Great Lakes WISE

February 2025

Regional Gap Analysis

Understanding gaps and opportunities for corporate water stewardship and watershed protection in the Great Lakes region

Regional Gap Analysis February 2025

Great Lakes WISE
Water Innovation and Stewardship Exchange

POWERED BY COUNCIL OF THE GREAT LAKES REGION
Solving for Sustainability®

FRESH COAST Climate Solutions

Report prepared by Fresh Coast Climate Solutions

Acknowledgement

CGLR would like to thank the following founding partners of Great Lakes WISE for their support and commitment to water stewardship and sustainable best practice in the Great Lakes region. Their shared experience and insights on best practices and water stewardship were valuable contributions to the gap analysis process.

Special acknowledgement goes to Fresh Coast Climate Solutions, particularly Matthew Paper and Rae Mindock, who diligently carried out the regional gap analysis to produce this report.

This regional positioning gap analysis will serve as the foundation for developing a strategy and forming project ideas that can be carried out collectively through Great Lakes WISE.

Table of Contents

List of Tables

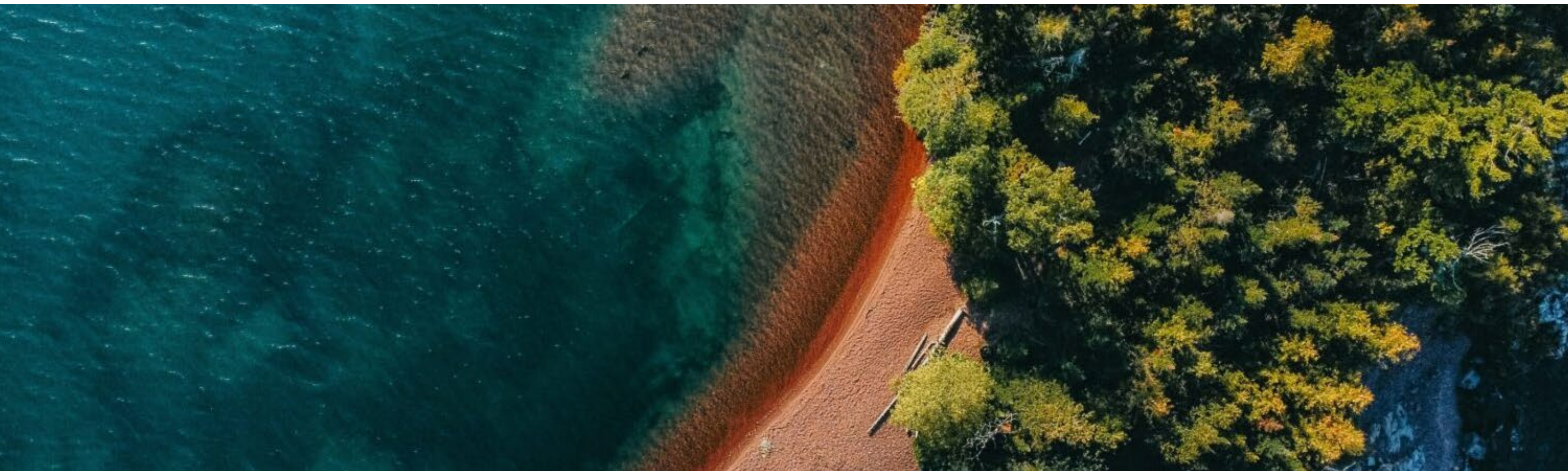
List of Figures

Abbreviations

AMI Advanced Metering Infrastructure
BAP Biological Assessment Profile
BMPs Best Management Practices
BOD Biochemical Oxygen Demand
CABIN Canadian Aquatic Biomonitoring Network
CAWS Chicago Area Waterway System
CECs Contaminants of Emerging Concern
CEPA Canadian Environmental Protection Act
CESI Canadian Environmental Sustainability Indicators
CEW Circular Economy of Water
CGLR Council of the Great Lakes Region
CMCs Chemicals of Mutual Concern
COA Canada -Ontario Agreement on Great Lakes Water Quality and Ecosystem Health
CO-OPS NOAA's Center for Operational Oceanographic Products and Services
CSOs Combined Sewer Overflows
CWA Clean Water Act
CWA Canada Water Agency
DEC Department of Environmental Conservation
DEP Department of Environmental Protection
DOH Department of Health
DOW Division of Water
DPR Direct Potable Reuse
DWSP Drinking Water Surveillance Program
ECCC Environment and Climate Change Canada
EGLE Michigan Department of Environment, Great Lakes, and Energy
EPA Environmental Protection Agency
EQIP Environmental Quality Incentives Program
FAP Freshwater Action Plan
GLOS Great Lakes Observing System
GLPI Great Lakes Protection Initiative
GLRI Great Lakes Restoration Initiative
GLWA Great Lakes Water Authority
GLWQA Great Lakes Water Quality Agreement

Abbreviations (Cont.d)

HABs	Harmful Algal Blooms
HBCD	Hexabromocyclododecane
IDEM	Indiana Department of Environmental Management
IDNR	Illinois Department of Natural Resources
IJC	International Joint Commission
LC-PFCAs	Long-Chain Perfluorinated carboxylic acids
LEAUs	Lake Erie Assessment Units
LRAUs	Large River Assessment Units
MAPAQ	Ministry of Agriculture, Fisheries and Food
MDA	Minnesota Department of Agriculture
MDARD	Michigan Department of Agriculture and Rural Development
MDH	Minnesota Department of Health
MDHHS	Michigan Department of Health and Human Services
MDNR	Michigan Department of Natural Resources
MDNR	Minnesota Department of Natural Resources
MECP	Ontario Ministry of the Environment, Conservation and Parks
MELCC	Ministry of the Environment and the Fight Against Climate Change
MFFP	Quebec Ministry of Forests, Wildlife and Parks
MGD	Million Gallons per Day
MiCorps	Michigan Clean Water Corps
MPCA	Minnesota Pollution Control Agency
NGOs	Non-Governmental Organizations
NHN	National Hydrometric Network
NHS	National Hydrological Service
NRCS	Natural Resources Conservation Service
NSRPS	National Surface and River Prediction System
NWDC	National Water Availability Assessment Data Companion
NYSERDA	New York State Energy Research and Development Authority
ODH	Ohio Department of Health
ODNR	Ohio Department of Natural Resources
Ohio EPA	Ohio Environmental Protection Agency
ORAUs	Ohio River Assessment Units
OWDA	Ohio Water Development Authority
PACES	Groundwater Knowledge Acquisition Program
PCBs	Polychlorinated Biphenyls
PDWS	Public Drinking Water Supply
PFAS	Per- and Polyfluoroalkyl Substances
PFOS	Perfluorooctane Sulfonate
PWQMN	Provincial (Stream) Water Quality Monitoring Network
SCCPs	Short-Chain Chlorinated Paraffins
SP	Suppliers Partnership for the Environment
SRBC	Susquehanna River Basin Commission
TDS	Total Dissolved Solids
TMDLs	Total Maximum Daily Loads
TSCA	Toxic Substances Control Act
TSS	Total Suspended Solids
TWC	The Water Council
USDA	U.S. Department of Agriculture
USGS	US Geological Survey
VOCs	Volatile Organic Compounds
WAUs	Watershed Assessment Units
WDNR	Wisconsin Department of Natural Resources
WISE	(Great Lakes) Water Innovation and Stewardship Exchange
WPDES	Wisconsin Pollutant Discharge Elimination System
WWTPs	Wastewater treatment plants



Executive Summary

This regional gap analysis set out to dive deep into the challenges surrounding water resource management in the Great Lakes region, focusing on the combined effects of climate change, population growth, economic development, aging infrastructure, and emerging contaminants. The goal is to understand how these pressures are impacting the region's water system and to identify solutions that help protect water quality, ensure sustainability, and build resilience for the future. By exploring adaptive strategies and fostering collaboration across various sectors, this paper seeks to offer practical best practices for a balanced and sustainable approach to managing the Great Lakes region's vital freshwater resources.

Agreements like the Great Lakes Water Quality Agreement (GLWQA) and the Great Lakes Restoration Initiative (GLRI) in the US and the Great Lakes Freshwater Ecosystem Initiative in Candada are crucial in guiding efforts to protect the lakes. These agreements emphasize collaboration between the U.S. and Canada, as well as the involvement of Indigenous communities and non-governmental organizations. These frameworks can be used by further incorporating Indigenous knowledge and improving cross-jurisdictional coordination to achieve lasting, effective solutions.

As the population in the Great Lakes region grows, so does the demand for water, which places additional strain on water resources and often leads to poorer water quality. Urban and agricultural development, particularly in the southern basins, contributes to pollution and runoff. If not carefully managed, this growth can accelerate environmental degradation and make water resources harder to manage.

Much of the region's infrastructure is outdated and ill-equipped to handle the increased pressure from population growth, climate change, and more frequent storms. Aging sewer systems and combined sewer overflows (CSOs), where untreated sewage is released into lakes and waterways, are still occurring. To avoid further damage, the region needs significant investments in infrastructure upgrades, along with better land-use planning and stronger regulations.

New emerging contaminants like PFAS, microplastics, and pharmaceuticals are entering the region's water systems through wastewater, agricultural runoff, and industrial discharge. These pollutants pose a threat to both environmental and human health. While steps are being taken in both the U.S. and Canada to address the contamination, more research, expanded regulations, and better coordination are needed to tackle the growing problem.

Companies in the Great Lakes region are increasingly recognizing the importance of responsible water stewardship and aware of their opportunity to drive impact through enterprise-wide actions. Scaling up the practices of reduction, reuse and recycling within operations and across corporate structure requires better education, incentives, and partnerships between public and private sectors to ensure widespread adoption and implementation.

Introduction

The Great Lakes mega-region (here on refered to as region), encompassing eight U.S. states (Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York), two Canadian provinces (Ontario and Quebec) and hundreds of First Nations and Tribal communities, is a critically important area, both environmentally and economically (Figure 1).

Economically, the Great Lakes region is a juggernaut, contributing a combined US$8.0 trillion in economic activity to the U.S. and Canadian economies, which is greater than the economies of most nations, including Japan, Germany, India, France, and the United Kingdom. Due the size of the region's industrial base, the region generates more than half of U.S./Canada cross-border trade (1). Key business sectors by employment and industry concentration includes education and health, manufacturing, financial and real estate, transportation and warehousing, energy and water utilities, construction, professional services, leisure and hospitality, and government. The Great Lakes region also accounts for approximately 60% of North America's steel production and is a prominent provider of North America's grain, corn, and soybeans (2).

In addition to these traditional industries, the Great Lakes region is seeing growth in new sectors such as semiconductor manufacturing, data centers, biopharmaceuticals, and clean energy technologies. These emerging industries are attracted by the region's abundant water resources, reliable and mixed power supply (e.g., nuclear, hydroelectric, natural gas, solar, wind, etc.), favorable climate conditions, and skilled workforce, among many other attributes of the region's investment attraction and economic development.

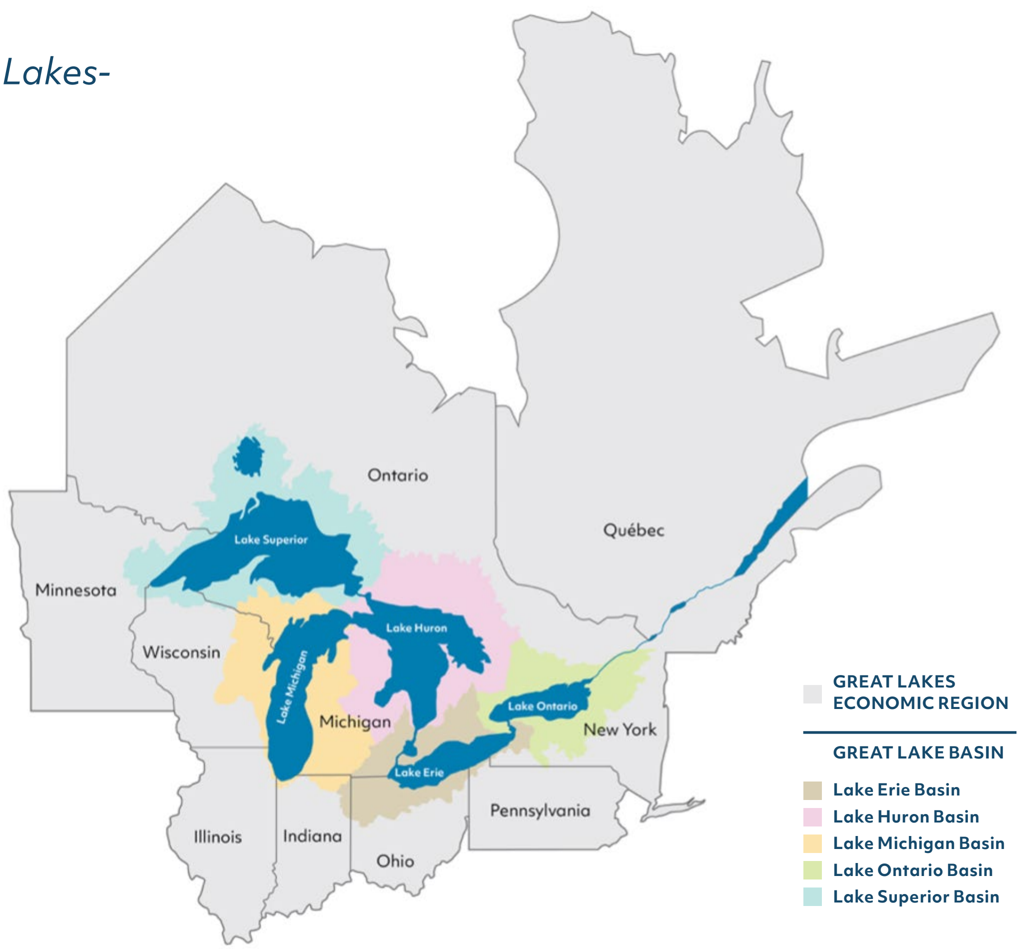
At the heart of this economic engine, are the five Great Lakes—Superior, Michigan, Huron, Erie, and Ontario—which collectively hold 20% of the world's and 84% of North America's surface fresh water supply (3). This inland sea, together with the region's other surface water resources and underground aquifers, sustain numerous species of fish, birds, and other wildlife as well as the livelihoods of over 110,000 million Americans and Canadians, with some 40 million residents living in the Great Lakes basin.

Great Lakes Water Innovation and Stewardship Exchange (WISE)

The Great Lakes Water Innovation and Stewardship Exchange (WISE), administered by the Council of the Great Lakes Region (CGLR) and supported by The Water Council (TWC), is a collaborative initiative aimed at advancing water sustainability and stewardship in the Great Lakes region. This peer-to-peer network brings together cross-sector stakeholders, including businesses, academic institutions, and NGOs, to develop and implement effective water sustainability solutions. The program focuses on enhancing corporate water stewardship, addressing regional water challenges, and fostering innovation through collective action. WISE has initiated this regional gap analysis to understand how the region is positioned with respect to best practices, including corporate stewardship, water use, water quality, vulnerabilities, policy, data gaps, and stakeholder engagement.

Given the region's economic and ecological significance, there is a pressing need to assess the current status of water resources in the Great Lakes basin and the broader region, this regional gap analysis aims to provide a comprehensive overview of regional water use, quality, policies, data gaps, vulnerabilities, and corporate water stewardship practices. Findings from this gap analysis will be used to develop a strategy and action plan for Great Lakes WISE.

Figure 1 – *The Great Lakes-Region and Basin*



Great Lakes Regional Governance

The Great Lakes region and basin benefit from a robust framework of federal and state/provincial policies, regulations and international agreements and compacts aimed at protecting its water resources and ecosystems. For example, the Boundary Waters Treaty of 1909, which created the International Joint Commission, provides a framework for preventing and resolving disputes over the use of the waters shared by Canada and the United States and to settle other transboundary issues.

More recently, the 1972 United States-Canada Great Lakes Water Quality Agreement (GLWQA), amended in 1983 and 1987 and updated in 2012, exemplifies the collaborative efforts to protect the physical, chemical, and biological integrity of this life sustaining natural resource. This agreement has led to significant improvements in water quality, such as the reduction of toxic chemicals managing nutrients and restoring habitats (4).

Ultimately, the goals and targets of the GLWQA aim to balance economic activity with environmental protection, ensuring the long-term health of the Great Lakes ecosystem. These collaborative efforts, involving multiple levels of government and stakeholders, are essential for maintaining the environmental health and economic vitality of not only the Great Lakes, but also the Great Lakes basin and the broader region.

Additionally, the Great Lakes Restoration Initiative (GLRI), a federal U.S. program created in 2010, provides funding to address some of the biggest threats to the Great Lakes, issuing 5-year Action Plans to accelerate U.S. federal actions to address key issues such as invasive species, nonpoint source pollution, and habitat restoration (5). Similarly, Canada's Freshwater Action Plan (FAP) renewed in 2023 further supports these efforts by funding initiatives like the Great Lakes Freshwater Ecosystem Initiative (FEI), which targets harmful algae, chemical pollutants, and nearshore water quality (1).

These federal programs and cross-border agreements, when coupled with other federal statutes, set the policies and strategies and priorities for restoring and protecting the Great Lakes and the region's surface and ground water resources, as well as the standards and permitting requirements for allowable levels of pollution discharges and water usage that are then enforced by the responsible federal or state/provincial agency.

The agencies mostly in charge of overseeing the management, protection, and restoration of the Great Lakes and the region's water resources are the U.S. Environmental Protection Agency (EPA) and Environment and Climate Change Canada (ECCC) in collaboration with the new Canada Water Agency (CWA), a federal body created to coordinate federal efforts to manage and protect Canada's freshwater resources, including those in the Great Lakes basin, supporting initiatives to improve water quality, enhance water security, and promote sustainable water use.

For its part, the U.S. EPA coordinates with other federal departments and agencies, states, local communities, tribes, regional bodies, and other interests through the Great Lakes Agency Task Force and Regional Working Group. In Canada, ECCC and CWA are the primary federal authorities responsible for environmental protection, including water quality in the Great Lakes, conducting scientific research, monitoring water quality, and enforcing regulations to reduce pollution in partnership with other federal departments, notably Fisheries and Oceans Canada, Natural Resources Canada and Agriculture and Agri-Food Canada. In addition, in Canada, the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health (COA) provideds a five year coordinated federal-provincial (multi-agency) action plan which outlines specific actions in the province of Ontario relating to the protection and restoration of the Great Lakes, focusing on reducing harmful pollutants, restoring degraded areas, and conserving aquatic habitats. The Ontario Ministry of the Environment, Conservation and Parks (MECP) is the lead provincial ministry responsible for developing and implementing provincial policies and regulations related to water quality and conservation in Ontario, working closely with federal agencies and local stakeholders. The Great Lakes basin benefits from a robust framework of policies and agreements aimed at protecting its water resources and ecosystems.

