Indiana Water Summary 2018

Annual Report

Prepared by
The Indiana Water Monitoring Council

Acknowledgments

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

Figures on the cover (Clockwise from top). *Flat Rock River near St. Paul, Indiana (Photo by Jeff Sallas, USGS); Eagle Creek Reservoir Dam (Photo by Jeff Sallas, USGS); Wabash River near Riverton, Indiana (Photo by Jeff Sallas, USGS); Weather station near School Branch, Hendricks County (Photo by Sally Letsinger, IGWS)*

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Indiana Water Summary 2018 Annual Report

INTRODUCTION

The purpose of the Indiana Water Summary is to describe water related monitoring and research in the State of Indiana. The Indiana Water Report is compiled by the Indiana Water Monitoring Council. A brief description of the Indiana Water Monitoring Council is followed by two introductory articles and summaries of individual projects across the State. The two introductory articles describe larger collaborations within the State of Indiana and exemplify recognition by the scientific community that better products are realized by working together. The individual project descriptions are organized alphabetically by organizational affiliation. Key information and a project contact for each project are summarized in Table 1.

This is the second annual Indiana Water Summary. Forty-eight (48) individuals contributed 74 project summaries to the 2018 report. Some of the summaries are updated contributions from 2017 but others are new projects. The 2018 report includes eight summaries from organizations that did not participate in the 2017 report. Locations of the individual projects are shown in Figure 1.

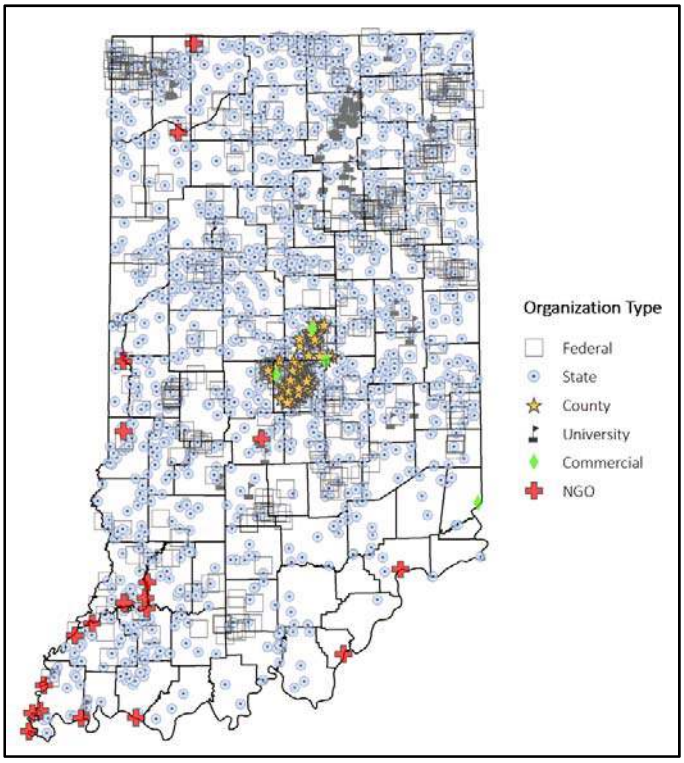

Figure 1. *Locations of water monitoring and projects in the State of Indiana during 2018 and the responsible organization type.*

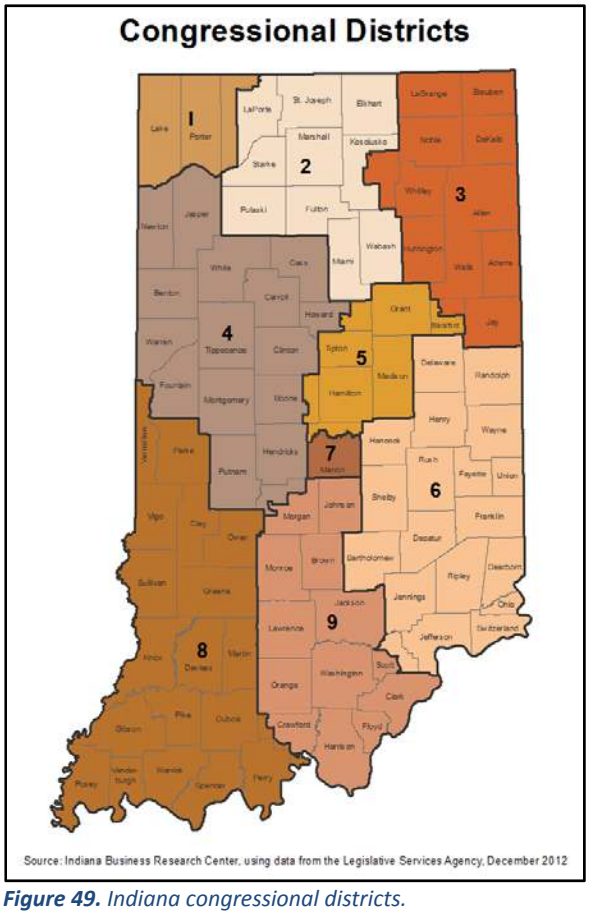

Figure 49. *Indiana congressional districts.*

Table 1. *Summary of water projects described in this report.*

Summary of Water Projects Described in this Report									
Organization	***Contact***	***Email***	***Project Title***	***Project Period***	***Focus*** Q = Water Quality A = Water Availability H = Water Hazard	***Domain*** G = Groundwater S = Streams P = Precipitation O = Other	***Project Scope*** L = Local R = Regional or Multi-County S = Statewide N = Nationwide	***Congressional District*** 1–9, All	***Page of Project Summary in this Report***
Ball State University – Department of Natural Resources	Bangshuai Han	bhan@bsu.edu	Water Quality of Prairie Creek Reservoir	2018 – Present	Q	O	L	6	9
Center for Earth and Environmental Science at Indiana University – Purdue University (IUPUI)	Pierre-Andre Jacinthe	pjacinth@iupui.edu	Starkey Farms Edge of Field Sampling Project	2006 – Present	Q	S	L	4	9
Ecosystems Connections Institute, LLC in collaboration with Manchester University	Jerry Sweeten Herb Manifold	jesweeten@ecosystemsconnections.com jesweeten@manchester.edu hfmanifold@manchester.edu	Stream Response to Holistic Restoration Strategies Through Innovative Conservation Partnerships	2009 – Undetermined	Q, H	S, O	R	2	6
Grace College – Lilly Center for Lakes and Streams	Adrienne Funderburg	lakes@grace.edu	Water monitoring and research in Koskiosko County	2007 – Present	Q	S, O	R	2, 3	10
Hamilton County Soil and Water Conservation District	Ginger Davis	ginger.davis@hamiltoncounty.in.gov	Private Well Water Monitoring and Maintenance Initiative	2017 – Present	Q, H	G	L	5	11
Hamilton County Health Department	Morgan Bennett	morgan.bennett@hamiltoncounty.in.gov	Hamilton County Health Department Water Quality Program	2004 – Present	Q	S, O	L	5	11
Hoosier Environmental Council	Indra Frank	ifrank@hecweb.org	The Impact of Coal Ash on Indiana Groundwater	2016 – Present	Q	G, O	S	All	13
Indiana Department of Environmental Management	Jim Sullivan	jsulliva@idem.in.gov	Statewide Ground Water Monitoring Network	2008 – Present	Q	G	S	All	13
	Marylou Renshaw	mrenshaw@dem.in.gov	Fixed Station Monitoring		Q	S	S	All	13
	Marylou Renshaw	mrenshaw@dem.in.gov	Probabilistic Monitoring		Q	S	R	1, 2, 3	14
	Marylou Renshaw	mrenshaw@dem.in.gov	Reference Site Monitoring		Q	S, O	R	6, 8, 9	15
	Marylou Renshaw	mrenshaw@dem.in.gov	Contaminants Monitoring Program		Q	S, O	L, R	All	15
	Marylou Renshaw	mrenshaw@dem.in.gov	Blue-Green Algae Beach Sampling		Q	O	S	All	15
	Marylou Renshaw	mrenshaw@dem.in.gov	Performance Measures Monitoring		Q	S	S	3	16
	Marylou Renshaw	mrenshaw@dem.in.gov	Thermal Verification Projects		Q	S	S	8	17
	Marylou Renshaw	mrenshaw@dem.in.gov	Watershed Characerization Monitoring Projects		Q	S, O	R	8	17
	Marylou Renshaw	mrenshaw@dem.in.gov	Hoosier Riverwatch Volunteer Stream Monitoring		Q	S, O	S	All	17
Indiana Department of Natural Resources – Division of Reclamation	Peter Burch	pburch@dnr.in.gov	Monitoring of Streams Impacted by Past Coal Mining Activities in Southwestern Indiana	1994 – Present	Q	S	R	8	19
Indiana Department of Natural Resources – Division of Water	Mark Basch or Bill Davis	mbasch@dnr.in.gov wdavis@dnr.in.gov	Indiana's Water Shortage Plan	Continuous	A	G, S, P	S	All	19
	Bill Davis	wdavis@dnr.in.gov	Indiana Water Resource Updates	Continuous	A	G, S, P, O	S	All	19
	Mark Basch	mbasch@dnr.in.gov	Great Lakes-St. Lawrence River Basin Resources Compact	Continuous	Q, A	H, G, S, O	R	1, 2, 3	19
	Bill Davis	wdavis@dnr.in.gov	Voluntary Monitoring Program	Continuous	A	G	S, N	All	20
	Bill Davis	wdavis@dnr.in.gov	Potentiometric Surface Mapping	Continuous	A	G	S	All	20
	Mark Basch	mbasch@dnr.in.gov	Emergency Regulation of Groundwater Rights and of Surface Water Rights	Continuous	Q, A	G, S, O	S	All	21
	Mark Basch	mbasch@dnr.in.gov	Water Use Reporting	Continuous	A	G, S, O	S	All	21
	Mark Basch	mbasch@dnr.in.gov	Significant Water Withdrawal Registration	Continuous	A	G, S, O	S	All	21
	Mark Basch	mbasch@dnr.in.gov	Water Well Driller and Pump Installer Licensing, Continuing Education, Water Well Record Submittal, Well and Pump Installation Standards	Continuous	A	G	S	All	21
Indiana Geographic Information Council	Mike Martin	mmartin@dnr.in.gov	The IGIC Waters Workgroup	2007 – Present	A, H	S, O	S	All	22

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					Q = Water Quality A = Water Availability H = Water Hazard	**G = Groundwater S = Streams P = Precipitation O = Other**	**L = Local R = Regional or Multi-County S = Statewide N = Nationwide**	**1–9, All**	
Indiana Geological and Water Survey	Shawn Naylor	snaylor@indiana.edu	Bedrock topography (BRT) of Indiana and the Continentally Glaciated U.S.	2010 – Present	A	O	S	All	23
	Shawn Naylor	snaylor@indiana.edu	The National Groundwater Monitoring Network: Contributions from IGWS	2017 – Present	A	G	S	All	23
	Bob Autio	rjautio@indiana.edu	Unconsolidated Sediment Database Description Tool	2018 – Present	A	O	S	All	23
	Bob Autio	rjautio@indiana.edu	Long-term monitoring of an urban/forest interface	2004 – Present	A	S, G	L	9	23
	Tracy Branam	tbranam@indiana.edu	Groundwater geochemistry of Indiana aquifers	1986 – Present	Q	G	S	All	24
	Kevin Ellett	kmellett@indiana.edu	Integrating Hydrogeological Studies with U.S. Geological Survey-Funded Mapping Projects	2018 – Present	A	G	S	All	24
	Lee Florea	lflorea@indiana.edu	Indiana Karst Observatory	2018 – Present	A, Q	G	R	8, 9	24
	Lee Florea	lflorea@indiana.edu	Indiana Dye Trace Database	2018 – Present	A, Q	G	R	All	24
	Lee Florea	lflorea@indiana.edu	Delineating the Harrison-Crawford Karst Aquifer	2018 – Present	A, H	G	R	9	25
	Adam Kuban	ajkuban@bsu.edu	Water Quality Indiana	2018 – Present	A, Q	S	L	R	25
	Shawn Naylor	snaylor@indiana.edu	The Indiana Water Balance Network	2011 – Present	A	G, P, O	S	All	25
	Shawn Naylor	snaylor@indiana.edu	Evaluating Tillage Practices on Near-Surface Groundwater Recharge: School Branch Watershed, Hendricks County, Indiana	2016 – Present	A	G	L	4	26
Indiana State Department of Agriculture	Julie Harrold	jharrold@isda.in.gov	Highlighting Indiana's Commitment to Enhance Water Quality through the use of GIS Story Maps of the Major River and Lake Basins in Indiana	2017 – Present	Q	S, O	S	All	26
Indiana State Department of Health	Mike Sutton	Msutton@isdh.in.gov	Monitoring of Environmental Public Health Division	2015 – Present	Q, H	G, S	S	All	27
Indiana University – Department of Geography	Sally Letsinger	sletsing@indiana.edu	Spatial analysis of significant water withdrawal facilities in Indiana	2015 – 2018	A	S, G	S	All	27
	Sally Letsinger	sletsing@indiana.edu	Geological investigations to understand the distribution of arsenic in groundwater	2015 – Present	Q	G	S	All	27
	Sally Letsinger	sletsing@indiana.edu	Indiana School Lead Sampling Program	2017 – Present	Q	S, G	S	All	5, 28
	Sally Letsinger	sletsing@indiana.edu	An Assessment of the Persistence of Chloride from Source Water to Tap and its Implications for Potential Corrosion of Metal Pipes: A Pilot Study	2017 – 2018	Q	S, G	S	All	28
Indiana University Northwest	Erin Argyilan	eargyilan@iun.edu	Great Lakes Innovative Stewardship Through Education Network (GLISTEN)		Q	S	R	1	28
Marion County Public Health Department	Gretchen Quirk	gquirk@marionhealth.org	Marion County Public Health Department Monitoring	1995 – Undetermined	Q	G, S	L	7	29
Mundell & Associates, Inc.	Paul Seymour	paul.sgc44@gmail.com	Groundwater Monitoring for Lawrenceburg Conservancy District	2018 – Present	A	G	L	6	29
National Oceanic and Atmospheric Administration / National Integrated Drought Information System	Molly Woloszyn	molly.woloszyn@noaa.gov	Midwest Drought Early Warning	2018 – Present	A	G, S, P, O	S	All	29
The Nature Conservancy	Brad Smith	bsmith@tnc.org	Promotion of NRCS Easements Through a WREP Agreement Focused on the Lower White and Lower Wabash River Floodplain	2017 – 2022	Q	G, S	R	8	30
Purdue University – Department of Agricultural and Biological Engineering	Margaret Gitau	mgitau@purdue.edu	Land Use, Land Management, and Climate Trends and Impacts on Hydrology and Water Quality		Q	G, S	L	All	30
	Keith Cherkhauer	cherkaue@purdue.edu	Statewide Hydrologic Modeling Efforts		A	S, O	S	All	31

