Indiana Water Report 2020

ANNUAL REPORT PREPARED BY:

The Indiana Water Monitoring Council

Acknowledgments

This document was compiled for the Indiana Water Monitoring Council (InWMC) by the Groundwater Focus Committee. Editorial review was provided by Alisha Turnbow, Indiana Department of Environmental Management (IDEM).

Figures on the cover (Clockwise from top). *Collecting a water sample from the East Branch of the Calumet River, Porter County, Indiana (Photo by Jared O'Brien, Porter County Soil & Water Conservation District (SWCD)); A flowing agricultural tile drain at School Branch, Hendricks County, Indiana (Photo by Aubrey Bunch, United States Geological Survey (USGS)); Ditched drainage in the Kankakee River Watershed (Photo by Porter County Soil Water Conservation District); Little Cicero Creek at Bishops Park, Cicero, Indiana (Photo by Morgan Bennett, Hamilton County Health Department).*

Contents

Indiana Water Summary 2020 Annual Report

INTRODUCTION

The purpose of the Indiana Water Report is to describe current water monitoring and research in the State of Indiana. The Indiana Water Report is compiled for the Indiana Water Monitoring Council (InWMC) by the Groundwater Focus Committee. The 2020 Indiana Water Report includes brief description of the InWMC, an extended length article about the Coal Ash and Groundwater by the Hoosier Environmental Council (HEC), and summaries of individual projects from across the State. The individual project descriptions are organized by region and then alphabetically by organizational affiliation. There are also two indexes one by organization and the other by general topic.

This is the third Indiana Water Report. Fifty (50) organizations contributed 67 project summaries to the 2020 report. Some of the summaries are updated contributions from 2018 but others are new projects. Locations of the individual projects and data-collection sites are shown in **Figure 1**.

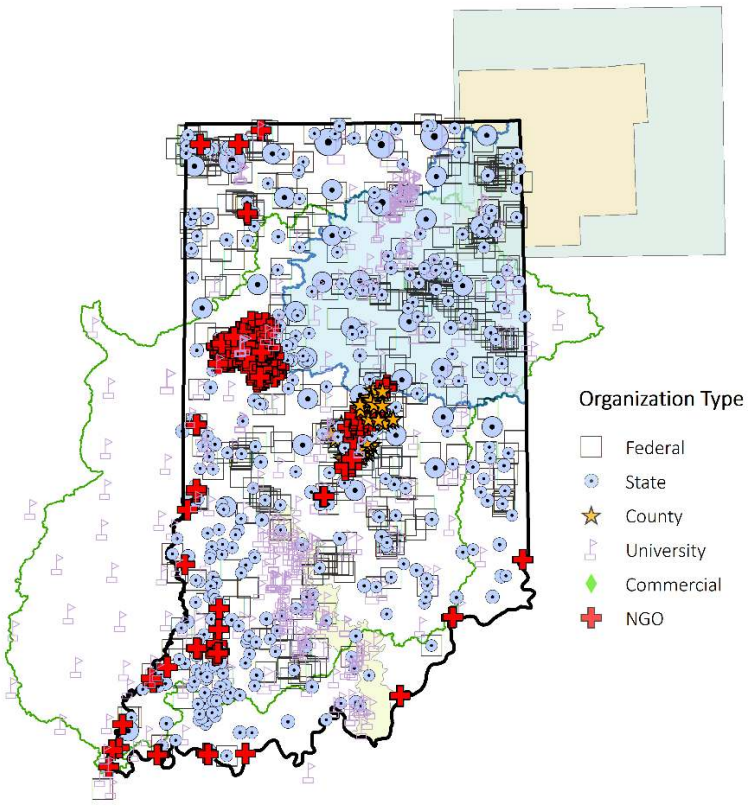

Figure 1. *Map showing water-resource projects conducted throughout Indiana in 2020. Projects include special projects or studies, as well as continuous or ongoing monitoring. Locations are denoted by the organization type conducting the study. Several regional project areas are shown as polygons. Symbol sizes denote multiple samples per county for a number of regional or statewide studies (e.g., the largest symbols represent more than 50 monitoring or sample sites in a single county) (Map by Sally Letsinger).*

Indiana Water Monitoring Council (InWMC)

The Indiana Water Monitoring Council (InWMC) is a network of professionals and volunteers dedicated to communication, coordination, and sharing of monitoring information to support the stewardship of Indiana waters. Together, the InWMC is leading the way in improving the ability to address the full scope of Indiana's water resource issues now and in the future.

The InWMC is led by a 19-member Board of Directors who guide the implementation of the Strategic Plan. The InWMC website, www.inwmc.net, provides more details about the Council and benefits for members. Members of the council include local, state, and federal government agencies and of non-governmental organizations such as local watershed initiatives, consultants, non-profits, and industry representatives. If you are interested in becoming a part of the InWMC we welcome you, more information about member benefits is available at: https://www.inwmc.net/.

For more information: Dave Scott, Indiana Water Monitoring Council (InWMC), President (scottde@purdue.edu).

Coal Ash and Groundwater

Indiana has been burning coal and generating coal ash for more than 100 years. The state's electric utilities currently produce six to seven million tons of coal ash per year and dispose of it in impoundments or landfills. Most of the state's coal ash impoundments are unlined and located in the floodplain of Lake Michigan or one of the state's rivers.

Groundwater monitoring has been required at active coal ash impoundments since 2016 under the federal Coal Combustion Residuals Rule (CCR Rule) and can be accessed online: https://www.in.gov/idem/landquality/2503.htm. Indiana has required groundwater monitoring at coal ash landfills for more than 20 years, and reports are available on Indiana Department of Environmental Management's (IDEM's) Virtual File Cabinet at: https://www.in.gov/idem/legal/2363.htm.

The Hoosier Environmental Council (HEC) compared groundwater data from the downgradient monitoring wells for coal ash impoundments at 15 Indiana power plants to health-based standards for drinking water: the Maximum Contaminant Limit (MCL) under the United States Safe Drinking Water Act; or for contaminants that lack an MCL, the Safe Drinking Water Act Health Advisory or EPA's Risk-Based Screening Level for Tapwater.

The data show that coal ash at all 15 power plant sites are impacting the groundwater, though the sites vary in their combinations and concentrations of molybdenum, lithium, boron, arsenic, sulfate, cobalt, antimony, radium, lead, selenium, and thallium. The maximum concentrations detected often exceed drinking water standards by manyfold. All but one site exceeds the drinking water standard for molybdenum, half of them exceed it by 10-fold or more. Seventy-three percent (73%) of sites have at least double the standard for lithium. Seventy-eight percent (78%) of sites have at least double the standard for arsenic. Boron is elevated at 80% of sites, all but one of which have at least double the standard.

Private wells have been impacted by coal ash near the Cayuga, Gibson, and Noblesville power plants as well as near a coal ash landfill in the Town of Pines; and the utilities have been providing replacement drinking water for the private wells that are impacted. At Tanners Creek, municipal wells are as close as 500-feet from coal ash impoundments, though contaminants in those wells have not exceeded drinking water standards, yet.

Groundwater surface maps show that coal ash contaminated groundwater is seeping into adjacent waterbodies (Lake Michigan and the Kankakee, Wabash, White, Whitewater, and Ohio Rivers) from all the monitored sites except Tanners Creek. At Cayuga, the seepage is monitored and amounts to between 670,00 and 3,080,000 gallons per day depending on the season.

The groundwater at coal ash sites has not been tested for hexavalent chromium (CR VI), but according to a coal ash leaching study, it is likely

there[1]. The same study showed that mercury in coal ash leachate often exceeds the Indiana Water Quality Criterion of 12 ng/L, but most sites used a detection limit of 200 ng/L and so failed to detect it.

For coal ash sites with groundwater contamination, the CCR Rule requires studying the nature and extent of groundwater contamination plumes and corrective action. Deadlines for these actions are still playing out at the time of this writing.

Federal and state regulations do not currently apply to the millions of tons of coal ash that have been used as fill material in Indiana nor to the coal ash residing in historical impoundments from the many decades of burning coal in the state, though they are likely also impacting groundwater.

HEC's full report *Our Waters at Risk, Part 2: The Impact of Coal Ash on Indiana's Water Resources* is available at: IndianaCoalAsh.org.

For more information: Indra Frank, Hoosier Environmental Council (HEC), Director of Environmental Health and Water Policy (ifrank@hecweb.org).

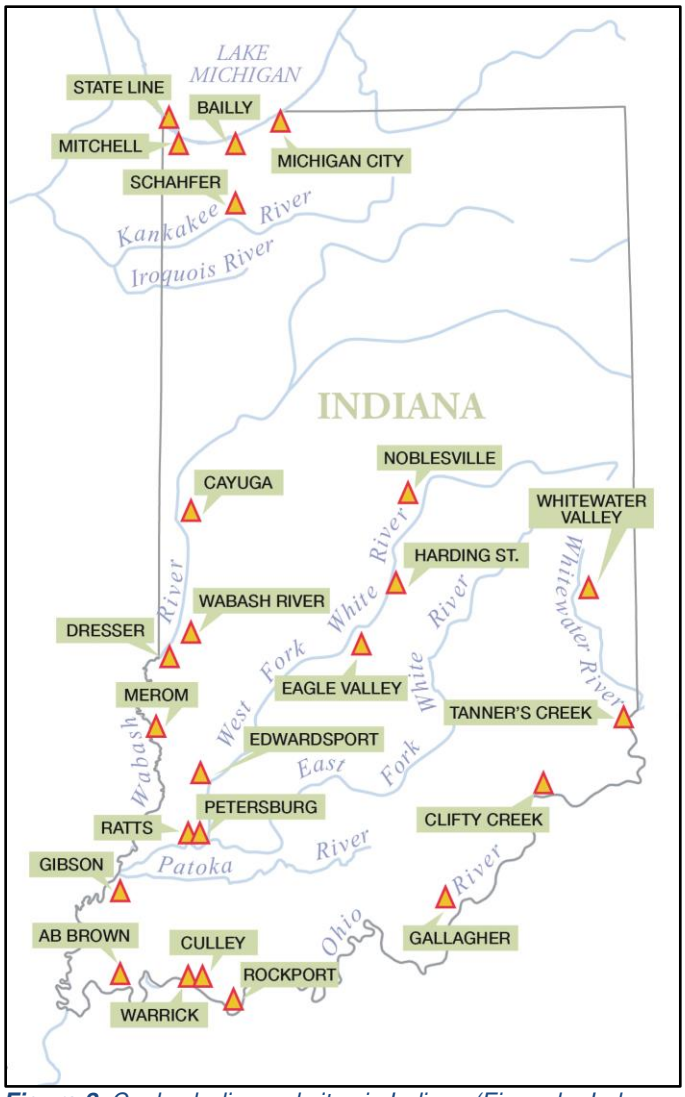

Figure 2. *Coal ash disposal sites in Indiana (Figure by Indra Frank).*

[1] Electric Power Research Institute (2006). *Characterization of Field Leachates at Coal Combustion Product Management Sites*

WATER MONITORING ACTIVITIES IN INDIANA DURING 2020

The summaries for individual projects are organized by region in the State and then alphabetically by organizational affiliation. The regions follow the boundaries of the nine climate divisions established by the National Oceanic and Atmospheric Administration (NOAA). This format was adapted in 2020 to facilitate rapid identification of projects that are relevant to each reader's area of concern. Some projects are mostly located in one region but may contain parts of additional regions. The additional regions are identified in the project summaries and in. Projects that are generally distributed throughout the State are listed under the MULTI-REGION AND STATEWIDE header below.

MULTI-REGION AND STATEWIDE ACTIVITIES

Hoosier Environmental Council (HEC)

[See section listed as Coal Ash and Groundwater]

Indiana Department of Environmental Management (IDEM) – Drinking Water Branch

Statewide Ground Water Monitoring Network

The Indiana Department of Environmental Management (IDEM) – Drinking Water Branch's Groundwater Section manages a statewide Ground Water Monitoring Network (GWMN) to evaluate ambient groundwater quality across the state. The GWMN consists of private residential wells and noncommunity public water systems (PWSs). Sampling for the GWMN has been conducted annually since the inaugural year of 2008. To date, over 3,400 groundwater samples have been collected from more than 1,400 individual water well sites. The study has identified several contaminants of concern that can be considered regional scale groundwater issues including arsenic, nitrates, and degraded agricultural pesticides. Additional investigation into the nature and occurrence of the arsenic contamination that has been identified across the glaciated areas of Indiana occurred in 2018. Approximately 240 samples were collected from wells that previously showed high levels of arsenic to determine the ratio of the different forms of arsenic, arsenic three (AsIII) and arsenic 5 (AsV), in groundwater. The study showed that the prevalent form of arsenic in Indiana groundwater is AsIII, which is more unsafe and more difficult to remove from drinking water through conventional treatment. In 2020, approximately 250 of the previously sampled residential wells were resampled to collect updated data on groundwater chemistry. Preliminary sampling results from the first several rounds of sampling are available through the *2016 GWMN Summary and Results Report* and can be at: http://in.gov/idem/cleanwater/2453.htm.

For more information: Kevin Spindler, Indiana Department of Environmental Management (IDEM) – Drinking Water Branch (kspindle@idem.in.gov).

Figure 3 (Left) and Figure 4 (Right). *Jake Ivers, summer intern for the Indiana Department of Environmental Management (IDEM) – Drinking Water Branch, measuring water quality parameters in well-water samples (Left) and preserving well-water samples (Right).*

Assessment of Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water

The Indiana Department of Environmental Management (IDEM) – Office of Water Quality (OWQ) – Drinking Water Branch, working in partnership with the Indiana Department of Health (IDOH) will investigate the potential exposure to 18 per- and polyfluoroalkyl substances (PFAS) in community public drinking water systems (CWS). Sampling will take place in three phases based on the population served by the CWSs. The purpose of the sampling program is to evaluate the statewide occurrence of PFAS compounds in raw and finished water samples of approximately 778 CWS across the state. Information about this project is available at: https://www.in.gov/idem/7193.htm.

For more information: Samuel Blazey, Indiana Department of Environmental Management (IDEM) – Drinking Water Branch (sblazey@idem.in.gov).

Indiana Department of Environmental Management (IDEM) – Water Assessment and Planning Branch

Probabilistic Monitoring

The objective of the probabilistic monitoring program is to provide a comprehensive, unbiased statistical assessment of the ability of rivers and streams in a targeted river basin to support aquatic life and recreational uses. In 2020, randomly generated (probabilistic) sites were sampled in West Fork and Lower White River Basin. Three rounds of water chemistry were collected at 48 sites between May-June (late start due to COVID-19), July, and September-October. With this, orthophosphate was also collected at 17 sites where continuous dissolved oxygen measurements were collected for two weeks in August. During round three of water chemistry, algal samples were collected at 45 sites to characterize the diatom community and Chlorophyll *a* levels. From June-October, 42 sites were sampled for fish and macroinvertebrate communities, after which a Qualitative Habitat Evaluation Index Form (QHEI) was completed to characterize in-stream and riparian habitat. Bacteria (*E. coli*) levels were sampled five times within a 30-day period for 39 sites during the recreational season (April through October). Data should be available in March 2021. The project work plan is available at: https://www.in.gov/idem/cleanwater/files/swq_workplan_B-047-OWQ-WAP-PRB-20-W-R0.pdf.

For more information: Stacey Sobat, Indiana Department of Environmental Management (IDEM) – *Watershed Assessment and Planning Branch* (ssobat@idem.in.gov).

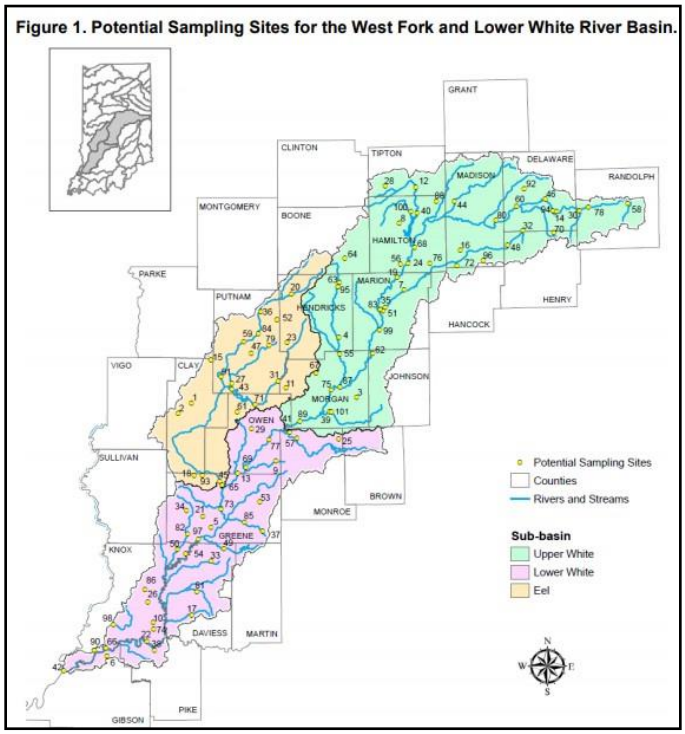

Figure 5. *Potential sampling sites for the West Fork and lower White River Basin.*

White River Mainstem Project

The 2020 White River Mainstem monitoring project was a collaborative effort between the Indiana Department of Environmental Management (IDEM), Indiana Department of Natural Resources (IDNR), and the Muncie Sanitary District's Bureau of Water Quality. The project objective was to provide a comprehensive assessment of the ability of the mainstem White River to support aquatic life use with particular emphasis on fish communities. Sites were chosen based on previous sampling events, access to the river, and an attempt to sample all assessment units on the mainstem West Fork and Lower White River. For fish communities, 51 sites were sampled with appropriate electrofishing gear, after which a Qualitative Habitat Evaluation Index (QHEI) was completed to characterize in-stream and riparian habitat. Three rounds of water

chemistry were collected at 48 sites. Additionally, at the 11 probabilistic sites on the mainstem, algal samples were collected during the third round of water chemistry to characterize the diatom community and measure Chlorophyll *a* levels; three rounds of orthophosphate were collected; two weeks of continuous dissolved oxygen measurements were taken; and macroinvertebrate communities were sampled. Data should be finalized and available in March 2021. More information on the project is available on a Story Map at: https://storymaps.arcgis.com/stories/3329a43505094393b573f0788e1933d7.