Table 1 – *Hierarchical Governance Framework in the Great Lakes Region*

International	**Great Lakes Water Quality Agreement (GLWQA)**	Framework for U.S.-Canada cooperation on restoring water quality and ecosystem health.
	International Joint Commission (IJC)	Resolves disputes and monitors water quality under the 1909 **Boundary Waters Treaty** and **GLWQA.**
	Great Lakes Fishery Commission (GLFC)	Manages fisheries and controls invasive species under the 1954 **Convention on Great Lakes Fisheries.**
	Boundary Waters Treaty	Protects boundary water shared by Canada and the United States
Federal (Canada)	**Environment and Climate Change Canada (ECCC)**	Leads water quality research and monitoring and GLWQA implementation in Canada.
	Fisheries and Oceans Canada (DFO)	Manages fisheries and aquatic habitats in the Great Lakes region.
	Canadian Water Agency (CWA)	Emerging body to coordinate national freshwater management and federal-provincial efforts.
Federal (U.S.)	**U.S. Environmental Protection Agency (EPA)**	Leads U.S. efforts under the GLWQA, manages Areas of Concern (AOCs), and enforces the Clean Water Act.
	U.S. Army Corps of Engineers (USACE)	Manages water levels, dredging, and restoration projects in the Great Lakes region.
	National Oceanic and Atmospheric Administration (NOAA)	Provides climate data, supports habitat restoration, and contributes to the Great Lakes Restoration Initiative.
Regional Frameworks	**Great Lakes–St. Lawrence River Basin Sustainable Water Resources Agreement**	Establishes sustainable water use and diversion prevention among U.S. states, Ontario, and Quebec.
	Great Lakes Compact	Legally binding agreement among eight U.S. states to regulate water withdrawals.
	Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem	Coordinates federal and provincial actions in Ontario to restore and protect Great Lakes water quality.
	Great Lakes Commission (GLC)	Coordinates water resource management and policy alignment among U.S. states and Canadian provinces.
	Council of Great Lakes Governors and Premiers	Aligns policies across states and provinces for sustainable growth and water protection.
State/Provincial (U.S.)	**Minnesota Pollution Control Agency (MPCA)**	Protects water resources through permitting, monitoring, and enforcement.

	Wisconsin Department of Natural Resources (WDNR)	Oversees water quality, fisheries, and wetland protection in Wisconsin.
	Illinois Environmental Protection Agency (IEPA)	Implements water quality standards and pollution control measures in Illinois.
	Indiana Department of Environmental Management (IDEM)	Manages water permitting, pollution control, and remediation efforts in Indiana.
	Michigan Department of Environment, Great Lakes, and Energy (EGLE)	Regulates water use, protects the Great Lakes, and manages pollution in Michigan.
	Ohio Environmental Protection Agency (Ohio EPA)	Monitors and restores water quality, especially in the Lake Erie basin.
	Pennsylvania Department of Environmental Protection (PA DEP)	Manages water resources and quality in the Lake Erie watershed.
	New York State Department of Environmental Conservation (NYSDEC)	Supports water quality standards and restoration efforts in New York.
State/Provincial (Canada)	**Ontario Ministry of the Environment, Conservation and Parks (MECP)**	Manages water quality and conservation efforts in Ontario.
	Quebec Ministry of the Environment, Fight Against Climate Change, Wildlife, and Parks (MELCCFP)	Oversees water management for the St. Lawrence River and tributaries in Quebec.

Table 1: Hierarchical governance framework for water quality and ecosystem health in the Great Lakes region: key international, federal, provincial/state, and regional entities, agreements, and compacts providing oversight of water quality in the Great Lakes region.

However, despite the federal and state/provincial laws, policies and programs that exist, the Great Lakes still faces environmental challenges, with both the U.S. EPA and the ECCC rating the health of the Great Lakes as fair and unchanging in their 2022 State of the Great Lakes report (6). For instance, the 2014 Toledo water crisis, where microcystin contamination from algal blooms rendered the water supply unsafe and unusable, underscores the importance of source water protection and the adoption of water quality management best practices from an agricultural perspective. Other notable concerns include toxic chemicals, contaminants in edible fish, invasive species and habitat loss, nutrients, and climate change. Similar issues and concerns exist across the entire Great Lakes region. The diverse industrial activities in the Great Lakes region utilize vast land areas and natural resources, such as water, making sustainable management crucial for maintaining both the region's economic vitality and environmental health, highlighting the need for industries to fully integrate environmental conservation and protection practices into their business to prevent or mitigate the impacts of their operations, including water withdrawals, use, and effluent.

Current Water Landscape

Much of the Great Lakes economic region relies heavily on the Great Lakes for water withdrawal, usage, and availability, supporting a diverse range of activities from public supply, transportation and toursim to industrial use. The USGS Water Resource Mission Area plays a vital role in monitoring and managing water resources in the U.S. states, while the ECCC provides comprehensive regional monitoring for the Canadian provinces. The USGS National Water Availability Assessment and its companion tool, the National Water Availability Assessment Data Companion (NWDC) released in January 2024, provide comprehensive and regularly updated information on water quantity, quality, and use across the United States. Water quantity data includes groundwater data when available. These assessments, produced by the USGS Water Resource Mission Area, offer insights into historical, current, and future water availability, helping to identify areas where water supply may not meet demand. The NWDC extends the data available through the USGS Water Data for the Nation by offering modeled data and long-term trend calculations, supporting better water management decisions. Currently, the most up to date report available is the USGS 2018 Estimated use of water in the United States in 2015 which provides insight into water use from 1950-2015. With the improvements suggested by the USGS Water Resource Mission Area, water use models are available for 2000-2020 for public supply, self-supplied thermoelectric power, and self-supplied crop irrigation and a compiled report is expected in 2025.

In Canada, a similar role is played by the CWA and ECCC, which conduct extensive monitoring and reporting on water resources. CWA and ECCC programs, such as the Canada Water Act and the Canadian Environmental Sustainability Indicators (CESI), provide critical data on water quality and quantity, supporting sustainable water management practices across the country. Both the USGS and CWA/ECCC programs are essential for understanding and managing water resources in their respective nations, ensuring the long-term sustainability of these vital resources.

Figure 2 – *Total Freshwater and Saline-Water Withdrawals*

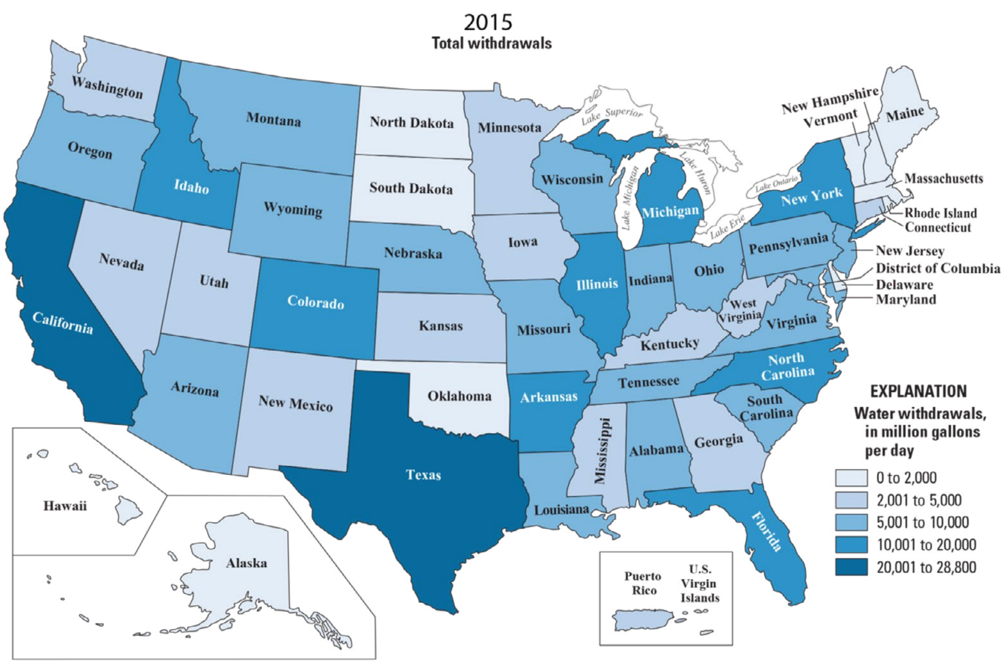


Figure 2: Total freshwater and saline-water withdrawals for 2015 across the United States. Image extracted from U.S. Geological Survey, Estimated Use of Water in the United States in 2015. Avaliable at: https://pubs.usgs.gov/circ/1441/circ1441.pdf

In the U.S. Great Lakes states, the largest water withdrawals—driven by public supply, thermoelectric power generation, industrial use, and irrigation—align with the USGS Water Resource Mission Area's identified major use categories. Figure 2 illustrates the total water withdrawal across the 50 States. Of the total 322 bgal/d (1,219 $milm^3$/day) extracted from surface and ground water systems across the US, the states of Illinois, Michigan, and New York withdrawals equated to an estimated 10,500, 10,100, and 10,800 mgal/d (39.7, 38.2, and 40.9 $milm^3$/day) respectively, with much of the water coming from the Great Lakes basin (7).

In Canda, 27.7 bgal/day (104.8 million m^3/day) of water were withdrawn from Canada's rivers, lakes, groundwater and oceans in 2013 (8). ECCC's regional monitoring indicates that Ontario's water withdrawal is dominated by public supply, industrial use, and power generation. Ontario's total water withdrawal rate (including volumes from industrial users) is approximately 2.52 bgal/day (9,55 milm³/day) in 2013, positioning it among the higher water-withdrawing provinces in Canada (9). Key aspects of water withdrawal in Ontario include its high per capita usage, which places the province near the top in Canada. The industrial sector, particularly mining, contributes significantly to water withdrawal in certain regions. To address these concerns, Ontario has implemented water management programs and regulations that require permits for large-scale water withdrawals, ensuring more sustainable use of its water resources.

As of 2022, Quebec's water withdrawal patterns show that municipalities, especially Montreal, are the largest consumers of water in the province, with industrial sectors such as aluminum production and paper mills also contributing significantly. While agricultural water use is lower, it still plays a role in overall consumption. According to data from the Conference Board of Canada, the total water withdrawal for Quebec was approximately 2.19 bgal/day (8.29 milm³/day) (9). To address water usage and ensure sustainability, Quebec introduced Bill 20 in 2023, which mandates companies to declare their water withdrawals and establishes the Blue Fund for improved resource management. These efforts aim to increase transparency and support sustainable water use across the province.

The Great Lakes region's industrial water use, driven by manufacturing, paper production, and petroleum refining, is projected to grow modestly under moderate economic scenarios and significantly under high-growth scenarios. Structural shifts toward less water-intensive industries and improved efficiency may mitigate overall demand, though localized increases could strain water resources in areas with limited capacity (10). Thermoelectric power generation remains a major water user. Technological advances like closed-loop cooling systems are expected to lower withdrawal rates while increasing consumptive use. Population growth and rising temperatures could drive higher electricity demand, particularly under drier scenarios, intensifying competition for water resources. Agriculture, though a smaller water user in the region, remains crucial. Climate variability will shape demand, with dry scenarios requiring more irrigation due to higher evapotranspiration, while wet scenarios may reduce water needs. Adaptation will be essential in agricultural areas to sustain resources under drier conditions (11).

Total consumptive water use projections range widely:

- Best-Case Scenario: Up to 8% decrease with moderate emissions and wetter conditions.
- Worst-Case Scenario: Up to 235% increase, driven by high emissions, population growth, and increased agricultural and thermoelectric demand.

These outcomes depend on factors like climate variability, socioeconomic changes, and sector-specific dynamics. In regions dominated by agriculture or thermoelectric generation, climatic factors (e.g., temperature and precipitation changes) like those seen in the Great Lakes states and provinces could significantly influence outcomes. Adaptive measures, such as enhanced efficiency in water-intensive sectors and investments in resilient infrastructure, will be critical to mitigating risks.

Uncertainty in model projections underscores the importance of robust water management strategies that account for a wide range of possible futures. Climate models that predict drier conditions suggest higher water use and demand, while wetter conditions suggest reduction in total water use and consumption. Variability is introduced through socioeconomic factors like industrial growth, population growth and efficiency improvements, which are variable across the Great Lakes region.

A key consideration for industrial water users is the compound annual escalation rates for water and utilities which provides industrial users trend information to make strategic decision on water use and availability for the operations. Water utilities rates escalation is variable across time and region, with factors such as local infrastructure costs, regional regulatory compliance requirements, supply and demand dynamics, energy costs, climate change risks and policy and governance pertaining to utility structure and economic profitability goals affecting rates of escalation (12). Compound annual escalation rates for water and wastewater utility rates for industrial users in the U.S. Great Lakes region shows a general trend of moderate to high increases in utility prices, with significant variation across different cities. For water utilities, cities like Rochester, MI, and Holland, MI, experienced notable escalation rates of 11.5% and 10.9%, reflecting substantial price hikes from 2008 and 2021. In contrast, cities such as Grand Rapids, MI, and Minneapolis, MN, saw much more stable water rates, with Grand Rapids reporting a minimal increase of just 0.7% and Minneapolis experiencing an almost negligible rise of 0.3%. Similarly, wastewater utility rates in the region displayed a mixture of rising and declining trends. Fort Wayne, IN, saw a significant increase in wastewater rates at 4.9%, while Kenosha, WI, experienced a slight decline of 0.4%. It is important to note that the data provided is incomplete as utilities voluntarily report to the American Water Works Association (AWWA), and there are no publicly available comprehensive projections of future price escalation rates for water and wastewater(12). The absence of governmental oversight on future pricing trends adds a layer of uncertainty to understanding long-term cost trends for water and wastewater services in the region.

In the Great Lakes region, water and wastewater utility rates for industrial users have been subject to various trends influenced by regional policies, infrastructure needs, and economic factors. In Ontario, municipalities like London have projected water and wastewater rate increases to keep pace with rising costs. For instance, London recommended a 2.5% increase in water rates for 2024, with similar increases anticipated in the following years (13). The wastewater and stormwater rate are recommended to rise by 4% in 2024, with potential annual increases until 2027 (13).

In Quebec, while specific projections for water and wastewater rate increases are less readily available, the province has been focusing on infrastructure investments and sustainability initiatives. A report by Bluefield Research forecasts that capital and operating expenditures for water and wastewater utilities in Canada, including Quebec, will grow from US$188 billion in 2022 to US$223 billion in 2030 (14). This indicates a projected annual growth rate of approximately 2.2%, reflecting the ongoing need for infrastructure development and maintenance.

The variability in reporting practices between Canada and the U.S. also makes direct comparisons challenging. Canadian municipalities may have less standardized reporting mechanisms, which can lead to differences in the comprehensiveness and availability of data. Additionally, provincial regulatory environments in Ontario and Quebec may impact pricing trends differently from the U.S. Great Lakes region, as water management and utility oversight vary between the two countries. Despite these differences, both regions are likely to experience continued pressure on water and wastewater pricing due to the challenges of maintaining infrastructure and addressing environmental impacts, particularly as climate change and population growth continue to influence water demand and supply across the Great Lakes basin.

Basin Water Use and Availability

The water use data from the Great Lakes Commission is available through 2022 due to the extensive time required for data collection, verification, and reporting across multiple jurisdictions. Ensuring accuracy involves rigorous quality assurance processes and an annual reporting cycle. This approach maintains the integrity and reliability of the data, essential for effective water resource management in the Great Lakes basin.

In 2022, total water withdrawn for the water bodies (including surface, lakes and groundwater) in the Great Lakes basin was 40,820.60 million gallons per day (mgd), this marks a 3% decrease in water withdrawn from 2021 to 2022 (15). Since 2014 there has been a general trend of decline in water withdrawal of approximately 1-4% depending on the period with the greatest continuous declining trend occurring between 2018 and 2020. The year 2021 saw a significant increase in water withdrawal of 42,146 mgd, approximate 11% increase from 2020. The increase in total withdrawal in the basin was attributed to the province of Ontario which experienced a significant spike in 2021 (approximately 11% increase from 2020), this value amounted to a 4,679.0 mgd increase in water withdrawn in the province. Ontario, which has the largest land area in the basin of the 10 jurisdictions (108,680 square miles) was the largest withdrawer of Great Lakes water in 2022 (Figure 2). Facilities in Ontario withdrew 18,717 mgd accounting for 46 percent of the total withdrawal amount across all jurisdictions. In contrast, Pennsylvania, which has the smallest land area in the basin consisting of 511 square miles, withdrew 29.9 mgd or less than 0.1 percent of the total withdrawal amount.

Figure 3 – *Total Withdrawals for the Great Lakes Basin*

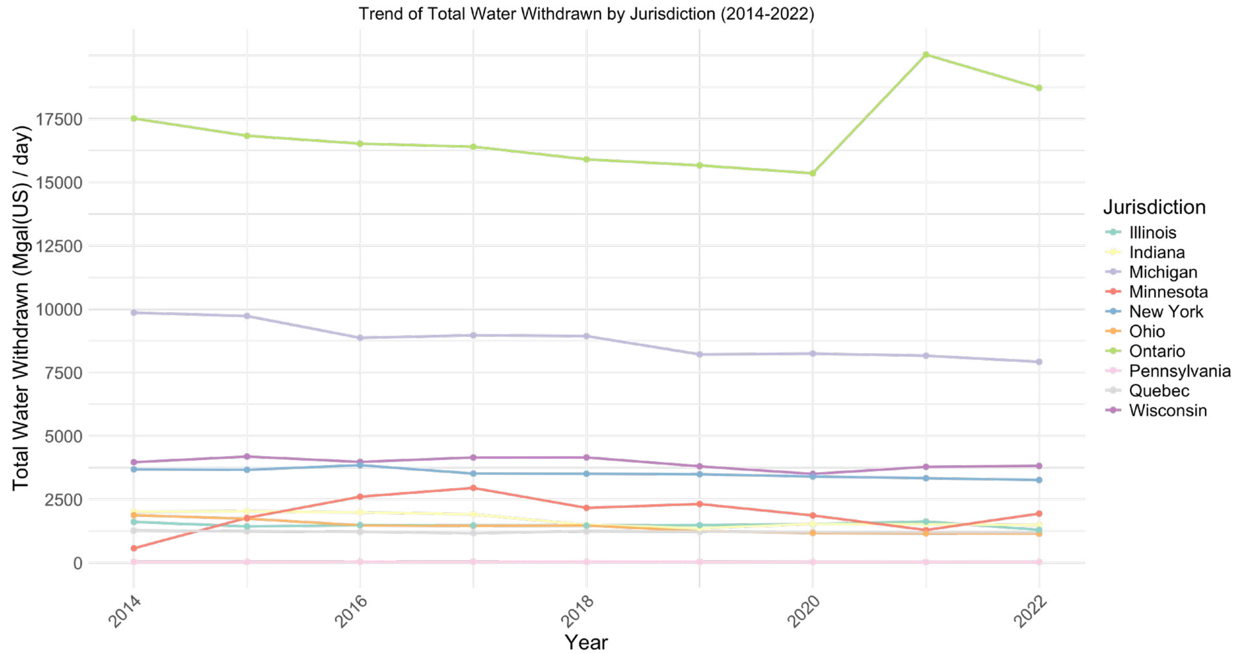


Figure 3: Total withdrawals (excluding In-Stream Hydroelectric Water Use) for the Great Lakes basin (including groundwater) for the period of 2014-2022. Data extracted from the Great Lakes Commission. (2022). Great Lakes regional Water Use Database. Extracted from https://waterusedata.glc.org/ [accessed 10/17/2024]

Consumptive use is the portion of the water withdrawn or withheld from the basin that is lost from or otherwise not returned to the basin due to evaporation, incorporation into products or other processes. In 2022, the total reported consumptive use for the Great Lakes basin was 1,878 mgd, representing a relatively small fraction of total water use in the basin when compared to total withdrawal (15) (Figure 3). While Ontario is the largest withdrawal jurisdiction, Michigan had the highest consumptive use among all watersheds when compared to total withdrawn from the Great Lakes basin, totaling 678 mgd or 36% of the basin's total (15). Yet when comparing this to the total ratio of water use to consumption, this value is only making approximately 6% of total withdrawal for the state of Michigan. The largest direct consumers of water withdrawn were Indiana and Quebec, 18% and 20% of water withdrawn respectively. The lowest water consumers when by jurisdiction were Illinois and Pennsylvania.