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Purdue University – Department of Agronomy	Sanoar Rahman	rahman17@purdue.edu	Naturalized Streamflow for the Wabash River	2014 – Present	A, H	S	R	2, 3, 4, 5	31
	Laura Bowling	bowling@purdue.edu	Evaluation of Best Management Practices (BMPs) for Water Quality in Elliot Ditch, Indiana		Q	S	L	4	31
University of Notre Dame – Department of Biological Sciences	Jennifer Tank	jtank@nd.edu	Preventing Nutrient Loss From Indiana Farms With Watershed-Scale Pairing of Cover Crops and the Two Stage Ditch	2015 – 2019	Q	G, S	R	4, 2	32
University Of Southern Indiana – Department of Geology	Paul K. Doss	pdoss@usi.edu	Groundwater Monitoring Lab at USI	2002 – Present	Q, A	G, P	L, R	8	32
U.S. Army Corps of Engineers	Jade L. Young	Jade.L.Young@usace.army.mil	U.S. Army Corps of Engineers 2017 Water Quality Sampling	2017	Q	S, O	S	2-9	33
U.S. Department of Agriculture – Agricultural Research Service	Dennis Flanagan	Dennis.Flanagan@ars.usda.gov	USDA-ARS National Soil Erosion Research Laboratory	1954 – Present	Q	S, P, O	N	All	33
U.S. Geological Survey	Jeff Woods	jwoods@usgs.gov	USGS Streamgages in Indiana		A, H	S	S	All	34
	Randy Bayless	ebayless@usgs.gov	USGS Groundwater Network in Indiana		A	G	S	All	34
	Travis Cole	tcole@usgs.gov	Indiana Periodic Groundwater Networks	1970's – Present	Q, A, H	G	L, R	1, 2, 5	34
	Tim Lathrop	trlathro@usgs.gov	USGS Super Gages Monitor Continuous Water Quality at Streamflow Gages	2010 – Present	Q	S	S	All	35
	Gary Martin	grmartin@usgs.gov	Estimated Water Use in the United States	1950 – Present	A	G, S	N	All	35
	Travis Cole	tcole@usgs.gov	Evaluation of Restoration Efforts at Urban Beaches on Southern and Western Lake Michigan Networks	2015 – Present	Q, H	G, S, P, O	R	1	36
	Megan Shoda	meshoda@usgs.gov	National Assessment of Pesticides in Streams, Rivers, and Groundwater	1992 – Present	Q	S	N	All	36
	Jeff Frey	jwfrey@usgs.gov	National Water Quality Network for Rivers and Streams	1991 – Present	Q	S, O	N	All	37
	David Lampe	dclampe@usgs.gov	Monitoring and Quantifying the Impacts of Green Infrastructure on Storm Water Flows in Urban Environments	2016 – 2021	A, Q	G, S, O	L	1	37
	Edward Dobrowolski	edobrowo@usgs.gov	Edge of Field Monitoring in Black Creek Watershed in Northeastern, Indiana	2015 – Present	Q	S, O	R	3	38
	Edward Dobrowolski	edobrowo@usgs.gov	Hydraulic and Water Quality Evaluations of Invasive Carp	2013 – Present	O	O	N	All	38
	Edward Dobrowolski	edobrowo@usgs.gov	Monitoring Water Quality in the St. Mary's Watershed	2017 – Present	Q	S	R	3	38
	Kayla Christian	kmchristian@usgs.gov	Contaminants of Environmental Concern	2010 – 2018	Q	S	R	1	39
	Leslie Arihood	larihood@usgs.gov	Comparison of Water Quality Characteristics Between a Natural and a Managed Wetland	1997 – Present	Q	G, S	L	1	39
	Leslie Arihood	larihood@usgs.gov	New approach to groundwater model construction	2007 – Present	A	G	N	2	40
U.S. Geological Survey	Moon Kim	mkim@usgs.gov	USGS Flood Inundation Mapping Program of Indiana		H	S	S	All	40
Valparaiso University – Department of Biology	Laurie Eberhardt	laurie.eberhardt@valpo.edu	Biomonitoring of Headwater Streams in Northwest Indiana, Salt Creek Watershed		Q	S	L	1	40
	Laurie Eberhardt	laurie.eberhardt@valpo.edu	Biomonitoring of Storm Water Receiving Waters for MS4 Compliance Requirements in Valparaiso, Indiana	2004 – Present	Q	S	L	1	40
Valparaiso University – Department of Chemistry	Julie Peller	julie.peller@valpo.edu	Integrating microplastics pollution into traditional water quality monitoring protocol in the Salt Creek Watershed in Porter County, Indiana	2015 – Present	Q	S	L, R	1	41

The Indiana Water Monitoring Council

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 agencies; non-government 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: *Jeremy Webber, President, Indiana Water Monitoring Council (jwebber@iupui.edu).*

Proactive Sampling Campaign to Identify Lead Contamination in School Drinking Water Fixtures

A public-private partnership has been underway for over a year to collaboratively conduct a statewide program to sample drinking water in over 900 public schools in Indiana for lead contamination. The Lead Sampling Program for Public Schools is a program that offered drinking water sampling and testing of Indiana public school buildings to ensure Indiana's public schools provide safe drinking water. The program was initiated by the Indiana Finance Authority (IFA), who has provided leadership and technically adept staffing to guide protocol guidance to the other team members. The IFA conducted detailed surveys of all registered schools and has handled review of the drinking water sample analysis results and working one-on-one with schools to remediate any problems found during the program.

The Indiana Department of Environmental Management (IDEM) was integral in the development and review of the sampling protocols and procedures, and they contributed their expertise in the rapid initiation of the project. Although the Lead Sampling Program for Public Schools was a voluntary, non-regulatory program, the technical oversight was an important quality-control element that improved the results.

Indiana University (IU) coordinated the statewide sampling team, which was distributed into nine regional sampling centers across the state. This team was composed of new and experienced college graduates in geology, environmental science, biology, and epidemiology, as well as current and retired staff from the regulatory sector, academia, and water and wastewater treatment. Student sampling assistants participated from all major state universities (and some private) throughout the state. Indiana University adhered to rigorous standards and completed the program in a single school year. The entire IU program, including coordination, support, administration, and field staff, encompassed 80 people, all dedicated to the common goal of accurately describing and documenting every drinking water fixture and collecting water samples from those fixtures. Indiana University is responsible for the final project analysis, producing a final project report in January 2019.

A small Indiana based start-up company named 120WaterAudit participated in the program in an integral way by creating a web-based software platform to host and populate the database that holds all the detailed information about every drinking water fixture and every sample collected in the program and programming, testing, and deploying frequent updates to improve the functionality of the platform. The team described it as building a ship while it was being sailed. The software was integral in the standardization of the program statewide, allowing the field Technical Assistance Providers to conduct their inventories online, the coordinators to document every school visit, and the IFA to review results and document remediation measures. 120WaterAudit was also the direct link to the network of laboratories conducting the water analyses. They coordinated and tracked the shipment of tens of thousands of sample bottles to the schools and then on to the laboratories.

This ambitious and fast paced program was only achievable because of the commitment of the entire team to the public health goals established by the IFA. The word "team" was truly applicable in the partnership that executed the sampling, analysis, and remediation of contaminated drinking water fixtures and should be held as an example of high quality results that can be achieved through true collaboration.

For more information: *Visit https://www.in.gov/ifa/2958.htm or contact Sally Letsinger, Indiana University, Department of Geography (sletsing@indiana.edu).*

Stream Response to Holistic Restoration Strategies Through Innovative Conservation Partnerships: The Eel River Ecosystem Story

Successful ecological restoration rests squarely on the relationship humans have to the earth and to each other. I arrived at Manchester College (now University) in 2004 to teach Biology and direct the Environmental Studies Program. Manchester is a small liberal arts college in north central Indiana and on the banks of the Eel River. It quickly became apparent three weekly lectures along with a laboratory was less than adequate for students to grasp knowledge, respect, and appreciation for the intricate structure and function of natural systems that supports every human endeavor. The Eel River was in our backyard! This was a perfect academic opportunity to help students understand the intersection of science, economics, and politics as they relate to an agricultural watershed. The Eel River is a 5th order stream with a watershed area of about 750 square miles and joins the Wabash River in Logansport.

Figure 2. *Photo of Eel River project's natural channel design.*

In 2005 we established a long-term research site on the Eel River to better understand and describe the physical, chemical, and biological parts of the river. My scientific interest and research were focused on the effect of suspended sediment on the growth and survival smallmouth bass. Since the watershed land use is 85% agriculture, there was no shortage of stream sediment for smallmouth bass research. What happened next was nothing short of remarkable! Through serendipitous conservation partnerships with federal, state, and county natural resource agencies, private donations, nongovernmental organizations and local farmers, we were collectively able to remove three dams and build a prototype fish ladder that reconnected over 750 miles of the river.

Figure 3. *Manchester University students collecting data at the Eel River fish ladder.*

We built an experimental natural channel design farm drainage ditch (1,300 feet long), reintroduce a federally endangered mussel (clubshell), sampled thousands of fish, and operated six water quality gage stations where we analyzed thousands of water samples for suspended sediment and nutrients. The middle part of the Eel River basin ranked in the 95th percentile for acres of conservation practices relative to the basin size and nearly 100 students were funded for summer internships and had the opportunity to become engaged in true experiential learning and scientific research. The Eel River restoration work was listed as one of top 10 watersheds to watch in the United States by the United States Fish and Wildlife Service.

Figure 4. *Manchester University students collecting data at the Eel River fish ladder.*

Perhaps one of the most significant accomplishments from these partnerships and opportunities was the conservation cultural bridge between the college students, our stream ecological research, and local farmers. At the beginning there was plenty of cautious skepticism from the farmers side of the ledger. Farmers learned that college students were hard working young people and students learned that farmers were real people who care.

Figure 5. *Manchester University students helping with reintroduction of Clubshell ((Pleurobema clava) in the Eel River. This is a cooperative Eel River restoration project in partnership with the nongame aquatic program of IDNR. After three years there is 95% survival of the mussels.*

At the end of my tenure at Manchester in May 2018, all our gage stations were on private farms and it was not uncommon for farmers to visit our water quality laboratory with a keen interest in water quality data. Aldo Leopold wrote, "One of the penalties of an ecological education is that one lives alone in a world of wounds. Much of the damage inflicted on land is quite invisible to laymen. An ecologist must either harden his shell and make believe that the consequences of science are none of his business, or he must be the doctor who sees the marks of death in a community that believes itself well and does not want to be told otherwise." The insight of Leopold continues to be a clear and critical reminder of environmental world view differences between our neighborhoods and scientists. Many environmental challenges we wrestle with today do not depend on scientific explanation, but rather societal priorities. Our culture needs a healthy dose of ecological education and a refreshed and energized political trajectory for ecological restoration and pragmatic environmental research.

The Eel River still has plenty of suspended sediment and nutrients headed for the Gulf of Mexico, but serendipitous conservation partnerships along with hard work forever changed the lives of young scientists and the Eel River ecosystem. A project summary and more details on the project can be viewed at https://www.manchester.edu/middle-eel-river-watershed-initiative/middle-eel-river-initiative and at http://www.fishhabitat.org/waters-to-watch/detail/eel-river-indiana.

For more information: *Jerry Sweeten or Herb Manifold, Manchester University, Ecosystems Connections Institute (*jesweeten@manchester.edu or jesweeten@ecosystemsconnections.com; hfmanifold@manchester.edu*).*

Figure 6. *Manchester University interns gained valuable stream ecological research experience with pre and post dam removal research.*

Figure 7. *Troy Eads Excavating removed all three dams from the Eel River.*

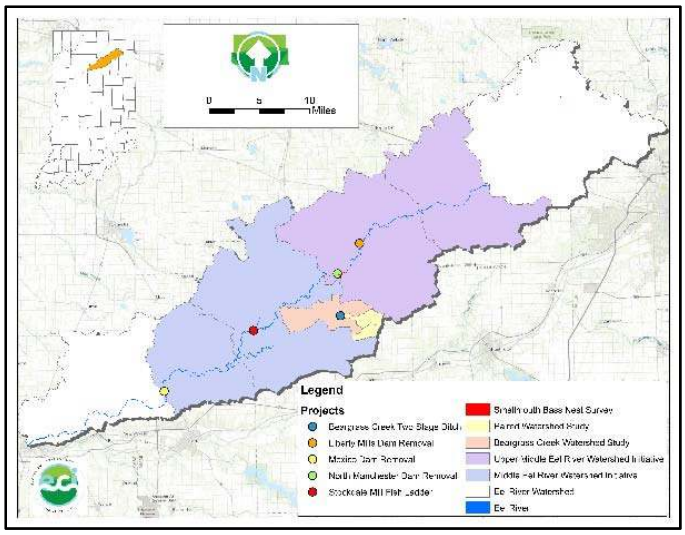

Figure 8. *Location of Eel River ecological restoration research sites.*

ACTIVITIES AND ACCOMPLISHMENTS IN 2018

Ball State University

Water Quality of Prairie Creek Reservoir

Prairie Creek Reservoir, located in Delaware County, Indiana, is Muncie's largest recreational park and secondary drinking water source. Due to heavy agricultural practices in this watershed, previous studies have identified the reservoir as "eutrophic," or having excessive nutrients. To protect this water source and improve its water quality, soil and conservation measures from the Prairie Creek Master Plan have been applied since 2007, but no study has been conducted in the recent decade to test for water quality change. Dr. Bangshuai Han and an undergraduate student, Matt Thindall, conducted preliminary tests for basic water quality parameters, e.g., pH, conductivity, temperature, dissolved oxygen, Secchi disk transparency, and nutrient levels of the Prairie Creek Reservoir in summer 2018. This work will be able to continue in 2019 with new funding support from Indiana Academy of Science. The results will be published and shared with local stakeholders to help with decision making on local water conservation.