***For more information*:** Stacey Sobat, Indiana Department of Environmental Management (IDEM) – Watershed Assessment and Planning Branch (ssobat@idem.in.gov).

Figure 6. *Indiana Department of Environmental Management (IDEM), Indiana Department of Natural Resources (IDNR), and Muncie Sanitary District's Bureau of Water Quality staff electrofishing along the White River Mainstem Project.*

Figure 7. *Kevin Gaston, Indiana Department of Environmental Management (IDEM), holding an American eel from the White River fish community sampling in August 2020.*

Reference Site Monitoring

The objective of the reference site monitoring program is to provide data used to establish and refine the index of biotic integrity (IBI) for aquatic assemblages as well as biological criteria for aquatic life use assessments. Reference sites are in areas with the least amount of anthropogenic (related to or resulting from the influence of human beings on nature) disturbance and considered the most natural remaining areas within a specified geographic boundary. The original plan was to sample 30 sites; however, due to COVID-19 and limits on overnight travel, only 10 historical sites were sampled in the Wildcat Creek Watershed in 2020. Sites were sampled for fish and macroinvertebrate communities, after which a qualitative habitat evaluation index was completed to characterize in-stream and riparian habitat. Three rounds of water chemistry were collected at each site with an algal sample collected during the third round to characterize the diatom community and quantify Chlorophyll *a* levels. Data should be available in March 2021.

For more information: Stacey Sobat, Indiana Department of Environmental Management (IDEM) – Watershed Assessment and Planning Branch (ssobat@idem.in.gov).

Fish Tissue Contaminants Monitoring Program

The objective of Indiana Department of Environmental Management's (IDEM's) contaminants monitoring program is to generate results for use as ecological indicators, to support development of the Indiana Fish Consumption Advisory, and to evaluate contaminant trends in fish. Monitoring sites are targeted based on historical sampling locations, environmental problems, date of last sampling event, public access, and recreational potential. In 2020, 36 sites were sampled for contaminants in fish tissue with six sites in the Ohio River Basin, five sites in the Lake Erie Basin, and 20 sites (where Indiana Department of Natural Resources (IDNR) collected the samples) in the Lake Michigan Basin including the open waters of Lake Michigan, Sylvan Lake, Wolf Lake, and Little Pigeon River. All fish tissue samples will be analyzed for percent lipid, total polychlorinated biphenyls (PCBs), organochlorine pesticides,

metals, and methyl- mercury. Polynuclear aromatic hydrocarbons and perfluorinatedalkyl acids (PFAAs) will also be analyzed on selected samples.

For more information: Cyndi Wagner, Indiana Department of Environmental Management (IDEM) – Watershed Assessment and Planning Branch (cwagner@idem.in.gov).

Figure 8. *Ali Meils and Ross Carlson, Indiana Department of Environmental Management (IDEM), electrofishing.*

Great Lakes Restoration Initiative *(GLRI) Per- and Polyfluoroalkyl Substances (PFAS) Grant Project*

At the end of August, the Indiana Department of Environmental Management (IDEM) received Great Lakes Restoration Initiative (GLRI) grant funding to collect fish from sites in the Great Lakes Basins for fish tissue analysis of per- and polyfluoroalkyl substances (PFAS). The timeframe for sampling was very compressed given the sampling season for other projects was delayed until COVID-19 safety protocols were developed and put into place. Forty-six (46) sites of the original 49 sites selected for collecting fish were successfully sampled. The remaining three sites were found to be salmon stocking areas, so those were not sampled.

For more information: Cyndi Wagner, Indiana Department of Environmental Management (IDEM) – Watershed Assessment and Planning Branch (cwagner@idem.in.gov).

Figure 9. *Ross Carlson from the Indiana Department of Environmental Management (IDEM) cutting fish for analysis.*

Cyanobacteria Beach Monitoring

The Indiana Department of Environmental Management (IDEM) completed its cyanobacteria beach monitoring program for the purpose of providing the Indiana Department of Natural Resources (IDNR) information for recreational alerts without interruption from May through the end of August at 17 swimming beaches at 14 IDNR owned or managed sites and one state park dog park lake. Cyanobacteria is also known as blue-green algae and is associated with Harmful Algal Blooms. Some blue-green algal strains produce toxins, threatening human and animal health. More information is available at: https://www.in.gov/idem/algae/.

For more information: Cyndi Wagner, Indiana Department of Environmental Management (IDEM) – Watershed Assessment and Planning Branch (cwagner@idem.in.gov).

Indiana Department of Environmental Management (IDEM) Fixed Station Monitoring Program

Monthly sampling at Indiana Department of Environmental Management's (IDEM's) fixed station ambient water quality monitoring network consisting of 165 sites across the state was interrupted from the end of March through early May due to COVID-19 restrictions. As a result, 15% of the yearly samples were not taken or were not able to be analyzed. Details about the sample sites is available at: https://www.in.gov/idem/cleanwater/pages/fixed_station/.

***For more information*:** Cyndi Wagner, Indiana Department of Environmental Management (IDEM) – Watershed Assessment and Planning Branch (*cwagner@idem.in.gov*).

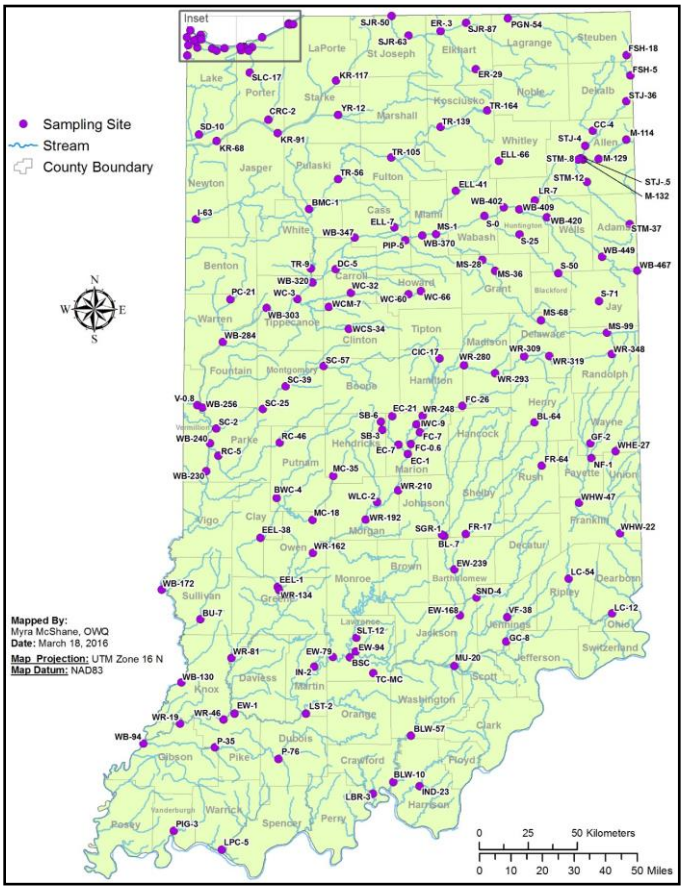

Figure 10. *Map of Indiana Department of Environmental Management's (IDEM's) fixed station ambient water quality monitoring network site locations.*

The objective of Indiana Department of Environmental Management's (IDEM's) watershed characterization projects is to determine the source and extent of impairments for developing total maximum daily load (TMDL) reports and for watershed planning. Site selection is based on a modified geometric design as well as input from local stakeholders. The Maria Creek Watershed characterization project with 18 sites began in November of 2019. Monthly sampling was interrupted in April and May due to COVID-19 but was completed in October of 2020. The Vernon Fork Watershed characterization project comprised of 24 sites and will commenced monthly sampling in November and will continue through October 2021. An auto-sampler has been added to one of the monthly grab sample sites for data comparability. Project details can be found at: https://www.in.gov/idem/nps/4064.htm.

For more information: Cyndi Wagner, Indiana Department of Environmental Management (IDEM) – Watershed Assessment and Planning Branch (cwagner@idem.in.gov).

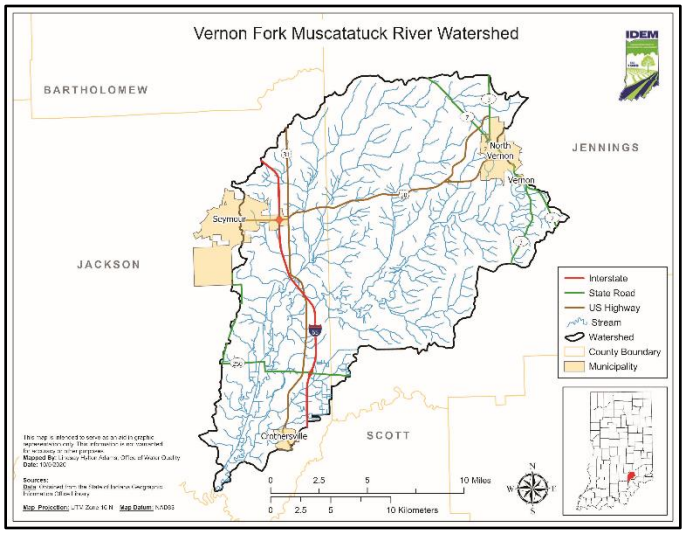

Figure 11. *Map showing the Muscatatuck Watershed area evaluated by this project.*

Watershed Characterization Projects

Indiana Department of Natural Resources (IDNR) – Division of Water (DOW)

Water Use Reporting Significant Water Withdrawal Registration

Indiana Code (IC 14-25-7-15) requires all Significant Water Withdrawal Facilities (SWWF) to register with the Indiana Department of Natural Resources (IDNR) – Division of Water (DOW) and report water use annually. A SWWF is defined as a facility that, in the aggregate from all sources and by all methods, has the capability of withdrawing more than 100,000 gallons of groundwater, surface water, or groundwater and surface water combined in one day. Annual water use reporting is required by April 1 for the previous year. There are 4,244 SWWF currently registered with the IDNR – DOW with an approximate 98% compliance rate for the reported annual water use. The validation of SWWF well and intake locations has been conducted by staff of the Indiana Geological and Water Survey (IGWS) (under IC 14-25-7-18) with assistance of IDNR – DOW staff. A USGS grant to improve completeness and accuracy of water use data is being implemented by IDNR – DOW staff. Additional information and related links can be found at: https://www.in.gov/dnr/water/4841.htm and http://www.in.gov/dnr/water/4847.htm.

For more information: Mark Basch, Indiana Department of Natural Resources (IDNR) – Division of Water (mbasch@dnr.in.gov).

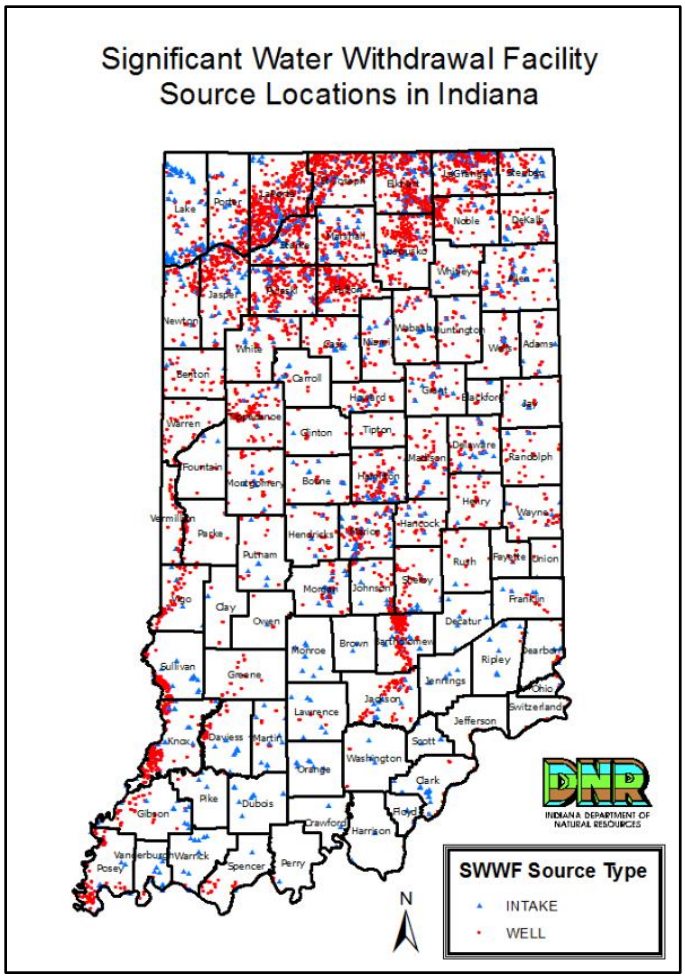

Figure 12. *Map of Significant Water Withdraw Facility Source Locations in Indiana.*

Volunteer Monitoring Program

The Voluntary Monitoring Program (VMP) is a cooperative effort between the Indiana Department of Natural Resources (IDNR), the United States Geological Survey (USGS), private land-owners, and public water utilities (volunteers) to monitor and record depth to groundwater levels from water monitoring wells across the state. Since the program's inception, more than 55 groundwater wells have been set up for data gathering. The Resource Assessment Section of the IDNR provides the equipment for data collection for most of the VMP network wells. IDNR – Resource Assessment Section staff are directly responsible for the management, physical maintenance, data retrieval, and data download of more than 40 VMP network wells. Additionally, the Resource Assessment Section provides equipment and support for the volunteer data collection from 10 of the VMP network wells. The USGS analyzes and posts manual and continuous water level data to a web

portal. As part of the USGS Groundwater Watch Program the information for specific wells of the Indiana well network and related groundwater data can be accessed at: http://groundwaterwatch.usgs.gov/netmapT4L1.asp?ncd=IDV. This information and the data are also incorporated as part of the USGS National Active Groundwater Level Network, accessed at: http://groundwaterwatch.usgs.gov/default.asp.

For more information: Bill Davis, Indiana Department of Natural Resources (IDNR) – Division of Water (wdavis@dnr.in.gov).

Indiana Water Resource Updates

Although a water shortage can occur for different reasons, drought is typically the most recognized cause, impacting many users over large geographical regions. The Resource Assessment Section of the Indiana Department of Natural Resources (IDNR) – Division of Water (DOW) completes a monthly update summary of key parameters used to predict/monitor drought conditions in the nine climate divisions of Indiana. These parameters include: the SPI Drought Index, precipitation and temperature data; stream flow data of 12 streams across Indiana; Lake Michigan-Huron water level data; water levels at 11 Indiana reservoirs; and groundwater levels for nine observation wells. These monthly summaries are compiled from IDNR – DOW data, as well as information and data provided by the National Oceanic and Atmospheric Administration (NOAA); the National Weather Service; the Midwestern Regional Climate Center; the National Drought Mitigation Center; the Western Regional Climate Center; the United States Geological Survey (USGS); the United States Army Corps of Engineers– Detroit District; the United States Army Corps of Engineers – Louisville District; and the Indiana State Climate Office. Additional information and related links can be found at: http://www.in.gov/dnr/water/4858.htm.

For more information: Bill Davis, Indiana Department of Natural Resources (IDNR) – Division of Water (wdavis@dnr.in.gov).

Potentiometric Surface Mapping

The Potentiometric Surface Mapping project is a series of county maps showing the generalized groundwater surface in bedrock and unconsolidated aquifer systems. In Indiana, unconsolidated aquifers consist primarily of sand and gravel, whereas the major bedrock aquifers are carbonates (limestone and dolomite) and sandstones. The maps are compiled by the Indiana Department of Natural Resources (IDNR) – Division of Water (DOW) Resource Assessment Section using groundwater level measurements indicated on water well records submitted by well drillers. The maps are intended to be used for general estimates (such as regional groundwater flow direction and areas of groundwater recharge and discharge). Also, the finished maps can be used to calculate hydraulic gradients and groundwater velocity; to determine groundwater availability, estimates of aquifer yield, and changes in static water levels over time; to enhance technical studies; and to analyze changes in water levels related to pumpage. The potentiometric surface maps are not intended to be used for site-specific conditions. Additional information and related links can be found at: http://www.in.gov/dnr/water/7256.htm.

For more information: Bill Davis, Indiana Department of Natural Resources (IDNR) – Division of Water (wdavis@dnr.in.gov).

Emergency Regulation of Groundwater Rights and of Surface Water Rights

The Indiana Department of Natural Resources (IDNR) – Division of Water (DOW) annually resolves between 100 to 150 different investigations of water rights complaints. In addition, water level data is collected from 25 monitoring well networks visited by IDNR – DOW staff on a quarterly or a biannual schedule. Small capacity well owners are protected against the impacts of high capacity groundwater pumping if it substantially lowers water levels, resulting in the failure of a small capacity well (IC 14-25-4). Owners of freshwater lakes are protected against "significant environmental harm" resulting from a significant lowering of the lake level due to nearby high capacity groundwater or surface water withdrawals (IC 14-25-5). Additional information and related links can be found at:

http://www.in.gov/dnr/water/4849.htm.