Figure 4 – *Total Withdrawals and Consumption for the Great Lakes Basin*

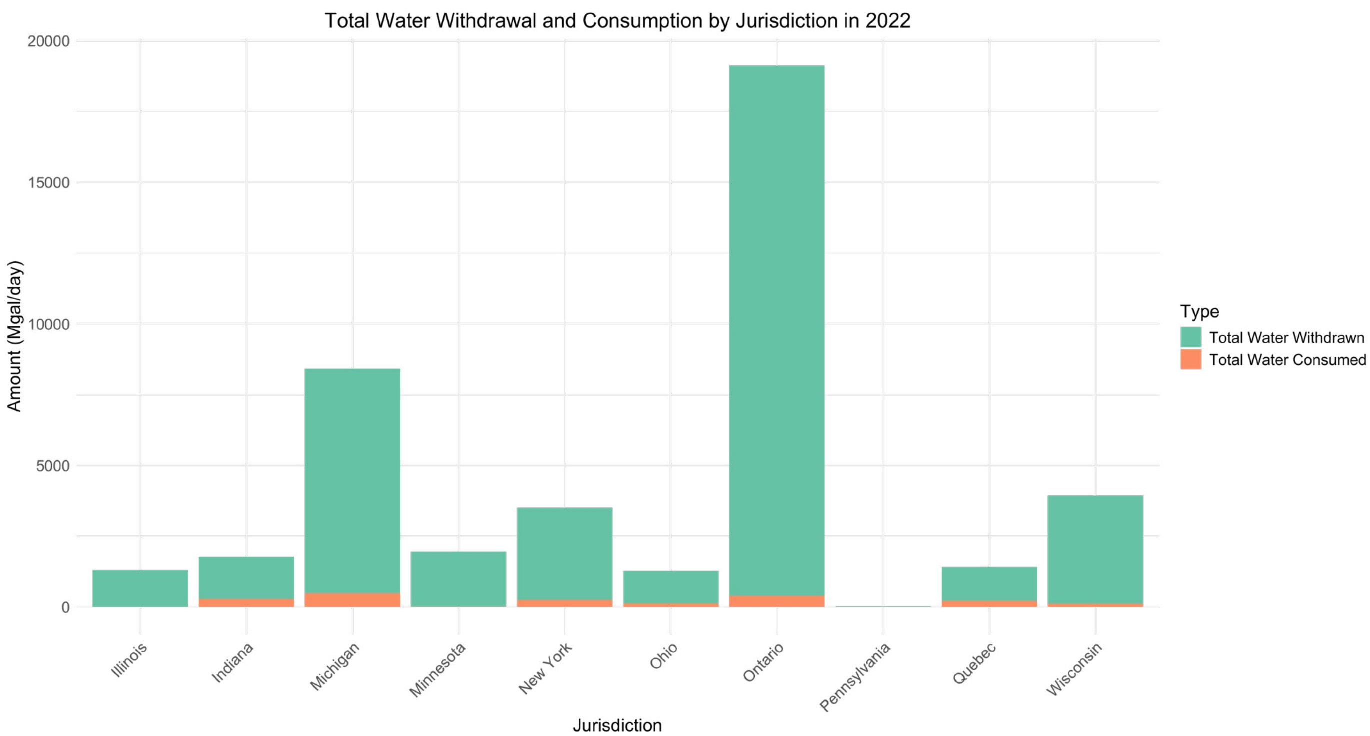


Figure 4: Water consumption as a portion of total water withdrawal categorized by state/province of the Great Lakes basin in 2022 (excluding In-Stream Hydroelectric Water Use. Data extracted from the Great Lakes Commission. (2022). Great Lakes Water Use Database. Extracted from https://waterusedata.glc.org/ [accessed 10/17/2024]

The Great Lakes-St. Lawrence River basin is a vital water resource that supports diverse industrial, agricultural, and municipal activities, with total withdrawals reaching 40,805 mgd in 2022 (15) . However, water availability is impacted by substantial diversions, primarily the Illinois Diversion, which redirects approximately 965 mgd from Lake Michigan into the Mississippi River watershed to meet the needs of the Chicago metropolitan area (15). This diversion equating to 2.4% of the total Great Lakes basin withdrawal and accounts for around 88% of the basin's total diverted volume, has the potential to impact water available within the Great Lakes basin if this diversion proportion were to increase. Though return flows from smaller diversions offer some replenishment, they remain insufficient to offset overall losses, contributing to a net reduction in the basin's water resources. Such diversions place additional strain on regional water supplies, necessitating advanced water management and conservation measures as industries like manufacturing, energy, and agriculture continue to compete for limited water resources.

Water Use by Sector

Within the Great Lakes basin, the sectors that withdrew significant volumes across the basin are thermoelectric power energy production (specifically once through cooling), public water supply and the industrial sector. There has been relatively steady trend of water use across all sectors (Figure 5), while thermoelectric power generation did experience a declining trend until 2020. This was likely due to higher reported thermoelectric through cooling in Ontario in 2021, as seen in Figure 5.

Figure 5 – *Total Withdrawals by Sector for the Great Lakes Basin*

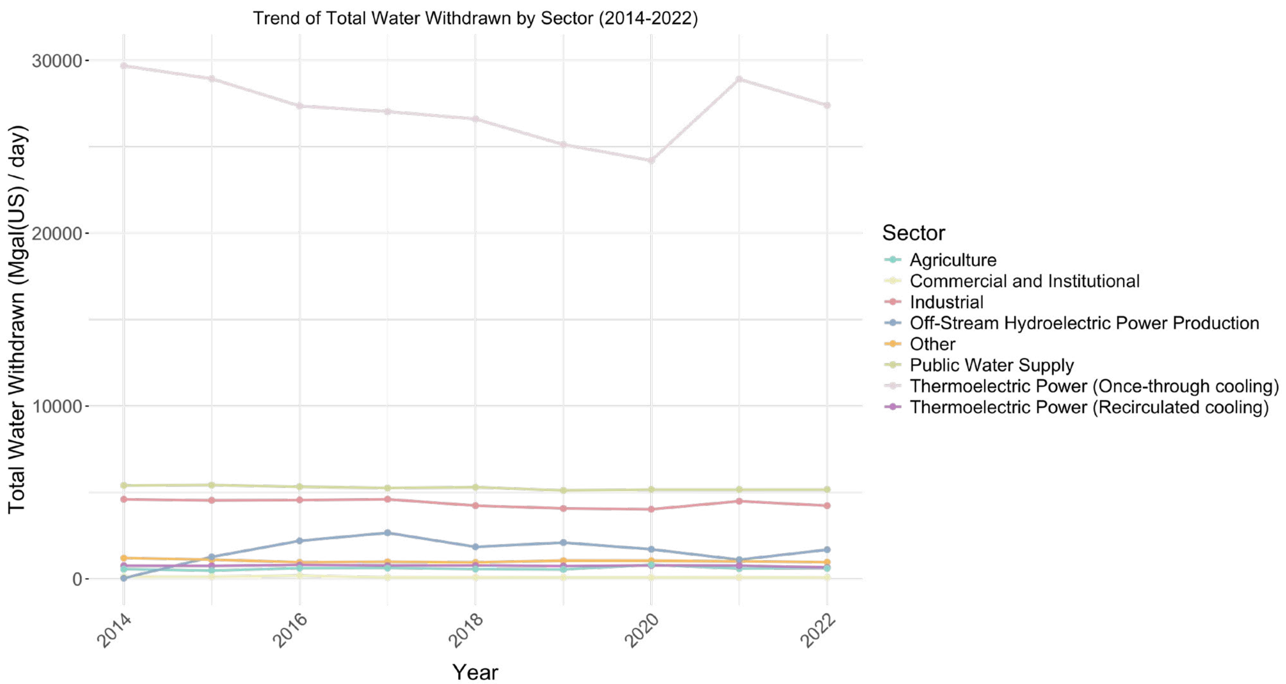


Figure 5: Total water withdrawal by sector for the year 2014-2022. Data extracted from the Great Lakes Commission. (2024). Great Lakes basin Water Use Database. Extracted from https://waterusedata.glc.org/ [accessed 10/17/2024]

Figure 6 illustrates the total daily consumption (mgd) for each economic sector for the various Great Lakes basin jurisdictions. Several established industries and sectors, most notably industrial manufacturing, the public water supply sector, and agriculture are major water consumers in the Great Lakes region. These sectors require significant volumes of water for essential processes and service delivery.

Figure 6 – *Total Water Consumed for the Great Lakes Basin*

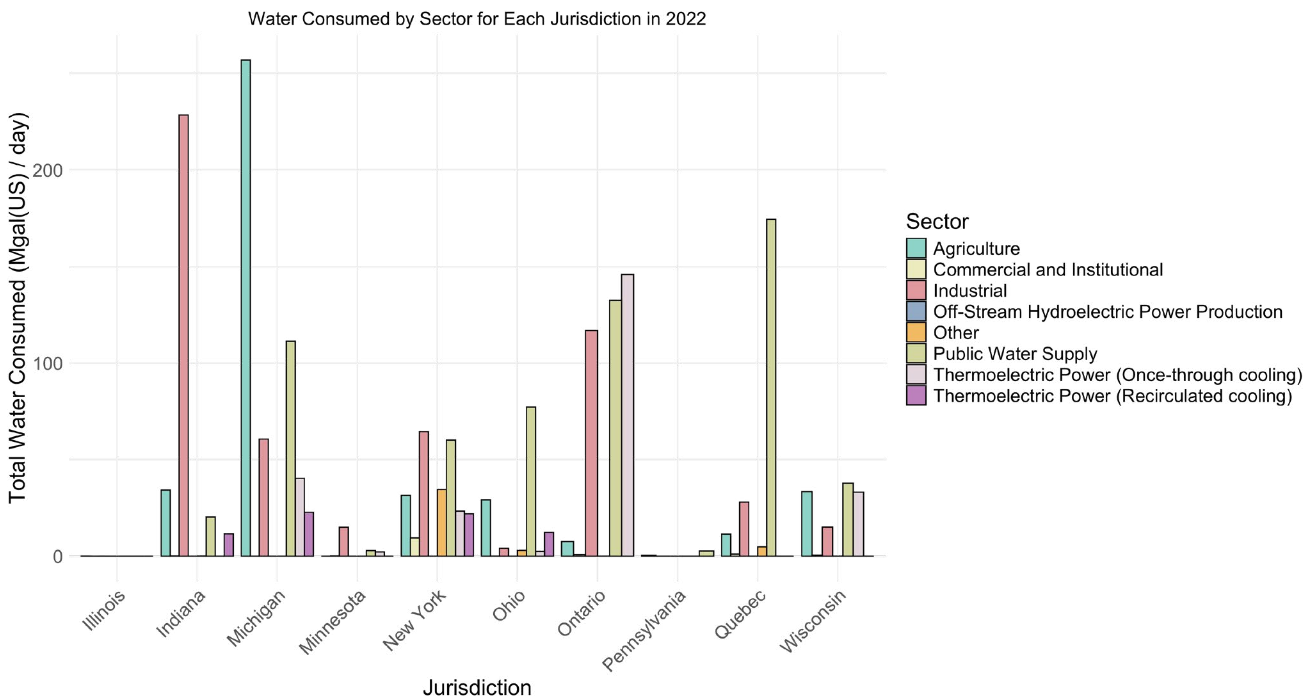


Figure 6: Total water consumption by sector, categorized by jurisdiction. Data extracted from the Great Lakes Commission. (2024). Great Lakes basin Water Use Database. Extracted from https://waterusedata.glc.org/ [accessed 10/17/2024]

Industrial Sector

The industrial sector in the Great Lakes region spans eight U.S. states (Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York) and two Canadian provinces (Ontario and Quebec), and is recognized for its manufacturing prowess, particularly in automotive and aerospace production, with key players like Ford, GM, Chrysler, Bombardier, and GE Aviation. In 2022, the U.S. and Canada consumptive industrial uses equated to approximately 532 mgd, or 27% of total water consumption for the Great Lakes region, this only refers to self-supply while any water extracted from municipal systems is folded into the public water supply sector(15). Despite the increasing regulation and competition for water resources, industrial water use has remained stable over the past 30 years.

The industrial sector is a significant employer, generating millions of jobs across a variety of industries, from manufacturing, mining, pulp and paper, food processing, primary metal production, power generation, chemical manufacturing, and recreation. In Canada, industrial water demand is high, especially in manufacturing and energy. Ontario, with its robust manufacturing infrastructure, and Quebec, known for hydroelectric power, are major contributors to the region's industrial water usage. In the U.S., Michigan, Illinois and Ohio are heavily industrialized, particularly in automotive and steel production, both of which require substantial water resources. The industrial sectors in Indiana, which focus heavily on steel, automotive, and food processing, rely on water sourced from Lake Michigan and nearby bodies of water and consume approximately 228 mgd in 2022. Ontario, in Canada, emerges as the largest water consumer in the basin, with its automotive and steel manufacturing industries, along with agriculture, driving considerable water withdrawals. While Quebec's industrial sector is not considered a large water consumer according to 2022 data, the new regulation such as the Blue Fund and amending other legislative provisions (Bill 20)(16) brought into effect in 2023 will enforce certain industrial water consumption reporting and may show larger consumption in later years. Currently, largest consumers are aluminum and paper mills but only approximately 1.5% of industries are currently reporting under the new bill. The ongoing water requirements of these established sectors highlight the urgent need for sustainable water management and improved reporting as industries expand and vie for increasingly limited resources.

Public Water Supply Sector

Public water supplies in the Great Lakes basin accounted for approximately 619 mgd (Figure 6) daily water consumption for the Great Lakes region, equating to 32% of water consumption. The public water supply sector is a critical component of the Great Lakes region, providing essential services to millions of residents across various states and provinces. Across the Great Lakes region, Quebec was shown to have the largest daily public water supply consumption of any province or state, equating to 174 mgd (28%) consumed by the province to support its growing population and industries, especially in the City of Montreal(17). The region is known for its abundant water supply and low water cost, which has led to an increase in water use by both public and industrial water consumers that utilize municipal systems. The increase in royalties and the creation of the Blue Fund will raise rates for most industries to improve future water stress resiliency. Industries that consume water will see the largest increase in rates, of up to $150 (CAN) per million liters, with an additional $350 (CAN) per million liters when water is used in the production of water for bottling(17). This scenario underscores the necessity of balancing industrial demands with available water resources, even in regions considered to be abundant in water resources. Similarly, Ontario is a major user of Great Lakes water for public supply, with consumption equating to 133 mgd (21%) of public water supply consumed in the Great Lakes region, much of this was focused within the cities of Toronto and Hamilton drawing significant amounts from Lake Ontario. In the U.S., states like Michigan, Illinois, and Ohio rely heavily on the Great Lakes for their public water supplies. Michigan, for instance, consumes approximately 111 mgd and makes use of the Great Lakes Water Authority (GLWA), which serves 3.5 million residents in Southeast Michigan, drawing water from Lake Huron, Lake St. Clair, and the Detroit River. Similarly, Illinois and Ohio have extensive public water systems that depend on Lake Michigan and Lake Erie, respectively, to meet the needs of their urban and rural populations. While Illinois shows very little consumption across all sectors it should be noted that the state makes use of diverted water supply through the Illinois Diversion. The Illinois Diversion diverts water from Lake Michigan through the Chicago Area Waterway System (CAWS) into the Mississippi River watershed and is comprised of three elements: public water supply, stormwater runoff and direct diversion. The amount of water diverted for public water supply was approximately 784 mgd, and is not provided in the 2022 Water Use data set as a consumption metric.

There is substantial use variance across the states and sectors with variation in reporting transparency, water rates for different industries across the region as well as hubs of activity that require greater or lesser water, placing an irregular pressure on water sources that are often misidentified as abundant in many regions. The substantial usage underscores the importance of sustainable water management practices to ensure the long-term use of this vital resource. As populations grow and climate change impacts water availability, the need for efficient and effective water use strategies becomes increasingly critical.

Agricultural Sector

Within the Great Lake basin, the agriculture sector including fishing and food production (livestock and crop) is one of the major employers, contributing approximately 10% jobs (~160, 000 jobs) in 2018(18), and producing approximately $14.5 billion in agricultural sales. The sector constitutes nearly 25% of Canada's agricultural production and 7% of USA's with over 26% of land use in the Great Lakes comprising of agricultural productive land(6). The encompassing land use makes the agricultural sector a significant consumer of water in the Great Lakes, utilizing approximately 405 mgd (Figure 6), representing 21% of total water consumption in the Great Lakes basin and contributes meaningfully to water quality related concerns in the Great Lakes region.

The agricultural sector in Michigan is the largest consumer of water across the Great Lakes region, reporting over 257 mgd in 2022, representing 63% of reported water consumption in the agricultural sector. This shows an increase from previous years, due to the increased demand and expansion of the agricultural lands, with most of the water (about 70%) coming from high-capacity wells(19). Similarly, the combined water consumption of the remaining states and provinces of the Great Lakes region equals 148 mgd, of this Indiana, New York, Ohio and Wisconsin consumption equals the majority of this. All states and provinces utilize considerable ground water resources with Wisconsin showcasing particularly expansive high capacity and low capacity well monitoring network and reporting, indicating that Wisconsin has over 3,500 high capacity wells which are associated with agriculture(20). Ontario consists of the largest agricultural land use between Canada's Great Lake provinces, yet agricultural consumption is considered low, fluctuation in irrigation practices due to favorable precipitation in the central and southeast region where the majority of agricultural landcover is situated (Figure 7)(21). Efforts to improve irrigation efficiency and water conservation across the Great Lakes region are ongoing, with practices such as precision irrigation and soil moisture monitoring being promoted to reduce water waste and enhance crop yields. These measures are essential for the region to continue to balance the demands of agricultural water use with the need to protect its vital water resources.

