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Science Center Capabilities to Monitor and Investigate Michigan's Water Resources, 2016

Michigan faces many challenges related to water resources, including flooding, drought, water-quality degradation and impairment, varying water availability, watershed-management issues, stormwater management, aquatic-ecosystem impairment, and invasive species. Michigan's water resources include approximately 36,000 miles of streams, over 11,000 inland lakes, 3,000 miles of shoreline along the Great Lakes (MDEQ, 2016), and groundwater aquifers throughout the State.

The U.S. Geological Survey (USGS) works in cooperation with local, State, and other Federal agencies, as well as tribes and universities, to provide scientific information used to manage the water resources of Michigan. To effectively assess water resources, the USGS uses standardized methods to operate streamgages, water-quality stations, and groundwater stations. The USGS also monitors water quality in lakes and reservoirs, makes periodic measurements along rivers and streams, and maintains all monitoring data in a national, quality-assured, hydrologic database.

The USGS in Michigan investigates the occurrence, distribution, quantity, movement, and chemical and biological quality of surface water and groundwater statewide. Water-resource monitoring and scientific investigations are conducted statewide by USGS hydrologists, hydrologic technicians, biologists, and microbiologists who have expertise in data collection as well as various scientific specialties. A support staff consisting of computer-operations and administrative personnel provides the USGS the functionality to move science forward. Funding for USGS activities in Michigan comes from local and State agencies, other Federal agencies, direct Federal appropriations, and through the USGS Cooperative Matching Funds, which allows the USGS to partially match funding provided by local and State partners.

This fact sheet provides an overview of the USGS current (2016) capabilities to monitor and study Michigan's vast water resources. More information regarding projects by the Michigan Water Science Center (MI WSC) is available at http://mi.water.usgs.gov/.

U.S. Department of the Interior
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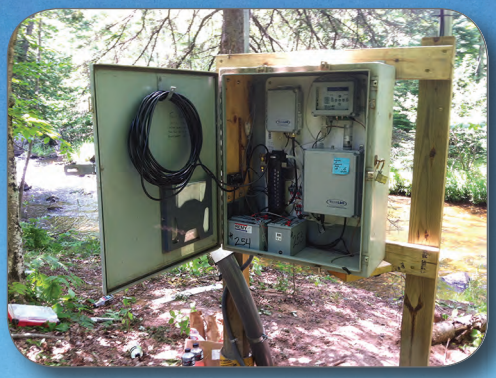
Continuous Monitoring



The USGS provides access to water-resources data collected at approximately 350 sites in Michigan, including surface water, groundwater, water quality, precipitation, and lakes. The USGS investigates the occurrence, quantity, quality, distribution, and movement of surface water and groundwater and disseminates the data to the public. The data are collected by automatic recorders and manual measurements at field installations across the State. Data are available through the USGS National Water Information System (NWIS) *which is the Nation's principal repository of water-resources data.*

Streamflow Data Available Online

The USGS operates approximately 180 streamgages in Michigan that continually record stage and streamflow and 11 lake-level gages. Streamflow information from streamgages, available through NWIS, has a wide variety of uses, including flood prediction, water management and allocation, engineering design, scientific research, and recreation. The streamflow data are generally collected in 15-minute increments and transmitted to the NWIS Web site every 1 to 2 hours in near real-time. In addition, field-measurement data, streamflow statistics, and annual peak streamflows from each station are available online through the NWIS and USGS WaterWatch Web sites.

NWIS
http://waterdata.usgs.gov/mi/nwis/rt

USGS WaterWatch
http://waterwatch.usgs.gov/

Photo, top left. Streamflow monitoring station at Falls River near L'Anse, Michigan.

Groundwater Data Available Online

The USGS collects and maintains groundwater data across the State. The MI WSC and local partners currently monitor groundwater levels at approximately 100 wells. Of those wells, approximately 35 are continuously monitored, with data from 3 of those sites displayed in near real-time. The NWIS groundwater database consists of more than 850,000 records of wells, springs, test holes, tunnels, drains, and excavations in the United States. All current and historical data are available online through the NWIS and USGS Groundwater Watch Web sites.