For more information: Mark Basch, Indiana Department of Natural Resources (IDNR) – Division of Water (mbasch@dnr.in.gov).

Great Lakes-St. Lawrence River Basin Water Resources Compact

The Great Lakes-St. Lawrence River Basin Water Resources Compact is a cooperative effort between eight Great Lakes states and two Canadian provinces and is an agreement to regulate diversion of water from the Great Lakes Basin. The Great Lakes-St. Lawrence River Basin Resources Compact addresses both surface water and groundwater within the geographic areas where water drains toward the Great Lakes. The Great Lakes-St. Lawrence Basin Compact bans new or increased diversions with limited and strictly regulated exceptions. The standards are intended for new or increased water withdrawals. Total water withdrawal capability currently registered for Significant Water Withdrawl Facilities (SWWF) and current diversions are considered to be the existing approved amount for the Great Lakes-St. Lawrence River Basin Compact. Water conservation and efficiency programs have been developed by each state in order to reduce waste by all users. Amendments to Great Lakes Compact Rule (312 IAC 6.2) addressing discontinued facilities, facility transfer, and salmonid streams became effective June 8, 2018. About 20% of registered SWWF, accounting for approximately 25% of the reported annual water use in Indiana, are located within the Great Lakes Basin. Additional information and related links can be found at: http://www.in.gov/dnr/water/5216.htm.

For more information: Mark Basch, Indiana Department of Natural Resources (IDNR) – Division of Water (mbasch@dnr.in.gov).

Figure 13. *Map of Indiana Great Lakes Basin and Lake Michigan Basin Diversion Boundaries.*

Water Well Driller and Pump Installer Licensing, Continuing Education, Water Well Record Submittal, Well and Pump Installation Standards

Approximately 900 well drillers and pump installers are currently licensed in Indiana in accordance with Indiana Code (IC 25-39). There are between 10,000 to 12,000 water well records submitted annually as drillers are required to submit copies of each well record to the Indiana Department of Natural Resources (IDNR) – Division of Water (DOW). Licenses are renewed annually, and water well records are reviewed by staff and input into an on-line digital database containing over 400,000 records. Six hours of continuing education for each licensed well driller and pump installer are required every two years. Minimum well and pump installation standards are developed and administered by the IDNR – DOW Water Rights and Use Section. Division of Water staff conducted seven Continuing Education programs during 2018 and are currently scanning well installation and abandonment records. Additional information and related links can be found at: http://www.in.gov/dnr/water/2457.htm

For more information: Mark Basch, Indiana Department of Natural Resources (IDNR) – Division of Water (mbasch@dnr.in.gov).

Indiana's Water Shortage Plan

The need to monitor and mitigate the negative effects of ground and surface water shortages became a reality during the intense drought of 1988. In 1991, the Indiana General Assembly enacted Indiana Code 13- 2- 6-1 (since repealed) that required the Indiana Department of Natural Resources (IDNR) to develop a response plan when water shortages threaten: 1) the health, safety, welfare, or economic well- being of the citizens; or 2) the environment of any part of Indiana.

The initial Indiana Water Shortage Plan report was completed in 1994. Indiana Code 14- 25- 14 was enacted (since repealed) in 2006 resulting in the appointment of a Water Shortage Task Force to administer and update Indiana's Water Shortage Plan. Composed of a diverse and experienced group of experts, the Task Force completed a revised Water Shortage Plan in July 2009. The most recent revision to Indiana's Water Shortage Plan was completed in March 2015 and an update is planned for 2021.

The flash drought of 2012 re-focused attention on both the localized and widespread impacts of such a natural disaster. A primary activity of the Division of Water is to provide early detection of drought and its impacts through continuous monitoring of water resources. Currently, in partnership with state and federal agencies, the Division of Water coordinates a team of over 40 water resource professionals to assess water and soil moisture conditions across Indiana. The Indiana Drought Monitor Advisory Team provides detailed recommendations to the author of United States Drought Monitor each week.

Additional information about Indiana's Water Shortage Plan and links to the United States Drought Monitor, Midwest Drought Early Warning System, and NWS Indiana Drought Information webpage can be found at: http://www.in.gov/dnr/water/3124.htm.

For more information: Bill Davis, Indiana Department of Natural Resources (IDNR) – Division of Water, Resource Assessment Section (wdavis@dnr.in.gov); and David Smith, IDNR – Division of Water, Project Development Section (davsmith1@dnr.in.gov).

Indiana Finance Authority (IFA)

Central Indiana Water Study

The Indiana Finance Authority (IFA), in cooperation with INTERA Geoscience and Engineering Solutions, the United States Geological Survey (USGS), the Indiana Department of Natural Resources (IDNR), the Indiana Geological and Water Survey (IGWS), and Empower Results, is evaluating current water resources availability and future demands in Central Indiana (Marion and the surrounding eight counties). The study is assessing current and projected water resources, identifying data gaps, and upgrading surface and groundwater monitoring networks. Hydrologic calculations that forecast changes in water use and availability through 2070 consider water use data, projected changes in population and economic growth, hydrologic information, and climate-change scenarios. Assessment of existing and projected water infrastructure needs, as well as recommendations for a range of solutions, will be presented in the reports. These results will provide utilities and other stakeholders with the information required to manage existing resources and plan for future demands. The results of the Central Indiana Water Study will be publicly available in 2021 and project updates are available at: https://www.in.gov/ifa/regional-water-studies/central-indiana-water-study/.

For more information: Sarah Hudson, Indiana Finance Authority (IFA) – Water Resources and Infrastructure Planning Program, Director (sahudson@ifa.in.gov).

Indiana Geological and Water Survey (IGWS)

The Indiana Karst Observatory

The Mitchell Plateau, extending from Eastern Owen County to the Ohio River in Harrison County, is an iconic karst landscape of the United States. The sinkhole-dimpled forests, fields, and farms, extensive cave systems, and deep windows into the groundwater system have fostered curiosity, encouraged exploration, and served as the focus of scientific undertakings since the mid-1800's. The purpose of this set of Indiana Karst Observatory investigations is to gather existing data, develop collaborative relationships, install monitoring systems, and collect new data within the karst aquifers of Southwest Central Indiana, a region where access to water (or lack thereof) is a distinct socio-economic factor impacting development. This research consists of two primary goals: 1) to better characterize carbon, nutrient, and sediment transport in the critical zone *(the part of the Earth actively engaged in biogeochemical cycling)*; and 2) to establish study sites that can fold into a program that focuses on the physical, chemical, and biological interactions that are occurring within this near-surface, heterogeneous environment. Details about this project are available at: https://igws.indiana.edu/research/ProjectSheet.cfm?sheet_id=557.

For more information: Lee Florea, Indiana Geological and Water Survey (IGWS) (lflorea@indiana.edu).

Figure 14. *Indiana Geological and Water Survey (IGWS) Team at Bluespring Caverns (Photo by the Indiana University Center for Rural Engagement).*

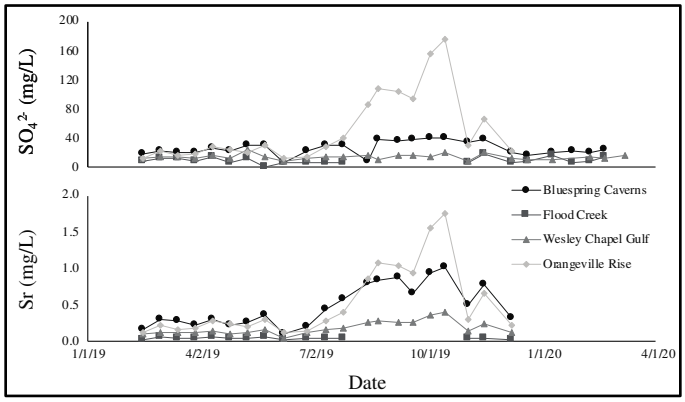

Figure 15. *A plot of time series data from four locations in the Mitchell Plateau in the critical zone network (Data provided by Sarah Burgess).*

Locating and Characterizing Important Springs of the Indiana Uplands

Springs in Southwest Central Indiana (SWCI), where groundwater emerges, have been historically important to communities as a source of drinking water, a resource for livestock and agricultural uses, and for commercial enterprises. Where surface water is scarce, such as on the karst landscapes riddled with sinkholes and caves, springs emerged as a community nexus. Where these springs were mineralized because of the underlying geology, they arose as a valuable economic resource which supported the spa industry that peaked in the early 20th century. Since available water remains a chief limiting factor for the economic and human development in the SWCI region, understanding the distribution and water quality in springs and how time has impacted the quantity and quality of these spring waters is of principal importance. In this proposal, the Indiana Geological and Water Survey (IGWS) will combine historic data with new data to ascertain a baseline of water quantity and quality for a subset of the 360 known karst and mineral springs in the Indiana Uplands. Specifically, the IGWS will: 1) scour publication archives for historic spring data that date back to 1901; 2) visit 100 springs to sample water quality and compare these results to available historic data; 3) develop and make available a geospatial database of springs comprising available data; and 4) develop a crowd-sourcing geospatial tool to acquire information on springs throughout SWCI.

For more information: Tracy Branam, Indiana Geological and Water Survey (IGWS) (tbranam@indiana.edu).

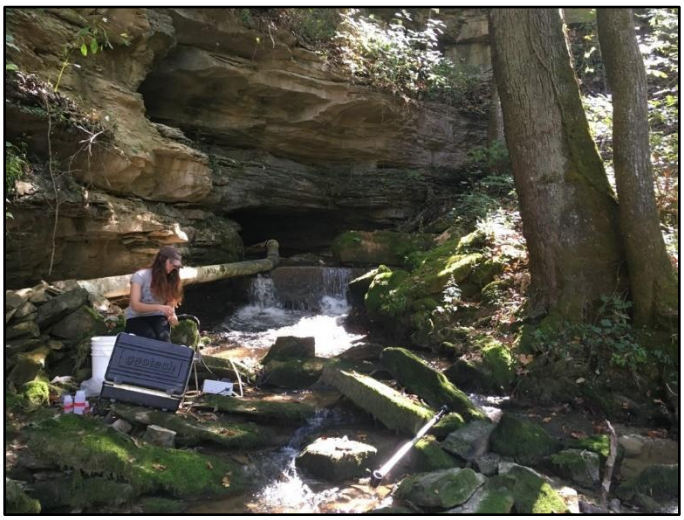

Figure 16. *Indiana Geological and Water Survey (IGWS) field geologist and Indiana University graduate student Sarah Burgess collects a water sample from the spring at Squire Boone Caverns.*

Characterizing Aquifer Geometrics in Northern Indiana Using Geophysical Techniques to Profile the Buried Bedrock Surface

Groundwater resource assessments in glaciated regions require buried bedrock elevation data to provide information related to aquifer geometry and to determine water resource availability. In Northern Indiana, such assessments are needed because expanded irrigation is increasing groundwater withdrawals in the region. Furthermore, naturally occurring contaminants have become an emerging issue, based on recent groundwater sampling data.

An improved understanding of bedrock valley morphology is also warranted by these concerns because rock-water interactions at the sediment/bedrock interface often control the geochemical characteristics of groundwater, highlighting the need to better constrain the hydrogeologic conditions at the base of glacial aquifers. This information will be important as increased withdraw can impact water levels, thereby changing the water chemistry, in turn effecting the water quality and impacts of the naturally occurring contaminants on Hoosiers. This work employs newly developed passive seismic geophysical techniques to establish additional bedrock elevation data and support higher-resolution maps of buried valleys that lie below the St. Joseph Aquifer System in St. Joseph and Elkhart Counties.

For more information: Robin Rupp, Indiana Geological and Water Survey (IGWS) (rrupp@indiana.edu).

The Indiana Water Balance Network

Water is lost from the landscape due to several processes such as transpiration and evaporation. Alternatively, during wet periods when rainfall is excessive, hydrologic components such as soil moisture become vital because they directly influence the timing and duration of flooding. With these concerns in mind, the Indiana Geological and Water Survey (IGWS) developed the Indiana Water Balance Network (IWBN) to monitor trends in water loss and gain for different components of the hydrologic cycle. Monitored hydrologic components include precipitation, soil moisture , evapotranspiration, and groundwater levels. Preliminary data from monitoring sites are available in real-time, and water year compilations of daily data are also available. The IWBN website showing site locations and real-time data is located at: https://igws.indiana.edu/cgda/waterBalanceNetwork where a new web site is under development.

For more information: Babak Shabani, Indiana Geological and Water Survey (IGWS) (bshabani@iu.edu); Robert J. Autio, IGWS (rjautio@indiana.edu).

The National Groundwater Monitoring Network (NGWMN): Contributions from the Indiana Geological and Water Survey (IGWS)

The National Groundwater Monitoring Network (NGWMN) is a compilation of selected groundwater monitoring wells from federal, state, and local groundwater monitoring networks across the nation. The NGWMN online data portal (https://cida.usgs.gov/ngwmn/) provides access to disparate groundwater databases in a web-based mapping application. The Indiana Geological and Water Survey (IGWS) has partnered with the United States Geological Survey (USGS) and 26 other contributing agencies to provide groundwater data for several principal aquifers in the United

States. The IGWS is currently providing daily groundwater-level data for 15 monitoring wells to the NGWMN. Two new wells were installed near Atlanta and Nappanee, Indiana in 2019 with data uploading started in 2020. The IGWS will install two additional wells in 2021 to monitor daily groundwater levels in buried valley aquifers in Central Indiana.

For more information: Babak Shabani, Indiana Geological and Water Survey (IGWS) (bshabani@iu.edu).

Integrating Hydrogeological Studies with United States Geological Survey (USGS) Funded Mapping Projects

The Indiana Geological and Water Survey (IGWS) has established a multi-disciplinary team of scientists to increase the value and influence of the United States Geological Survey (USGS) funded mapping projects by developing a new workflow that integrates geologic mapping with water resource assessments. Current projects include the development of three-dimensional (3-D) hydrogeologic framework models, volumetric analysis of aquifers, water quality sampling, and sensor testing for real-time monitoring.

For more information: Babak Shabani, Indiana Geological and Water Survey (IGWS) (bshabani@iu.edu).

Indiana State Department of Agriculture (ISDA)

Highlighting Indiana's Commitment to Enhance Water Quality Through the Use of Major River and Lake Basins GIS Story Maps

The Indiana State Department of Agriculture (ISDA) has developed 10 GIS Story Maps applications for the major river and lake basins in Indiana to showcase the efforts to enhance water quality as well as educate landowners (both rural and urban) about: local, state, and federal cost-share programs; educational opportunities; and rural and urban conservation practices. The story maps feature maps that allow users to click on watersheds, on water monitoring locations along with links to water quality data, and educational sites to view pop-ups which provide detailed information about each basin. Much of the water monitoring locations and data included on the story maps comes from information within the Indiana Water Monitoring Council's (InWMC's) Integrated Water Monitoring Network Optimization Taskforce White Paper titled *An Assessment for Optimization of Water-Quality Monitoring in Indiana, 2017*. The Story maps also contain information about local watershed groups and organizations, the number of conservation practices in specific watersheds, nutrient load reductions from BMPs, and any active grants. The development and purpose of these GIS story maps is making Indiana's nutrient reduction strategy more interactive. The story maps are available on the Indiana State Department of Agriculture (ISDA) web site at: https://www.in.gov/isda/divisions/soil-conservation/indiana-state-nutrient-reduction-strategy/.

For more information: Julie Harrold, Indiana State Department of Agriculture (ISDA) (jharrold@isda.in.gov).

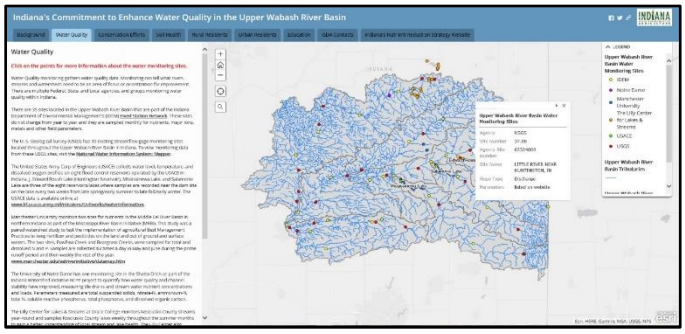

Figure 17. *A screenshot of a GIS Story Map used to enhance education about Indiana State Department of Agriculture's (ISDA's) water quality projects.*

Indiana State Department of Health (IDOH) – Environmental Public Health Division

Monitoring by Environmental Public Health Division

The Indiana State Department of Health's (IDOH's) – Environmental Public Health Division (EPH) collaborates on various projects with partners across the state to improve health outcomes and minimize risk to Hoosiers. Programs operated by the EPH are concerned with a mix of surface and groundwater. These programs include Commercial and Residential Onsite Septic Systems, Harmful Algal Bloom, Fish Consumption Advisory, Public Health Drinking Water and Unregulated Water Supply Support Program. The EPH provides direct assistance to local and county health officials, onsite sewage system construction permitting, beach water quality surveillance at regulated facilities, and direct private well-water outreach programs for communities (**Figure 18**). The IDOH website is: www.eph.in.gov.

For more information: Mike Sutton, Indiana State Department of Health (IDOH) – Environmental Public Health Division (msutton@isdh.in.gov).