Figure 7 *– Annual Mean Precipitation from 1981-2010*

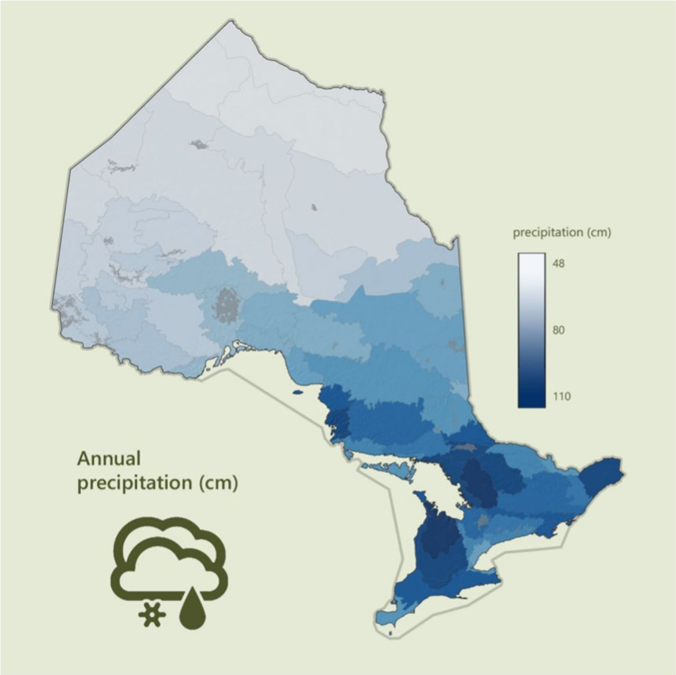


Figure 7: Annual mean precipitation from 1981-2010 by ecodistrict of Ontario Canada. Image extracted from Ministry of Natural Resources: Forest resources of Ontario 2021, Geographic Profiles (https://www.ontario.ca/document/forest-resources-ontario-2021/geographic-profiles)

Annual total withdrawal by farm for high-capacity wells are more commonly reported for the agricultural region as there are often regulations that require volume extracted to be documented over a certain threshold. The Michigan Department of Agriculture and Rural Development (MDARD) oversees water use regulated reporting for agricultural users. Farms with the capacity to withdraw over 100,000 g/d are required to report their water usage annually. Similar agencies across the Great Lakes region enforce withdrawal reporting in Wisconsin, Indiana, Ohio, and New York. Agencies in Minnesota and Pennsylvania support a 10,000 g/d withdrawal threshold for agricultural reporting while Ontario is shown to have a permit requirement of 13,000 g/d, but livestock farmers are excepted from requiring a permit.

Agricultural practices have continued as significant contributors to nutrient pollution in the Great Lakes basin, largely due to phosphorus runoff from nonpoint sources leading to algal blooms. Phosphorus runoff from farm land is increasing due to a higher frequency of storms. This nutrient pollution has led to harmful algal blooms (HABs) in Lake Erie and other major bays like Green Bay and Saginaw Bay. Nearshore algal issues such as high levels of toxic compounds produced by cyanobacteria, and widespread hypoxia, reduce water quality and harm ecosystems. While the Clean Water Act and the Great Lakes Water Quality Agreement initially reduced point-source nutrient pollution from municipal and industrial sources, nonpoint source pollution—especially agricultural runoff, current research has indicated that agricultural inputs of bioavailable phosphorus are a major driver of current eutrophication in the systems in the Great Lakes region and impairment of contributing streams that feed directly to the Great Lakes system(22).

Water Quality In The Great Lakes

Current Conditions & Water Quality Indicators

Surface and ground water quality in the Great Lakes region is impacted by a variety of factors, from direct chemical inputs via urban development, agricultural land use and industrial growth. Figure 8 illustrates the extent of land use change in the Great Lakes basin, with much occurring as agricultural and urban development in the southern portion of the Great Lakes basin. Alternatively, indirect impacts of invasives species on water quality and water systems' health also play a significant role with climate change exacerbating the impact of all factors on water quality in the Great Lakes. Degradation of water quality and quantity due to climate change has already altered the capacity of the Great Lakes region in agricultural output, decreased the ability to generate energy, and exacerbated environmental stressors such as toxic uptake. With the understanding that eliminating water pollution is costly and infeasible, regulators and policy makers must make decisions about the appropriate level of water pollution. In strictly economic terms, this calls for weighing the benefits from the polluting activity against the costs of pollution. A global model developed by the World Bank(23) estimated that regions experiencing medium to high levels of pollution can have significant impacts on GDP growth rates, projections suggest 1.4 - 2%. While high economic income regions such as the Great Lakes region are better equipped to mitigate these impacts, many suggest that the true impact of reduction in water quality is still underestimated and the impacts should be considered a greater burden than currently projected.

Figure 8 – *Current Land Cover for the Great Lakes Basin*

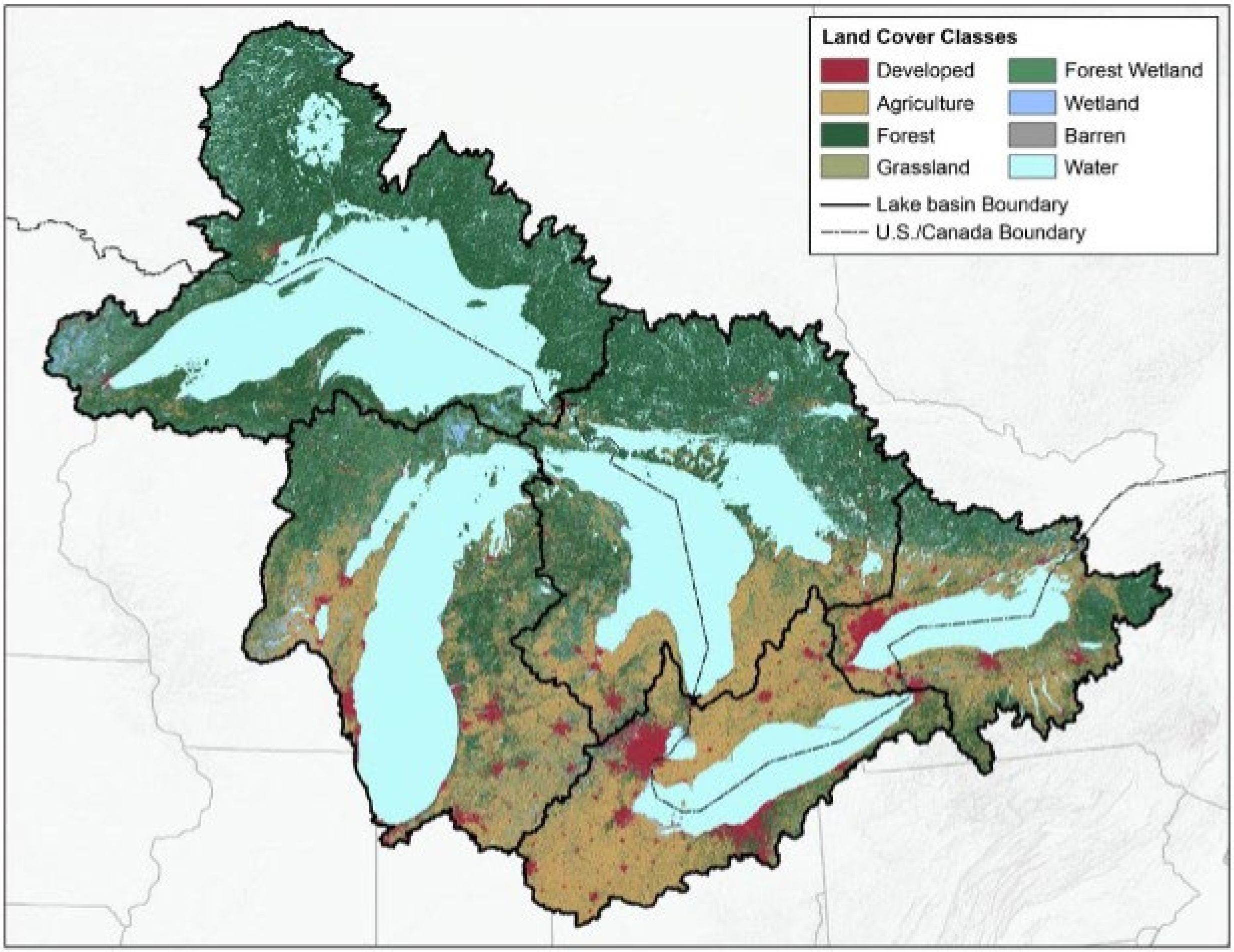


Figure 8: Current land cover by landcover classes for the Great Lakes basin, including both human and natural systems land cover. Extracted from the State of the Great Lakes Report Watershed Impacts and Climate Change Trends pg. 29: https://stateofgreatlakes.net/indicators/climate/

The Great Lakes basin, comprised of the five Great Lakes, thousands of miles of surface water tributaries and groundwater aquifers, is at risk of degradation of water quality. The Great Lakes region includes several designated Areas of Concern (AOCs), which are heavily impacted by pollution and environmental degradation, as defined by the Great Lakes Water Quality Agreement between the U.S. and Canada. These AOCs are primarily located along the U.S. and Canadian shores of the lakes, and they have been identified due to impairments in water quality, habitat loss, and other ecological issues. Key areas include the Cuyahoga River, Buffalo River, and Detroit River in Lake Erie, as well as Onondaga Lake in Lake Ontario and the Saginaw River in Lake Huron as illustrated in Figure 9. Restoration efforts are underway to address these impairments, as part of the U.S.-Canada Great Lakes Water Quality Agreement. These efforts aim to improve water quality and ecological health across the region.

Figure 9 – *Great Lakes Areas of Concern*

Figure 9: Areas Of Concern, image extracted from the International Joint Commission: Great Lakes Areas of Concern

As of 2022, as summarized in Table 2, four of the nine indicators of ecosystem health which makes use of water quality metrics and can be an indirect measure of water quality (Drinking Water, Beaches, Invasive Species Prevention and Ground Water) were considered "Good" yet important indicators such as Groundwater and Climate Trends lacked long term critical data to determine the trends in quality. Groundwater was considered "Good" in the basin region of Lake Ontario, predominately driven by in stream recharge impacted by land use pressure (continuous corn-soybean rotation, synthetic fertilizer application, and tile drainage, and urban area and population density). Indicators such as Toxic Chemicals, Habitat & Species, Nutrient & Algae and Watershed Impacts - all significant indicators of water quality - were considered "Fair" and are important indicators that are directly impacted by urban development, unsustainable agricultural land use practices and industrial sector growth. For example, estimated economic impacts of algal blooms on the Canadian Lake Erie basin were projected to cost 5.3 billion dollars over the next 30 years, significantly impacting tourism and property owners in the region(6).

Table 2 – *Summary of Ecosystem and Health Indicators for the Great Lakes Basin*

Great Lakes Water Quality Indicator	*Status*	*Trend*	*Lake of Concern*	*Cause*
Drinking Water	Good	Unchanging		
Beaches	Good	Unchanging to Improving		
Invasive Species Prevention	Good	Unchanging		
Groundwater	Good	Undetermined	Lake Ontario	
Toxic Chemicals	Fair	Unchanging to Improving	Lake Erie	PCB's, mercury, other toxic chemicals
Habitat & Species	Fair	Unchanging	Lake Michigan	Habitat loss, invasive species
Nutrient & Algae	Fair	Unchanging	Lake Erie	High nutrient levels, algal blooms
Watershed Impacts	Fair	Unchanging	Lake Erie	Nutrient runoff, habitat degradation
Invasive Species Impact		Unchanging	Lake Michigan	Invasive species
Climate Trends	Undetermined	Undetermined		

Table 2: The Great Lakes ecosystem, health indicators representing multiple water quality metrics and factors organized by status. Table adapted from the Status of the Great Lakes 2022 Report pg. 4. Green indicates "Good" status and "Improving" or "Unchanging to Improving" water quality trends, orange indicates "Fair" and "Unchanging", red indicates "Poor" status. Grey indicates undetermined status due to the lack of long-term data or robust enough modeling

What may be of greater concern is that many of the indicators given "Fair" status show trends that are considered "Unchanging", suggesting current actions implemented in these regions (from 2010-2020) with the revision of the Great Lakes Water Quality Agreement in 2012 have been ineffective or require longer time frames for positive outcomes to be realized.

The Canadian Great Lakes Freshwater Ecosystem Initiative, $76 million (CAN)(24) was appropriated to support 50 partner-led projects as part of the larger $420 million 10-year commitment to the Great Lakes under Canada's Freshwater Action Plan to boost action in supporting the phosphorus reduction goals(25). Phosphorus reduction goals in the central basin have proven ineffective as of 2022, with no evidence of a declining trend in phosphorus loads. The key indicators of concern for Lake Erie include nutrient levels and HABs, with western basin blooms regularly producing toxins(26). This additional funding to support reduction goals may drive change in pollution levels, however, greater budget will need to be dedicated towards a broader range of strategies to mitigate the signficiant issues facing the central basin.

Currently, Invasives Species Impact Status is considered "Poor" with an "Unchanging" trend. Invasive species currently in the Great Lakes continue to significantly impact water quality, having extensive impacts on local ecosystem health and economy. There are currently 188 characterized invasives species impacting the Great Lakes basin, with impacts ranging in severity from nuisance invaders like the *Morone americana* only marginally impacting fish diversity in certain regions to highly impactful invaders that disrupt entire industrial and commercial sectors such as *Dreissena polymorpha* (zebra mussel) and *D. bugensis* (Quagga mussel) impacting water in/out take systems in water treatment facilities and energy generation. It was estimated that in 2012 *Dreissena polymorpha* (zebra mussel) and *D. bugensis* (Quagga mussel) alone cost the Great Lake basin between $300-500 million in damages to power plants, not considering lapses in power output that would then negatively impact local commercial and industrial performance in the case of outages(27).

Regional Water Quality Landscape

Regional water quality is typically monitored and regulated by the state or province, and the respective water quality programs are summarized by jurisdiction in the following section. If data is not readily available, it has been noted in the table. Differences exist within each of the programs, which account for the slight variations in the following summary tables.

Minnesota

Category	*Details*
Streams Assessed	4,097 stations with data; 1,495 stations with enough data to run a test
Major Stream Impairments	Degraded habitat, altered hydrology, nitrate, chloride, trace elements, VOCs, PFAS, CECs
Lakes Assessed	4,876 lakes with data; 1,732 lakes
Major Lake Impairments	Phosphorus, total suspended solids, aquatic algae, mercury, PCBs, aldrin, endrin, dieldrin, heptachlor
Wetlands Assessed	Statewide and regional surveys; depressional wetlands monitored
Wetland Impairments	Vegetation quality varies; exceptional/good in the north, fair/poor in other regions
Groundwater Contaminants	Nitrate, chloride, trace elements, VOCs, PFAS, CECs
Challenges	Nonpoint source pollution, aging infrastructure, climate change, funding and resources
Impaired Water Bodies	Streams: 248 degrading, 314 improving; Lakes: 157 degrading, 533 improving
Agencies Involved	MPCA, MDA, MDH, MDNR, local governments, watershed organizations, NGOs

The 2024 Minnesota Water Quality Report (28) provides a comprehensive overview of the water quality status of surface and groundwater in Minnesota. As shown in the table, the state has assessed 4,097 stream stations, with 1,495 stations having enough data to provide insight into water quality. Major impairments in streams include degraded habitat, altered hydrology, nitrate, chloride, trace elements, volatile organic compounds (VOCs), per- and polyfluoroalkyl substances

(PFAS), and contaminants of emerging concern (CECs). For lakes, 4,876 lakes have been assessed, with 1,732 lakes reported as impairment from individual or a combination of phosphorus, total suspended solids, aquatic algae, mercury, polychlorinated biphenyls (PCBs), aldrin, endrin, dieldrin, and heptachlor. Wetlands in Minnesota are assessed through statewide and regional surveys, with a focus on depressional wetlands. Groundwater quality issues are primarily due to contamination from nitrate, chloride, trace elements, VOCs, PFAS, and CECs.

Minnesota faces several challenges in maintaining and improving water quality, including nonpoint source pollution from agricultural runoff and urban stormwater, aging infrastructure, climate change impacts, and limited financial resources for monitoring, assessment, and remediation efforts. The state has identified 248 stream stations with degrading trends and 314 with improving trends. For lakes, 157 show degrading trends while 533 show improving trends.

Various agencies are involved in efforts to improve water quality, including the Minnesota Pollution Control Agency (MPCA), Minnesota Department of Agriculture (MDA), Minnesota Department of Health (MDH), Minnesota Department of Natural Resources (MDNR), local governments, watershed organizations, and non-governmental organizations (NGOs). These agencies work together to implement monitoring, regulatory, and remediation programs to protect and enhance Minnesota's water resources. Continued investment in infrastructure, pollution control, and public education is essential to address these challenges effectively.

Wisconsin

Category	*Details*
Streams Assessed	88,000 miles
Major Stream Impairments	Phosphorus, mercury, PCBs, E. coli, degraded habitat, degraded biology, chloride, TSS
Lakes Assessed	1.2 million acres
Major Lake Impairments	Phosphorus, mercury, PCBs, aquatic plants, E. coli, PFOS
Wetlands Assessed	Statewide surveys; focus on invasive species control
Wetland Impairments	Purple loosestrife, other invasive species
Groundwater Contaminants	Nitrate, chloride, trace elements, VOCs, PFAS
Challenges	Nonpoint source pollution, aging infrastructure, climate change, funding and resources
Impaired Water Bodies	Streams: 1,264 impaired; Lakes: 367,444 acres impaired
Agencies Involved	WDNR, EPA, local governments, universities, citizen volunteers

The 2024 Wisconsin Water Quality Report (29) provides a comprehensive overview of the water quality status of surface and groundwater in Wisconsin for the years 2021-2022. As shown in the table, Wisconsin has assessed 88,000 miles of streams and 1.2 million acres of lakes. Major impairments in streams include phosphorus, mercury, polychlorinated biphenyls (PCBs), E. coli, degraded habitat, degraded biology, chloride, and total suspended solids (TSS). For lakes, common impairments include phosphorus, mercury, PCBs, aquatic plants, E. coli, and perfluorooctane sulfonate (PFOS).

Wetlands in Wisconsin are assessed through statewide surveys, with a focus on controlling invasive species such as purple loosestrife. Groundwater quality issues are primarily due to contamination from nitrate, chloride, trace elements, volatile organic compounds (VOCs), and per- and polyfluoroalkyl substances (PFAS).

Wisconsin faces several challenges in maintaining and improving water quality, including nonpoint source pollution from agricultural runoff and urban stormwater, aging infrastructure, climate change impacts, and limited financial resources for monitoring, assessment, and remediation efforts. The state has identified 1,264 impaired stream segments and 367,444 acres of impaired lakes.

Various agencies are involved in efforts to improve water quality, including the Wisconsin Department of Natural Resources (WDNR), U.S. Environmental Protection Agency (EPA), local governments, universities, and citizen volunteers. These agencies work together to implement monitoring, regulatory, and remediation programs to protect and enhance Wisconsin's water resources. Continued investment in infrastructure, pollution control, and public education is essential to address these challenges effectively.