NWIS
http://nwis.waterdata.usgs.gov/mi/nwis/gw

USGS Groundwater Watch
http://groundwaterwatch.usgs.gov/

Photo, center left. Monitoring well at Huron Meadows Metropark, Brighton, Michigan.

Water-Quality Data Available Online

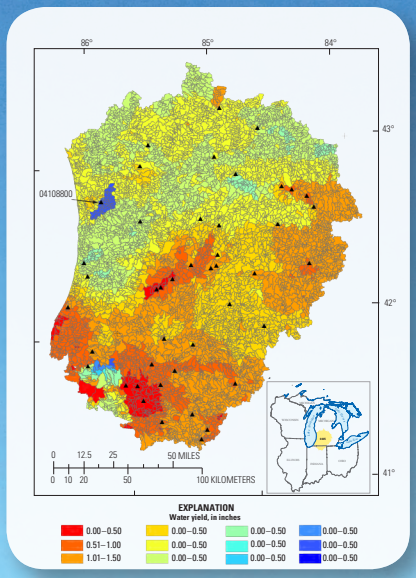
The USGS monitors water quality in Michigan at 45 real-time stations that provide data for temperature, specific conductance, pH, dissolved oxygen, and (or) turbidity. These data are used for decision-making about hydroelectric power generation, water treatment, fish-habitat management, regulatory programs, recreational and resource monitoring, ecosystem health, predictive modeling of nutrient chemistry, and public safety. The USGS NWIS water-quality database contains over 400,000 records of field and lab samples as well as the near-real time data from USGS continuous monitoring sites. All current and historical data are available online through the NWIS and USGS Water-Quality Watch Web sites.

NWIS
http://waterdata.usgs.gov/mi/nwis/qw

USGS Water-Quality Watch
http://waterwatch.usgs.gov/wqwatch/

Photo, bottom left. Station used for continuous water-quality monitoring in the Kalamazoo River at New Richmond, Michigan.

Streamflow information collected in Michigan by the USGS is an integral component in hydrologic investigations, which address a variety of water-resources issues in streams, including contamination, flooding, nutrient loading, and effects of land use, as well as low- and peak-flow analyses. Data and analyses from these studies are available in USGS peer-reviewed publications, which can be accessed online through the USGS Publications Warehouse Web site (http://pubs.er.usgs.gov).



Analysis of Flows In Networks of CHannels (AFINCH)

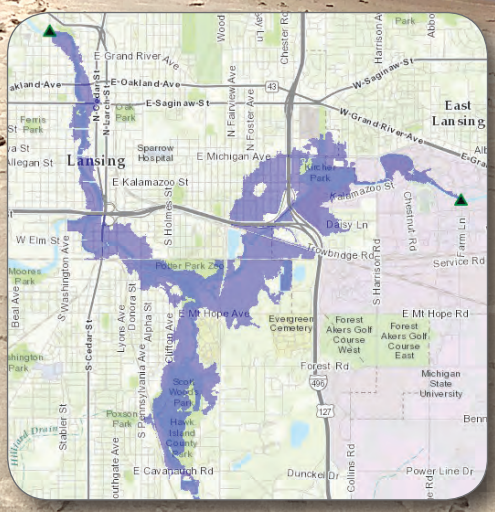
AFINCH is a computer application designed to generate time series of monthly flows at stream segments and corresponding water yields at catchments defined in the National Hydrography Dataset (NHDPlus, v. 2). The application provides a basis for integrating monthly streamflow data, water-use data, monthly climatic data, land-cover data, and catchment attributes to estimate monthly flows. AFINCH also provides an interactive graphical user interface for developing user-specified sets of multiple-regression equations to estimate monthly water yields. Time series of monthly flows generated by AFINCH can be tested for trends and used to develop monthly flow-duration curves. The technique has been applied to more than 100,000 stream segments in the Great Lakes basin to provide monthly flow data for the 1951–2012 period. Additional information about AFINCH is available at http://cida.usgs.gov/glri/afinch/.