Figure 18. *Indiana State Department of Health (IDOH) staff at the 2018 Indiana State Fair's Pathways to Water Quality discussing private water wells and onsite sewage systems.*

Indiana University – Department of Earth and Atmospheric Sciences

Modeling Spatial-Temporal Hydrological Changes at the Regional Scale Via a Science Gateway

Traditionally, we develop a hydrological model and publish it in a journal. This is the end story. However, the challenges of sustainability and climate adaptation require us to change our way of doing and communicating sciences. In 2020, we developed the *FutureWater* Science Gateway: https://futurewater.indiana.edu. The core of the gateway is coupled surface-water and groundwater models of the Wabash River Basin, which simulate the water cycle to the year 2100 under two Representative Concentration Pathways (4.5 and 8.5) climate scenarios. The outputs of the hydrological models (e.g., ET, soil moisture, groundwater recharge, base flow, stream flow) are visualized with detailed maps and interactive graphs. Data are available for download, and models are available to other researchers, state, and non-governmental organization (NGO) staff to run their own versions. The model is live and is updated with new available data.

The *FutureWater* gateway is built based on the Apache Airavata gateway middleware framework and hosted under the Science Gateway Platform (SciGaP) project at Indiana University. The gateway provides an integrated infrastructure for simulations based on the parallelized Soil and Water Assessment Tool (SWAT) and SWAT-MODFLOW software execution on Extreme Science and Engineering Discovery Environment (XSEDE) and Indiana University's high-performance computing (HPC) resources. It organizes data in optimized relational databases and enables intuitive simulation result data exploration.

The climate change concept is exceptionally amorphous and common examples of climate change impacts (e.g., polar bears on breaking away ice, sea level rise on the coasts, and the melting of Greenland glaciers) have not been effective in conveying the impacts of climate change on a local and personal level. To address this issue, teaching modules have been developed to allow students to explore water availability on the gateway under

various climate change scenarios near their hometowns (https://futurewater.indiana.edu/teaching-resources/index.html). These modules were distributed to science teachers in the state of Indiana to help the high schools with online instruction during the COVID-19 pandemic. A large number of faculty, staff, and students have contributed to this project.

For more information: Chen Zhu, Indiana University – Department of Earth and Atmospheric Sciences (chenzhu@indiana.edu).

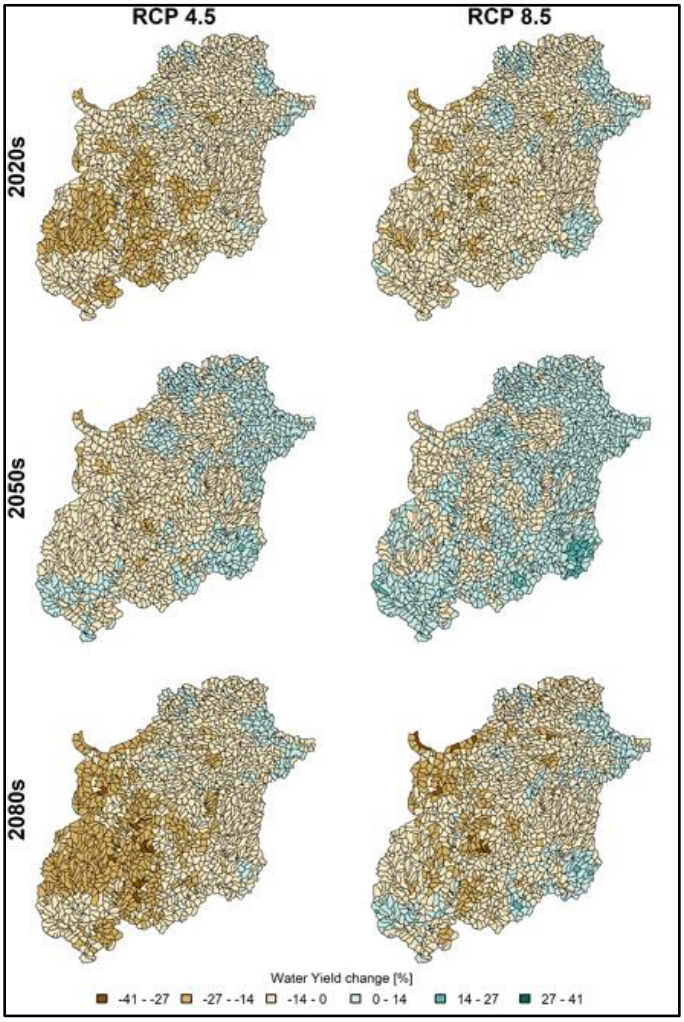

Figure 19. *Maps showing simulated water yield in subbasins under two CO_2 emission scenarios. Colors show percentage changes from historic mean (1971-2000).*

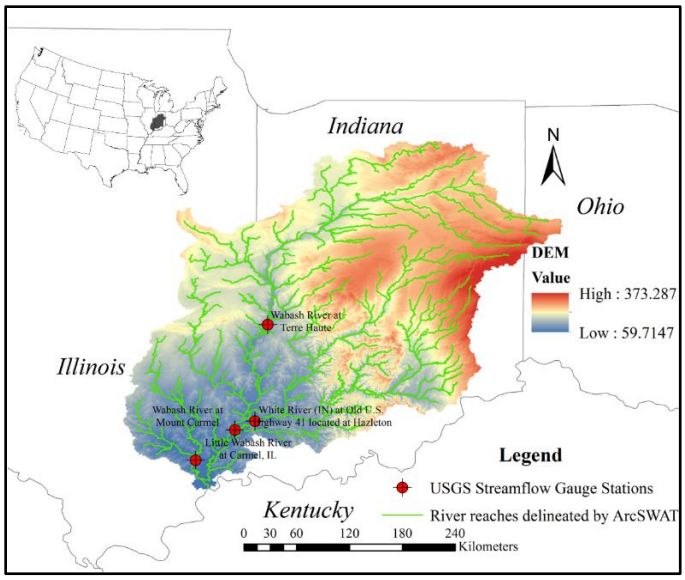

Figure 20. *Map showing the Wabash Basin and the hydrologic model areal coverage.*

Indiana University – Department of Geography

Implications to Aquifer Storage from Shifts in Timing of Water Balance Partitioning

As the timing and distribution of factors affecting the water-budget change in a warming climate (e.g., timing and intensity of precipitation events, daily and seasonal shifts in air and water temperature), associated hydrologic changes are being observed. Changes in snow accumulation and melt, flooding, and drought all affect the hydrological processes of infiltration, evapotranspiration, and runoff. This study seeks to investigate whether sufficient data is available to identify trends in groundwater recharge over time, testing the hypothesis that increasingly intense precipitation events resulting in extreme runoff events might be short-circuiting processes of infiltration and groundwater recharge. Decreased recharge across the landscape can result in reduced freshwater availability, drought resiliency, and increase the impact of flood events.

For more information: Sally Letsinger, Indiana University – Department of Geography (sletsing@indiana.edu).

Unconsolidated Aquifer Model of Indiana

This ongoing project harnesses the information about subsurface geologic materials reported in water-well records. The sediments of interest in this study are largely of glacial origin and contain important aquifer bodies that supply water to Hoosiers for drinking, irrigation, and industrial uses. Although the types and extents of aquifer systems have been mapped throughout the state, the dimensions (depth, extent, thickness, geometry) and connectivity of individual unconsolidated aquifers is largely unknown. A proof-of-concept project is underway using a subset of data for northeastern Indiana. Through this work, the general structure of the subsurface aquifer resources can be understood. The three-dimensional geologic framework model will then be used to answer water-availability questions.

For more information: Sally Letsinger, Indiana University – Department of Geography (sletsing@indiana.edu).

National Oceanic and Atmospheric Administration (NOAA) – National Integrated Drought Information System (NIDIS)

Midwest Drought Early Warning System

Water is a valuable and normally abundant resource across Indiana. However, extended periods of dry weather, often accompanied by summer heat waves, lead to periodic droughts that create adverse economic, environmental, and public health impacts. Improved monitoring, analysis, and communication of this information can provide early indication of developing drought conditions, enabling managers in water sensitive sectors to be proactive as the threat of a water shortage grows.

To advance drought science and preparedness across the United States, the National Integrated Drought Information System (NIDIS) was authorized by Congress in 2006 and reauthorized in 2014 and 2018 with an interagency mandate to develop a national drought early warning system (DEWS). NIDIS is working toward this goal by developing a network of regional DEWS, which includes a Midwest DEWS that was launched in 2016. Stakeholders from Indiana and the other states in the Midwest have been working with NIDIS to identify priorities and activities to advance drought early warning in the region. One of the priorities of the Midwest DEWS is to enhance drought observations and data availability, which includes not only increasing the number of observations (e.g., soil moisture, groundwater, precipitation), but also increasing the availability and ease of obtaining this data to aid in decision making for stakeholders and sectors across the region.

NIDIS is also the lead sponsor of the National Coordinated Soil Moisture Monitoring Network (NCSMMN), a multi-agency, multi-institutional initiative to integrate soil moisture data from around the country and to capitalize on its transformative potential for a wide range of applications across sectors of the economy. The NCSMMN aims to deliver high quality, easy-to-understand soil moisture products and tools to support better hazard early warning systems; reduce risks from hazards such as drought, flood, and fire; improve crop production and resilience; and improve characterization of water-budgets and climate models. The project website is: https://drought.gov/dews/midwest.

For more information or to become more involved in the Midwest Drought Early Warning System please email Molly Woloszyn, National Oceanic and Atmospheric Administration (NOAA) (molly.woloszyn@noaa.gov).

Purdue University – Department of Agricultural and Biological Engineering

State of Indiana Waters Website

The purpose of the State of Indiana Waters site is to create an up-to-date easily accessible web portal that geospatially displays metrics to convey the state of both Indiana ground and surface waters. The code written for this project retrieves data from Online water databases, such as those maintained by the United States Geological Survey (USGS) then completes automated data quality checking and calculates metrics for the current state (end of last water year) and long-term trends for Indiana water

resources. All analysis is conducted for the last 30 water years up to and including the most recent water year, which ends on September 30th as defined by the USGS. The current state of Indiana water resources is assigned based on a ranking of how the current groundwater and surface water metrics compare to the previous 29 years. Long-term trends are also assessed for the same 30 year period. Interactive webmaps are combined with end of water year snapshots of select reservoirs, streamflow gages, groundwater monitoring wells, and the state drought monitor web page. This is made available on the State of Indiana Water Resources Website (https://iwrrc.org/indiana-water/) with commentary concerning the status of water resources in the previous water year. The site is updated by November 1 of each year, allowing for full data availability from the just completed water year.

For more information: Keith Cherkauer, Purdue University – Department of Agricultural and Biological Engineering (cherkaue@purdue.edu).

Statewide Hydrologic Modeling Efforts

The Purdue Hydrologic Impacts Group, under the direction of Laura Bowling and Keith Cherkauer, have setup the Variable Infiltration Capacity (VIC) large-scale hydrology model for the State of Indiana. Simulations are run at resolutions of 1/8th and 1/16th degree and assessment of hydrologic variables are available for periods from 1915 through 2100. Historical analysis makes use of gridded sets of climate observations (primarily daily precipitation, and maximum and minimum air temperature), while future scenarios are based on multiple Coupled Model Intercomparison Project Phase 5 (CMIP5) Atmosphere Ocean Global Circulation Model (AOGCM) outputs using scenarios from the Intergovernmental Panel on Climate Change (IPCC). These data will be made available to the public after publication of the *Indiana Climate Change Impact Assessment* (IN CCIA). The standard VIC model calculates a complete water and energy balance for every grid cell, including simulation of snow and soil frost, soil moisture, surface runoff, baseflow and evapotranspiration. The model has been updated at Purdue University to include representation of lakes and wetlands, and subsurface drainage, along with a coupling framework to estimate soil loss using the Water Erosion Prediction Project (WEPP) model. Purdue now includes simulation of crop yields and water use with the VIC-CropSyst model and is developing a simplified groundwater algorithm so that water use can be constrained by actual water availability. Additional information can be found at: https://www.agry.purdue.edu/hydrology/.

For more information: Keith Cherkauer, Purdue University – Department of Agricultural and Biological Engineering (cherkaue@purdue.edu).

Developing a Large-Scale High-Resolution Flood Model for Entire Wabash Basin

Flooding is one of the most common natural hazards across Indiana, impacting lives and infrastructure throughout the state. Deploying robust flood warning systems and flood control measures require accurate information about the location, duration, and depth of flooding across the entire state. However, only select locations across major river systems are monitored for flood which leaves significant gaps in the availability of flood related information. Additionally, most of the flood maps available for Indiana are based on simplistic steady state hydraulic models that cannot capture the dynamic and complex nature of floods accurately. This can lead to significant error in estimating the magnitude and timing of flooding as well as identifying regions that are vulnerable to flood. Our research aims at providing accurate and dynamic flood extents for every stream in Indiana. We plan to achieve this goal by implementing a large-scale physically based distributed flood model, Integrated Channel and Pond Routing (ICPR), for the entire Wabash Basin (85,000 km^2). Using high performance computing (HPC), the modeling framework integrates multiple physical processes such as precipitation, infiltration, surface water-groundwater interactions while also ingesting the latest high-resolution input datasets to reduce model uncertainty. We have demonstrated its feasibility for medium sized subwatersheds (up to 3,800 km^2) in Indiana and are in the process of scaling it up it to the entire Wabash Basin. Upon successful deployment, this model will be capable of providing near real-time flooding extents and depth across Indiana which can be extremely useful for flood warning and decision making.

For more information: Dr. Venkatesh Merwade (vmerwade@purdue.edu) or Sayan Dey (dey6@purdue.edu), Purdue University.

Purdue University – Department of Agronomy

Naturalized streamflow for the Wabash River

In the Wabash River Basin in Indiana, streamflow trends due to changes in land management and climate are potentially masked by the effect of flood control reservoirs constructed on the Wabash, Salamonie, and Mississinewa Rivers in the mid-1960's. To investigate the impact of environmental changes on streamflow, historic daily data have been used to create statistical models to estimate what the daily streamflow would have been if the dams were not present (naturalized streamflow) for six sites in the Upper Wabash Basin using Maintenance of Variance type one and Drainage Area Ratio methods. The natural historical flow for the Wabash River at Huntington, Salamonie River at Dora, Wabash River at Wabash, Wabash River at Peru, Wabash River at Logansport, and the Wabash River at Lafayette has been reconstructed from 1968 to 2014. Trend analysis indicates that there would be statistically significant increases in Richards-Baker Flashiness Index, mean annual flow, annual maximum flow, and annual minimum flow all along the main stem of the Wabash River if the dams were not present. A summary of the project is available at: https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1069&context=purduegisday.

For more information: Sanoar Rahman and Laura Bowling, Purdue University – Department of Agronomy (rahman17@purdue.edu or bowling@purdue.edu).

Purdue University – Department of Earth, Atmospheric, and Planetary Sciences

Using Geochemical and Isotopic Tracers to Identify Sources of Baseflow and Salinity in the Wabash River Watershed

Baseflow is the portion of streamflow that comes from groundwater and other delayed stores of water, such as water stored in the soil. Baseflow is present year-round in perennial streams and it sustains low-flow periods that occur between storm events, during dry seasons, and during droughts. Therefore, baseflow is critical to aquatic and riparian ecosystems because streams and rivers would go dry without baseflow during extended dry periods. In agricultural watersheds, subsurface drainage modifications have the potential to alter baseflow generation processes *(where baseflow comes from)*. Over the fall and early winter of 2015, samples of baseflow were collected longitudinally from the headwaters of the Wabash River south of Fort Recovery, Ohio to the confluence with the Ohio River near New Haven, Illinois. Samples were also collected from major tributaries to the Wabash River upstream of their confluence with the Wabash. Water samples were analyzed for general geochemistry, stable isotopes ($\delta^{18}O$ and $\delta^{2}H$), chlorine-36 ($^{36}Cl/Cl$), strontium isotopes ($^{87}Sr/^{86}Sr$), and radon-222 (^{222}Rn). The data provide insight into the spatial variability of the sources of chloride in the watershed, interactions between shallow aquifers in unconsolidated glacial sediment and regional groundwater from the carbonate aquifer, and interactions between the shallow aquifers and aquifers associated with the buried Teays River Valley. The data also provide a baseline against which future changes in baseflow can be assessed. Some of the data is currently being revised for publication in a journal article. An additional journal article is being written on the tributaries.

For more information: Marty Frisbee, Purdue University – Department of Earth, Atmospheric, and Planetary Sciences (mdfrisbee@purdue.edu).

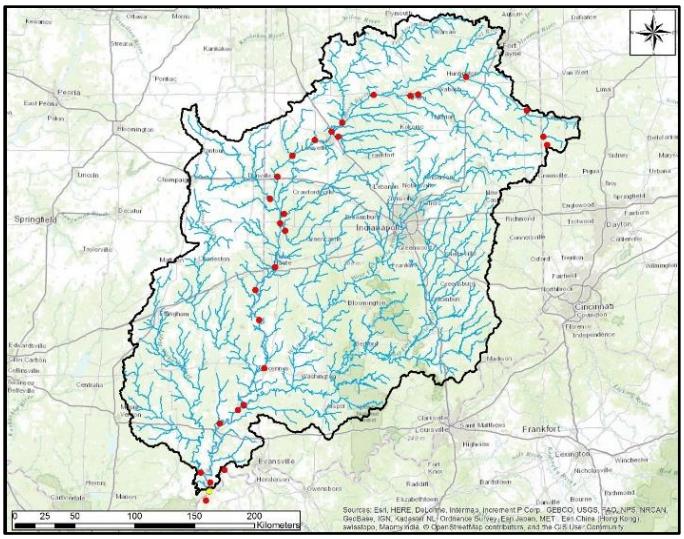

Figure 21. *Map of sites sampled for baseflow in the Wabash River Watershed.*

Purdue University – Lyles School of Civil Engineering and Environmental Ecological Engineering

Time Series Analysis of Water Use and Indirect Reuse at the Wabash River

Anthropogenic (*of, relating to, or resulting from the influence of human beings on nature)* water use and reuse represent major components of the water cycle. Unplanned, or *defacto*, indirect water use occurs in most of the United States river systems, however there is little documentation of it. In this project, we complete a time series analysis of water use and unplanned indirect reuse for the Wabash River Watershed. We aggregated reported significant withdrawals and point source wastewater discharges data at the watershed scale through nine years, from 2009 to 2017. Results, available at: https://www.sciencedirect.com/science/article/pii/S0048969720337426, document the occurrence of indirect water reuse in a water-rich watershed. The analysis shows that reported data effectively describe the water use trends, reflecting both anthropogenic and natural events. We demonstrate the feasibility and significance of using available water datasets to perform large scale water use analysis, describe limitations encountered in the process, and highlight areas for improvement in water data management.