Illinois

Category	***Details***
Streams Assessed	9,042 miles (7.6% of total 119,244 miles)
Major Stream Impairments	Fecal coliform bacteria, mercury, PCBs, aldrin, dieldrin, heptachlor, low dissolved oxygen, phosphorus, siltation, total suspended solids
Lakes Assessed	105 lakes covering 86,945 acres (26.8% of total 324,168 acres)
Major Lake Impairments	Phosphorus, total suspended solids, aquatic algae, mercury, PCBs, aldrin, endrin, dieldrin, heptachlor
Lake Michigan Assessment	196 square miles of open waters, 64 miles of shoreline, 2.14 square miles of harbors
Lake Michigan Impairments	Phosphorus, mercury, PCBs, E. coli bacteria (shoreline)
Wetlands Assessed	Data not readily available
Wetland Impairments	Data not readily available
Groundwater Contaminants	Nitrates, VOCs, pesticides, heavy metals
Challenges	Nonpoint source pollution, aging infrastructure, climate change, funding and resources
Impaired Water Bodies	Streams: 10,516 miles; Lakes: 151,884 acres; Lake Michigan: 64 miles of shoreline, 0.18 sq. miles of harbors
Agencies Involved	Illinois EPA, USEPA, IDNR, local agencies, watershed groups, NGOs

The 2024 Illinois Integrated Water Quality Report (30) provides a comprehensive overview of the water quality status of surface and groundwater in Illinois. As shown in the table, out of 119,244 miles of streams, 9,042 miles (7.6%) were assessed for at least one designated use. Major causes of impairment in these streams include fecal coliform bacteria, mercury, polychlorinated biphenyls (PCBs), aldrin, dieldrin, heptachlor, low dissolved oxygen, phosphorus, siltation, and total suspended solids. For lakes, 105 lakes covering 86,945 acres were assessed. Common causes of impairment in lakes include phosphorus, total suspended solids, aquatic algae, mercury, PCBs, aldrin, endrin, dieldrin, and heptachlor.

The state also assesses the quality of Lake Michigan's open waters, shoreline, and harbors. Of the total 1,526 square miles of Lake Michigan open waters in Illinois jurisdiction, 196 square miles were assessed. Significant impairments in Lake Michigan include phosphorus, mercury, and PCBs, with shoreline waters also impaired by E. coli bacteria.

Groundwater quality issues in Illinois are primarily due to contamination from nitrates, volatile organic compounds (VOCs), pesticides, and heavy metals. The state faces several challenges in maintaining and improving water quality, including nonpoint source pollution from agricultural runoff and urban stormwater, aging infrastructure, climate change impacts, and limited financial resources for monitoring, assessment, and remediation efforts.

In terms of impaired water bodies, Illinois has 10,516 miles of impaired streams, 151,884 acres of impaired lakes, and 64 miles of impaired Lake Michigan shoreline along with 0.18 square miles of impaired harbors. Various agencies are involved in efforts to improve water quality, including the Illinois Environmental Protection Agency (Illinois EPA), U.S. Environmental Protection Agency (EPA), Illinois Department of Natural Resources (IDNR), local agencies, watershed groups, and non-governmental organizations (NGOs). These agencies work together to implement monitoring, regulatory, and remediation programs to protect and enhance Illinois' water resources. Continued investment in infrastructure, pollution control, and public education is essential to address these challenges effectively.

Indiana

Category	*Details*
Streams Assessed	62,746 miles
Major Stream Impairments	Pathogens, PCBs, mercury, impaired biotic communities, nonpoint sources
Lakes Assessed	1,582 lakes
Major Lake Impairments	PCBs, mercury, phosphorus, aquatic plants, E. coli
Wetlands Assessed	Data not readily available
Wetland Impairments	Data not readily available
Groundwater Contaminants	Nitrate, arsenic, VOCs, pesticides, PFAS
Challenges	Nonpoint source pollution, aging infrastructure, climate change, funding and resources
Impaired Water Bodies	Streams: 36,264 miles assessed; Lakes: 62 lakes with fish consumption advisories
Agencies Involved	IDEM, EPA, local governments, universities, citizen volunteers

The 2024 Indiana Integrated Water Monitoring and Assessment Report (31) provides a comprehensive overview of the water quality status of surface and groundwater in Indiana. The Indiana Department of Environmental Management (IDEM) assesses 62,746 miles of streams and 1,582 lakes. Major impairments in streams include pathogens, polychlorinated biphenyls (PCBs), mercury, impaired biotic communities, and nonpoint sources. For lakes, common impairments include PCBs, mercury, phosphorus, aquatic plants, and E. coli.

Groundwater quality issues are primarily due to contamination from nitrate, arsenic, volatile organic compounds (VOCs), pesticides, and per- and polyfluoroalkyl substances (PFAS). Indiana faces several challenges in maintaining and improving water quality, including nonpoint source pollution from agricultural runoff and urban stormwater, aging infrastructure, climate change impacts, and limited financial resources for monitoring, assessment, and remediation efforts. IDEM has assessed 36,264 miles of streams and found 68% fully supporting aquatic life use, and 27% support full body contact recreational use. All 67 miles of Lake Michigan shoreline fully support aquatic life use, but none support full body contact recreational use or human health and wildlife use.

Various agencies are involved in efforts to improve water quality, including IDEM, U.S. Environmental Protection Agency (EPA), local governments, universities, and citizen volunteers. These agencies work together to implement monitoring, regulatory, and remediation programs to protect and enhance Indiana's water resources. Continued investment in infrastructure, pollution control, and public education is essential to address these challenges effectively.

Michigan

Category	*Details*
Streams Assessed	9,042 miles (7.6% of total 119,244 miles)
Major Stream Impairments	Fecal coliform bacteria, mercury, PCBs, aldrin, dieldrin, heptachlor, low dissolved oxygen, phosphorus, siltation, total suspended solids
Lakes Assessed	105 lakes covering 86,945 acres (26.8% of total 324,168 acres)
Major Lake Impairments	Phosphorus, total suspended solids, aquatic algae, mercury, PCBs, aldrin, endrin, dieldrin, heptachlor
Lake Michigan Assessment	196 square miles of open waters, 64 miles of shoreline, 2.14 square miles of harbors
Lake Michigan Impairments	Phosphorus, mercury, PCBs, E. coli bacteria (shoreline)
Wetlands Assessed	Data not readily available
Wetland Impairments	Data not readily available
Groundwater Contaminants	Nitrates, VOCs, pesticides, heavy metals
Challenges	Nonpoint source pollution, aging infrastructure, climate change, funding and resources
Impaired Water Bodies	Streams: 10,516 miles; Lakes: 151,884 acres; Lake Michigan: 64 miles of shoreline, 0.18 sq. miles of harbors
Agencies Involved	Michigan Department of Environment, Great Lakes, and Energy (EGLE), USEPA, Michigan Department of Natural Resources (MDNR), local agencies, watershed groups, NGOs

The water quality status in Michigan, as detailed in the 2024 EGLE Water Quality report (32), shows a varied picture across different water bodies. Surface water quality in the Great Lakes (Michigan, Superior, Erie and Huron) touching Michigan is generally good to excellent, although some nearshore areas influenced by urban and industrial activities show impairments. Inland lakes and rivers exhibit a range of water quality conditions, with the northern regions typically having better quality due to less urbanization and more forested areas.

Groundwater in Michigan is generally of high quality and abundant, supporting both ecological and human needs. However, the state faces several challenges in maintaining and improving water quality. These challenges include nutrient enrichment from agricultural runoff, sedimentation, toxic pollutants such as PCBs and mercury, and the impact of invasive species on aquatic ecosystems.

Contaminants of concern in Michigan's surface waters include PCBs, mercury, PFAS, nutrients, and E. coli. These contaminants have led to numerous water bodies being listed as impaired, including parts of the Great Lakes, various inland lakes, rivers, and wetlands. The state has identified specific areas where these impairments are most pronounced and is working to address them through various programs and initiatives.

Several agencies are involved in water quality management and improvement efforts in Michigan. The Michigan Department of Environment, Great Lakes, and Energy (EGLE) plays a central role, along with the Michigan Department of Health and Human Services (MDHHS), the Michigan Department of Natural Resources (MDNR), the United States Environmental Protection Agency (EPA), local health departments, and various watershed councils. Monitoring programs such as the Water Chemistry Monitoring Program, Fish Contaminant Monitoring, Beach Monitoring, and the Michigan Clean Water Corps (MiCorps) are crucial in assessing and tracking water quality. These programs help identify trends, assess the effectiveness of pollution control measures, and guide future actions.

The state indicates a persistent issue with PCBs and mercury, which continue to affect fish consumption advisories and aquatic life. Emerging concerns with PFAS are also noted, with these substances impacting both surface and groundwater. Nutrient-related impairments are significant in many inland lakes and rivers, leading to issues such as algal blooms and reduced dissolved oxygen levels.

Ohio

Category	*Details*
Streams Assessed	1,538 watershed assessment units (WAUs), 45 large river assessment units (LRAUs), 7 Lake Erie assessment units (LEAUs), 10 Ohio River assessment units (ORAUs)
Major Stream Impairments	Habitat modification, nutrient enrichment, sedimentation, organic enrichment, high bacteria levels (E. coli)
Lakes Assessed	Inland lakes assessed individually and as part of WAUs
Major Lake Impairments	Nutrient enrichment, harmful algal blooms (HABs), high bacteria levels (E. coli)
Wetlands Assessed	Data not readily available

Category	*Details*
Wetland Impairments	Data not readily available
Groundwater Contaminants	Fertilizers, storage tanks, landfills, septic systems, shallow injection wells, hazardous waste sites, pipelines, salt storage, suburban runoff, small-scale manufacturing, fire training facilities
Challenges	Nutrient enrichment, habitat modification, contamination (PCBs, mercury, etc.), high bacteria levels (E. coli)
Impaired Water Bodies	419 WAUs impaired for human health, 30 LRAUs impaired for human health, 7 LEAUs impaired for human health, 10 ORAUs impaired for human health; 1,234 WAUs impaired for recreation, 39 LRAUs impaired for recreation, 5 LEAUs impaired for recreation, 6 ORAUs impaired for recreation; 38 WAUs impaired for PDWS, 5 LRAUs impaired for PDWS, 5 LEAUs impaired for PDWS
Agencies Involved	Ohio EPA, ODNR, ODH, local health departments, U.S. EPA, OWDA

The Ohio 2024 Integrated Water Quality Monitoring and Assessment Report (33) provides a detailed overview of the water quality status in Ohio, focusing on surface and groundwater. The report assesses 1,538 watershed assessment units (WAUs), 45 large river assessment units (LRAUs), 7 Lake Erie assessment units (LEAUs), and 10 Ohio River assessment units (ORAUs). Major stream impairments include habitat modification, nutrient enrichment, sedimentation, organic enrichment, and high bacteria levels (E. coli). Inland lakes are assessed both individually and as part of WAUs, with major impairments being nutrient enrichment, harmful algal blooms (HABs), and high bacteria levels.

Groundwater quality is affected by various contaminants, including fertilizers, storage tanks, landfills, septic systems, shallow injection wells, hazardous waste sites, pipelines, salt storage, suburban runoff, small-scale manufacturing, and fire training facilities. The primary challenges facing Ohio's water quality include nutrient enrichment, habitat modification, contamination (such as PCBs and mercury), and high bacteria levels.

The report identifies numerous impaired water bodies: 419 WAUs, 30 LRAUs, 7 LEAUs, and 10 ORAUs are impaired for human health; 1,234 WAUs, 39 LRAUs, 5 LEAUs, and 6 ORAUs are impaired for recreation; and 38 WAUs, 5 LRAUs, and 5 LEAUs are impaired for the Public Drinking Water Supply (PDWS) beneficial use. Various agencies are involved in improving water quality, including the Ohio Environmental Protection Agency (Ohio EPA), Ohio Department of Natural Resources (ODNR), Ohio Department of Health (ODH), local health departments, U.S. Environmental Protection Agency (EPA), and Ohio Water Development Authority (OWDA). This comprehensive assessment highlights the ongoing efforts and challenges in maintaining and improving water quality in Ohio, emphasizing the need for continued monitoring, regulation, and collaboration among various agencies and stakeholders.

Pennsylvania

Category	Details
Streams Assessed	85,472 total miles, 85,030 miles assessed (99%); 28,820 miles impaired for any use (34%)
Major Stream Impairments	Siltation, pathogens, metals, mercury, habitat alterations, pH fluctuations, flow regime modification, nutrients, organic enrichment, polychlorinated biphenyls (pcbs), E. coli, total suspended solids (tss), perfluorooctane sulfonate (pfos), iron, total dissolved solids (tds), turbidity, aluminum, eutrophication, manganese, algae
Lakes Assessed	105,199 total acres, 103,777 acres assessed (99%%); 69,369 acres impaired for any use (66%)
Major Lake Impairments	Mercury, nutrients, ph fluctuations, dissolved oxygen, pathogens, organic enrichment, total suspended solids (tss), polychlorinated biphenyls (pcbs), noxious aquatic plants, algae, non-native fish/shellfish/zooplankton, metals, biochemical oxygen demand (bod), turbidity, habitat alterations, siltation, eutrophication
Wetlands Assessed	Data not readily available
Wetland Impairments	Data not readily available
Groundwater Contaminants	Nutrients (nitrogen, phosphorus), pathogens (bacteria, viruses), heavy metals (lead, arsenic, mercury), volatile organic compounds (VOCs), pesticides, per- and polyfluoroalkyl substances (PFAS), chlorides, nitrates, radionuclides (radon, uranium), petroleum products
Challenges	Nonpoint source pollution, acid mine drainage, climate change, sedimentation, heavy metals and legacy toxic substances, algae
	Expanded" (or "Statewide") Fixed Station Groundwater Quality Monitoring Network
Agencies and Programs Involved	Pennsylvania Department of Environmental Protection (DEP), Susquehanna River Basin Commission (SRBC), Natural Resources Conservation Service (NRCS), Environmental Quality Incentives Program (EQIP), Pennsylvania Department of Health (DOH)

The 2024 Pennsylvania Water Quality Report (34) provides a comprehensive overview of the water quality status of surface and groundwater in Pennsylvania. As shown in the table, the state has assessed numerous stream stations, with many stations having enough data to provide insight into water quality. Major impairments in streams include siltation, pathogens, metals, mercury, habitat alterations, pH, flow regime modification, nutrients, cause unknown, organic enrichment, polychlorinated biphenyls (PCBs), (E. coli), total suspended solids (TSS), perfluorooctane sulfonate (PFOS), pH (high and low), iron, total dissolved solids (TDS), turbidity, aluminum, eutrophication, manganese, dewatering, algae, thermal modifications, sulfate, dioxin toxicity, oil and grease, non-native fish/shellfish/zooplankton, organics, biochemical oxygen demand (BOD), fecal coliform, ammonia (un-ionized), dissolved oxygen, trash, pesticides, chlorine, lead, physical substrate habitat alterations, and stream modification.

For lakes, Pennsylvania has assessed many lakes, identifying common impairments such as mercury, nutrients, pH, dissolved oxygen, pathogens, organic enrichment, total suspended solids (TSS), polychlorinated biphenyls (PCBs), noxious aquatic plants, algae, invasive fish/shellfish/

zooplankton, metals, biochemical oxygen demand (BOD), turbidity, habitat alterations, and siltation.

Groundwater quality issues in Pennsylvania are primarily due to contamination from nutrients (nitrogen, phosphorus), pathogens (bacteria, viruses), heavy metals (lead, arsenic, mercury), volatile organic compounds (VOCs), pesticides, per- and polyfluoroalkyl substances (PFAS), chlorides, nitrates, radionuclides (radon, uranium), and petroleum products.

Pennsylvania faces several challenges in maintaining and improving water quality, including nutrient pollution, sedimentation and erosion, pathogens, toxic contaminants, habitat alteration, acid mine drainage, urban runoff, and climate change impacts. Various agencies are involved in efforts to improve water quality, including the Pennsylvania Department of Environmental Protection (DEP), Susquehanna River Basin Commission (SRBC), Natural Resources Conservation Service (NRCS), Environmental Quality Incentives Program (EQIP), Pennsylvania Department of Health (DOH). These agencies work together to implement monitoring, regulatory, and remediation programs to protect and enhance Pennsylvania's water resources. Continued investment in infrastructure, pollution control, and public education is essential to address these challenges effectively.

New York

Category	*Details*
Streams Assessed	Extensive monitoring program including fixed long-term trend networks, random probabilistic/rotational sites, and targeted/professional interest sites. Approximately 739 streams/rivers are considered impaired.
Major Stream Impairments	Nonpoint source pollution such as phosphorus, fecal coliforms, low dissolved oxygen, nitrogen. Point source pollutions such as PCB's, Dioxin, ammonia, abnormal iron and manganese concentrations
Lakes Assessed	Approximately 290 lakes/reservoirs considered impaired
Major Lake Impairments	Most lakes are oligotrophic with low nutrient levels and high-water quality. Nutrient pollution (nitrogen and phosphorus), pathogens, sediment, abnormal pH, PCB's and Chlordane
Wetlands Assessed	Data not readily available
Wetland Impairments	Data not readily available
Groundwater Contaminants	Bacteria, nutrients, inorganics, organics (including pesticides and VOCs), radiochemicals.
Challenges	Nonpoint source pollution from agricultural runoff and urban stormwater, specific basin impacts.
Impaired Water Bodies	Approximately 1029- water bodies considered impaired
Agencies Involved	New York State Department of Environmental Conservation (DEC), Division of Water (DOW), US Geological Survey (USGS), various federal and state agencies, local stakeholders (Water Assessments by Volunteer Evaluators (WAVE), Chambers of Commerce, Hudson River Watershed Alliance, New York State Energy Research and Development Authority (NYSERDA), Cornell Cooperative Extension

New York state has a comprehensive water quality monitoring program that assesses both surface and groundwater, which is reported on in the state's Clean Water Act Section 305(b) Water Quality Report (35). The program includes extensive monitoring of streams, lakes, and groundwater through various methods such as fixed long-term trend networks, random probabilistic/rotational sites, and targeted/professional interest sites.

For the period 2020-2022, only 1029 water bodies were considered impaired with 739 streams in New York and 290 lakes/reservoirs considered impacted (using Biological Assessment Profile (BAP) scores, which indicate that many streams have natural or slightly impacted water quality). Nonpoint source pollution remains a significant challenge, particularly in basins like the Atlantic Ocean/ Long Island Sound and the Mohawk River, which show moderate impacts. Lakes in New York are generally oligotrophic, meaning they have low nutrient levels and high-water quality. Despite this, major lake impairments include nutrient pollution from nitrogen and phosphorus, pathogens, and sediment. Groundwater monitoring, conducted in collaboration with the US Geological Survey (USGS), reveals contaminants such as bacteria, nutrients, inorganics, organics (including pesticides and VOCs), and radioactive materials.

