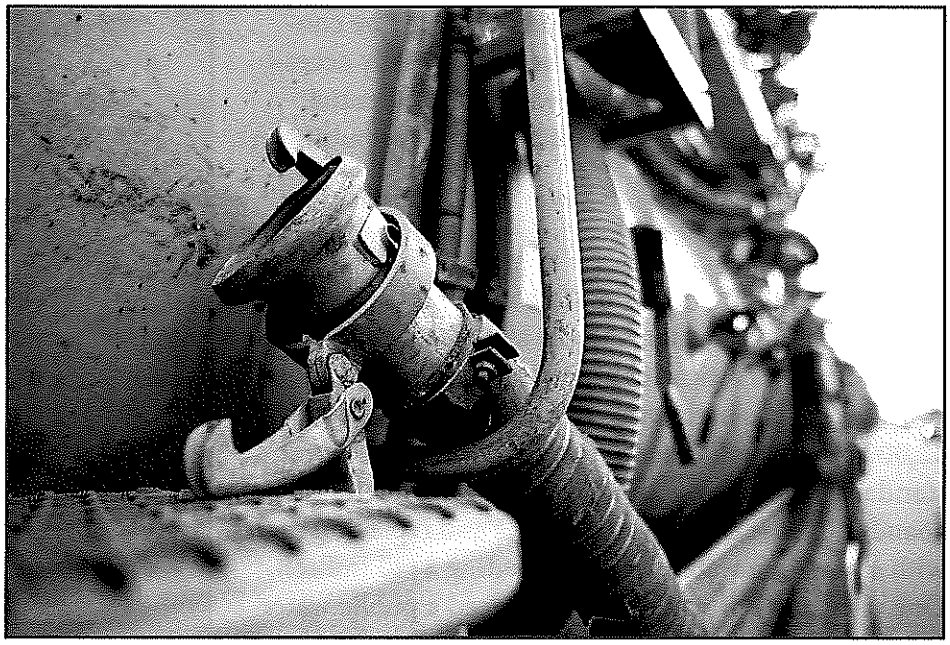
A newly drilled well with water gushing. (Credit: USGS)

Beginning in 2020, use of nitrogen fertilizer in the fall and on frozen soils was restricted in areas of Minnesota with vulnerable groundwater, such as areas with coarse textured soil, shallow bedrock, or karst geology, and in public wellhead areas with elevated nitrate levels. Farmers will not face enforcement, including penalties, unless they refuse to adopt the changes or nitrate levels get worse, and not for at least three years.

It is long past time for Michigan to address the primary sources of nitrate contamination of groundwater. The state should tighten proposed limits on application of agricultural fertilizer containing nitrogen in porous soils, in autumn and on frozen ground. Where contamination of private or public drinking water supplies from fertilizers has been detected, fertilizer applicators should be required to discontinue or strictly limit fertilizer use, as appropriate. Protection of public health must be paramount.

CHAPTER 3

The Last Holdout: Michigan's Failure To Act on Septic System Pollution



In *The Sixth Great Lake*, FLOW reported that an estimated 10% of Michigan's septic systems, approximately 130,000, are failing, releasing both bacteriological and chemical wastes to groundwater and surface water. EGLE estimates that failing septic systems discharge more than 31 million gallons of raw sewage every day into groundwater, the equivalent of 47 Olympic-sized swimming pools.[36]

This pollution has serious human health impacts. Speaking at a November 2019 Septic Summit in Traverse City hosted by FLOW, Dr. Mark Borchardt, a microbiologist with the U.S. Department of Agriculture's Agricultural Research Service in Wisconsin, said research demonstrates a correlation between the presence of septic systems and health impacts. "What we have seen in the studies we've done," Borchardt said, "is that the greater the number of septic systems, whether they're failing or not, the more likely it is that people become ill." In particular, he noted, the density of septic holding tanks in central Wisconsin is related to sporadic infectious diarrhea in children.

A 2015 study conducted by Public Sector Consultants (PSC) in mid-Michigan found levels of *E. coli* exceeded water quality standards at all sites sampled at some point.[37] Human DNA was the dominant marker, leading the study authors to conclude that failing septic systems were a significant pollution source throughout the Upper Maple River watershed. As part of the work, PSC found that 30% of homeowners questioned did not know they had a septic system, and therefore did not know its condition nor when it was last pumped or inspected.