For more information: Loring F. Nies Purdue University – Lyles School of Civil Engineering and Environmental and Ecological Engineering (nies@purdue.edu).

The Nature Conservancy

From Soil Health to Oxbow Biodiversity

Often The Nature Conservancy does not monitor water quality but relies upon the robust data of others to help understand where improvements to water, and hence in-stream habitat, are needed. A recent example of this is a partnership with the United States Geological Survey (USGS) to conduct an analysis of existing water quality data in the Upper White River (https://pubs.er.usgs.gov/publication/sir20195119). Citizen's Energy Group, the Indiana Department of Environmental Management (IDEM), and the Muncie Bureau of Water Quality contributed their long-term data sets to this work, which was funded by the Nina Mason Pulliam Charitable Trust. Understanding water quality trends is leading us to target soil health improvements in Delaware, Henry, and Randolph Counties.

Our work in the Wabash River spans the watershed with work in the headwaters of the Upper White River intended to lower nutrient export to the Lower Wabash and White River floodplains where we are working to understand water quality and fish use of oxbow lakes. Oxbow lakes are biodiversity hotspots in the floodplain, harboring a diversity of fish and birds, while also scrubbing flood waters of excess nutrients. Our oxbow lake monitoring program has generated a list of priority oxbows around which we are focusing our monitoring, research, and protection resources like the United States Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS) wetland reserves easements. Oxbow lakes within Gibson, Knox, and Posey Counties are being looked at to provide better water quality and habitat outcomes for wildlife and the waters of the Wabash as they leave Indiana.

For more information about our work in the Upper White River, please contact Seth Harden at seth.harden@tnc.org. To learn about our work in the Lower Wabash River, please contact Brad Smith at bsmith@tnc.org.

Figure 22. *Brad Smith, The Nature Conservancy, collecting water samples from Long Pond, Knox County, Indiana (Photo by Cassie Hauswald).*

United States Army Corps of Engineers – Louisville District

2018 Water Quality Sampling

In 2018, the United States Army Corps of Engineers – Louisville District sampled its eight reservoirs in Indiana. These reservoirs are Roush, Mississinewa, Salamonie, Harden, Brookville, Patoka, Monroe, and Cagles Mill. At all reservoirs, samples were collected from the reservoir body as well as their respective tailwaters and tributaries. Each sample station was measured for several field water quality parameters and samples were collected and shipped to the lab for additional analysis. At each site within the reservoir, the epilimnion *(upper layer of lake)*, metalimnion *(intermediate layer of lake)*, and hypolimnion *(lower layer of lake)* were sampled. Biological samples including phytoplankton and zooplankton were also collected at select sites and depths. Temperature and dissolved oxygen were collected near the dam and from the tailwater of each lake, approximately every two weeks from April through fall turnover. Jurisdiction of United States Army Corps of Engineer reservoirs Salamonie, Mississinewa, and Roush were transferred to the Chicago District as of October 1, 2020. To view reports for reservoirs in the Louisville District visit: http://www.lrl.usace.army.mil/Missions/Civil-Works/Water-Information/Water-Quality; and in the Chicago district visit: https://www.lrc.usace.army.mil/Missions/Water-Management/Water-Quality/

For more information: email louisvillewaterquality@usace.army.mil or call (502) 315-7439.

United States Geological Survey (USGS) – Ohio-Kentucky-Indiana Water Science Center

United States Geological Survey (USGS) Groundwater Network in Indiana

The United States Geological Survey (USGS) maintains a network of wells across Indiana to monitor the effects of droughts and other climate variability on groundwater levels. The network consists of approximately 49 wells that are funded by the USGS and the Indiana Department of Natural Resources (IDNR) and provide information to the public in near real-time online at: https://groundwaterwatch.usgs.gov/netmapT4L1.asp?ncd=IDN. These wells collect groundwater levels to better understand recharge rates, water withdrawal from irrigation, and climate variability.

In addition, the USGS, as directed by Congress, has established a national climate response network of groundwater wells (https://groundwaterwatch.usgs.gov/CRNHome.asp). As a part of the network each climate division in the country is to have at least one real-time monitoring well in a climate-responsive aquifer that is not affected by groundwater withdrawals or interactions with nearby surface water. Indiana has one designated climate response network well located in eight of the nine climate divisions. Data from these wells is compiled by the USGS and provides information to describe the natural variability in groundwater levels attributable to weather and climate.

For more information: Randy Bayless, United States Geological Survey (USGS) – Ohio-Kentucky-Indiana Water Science Center (ebayless@usgs.gov).

Figure 23. *A groundwater monitoring site in rural Indiana operated by the United States Geological Survey (USGS). The site is co-located with a rain gage and continuously transmits data by satellite to the internet.*

United States Geological Survey (USGS) Super Gages Monitor Continuous Water Quality at Streamflow Gages

The United States Geological Survey (USGS) operates 14 Super Gage sites in Indiana, cooperating with a variety of organizations (https://pubs.usgs.gov/fs/2015/3041/pdf/fs2015-3041.pdf). Super Gages provide real-time estimates of concentrations and loads of suspended sediment, total nitrogen, and/or total phosphorus within watersheds where they are deployed (https://www.usgs.gov/centers/oki-water/science/super-gage-network?qt-science_center_objects=0#qt-science_center_objects). Tasks performed at each site often include quantification of streamflow, operation of continuous water quality monitors, and discrete sampling, and modeling of constituents not easily measured in real-time. Continuous and publicly available data: 1) highlight 15-minute, daily, and event-driven fluctuations (https://waterdata.usgs.gov/in/nwis/current/?type=quality); 2) provide richer data sets for understanding relations between water quality, hydrology, geology, and land use; and 3) promote more effective resource management.

For more information: Aubrey Bunch, United States Geological Survey (USGS) – Ohio-Kentucky-Indiana (aurbunch@usgs.gov).

Figure 24. *United States Geological Survey (USGS) employee Cole Downhour servicing the super gage at Richmond (Photo by Maddie Messner).*

Indiana Periodic Groundwater Networks

The United States Geological Survey (USGS) in cooperation with the Indiana Department of Environmental Management (IDEM), the City of Carmel, the City of South Bend, and St. Joseph County Health Department collect individual measurements of groundwater levels in three networks.

One network is located in Lake and Porter Counties in Northwest Indiana and has been active since 1985. Water levels are collected quarterly for long-term seasonal variations. The network started as a project with United States Environmental Protection Agency (US EPA) as groundwater quality monitoring wells near Superfund sites. Currently the network consists of 68 groundwater monitoring wells (https://groundwaterwatch.usgs.gov/countymap.asp?sa=IN&cc=089).

The St. Joseph County groundwater network is measured once a year for annual comparison of water levels. The network has been in place since 1990. There are 58 monitoring wells in the network. The wells were installed as part of a St. Joseph County groundwater resources study in the early 1990's (https://groundwaterwatch.usgs.gov/countymap.asp?sa=IN&cc=141).

The Carmel network was installed in the 1970's as part of a groundwater availability study. The wells are measured bi-annually in April and September or October to get pre- and post-summer water levels. The network contains 31 wells (https://groundwaterwatch.usgs.gov/countymap.asp?sa=IN&cc=057).

For more information: Alex Riddle, United States Geological Survey (USGS) – Ohio-Kentucky-Indiana Water Science Center (ariddle@usgs.gov).

United States Geological Survey (USGS) Streamgages in Indiana

The United States Geological Survey (USGS) operates over 200 streamgages on rivers and streams across the state of Indiana. These gages measure water surface elevation and many compute discharge (volume of water moving past the streamgage) providing information to the public in near real-time on the USGS National Water Dashboard (https://dashboard.waterdata.usgs.gov/app/nwd/?region=in).%20). Streamgages are critical to National Weather Service flood forecasts and for flood control operations by the United States Army Corps of Engineers. They are also used for environmental compliance, water quality studies, ecological monitoring, water availability calculations, and by recreational users.

For more information: Jeff Woods, United States Geological Survey (USGS) – Ohio-Kentucky-Indiana Water Science Center (jwoods@usgs.gov).

Estimated Water Use in Indiana

The United States Geological Survey (USGS), as directed by Congress, has estimated water use in the United States every five years since 1950 (https://waterdata.usgs.gov/in/nwis/water_use/). Most of the estimates in recent compilations are based on data reported to the Indiana Department of Natural Resources (IDNR) – Water Rights and Use Program as part of the Significant Water Withdrawal Facility Registration Program (http://www.in.gov/dnr/water/4841.htm) mandated by Indiana Water Resource Management Act of 1983 (IC 14-25-7-15). Sectors of estimated water use compiled nationally include public supply, domestic, industrial, mining, thermoelectric power, irrigation, livestock, and aquaculture. Data for Indiana aggregated by county, HUC8, and aquifer are estimated annually. Ongoing long-term national collection of water use data facilitates identification of trends in water availability and use, the most recent report *Estimated Use of Water in the United States in 2015* is available at: https://pubs.er.usgs.gov/publication/cir1441. Indiana has had among the largest withdrawals for self-supplied industrial use (water supplies that are specifically installed and used for fabrication, processing, washing, and cooling) in the United States in recent national compilations. An estimated 4.9 million Hoosiers depended on public supplies (e.g., municipal or city water) for domestic water use in 2015 (the remaining 6.6 million Hoosiers depend on self-supplied water (e.g., private water wells) or purchased/delivered water).

For more information: Gary Martin, United States Geological Survey (USGS), Ohio-Kentucky-Indiana Water Science Center (grmartin@usgs.gov).

United States Geological Survey (USGS) Flood Inundation Mapping Program of Indiana

The United States Geological Survey (USGS) Flood Inundation Mapping Program (FIMP), https://www.usgs.gov/mission-areas/water-resources/science/flood-inundation-mapping-fim-program, is a national program that focuses its efforts at state and local levels to help communities understand flood risks and to assist in making cost-effective flood response, recovery, and mitigation decisions. The program partners with local communities and state officials to participate in the development and validation of flood inundation map (FIM) libraries. In turn, local and state stakeholders use these maps by accessing tools and information available on the USGS Flood Inundation Mapper (https://fim.wim.usgs.gov/fim) to help protect lives and property and to understand their local flood risks and mitigation options. The FIMP of Indiana is an integral part of the national program and is continuing to develop and generate these FIM libraries by cooperating with many different types of stakeholders including, but not limited to, private sector and educational institution, and local, state, and federal officials. Additional information regarding the completed FIM libraries in Indiana is also available online at:

https://www.usgs.gov/centers/oki-water/science/flood-inundation-mapping-ohio-kentucky-and-indiana.

For more information: Moon Kim, United States Geological Survey (USGS) – Ohio-Kentucky-Indiana Water Science Center (mkim@usgs.gov).

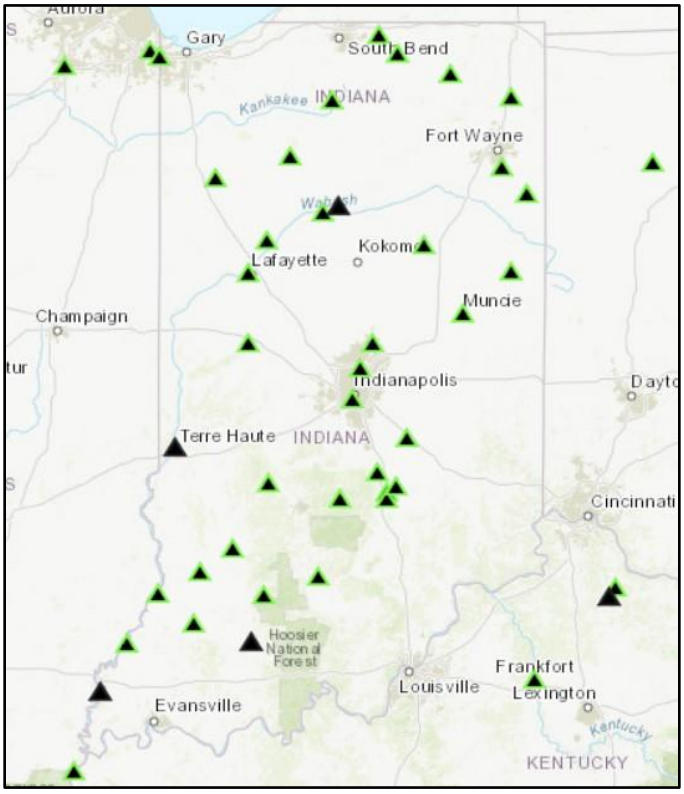

Figure 25. *Sites in Indiana with flood inundation maps appearing on the USGS FIM Mapper web page.*

University of Notre Dame – Department of Biological Sciences

Preventing nutrient loss from Indiana farms with watershed-scale pairing of cover crops and the two-stage ditch

Since 2015, the Indiana Watershed Initiative (IWI) Regional Conservation Partnership Program (RCPP) has documented the water quality and soil health benefits of watershed-scale implementation of winter cover crops and the two-stage ditch in two Indiana watersheds (Shatto Ditch Watershed in Kosciusko County and Kirkpatrick Ditch Watershed in Jasper County, Indiana). During the October 2018 to September 2019 water year, the IWI RCCP project paid out the last of its funds to farmers for incentivized conservation, having grown a model platform with unprecedented conservation adoption.

During 2020, we have continued this work with post-incentive sampling funded by other sources. The goal of our ongoing work is to document the lasting benefit of two important conservation practices after government incentives have ended, and to evaluate sustainability of these practices in Indiana in a manner that is meaningful to farmers, managers, and researchers.

We continue to quantify changes in nutrient loss from fields through subsurface tile drains as well as nutrient export from each watershed. We collect water grab samples year-round from tile drains throughout each watershed as well as at multiple points along the waterways. In addition, the project has deployed real-time water quality sensors co-located with United States Geological Survey (USGS) flow gages at each watershed outlet. We also conduct seasonal soil sampling on fields throughout each watershed to document changes in soil health.

Monitoring includes real-time sensors: continuous stream flow, nitrate, turbidity, dissolved oxygen, conductivity, and pH. Instantaneous tile drain flow is measured and water grab samples are analyzed for nitrate, ammonium, phosphorus, dissolved organic carbon, and silica. Soil analyses include organic matter, pH, nitrate, ammonium, water extractable phosphorus, total phosphorus, Mehlich III extractable phosphorus, aluminum, iron, calcium, magnesium, and cation exchange capacity. Real-time sensors make measurements every 30 minutes. Water grab samples are collected every two weeks and soil samples are collected twice per year (Fall and Spring). More details on the project can be found at: https://www.indianawatershedinitiative.com/.

For more information: Jennifer Tank, University of Notre Dame – Department of Biological Sciences (tank1@nd.edu).

University of Notre Dame – Environmental Change Initiative

Smart Water CrowdSensing Project

This project integrates expertise from seven disciplines (computer science and engineering, environmental engineering and science, community social science, biogeochemistry, hydrology, natural resource management, and statistics) to study the complete feedback loop of Smart Water CrowdSensing on how reliable data analytics and crowdsensing improves drinking water safety and management, and ultimately community well-being and sustainability.

Why do we care about nitrate contamination? The residential drinking water supplies in rural Northern Indiana rely on private groundwater wells and it is known that a serious problem is nitrate contamination according to a survey by the St. Joseph County. Nitrate contaminates the water supplies from such things as fertilizer applications or seepage of septic tanks. Ingestion of nitrates from contaminated waters results in methemoglobinemia.

The goal of the project is to improve our understanding of variability in data collected by citizen scientists: 1) by combining test strip data and lab measurements, we will be able to understand more about spatial and temporal variability in data reporting across urban, suburban, and rural communities in Northern Indiana; 2) we will empower homeowners with an improved understanding of their own water quality through community engagement in the scientific process; 3) our results will be useful to make recommendations of groundwater management at state and regional level through stakeholder partnerships. The project website is: https://swcproject.weebly.com/.

For more information: Casey Stoffel, University of Notre Dame – Environmental Change Initiative, Project Coordinator (cstoffe2@nd.edu).

NORTHWESTERN INDIANA ACTIVITIES

[Also see projects listed as MULTI-REGION AND STATEWIDE]

Porter County Soil & Water Conservation District (SWCD)

East Branch-Little Calumet River, Watershed Nutrient Study Program

In 2016, the Porter County Soil & Water Conservation District (SWCD) began monitoring surface water in the East Branch of the Little Calumet River. Water monitoring has continued with help from our conservation partners at the Indiana State Department of Agriculture (ISDA), the National Park Service (NPS), and United States Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS). The purpose of the watershed nutrient study program was to screen local streams to determine what nutrient levels were present and to evaluate the relationship between land management and surface water nutrient chemistry. Landscape analyses were performed to evaluate the current land use, commodity crop type and agricultural land management (i.e., tillage and cover crops). With help from the United States Geological Survey (USGS), water samples were analyzed for a presumed recent human fecal contamination to evaluate the potential issue of failing septic systems. This information will be used to help inform landowners and producers about watershed health, water quality and agricultural best management practices in the future. Porter County SWCD's website is: https://www.portercountyswcd.com/our-work/water-quality.