The state faces several challenges in maintaining water quality, primarily due to nonpoint source pollution from agricultural runoff and urban stormwater. Specific basins are particularly impacted, necessitating targeted efforts to address these issues. The report identifies impaired water bodies that require Total Maximum Daily Loads (TMDLs) for pollutants and prioritizes these for TMDL development. Multiple agencies are involved in water quality management in New York, including the New York State Department of Environmental Conservation (DEC) and its Division of Water (DOW), the US Geological Survey (USGS), and various federal and state agencies. Public participation is also encouraged through data solicitation and public comment periods for the 303(d) List of Impaired/TMDL Waters. These collaborative efforts aim to protect and improve water quality across the state.

Ontario

Ontario's water quality monitoring programs are robust and involve extensive collaboration between government agencies, local stakeholders, and volunteers. The Provincial (Stream) Water Quality Monitoring Network (PWQMN) measures water quality in rivers and streams across the province, providing data on nutrients, metals, and other parameters. The Lake Partner Program is a volunteer-based initiative that monitors the health of Ontario's inland lakes, focusing on total phosphorus and water clarity. Ontario also utilizes the Drinking Water Surveillance Program (DWSP) to monitor the quality of drinking water from municipal systems. These programs are supported by the efforts of Conservation Authorities, which manage water resources and provide additional data on water quality. The status of surface and groundwater quality in Ontario reveals a complex picture of regional variations and significant challenges. Surface water quality shows improvements in some areas, particularly in the Great Lakes, but continues to face issues such as nutrient pollution, industrial and agricultural contaminants, and eutrophication. For instance, Lake Erie suffers from algal blooms driven by phosphorus runoff from agricultural lands, while Lake Ontario is increasingly affected by microplastics and emerging contaminants like PFAS. Lakes like Lake Simcoe struggle with low dissolved oxygen levels, impacting aquatic life. The primary challenges include agricultural runoff, urbanization, and the impacts of climate change, which exacerbate water quality issues through increased temperatures and extreme weather events. Monitoring and management efforts by the Provincial (Stream) Water Quality Monitoring Network

(PWQMN) and other initiatives by the Ministry of the Environment, Conservation and Parks (MECP) are crucial in addressing these issues.

Ontario's streams and rivers, such as those in the Hudson Bay, Great Lakes, and Ottawa River watersheds, are vital to the province's environmental health and economy. These water bodies face similar challenges, including nutrient pollution from agricultural runoff, urbanization leading to increased stormwater runoff, and the impacts of climate change(36). The PWQMN monitors water quality in these rivers and streams, measuring parameters like nutrients, metals, and chloride. Conservation efforts by organizations like Ontario Streams are essential in addressing these challenges and promoting the protection and rehabilitation of stream, river, and wetland habitats. These water bodies also provide significant recreational and economic benefits to the province. Groundwater quality in Ontario is generally good especially to the east, with no significant widespread contamination issues. However, localized areas face challenges such as high-water withdrawals for residential, industrial, and agricultural use, and the presence of low levels of pesticides and radionuclides(36). PFAS contamination from sources like landfills also poses a threat. Aging infrastructure further complicates water management efforts. Programs like the Groundwater Knowledge Acquisition Program (PACES) help monitor and manage groundwater resources effectively. Overall, while there are positive trends in some areas, significant challenges remain, particularly related to agricultural impacts, urbanization, and emerging contaminants. Continued efforts from various governmental agencies and stakeholders are essential to maintaining and improving water quality in Ontario.

Quebec

Category	*Details*
Status	46% positive indicators; improvements in St. Lawrence River
Challenges	Agricultural runoff, climate change, biodiversity threats
Contaminants	Metals, PBDEs below harmful levels; concerns with pesticides and emerging contaminants
Impaired Water Bodies	Rivers and lakes in agricultural regions; estuary and gulf of St. Lawrence facing oxygen and acidity issues
Agencies	MELCC, MAPAQ, MFFP, other ministries; Saint-Laurent Action Plan, Groundwater Knowledge Acquisition Program (PACES)
Ground Water Quality	Data not readily available
Status	Generally good; no significant availability issues
Challenges	Localized pressure from high water withdrawals
Contaminants	Low levels of pesticides; radionuclides below harmful levels

The quality of surface water in Quebec shows significant regional variation, with 46% of the indicators being positive. Notably, there have been improvements in the St. Lawrence River, particularly in terms of water toxicity, sediment contamination, and fish contamination(37).

However, agricultural activities pose a major challenge, leading to nutrient and pesticide runoff that contaminates water bodies. Metals and PBDE's in southern Quebec's rivers and the St. Lawrence River are below harmful levels, but pesticides in agricultural areas and emerging contaminants like perfluorinated compounds remain concerns. Impaired water bodies include rivers and lakes in agricultural regions, as well as the Estuary and Gulf of the St. Lawrence, which face issues with dissolved oxygen and acidity. Agencies such as the Ministry of the Environment, the Fight Against Climate Change, Wildlife and Parks (MELCCFP), the Quebec Ministry of Agriculture, Fisheries and Food (MAPAQ), and the Quebec Ministry of Forests, Wildlife and Parks (MFFP) are actively involved in monitoring and improving water quality through initiatives like the Saint-Laurent Action Plan and the Groundwater Knowledge Acquisition Program (PACES). Groundwater quality in Quebec is generally good, with no significant availability issues reported. However, some localized areas face pressure from high water withdrawals. Contaminants in groundwater are minimal, with low levels of pesticides and radionuclides from nuclear facilities detected but remaining below harmful levels. There has been a general lack in the integration and use of the ground water monitoring information provided by PACE in land management, largely driven by the complexity of the data and to the lack of dedicated knowledge transfer initiatives.

Quebec's water quality monitoring programs are comprehensive and multifaceted, involving various tools and initiatives to ensure the health of its water bodies. The Water Atlas (Atlas de l'eau) provides an interactive map with data on water quality, pollution sources, and water availability by watershed. The Hydroclimatic Atlas of Southern Québec supports resilient water management by describing current and future water regimes. The Environnement-Plage directory offers information on the bacteriological quality of bathing water at numerous beaches. Hydrological Monitoring tools provide real-time data on water levels and discharges for specific water bodies. Additionally, the 2020 Report on the State of Québec's Water Resources and Aquatic Ecosystems offers detailed insights into the status and trends of water quality in rivers, lakes, and the St. Lawrence River(37).

Major Pollutants and Sectors

Common Contaminants

Surface and groundwaters of the Great Lakes region is facing significant contamination challenges from various point and non-point contaminant sources. Nutrient pollution is a major concern, primarily driven by urban center runoff, agricultural runoff(38) and drainage, and wastewater treatment plants. Excessive amounts of nitrogen and phosphorus enter the lakes, leading to harmful algal blooms that can deplete oxygen levels and produce toxins harmful to both wildlife and humans(39). Industrial chemicals, including legacy pollutants like PCBs (polychlorinated biphenyls) and emerging contaminants such as PFAS (Per- and Polyfluoroalkyl Substances), also contribute significantly to the pollution. These substances come from manufacturing processes. Additionally, pharmaceuticals enter the lakes and waterways through wastewater effluent, adding to the complex mix of contaminants. Several manufacturing sectors contribute to this contamination, these key sectors include chemical manufacturing, which produces a variety of industrial chemicals; metal production and processing, which releases heavy metals like mercury, lead, and chromium; petroleum refining, which contributes petroleum compounds and other pollutants; and paper and pulp manufacturing, which discharges organic pollutants and other chemicals used in the production process(40).

Chemicals of Mutual Concern (CMCs) are harmful substances found in the Great Lakes region that pose risks to aquatic ecosystems, habitats, and biodiversity. Some CMCs, such as many listed in Table 3, are persistent, accumulating in the food web and potentially exposing humans to harmful chemicals through fish consumption. With limited exceptions, the manufacturing, use, and import of these chemicals are restricted by law through the Toxic Substances Control Act (TSCA) in the US and the Canadian Environmental Protection Act (CEPA) to minimize environmental release. When a chemical is nominated as a CMC, it undergoes a review by ECCC and the EPA based on the Binational Screening Criteria under the GLWQA, ensuring a consistent assessment framework. In 2016, Canada and the U.S designated the following eight chemicals as the first set of CMCs under the GLWQA.

Table 3 – *Chemicals of Mutual Concern for the Great Lakes Region*

Chemical of Mutual Concern	*Description*	*Impact*
Hexabromocyclododecane (HBCD)	A brominated flame retardant used in building materials and textiles.	HBCD is persistent, bioaccumulative, and toxic to aquatic life.
Long-Chain Perfluorinated carboxylic acids (LC-PFCAs)	These chemicals are found in stain-resistant coatings and firefighting foams.	With long-term environmental persistence and adverse health effects.
Mercury	A toxic heavy metal, mercury contaminates water and paints.	Accumulates in fish, posing serious health risks to humans and wildlife.
Perfluorooctanoic acid (PFOA)	Used in non-stick cookware, PFOA	Resistant to environmental degradation
Perfluorooctane sulfonate (PFOS)	A synthetic compound found in firefighting foams and water-resistant textiles	PFOS is persistent, bioaccumulative, and toxic.
Polybrominated Diphenyl Ethers (PBDEs)	Common flame retardants in electronics and furniture.	PBDEs accumulate in the food web, affecting the nervous and reproductive systems of wildlife and humans.
Polychlorinated Biphenyls (PCBs)	Industrial chemicals once used in electrical equipment.	PCBs are persistent pollutants linked to cancer and other health risks.
Short-Chain Chlorinated Paraffins (SCCPs)	Used in metalworking and as flame retardants	SCCPs are persistent and toxic to aquatic life, raising concerns for both environmental and human health.

Table 3: Canada and the U.S designated the following eight chemicals as the first set of Chemicals of Mutual Concern (CMC) under the 2012 Great Lakes Water Quality Agreement

Regional Water Vulnerabilities

Climate Change Impacts

Climate change exacerbates impacts on the Great Lakes and the region's other water resources, influencing and interacting with all the ecosystem indicators of their health. There is ample credible science on the current and growing impacts of climate change in the region, including the United

States National Climate Assessment, Canada's Changing Climate report and the Canada in a Changing Climate: National Issues Report. The basin-wide, long-term trends in climate indicators used in the State of the Great Lakes 2022 Technical Report show rising surface water temperatures, declining ice cover, increasing precipitation and extreme weather events. Intensified rain and snowstorms, which are expected to become more frequent due to climate change, pose significant risks to both the environment and human health(41). These extreme weather events can increase soil erosion, elevate pollution levels, and exacerbate sewage and sediment runoff, all of which can harm ecosystems and water quality. For example, in 2019, the increased frequency and intensity of storms in Michigan contributed to higher levels of agricultural runoff into rivers and lakes, causing harmful algal blooms and reducing water quality.

Resiliency in the Great Lakes region involves developing adaptive capacity to withstand, adapt to, and recover from climate-related stressors and changing conditions(42). This includes addressing vulnerabilities such as extreme weather events, flooding, drought, and erosion, which are exacerbated by climate change. Effective planning and implementation of adaptation strategies, such as green infrastructure and water conservation efforts, are crucial for mitigating these impacts. Furthermore, integrating traditional ecological knowledge with scientific data can enhance community-based adaptation efforts, ensuring that strategies are trusted and effective. Centering justice is crucial, ensuring that all communities, especially those historically marginalized, have equitable access to resources and decision-making processes.

Economic and Population Expansion

The rapid population growth, driven by and drawn to the ever-increasing expansion of the Great Lakes economy has significant impacts on the on the Great Lakes basin freshwater resources that are shared by both the US and Canada. Population growth is directly linked to economic growth and often linked to water quality degradation and increased fluctuations in water extraction from local surface and ground water sources. Climate change amplifies these vulnerabilities, exacerbating the challenges posed by population expansion.

In the Great Lakes basin, urban development and agricultural land use make up a large portion of the landcover in the southern basin of the Great Lakes while the north is predominately natural systems. Data from 2015 indicated that Lake Superior's basin retained a significant proportion of natural land cover at 97%, in stark contrast to the Lake Erie basin, which had only 21%(43). Between 2000 and 2015, developed land in the Great Lakes region expanded by an estimated 2,893 km^2. During the same period, forested areas saw a net reduction of approximately 2,900 km^2, and wetlands decreased by 583 km^2 total(43). Population expansion and landcover change that is not adequality managed with effective impact mitigation strategies result in the increase of human effluent, industrial waste, and agricultural runoff volume entering the Great Lakes and further straining water quality in the region. Further development of the economy in the region may exacerbate impacts of population growth, resulting in increased water extraction by public and industrial sector, however trend data from 2014 to 2022 for water withdrawn by the public and industrial sector indicates a decline in water withdrawal which may be attributed to improved water use efficiency in the region (Figure 10).

Figure 10 – *Total Water Withdrawn by Public and Industrial Sectors.*

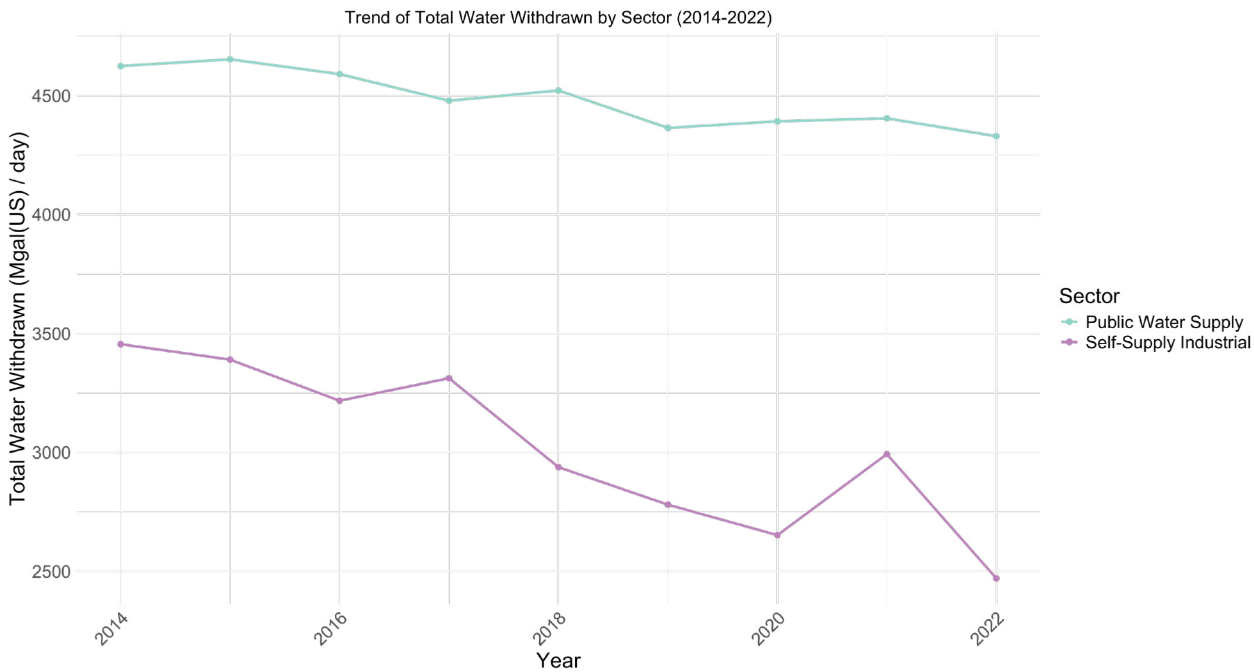


Figure 10: Trend of total water withdrawn by sector (2014-2022) illustrates the trend of total water withdrawals (mgd) from 2014 to 2022, focusing on the "Public Water Supply" and "Self-Supply Industrial" sectors. The data is grouped by year and sector, showing the annual sum of water withdrawals. Data extracted from the Great Lakes Commission. (2024).

A further complication to the situation for the Great Lakes region is the ageing infrastructure. Sewer systems across the Great Lakes region were designed decades ago, are no longer equipped to handle increased populations or more frequent heavy rainfall events that are currently occurring and expected to worsen in the coming decades. Recently the occurrence of combined sewer overflows (CSOs) has increased during the severe seasonal storms, with these combined outflows releasing large volumes of untreated sewage and stormwater directly into the lakes and waterways, while deteriorating shoreline infrastructure, such as seawalls, increases coastal erosion, threaten local shoreline infrastructure(44). To mitigate these impacts, several strategies should be considered and supported. Investing in further advanced wastewater treatment technologies can reduce pollutant discharge. Effective land use planning and stronger regulations to protect natural habitats and manage shoreline development are crucial for maintaining ecosystem integrity. Conservation efforts, such as wetland restoration and planting native vegetation, can improve pollution filtration and provide critical wildlife habitats. Public awareness campaigns are also essential for educating communities on the importance of protecting the Great Lakes ecosystem.

Emerging Contaminants of Concern

The Great Lakes region is facing a mounting issue of emerging contaminants that reflect the length and breadth of the industries present. Emerging Contaminants of Concern (ECC) such as pharmaceuticals, personal care products, synthetic chemicals, and microplastics are becoming common in urban watersheds linked to urban effluent indicators while ECC in agricultural land use are shown to have more pesticides and hormones(45). These pollutants enter lakes and waterways through wastewater effluents, agricultural runoff, industrial discharges, and urban stormwater, posing risks to both environmental and human health.

Table 4 – *Summary of Current Emerging Contaminants in the Great Lakes Basin*

Contaminant Class	*Contaminants*	*Description*	*Potential Sources*
Synthetic Sweeteners	Acesulfame Potassium (ACE-K), Sucralose	Common in wastewater due to high water solubility and resistance to degradation.	Wastewater treatment plants (WWTPs), personal care products.
Pharmaceuticals	Sulfamethoxazole, Acetaminophen, Lidocaine, Atenolol, Gemfibrozil, Iohexol, Estradiol, Testosterone, Progesterone, Ethinylestradiol	Includes antibiotics, analgesics, anesthetics, beta-blockers, lipid regulators, contrast agents, and synthetic hormones.	Medical and pharmaceutical industries, WWTPs, personal care products, agriculture operations.
Pesticides	Atrazine, Diaminochlorotriazine (DACT), Deethyl-atrazine (DEA), Deisopropylatrazine (DIA), 2,4-Dichlorophenoxyacetic Acid (2,4-D), Diuron, Sulfometuron-Methyl, Dichlorvos	Herbicides and degradation products commonly used in agriculture and urban landscaping.	Agricultural runoff, urban runoff, WWTPs.
Stimulants	Caffeine, Nicotine, Cotinine, Cocaine, Benzoylecgonine	Commonly detected stimulants and their metabolites.	Personal use products, WWTPs, urban runoff.
Microplastics	Plastics debris smaller than 5mm	They can be ingested by aquatic organisms, causing physical and chemical harm.	Synthetic clothing, plastic packaging, cosmetics, cleaning products, industrial waste, tire wear, agricultural films, improper disposal, urban runoff.
PFAS	Perfluorobutanoic Acid (PFBA), Perfluorobutane Sulfonic Acid (PFBS), Perfluoropentanoic Acid (PFPeA), Perfluorohexanoic Acid (PFHxA), Perfluorooctanoic Acid (PFOA), Perfluorooctane Sulfonate (PFOS), 6:2 Fluorotelomer Sulfonic Acid (6:2 FTSA)	Persistent "forever chemicals" used in various industrial and consumer products.	Industrial discharges, firefighting foams, WWTPs, military activities.
Flame Retardants	Polybrominated Diphenyl Ethers (PBDEs)	Used in a variety of consumer products to prevent fires.	Industrial discharges, WWTPs, consumer products.
Polycyclic Aromatic Hydrocarbons (PAHs)	Benzo[a]pyrene, Naphthalene	Byproducts of incomplete combustion of organic matter.	Industrial processes, vehicle emissions, WWTPs, urban runoff.
Alkylphenols and Alkylphenol Ethoxylates	Nonylphenol, Octylphenol	Used in industrial processes and consumer products.	Industrial discharges, WWTPs, consumer products.