In Kalkaska County, PSC estimated, failing septic systems are generating the equivalent of between 139 to 347 Olympic-size swimming pools of sewage annually. Dr. Joan Rose, the Nowlin Chair for Water Research at Michigan State University, authored a 2015 study examining 64 river systems that drain approximately 84 percent of the Lower Peninsula, analyzing for *E. coli* and the human-specific source tracking marker bacteria called *B. theta*: "Our research found a clear correlation: The more septic systems in the watershed, the more human fecal source tracking bacteria in the water."

EGLE estimates that failing septic systems discharge more than 31 million gallons of raw sewage every day into groundwater, the equivalent of 47 Olympic-sized swimming pools.

Because Michigan is the only state in the U.S. lacking a statewide sanitary code regulating septic systems, local governments are on their own regarding whether and how to regulate septic systems. Cur-

rently, 10 counties, seven townships, and two villages in Michigan have enacted their own regulations, requiring inspection periodically or at the time a property changes hands and, when necessary, maintenance or replacement.

Efforts to enact a statewide sanitary code have made little progress in the Michigan Legislature for the past two decades. Meanwhile, estimates of the expense to bring all septic systems in the state up to satisfactory levels suggest a significant cost. A 2016 report to former Governor Rick Snyder by the 21st Century Infrastructure Commission estimated that approximately 52,000—4 percent—of all septic systems should be replaced on an average annual basis at a cost of approximately $780 million. Although recommending that maintenance and replacement of septic systems should be primarily funded privately, the Commission proposed that $20 million in public funds annually be provided to owners of failed systems who need financial assistance. Governor Gretchen Whitmer in 2020 proposed the first-ever, one-time $35 million state assistance fund for septic tank replacement.

A state sanitary code likely would rely on permitting, inspection, and enforcement by Michigan's 45 local health department jurisdictions. Therefore, the legislation should ensure sustained funding is established that will reimburse local health departments no less than 50% of the cost to administer delegated provisions in a statewide onsite wastewater law and/or resulting code. In addition, the legislation should support the establishment of minimum performance-based treatment standards for the design of onsite septic systems taking into account statewide variability in Michigan's geologic landscape.

Michigan's largest spring is Kitch-iti-kipi, located in Palms Book State Park near Manistique.

Kitch-iti-kipi Spring

Thousands of springs feed lakes and streams in Michigan. The state's largest spring is Kitch-iti-kipi, located in Palms Book State Park near Manistique in the Upper Peninsula. It is 200 feet in diameter, and 42 feet deep, and delivers 16,000 gallons of clear water per minute. Visitors can ride the raft for a view across the spring.

Kitch-iti-kipi draws water from fissures in underlying limestone. This constant flow, plus continual temperatures of 45 degrees at all times, means this body of water never freezes, no matter how cold it gets during Michigan winters. This makes the spring a popular tourist destination year-round.

CHAPTER 4

The Need for a Michigan Groundwater Protection Act

Prioritizing groundwater protection is challenging for many reasons. The broad public consensus that exists for protecting the Great Lakes and their tributary rivers, streams, and wetlands is lacking in regard to groundwater.

INTEGRATING GROUNDWATER MANAGEMENT

Stewardship and management of groundwater is inherently more difficult and complex. Groundwater exists beyond our field of vision, requiring deliberate focus and recognition to bring awareness of groundwater issues to the attention of community members unless circumstances or events raise a particular groundwater problem. Local officials often lack the resources and technical and scientific expertise to manage groundwater, deferring matters of groundwater management and governance to state and federal agencies who also often lack the resources and trained staff to comprehensively address groundwater. Additionally, lack of data, inadequate monitoring capacity, and complicated hydrogeology present challenges that further hamper governmental efforts to manage and protect groundwater.

Groundwater exists beyond our field of vision, requiring deliberate focus and recognition to bring awareness of groundwater issues to the attention of community members.

The recognition of groundwater as part of a single hydrological system will bring new public awareness and stewardship to the importance of the role of groundwater in our watersheds and local communities. Adequate technical and scientific expertise and the collection of data will enable meaningful decisions and take preventative actions.