For more information: *Dr. Bangshuai Han, Ball State University, Department of Natural Resources and Environmental Management (bhan@bsu.edu).*

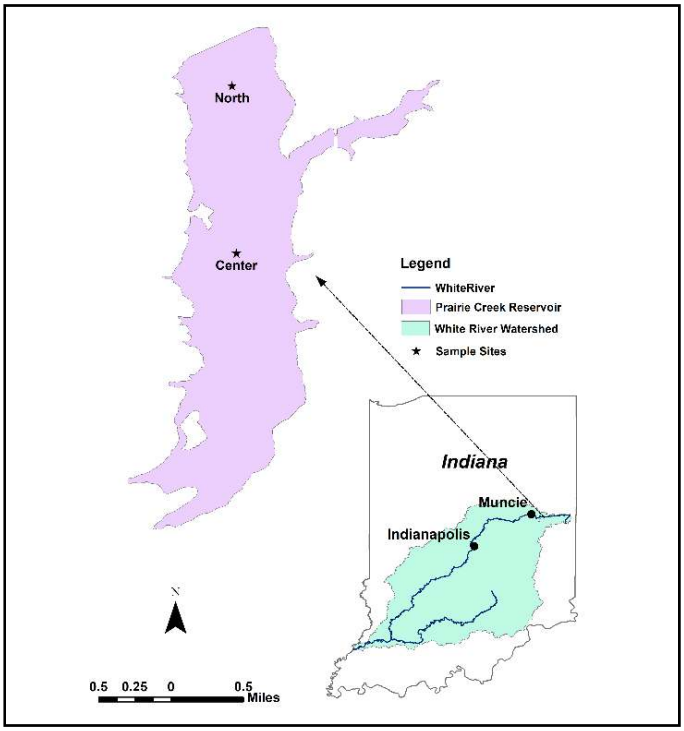

Figure 9. *Location of Prairie Creek Reservoir and our sampling sites*

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

The Starkey Farms Edge-of-Field Sampling Project

The Center for Earth and Environmental Science (CEES) at Indiana University-Purdue University (IUPUI) continues to refine the scale of it's 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. That Project is further discussed under "Evaluating Tillage Practices on Near-Surface Groundwater Recharge: School Branch Watershed, Hendricks County, Indiana" in this document. 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, the United Sates Department of Agriculture Natural Resources Conservation Service (USDA-NRCS), and the United States Geologic Survey (USGS). The EOF monitoring that began in early 2015, will continuously evaluate surface and sub-surface (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 2007–2012, as part of an IDEM 319 Grant, and a bio-swale monitoring project that is co-located with one side of the Edge-of-Field project.

In 2018 the Center in partnership with the USGS, began planning for 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, Professor, IUPUI, Department of Earth Sciences, and Director, Center for Earth and Environmental Science at IUPUI (CEES) (pjacinth@iupui.edu).*

Figure 10. *Installation of the west side equipment, February 2015*

Grace College – Lilly Center for Lakes & Streams

Water monitoring and research in Kosciusko County

The Lilly Center for Lakes & Streams at Grace College has helped monitor and 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's undergraduate research team samples 14 lakes, 12 of which are used as all-sport lakes, weekly throughout the summer. They also monitor twelve key streams on a bi-weekly basis year-round. The students gather 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's website. In addition to regular monitoring, the Lilly Center also engages in special research projects that focus on two-way interactions between human activity and water quality. In May 2018, the center partnered with a local watercraft dealership to perform a boating impacts study. The results will provide evidence based, best use boating practices for lake homeowners and community members, ultimately helping reduce sediment resuspension by watercraft. The Lilly Center 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 and Water Conservation District in order to strengthen water literacy and water conservation efforts.

For more information: *Visit Lilly Center for Lakes and Streams website at lakes.grace.edu or email lakes@grace.edu.*

Figure 11. *Grace College student and Lilly Center student staff member Jedidiah Harvey measures water depth and flow as a part of the Lilly Center's bi-weekly stream sampling. The stream is Turkey Creek flowing out of Syracuse Lake. The photographer is Abigail Phinney, the Lilly Center's communication specialist. Photo taken September 2018.*

Figure 12. *Lilly Center students and staff members take water samples on Lake Wawasee as a part of a boating impact study performed in May 2018. Dr. Nate Bosch, director of the Lilly Center, is in the blue shirt. The photographer is Caleb Yoder.*

Hamilton County Soil and Water Conservation District

Private Well Water Monitoring and Maintenance Initiative

Protecting groundwater resources through education, information sharing, and testing are the main goal of the Private Well Program provided by Hamilton County Soil and Water Conservation District (SWCD). In Hamilton County the SWCD is working with partnering agencies to help inform domestic well owners of their influence to the aquifer and groundwater by choices they make at the surface. In Hamilton County partnering with Rural Community Assistance Program (RCAP) has been a mutually beneficial partnership. The RCAP and SWCD representatives work at the homes of private well owners to discuss risks to their drinking water and provide basic education to safeguard their well and shared aquifers. RCAP provides water well assessments which can point out local potential sources of contamination, while the SWCD works with testing results and connects users to local resources. The program is only one year old but has grown substantially. Hamilton County SWCD has seen an increase in those signing up for assessments and those having their water tested for baseline considerations like inorganics and metals (https://www.hamiltonswcd.org/well-water-testing.html). New this year the Hamilton County SWCD is offering bacteria, metals, arsenic speciation, nitrogen, and radionucleotide testing through the Indiana State Department of Health Laboratory. This partnership has improved timing and efficiency which resulted in an increase in outreach at public events, hands on testing by students, and helping to create awareness in our community. Traditional water quality testing through Heidelberg University's National Center for Water Quality Research is also available to individuals in the area. The Hamilton County SWCD will also ask for the individuals to share the test result information for education purposes and to help shape the testing plan for others in the community. The data available in upcoming years will be put to good use by creating risk maps local concerns to safeguard our community.

For more information: *Hamilton County SWCD (soil.water@hamiltoncounty.in.gov) or Ginger Davis (ginger.davis@hamiltoncounty.in.gov).*

Figure 13. *Sheridan High School students work with Soil and Water Conservation District to analyze school participants' well water.*

Hamilton County Health Department

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 and monitored for temperature and dissolved oxygen. HCHD also utilizes the Hoosier Riverwatch principles (www.hoosierriverwatch.com) to perform a variety of chemical and physical testing 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 is currently working on placing permanent signage at each sample location to promote public awareness and direct individuals to the website for sample results and educational materials.

Hamilton County Water Quality Program's regulatory program includes permitting, sampling, and inspections of public and semi-public swimming pools and private water wells.

For more information: *Visit Hamilton County Water Quality Program website at www.hamiltoncounty.in.gov/328/Water-Quality-Program or contact Morgan Bennett (morgan.bennett@hamiltoncounty.in.gov).*

Figure 14. *One of the new water quality signs posted at a recreational surface water monitoring program sample location within Geist Park in Fishers, IN.*

Figure 15. *Summer interns identifying macroinvertebrates collected from Cicero Creek in Noblesville, IN.*

Figure 16. *Summer interns collecting water quality data in Stony Creek in Noblesville, IN.*

Hoosier Environmental Council

The Impact of Coal Ash on Indiana Groundwater

Coal ash is the material left after burning coal. Indiana produces several million tons of coal ash each year, most of which is disposed of in landfills and impoundments adjacent to power plants. Power plants were built next to sources of cooling water, so most Indiana coal ash disposal is in the floodplain of the state's major rivers or Lake Michigan. Coal contains traces of heavy metals that are more concentrated in the ash. When coal ash is in contact with water, the heavy metals can leach into the water.

Because of recent regulatory requirements, most coal ash disposal sites in Indiana now have groundwater monitoring. At some of the sites, nearby private wells have also been tested. The Hoosier Environmental Council (HEC) compiles groundwater data from coal ash disposal sites statewide and publishes updates at www.hecweb.org/coal-ash-groundwater/.

For more information: *Indra Frank, Hoosier Environmental Council (*ifrank@hecweb.org*).*

Figure 17. *Coal ash ponds at the A.B. Brown power plant near Evansville. The two ponds cover 156 acres and hold approximately 6.8 million cubic yards of ash slurry. (© 2016 BlairPhotoEVV)*

Indiana Department of Environmental Management

Statewide Ground Water Monitoring Network

The Ground Water Section of the Drinking Water Branch at the Indiana Department of Environmental Management (IDEM) manages a statewide Ground Water Monitoring Network (GWMN) to evaluate ambient groundwater quality across the state. The goal is to make informed decisions about the water that serves Indiana's drinking water wells and thereby protect Hoosiers. Sampling for the GWMN began in 2008 and is conducted annually. To date, over 2,300 groundwater samples have been collected from more than 1,400 individual water well sites. The GWMN consists of primarily of private residential wells with some non-community public water systems (PWSs) wells (ex: churches and schools). The study has identified several contaminants of concern that were found throughout Indiana including arsenic, nitrates, and degraded agricultural pesticides. An additional investigation is underway to provide details of the nature and occurrence of the arsenic contamination that has been identified across the glaciated areas of Indiana. Approximately 240 samples during 2018 will be 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 five (AsV) in groundwater. Arsenic three is more difficult to remove during treatment and requires pretreatment to convert it to Arsenic five. This data will provide additional information about the occurrence and mobility of arsenic in groundwater. More information about the GWMN and the results of the testing are available through the 2016 GWMN Summary and Results can be found on IDEM's website at http://in.gov/idem/cleanwater/2453.htm.

For more information: *Jim Sullivan, Indiana Department of Environmental Management, Drinking Water Branch (*jsulliva@idem.in.gov*).*

Fixed Station Monitoring

The fixed station monitoring program collects monthly water quality samples to provide basic ambient water quality data for assessment of the major rivers of Indiana. Additionally, this data supports development of Total Maximum Daily Load (TMDL) reports, provides data to calibrate and verify waste load allocations for National Pollutant Discharge Elimination System (NPDES) permits, and helps to determine long-term

water quality trends. Monitoring at municipal drinking water intakes occurs at a subset of sites on Lake Michigan. The following parameters are collected:

- General water chemistry, total metals with dissolved metals collected at a subset of 12 sites across the state that represent different ecoregions, and nutrients including dissolved reactive phosphorus at sites in the Western Lake Erie Basin.
- Field chemistry, *E. coli*, and ambient conditions notes.
- Organics/pesticides at select sites and drinking water intakes.

For more information: *Marylou Renshaw, Indiana Department of Environmental Management (mrenshaw@dem.in.gov).*

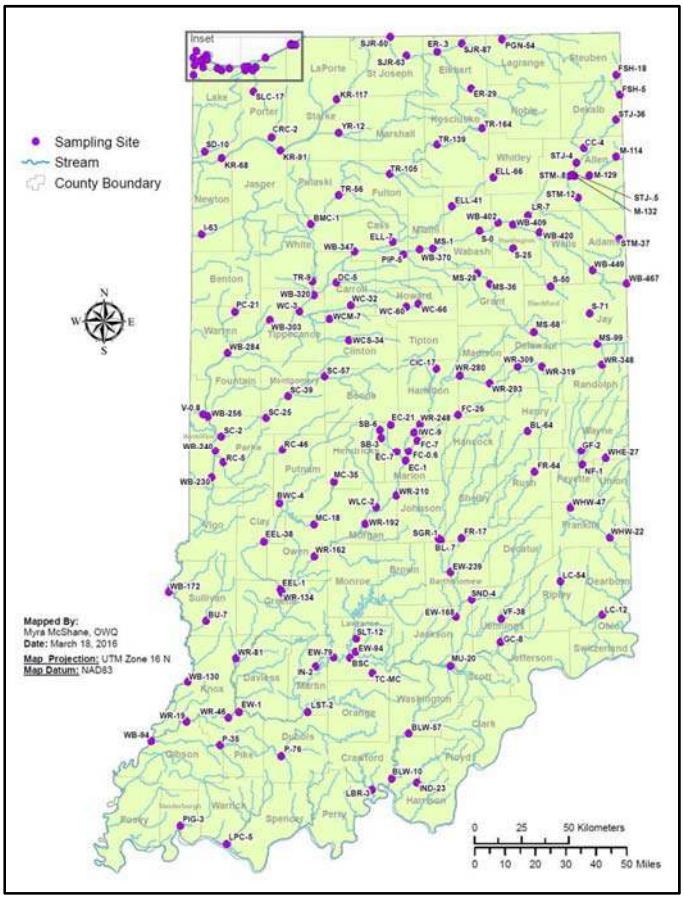

Figure 18. *Fixed station monitoring sites.*

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. Thirty-eight (38) randomly generated (probabilistic) sites were sampled in the tributaries to the Great Lakes Basin (Lake Michigan and Lake Erie) in northern Indiana in 2018. Each site was sampled for fish and macroinvertebrate communities, after which a Qualitative Habitat Evaluation Index Form (QHEI) 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 Chlorophyll a and Pheophytin a levels. Bacteria (E.coli) levels were sampled five times within a 30 day period during the recreational season (April through October).