Table 4 Persistent contaminants of emerging concern in the Great Lakes basin(46).

Microplastic pollution in the Great Lakes has become an increasing concern for both the U.S. and Canada. In the U.S., the EPA has been involved in research to monitor microplastic levels and their impact on aquatic life. Additionally, various states have implemented legislation to reduce plastic waste entering the lakes, focusing on improving waste management systems and encouraging public awareness. Canada, through initiatives like the "Great Lakes Protection Act," has committed to reducing plastic pollution by addressing the sources of microplastics and supporting research on their effects. Indigenous groups, such as the Anishinabek Nation, are also playing a key role in monitoring microplastic contamination on their lands. These collaborative efforts between the U.S., Canada, and Indigenous communities reflect a growing commitment to combating microplastic pollution and protecting the region's water resources. As research progresses, policies and actions are expected to adapt, aiming for long-term solutions to this persistent environmental issue.

Additionally, the United States and Canada have implemented strategic measures to address PFAS contamination in the Great Lakes region. In the U.S., the EPA has introduced the "PFAS Strategic Roadmap," which establishes enforceable limits on PFAS in drinking water, funds research, and supports state and local monitoring and remediation efforts(47). The EPA has also provided substantial funding to institutions, such as Indiana University, to conduct long-term monitoring of PFAS levels in the Great Lakes(48). Canada's approach is outlined in the "Great Lakes Strategy for Perfluorooctane Sulfonate, Perfluorooctanoic Acid, and Long-Chain Perfluorocarboxylic Acids." This strategy prioritizes reducing PFAS presence through regulatory actions, research initiatives, and collaboration with stakeholders(49). Additionally, Indigenous groups, such as the Little Traverse Bay Bands of Odawa Indians, contribute to these efforts by independently monitoring PFAS impacts on their lands and communities. The initiatives of the US and Canada and the region's First Nations reflect a growing focus on stricter regulations and enhanced monitoring programs for PFAS in the Great Lakes. These measures aim to address existing contamination and are expected to evolve as new data and research become available.

Key Policies And Agreements

The Great Lakes region is governed by comprehensive policies and programs designed to protect and manage its water resources. Key international agreements, such as the Boundary Waters Treaty and the GLWQA, establish foundational principles for U.S.-Canada cooperation in maintaining the chemical, physical, and biological integrity of the Great Lakes. Regional agreements, including the Great Lakes-St. Lawrence River Basin Water Resources Compact and the Sustainable Water Resources Agreement, provide a cooperative framework for managing water resources across U.S. states and Canadian provinces, ensuring sustainable use and preventing significant withdrawals.

National laws like the U.S. CWA and the Canada Water Act set water quality standards and regulate discharges to protect surface water quality. Federal programs such as the GLRI in the U.S. and Canada's GLPI provide targeted funding and strategic direction to address critical environmental challenges, including toxic substances, invasive species, and habitat restoration.

The U.S. GLRI operates as a non-regulatory, collaborative initiative led by the EPA, focusing on species protection, delisting Areas of Concern, invasive species control, nutrient runoff reduction, and habitat restoration. In Canada, the GLPI, administered by CWA, emphasizes Indigenous collaboration and aligns priorities across stakeholders, including the prevention of toxic algae and investing $650 million over 10 years through the Freshwater Action Plan. Both frameworks use federal oversight to manage activities but differ in implementation methods. The GLPI emphasizes clear intergovernmental roles, including Indigenous partnerships, while the GLRI encourages collaboration without direct legal mandates. Canada's GLPI highlights provincial environmental policies as barriers but maintains a federal commitment to share risks and benefits equitably across jurisdictions. Both nations' action plans employ measurable targets; the GLRI includes a reporting plan for data coordination and assessment.

Table 5 – *Summary of Key State and Provincial Gap Assessment*

State/Province	*Existing Policies*	*Gaps*	*Additional Gaps*
Minnesota	Minnesota Clean Water Legacy Act, Minnesota Water Quality Standards	Inconsistent enforcement, Agricultural runoff	Limited funding for water quality initiatives, Lack of comprehensive climate change adaptation measures
Wisconsin	Wisconsin Pollutant Discharge Elimination System (WPDES), Wisconsin Water Quality Standards	Insufficient invasive species control, Agricultural runoff	Aging infrastructure, Limited groundwater protection measures
Illinois	Illinois Environmental Protection Act, Clean Water Initiative	Limited funding for infrastructure upgrades, Nutrient pollution from agriculture, Lead contamination in drinking water	Aging water infrastructure, Over-extraction of groundwater, Lack of comprehensive water recycling policies
Indiana	Indiana Water Quality Standards, Clean Water Indiana Program	Limited groundwater protection, Aging water infrastructure	Insufficient funding for water quality projects, Lack of integrated water management plans
Michigan	Michigan Water Strategy, Safe Drinking Water Act	Limited groundwater protection, Contaminant issues such as PFAS	Aging infrastructure, Inconsistent enforcement of water quality regulations
Ohio	Ohio Water Quality Standards, Ohio Clean Lakes Initiative	Limited funding for pollution control, Agricultural runoff	Aging water infrastructure, Inconsistent enforcement of water quality standards
Pennsylvania	Pennsylvania Clean Streams Law, Pennsylvania Safe Drinking Water Act	Limited groundwater protection, Legacy pollution from mining	Insufficient funding for water quality projects, Inconsistent enforcement of regulations
New York	Environmental Conservation Law, Drinking Water Protection Program	Lack of climate change adaptation, Aging infrastructure	Nutrient pollution from agriculture, Inconsistent enforcement of water regulations
Ontario	Ontario Water Resources Act, Clean Water Act	Inconsistent enforcement, Industrial pollution	Limited focus on groundwater protection, Aging water infrastructure
Quebec	Quebec Water Policy, Regulation Respecting the Quality of Drinking Water	Inconsistent enforcement, Industrial and agricultural pollution	Limited groundwater management, Aging infrastructure

Corporate Water Stewardship

Corporations implement practices to manage and use water resources responsibly supporting water stewardship. The aim is to minimize environmental impact, practice sustainability and support local communities as described in the following discussion.

Circular Economy of Water

The Circular Economy of Water (CEW) framework provides a robust foundation for developing best management practices (BMPs) in water conservation and quality protection within the Great Lakes region. This approach focuses on reducing, preserving, and optimizing water use through waste avoidance, efficient utilization, and quality retention(50). Despite the region's abundant water supply, industries face challenges such as low return on investment, undervaluation of water, and lack of regulatory frameworks. However, pioneering companies in the Great Lakes WISE are leading the way by implementing BMPs that include reducing water use, reusing and recycling water, and storing water for future use. To scale up these practices, there is a need for enhanced education, regulatory and economic incentives, technological advancements, and collaboration through public-private partnerships. These efforts are crucial for ensuring sustainable water management and protecting the vital freshwater resources of the Great Lakes region.

Water Efficiency and Reuse

Water efficiency and reuse actions can involve a number of initiatives. These initiatives may be state or province led, but often they are associated with common water use practices. Several potential efficiency and reuse options are summarized below.

- **Restroom Fixture Upgrades:** Upgrading restroom fixtures is a straightforward yet impactful measure for enhancing water efficiency. Like how LED bulbs revolutionized energy savings in lighting, modern restroom fixtures such as low-flow toilets, faucets, and urinals can significantly reduce water consumption. These upgrades are cost-effective and can be easily implemented in both new constructions and retrofits, making them an essential first step in water conservation efforts.
- **On-site Water Treatment and Reuse:** Implementing on-site water treatment and reuse systems is another critical practice. For instance, above-ground ponds can be used to store stormwater, which can then be treated and reused for non-potable purposes such as irrigation, cooling, or industrial processes. This not only reduces the demand for fresh water but also mitigates the impact of stormwater runoff on local water bodies, enhancing overall water management.
- **Policy Development:** National policies on water reuse are gradually being developed. Regions have also begun to develop policy associated with local practices although the Midwest appears to lag. In Canada, for example, building codes are being updated to incorporate water reuse systems in new constructions. Similarly, in the U.S., there is a growing focus on integrating water reuse policies into new builds, with some successful retrofitting projects demonstrating the feasibility and cost-effectiveness of these measures.

Best Management Practices (BMPs)

A combination of practices and actions lead to best management practices as described below as organized by Corporate Action, Site Action or Engagement Action.

Corporate Actions

- **Executive Advocacy:** While grassroots support is essential, executive advocacy is equally crucial for the successful adoption of BMPs. Senior executives have the authority to allocate resources, set priorities, and drive organizational change. Their commitment to water management initiatives can inspire and motivate the entire organization to follow suit. Executive advocacy ensures that water management is integrated into the company's strategic goals and that sufficient funding and support are provided for implementing BMPs. By championing these initiatives, executives can create a top-down approach that aligns with the bottom-up efforts of engineering and maintenance teams, resulting in a cohesive and comprehensive water management strategy.
- **Water Quality Targets:** The focus of water management is shifting from availability to quality. High levels of water efficiency can stress water reclamation districts, making it essential to prioritize water quality targets. Metrics such as overall withdrawal intensity, which measures the total volume of water withdrawn relative to production output, are tracked to ensure sustainable water use. Common reductions in withdrawal intensity indicate progress in reducing the environmental impact of water use.
- **Invest in R&D:** Support research and development to create more efficient and cost-effective water treatment technologies. Focus on advancements in membrane filtration, advanced oxidation processes, and biological treatment methods.
- **Advanced Measures:** Implementing advanced water management measures often requires significant capital investment and customized designs tailored to the specific needs of the facility. Tools like The Water Council's WAVE program can help companies prioritize strategic upgrades by assessing the cost-effectiveness and potential impact of various water-saving measures. These advanced measures might include sophisticated water recycling systems, closed-loop water processes, and innovative technologies for water treatment and reuse.

Site Actions

- **Establish Baseline Water Use:** Understanding the current water usage is crucial for any water management strategy. Establishing a baseline involves detailed metering and monitoring to identify where and how water is being used within the facility. This data serves as the foundation for setting realistic water conservation targets and tracking progress over time.
- **Implement "Turn It Off" Programs:** Automated systems that shut off water when not in use can drastically reduce unnecessary water consumption. These programs can be integrated into various processes within manufacturing facilities, ensuring that water is only used when necessary.
- **Metering and Monitoring:** Continuous metering and monitoring are essential baseline requirements for effective water management. Advanced metering infrastructure (AMI) can provide real-time data on water use, helping to identify leaks, inefficiencies, and opportunities for conservation.

- **Engineering and Maintenance Teams:** Engineering and maintenance teams play a pivotal role in the successful implementation of best management practices (BMPs) for water management. These teams are on the front lines, directly interacting with the systems and processes that use water. Their technical expertise and hands-on experience are invaluable for identifying inefficiencies, troubleshooting issues, and implementing practical solutions. By fostering a culture of sustainability on the floor in a manufacturing facility, engineering and maintenance teams can drive significant improvements in water use efficiency and quality. Their involvement ensures that BMPs are not only theoretically sound but also practically feasible and effective in real-world applications.
- **Integrate Digital Technologies:** Promote the use of real-time monitoring and data analytics to enhance water management systems. Use smart sensors and meters for continuous data on water flow, pressure, and quality, and employ data analytics to optimize water use.

Engagement Actions

- **Public-Private Partnerships:** Foster collaboration between public and private sectors to facilitate data sharing and coordinated water management strategies. Develop shared water databases and support joint conservation initiatives.
- **Stakeholder Interactions:** Before siting new projects or implementing significant changes to existing operations, it is essential to conduct thorough due diligence. This involves assessing the potential environmental, social, and economic impacts of the project and understanding the concerns and sentiments of the local community. Canvassing, or systematically gathering feedback from community members, is a vital part of this process. It ensures that the voices of all stakeholders are heard and considered, leading to more informed and balanced decision-making. Engaging with cross-border and cross-sector organizations, such as the Council of the Great Lakes Region (CGLR) and The Water Council (TWC), provides an opportunity for all stakeholder groups - from government and local policymakers to NGOs, businesses and academia - to share knowledge and innovation, ultimately creating space for common understanding that will support long term water solutions.
- **Supply Chain Engagement:** Identification of water use in the supply chain is critical to demonstrate responsible water practices throughout production. Important reasons to understand and monitor supply chain water use include operational efficiency and costs, mitigating environmental risks and maintaining a positive brand reputation. This is particularly important for industries with heavy water use such as agriculture, manufacturing and food/beverage production. As water stewardship practices mature, obtaining this information is critical.
- **Local Community Engagement:** Engaging with local communities is a critical component of effective water management. Local communities are often directly affected by industrial water use and can provide valuable insights into the environmental and social impacts of water management practices. Community engagement drives transparency and accountability, encouraging organizations to monitor their water use more rigorously and to push the boundaries of what is possible in terms of sustainability. By involving local stakeholders in the decision-making process, companies can build trust and foster a collaborative approach to water management. By understanding community sentiment, organizations can anticipate and address potential issues before they become significant problems, thereby reducing the risk of conflicts and enhancing the overall success of their water management initiatives.

Emerging Initiatives

In addition to the water stewardship practices previously discussed, there are also emerging initiatives with opportunities focused on minimizing water usage and impacts to surrounding communities.

- **Leveraging Data Centers More Effectively:** Data centers are known for their high-water usage, primarily for cooling purposes. However, they also present an opportunity for innovative water management practices. By leveraging the waste heat generated by data centers, industries can reduce their overall water and energy consumption. For instance, the waste heat from data centers can be used in district heating systems, providing a sustainable source of heat for nearby buildings and reducing the need for additional water and energy resources. An example of this practice was the effective use of recovered waste heat from the Frontier high-performance computing data center and provide hot water for district heating at the U.S. Department of Energy's Oak Ridge National Laboratory campus(51).
- **Addressing Tensions Between Perceived and Actual Water Issues:** One of the significant challenges in water management is the gap between perceived and actual water issues. Public perception often does not align with the scientific reality of water availability and quality, leading to misinformed decisions and policies. Addressing this tension requires comprehensive public education and transparent communication strategies. For example, in the Great Lakes region, there is a common perception that water is abundant and inexhaustible. However, this overlooks critical issues such as water quality degradation and the impacts of climate change. Collaborative efforts like the Great Lakes Water Quality Agreement between the United States and Canada help address these misconceptions by establishing initiatives to monitor, protect, and restore the water quality of the Great Lakes, which involves extensive public outreach and education campaigns to align public perception with the actual state of water resources, ensuring informed decision-making and effective water management policies.
- **Direct Potable Reuse (DPR):** DPR is an innovative approach to water management that involves treating wastewater to a level safe for human consumption and then directly reintroducing it into the potable water supply. This method can significantly enhance water sustainability, especially in regions facing water stress. DPR systems typically involve advanced treatment processes such as microfiltration, reverse osmosis, and ultraviolet disinfection to ensure the water meets stringent safety standards. Although this is currently being used in water scarce areas, it is a potential option for other areas.

Education and Awareness

Education impacts water stewardship by increasing awareness of stewardship actions and promotes responsible water use habits.

- **Educate Stakeholders:** Inform stakeholders about the true cost of water and the benefits of water stewardship. Workshops, seminars, and informational campaigns can be used to raise awareness among industry leaders, policymakers, and the public.
- **Basic Understanding of Stewardship:** Training programs and educational materials can be made available to industry stakeholders to help them understand stewardship principles and how to implement them. Use case studies to illustrate successful implementations.

Regulatory and Economic Incentives

There are limited incentives such as rebates and tax credits which are economically beneficial to stewardship practices. In addition, policies and regulations exist which reward responsible water management.

- **Financial Incentives:** Offer subsidies, tax breaks, or grants for companies investing in water-efficient technologies. Impose penalties on those failing to meet standards to drive compliance.
- **Adjust Wastewater Disposal Rates:** Increase rates for wastewater disposal to make reclaimed water more economically attractive, encouraging investment in water treatment and recycling technologies. Additional information is required on this type of incentive, including evaluating unintended consequences.
- **Mandate CEW Practices:** Implement regulations that require the use of CEW principles, such as water reuse and conservation measures. Ensure enforcement and penalties for non-compliance.

Data Tools And Gap

Key Data Tools

Table 6 – *Key Data Tools for Water Monitoring and Management in the Great Lakes Region*

Key Data Tool	*Country*	*Description*	*Additional Information*
Great Lakes Observing System (GLOS)	US & Canada	Provides real-time data and information on the Great Lakes' conditions to support decision-making and research.	
National Hydrometric Network (NHN)	Canada	Managed by Environment and Climate Change Canada's National Hydrological Service (NHS). Includes the National Surface and River Prediction System (NSRPS), an integrated atmospheric, land surface, and streamflow prediction system.	In 2022-2023, ECCC published a pre-release of NHN basin delineation polygons, accessible through Water Office.
National Water Data Archive	Canada	Hydrometric data collected by Water Survey of Canada's regional offices, housed in HYDEX and HYDAT databases.	HYDEX contains inventory information on streamflow, water level, and sediment stations. HYDAT contains computed data, including daily and monthly means of flow, water levels, and sediment concentrations
Canadian Aquatic Biomonitoring Network (CABIN)	Canada	Monitoring network used by non-government organizations, Indigenous groups, and citizen scientists.	In 2022-2023, ECCC focused on making CABIN training and certification more accessible and inclusive.

Key Data Tool	Country	Description	Additional Information
NOAA Great Lakes Water Level Monitoring	US	Monitors water levels in the Great Lakes using a network of water level gauges and provides real-time data and forecasts.	NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) maintains a network of 53 water level gauges throughout the U.S. waters of the Great Lakes.
Great Lakes Restoration Initiative (GLRI)	US	A collaborative effort to address the most significant problems facing the Great Lakes, including water quality and ecosystem health.	Managed by EPA and other federal agencies, focusing on issues like toxic substances, invasive species, and habitat restoration.
Great Lakes Water Quality Monitoring Program	US	Monitors water quality in the Great Lakes, including biological, chemical, and physical parameters.	Part of the U.S. EPA's efforts to ensure the health of the Great Lakes ecosystem.

Table 6: Summarizes essential data tools used for monitoring and managing water resources in the Great Lakes region, highlighting their country of operation, descriptions, and additional information.