Image, top left. Map created using U.S. Geological Survey AFINCH application.

Streamflows Within the Connecting Channels of the Great Lakes

The USGS has expertise in acoustic Doppler velocity meter (ADVM) installations and acoustic Doppler current profilers (ADCPs), which are used to measure velocity in wide channels under variable flow conditions. In cooperation with the International Joint Commission, the MI WSC and Water Survey Canada measure flows in the channels connecting the Great Lakes—the St. Marys, St. Clair, and Detroit Rivers—in response to variations in Great Lakes water levels. To accommodate the effects of variable backwater and unsteady flow in the upper channels, the MI WSC deploys fixed-location ADVMs to continuously monitor water velocities and water levels at a specific location along each of these channels. These index-velocity relations are continually monitored and refined as new data become available.

Photo, center left. Data-collection platforms for acoustic Doppler velocity meters at St. Marys River, a connecting channel near Sault Ste. Marie, Michigan.

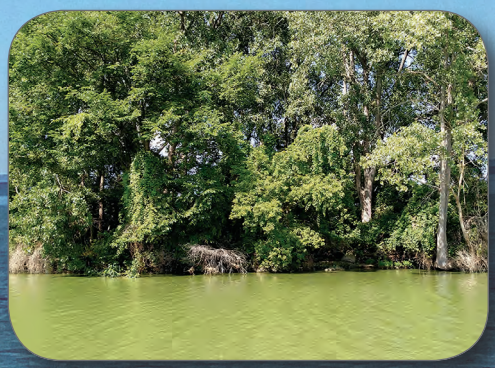


Hydraulic Modeling and Flood Inundation Mapping Program

Hydraulic modeling can be used to describe water-surface profiles along streams for a range of high-water conditions. When combined with detailed topographic information in adjacent low-lying areas, the profiles provide a basis for mapping areas likely to be inundated during flood-flow conditions along streams. Sets of flood inundation maps (FIMs) for a range of high-water conditions can be used to form a library of static maps that provide a basis for notifying affected communities in near real-time about potential flood areas. The FIMs provide information that can be used for preparedness, emergency response (because these maps are linked to real-time streamgages and National Weather Service [NWS] forecast locations), emergency recovery, mitigation and planning, and environmental and ecological assessment. The USGS works with the NWS and U.S. Army Corps of Engineers to provide FIMs to local communities to be used in their efforts to design flood-management plans and mitigate flood impacts. The USGS Flood Inundation Mapper is available at http://wimcloud.usgs.gov/apps/FIM/FloodInundationMapper.html.

Photo, bottom left. U.S. Geological Survey Flood Inundation Mapper showing affected areas at Grand River, Sycamore Creek, and Red Cedar River, Lansing, Michigan.

Water-Quality Studies



The USGS leads, coordinates, and participates in environmental investigations that assess the quality of the State's water resources. Scientists collect, analyze, and interpret water-quality data and work with local, State, and Federal partners to determine and better understand environmental issues and concerns, such as nutrient loading and lake eutrophication, harmful algal blooms, and contaminants in urban and agricultural runoff.

Inland Lakes Water Quality and Remote Sensing

The USGS monitors and models the water-quality characteristics of Michigan's inland lakes, including monitoring the effect of residential development as well as identifying and quantifying nutrient sources that cause algal blooms and lake eutrophication. The USGS has also created an interactive map viewer that relates water-quality measurements to satellite imagery and serves as a predictive tool for lake eutrophication.

More information about remote sensing of inland lakes in Michigan is available at http://mi.water.usgs.gov/preview/projects/RemoteSensing/index.html.

Example of a lake eutrophication study in Michigan: http://pubs.er.usgs.gov/publication/sir20155158.