For more information: *Marylou Renshaw, Indiana Department of Environmental Management (mrenshaw@dem.in.gov).*

Figure 19. *Fish tissue crew posing with a smallmouth bass, channel catfish, and two flathead catfish collected from Sand Creek near Westport. From left: David Jordan, Adam Casey, Kevin Gaston, Tim Fields.*

Figure 20. *Todd Davis completing a 15 minute field pick of macroinvertebrates.*

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 located in areas with the least amount of anthropogenic disturbance and considered the most natural remaining areas within a specified geographic boundary. Thirty (30) historical sites were sampled in the following sub-basins in southern Indiana in 2018: Whitewater, Middle Ohio-Laughery, Patoka, Blue-Sinking, and Lower Ohio-Little Pigeon. Each site was sampled for fish and macroinvertebrate communities, after which a Qualitative Habitat Evaluation Index (QHEI) form 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 Chlorophyll a and Pheophytin a levels.

For more information: *Marylou Renshaw, Indiana Department of Environmental Management (mrenshaw@dem.in.gov).*

Contaminants Monitoring Program

The objective of the 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. Forty-four (44) sites from the Upper Wabash basin were sampled for contaminants in fish tissue. These sites were comprised of 12 lakes or reservoirs and 32 rivers or streams. Additionally, the Indiana Department of Natural Resources (IDNR) – Division of Fish and Wildlife (DFW) assisted with collection of fish from several waterbodies, including the collection of fish tissue samples from the Indiana waters of southern Lake Michigan. All fish tissue samples were analyzed for percent lipid, total polychlorinated biphenyls (PCBs), organochlorine pesticides, metals, and methyl-mercury. Polynuclear aromatic hydrocarbons and perfluorinatedalkyl acids were also analyzed on selected samples.

For more information: *Marylou Renshaw, Indiana Department of Environmental Management (mrenshaw@dem.in.gov).*

Blue-Green Algae Beach Sampling

To support recreational advisories, IDEM samples the water at 16 swimming beaches owned or managed by the Indiana Department of Natural Resources (IDNR) monthly to bimonthly from May through August. Samples are analyzed for cyanobacterial identification and cell counts, and for the toxins microcystin, anatoxin-a, saxitoxin and cylindrospermopsin. Water quality is analyzed for nutrients, dissolved oxygen, dissolved oxygen saturation, pH, and turbidity. DNR posts recreational advisories when cell counts reach 100,000 cells/ml, and a system is in place for additional warnings and/or closure when certain toxin thresholds are met. The DNR Dog Lake at the Ft. Harrison State Park Dog Park is sampled weekly for microcystin, anatoxin-a, saxitoxin and cylindrospermopsin from May through October. A system is in place to close the lake to dogs when certain toxin thresholds specific to dogs are met. The water sample results from IDNR owned or managed facilities are posted weekly on http://www.algae.IN.govas well as on the DNR webpages for the specific properties.

For more information: *Marylou Renshaw, Indiana Department of Environmental Management (mrenshaw@dem.in.gov).*

Figure 21. *Sampling bluegreen algae at a state park beach. From left: Ross Carlson, Kevin Gaston.*

Performance Measures Monitoring

Sampling is conducted to determine if watershed planning and restoration efforts have improved water quality in watersheds that have been listed as impaired (not meeting water quality standards or their designated uses). This type of monitoring provides chemical, physical, biological, and/or bacteriological data that can be reported to U.S. EPA Region 5's Nonpoint Source Program to show successful implementation of best management practices. In 2018, there were nine sites sampled in three counties across five Indiana sub-watersheds. All nine sites were sampled only for biology (fish and macroinvertebrates). Additionally, one of the nine sites was also sampled to be assessed for improvement of dissolved oxygen.

For more information: *Marylou Renshaw, Indiana Department of Environmental Management (mrenshaw@dem.in.gov).*

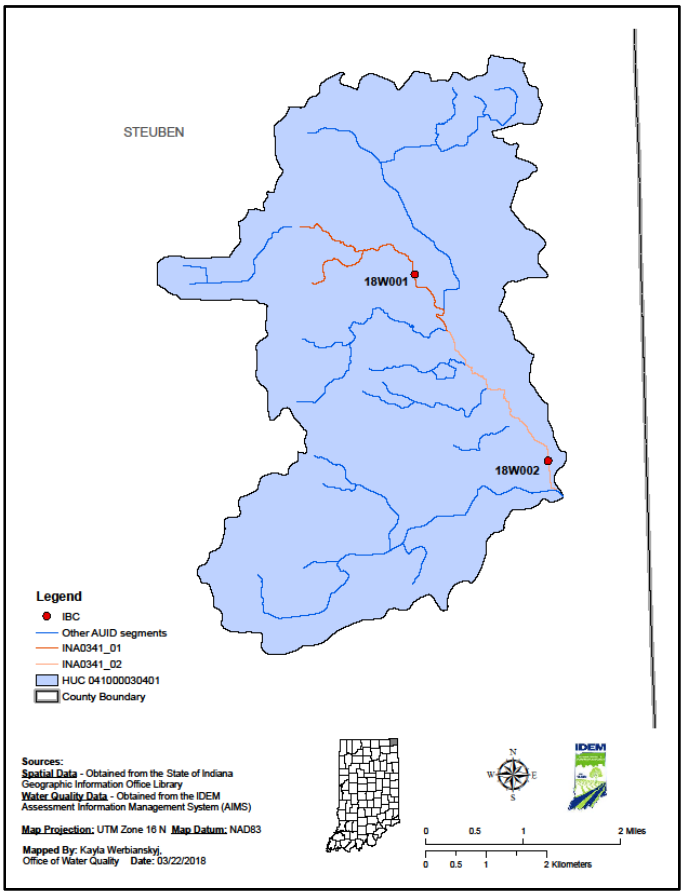

Figure 22. *Performance monitoring sampling area, AUID stream segments, and site sampling parameters for West Branch Fish Creek (041000030401) sub-watershed.*

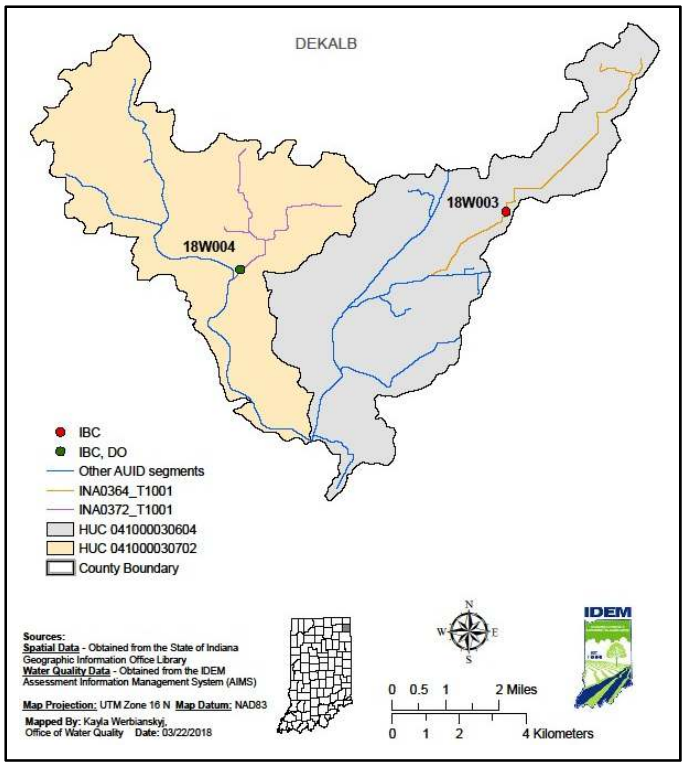

Figure 23. *Performance monitoring sampling area, AUID stream segments, and site sampling parameters for sub-watersheds Smith Ditch-Cedar Creek (041000030604) and Peckhart Ditch-John Diehl Ditch (041000030702).*

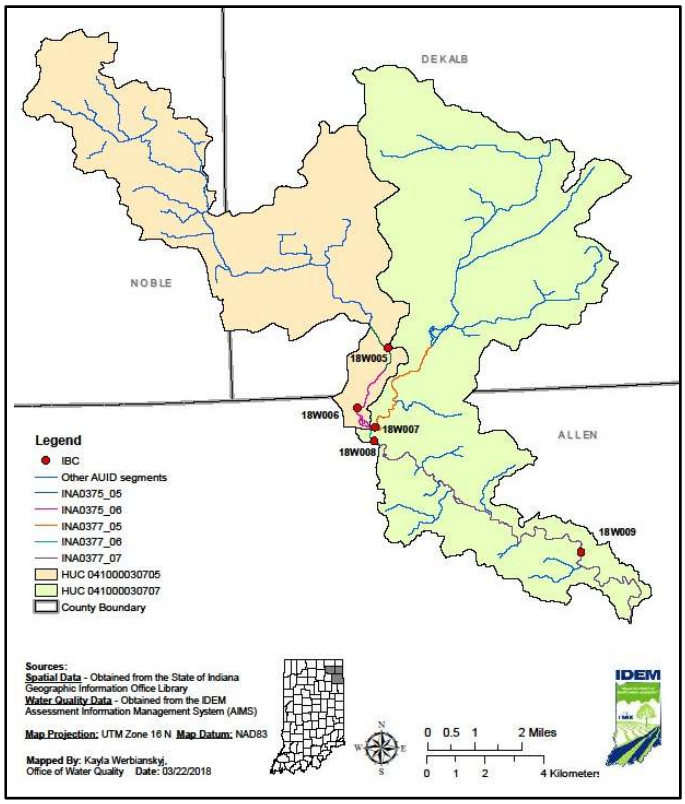

Figure 24. *Performance monitoring sampling area, AUID stream segments, and site sampling parameters for sub-watersheds King Lake-Little Cedar Creek (041000030705) and Dosch Ditch-Cedar Creek (041000030707)*

Thermal Verification Projects

One "thermal verification study" was conducted in the summer of 2018 to determine biological community response and condition (fish and benthic macroinvertebrates) to increased temperature loads from the cooling water thermal discharge of a coal fired electrical generating station into a reservoir constructed specific for the purpose of cooling water. "Thermal verification studies" are conducted to support decision making concerning temperature variance requests for National Pollutant Discharge Elimination System (NPDES) permits. The objectives of these studies are to:

- Provide information that will enable an assessment and understanding of response downstream from thermal discharges;
- Implement the Traveling Zone (T-zone) or other sampling method to determine applicability for understanding fish and/or aquatic macroinvertebrate community response and recovery downstream of thermal discharges and to recommend modifications to the method if necessary; and
- Collect data to support, corroborate, or dispute conclusions concerning "No Harm" to a Balanced Indigenous Community (BIC) due to anthropogenic input of thermal loads by the NPDES permitted discharger when requesting Alternate Temperature Effluent Limits.

The one "Thermal Verification" Study was conducted on Turtle Creek Reservoir, Sullivan County, Indiana.

For more information: *Marylou Renshaw, Indiana Department of Environmental Management (mrenshaw@dem.in.gov).*

Watershed Characterization Monitoring Projects

The main objective of watershed characterization monitoring projects is to use an intensive targeted watershed design to characterize the current condition of an individual watershed (HUC 10 scale). After IDEM identifies a waterbody as having impairments and places it on Indiana's Section 303(d) List of Impaired Waters, IDEM then implements a targeted sampling plan in the larger watershed to determine the extent and the magnitude of the impairment. This type of monitoring provides valuable data for the purposes of assessment, total maximum daily load (TMDL) development, and watershed planning, and allows for the future evaluation of changes in water quality within the watershed. IDEM currently conducts monitoring in one watershed per year at this level.

For 2018, IDEM selected the Lower East Fork White River watershed (HUC 0512020815) as its watershed characterization project. Sample sites were chosen using a modified geometric site selection process as well as targeted site selection in order to get the necessary spatial representation of the entire study area. Seventeen bridge sites were sampled from November 2017 through October 2018. Monitoring for water chemistry occurred monthly at key "pour point" sites while monitoring for biological communities (fish and aquatic insects) and bacteria concentrations (E. coli) occurred only from April through October.

For more information: *Marylou Renshaw, Indiana Department of Environmental Management (mrenshaw@dem.in.gov).*

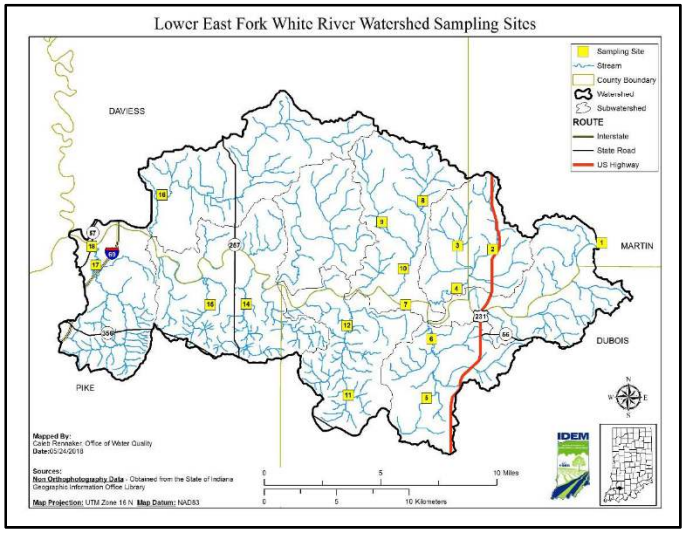

Figure 25. *Lower East Fork White River Watershed Sampling Sites.*

Hoosier Riverwatch Volunteer Stream Monitoring

This program trains, equips and supports the efforts of interested citizens in monitoring wadable streams. Sixteen new instructors were trained this spring giving us 39 active instructors. Upon completing an eight hour basic training workshop, citizens can collect and enter data for stream temperature, dissolved oxygen, nitrates, nitrites, orthophosphates, pH, turbidity, habitat, flow, and macroinvertebrate data. With an additional three hour training, they may also sample E. coli.