For more information: Jared O'Brien, Porter County Soil & Water Conservation District (SWCD) (jared.obrien@in.nacdnet.net).

Figure 26. *Water sampling in Kemper Ditch (Photo by Porter County Soil & Water Conservation District (SWCD)).*

Kankakee River Watershed, Water Quality Monitoring Program

The Porter County Soil & Water Conservation District (SWCD) started water sampling in the Kankakee River Watershed in 2019. With assistance from conservation partners at the Indiana State Department of Agriculture's (ISDA's) – Division of Soil Conservation, water samples were collected from each watercourse that drains into the Kankakee River within Porter County to assess nutrient levels. Sampling occurred once a month (May-October) at eight sites. Parameters included total nitrogen (TN), total phosphorus (TP), Ammonia (NH_3), and total Kjeldahl nitrogen (TKN). After reviewing the 2019 water monitoring results, the District intends to focus our continued efforts on the watershed that exhibited the highest concentration of nutrients. Through cost-share programs, targeted outreach, and the use of agricultural conservation practice siting tools the Soil & Water Conservation District (SWCD) will continue to assist producers with the adoption of best management practices to further reduce the nutrient and sediment loading in the watershed. Porter County SWCD's website is: https://www.portercountyswcd.com/our-work/water-quality.

For more information: Jared O'Brien, Porter County Soil & Water Conservation District (SWCD) (jared.obrien@in.nacdnet.net).

Figure 27. *Water sampling in the Kankakee Watershed (Photo by Porter County Soil & Water Conservation District (SWCD)).*

United States Geological Survey (USGS) – Ohio-Kentucky-Indiana Water Science Center

Green Infrastructure Evaluation at Gary City Hall

In collaboration with the City of Gary and the Great Lakes Restoration Initiative, the United States Geological Survey (USGS) is studying the effects of planned stormwater reduction strategies and infrastructure on the hydrology of the highly permeable surficial aquifer material and storm-sewer flows during a five-year study. The United States Geological Survey (USGS) has installed and will monitor and analyze hydrologic data from a network of groundwater observation wells, soil moisture sites, storm sewers, flumes, and a weather station to understand the effect of the rain garden and other green infrastructure installations on stormwater reduction. Physical and chemical properties of soils will also be measured. Monitoring hydrologic variables at the Gary green infrastructure site will assess: 1) reductions in stormwater discharged to the sewer as a result of the green infrastructure installation; 2) changes in water-budget components; 3) fates of deicer compounds applied at the site; and 4) rain garden sustainability.

More information on the project can be found online at: https://www.usgs.gov/centers/wisconsin-water-science-center/science/assessing-stormwater-reduction-using-green?qt-science_center_objects=0#qt-science_center_objects

For more information: Randy Bayless, United States Geological Survey (USGS) – Ohio-Kentucky-Indiana Water Science Center (ebayless@usgs.gov).

Valparaiso University – Department of Biology

Valparaiso University Students Monitor the Stormwater Receiving Streams in the City of Valparaiso as Part of the Municipal Separate Storm Sewer Systems (MS4) Program

Each Fall, near the end of October, science majors from the Valparaiso University Ecology course monitor multiple sites in the Salt Creek Watershed using modified citizen science protocols from the Hoosier Riverwatch (www.hoosierriverwatch.com) program. This Fall, 2020, fewer sites were monitored than usual due to COVID-19 restrictions. The two sites for 2020 were Parker Ditch where it flows under U.S. 2 on the south side of Valparaiso (upstream of most stormwater inputs) and Salt Creek at the Highway 30 bridge (a site that is downstream of many stormwater inflows). The City of Valparaiso also monitors these sites during the same weeks for key water chemistry parameters.

For more information: *Laurie Eberhardt, Valparaiso University – Department of Biology (laurie.eberhardt@valpo.edu).*

Figure 28. *The 2020 group posing by the stream after monitoring sampling sites along the upper reaches of Salt Creek, in the City of Valparaiso (Photo by Laurie Eberhardt).*

Valparaiso University – Department of Chemistry

Quantifying Microplastics in Indiana's Lake Michigan Watershed and Submerged Aquatic Vegetation

Synthetic microfibers are a class of microplastics most prevalent in surface waters. A main source of these pollutants is wastewater treatment plants which discharge into surface waters, including those that flow into Lake Michigan. Microplastics can settle into aquatic sediment or exist for lengths of time in the swash zone of the lakes; they can be ingested by organisms or concentrated in algae or other lake plankton, among other possibilities.

As part of a larger Great Lakes study of the growth and senescence *(gradual deterioration of functional characteristics)* of submerged aquatic vegetation (SAV), the loads of synthetic microfibers in the SAV have been determined from Lake Michigan samples collected during the summer months of 2018, 2019, and 2020; and from various samples collected in the watershed and along the shoreline in Northwest Indiana.

In order to effectively address microplastics pollution, a complete understanding of the distribution and fate of these pollutants is needed; this project is working toward that goal.

Figure 29. *Eddie Kostelnik at Portage, Indiana, Lake Michigan shoreline (Photo by Jon Hendricks, Valparaiso University).*

For more information: *Julie Peller, Valparaiso University – Department of Chemistry, Principal Investigator (julie.peller@valpo.edu). Project Team: Julie Peller, Valparaiso University; Meredith Nevers, Murulee Byappanahalli and Mary Anne Evans, United States Geological Survey (USGS) – Great Lakes Science Center.*

NORTH CENTRAL INDIANA ACTIVITIES

[Also see projects listed as MULTI-REGION AND STATEWIDE]

Lilly Center for Lakes & Streams at Grace College

Water Monitoring and Research in Kosciusko County

The Lilly Center for Lakes & Streams at Grace College has monitored, researched, and helped to protect Kosciusko County's waterways since 2007, and as a result, the county's lakes and streams are some of the most studied in the state of Indiana. The Lilly Center for Lakes and Streams at Grace College's research team, comprised of regular and undergraduate staff, samples 14 of the county's major lakes weekly throughout the summer. They also monitor 12 key streams on a bi- weekly basis year- round. The Lilly Center for Lakes and Streams at Grace College gathers data on a range of chemical, physical, and biological characteristics including water temperature, clarity, dissolved oxygen content, nutrient content, algae populations, and cyanobacterial toxin levels. Water quality reports, special research results, and educational materials are freely available on the Lilly Center for Lakes and Streams at Grace College's website lakes.grace.edu/.

In addition to regular monitoring, the Lilly Center for Lakes and Streams at Grace College also engages in special research projects that focus on two- way interactions between human activity and water quality. For example, in 2012-2013 and in 2019-2020, research team members took baseline condition measurements on the Barbee Chain of Lakes (Big Barbee, Little Barbee, Banning, Irish, Kuhn, Sawmill, and Sechrist Lakes), using the nearby Chapman Lakes (Big Chapman and Little Chapman) as a control system. Between these two periods, a sewer system was installed around the Barbee lakes. Data is currently being analyzed for the potential effects on water quality in a local lake system after the installation of a sewer system. The Lilly Center for Lakes and Streams at Grace College partners with organizations that also focus on water quality in Kosciusko County, including City of Warsaw Stormwater Utility, The Watershed Foundation, Wawasee Area Conservancy Foundation, and Kosciusko County Soil & Water Conservation District (SWCD) in order to strengthen water literacy and water conservation efforts.

For more information visit Lilly Center for Lakes and Streams at Grace College's website at: lakes.grace.edu or email lakes@grace.edu.

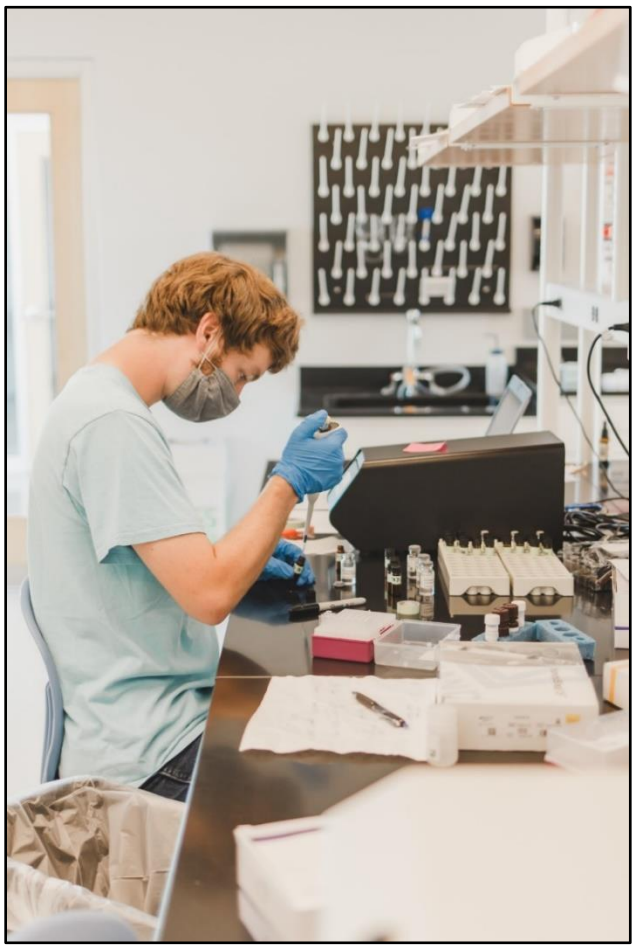

Figure 30. *Grace College student and Lilly Center for Lakes and Streams student staff member Jedidiah Harvey measures lake samples for microcystin concentrations, an important measurement that is reported weekly during the summer months to the public on the Lilly Center for Lakes and Streams at Grace College's website (Photo by Abigail Phinney, Lilly Center for Lakes and Streams at Grace College, communication specialist).*

NORTHEASTERN INDIANA ACTIVITIES

[Also see projects listed as MULTI-REGION AND STATEWIDE]

Biomonitor, Inc.

Tracking E. coli Sources Using Environmental DNA

E. coli bacteria originate in the gut of warm-blooded animals. They are used as an indicator of fecal contamination in surface water samples. Many Indiana streams frequently exceed the state water quality standard for *E. coli*, especially during rainfall events. The semi-annual assessment of our state's water quality by the Indiana Department of Environmental Management (IDEM) always lists *E. coli* contamination as the primary cause of impaired water quality. However, identifying the sources of *E. coli* to reduce their impact has been difficult and frequently too expensive to carry out regularly.

We used an environmental DNA (eDNA) technique to determine sources of *E. coli* in two streams in Steuben County. Both streams flow into Crooked Lake and a public beach lying near the confluence of both streams has frequently been closed to swimming because of E. coli contamination. Samples of water from various locations in both streams were sampled for the presence of eDNA from a variety of warm-blooded animals. One stream has consistently higher eDNA and *E. coli* during rain events. Human eDNA is far more abundant than any other species. In depth monitoring within the stream has located a primary source of this human eDNA so that sources can be eliminated and *E. coli* concentrations reduced. The cost of monitoring is less than $200 per sample.

For more information: Arizona Fox, Biomonitor, Inc. (arizona@biomonitor.com).

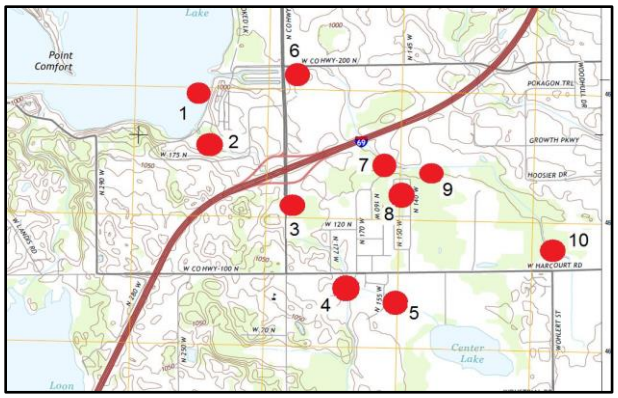

Figure 31. *Map of sites sampled for E. coli by Biomonitor, Inc. in Steuben County.*

Purdue University – Department of Agronomy, Department of Agricultural and Biological Engineering, and Department of Forestry and Natural Resources

St. Mary's River Watershed Initiative

Purdue University is working with producers and conservation groups in the St. Mary's River Watershed to assess the effectiveness of agricultural conservation practices on soil health and ultimately water quality. Researchers are using a paired watershed approach in Nickelsen Creek and Weber Ditch Subwatersheds to monitor stream flow, water chemistry, and biological integrity; characterize soil health parameters as a function of agricultural conservation practices; and identify education goals to target future watershed-wide outreach efforts. In partnership with the United States Geological Survey (USGS), data is being collected during storms and baseflow conditions to measure flow and water chemistry. Twice annual surveys of physical and biological soil properties, and biological assessments of fish and macroinvertebrate communities and in-stream habitat are also being collected. Lastly, social surveys and interviews of producers, conservation practitioners, and Certified Crop Advisors working throughout the watershed are being done to catalog current education levels, document existing education and outreach efforts, and identify areas for future outreach targeting. Together these data aim to help guide management decisions that lead to positive impacts on the St. Mary's Watershed and Western Lake Erie Basin. The project website is: http://stmaryswatershed.com/.

For more information: Dr. Ron Turco, Purdue University – Agronomy Department (rturco@purdue.edu); Dr. Sara Winnike McMillan and Dr. Reuben Gorforth, Purdue University – Department of Agriculture and Biological Engineering (smcmillan@purdue.edu and rgoforth@purdue.edu, respectively); or Dr. Linda Prokopy, Purdue University – Department of Forestry and Natural Resources (lprokopy@purdue.edu).

United States Department of Agriculture (USDA) – Agricultural Research Service (ARS)

United States Department of Agriculture (USDA) – Agricultural Research Service (ARS) National Soil Erosion Research Laboratory (NSERL)

Federal laboratory devoted to research, monitoring, and modeling efforts on conservation of soil and water resources within the United States. Major past efforts by this research group include development of the Universal Soil Loss Equation (USLE), and development of erosion research methods and equipment such as rainfall simulators and laser topographic scanners. Expanded efforts in the past 20 years include water quality monitoring and modeling, particularly in the Western Lake Erie Basin, and numerous water monitoring stations in DeKalb County, Indiana examining nutrient and pesticide losses from surface and subsurface flows, and innovative pollutant control methodologies. Monitoring efforts in the St. Joseph River Watershed in Northeastern Indiana are also part of the national United States Department of Agriculture's Conservation Effects Assessment Project (CEAP). Real-time monitoring information for the sites is available at: http://amarillo.nserl.purdue.edu. Modeling efforts include development and implementation of the Water Erosion Prediction Project (WEPP) model by the United States Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS). NSERL research information and software is available via our main website at: https://www.ars.usda.gov/midwest-area/west-lafayette-in/national-soil-erosion-research/.

For more information: Dennis Flanagan, United States Department of Agriculture – Agricultural Research Service (dennis.flanagan@usda.gov).

Figure 32. *The United States Department of Agriculture (USDA) – Agricultural Research Service (ARS) National Soil Erosion Research Laboratory (NSERL) on the campus of Purdue University in West Lafayette, Indiana.*

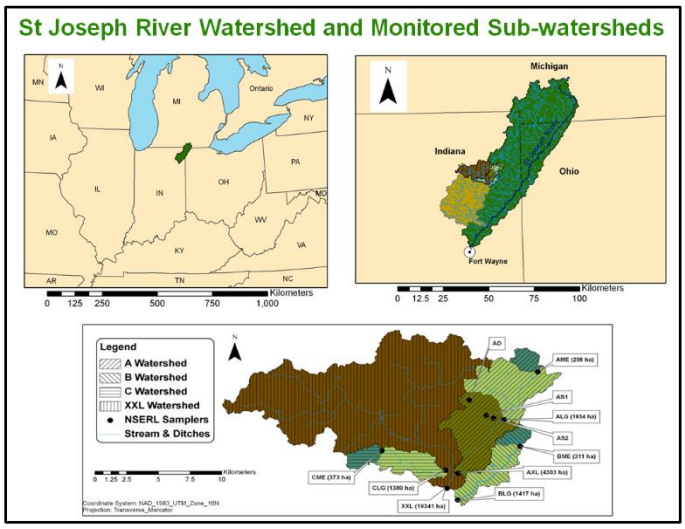

Figure 33. *United States Department of Agriculture (USDA) – Agricultural Research Service (ARS) National Soil Erosion Research Laboratory (NSERL) monitoring sites in Northeastern Indiana, in the Upper Cedar Creek Watershed, a subcatchment of the St. Joseph River Watershed.*

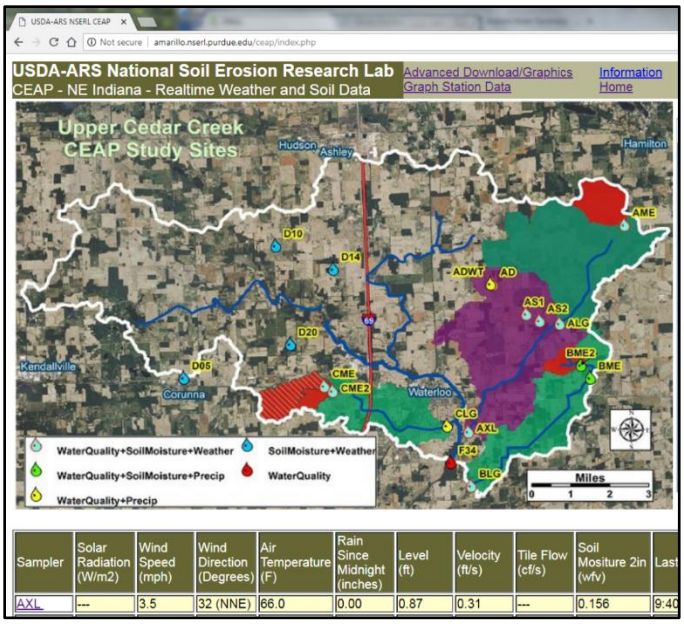

Figure 34. *Screenshot of monitoring data available at: http://amarillo.nserl.purdue.edu.*

United States Geological Survey (USGS) – Ohio-Kentucky-Indiana Water Science Center

Monitoring Water Quality in the St. Mary's Watershed

Sites were installed at the St. Mary's River near Fort Wayne and the Maumee River at New Haven to collect water quality samples and measure stream discharge. Nutrient and sediment sample data will be entered into the USGS National Water Information System (NWIS) database and will be available for review and retrieval through NWISWeb for the St. Mary's River at: https://waterdata.usgs.gov/in/nwis/uv/?site_no=04182000; and for the Maumee River at: https://waterdata.usgs.gov/in/nwis/uv/?site_no=04183000.