POLICY

Nowhere in Michigan's voluminous environmental laws and regulations does the state set forth a formal state policy regarding groundwater. Groundwater was once part of the former Water Resources Commission Act (WRCA), which provided for broad management and protection of Michigan's groundwater, lakes, and streams as the "waters of the state."[38]

Under the act, disputes over pollution and water quality of the state could be brought to the attention of a Water Resources Commission, with public notice, hearings, public participation, and open decision-making on policy and permits.[39] But the Water Resources Commission was abolished in 1991 by Governor John Engler and groundwater and surface water management were consolidated by Engler's executive Order into a newly established Department of Environmental Quality (DEQ),[40] headed by a director who reported directly to the Governor.

Under Michigan's Constitution, the legislature is compelled to provide by law for the protection of the air, water, and natural resources of the state from pollution, impairment, or destruction.[41] Under our water quantity laws, groundwater is considered to be part of a single hydrologic system and of immense public value, and held in trust for the benefit of citizens.[42] It would be appropriate to manage water quality or pollution with the same overarching constitutional and stewardship, or trust, responsibility.

The successor to the DEQ, the Department of the Environment, Great Lakes and Energy (EGLE), manages an overall water policy that by default operates a patchwork of laws and requirements. The regulatory scheme includes specific pollution sources, cleanup standards, well drilling, wellhead protection, wastewater treatment, runoff and soil erosion and sedimentation, oil and gas, minerals and mining, and the sometimes uncertain roles of the state and local governments and health departments, along with other piecemeal features of the state's Natural Resources and Environmental Protection Act (NREPA). While the NREPA recodified the environmental laws of the state

of Michigan into a single statute, it did not establish an overall unifying policy with an overarching framework, principles, and permitting programs. As a result, amendments to the NREPA, although intended to improve management and programs of the EGLE, only add to the array of programs to conserve, protect, and manage the waters of the state.

As noted above, article 4, section 52 of Michigan's Constitution envisioned a holistic policy that water, air, and natural resources as a whole are a matter of "paramount concern" and charged the legislature and state to protect water and these natural resources from "pollution and impairment." Articulating such a holistic and comprehensive policy can help guide state agencies and improve public awareness of the need to prevent groundwater contamination.

Some of Michigan's neighboring Great Lakes states have adopted groundwater policies. Minnesota's groundwater statute declares that "it is the goal of the state that groundwater be maintained in its natural condition, free from any degradation caused by human activities."

Illinois state policy holds that groundwater resources should be utilized for beneficial and legitimate purposes, that waste and degradation of the resources should be prevented, and that underground water resources should be managed to allow for maximum benefit of the people of Illinois.

State of New York law finds that "Adequate supplies of good quality groundwater are critical to the health and welfare of the residents of the state and to their economic well-being. The levels and types of contaminants, the extent of contamination, and the present and potential impacts on public health and the environment vary widely from site to site, but cumulatively could endanger the integrity of the water resources of New York state...It is the intent of the legislature that groundwater be protected for its classified use, the highest of which is drinking water."

Looking beyond the Great Lakes Basin, Vermont has an extensive statutory groundwater policy, whose tenets are:

- The withdrawal of groundwater of the State should

be regulated in a manner that benefits the people of the State; is compatible with long-range water resource planning, proper management, and use of the water resources of Vermont; and is consistent with Vermont's policy of managing groundwater as a public resource for the benefit of all Vermonters.

- The State shall protect its groundwater resources to maintain high-quality drinking water.
- The groundwater resources of the State shall be managed to minimize the risks of groundwater quality deterioration by regulating human activities that present risks to the use of groundwater in the vicinities of such activities while balancing the State's groundwater policy with the need to maintain and promote a healthy and prosperous agricultural community.
- The groundwater resources of the State are held in trust for the public.[43]

A state policy for Michigan should include the best of these examples, articulating the importance of groundwater for drinking water and ecological sustainability, giving state agencies a clear mandate guiding all decisions affecting groundwater management.

INSTITUTIONAL CONTROLS: Leaving, Not Cleaning, Groundwater Contamination

At more than 2,000 groundwater contamination sites in Michigan, state policy initiated in the 1990s does not require complete or even substantial cleanup provided that the party responsible for the polluted site can control human exposure through what are termed "institutional controls." These controls typically consist of local ordinances banning use of groundwater in specific areas and/or human access to the contaminated soils. The state may also approve deed restrictions for individual properties that meet the same requirements. This policy was a dramatic shift from the previous requirement for cleanup to the "natural background level," unpolluted by human activity. Contaminated sites with institutional controls are scattered across Michigan's Upper and Lower peninsulas.