Data Gaps

Despite these robust tools, there are notable data gaps in water monitoring. The International Joint Commission has identified the absence of US data as part of the tributary water quality sub-indicator as a significant gap as well as insufficient data on how climate change affects various indicators such as water levels, water quality, and ecosystem health. Irregular intervals of data collection for nearshore and tributary surveys limit the ability to model and predict changes in watershed hydrology and nutrient loading. The lack of streamflow data in many areas also inhibits accurate modeling of potential changes in watershed hydrology and sediment loading as well as the near lack of groundwater-quantity and quality information availability. Enhanced coordination among federal, state, municipal, tribal, and private entities is needed to effectively manage and share data across different types and scales. Addressing these gaps will enhance the ability to manage and protect the water resources of the Great Lakes region effectively, ensuring the sustainability of these vital resources for future generations. Furthermore, future progress reporting would benefit from including information on the cross-cutting effects of climate impacts on other prioritized indicators.

Conclusions

Key Takeaways

The Great Lakes region faces a complex mix of challenges related to climate change, economic growth, and pollution. Building resilience in both natural systems and communities is essential to navigate these difficulties. This means not only protecting water resources but also ensuring that all communities are able to adapt to and recover from the stresses of a changing climate.

Addressing the identified data gaps in water monitoring is essential for effectively managing and protecting the Great Lakes region's water resources. Improved coordination among federal, state, municipal, tribal, and private entities, alongside enhanced data collection, uniformity and transparency of streamflow, groundwater, sectoral and state level extraction volumes and climate impacts, will enable more accurate modeling especially in the uniquely challenging Great Lakes region and allow for better prediction of future watershed changes. These efforts will ensure the sustainability of the region's water resources and provide a stronger foundation for future progress reporting, particularly on the interconnected effects of climate change on key environmental indicators.

Effective water management in the Great Lakes region cannot be achieved in isolation. Governments, Indigenous communities, businesses, and the public all need to work together. Strengthening these partnerships, particularly by integrating Indigenous knowledge into decision-making, will help ensure that policies are both effective and equitable.

The region's infrastructure is struggling to keep up with the growing demands placed on it. Updating and expanding systems for wastewater treatment, stormwater management, and shoreline protection is crucial. Investing in these improvements today will help prevent future water quality crises and infrastructure failures.

The rise of new contaminants, like PFAS and microplastics, presents a growing threat to the Great Lakes and the region's waterways. Tackling this problem requires a coordinated response across borders and sectors, with stronger regulations, more research, and proactive monitoring to identify and address emerging pollutants.

Businesses have a critical role to play in protecting the Great Lakes. By adopting best practices for water conservation, quality, efficiency, and reuse, companies can help reduce their environmental footprint. It's essential to encourage these efforts through regulation and incentives, as well as by fostering collaboration between businesses and other stakeholders.

Future Directions

Moving forward, it's important to develop specific, measurable climate resilience goals for the

Great Lakes basin and the wider region. These goals should be based on a deep understanding of both environmental needs and community vulnerabilities. Clear targets and regular progress assessments will ensure that resilience-building efforts remain on track and adaptable to changing conditions. Effective water management depends on accurate, up-to-date data. There are significant gaps in our understanding of water quality, groundwater conditions, and the impacts of climate change. Enhancing monitoring systems and coordinating data and common metrics across various agencies will help ensure that decisions are based on the best available information.

To move the needle on water conservation, there must be broader adoption of water stewardship practices in the corporate sector. Updating regulations to include incentives for water efficiency, investing in innovative technologies, and fostering collaboration between businesses and communities will be essential for scaling up these efforts. New technologies for water treatment, including systems for on-site treatment and direct potable reuse, offer promising solutions to water scarcity and quality issues. Investment in research and development, as well as pilot projects, will be crucial to improving these technologies and making them more cost-effective and widely accessible.

The Great Lakes region's water challenges span both the U.S. and Canada, making cross-border collaboration essential. Strengthening governance frameworks, incorporating more voices (especially from Indigenous groups), and aligning policies across jurisdictions will help ensure that resources are managed effectively and equitably. The success of these efforts will depend on consistent and long-term funding. Governments, businesses, and non-profit organizations must invest in solutions that will secure the health of the Great Lakes and the broader region for generations to come. This means committing to dedicated funds for water innovation, research, and environmental restoration initiatives. By focusing on these future directions, the Great Lakes region can address its current challenges while setting the stage for a more resilient, sustainable, and equitable future.

References

1. The Government of Canada. Canada-United States relations. 2024 [cited 2024 Nov 23]. Canada United States relations: Bilateral relations. Available from: https://www.international.gc.ca/country-pays/us-eu/relations.aspx?lang=eng#a1.

2. Conservancy TN. https://www.nature.org/en-us/about-us/where-we-work/priority-landscapes/great-lakes/great-lakes-agriculture-/. 2024 [cited 2024 Oct 24]. Great Lakes Agriculture in the Midwest "Growing clean water" while feeding the world. Available from: https://www.nature.org/en-us/about-us/where-we-work/priority-landscapes/great-lakes/great-lakes-agriculture-/

3. National Oceanic and Atmospheric Administration. Great Lakes Ecoregion [Internet]. 2019 [cited 2024 Oct 23]. Available from: https://www.noaa.gov/education/resource-collections/freshwater/great-lakes-ecoregion

4. The International Joint Commission. The IJC and the Great Lakes Water Quality Agreement [Internet]. 2013 [cited 2024 Oct 23]. Available from: https://www.ijc.org/en/what/glwqa-ijc

5. Great Lakes Restoration Initiative (GLRI). Great Lakes Restoration Initiative Action Plan IV (2024–2029) [Internet]. 2024 [cited 2024 Dec 15]. Available from: https://www.glri.us/sites/default/files/glri-action-plan-4-202411-43pp_0.pdf

6. EPA Great Lakes National Program Office & Environment Canada. State of the Great Lakes Report - 2022 An overview of the status and trends of the Great Lakes ecosystem [Internet]. 2022. Available from: https://binational.net/wp-content/uploads/2022/07/State-of-the-Great-Lakes-2022-Report.pdf

7. U.S. Geological Survey. Estimated Use of Water in the United States in 2015 [Internet]. 2018. Available from: https://pubs.usgs.gov/circ/1441/circ1441.pdf

8. Environment and Climate Change Canada. Canadian Environmental Sustainability Indicators: Water Withdrawal and Consumption by Sector [Internet]. 2016 [cited 2024 Nov 12]. Available from: www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=5736C951-1

9. The Conference Board of Canada. Water Withdrawals [Internet]. Available from: https://www.conferenceboard.ca/hcp/water-withdrawals-aspx/

10. Mayer A, Mubako S, Ruddell BL. Developing the greatest Blue Economy: Water productivity, fresh water depletion, and virtual water trade in the Great Lakes basin. Earths Future [Internet]. 2016 Jun [cited 2025 Jan 24];4(6):282–97. Available from: https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2016EF000371

11. Warziniack T, Arabi M, Brown TC, Froemke P, Ghosh R, Rasmussen S, et al. Projections of Freshwater Use in the United States Under Climate Change. Earths Future [Internet]. 2022 Feb [cited 2025 Jan 24];10(2):e2021EF002222. Available from: https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021EF002222

12. Unger S, Kilgannon E, Elliott D, Cort K, Stoughton K. Water and Wastewater Annual Price Escalation Rates for Selected Cities Across the United States: 2023 Edition [Internet]. 2023 Mar [cited 2025 Jan 24] p. PNNL--34006, 1975260. Report No.: PNNL--34006, 1975260. Available from: https://www.osti.gov/servlets/purl/1975260/

13. The City of London, Canada. Property Tax, Water, Wastewater & Treatment Budgets: 2024 – 2027 Multi-Year Budget Draft – December 12, 2023 [Internet]. 2023 Dec. (2024-2027 Multi-Year Budget). Available from: https://london.ca/sites/default/files/2023-12/DRAFT%202024-2027%20Multi-Year%20Budget.pdf

14. Bluefield Research. U.S. & Canada Municipal Water Outlook: Utility CAPEX & OPEX Forecasts, 2022–2030 [Internet]. 2022 Nov. Available from: https://www.bluefieldresearch.com/research/u-s-canada-municipal-water-outlook-utility-capex-opex-forecasts-2022-2030/

15. Lacs GLC des G. 2023 Great Lakes Commission Annual Report [Internet]. Great Lakes Commission des Grands Lacs; 2023 [cited 2024 Oct 2]. Available from: https://waterusedata.glc.org/reports/annual-reports

16. Regulation respecting the declaration of water withdrawals [Internet]. 20 Jan 11, 2024. Available from: https://www.legisquebec.gouv.qc.ca/fr/document/rc/Q-2,%20r.%2014

17. Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs. Regulation respecting the charges payable for the use of water [Internet]. 2024 [cited 2024 Oct 21]. Available from: https://www.environnement.gouv.qc.ca/eau/redevance/reglement-en.htm?utm_source=chatgpt.com

18. Michigan MSGU of. The Dynamic Great Lakes Economy: employment trends from 2009- 2018 [Internet]. https://www.michiganseagrant.org/wp-content/uploads/2020/10/MICHU-20-715-Great-Lakes-Jobs-Report-fact-sheet.pdf. 2020. Available from: https://www.michiganseagrant.org/wp-content/uploads/2020/10/MICHU-20-715-Great-Lakes-Jobs-Report-fact-sheet.pdf

19. Schneider K. Michigan's Annual Groundwater Use For Agriculture Is 187 Billion Gallons. ModeShift At the Frontlines of the Global Transition: Water Crisis [Internet]. 2022 Dec; Available from: http://modeshift.org/419/michigans-annual-groundwater-use-for-agriculture-is-187-billion-gallons/

20. Resources WUSWD of N. A Decade of Wisconsin Water Withdrawals Water Quantity in Wisconsin. 2023.

21. Resources M of N. Forest Resources of Ontario: Geographic profiles. 2021.

22. International Joint Commission: Great Lakes Connection. Green Without Envy: Great Lakes Drown in Excessive Nutrient Pollution. 2018 Aug 3; Available from: https://www.ijc.org/en/green-without-envy-great-lakes-drown-excessive-nutrient-pollution?utm_source=chatgpt.com

23. Desbureaux, S, Damania, R, Rodella, A, Russ, J, Zaveri, E. The Impact of Water Quality on GDP Growth [Internet]. 2019. Available from: https://www.researchgate.net/profile/Aude-Sophie-Rodella/publication/338642828_The_Impact_of_Water_Quality_on_GDP_Growth_Evidence_from_Around_the_World/links/5e3d89d3299bf1cdb917061c/The-Impact-of-Water-Quality-on-GDP-Growth-Evidence-from-Around-the-World.pdf

24. Environment and Climate Change Canada. The Government of Canada invests $76 million to support 50 partner-led projects as part of the Great Lakes Freshwater Ecosystem Initiative. 2024.

25. Environment and Climate Change Canada. Federal Government opens the door to projects that help keep Canadian fresh water clean and healthy [Internet]. 2024. Available from: https://www.canada.ca/en/environment-climate-change/news/2024/01/federal-government-opens-the-door-to-projects-that-help-keep-canadian-fresh-water-clean-and-healthy.html

26. Agreement EGLWQ. Lake Erie Water Quality Data, Great Lakes Water Quality Agreement Annexes. 2024.

27. Warziniack T, Haight RG, Yemshanov D, Apriesnig JL, Holmes TP, Countryman AM, et al. Economics of invasive species. Invasive Species For Rangel U S Compr Sci Synth U S For Sect. 2021;305–20.

28. State of Minnesota: Minnesota Pollution Control Agency. 2024 Minnesota water quality. 2024.

29. Wisconsin Department of Natural Resources. Wisconsin Water Quality Report to Congress 2024 [Internet]. 2024. Available from: https://dnr.wisconsin.gov/topic/SurfaceWater/Congress.html

30. Illinois Environmental Protection Agency. Illinois Integrated Water Quality Report and Section 303(d) List, 2024 Draft [Internet]. 2024. Available from: https://epa.illinois.gov/content/dam/soi/en/web/epa/topics/water-quality/watershed-management/tmdls/documents/303d/2024-IR.pdf

31. Indiana Department of Environmental Managment,Office of Water Quality. 2024 Indiana Integrated Water Monitoring and Assessment Report [Internet]. 2024. Available from: https://www.in.gov/idem/nps/watershed-assessment/water-quality-assessments-and-reporting/integrated-water-monitoring-and-assessment-report/

32. Michigan Department of Environment, Great Lakes, and Energy, Water Resources Division. Water Quality and Pollution Control in Michigan 2024 Sections 303(d), 305(b), and 314 Integrated Report [Internet]. 2024. Available from: https://www.michigan.gov/egle/about/organization/water-resources/glwarm/integrated-report

33. Ohio Environmental Protection Agency. Ohio 2024 Integrated Water Quality Monitoring and Assessment Report [Internet]. 2024. Available from: https://epa.ohio.gov/divisions-and-offices/surface-water/reports-data/ohio-integrated-water-quality-monitoring-and-assessment-report

34. Department of Environmental Protection. Integrated Water Quality Report – 2024 [Internet]. 2024. Available from: https://www.pa.gov/agencies/dep/programs-and-services/water/clean-water/water-quality/integrated-water-report/integrated-water-quality-report-2024.html

35. Department of Environmental conservation. Clean Water Act Section 305(b) Water Quality Report 2020/2022 [Internet]. 2022. Available from: https://dec.ny.gov/sites/default/files/2024-09/cleanwateractreport.pdf

36. Water Quality in Canadian Rivers, Canadian Environmental Sustainability Indicator [Internet]. 2024. Water quality in Canadian rivers. Available from: https://www.canada.ca/content/dam/eccc/documents/pdf/cesindicators/water-quality/2024/Water-quality-canadian-rivers-en_2024.pdf

37. Ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC). Rapport sur L'état des Ressources en eau et des Écosystés Aquariques du Québec 2020 [Internet]. 2020. Available from: https://www.environnement.gouv.qc.ca/eau/rapport-eau/rapport-eau-2020.pdf

38. Alliance for the Great Lakes. Alliance for the Great Lakes Watermarks: Agricultural Pollution and the Great Lakes [Internet]. https://greatlakes.org/wp-content/uploads/2023/01/11611_

Ardent_AGL_Watermarks-Fall-22.pdf. 2022. Available from: https://greatlakes.org/wp-content/uploads/2023/01/11611_Ardent_AGL_Watermarks-Fall-22.pdf

39. Scavia D, Allan JD, Arend KK, Bartell S, Beletsky D, Bosch NS, et al. Assessing and addressing the re-eutrophication of Lake Erie: Central basin hypoxia. J Gt Lakes Res. 2014;40(2):226–46.

40. Jorgenson ZG, Thomas LM, Elliott SM, Cavallin JE, Randolph EC, Choy SJ, et al. Contaminants of emerging concern presence and adverse effects in fish: A case study in the Laurentian Great Lakes. Environ Pollut. 2018;236:718–33.

41. Great Lakes Integrated Sciences, Assessments (GLISA). Climate change in the Great Lakes region. [Internet]. 2019. Available from: http://glisa.umich.edu/media/files/GLISA%202%20Pager%202019.pdf.

42. Abdel-Fattah S, Krantzberg G. A review: Building the resilience of Great Lakes beneficial uses to climate change. Sustain Water Qual Ecol. 2014;3:3–13.

43. United States Environmental Protection Agency (EPA) & Environment and Climate Change Canada (ECCC). State of the Great Lakes 2022 Report: Land Cover Subindicator Report [Internet]. 2022. Available from: https://stateofgreatlakes.net/wp-content/uploads/2022/07/Land-Cover-Subindicator-Report-SOGL-2022.pdf?utm_source=chatgpt.com

44. United States Environmental Protection Agency (EPA). Report to Congress on Combined Sewer Overflows to the Great Lakes Basin [Internet]. 2016. Available from: https://www.epa.gov/sites/default/files/2016-05/documents/gls_cso_report_to_congress_-_4-12-2016.pdf

45. Baker BB, Haimbaugh AS, Sperone FG, Johnson DM, Baker TR. Persistent contaminants of emerging concern in a great lakes urban-dominant watershed. J Gt Lakes Res. 2022;48(1):171–82.

46. Villeneuve D, Corsi S, Custer CM, Johnson WE, Hummel S, Schoenfuss H, et al. "Contaminants of emerging concern in the Great Lakes: Science to inform management practices for protecting the health and integrity of wildlife populations from adverse effects: GLRI action plan I, focus area 1, goal 5" & "Contaminants of emerging concern in the Great Lakes: GLRI integrated phase II group progress report" [Internet]. The United States Environmental Protection Agency's Center for Computational Toxicology and Exposure; 2023 [cited 2025 Jan 27]. p. 10384667 Bytes. Available from: https://epa.figshare.com/articles/online_resource/_Contaminants_of_emerging_concern_in_the_Great_Lakes_Science_to_inform_management_practices_for_protecting_the_health_and_integrity_of_wildlife_populations_from_adverse_effects_GLRI_action_plan_I_focus_area_1_goal_5_Contaminants_of_emerging/21044455/1

47. United States Environmental Protection Agency (EPA). EPA's PFAS Strategic Roadmap: Three Years of Progress [Internet]. 2024. Available from: https://www.epa.gov/system/files/documents/2024-11/epas-pfas-strategic-roadmap-2024_508.pdf

48. United States Environmental Protection Agency (EPA). EPA Awards More Than $7 Million to Indiana University to Monitor Toxic Chemicals Entering the Great Lakes [Internet]. 2024 [cited 2024 Dec 10]. Available from: https://www.epa.gov/newsreleases/epa-awards-more-7-million-indiana-university-monitor-toxic-chemicals-entering-great

49. Environment and Climate Change Canada. Canada's Great Lakes Strategy for PFOS, PFOA, and LC-PFCAs Risk Management [Internet]. 2022. Available from: https://binational.net/wp-content/uploads/2022/03/Canada-Great-Lakes-Strategy-for-PFOS-PFOA-and-LC-PFCAs-Risk-Management.pdf

50. Morseletto P, Mooren CE, Munaretto S. Circular Economy of Water: Definition, Strategies and Challenges. Circ Econ Sustain [Internet]. 2022 Dec [cited 2025 Jan 27];2(4):1463–77. Available from: https://link.springer.com/10.1007/s43615-022-00165-x

51. Wang P, Kowalski S, Gao Z, Sun J, Yang CM, Grant D, et al. District heating utilizing waste heat of a data center: High-temperature heat pumps. Energy Build [Internet]. 2024 Jul [cited 2025 Jan 27];315:114327. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0378778824004432

Great Lakes WISE

Water Innovation and Stewardship Exchange

For more information about this report or Great Lakes WISE, please visit:
https://councilgreatlakesregion.org/program/great-lakes-wise/

Contact to get involved:
Lora Shrake, Senior Program Director,
Business and Sustainability, Council of the Great Lakes Region
lora@councilgreatlakesregion.org

Mark Fisher, President and CEO, Council of the Great Lakes Region
mark@councilgreatlakesregion.org