To-date, citizens are responsible for deciding where, when, and what to monitor based on their training and local interest. Many groups who receive Section 319 or

other federal grants from IDEM report data directly to the Nonpoint Source (NPS) staff. This data is not captured via the online database. Of the data entered into the database so far, the following has occurred in calendar year 2018:

- 8 months of sampling (January to August) has occurred;
- 1,481 results reported;
- 147 events have occurred;
- 71 sites currently being monitored, from 1–6 visits each;
- 34+ trained volunteers actively monitoring (Some groups use multiple field volunteers with only one central Volunteer ID for data entry);
- 25 registered organizations involved in monitoring;
- 8 of the volunteers listed above collected data on their own cognizance, without being a part of an organization. Extra kudos to these folks who travel to borrow and return a loaner kit, rather than rely on use of a stream monitoring kit awarded to them by the state.

For more information: *Visit the Hoosier Riverwatch website at* http://www.hoosierriverwatch.com/ *or contact Marylou Renshaw, Indiana Department of Environmental Management (*mrenshaw@dem.in.gov*).*

Figure 26. *Julie Lowe and Dennis Tibbets are Sierra Club volunteers who use HRW to regularly monitor E. coli on waters flowing through Columbus, Indiana.*

Figure 27. *Eight of the 16 new instructors trained in 2018. In real life they are employed or volunteer with city and county parks, state agencies, Soil and Water Conservation Districts, The Nature Conservancy, and the Sierra Club.*

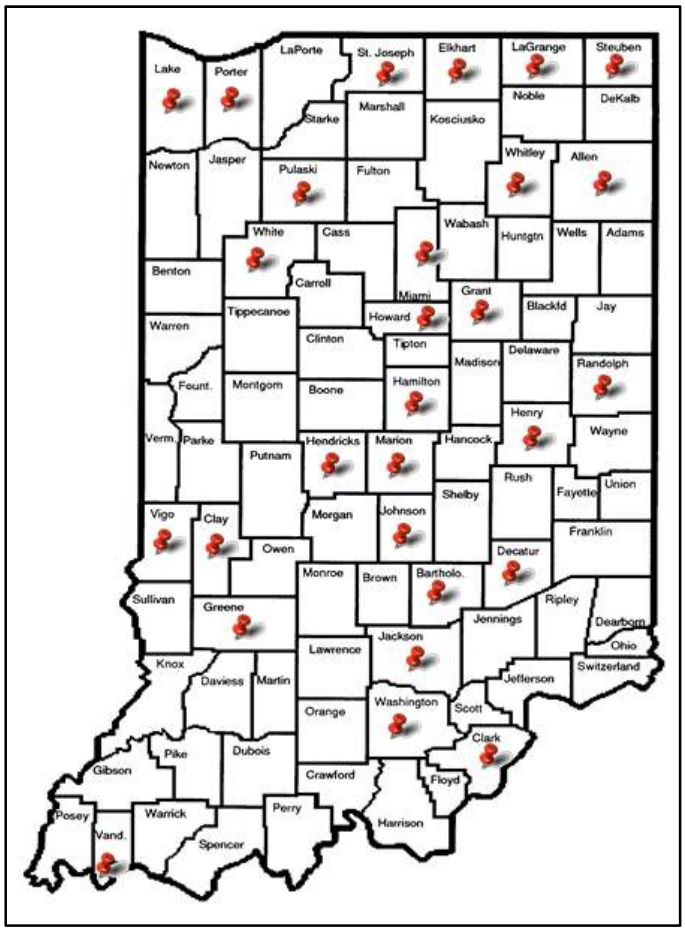

Figure 28. *Map of 2018 HRW Volunteer Stream Monitoring Activity by County.*

Indiana Department of Natural Resources – Division of Reclamation

Monitoring of streams impacted by past coal mining activities in southwestern Indiana

The Indiana Department of Natural Resources – 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 25 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, Division of Reclamation (*pburch@dnr.in.gov*).*

Indiana Department of Natural Resources – Division of Water

Indiana's Water Shortage Plan

The drought of 1988 focused attention on the widespread impacts of such a natural disaster, highlighting the need for a plan minimizing the negative effects of a water shortage and maximizing the positive response to it. This need was addressed by the Indiana General Assembly in 1991 when Indiana Code 13-2-6.1 (since repealed) required the Indiana Department of Natural Resources (IDNR) to develop a plan defining the needs when a water shortage threatens 1) the health, safety, welfare, or economic well-being of the citizens or 2) the environment of any part of Indiana. The initial Indiana's 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. Additional information and related links can be found at http://www.in.gov/dnr/water/3124.htm

For more information: *Bill Davis, Indiana Department of Natural Resources, 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 twelve streams across Indiana; Lake Michigan-Huron water level data; water levels at 11 Indiana reservoirs; and groundwater levels for nine observations wells. These monthly summaries are compiled from IDNR-DOW data, as well as information and data provided by the National Oceanic and Atmospheric Administration; the National Weather Service; the Midwestern Regional Climate Center; the National Drought Mitigation Center; the Western Regional Climate Center; the U.S. Geological Survey (USGS); the U.S. Army Corps of Engineers-Detroit District; the U.S. 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, Division of Water (*wdavis@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 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 Withdrawal 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, Division of Water (mbasch@dnr.in.gov).*

Figure 29. *Indiana Great Lakes Basin and Lake Michigan Basin Diversion Boundaries.*

Voluntary Monitoring Program

The Voluntary Monitoring Program (VMP) is a cooperative effort between the IDNR, the 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 50 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. Resource Assessment Section staff are directly responsible for the management, the physical maintenance, the data retrieval and the data download of more than forty 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, 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 IDNR-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, Division of Water (wdavis@dnr.in.gov).*

Emergency Regulation of Groundwater Rights and of Surface Water Rights

The IDNR-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, Division of Water (mbasch@dnr.in.gov).*

Water Use Reporting

Significant Water Withdrawal Registration

Indiana Code 14-25-7-15 requires all Significant Water Withdrawal Facilities to register with the IDNR-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 4,138 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 (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 http://www.in.gov/dnr/water/4847.htm.

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

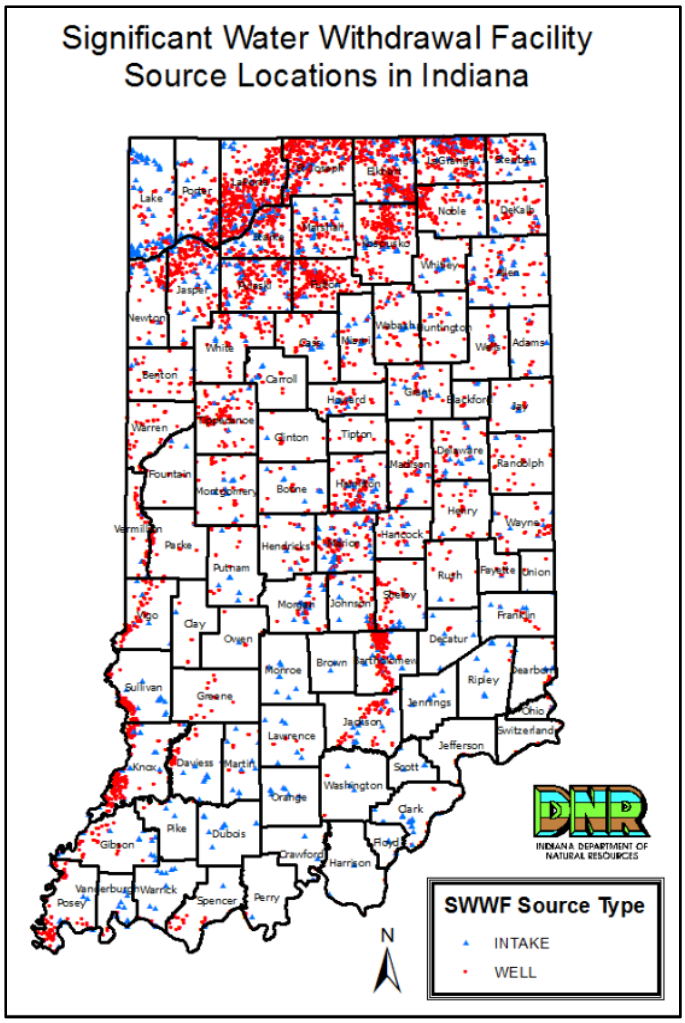

Figure 30. *Significant Water Withdraw Facility Source Locations in Indiana.*

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 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 IDNR-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, Division of Water (mbasch@dnr.in.gov).*

Indiana Geographic Information Council

The IGIC Waters Workgroup

The Indiana Geographic Information Council's (IGIC) Waters Workgroup was formed in 2007 to develop plans, standards, and technical implementation guidance for the IndianaMap waters framework data layers. At the workgroup's recommendation, IGIC adopted the National Hydrography Dataset (NHD) for Indiana as the waters framework data.

The NHD is a feature-based database of the nation's surface water drainage system. It includes area, line, and point features, as well as a topological network that models the flow of water. Further details about the NHD can be found at the USGS NHD website: http://nhd.usgs.gov/.

In 2016, work was completed on a multi-year statewide project to upgrade the NHD flowline, waterbody, and area features and network topology for Indiana to a scale of 1:2,400 (considered to be local resolution). Full geodatabases for the subbasins in Indiana can be downloaded from the USGS NHD site, and they include a Hydrography feature dataset and a Watershed Boundary Dataset. The Hydrography feature dataset includes network topology and the following feature classes: NHDArea, NHDFlowline, NHDLine, NHDPoint, and NHDWaterbody. Vector feature classes without network topology are available from the IndianaMap. These feature classes include Rivers (2d) (NHD Areas including 2d rivers, inundation areas, canals, ditches, submerged streams and other linear waterbody areas), lakes (NHD Waterbodies, including lakes, ponds, reservoirs, swamps and marshes), classified flowlines (NHD Flowlines classified as perennial and intermittent streams, rivers, canals, ditches, artificial paths, connectors and pipelines), and unclassified flowlines (NHD Flowlines not classified beyond Stream/River, most of which are drainages that may or may not have water present outside of a rain event, and may or may not exhibit channelization associated with streams).

The Indiana Geographic Information Officer (GIO) is the official steward for the Indiana local resolution NHD data. The office works closely with and rely on other state agencies, local agencies, and other organizations to assist with the stewardship activities. In addition to the NHD, the stewardship agreement with USGS includes the Watershed Boundary Dataset (WBD) in partnership with the Indiana Office of the USDA – NRCS Office. Future updates and improvements to each dataset will be submitted to both USGS and the IndianaMap.

Short and long-term plans for the workgroup are:

- Using NHD Update tools, edit the USGS NHD database to correct errors that are found.
- Rolling out the USGS Markup tool for crowd sourcing input. Taking advantage of the work USGS did on creating the mark up tool, we have incorporated it into our crowd sourcing plan to receive suggestions and requested error fixes.
- Adding names to rivers, streams, and lakes that are currently unnamed in the NHD by using the web application for users to submit names for unnamed streams and lakes. After completing the Board of Geographic Names review process, approved names would be added.
- Working with USGS to add a category of Inferred Drainage, which could then be initially applied to the unclassified flowlines dataset.
- Creating an automated process to determine and properly code unclassified flowlines as perennial, intermittent, or ephemeral streams, or as inferred drainage.
- Update the Watershed Boundaries Dataset for Indiana based upon the local resolution NHD and updated elevation data.

Updates on the IGIC Waters Workgroup's activities are posted at http://www.igic.org/igic-indianamap-workgroups/indianamap-waters-workgroup/.

For more information: *Mike Martin, Chair, IGIC Waters Workgroup (mmartin@dnr.in.gov).*

Indiana Geological and Water Survey

Bedrock Topography of Indiana and the Continentally Glaciated United States: Implications for improving our understanding of buried valley aquifers in the region

Bedrock elevation data associated with recently completed Indiana bedrock topography and sediment thickness maps were combined with the latest bedrock elevation data from other states. Bedrock topography and sediment thickness maps for much of the continentally glaciated portion of the United States were developed, including analyses of glacial erosion and deposition patterns that have influenced aquifer characteristics. Currently, the bedrock topography data and reconstructed preglacial topography are being used as input for a continental ice sheet numerical model to improve our understanding of erosion and deposition patterns and drainage reorganizations caused by glacial advance and retreat. The resulting insights will enhance conceptual models for sediment fill sequences in deeply buried valleys in Indiana where there is limited core data to constrain aquifer geometries.

For more information: *Shawn Naylor, Indiana Geological and Water Survey (snaylor@indiana.edu).*

The National Groundwater Monitoring Network: Contributions from the Indiana Geological and Water Survey

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/index.jsp) provides access to disparate groundwater databases in a web-based mapping application. The Indiana Geological and Water Survey has partnered with the U.S. Geological Survey and 26 other contributing agencies to provide groundwater data for several principal aquifers in the United States. The Indiana Geological and Water Survey is currently providing daily groundwater level data for several monitoring wells to the NGWMN, and two additional wells will be installed in 2019 to monitor daily groundwater levels in buried valley aquifers in central and northern Indiana.

For more information: *Shawn Naylor, Indiana Geological and Water Survey (snaylor@indiana.edu).*

Unconsolidated Sediment Database Description Tool

The Indiana Geological and Water Survey is developing a suite of Microsoft Access database forms that will be used to efficiently describe unconsolidated sediment (soil) cores. This tool replaces traditional data collection (paper field notes and subsequent data entry) by electronically streamlining the acquisition of all relevant information from the unconsolidated sediment cores and immediately creating database files for later display, analysis, and reporting. Outcrop availability is scarce in many areas of Indiana, and cores are the primary data source for unraveling the geologic complexity and delineating aquifer boundaries. The Indiana Geological and Water Survey is acquiring many hundreds of meters of core for various projects, and an efficient tool is needed to collect, manage, and archive all of the new data being generated.