To evaluate the effectiveness of this policy, under the guidance of two University of Michigan faculty, graduate students evaluated risk-based management of groundwater under Part 201 of NREPA. They reported on their findings in 2020. Several state officials interviewed raised concerns that once institutional controls are in place, there is no incentive or requirement to clean up contamination because the responsible party has adhered to state laws. Some noted that aquifers are rare and highly valued globally and that leaving contamination in place often imposes long-term social and economic costs associated with the use of institutional controls on these vital resources.

One interviewee expressed concern "that, in some ways, we are writing off aquifers. If we're not actively

Charlevoix: The Harmful Legacy of Leaving Pollution in the Ground

The unforeseen costs and health risks of leaving groundwater contaminants in place are illustrated by a case in the Charlevoix area. In 1981, tetrachloroethylene (PCE) and TCE contamination from dry cleaners and a tool shop was detected in the city's drinking water supply, whose source was groundwater. The U.S. EPA, under the Superfund program, paid approximately $3 million to switch the city's supply source to Lake Michigan, while restricting access to the contaminated groundwater. The agency reasoned that the cost of the drinking water supply switch was cheaper than attempting to fully remediate the groundwater. In 1993, EPA removed the Charlevoix contamination site from its Superfund National Priority List. The agency forecast that the contamination would naturally attenuate to safe levels within 50 years.

But as science advanced, the EPA and the Michigan DEQ recognized a previously unknown risk. Volatile chemicals like TCE can vaporize in the ground, penetrate foundations and basements, and expose those working or living in affected structures to unhealthy levels of air pollution. EPA equipped 16 houses in the area of contaminated groundwater with vacuum systems to remove the toxic vapors and proposed demolishing a home and two businesses and spending approximately $15 million to address the contaminated groundwater.

cleaning up a groundwater plume, then we are writing off this portion of the aquifer in perpetuity. I have concerns about that because some of our plumes [and] contamination sites are very well characterized and some of them are horribly characterized."

The study recommended enhanced data availability and accessibility, enabling better understanding of contaminated sites for local officials and the public; changes in state law, including requiring all instances of hazardous substance releases be reported to the state; and additional funding and staff for the cleanup program.

EGLE has now commissioned a $350,000 study to evaluate the costs, both foreseen and unforeseen, of using institutional controls. The request for proposal seeks an evaluation of EGLE's process and criteria for determining when institutional controls are the appropriate response to groundwater contamination. EGLE is pursuing "a set of case studies to determine the cost of past uses of institutional controls and restrictive covenants and develop a decision-making framework for future instances of groundwater contamination based on a holistic prediction of long-term risk and cost. The project will seek to incorporate the risk of additional unexpected costs into this framework as well as changes in risk associated with expected demographic change and the cumulative risk of using institutional controls at many sites within the same geographic area." Finally, EGLE is seeking recommendations on a decision-making framework to assist the State as it moves forward in addressing contamination."

CLEANING UP SITES CONTAMINATED IN THE FUTURE

There is no legal or moral right to contaminate groundwater, which, because it generally connects with surface water, is a public resource. The public trust doctrine holds that water is a commons reserved for public uses such as drinking water, and that state government has an affirmative obligation to protect the commons on behalf of the people. Contamination of groundwater by definition impairs the commons. State law should require the assessment of damages for all future groundwater contamination. It should also require cleanup at these sites to be consistent with residential use. If this is technically infeasible, the law should allow for escalated damages to compensate the public for the impaired resource.

Unique Wetlands

Fens are unique wetlands that require groundwater flow to be sustained. These habitats support many rare types of plants and animals by creating an environment of steady soil saturation. Fen types are defined by geographic location and vegetation growth. In Michigan, all fens are listed as either vulnerable or imperiled. For example, Prairie Fens occur where cold, calcareous groundwater flows through the community's organic soil and reaches the surface in the form of perennial springs and seeps.

Although it is impracticable in some cases to clean up existing contaminated sites completely, parties that contaminate groundwater now, and in the future, should be held fully accountable. To allow "institutional controls" as the remedy for these sites is, in essence, to say that current and future polluters can use a portion of Michigan's groundwater resources as a waste receptacle, minimizing both operational and cleanup costs.