The St. Mary's station was chosen to quantify nutrient and sediment loads from major tributaries of the Maumee River as an addition to the existing Western Lake Erie Basin monitoring network. The site is also an Indiana Department of Environmental Management (IDEM) Fixed Network sampling site (https://www.in.gov/idem/cleanwater/2338.htm), which will minimize cost and allow trends analysis using historical data.

Samples will be collected for nutrients and sediment by use of an automatic pumping sampler during five to eight (5-8) events each year, with four to six (4-6) samples collected per event (20-48 samples in all). The pumping sampler will be set up to collect samples during specific events and will be triggered by the rise and fall of the stream. Data from the sampling and streamflow gage will be used to compute daily loads to the watershed.

For more information: Edward Dobrowolski, United States Geological Survey (USGS) – Ohio-Kentucky-Indiana Water Science Center (edobrowo@usgs.gov).

Edge-of-Field Monitoring in Black Creek Watershed, Northeastern Indiana

The United States Geological Survey (USGS), in cooperation with the Great Lakes Restoration Initiative (GLRI), is monitoring water quality of storm runoff from crop fields, subsurface tile drains, and streamflow in the Black Creek Watershed near Harlan, Indiana. Black Creek is a subwatershed of the Maumee River, and is being studied to further understand the complex processes involved with nutrient loading of the Western Lake Erie Basin.

This study will provide GLRI with data from intensive water quality sampling detailing the effects of best management conservation plans on nutrient and suspended sediment loads found in baseflow and storm runoff in the watershed. The water quality data will also be used in a model to evaluate the effectiveness of best management practices in reducing nutrient and sediment loading into the Lake Erie drainage basin. Additional information may be found at the GLRI Edge-of-Field Monitoring website at: http://wim.usgs.gov/geonarrative/glri-eof/.

For more information: Edward Dobrowolski, United States Geological Survey (USGS) – Ohio-Kentucky-Indiana Water Science Center (edobrowo@usgs.gov).

Hydrogeologic Mapping, Data Collection, and Geologic Framework of Glacial Deposits in a Multi-County Area of Northwest Ohio, Northeast Indiana, and South Michigan

In collaboration with the Ohio Environmental Protection Agency, the United States Geological Survey (USGS) is compiling data from driller's log databases to produce a hydrogeologic framework for the aquifer materials in an 11 county area in Northwestern Ohio, Northeastern Indiana, and Southeastern Michigan. The framework, when completed, will provide a three-dimensional (3-D) distribution of aquifers (and their hydrogeologic characteristics) in this region that could become the framework for a regional groundwater flow model. The digital geological framework also can be used to identify locations where additional resource monitoring is needed. An initial gap analysis has identified locations where monitoring wells can be added to provide additional information on the aquifer extent and hydrogeologic characteristics and bolster the monitoring network in the area. Thus far, three monitoring wells have been instrumented to provide near real-time water levels, and four more wells will be instrumented in 2021. Two synoptic surveys of groundwater levels are scheduled to be completed in 2021, targeting 150 to 200 existing wells within the study area. The data collected, methods used to build the hydrogeologic framework, and the datasets themselves will be published in a USGS series publication in 2021. More information on the project, including links to USGS groundwater monitoring wells in the study area, can be found at the following website: https://www.usgs.gov/centers/oki-water/science/hydrogeologic-mapping-data-collection-and-geologic-framework-glacial?qt-science_center_objects=0#qt-science_center_objects.

For more information: Dave Lampe, United States Geological Survey (USGS) – Ohio- Kentucky-Indiana Water Science Center (dclampe@usgs.gov).

WEST CENTRAL INDIANA ACTIVITIES

[Also see projects listed as MULTI-REGION AND STATEWIDE]

Biomonitor, Inc.

Bioassessment of the Wabash River in Tippecanoe County

Bioassessment is a monitoring technique that uses ecological information on aquatic animals to measure water quality. Benthic macroinvertebrates (e.g., insects, molluscs, worms, and crustaceans) are frequently used for bioassessments because they are abundant, easily collected, and very diverse. By collecting, counting, and identifying them in a standardized fashion, the ecological health of the community and a corresponding water quality determination can be made.

We have collected and analyzed benthic macroinvertebrate communities annually from 10 sites on the Wabash River in Tippecanoe County for nearly 30 years. Sampling sites were chosen to determine potential negative effects that could be associated with combined sewer overflows in Lafayette and West Lafayette. The ecological health of the Wabash River in Tippecanoe County is generally good. Sensitive species of caddisflies and mayflies are dominant in most years. Occasionally a combined sewer overflow has been shown to negatively affect the aquatic community for a short distance. Conditions have improved over 30 years as the frequency of combined sewer overflows has been reduced.

For more information: Melody Myers-Kinzie, Biomonitor, Inc. (myerskinzie@att.net).

Figure 35. *Biological sampling of the Wabash River (Photo by Greg Bright).*

Purdue University – Department of Agricultural and Biological Engineering

Integrating Drivers of Nutrient Biogeochemistry in Riverine Floodplains to Inform Restoration Design

Exchange of water between river and floodplain during floods plays an important role in removing nutrients flowing in the river, which in turn, improves the water quality in the river. Quantifying the transportation of nutrients in floodplains is important for managing water quality in river systems and identifying potential sites for river restoration. However, nutrient dynamics in river floodplains is driven by a complex interplay of hydrologic, geomorphic, and biogeochemical processes which are difficult to quantify or measure in the field. Therefore, water quality modelers rely on modeling frameworks for identifying the key controls in nutrient transport in river systems. This study analyzes the efficacy of different hydrodynamic models in quantifying the connectivity between river channel and floodplain for estimation of nutrient load across different sites. Our team is comparing metrics of floodplain connectivity as estimated by three flood models of increasing complexity with field measurements of nitrogen and phosphorus retention and removal across different sites with varying geomorphic characteristics. We have developed three flood models for the Wabash-Tippecanoe River confluence and collected field measurements for four sites representative of floodplains across Indiana: two restored prairie sites, a restored wetland, and an agricultural field. Results from this study can provide guidance regarding the choice of flood model for estimating the hydrologic and hydrodynamic drivers of nutrient transport in floodplains.

For more information: Dr. Sara Winnike McMillan or Dr. Venkatesh Merwade, Purdue University – Department of Agricultural and Biological Engineering (smcmillan@purdue.edu or vmerwade@purdue.edu, respectively).

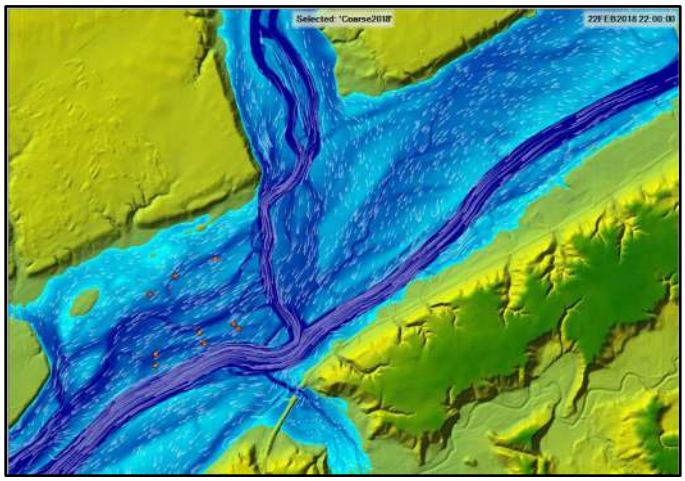

Figure 36. *Maximum inundation (flooding) at the Tippecanoe and Wabash Rivers during a large spring flood.*

Purdue University – Department of Earth, Atmospheric, and Planetary Sciences

Using Geochemical and Isotopic Tracers to Quantify Baseflow Processes in Shades State Park, Waveland, Indiana and Ross Hills Park and Ross Reserve, West Lafayette, Indiana

Baseflow processes were investigated in small catchments draining Shades State Park located near Waveland, Indiana and Ross Hills Park and Ross Reserve located near West Lafayette, Indiana as part of the larger baseflow study of the Wabash River Watershed. Shades State Park offers a unique opportunity to investigate baseflow processes and groundwater flow in geologic units found beneath the glacial sediment, whereas the catchments in Ross Hills Park and Ross Reserve have developed primarily in glacial sediment. The Mansfield Formation sandstone found beneath the glacial

sediment in Shades State Park also outcrops in a few locations in Ross Hills Park. Quantifying baseflow generation processes improves our knowledge on what sustains perennial flow in streams, springs, and seeps found in both study sites. Numerous springs discharge in Shades State Park and these springs likely hold historical significance and ecological significance. Samples of baseflow, streamflow, and spring water were collected in Shades State Park from 2015 to 2016. Sampling is ongoing, although sporadic, in Ross Hills Park and Ross Reserve. At Ross Hills Park and Ross Reserve, water samples were analyzed for general geochemistry, stable isotopes ($\delta^{18}O$ and $\delta^{2}H$), strontium isotopes ($^{87}Sr/^{86}Sr$), chlorofluorocarbons (CFCs), sulfur hexafluoride (SF_6), and radon-222 (^{222}Rn). At Shades State Park, all of the tracers shown above were sampled plus tritium (^{3}H), chlorine-36 ($^{36}Cl/Cl$), and iodine-129 (^{129}I) were also analyzed. The initial publication resulting from this dataset can be found at: https://onlinelibrary.wiley.com/doi/10.1002/hyp.11345. Dr. Frisbee and Dr. Caffee are currently finishing up the tritium, chlorine-36, and iodine-129 analyses for Shades State Park. These data provide insight into groundwater flow in geologic units located beneath the glacial sediment (namely the Mansfield Formation and Borden Group), how this water supports flow from springs and baseflow in streams in Shades State Park, and provides valuable data on residence times of water in these small catchments. This data will become available in a future journal article.

For more information: Marty Frisbee, Purdue University – Department of Earth, Atmospheric, and Planetary Sciences (mdfrisbee@purdue.edu).

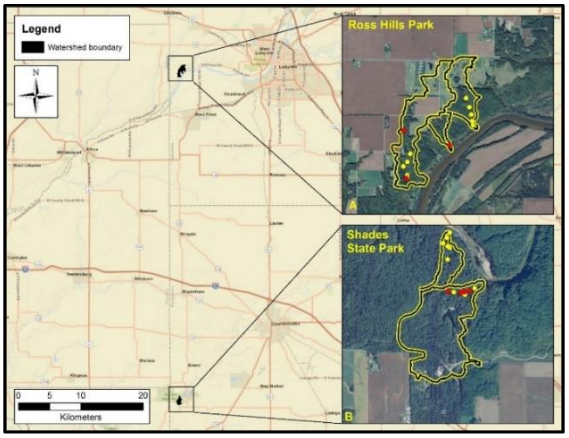

Figure 37. *Map of sites sampled for baseflow tracers at Ross Hills Park and Shades State Park.*

Wabash River Enhancement Corporation (WREC)

Tippecanoe County – Wabash Sampling Blitz

The Wabash Sampling Blitz (http://www.wabashriver.net/wabash-sampling-blitz) is a biannual event in which volunteer citizen scientists collect in-stream data to learn about water quality. This event takes place in the Region of the Great Bend of the Wabash River Watershed and the Wildcat Creek Watershed. Volunteers measure temperature, transparency, nutrient levels, and collect samples to be analyzed in a laboratory at almost 200 stream and river sites each spring and fall.

Figure 38. Citizen scientists in action collecting water samples (Photo taken in 2017).

This region-wide monitoring effort educates the general public on water quality issues in their communities through hands-on, boots-muddy experiences. Participants see first-hand the different physical properties in a wooded stream versus an agricultural ditch versus an urban area. Data can be used to identify issues and problem areas in the watershed. Collected data is mapped using GIS and made available to the public on Wabash River Enhancement Corporation's website for broad watershed wide education: www.wabashriver.net.

For more information: *Amy Krzton-Presson, Wabash River Enhancement Corporation (akrztonpresson@tippecanoe.in.gov).*

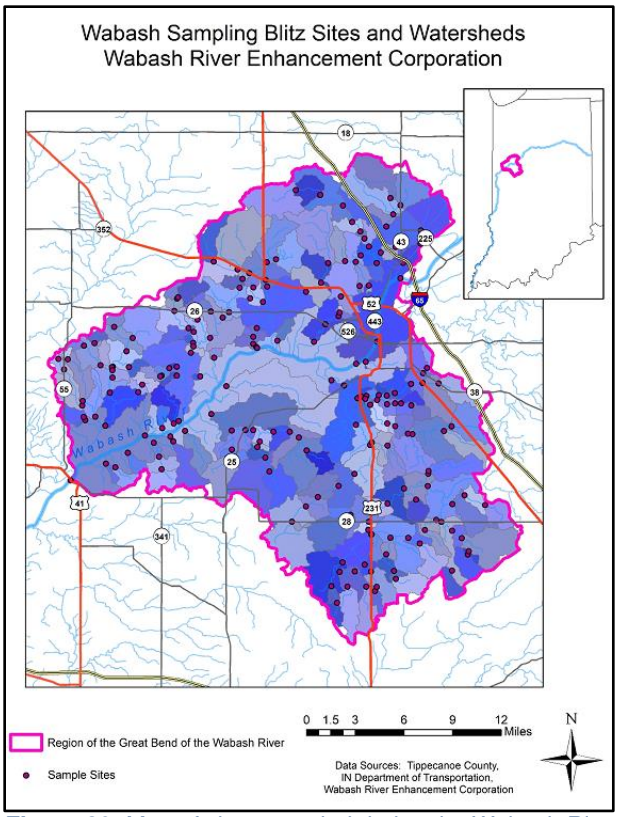

Figure 39. *Map of sites sampled during the Wabash River Sampling Blitz.*

Figure 40. *Citizen scientists using test strips to measure nutrient levels in their water samples (Photo taken in 2017).*

CENTRAL INDIANA ACTIVITIES

[Also see projects listed as MULTI-REGION AND STATEWIDE]

Center for Earth and Environmental Science (CEES) at Indiana University-Purdue University (IUPUI)

Appropriate Scales for Monitoring to Assess Water Quality and Stream Health

The Center for Earth and Environmental Science (CEES) at Indiana University- Purdue University (IUPUI) continues to refine the scale of its monitoring efforts. Starting with early studies in the Upper White River Watershed, and continuing into the Eagle Creek Watershed, the Center has focused its efforts on trying to find the appropriate scale for monitoring the effects of land use, climate change, and conservation practices on water quality and stream health. Since 2006 the focus of most of the Center's monitoring efforts have been in the School Branch Watershed, a subwatershed of the Eagle Creek Watershed, which is now the focus of a National Water Quality Initiative (NWQI) Watershed Project. As part of the larger NWQI effort, CEES, is coordinating an Edge- of- Field (EOF) sampling project in collaboration with the farmer Mike Starkey, researchers from the Department of Earth Sciences at IUPUI, the Indiana Geological and Water Survey (IGWS), the United States Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS), and the United States Geologic Survey (USGS). The EOF monitoring, that began in early 2015, will continuously evaluate surface and sub- surface (e.g., tile drainage) water quality from paired drainage areas by switching the rate, form, placement, and timing of phosphorus fertilizer application in combination with no- till, cover crops, and intense nitrogen management practices. This work builds upon earlier monitoring of 11 stream sites in the larger Eagle Creek Watershed that were sampled by CEES from 2007 through 2012, as part of an Indiana Department of Environmental Management (IDEM) 319 Grant, and a bioswale monitoring project that is co-located with one side of the EOF project. In 2020,

the Center in partnership with the USDA – NRCS and USGS, began installing an additional EOF site designed to sample surface and sub- surface water quality from a conventionally managed field near the current EOF project. The new EOF location will allow real- time comparison of both soil health and conventional tillage practices with water quality, stream health, and crop production. Project updates and details can be found at: http://cees.iupui.edu/research/EOF.

For more information: Pierre- Andre Jacinthe, Indiana University-Purdue University (IUPUI), Department of Earth Sciences; Center for Earth and Environmental Science (CEES) at IUPUI, Director (pjacinth@iupui.edu).

Figure 41. *Installation of the west side equipment, February 2015.*

Hamilton County Health Department

Water Quality Program

The Hamilton County Health Department (HCHD) recreational surface water monitoring program began in 2004. Since that time, it has grown to over 20 sites which are sampled monthly from April to October, during the recreational season. Surface water is collected from various rivers, lakes, and reservoirs where people recreate. These samples are tested for *E. coli*, monitored for temperature, and monitored for dissolved oxygen. HCHD also utilizes the Hoosier Riverwatch principles (www.hoosierriverwatch.com) to perform a variety of chemical and physical tests and to identify macroinvertebrates at two separate locations. The goal of the program is to monitor the overall health of these recreational waterways by utilizing a variety of water quality monitoring standards. HCHD has placed signage at each sample location to promote public awareness and direct individuals to the website for sampling results and educational materials.