For more information: *Bob Autio, Indiana Geological and Water Survey (rjautio@indiana.edu).*

Long-Term Monitoring of an Urban/Forest Interface: Griffy Woods Research and Teaching Preserve, Bloomington, Indiana

The Indiana Geological and Water Survey is documenting baseline conditions for Sycamore Creek in Monroe County, Indiana, prior to land development upstream for a hospital complex. Long-term streamflow data from a broad-crested weir (Figure 31) and a micrometeorological station in the Griffy Woods Research and Teaching Preserve will provide data that facilitate the joint efforts of Indiana Geological and Water Survey and Indiana University researchers to monitor the downstream hydrogeological, erosional, and water quality impacts that this new development will have on the watershed.

For more information: *Bob Autio, Indiana Geological and Water Survey (rjautio@indiana.edu).*

Figure 31. *Broad-crested weir located in a steep sided stream valley measures water flow. This location will soon be receiving water from land that is undergoing extensive urban development.*

Groundwater Geochemistry of Indiana Aquifers: Database development and analysis of the natural chemical character of bedrock and glacial aquifer systems

The mineral character of groundwater varies greatly throughout Indiana, affecting both the taste of drinking water and industrial applications of the water. Geochemical analyses conducted on the groundwater of Indiana are being compiled into a standardized database. Within the database, these analyses are further being subdivided into stratigraphic bedrock aquifer systems or morphologically and spatially unique glacial/alluvium aquifer units.

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

Integrating Hydrogeological Studies with U.S. Geological Survey-Funded Mapping Projects

The Indiana Geological and Water Survey has established a multi-disciplinary team of scientists to increase the value and influence of 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 hydrogeologic framework models, volumetric analysis of aquifers, water quality sampling, and sensor testing for real-time monitoring.

For more information: *Kevin Ellett, Indiana Geological and Water Survey (kmellett@indiana.edu).*

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 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.

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

Indiana Dye Trace Database

Karst landscapes like the Mitchell Plateau make up more than a fifth of the land area of the United States. The interaction between surface water and groundwater in karst dominates the quality of water over small spatial and temporal scales. This project will design and implement an online registry and inventory system for dye traces that will be reflected on the interactive IndianaMap and provide notifications to the Indiana Department of Homeland Security and emergency management professionals. In addition, we will solicit existing dye trace data at state and federal agencies, universities, and consulting firms to enhance the presently existing spatial data curated in IndianaMap. This project mimics the Kentucky Division of Water's online dye-trace notification system, which provides a record of all dye traces conducted in that state. The information from these dye traces will be incorporated into Indiana's statewide maps, helping state agencies create plans for future development and construction.

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

Delineating the Harrison-Crawford Karst Aquifer

In karst aquifers, contaminants may travel long distances (miles) in hours, affecting the quality of water. In some instances, karst springs are sole source water supplies for landowners or communities. In other cases, some species in cave streams are endangered because of their restricted habitat. In all cases, additional study of karst aquifers can help Indiana manage this unique geological and water resource. In the case of Harrison and Crawford Counties, existing cave mapping and dye trace data suggests the presence of a highly complex and extensive karst aquifer system with multiple flow vectors and overflow routes spanning much of the southern Mitchell Plateau, encompassing Indiana's longest known cave system, and culminating at the largest spring in the state. This project will conduct a sequence of dye traces in collaboration with private landowners, tourist caves, state and federal agencies, and municipalities to better outline the extent of this groundwater basin.

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

Water Quality Indiana

Water Quality Indiana (WQI) uses experiential learning to blend science with journalism, which has resulted in effective recruitment into both the STEM and media fields. Students collect a range of water quality data from local waterways and conduct interviews with stakeholders. They then transform this knowledge into judgment by producing defendable scientific results and generating multimedia products. Students effect action by disseminating their deliverables to a public audience of consultants, regulators, and landowners, helping to create a more sustainable future. The overarching goal of the WQI program is not just to engage community partners in examining local water quality issues, but to emphasize the connection between these local water quality issues and their broader implications for the community. Visit Water Quality Indiana's website at: http://www.waterqualityin.com/.

For more information: *Adam Kuban, Ball State University, Department of Journalism (ajkuban@bsu.edu); Lee Florea, Indiana Geological and Water Survey (lflorea@indiana.edu).*

The Indiana Water Balance Network

Climate change with its associated droughts and floods highlight the need to improve our understanding of water budgets in Indiana to facilitate improved water resource planning. The Indiana Water Balance Network (IWBN) was developed to monitor trends in water loss and gain for different components of the hydrologic cycle in various hydrogeologic settings. Currently 13 sites are being monitored across Indiana. Monitored hydrologic components include precipitation, evapotranspiration, soil moisture, and groundwater levels (figure 32). Preliminary data from monitoring sites are available in real-time on the IWBN website: https://igws.indiana.edu/CGDA/waterBalanceNetwork.cfm.

For more information: *Shawn Naylor, Indiana Geological and Water Survey (snaylor@indiana.edu).*

Figure 32. Energy and water balance station located in central Indiana. Co-located at this site are micrometeorological, soil, and groundwater monitoring sensors.

Evaluating Tillage Practices on Near-Surface Groundwater Recharge: School Branch Watershed, Hendricks County, Indiana

An outdoor laboratory has been established in the School Branch watershed, which is a tributary to Eagle Creek on the west side of Indianapolis. This watershed is being studied by numerous agencies (NRCS, USGS, IDEM, Indiana Geological and Water Survey – CGDA, IUPUI-CEES, and others) to evaluate the effect of tillage practices on nutrient mobility in surface and groundwaters. The Indiana Geological and Water Survey's Center for Geospatial Data Analysis (CGDA) monitors the water balance at several locations in the watershed. The goals of this project are to install sensors and monitor the resultant water balance data in different areas of the small watershed being subjected to different land management (particularly agricultural) practices. Over time, statistically significant differences in the sites might be able to be linked to land management practices. Project updates and details can be found at http://cees.iupui.edu/research/EOF.

For more information: *Shawn Naylor, Indiana Geological and Water Survey (snaylor@indiana.edu).*

Indiana State Department of Agriculture

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 ten (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 interactive maps which allow users to click on watersheds, on water monitoring locations along with links to water quality data, and educational sites and then 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) Integrated Water Monitoring Network Optimization Taskforce White Paper titled An Assessment for Optimization of Water Quality Monitoring in Indiana. The Story maps also contain information about local watershed groups and organizations, the number of conservation practices in specific watersheds, nutrient load reductions from best management practices (BMPs), and any active grants. The development and purpose of these GIS story maps is making Indiana's nutrient reduction strategy more interactive.

For more information: *Visit the ISDA website* http://www.in.gov/isda/2991.htm *or contact Julie Harrold, Indiana State Department of Agriculture (jharrold@isda.in.gov).*

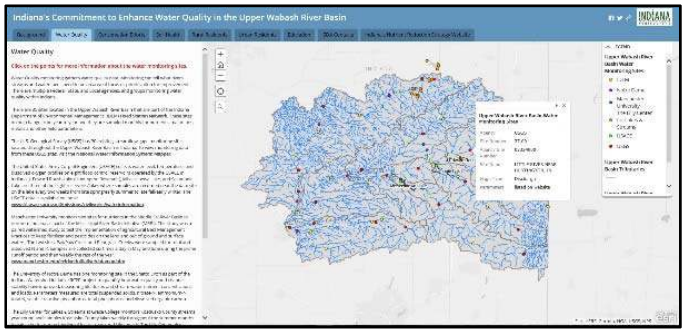

Figure 33. Image of Water Quality tab on the Upper Wabash Basin Story Map.

Indiana State Department of Health

Monitoring by Environmental Public Health Division

The Indiana State Department of Health's (ISDH) – 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. The ISDH website is https://www.in.gov/isdh/.

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

Figure 34. *ISDH staff at the 2018 Indiana State Fair's Pathways to Water Quality discussing private water wells and onsite sewage systems.*

Indiana University – Department of Geography

Spatial Analysis of Significant Water Withdrawal Facilities in Indiana

Legislators and state agencies have taken initial steps to improve databases needed for water resources planning in Indiana. In 2016, Indiana Senate Bill 347 was enacted to improve the state's understanding of water use in Indiana. As a part of that effort, Indiana University has implemented a program to provide accurate location information for significant water withdrawal facilities (high-capacity water users) registered with the Indiana Department of Natural Resources (IDNR) – Division of Water. Locations for approximately 19,000 wells and intakes (including approximately 9,000 active water sources) at facilities registered with the IDNR were reviewed or corrected. Public water supply wells and intakes were matched with those in Indiana Department of Environmental Management databases on drinking water quality. In addition, potentially unregistered water sources were identified for potential inclusion in water use reporting in Indiana.

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

Geological Investigations to Understand the Distribution of Arsenic in Groundwater

Arsenic is known to have adverse health effects on humans. Because bedrock lithology can play a role in groundwater chemistry in the dissolved phase, we hypothesize that the composition of unconsolidated materials that contain bedrock fragments might also yield insights into the distribution of elevated arsenic concentrations in groundwater. This project seeks to investigate the relationship between lithology and groundwater chemistry, as it relates to arsenic in groundwater. The primary task is analyzing existing borehole samples from various glacial-ice lobe deposits in Indiana. We are using a portable X-ray fluorescence sensor to analyze solid earth cores for arsenic in the sediments. Selected samples are being further studied to delineate their mineralogy (clay, trace elements), including the identification of clast lithology and their estimated abundance. For a very few select samples, we are also conducting zircon age analyses.

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

Indiana School Lead Sampling Program

The state of Indiana has tested drinking water for the presence of lead in public school buildings (Figure 35). The state's objective is to provide comprehensive planning, coordination, and sampling services for all schools that express interest and participate in the Indiana school water sampling program. Because lead can enter the drinking water distribution system through the corrosion of a variety of plumbing materials (pipes, fittings, fixtures, solder, and flux), it is important to identify potential problems at the fixture level under normal water use conditions (namely, when schools are in session). Working with the Indiana Finance Authority, Indiana University has completed inventories and collected 57,000 samples from drinking water fixtures in the more than 900 schools that participated in the program. Data synthesis, analysis, and reporting are currently underway. For more information visit https://www.in.gov/ifa/2958.htm.

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

Figure 35. *A Technical Assistance Provider inventories kitchen fixtures in a school that was sampled for lead in drinking water.*

An Assessment of the Persistence of Chloride from Source Water to Tap and its Implications for Potential Corrosion of Metal Pipes: A pilot study

Chloride is a conservative constituent of surface and groundwater, occurring naturally and anthropogenically from substances applied to the land surface (for example agricultural fertilizers, and road deicers). Because chloride dissolves completely, it is difficult to remove from the environment, especially water, except by expensive processes such as reverse osmosis. The inquiry into chloride for this study is its potential role in corrosion of metal infrastructure, including water distribution pipelines and solder. The presence of chloride can increase reactivity of metal complexes, initiating corrosion. We tested water collection and analysis methods along the treatment pathway from raw source water composition through the distribution system and at the destination (drinking water tap) to bolster the understanding of the persistence of chloride throughout that journey and document any changes along the way. A companion spatial analysis is underway to provide a statewide assessment of chloride in Indiana waters.

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

Indiana University Northwest

Great Lakes Innovative Stewardship Through Education Network (GLISTEN)

The Calumet cluster of Great Lakes Innovative Stewardship Through Education Network (GLISTEN) is a collaborative and interdisciplinary effort by local colleges, universities and environmental community partners to engage students in direct-action to preserve and restore the environmental health of the Lake Michigan watershed. Rooted in the goal of integrating meaningful watershed science in to science, technology, engineering, and math (STEM) curricula, GLISTEN partners develop curriculum components, organize service/stewardship activities, and conduct research with the objectives of addressing water quality and quantity issues across the Calumet region, largely in the Little Calumet-Galien watershed. A variety of individual projects exists within GLISTEN. Landscape restoration and stewardship activities are conducted within the context of a watershed approach. Ongoing stream monitoring efforts assess water chemistry, stream biology and habitat, physical parameters, and plastics

pollution. Data and educational tools are developed and shared to foster collaboration and increased awareness across our region. For more information visit http://greatlakesed.ipower.com/calume/.

For more information: *Erin Argyilan, Indiana University Northwest, Geosciences Department (eargyila@iun.edu).*

Manchester University – Biology Department

[See Stream Response to Holistic Restoration Strategies Through Innovative Conservation Partnerships: The Eel River Ecosystem Story]

Marion County Public Health Department

Marion County Public Health Department 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. 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 36).

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.

For more information: *Gretchen Quirk, Marion Co. Public Health Dept. (gquirk@marionhealth.org).*

Figure 36. *New informational sign posted near sampling site (Photo by Adam Rickert, MCPHD).*

Mundell & Associates, Inc.

Groundwater Monitoring for Lawrenceburg Conservancy District

The Lawrenceburg Conservancy District in Lawrenceburg, Indiana monitors water levels continuously with installed transducers a total of 25 piezometers located within and along the Lawrenceburg/Greendale Levee System located adjacent to the Ohio River. To assess the relative changes of the Ohio River water level relative to these groundwater levels, a new gauging station was also installed at Lawrenceburg. To learn more visit http://lawrenceburgconservancydistrict.com/understanding-the-river-level.

For more information: *Paul Seymour, Lawrenceburg Conservancy District (paul.sgc44@gmail.com).*

National Oceanic and Atmospheric Administration

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 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 identified in the 2018–2019 Strategic Plan 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 easy of obtaining this data to aid in decision making for stakeholders and sectors across the region.

For more information *or to become more involved in the Midwest Drought Early Warning System, please email Molly Woloszyn (*molly.woloszyn@noaa.gov*).*

The Nature Conservancy

Protection of floodplain habitat along the lower Wabash and White Rivers

The Nature Conservancy along with the Natural Resource Conservation Service (NRCS) in Indiana are working to protect floodplain habitat along the lower Wabash and White Rivers in Southwest Indiana. One aspect of this work is the protection of a specific habitat within the floodplain, the oxbow lake. These lakes are breeding and nursery grounds for several species of river fish. As part of this effort we are conducting monthly water sampling from spring to fall to get an idea of nutrient loads in the lakes and the potential impacts from hypoxia. The NRCS easement program WREP gives higher ranking to easement applications that are located within the sub-basins surrounding these lakes. Helping to ensure lower nutrient loads are entering the lakes outside of flood conditions.