INFORMATION, DATA, AND EXPOSURE HAZARDS

Poorly collected, stored, and retrievable data management complicates groundwater and soil monitoring and cleanup in Michigan. The current state database is not up to date. Data needed to address groundwater contamination is scattered across multiple sources. Many obstacles to addressing groundwater contamination at the state level relate to capacity and available resources. A lack of resources makes mapping groundwater contamination difficult.

A particular problem is the absence of an accessible, centralized database of locations where the state's policy of leaving groundwater contamination in place could pose future hazards. There are thousands of sites in Michigan with groundwater contamination where soil contamination, concentrated wastes, or containment systems are left in place.

Because adequate information about these sites is not easily accessible to the public, there is a risk of accidental exposures or damage to exposure barriers, test wells, or containment structures. There is no effective system to alert personnel unfamiliar with a site about the potential hazards. Yet construction, excavation, utility, and maintenance work go on daily throughout the state. Owners of properties with deed restrictions resist clearly marking things like exposure barriers, even when required to do so.

Michigan should institute a public database and notification system for contaminated properties similar to the state's successful MISS DIG program for identifying the location of underground utilities.

Michigan should institute a public database and notification system for contaminated properties similar to the state's successful MISS DIG program for identifying the location of underground utilities.

MISS DIG 811 is a one-call notification system to provide excavators and the general public the ability to inform multiple owners of underground facilities, such as gas lines, of planned excavation with a single call. MISS DIG 811 has received over 21 million locate requests resulting in nearly 189 million transmissions since 1970. MISS DIG 811 is a non-profit company that passes the call information along to affected utilities. The utilities are then required to mark their utilities within a specified time period. The MISS DIG 811 system is designed and operated for the express purpose of assuring that excavation activities do not inadvertently damage buried utility infrastructure or cause safety hazards.

A similar system makes sense for contaminated properties that could pose health and safety hazards. The most efficient approach may be to piggyback in some fashion with MISS DIG 811, so that one call to it results in a notification to EGLE. MISS DIG operation staff would need to know where contaminated sites are and EGLE would need to follow-up in some fashion. This would require some additional funding. That funding should come from liable parties or property owners when they choose to leave contamination in place rather than adequately cleaning it up.

FEDERAL AND STATE LIABILITY LAWS

In the 1970s and 1980s, responding to historical discharges of industrial wastes and hazardous substances, governments backed by strong public support enacted powerful new laws that imposed broad legal liability on parties the law deemed responsible for these hazardous conditions.

Public outrage concerning the uncontrolled release of toxic substances into the environment propelled the enactment by Congress in 1980 of the Comprehensive Environmental Response, Compensation and Liability Act, known as CERCLA or "Superfund." The sensational national case often linked to passage of the law is the infamous Love Canal in New York, where Hooker Chemical Company disposed of thousands of tons of hazardous wastes resulting in profound public health impacts in a residential neighborhood. But Michigan had many similar cases, including a massive contamination site created by the same Hooker Chemical Company at Montague, north of Muskegon. Years of improper management of chemical wastes – including a "barrel dump" behind the facility – led to a large area of contaminated groundwater and soils, and public fears about health impacts.

CERCLA's liability provisions were designed not only to capture money from responsible parties for clean-up, but also to deter future mismanagement of toxic chemicals. The new law imposed "strict liability" on both current and former owners and operators of contaminated sites regardless of whether they were at fault, negligent, or otherwise responsible for the hazardous conditions, including those who "transported" or "arranged for the disposal" of the hazardous substances. Historically, strict liability had attached to those persons or parties who engaged in abnormally dangerous or ultrahazardous activities. By crafting CERCLA's liability provisions, Congress was clearly indicating that the handling of hazardous wastes and toxic substances was an activity that inherently threatened and endan-

Au Sable River

Trout Streams

Trout, one of Michigan's most prized game fish, rely on the water conditions that result from groundwater inputs, which maintain water levels throughout the year and keep water temperatures low. And cold water equals more available oxygen for fish. Large amounts of groundwater moderate stream temperatures throughout the year, keeping them cooler in the summer and warmer in the winter. In Michigan, an estimated 29,538 miles of stream support trout and are legally classified as Designated Trout Streams.

gered public health and safety and the environment and merited expansion of the "responsible parties."