The regulatory program includes permitting and sampling of private water wells and permitting and inspections of public and semi-public swimming pools.

For more information visit the website at: https://www.hamiltoncounty.in.gov/334/Recreation-Water-Sampling-Program or email health@hamiltoncounty.in.gov.

Figure 42. *Summer interns for Hamilton County Health Department identifying macroinvertebrates while social distancing at Little Cicero Creek, Bishops Park, Cicero, Indiana (Photo by Morgan Bennett).*

Figure 43. *Hamilton County Health Department signage at DePotters Bridge Park, Noblesville, Indiana (Photo by Morgan Bennett).*

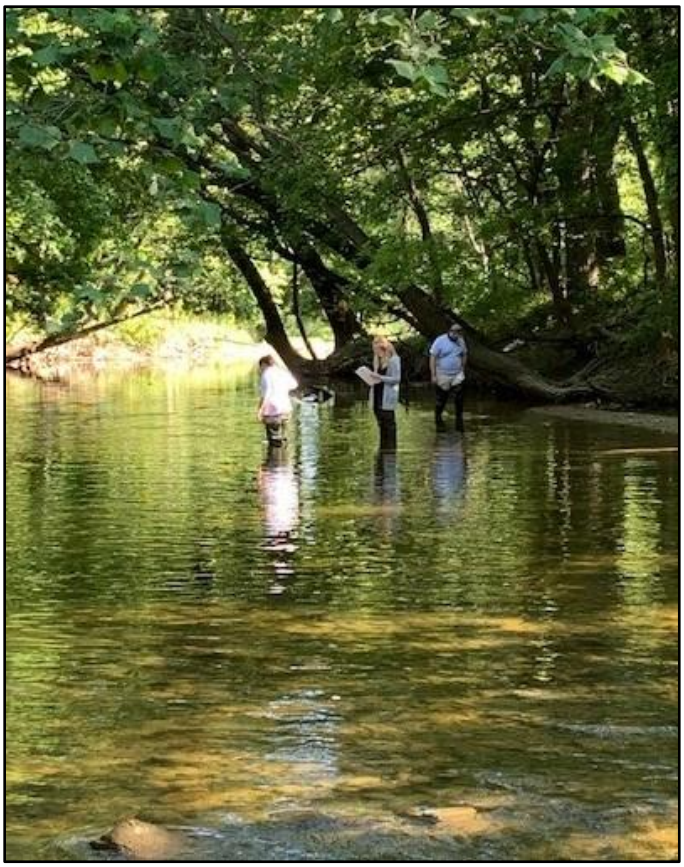

Figure 44. *Summer interns for Hamilton County Health Department surveying Cicero Creek downstream from Morse Reservoir Spillway, Noblesville, Indiana (Photo by Morgan Bennett).*

Indiana University-Purdue University Indianapolis (IUPUI) – Department of Earth Sciences

The Impacts of Vegetation Restoration on Urban Stream Health

Stream degradation due to urbanization is an increasing issue across the world to both the ecological systems that depend on streams and the human populations that live along the streams. The impacts of urbanization on local water quality have been studied in different regions. However, there are fewer studies evaluating the impacts of vegetation restoration on stream health in an urban setting. To evaluate the effects of urbanization on stream health and the impacts of vegetation restoration on stream health, Indiana University-Purdue University Indianapolis (IUPUI) Principles of Hydrology (GEOL-G430) class students work with Reconnecting to Our Waterways (ROW) conducted stream monitoring at one restoration site and one control site along the Pogue's Run in Marion County, Indiana in 2018, 2019, and 2020. The restoration site is in Spade park (39.786079°, -86.128318°) and it went through vegetation restoration starting in 2016. The control site is near Harshman Middle School (39.780767°, -86.133356°) with no restoration activities performed.

We quantified soil quality, vegetation characteristics, and water quality using a variety of methods. The soil measurements included infiltration, hydraulic conductivity *(the ease with which a fluid (usually water) can move through pore spaces or fractures)* using a MiniDisk infiltrometer, bulk density, porosity, gravimetric water content, and heavy metal measurements (using handheld XRF). The vegetation characteristics were assessed following reach level assessment from the Center for Watershed Protection's Unified Stream Assessment manual. The water quality parameters include water temperature, dissolve oxygen, pH, phosphate, nitrate, nitrite, and turbidity and were collected following Hoosier Riverwatch (www.hoosierriverwatch.com) methodology.

Both locations seemed to have an overall poor physical quality and some chemical parameters are similar between the two sites. However, we also show measurable improvements in terms of site habitat, soil hydraulic conductivity, and trace metal pollution between the restored section of Pogue's Run and the control site. More frequent and longer-term monitoring is needed to fully understand the impacts of restoration on urban stream health.

For more information: *Lixin Wang, Center for Earth and Environmental Science (CEES) at Indiana University-Purdue University (IUPUI) – Department of Earth Sciences (lxwang@iupui.edu); or Kelly Brown, Reconnecting to Our Waterways (ROW) (kelly@ourwaterways.org).*

Figure 45. *The student led stream assessment in October 2019 and November 2020.*

Marion County Public Health Department (MCPHD)

Marion County Public Health Department (MCPHD) Monitoring

The Marion County Public Health Department (MCPHD) monitors the water quality of rivers and streams throughout the Indianapolis area. Surface water is sampled and tested for a variety of bacteria, physical, and chemical parameters. Macroinvertebrate sampling is also conducted at several sites, which helps determine the overall stream health. Most sampling sites are located near areas frequented for recreation, public water intakes, or combined sewer overflows that can discharge raw sewage into the streams. Sampling data for some sites date back to 1995; current and historic sampling data can be found on the MCPHD website: http://marionhealth.org/surface-water-program/. Permanent signs posted near some of the sampling sites promote the water quality data available on the website and provide a mechanism to educate the public about surface and groundwater quality (**Figure 46**).

MCPHD also routinely samples and tests well-water from private residences so that threats to public health are identified, understood, and mitigated. Groundwater is tested for bacterial and chemical contamination by MCPHD's Public Health Laboratory. Samples are taken as part of the well permit process, neighborhood groundwater assessments, and individual requests from residents. Residents are offered free water testing and then educated about their drinking water quality, water treatment options, general well maintenance, and the importance of regular testing. Details about the work MCPHD does is available at: http://marionhealth.org/programs/environmental-health/water-quality-and-hazardous-materials-management/.

For more information: Gretchen Quirk, Marion County Public Health Department (MCPHD) (gquirk@marionhealth.org).

Figure 46. *New informational sign posted near sampling site (Photo by Adam Rickert, MCPHD).*

United States Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS)

School Branch Watershed Monitoring Partnership Project

School Branch is a 5,376-acre subwatershed of the Eagle Creek Watershed, a primary source of drinking water for Indianapolis. Land use in the watershed is predominately agricultural with interspersed residential and populated areas and is on the Indiana Department of Environmental Management (IDEM) 303d List as Impaired Waters due to high levels of nutrients and sediment.

Through a special collaborative effort of federal, state, local, and academic entities along with dedicated conservation minded farmers, the School Branch project is a unique monitoring opportunity to assess the chemical, physical, and biological

impacts of conservation practices at the watershed, subwatershed, and edge-of-field scales.

Stream water and edge-of-field surface runoff and subsurface flows are automatically and continuously monitored for nitrogen, phosphorus, and suspended sediment year-round; groundwater is monitored for nitrogen and phosphorus; streamflow and groundwater levels are being measured; and the water balance is monitored at several locations.

Supplementary biological indicators are used to evaluate factors affecting water quality. Nutrient source tracking from field; in-stream, bed, and bank; residential sources; and sediment characteristics analyses are conducted. Soil moisture, water holding capacity, and nutrient content parameters are also measured.

The data collected in this watershed allows the evaluation of how production agriculture can complement sustainable water resources. Water quality associated with complete soil health management systems (e.g., cover crops, no-till, adaptive nutrient management, and buffers) at the edge-of-field, is compared with two United States Geological Survey (USGS) Super Gages evaluating continuous in-stream water quality parameters from differing landscape-level agricultural management systems. The baseline sampling period is complete, and the project is in the treatment phase. Results show that agricultural productivity can be maintained while improving the water quality of surface and tile water from cropland by implementing soil health management systems.

The project combines the partnership efforts between farmers, Soil & Water Conservation Districts (SWCDs), Center for Earth and Environmental Science (CEES) at Indiana University-Purdue University Indianapolis (IUPUI), Marion County Public Health Department (MCPHD), Indiana Department of Environmental Management (IDEM), Indiana Geological and Water Survey (IGWS), United States Geological Survey (USGS), United States Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS), Indiana Soybean Alliance/Indiana Corn Marketing Council, and others. Project updates and details can be found at: http://cees.iupui.edu/research/EOF.

For more information: Tony Bailey, United States Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS) (tony.bailey@usda.gov).

Figure 47. *Weir and autosampler monitoring water leaving agricultural field in the School Branch Watershed.*

Figure 48. *Edge-of-field monitoring station in the School Branch Watershed.*

United States Geological Survey (USGS) – Ohio-Kentucky-Indiana Water Science Center

Hydrology, Water Quality, and Ecology of the School Branch Watershed

School Branch in Hendricks County, Indiana, is a small stream with a variety of agricultural and suburban land uses nested in the Eagle Creek Watershed west of Indianapolis, Indiana. The School Branch Watershed has become the focus of a collaborative partnership of federal, state, and local agencies; a university research center; and agricultural producers to understand the effects of land use and management practices on water quality and water quantity in the watershed. The United States Geological Survey (USGS) in collaboration with the Indiana Department of Environmental Management (IDEM) and the United States Department of Agriculture (USDA) – Natural Resources Conservation Service (NRCS) are working on a variety of projects to help better understand how land use practices in the watershed

influence hydrology, water quality, and ecology of the stream. The United States Geological Survey (USGS) operates two streamflow gaging stations (super gages) along School Branch where continuous measurements of dissolved oxygen, pH, temperature, specific conductance, turbidity, nitrate, and orthophosphate are recorded year-round. Additional investigations have included using passive samplers to identify wastewater indicators; ecological sampling; sampling for nutrients, sediment, major ions, and stable isotopes; and using nested groundwater monitoring stations at CR750N to determine if any hydrologic connections exist between the groundwater and surface water. A synoptic study of the subsurface tile drains has also been done to help better understand the variability and contribution of nutrients and *E. coli* from tile drains. Project information is available at: https://www.usgs.gov/centers/oki-water/science/conservation-farming-relating-water-quality-and-quantity?qt-science_center_objects=0#qt-science_center_objects.

For more information: Aubrey Bunch, *United States Geological Survey (USGS)* – Ohio-Kentucky-Indiana (aurbunch@usgs.gov).

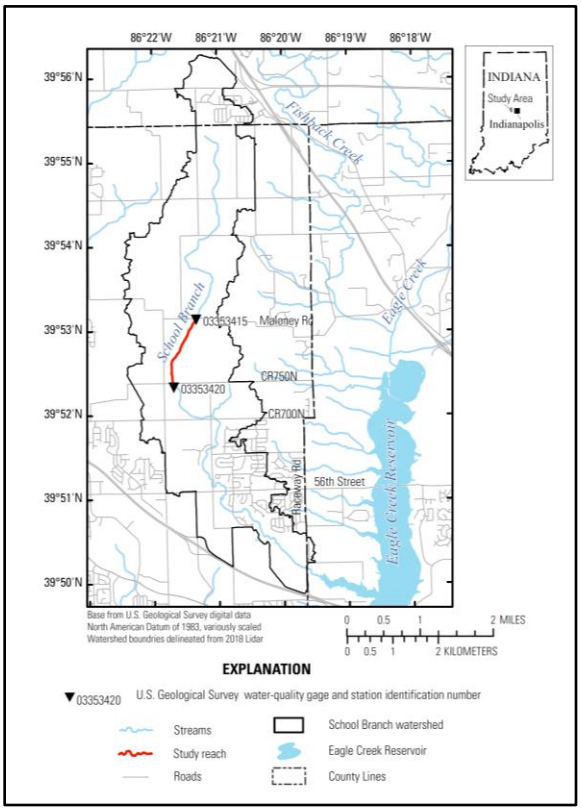

Figure 49. *Map showing the study reach of the School Branch Watershed.*

Figure 50 (Left). *Dawn McCausland, United States Geological Survey (USGS), collects a water sample from School Branch.*

Figure 51 (Right). *Dawn McCausland, United States Geological Survey (USGS), collects water sample from agricultural drainage tile in the School Branch Watershed.*

White River Alliance (WRA)

The White River Alliance's River Assessment Field Teams (RAFT) Program

The White River Alliance (WRA) recently developed an advanced citizen science program, River Assessment Field Teams (RAFT), to strategically assess water quality in the Upper White River Watershed. This volunteer monitoring program collects high quality data to help fill agency data gaps, tease out pollution hot spots, and measure trends over time. RAFT also helps inform and direct the WRA educational and cost-share resources and other regional projects and programs. RAFT's 44 sampling sites are strategically located on tributaries of the White River in Marion and Hamilton Counties, not currently monitored by agency partners. Using procedures approved by Indiana Department of Environmental Management (IDEM) and aligned with External Data Framework protocols, RAFT measures conductivity, dissolved oxygen (DO), nitrate, nitrite, orthophosphate, pH, temperature, transparency, flow, land use, riparian vegetation, stream shape, substrate, and *E. coli*. Sampling occurs at least monthly, but the number of sites sampled each month varies based on volunteer engagement levels. RAFT aims to sample each of the 44 sites at least four times a year. The project website is: https://thewhiteriveralliance.org/programs/river-assessment-field-team-raft/.

For more information: *Kelly Brown, White River Alliance (WRA) (kelly@thewhiteriveralliance.org).*

Figure 52 (Left). *East Fork Sly Run, Hamilton County. Volunteer using a handheld meter (Photo by Kelly Brown).*

Figure 53 (Right). *Vestal Ditch, Hamilton County. Volunteers taking grab sample (Photo by 12 Star Media).*

Figure 54 (Left). *Vestal Ditch, Hamilton County. Volunteers wading in stream (Photo by Jill Hoffman).*

Figure 55 (Right). *Kirkendall Creek, Hamilton County. Volunteers measuring flow (Photo by 12 Star Media).*

EAST CENTRAL INDIANA ACTIVITIES

[Also see projects listed as MULTI-REGION AND STATEWIDE]

SOUTHWESTERN INDIANA ACTIVITIES

[Also see projects listed as MULTI-REGION AND STATEWIDE]

Indiana Department of Natural Resources (IDNR) – Division of Reclamation

Monitoring of Streams Impacted by Past Coal Mining Activities in Southwestern Indiana

The Indiana Department of Natural Resources (IDNR) – Division of Reclamation conducts a quarterly water sampling program to monitor water quality impacts from coal mining activities that took place prior to the establishment of the Surface Mining Control and Reclamation Act (P.L. 95-87) in 1977. The sampling program monitors mine-impacted streams to quantify environmental impacts and provide supporting data to assist in the design of remediation projects. Additionally, the quarterly sampling program monitors the health and effectiveness of 26 passive treatment systems built by the Division in order to assess overall performance and maintenance needs. The IDNR – Division of Reclamation web site provides additional information: http://www.in.gov/dnr/reclamation/.

For more information: Peter Burch, Indiana Department of Natural Resources (IDNR) – Division of Reclamation (pburch@dnr.in.gov).

University of Southern Indiana (USI) – Department of Geology and Physics

The Groundwater Monitoring Lab at the University of Southern Indiana (USI)

The University of Southern Indiana (USI) Groundwater Monitoring Lab was established in 2002 for teaching and long-term research and monitoring activities with undergraduate student collaborators in the Department of Geology and Physics. Continuous high-resolution monitoring targets the Inglefield Sandstone Aquifer in Southwestern Indiana, a locally important source of domestic groundwater. The Groundwater Monitoring Lab consists of a deep-shallow piezometer nest, measuring groundwater at 60-foot and 110-foot depths. Research and monitoring efforts focus on physical characterization of the aquifer, a decadal stable isotope study, observations of barometric influence on groundwater levels, and

the influence of Earth tides on groundwater potential. Selected geochemical parameters have been quantified intermittently. Hourly groundwater levels are collected from both wells and augmented with manual measurements. The lab is used regularly for education and outreach to the university and larger community to educate and inform about groundwater (**Figure 56**). An analysis of the barometric and Earth-tide induced water level fluctuations is available at: https://journals.iupui.edu/index.php/ias/article/download/8560/8551.

These wells are part of the United States Geological Survey (USGS) National Groundwater Monitoring Network (NGWMN). Summary water levels and well construction data can be accessed at: https://cida.usgs.gov/ngwmn/provider/USGS/site/375750087404201/ and https://cida.usgs.gov/ngwmn/provider/USGS/site/375750087404202/.

For more information: Paul Doss, University of Southern Indiana (USI), Department of Geology and Physics (pdoss@usi.edu).

Figure 56. *A visit to the Groundwater Monitoring Lab in the Department of Geology and Physics at the University of Southern Indiana (USI) by the local NBC news affiliate to discuss issues of water quality and water resources in Southwestern Indiana.*

SOUTH CENTRAL INDIANA ACTIVITIES

[Also see projects listed as MULTI-REGION AND STATEWIDE]

SOUTHEASTERN INDIANA ACTIVITIES

[Also see projects listed as MULTI-REGION AND STATEWIDE]

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