For more information: *Brad Smith, The Nature Conservancy, Lower Wabash and Wetlands Program Director (*bsmith@tnc.org *).*

Purdue University – Department of Agricultural and Biological Engineering

Land use, land management, and climate trends and impacts on hydrology and water quality

Dr. Margaret Gitau's Water Resources and Ecohydrologic Engineering Research Group works on water quality with focus areas including hydrologic and water quality modeling, contaminant fate and transport, and the development of computer and internet based applications for water quality decision making and management. In a recent study, watershed hydrology and water quality responses to different projected climate scenarios were studied in an agriculturally dominated tile drained watershed in NE Indiana using the Soil and Water Assessment Tool (SWAT). Subsurface drains can provide accelerated conduits through which water and soluble nutrients make their way directly to main channels. Associated potential crop yield responses were also studied. Results of this study provide information necessary for decision making and developing strategies to control and mitigate the influence of anticipated changes in nutrient loadings. In a different study, the effectiveness of eight Green Infrastructure (GI) practices including rain barrels/cisterns, green roofs, green roofs plus rain barrels/cisterns, bioretention, porous roads, porous parking lots, porous sidewalks, and porous driveways on hydrology and water quality at a sewershed scale was evaluated using the enhanced Long-term Hydrologic Impact Assessment (L-THIA-LID 2.2) model. The total cost and the cost effectiveness for each scenario considering a 20 year lifetime for GI practices were also examined. Results from this study provide potential impacts of GI practices implementation on hydrology and water quality in the study site. The methodologies developed can be applied to other locations to support assessing the beneficial uses of GI practices.

For more information: *Margaret Gitau, Purdue University, Department of Agricultural and Biological Engineering (*mgitau@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 CMIP5 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 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).*

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 1 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.

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

Evaluation of Best Management Practices (BMPs) for water quality in Elliot Ditch, Indiana

Elliot Ditch is an urban/urbanizing watershed located in the city of Lafayette, IN. The city continues to struggle with storm water management and combined sewer overflow (CSO) events. Several best management practices (BMPs) such as rain gardens, green roofs, and bioswales have been implemented in the watershed, but the level of adoption needed to achieve meaningful impact is currently unknown. This USGS funded study's goal is to determine what level of BMP coverage is needed to impact water quality, whether meaningful impact is determined by achieving water quality targets or statistical significance. A power analysis was performed using water quality data for total suspended solids (TSS), E.coli, total phosphorus (TP) and nitrate-nitrite from Elliot Ditch from 2011 to 2015. The minimum detectable difference (MDD) was calculated as the percent reduction in load needed to detect a significant change in the watershed. The water quality targets were proposed by stakeholders as part of a watershed management planning process. The water quality targets and the MDD percentages were then compared to simulated load reductions due to BMP implementation using the Long-term Hydrologic Impact Assessment-Low Impact Development (LTHIA-LID) model. The model provides the baseline for targeted implementation scenarios designed to determine if statistically and physically meaningful load reductions can be achieved through BMP implementation alone.

For more information: *Sanoar Rahman and Laura Bowling, Purdue University (rahman17@purdue.edu; bowling@purdue.edu) and Fushcia-Ann Hoover, U.S. Environmental Protection Agency (fhoover@purdue.edu).*

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

The Indiana Watershed Initiative Regional Conservation Partnership Program (IWI RCPP) is pairing watershed scale implementation of winter cover crops and the two-stage ditch in two Indiana watersheds over four years (2015–2019). The project is quantifying changes in nutrient loss from fields through subsurface tile drains as well as ditches while also documenting changes in soil health. Water sampling occurs via year-round grab samples on the majority of tile drains in each watershed as well as at multiple points along the waterways. In addition, the project has deployed real-time nutrient sensors at the outlet of each watershed. The goal over the four year project is to achieve adoption of cover crops on 85% of cropland and installation of the two-stage ditch along the majority of channelized ditch draining the two demonstration watersheds, with the expectation that the two paired conservation practices (one landscape and one waterway) can provide a practical solution to nutrient and sediment loss from cropland. More details on the project can be found at https://environmentalchange.nd.edu/projects/preventing-nutrient-loss-from-indiana-farms-watershed-scale-pairing-of-cover-crops-and-the-two-stage-ditch/.

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

University of Southern Indiana – Department of Geology and Physics

The groundwater monitoring lab at the University of Southern Indiana

The University of Southern Indiana Groundwater Monitoring Lab was established in 2002 for teaching, research, and long-term monitoring 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 lab comprises a deep-shallow piezometer nest, measuring groundwater at 60 and 110 foot depths. Research and monitoring efforts focus on physical and stable isotopic characterization of the aquifer, and aquifer stressors including barometric influence and Earth tides. 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 37).

- Recent findings and updates of student involvement in the groundwater monitoring lab are posted at:

  https://www.facebook.com/USI-Undergraduate-Water-Resources-Teaching-and-Research-Lab-164934688093/

- 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

- The data collected at the USI Groundwater Monitoring Lab is also provided to the Voluntary Monitoring Program, a partnership between the IDNR and USGS. Archived water levels can be accessed at:

  https://nwis.waterdata.usgs.gov/nwis/gwlevels/?site_no=375750087404201

  https://nwis.waterdata.usgs.gov/nwis/gwlevels/?site_no=375750087404202

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

Figure 37. *A visit to the Groundwater Monitoring Lab in the Department of Geology and Physics at the University of Southern Indiana by the local NBC news affiliate to discuss issues of water quality and water resources in Southwestern Indiana.*

U.S. Army Corps of Engineers

U.S. Army Corps of Engineers Louisville District 2018 Water Quality Sampling

In 2018, the U.S. 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 eight 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 for additional analysis. At each site within the reservoir, the epilimnion, metalimnion, and hypolimnion 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.

For more information: *Visit the Louisville District Water Quality website at http://www.lrl.usace.army.mil/Missions/Civil-Works/Water-Information/Water-Quality/; or email louisvillewaterquality@usace.army.mil or call (502) 315-7439.*

U.S. Department of Agriculture – Agricultural Research Service

USDA-ARS National Soil Erosion Research Laboratory (NSERL)

The USDA-ARS National Soil Erosion Research Laboratory (NSERL) is a 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 15 years at the NSERL 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 U.S. 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 Natural Resources Conservation Service (NRCS). NSERL research information and software is available via our main website (https://www.ars.usda.gov/midwest-area/west-lafayette-in/national-soil-erosion-research/).

For more information: *Dennis Flanagan, U.S. Department of Agriculture, Agricultural Research Service (dennis.flanagan@ars.usda.gov).*

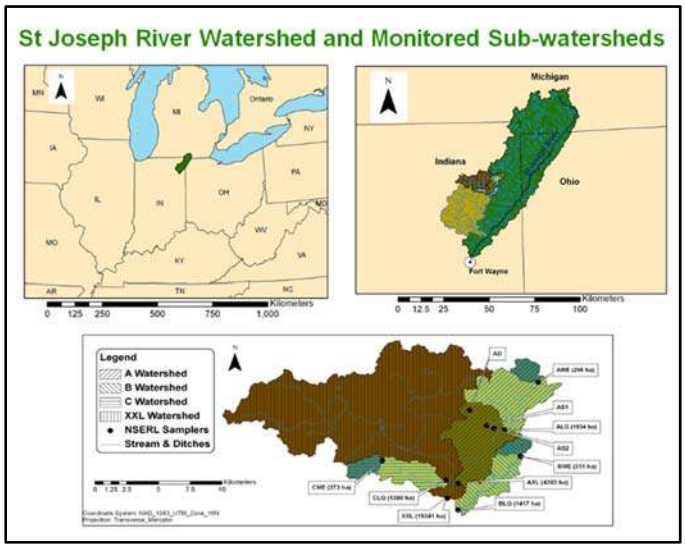

Figure 38. *NSERL monitoring sites in northeastern Indiana, in the Upper Cedar Creek watershed, a subcatchment of the St. Joseph River watershed.*

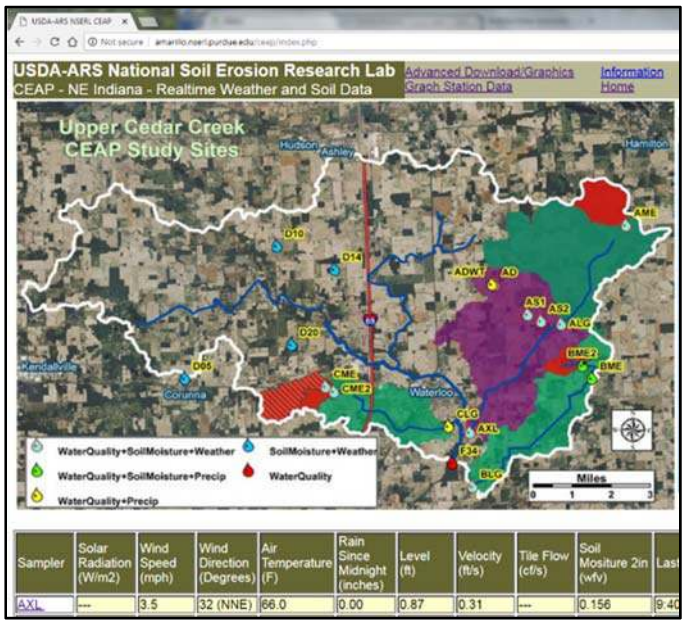

Figure 39. *Monitoring data available at http://amarillo.nserl.purdue.edu.*

U.S. Geological Survey

USGS Streamgages in Indiana

The U.S. 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 via the internet (https://waterdata.usgs.gov/in/nwis/rt). Streamgages are critical to National Weather Service flood forecasts and for flood control operations by the U.S. Army Corps of Engineers. They are also used for environmental compliance, water quality studies, ecological monitoring, water availability calculations, and recreational users.

For more information: *Jeff Woods, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (jwoods@usgs.gov).*

USGS Groundwater Network in Indiana

The U.S. Geological Survey 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 40 wells that are funded by the USGS and the Indiana Department of Natural Resources. Within the network, approximately 30 wells provide information to the public in near real-time via the internet. These wells collect groundwater levels to better understand recharge rates, water withdrawal from irrigation, and climate variability. Visit https://groundwaterwatch.usgs.gov/netmapT4L1.asp?ncd=IDN for more information.

In addition, the USGS, as directed by Congress, has established a national climate response network of groundwater wells. 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. Visit https://groundwaterwatch.usgs.gov/net/ogwnetwork.asp?ncd=crn for more information.

For more information: *Randy Bayless, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (ebayless@usgs.gov).*

Figure 40. *A groundwater monitoring site in rural Indiana operated by the U.S. Geological Survey. The site is co-located with a rain gage and continuously transmits data by satellite to the internet.*

Indiana Periodic Groundwater Networks

The U.S. Geological Survey in cooperation with the Indiana Department of Environmental Management, the city of Carmel, the city of South Bend, and St Joseph County Health Department collect individual measurements of groundwater level in three networks.

One 68 well network is located in Lake and Porter Counties in northwest Indiana and has been active since 1985 (Figure 41). Water levels are collected quarterly for long-term seasonal variations. The network started as a project with US Environmental Protection Agency to characterize baseline groundwater quality in the regional aquifer. https://groundwaterwatch.usgs.gov/netmapT4L1.asp?ncd=IDM

The 57 well St. Joseph County groundwater network is measured once a year for annual comparison of water levels.The wells were installed as part of a St. Joseph County groundwater resources study in the early 1990's https://groundwaterwatch.usgs.gov/netmapT4L1.asp?ncd=ISJ

The 31 well 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. https://groundwaterwatch.usgs.gov/netmapT4L1.asp?ncd=HCN .

For more information: *Travis Cole, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (tcole@usgs.gov).*

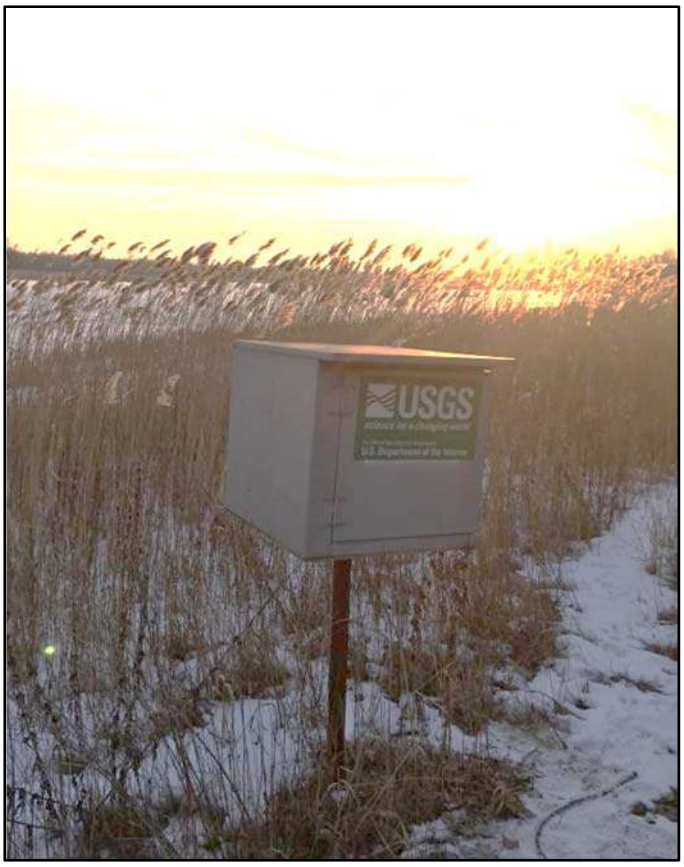

Figure 41. *Well E-3 located within Indiana Dunes National Lakeshore in the USGS Northwest Indiana periodic groundwater network.*

USGS Super Gages Monitor Continuous Water Quality at Streamflow Gages

The U.S. Geological Survey operates twelve 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://nrtwq.usgs.gov/in/). Tasks performed at each site often include quantification of streamflow, operation of continuous water quality monitors, discrete sampling, and modeling of constituents not easily measured in real-time. Continuous, and publicly available data highlight 15 minute, daily, and event driven fluctuations (https://waterdata.usgs.gov/in/nwis/current/?type=quality), provide richer data sets for understanding relations between water quality, hydrology, geology, and land use, and promote more effective resource management.