CERCLA's legal framework also imposed "joint and several liability" on parties responsible for the release of hazardous substances. When multiple parties are jointly and severally liable for the environmental harm, each party is independently liable for the full extent of the liability associated with the harm. The law then provides for "contribution claims" that allow the responsible party to seek legal contributions from other responsible parties. In this way, joint and several liability switches much of the burden of identifying all the responsible parties from the government to the defendants who are in the best position to know the most about who may be responsible for the conditions at a site. Strict, joint and several liability provides a powerful financial incentive for businesses, corporate managers, and employees to implement waste handling practices that minimize the threat or harm to the environment.

Numerous studies have shown that strong environmental liability measures have a deterrent effect and influence the behavior of corporate managers to reduce environmental risks that can result in liability. Those who perceive that environmental laws are strong are significantly less likely to engage in noncompliant behavior. These studies are consistent with the findings of long-term research that strong environmental regulations not only reduce the threat of future environmental harm, but also have a beneficial effect on the economy.

State legislatures followed Congress by enacting CERCLA-like state laws, strengthening the states' legal authority to redress conditions creating environmental harm. In 1990, the Michigan Legislature enacted a "polluter pay" law with strong contamination liability provisions. In its first five years, the law resulted in $100 million in private-party costs for cleanup that otherwise could have shifted to the public or gone unfunded. But just five years later, in 1995, the Legislature in effect repealed the liability provisions, weakening the state's ability to capture funds from parties who are responsible for contamination. A review of this policy reversal is in order, as Michigan places an undue burden on the general public to pay for cleanup of private pollution through tax revenues.

CHAPTER 5

Recommendations: Building Blocks for a Michigan Groundwater Protection Act

Michigan should formally adopt a groundwater policy that calls for protection of groundwater as part of a single, hydrological whole. In connection with streams, lakes, and wetlands, groundwater is held in trust for the benefit of citizens, protected from pollution or impairment, a critical drinking water source, directly related to public health. The policy should emphasize the state's primary duty to prevent pollution of groundwater or its connected waters of the state, and to support public education concerning groundwater consistent with this overall policy.

REGULATION OF TOXIC CHEMICALS

Michigan state government was the first to cancel most uses of DDT—in 1969, three years before the federal ban. Michigan also took early action to control PCBs, chlordane and other toxic chemicals. This tradition should be a guidepost for the state today.

The State of Michigan should immediately begin the process of reviewing TCE uses and, where feasible and prudent alternatives exist, ban such uses. Additionally, Michigan should review the chemical pollutants most prevalent in Michigan's groundwater and set priorities for study and banning or stricter control.

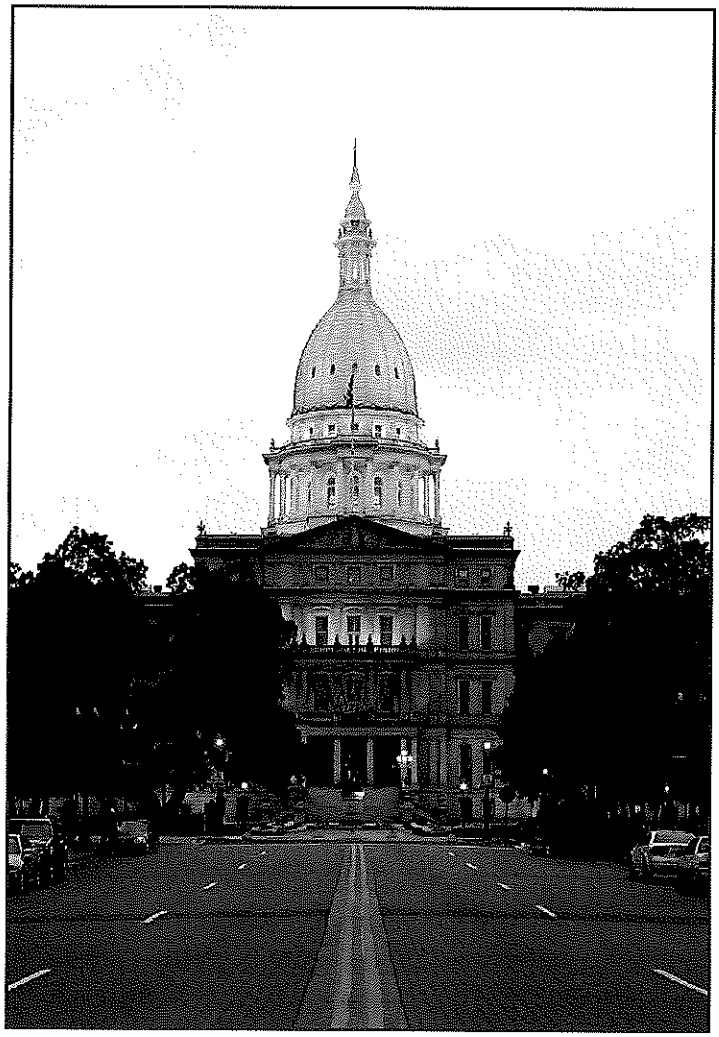
The U.S. must adopt the precautionary principle -- taking preventive action in the face of uncertain but potentially great risk—as the foundation of chemical policy and regulation. Current and past policies that rarely call for upfront testing of chemicals have contributed to problem after problem with an alphabet soup of toxic compounds, from PCBs to PBDEs.