Photo, top left. Silver Lake Dunes State Park near Mears, Michigan.

Harmful Algal Blooms

Some cyanobacteria species produce algal toxins that can result in harmful algal blooms (HABs). These HABs pose potential health risks to humans and wildlife and, consequently, are of great concern when they occur near drinking-water intakes or aquatic recreational areas. The USGS is currently assessing HABs in Michigan, which involves monitoring nutrient concentrations and flows in tributaries of the Great Lakes. The USGS is also using next-generation sequencing to characterize the bacteria present in sediment and the water column prior to, during, and after algal blooms in order to understand how the microbial community and microbial mediated processes relate to bloom formation and algal toxin production.

Photo, second from top left. Harmful algal bloom in Brest Bay (Lake Erie) near Monroe, Michigan.

Urban Hydrology and Best Management Practices

Urban stormwater and runoff can be a substantial source of nutrients, sediment, emerging contaminants, and pathogens to streams, and ultimately, nearshore areas of the Great Lakes. The USGS monitors the hydrology, hydraulics, and water quality at green infrastructure sites in Michigan to more fully characterize their performance and to provide the data needed to improve future design and implementation of best management practices (BMPs). Monitoring includes measuring groundwater-level response to storm events, surface-water flow, and water-quality characteristics, such as concentrations of emerging contaminants, nutrient, and sediment in stormwater. In addition, the MI WSC seeks to determine whether urban stormwater runoff contains any pathogens and contaminants known to negatively affect wildlife and human health, determine the concentration and abundance of these contaminants, and quantify the effect stormwater BMPs have on their transport.

Photo, second from bottom left. Urban runoff drainage near Romeo, Michigan.

Monitoring Agricultural Environments

The USGS is involved in edge-of-field, subsurface-drain, and receiving-stream monitoring in Michigan to understand the effect of implementing various agricultural land-management practices on runoff water quantity and quality. Monitoring data collected through these efforts can assist those involved in selecting conservation practices as well as nutrient and pesticide-management practices aimed at reducing edge-of-field runoff. Current efforts include monitoring at field edges to determine nutrient and sediment loads to streams and to determine the presence and concentration of pesticides in event runoff at field edges and in adjacent surface water.

Photo, bottom left. Edge-of-field monitoring near Swartz Creek, Michigan.

The USGS Michigan Bacteriological Research Laboratory (MI-BaRL) incorporates a wide array of traditional and modern molecular approaches to address how microorganisms affect water quality, the environment, and human health. These analytical approaches include traditional culturing and plating methods, fluorescence microscopy, the IDEXX method for enumeration of Escherichia coli and enterococci, polymerase chain reaction (PCR) for pathogens and antibiotic-resistance genes, quantitative PCR (qPCR) for both pathogen and microbial source-tracking markers, cloning and sequencing, and next-generation sequencing and bioinformatics.

Using Next Generation Sequencing to Address Water Quality and Environmental Health

The USGS MI-BaRL incorporates next-generation sequencing in several studies to better understand how HAB formation and toxin production, as well as other contaminated environments, affect microbial communities. Next-generation sequencing enables microbiologists to not only characterize the bacterial species present but also determine how a microbial community changes in response to biological and chemical stressors in its environment. Other studies incorporate metagenomic profiling to address potential metabolic capabilities and functions of microbial communities. The USGS MI-BaRL has specific interest in genes involved in nutrient cycling, biodegradation, pathogenicity, and antibiotic resistance.

Photo, top right. Public beach at Grand Haven State Park, Michigan.

Bacterial Pathogens—Sources and Environmental Threats

The USGS MI-BaRL uses traditional and modern molecular approaches to investigate pathogens in the environment, focusing on their source, occurrence, and distribution; transport, delivery, and fate; and survival and persistence. Most of this research is centered on animal or human-associated pathogens and the influence of these pathogens on recreational water quality, drinking-water quality, and water quality in agricultural and urban watersheds. This research also extends to understanding pathogen occurrence and abundance in relation to that of fecal indicator bacteria and pollutants of emerging concern, as well as factors such as land-use, hydrology, and seasonal climatic variation.