LIABILITY FOR CONTAMINATION

Michigan should reinstate the polluter pay laws abandoned in 1995, with strict, joint and several liability for contamination sites identified beginning with the effective date of this amendment.

FULL CLEANUP AND/OR DAMAGES

For new contamination sites, Michigan should require the assessment of fines, penalties, and damages for impairment of the groundwater resource and should require full cleanup by responsible parties unless technically infeasible. In such cases, the dollar amount of fines, penalties, and damages should be escalated.



The Michigan State Capitol in Lansing.

EMPOWERING AFFECTED PERSONS AND COMMUNITIES' LEGAL RIGHTS

When groundwater contamination threatens persons, families, and communities with serious harm or damages from groundwater contamination, these persons and communities should have access to all relevant hydrogeological, ecological, health, and related infor-

mation, and a right to intervene or participate in state cleanup or enforcement proceedings to protect their interests. The affected residents and communities should have a statutory right to a civil suit or action to address the pollution or threatened pollution of their groundwater or affected creeks, streams, and lakes. The relief should include cleanup, damages, and injunctive or equitable orders. Because of the immense cost for needed experts and attorneys, the law should provide that a court may award to the affected residents and communities "costs, interests, and fees, including legal fees, in the interests of justice."

ASSURING PUBLIC SAFETY AND ENVIRONMENTAL PROTECTION AT CONTAMINATED SITES

Because state policy in Michigan has allowed thousands of sites to remain contaminated rather than being fully cleaned up, there is a risk of explosions, toxic exposures, or environmental damage at such sites when there is excavation or other activities that disturb the subsurface. The state should create a one-call system where parties who intend to conduct excavation can learn whether contaminants that cause such hazards exist on specific sites.

WATER TESTING

Michigan homeowners with private wells are not served by routine water testing and may unknowingly consume contaminated water. The state should create a fund to assist such homeowners, largely in rural areas, in regular water well testing.

INFORMATION AND DATA

Improved groundwater quality protection will depend to a great degree on improved understanding of the resource. To move in that direction, the State of Michigan and partners in research and groundwater management institutions should:

- Establish a framework to organize data, knowledge, and understanding of hydrologic systems, and develop an understanding of data gaps and informational needs that will result in better programmatic oversight of groundwater.
- Gain a better understanding of existing sites of known groundwater contamination by supporting an enhanced monitoring program that can characterize groundwater quality, aquifer profiles, and groundwater flow direction.
- Better integrate existing databases and monitoring capabilities—MiWaters should redouble efforts to integrate and systematize the existing network of groundwater monitoring capacities. Existing databases like WellLogic, Wellhead Protection, U.S. Geological Survey groundwater data for Michigan, Michigan State University's groundwater inventory and mapping project, and Western Michigan University's archive of subsurface geological data could be better integrated and used to inform and improve our understanding of groundwater productivity and flows.
- Establish an educational program within EGLE, supported by the Michigan Department of Agriculture and Rural Development and the Department of Health and Human Services for local units of government directed at improving groundwater protection. The education program should address at least the following topics: hydrogeologic principles, groundwater protection issues, state groundwater policy, potential contamination sources, potential water quality problems, well protection measures, and the need for periodic well tests.

Offshore Sinkholes

One of the most interesting connections between groundwater and surface water manifests as sinkholes in Lake Huron. These sinkholes were discovered in 2001 while researchers were looking for shipwrecks. They range in size from a few feet to the size of a football field.

Lake Huron sits on an ancient sea bed that, when it evaporated, left deposits of salt and sulfur. As groundwater is released in the sinkholes, it passes through these deposits creating an environment that is deprived of oxygen and high in saline and sulfur. Only unique lifeforms can survive here, and researchers are still exploring this region.

STATEWIDE GROUNDWATER POLLUTION RANKING

The state of Michigan should reinstate an annual report based on a comprehensive public database that identifies and ranks by degree of hazard all sites of contaminated groundwater and connected overlying land as well as downgradient groundwater, creeks, streams, lakes, and wetlands. The database should be part of Michigan's publicly accessible geographic information system for mapping. This database and mapping can build on, and provide better site specific hydrogeological, ecological, and pollution information under, Public Act 142, Michigan Public Acts of 2003.[44]

Liam Schamper collects groundwater flowing into a cistern at a historic farm on Old Mission Peninsula. The water then flows into the east arm of Grand Traverse Bay. He is learning about the water cycle and how to analyze the water for his Cub Scout STEM award. (Credit: Rick Kane)

Conclusion

Michigan groundwater policy has failed to evolve even as understanding has grown about groundwater's importance and its interconnection with the Great Lakes. The simple fact that Michigan has approximately 7,000 orphan groundwater contamination sites with an estimated cleanup bill of $1.4 billion—likely to be charged to taxpayers—should make groundwater a public policy imperative.

The first major step toward fulfilling the public commitment to groundwater is the enactment of a Michigan Groundwater Protection Act with elements described in this *Deep Threats* report. FLOW stands ready to engage in good faith discussions about this with parties both outside and inside of government. We believe such discussions will result in better stewardship of Michigan's priceless groundwater.

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[9] Id.; e.g. Vt. Stats., Title 10, Sec. 1390.

[10] See, generally, Michael Blumm and Mary Woods, The Public Trust Doctrine in ENvironmental and Natural Resources Law (Carolina Press, 2013); James Olson, All Aboard: Navigating the Course for Universal Adoption of the Public Trust Doctrine, 15 Vt. J. Env. Law, 135-191 (2015).

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[40] MCL 324.3101 et seq. "The department shall protect and conserve the water resources of the state and shall have control of the pollution of surface or underground waters of the state and the Great Lakes, which are or may be affected by waste disposal of any person. MCL 3243103(1).

[41] Mich Const. 1963, art. 4, sec. 52. Air, water, and natural resources are declared to be of "paramount public concern" or public interest. The Supreme Court has interpreted the provision to be self-executing on the legislature and in some instances to impose an overall legal duty on state and local governments to prevent or minimize likely environmental degradation. Highway Department v Vanderkloot, 392 Mich 159 (1974); Ray v Mason County Drain Comm'r, 393 Mich 294 (1975).

[42] The waters of the state are valuable public natural resources held in trust by the state, and the state has a duty as trustee to manage its waters effectively for the use and enjoyment of present and future residents and for the protection of the environment." MCL 324.32702(1)(c) and (d).

[43] Vt. Stats., Title 10, Sec. 1390.

[44] 2003 PA 142; see https://www.egr.msu.edu/igw/GWIM%20Figure%20Webpage/.

TAKE ACTION TO PROTECT GROUNDWATER

Take action and help protect the groundwater that current and future generations need.
Ways to help:

- Dispose of toxic household chemicals, as well as used oil and antifreeze, through a local hazardous waste center.
- Utilize organic or slow-release fertilizers on your property.
- Share this *Deep Threats* report with friends who may be interested and organizations that can make a difference. Contact FLOW for more information and additional copies.
- Contact your state and local lawmakers: Express concern to your state senator, state representative, and local elected officials.
- Sign petitions to make your voice heard. See FLOW's list here.
- Have a private well or septic tank? Resources for maintenance and testing: EGLE: SepticSmart; Michigan State University on how to protect the quality of your water well.

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FLOW
FOR LOVE OF WATER

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