Photo, second from top right. Holstein cow at agricultural research station in Hickory Corners, Michigan.

Antibiotic Resistance in the Environment

Antibiotics and household antimicrobial agents have been detected in the Nation's waters, and antibiotic resistance within bacteria is a serious public health concern. The USGS MI-BaRL investigates the environmental distribution of antibiotic-resistant bacteria and antibiotic resistance genes in a variety of environments influenced by agricultural practices and animal-feeding operations, wastewater, and urban activity. MI-BaRL research explores the relations between antibiotic resistance and the concentrations of the antibiotics and other chemical contaminants in similar environmental matrices; how exposure to antibiotics influences microbial community composition and microbial-mediated processes; and factors influencing gene transfer and maintenance in the environment.

Photo, second from bottom right. Cultures used to analyze antibiotic resistance.

Microbiology and Wildlife Health

The USGS MI-BaRL investigates how environmental change and contaminants in the environment (pathogens, toxins, and antibiotic resistance genes) influence the wildlife host microbiome and, in turn, wildlife health. The USGS MI-BaRL has partnered with other USGS centers and Federal agencies to investigate whether lake sediment, lake water, *Cladophora*, mussels, mussel microhabitat, and benthic invertebrates are potential environmental sources for the *Clostridium botulinum* toxin that is contributing to mass mortality events among shorebird populations.

Photo, bottom right. Tunnel Park Beach at Holland, Michigan.

Groundwater Studies

The USGS in Michigan participates in many local, regional, and national studies to quantify groundwater availability and monitor groundwater quality. These studies involve monitoring water levels in wells, applying geophysical or aquifer-test methods to determine hydraulic characteristics of aquifers, modeling groundwater flow, and monitoring groundwater contaminants and nutrients. Groundwater-availability studies are designed to quantify the groundwater-flow budget of a system and the response of the system to changes in pumping or climate. Understanding how groundwater interacts with surface water is a fundamental part of evaluating groundwater resources. The USGS seeks to understand the quantity, timing, and quality of water flow required to maintain the ecological function within streams and lakes, and the processes of groundwater to surface-water exchange that influence water quality.

Example of a local groundwater-availability study in Clinton, Eaton, and Ingham Counties, Michigan: http://pubs.er.usgs.gov/publication/sir20095244.

Example of a regional groundwater-availability study in the Great Lakes basin: http://pubs.er.usgs.gov/publication/pp1778.

Example of a national groundwater-availability study of the glacial aquifer system: http://mi.water.usgs.gov/projects/WaterSmart/.

Photo, top left. Drilling a monitoring well near Schoolcraft, Michigan.

Water Use

The USGS has compiled a survey of Michigan water-use information by county, including measured and estimated amounts, sources, and categories of monthly water use, every 5 years since 1950. Water-use information complements and supports surface-water- and groundwater-availability studies and water-budget totals that are critical to these studies. This information is essential to accurately understand how future water demands will be met while maintaining adequate water quality and quantity for human and ecosystem needs. Water-use data are compiled from a variety of local, State, and national sources and must be supplemented with estimates in areas where water use is not actively monitored.

The USGS in Michigan works with regional partners to improve the accuracy of water-use information needed to implement and oversee the Great Lakes Compact (http://www.glslcompactcouncil.org/).

Water-use data for Michigan are available at http://waterdata.usgs.gov/mi/nwis/wu.

Photo, immediate left. Sevie Kenyon, University of Wisconsin-Madison College of Agricultural and Life Sciences (CALS).

Reference Cited

Michigan Department of Environmental Quality (MDEQ), 2016, Inland Lakes & Streams: Accessed May 9, 2016, at https://www.michigan.gov/deq/0,4561,7-135-3313_3681—,00.html.

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