For more information: *Tim Lathrop, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (trlathro@usgs.gov).*

Figure 42. *U.S. Geological Survey Super Gage, 05515500 Kankakee River at Davis, Indiana, measures, records, and transmits publicly available continuous water quality characteristics. Photo taken in 2015 (Lathrop).*

Estimated Water Use in Indiana

The U.S. Geological Survey, 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 – 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. 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. Indiana has had among the largest withdrawals for self-supplied industrial use in the U.S. in recent national compilations. An estimated 4.9 million Hoosiers depended on public supplies for domestic water use in 2015.

For more information: *Gary Martin, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (grmartin@usgs.gov).*

Evaluation of Restoration Efforts at Urban Beaches on Southern and Western Lake Michigan

The U.S. Geological Survey, in cooperation with the Great Lakes Restoration Initiative, is collecting data to study the sources and occurrences of continual high E. coli detections at urban beaches along the Lake Michigan shoreline in northwest Indiana and northeastern Illinois (Figure 43). High E. coli detections cause the beaches to be closed for recreation use until additional samples verify that E. coli levels have fallen below the threshold of a maximum 235 counts per 100 ml. The project has been using microbial source tracking (MST) and metagenomics to identify the sources of E. coli. Additionally, continuous water quality parameters and surface water samples were collected to look at biological and environmental indicators. Synoptic surveys of water quality, circulation/transport, and bathymetry were done to help study surface water flow patterns. Groundwater samples were taken to compare with surface water E. coli results. Groundwater wells were installed at Jeorse Park Beach in 2017, and additional wells were installed at Whihala West beach in late 2017 and early 2018. The groundwater samples showed little to no presences of E. coli. Sand cores were collected and showed low levels of E. coli, but produced different biological communities than those found out in the lake water and sediments. These data will detailed in USGS data releases and published in a journal article during calendar year 2019.

For more information: *Travis Cole, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (tcole@usgs.gov).*

Figure 43. *Sand core collection at one of the Jeorse Park beach wrack line wells.*

National Assessment of Pesticides in Streams, Rivers, and Groundwater

The U. S. Geological Survey National Water Quality Program assessment of pesticides provides the most comprehensive national scale analysis of pesticide occurrence in surface waters and groundwater.

- Estimates of agricultural pesticide use and accompanying maps are provided on the Pesticide National Synthesis Project website (https://water.usgs.gov/nawqa/pnsp/usage/maps/index.php).
- The online mapper "Water-Quality Changes in the Nation's Streams and Rivers" (https://nawqatrends.wim.usgs.gov/swtrends/) describes the trends in changing water quality at hundreds of sites across the U.S. for dozens of constituents including pesticides, nutrients, sediment, and parameters related to ecological conditions.
- Watershed Regressions for Pesticides (WARP; https://cida.usgs.gov/warp/home/) is an online mapper that provides pesticide concentrations and the probability of exceeding human health and aquatic life benchmarks for 108 pesticides every five years, beginning in 1992. The mapping tool can be focused onto specific stream reaches to obtain predicted pesticide concentrations on a local level.
- The Pesticide Toxicity Index (PTI; https://www.sciencedirect.com/science/article/pii/S0048969713015714) is a screening tool to assess potential aquatic toxicity of complex pesticide mixtures through the use of an additive model. PTI values are determined for fish, benthic invertebrates, and cladocera. A WARP-PTI model was used to predict PTI in streams of the Midwest in 2013 (https://dl.sciencesocieties.org/publications/jeq/pdfs/45/6/1856).

For more information: *Megan Shoda, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (meshoda@usgs.gov).*

National Water Quality Network for Rivers and Streams

The U.S. Geological Survey National Water Quality Network for Rivers and Streams (NWQN) includes four sites in Indiana monitored by the USGS National Water Quality Program (NWQP). Primary objectives of the NWQN are to:

1. determine the status and trends of loads and concentrations of contaminants, nutrients, and sediment in the Nation's large rivers, including loads to selected estuaries;
2. determine the status and trends of concentrations of contaminants, nutrients, and sediment for selected streams in selected land use and environmental settings; and
3. determine trends in ecological condition in relation to trends in contaminants, nutrients, sediment, and streamflow alteration for selected streams in selected land use and environmental settings.

The NWQP continues to study nutrient transport to the Mississippi-Atchafalaya River Basin related to hypoxia in the Gulf of Mexico. NWQN sites in Indiana are sampled for nutrients, major ions, pesticides, suspended sediment, and dissolved organic carbon.

- The large inland river sites Wabash River at New Harmony and Ohio River at Cannelton Dam at Cannelton are sampled 14 times per year.
- The large inland river site White River at Hazleton has been monitored since 1991, and is currently sampled 18 times per year.
- Sugar Creek at New Palestine is a wadable stream in an agricultural land use setting. This site has been monitored since 1993, and is currently sampled 24 times per year. The Sugar Creek site is also sampled for biological communities (algae, invertebrates, and fish) and habitat, and has been sampled for ecological communities 19 times since.

Water quality summaries for NWQN sites that include annual loads and flow weighted concentrations can be found on the water quality tracking website at https://cida.usgs.gov/quality/rivers/sites.

For more information: *Jeff Frey, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (jwfrey@usgs.gov).*

Monitoring and Quantifying the Impacts of Green Infrastructure on Storm Water Flows in Urban Environments

In collaboration with the City of Gary and the Great Lakes Restoration Initiative, the U.S. Geological Survey is studying the effects of planned storm water reduction strategies and infrastructure on the hydrology of the highly permeable surficial aquifer material and storm sewer flows during a five year study. The USGS has installed and will monitor and analyze hydrologic data from a network of groundwater observation wells, soil moisture sites, storm sewers, and a weather station to understand the effect of the rain garden and other green infrastructure installations on storm water reduction. By monitoring conditions before and after the installation of green infrastructure, this study will assess:

1. the volume of precipitation at the green infrastructure installation and a control site,
2. the volume of water lost to evapotranspiration,
3. discharge to storm sewers in order to characterize changes in runoff volume due to increased infiltration,
4. Changes in the volume of storm water treated and infiltrated, and other hydrologic characteristics.

More information on the project can be found at the following website: 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: *Dave Lampe, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (dclampe@usgs.gov).*

Figure 44. USGS hydrologist collecting groundwater level data from a monitoring well at the Gary City Hall storm water reduction monitoring project site.

Edge of Field Monitoring in Black Creek Watershed, Northeastern Indiana

The U.S. Geological Survey, 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 plans 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, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (edobrowo@usgs.gov).*

Hydraulic and Water Quality Evaluations of Invasive Carp

The U.S. Geological Survey, in cooperation with the Great Lakes Restoration Initiative (GLRI), is collecting continuous data to monitor the movements of tagged invasive carp in the Ohio River. This data will help evaluate the effectiveness of the separation of the Wabash and Maumee River basins to prevent migration of invasive carp and verify that the final implemented barrier has no adverse impact on local flooding.

Hydrologic measurements funded through this project and field observations in 2013–2015 have identified regular spring flood conditions when the Wabash River basin intermittently connects with the Maumee River basin (Lake Erie) through a former glacial channel at Eagle Marsh in northeast Indiana (Figure 45). Construction of an aquatic nuisance species control barrier and spillway has been completed by partner agencies and NGOs along Graham-McCulloch Ditch to enhance separation of the basins and prevent migration of Asian carp and other aquatic invasive species through the marsh.

Streamflow and water temperature data demonstrate that separation of the Wabash and Maumee River basins is effective to prevent migration of Asian carp, and verify that the final implemented barrier has no adverse impact on area flooding. This project also included monitoring real-time video from a webcam installed in Eagle Marsh for water level changes that may allow the Wabash and Maumee River basins to connect. Continued regional monitoring of tagged carp species at other sites can be found on the Illinois Water Science Center Fish Telemetry website at https://il.water.usgs.gov/data/Fish_Tracks_Real_Time/.

For more information: *Edward Dobrowolski, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (edobrowo@usgs.gov).*

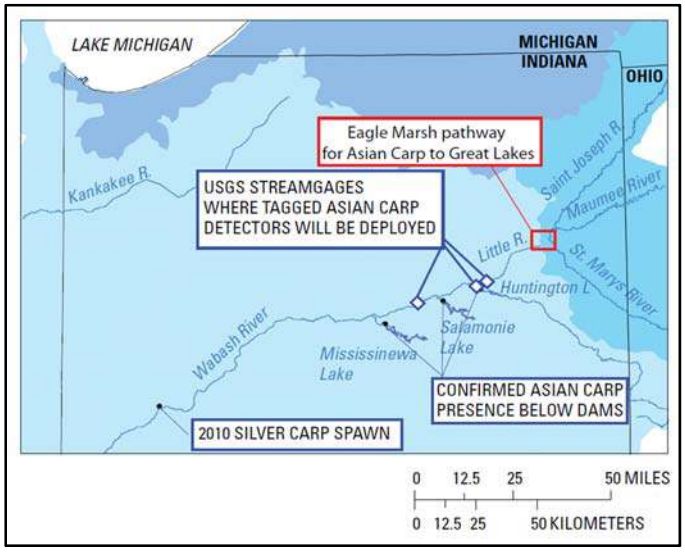

Figure 45. Location of Eagle Marsh site in relationship Great Lakes watersheds.

Monitoring Water Quality in the St. Mary's Watershed

An automatic water quality sampler was installed at the St. Mary's River near Fort Wayne streamflow gage operated by the U.S. Geological Survey. Water samples will be analyzed for nutrient and sediment concentrations needed to compute loads from the St. Mary's River. 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 at: https://waterdata.usgs.gov/in/nwis/uv/?site_no=04182000.

The 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 Fixed Network sampling site, 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 5–8 events each year, with 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, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (edobrowo@usgs.gov).*

Contaminants of Environmental Concern

Sampling sites to measure contaminants of environmental concern in the Great Lakes are located at the Indiana Harbor Canal in East Chicago, Portage Burns Waterway at Portage, Burns Ditch at Lake Station, and Salt Creek at Prairie Duneland Trail. Constituents for analyses varied annually and have included biological and chemical samples, pesticides, microplastics, wastewater compounds, polyaromatic hydrocarbons (PAH's), pharmaceutical compounds, and Poly- and perfluoroalkyl substances (PFASs). These sites are tributaries to Lake Michigan and can affect the water quality for aquatic and recreational activities in Lake Michigan. Water quality samples were collected quarterly from 2010 to 2014, and from 2016 to 2018.

For more information: *Kayla Christian, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (kmchristian@usgs.gov).*

Figure 46. *USGS hydrologists collecting a water sample at site 04092750 Indiana Harbor Canal at East Chicago, IN.*

Comparison of Water Quality Characteristics Between a Natural and a Managed Wetland

The U.S. Geological Survey and the U.S. Environmental Protection Agency collected isotopic, hydrologic, and water quality data from a natural (LaSalle State Fish and Wildlife Area) and a managed (Hog Marsh) wetland located along the Kankakee River in northwestern Indiana. One objective of the study was to compare differences in surface and groundwater quality between the two sites as well as the general area. Water quality characteristics vary between the two sites because of the different sources of water to the wetlands. The LaSalle wetland is supported by precipitation and natural groundwater flow, whereas Hog Marsh receives considerable surface water pumped from the Kankakee River to improve waterfowl habitat during periods of migration. The differences in water quality are important because of the impact that water quality has on wetland plant development. Data preparation is finished, and data analysis is beginning. The study will provide information on wetland water quality when wetland restoration is accomplished through creating managed wetlands. The study also will provide a rare and fairly complete water quality dataset for two types of Indiana wetlands, natural and managed. A companion report describes the difference in hydrologic characteristics between the two wetlands, such as the difference in groundwater level fluctuations. It is available online: https://pubs.usgs.gov/sir/2006/5222/.

For more information: *Les Arihood, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (larihood@usgs.gov).*

New approach to groundwater model construction

The U.S. Geological Survey is comparing a conventional groundwater model construction technique to a new technique that uses lithologic records from the Indiana Department of Natural Resources water well log database and a process called three-dimensional kriging. Typically, a model framework is built using a limited, hand selected number of well log records from the database, and layer thicknesses are interpreted for aquifer and non-aquifer deposits. In this new approach, all well logs within the database are used to improve the definition of deposits and therefore, model predictions. Texture based hydraulic properties are determined at regular intervals along the lithologic record. A computer program that does the three-dimensional kriging reads the hydraulic property values and outputs an estimated continuous three-dimensional distribution of hydraulic conductivity for the model. The new approach results in a reduction in model construction time, thereby decreased manpower requirements, and increasing improvements in model predictions over the conventional modeling approach. The comparisons are being made using a groundwater flow model of northwestern Elkhart County, Indiana. The report is near final approval.

For more information: *Les Arihood, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (larihood@usgs.gov).*

USGS Flood Inundation Mapping Program of Indiana

The U.S. Geological Survey Flood Inundation Mapping Program (FIMP) 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 website (https://wimcloud.usgs.gov/apps/FIM/FloodInundationMapper.html) 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, educational institutions, and local, state, and federal agencies. Currently, there are 33 sets of completed FIM libraries in Indiana and four more sets of FIM libraries will be completed soon. Completed FIM libraries in Indiana are available online at https://www.usgs.gov/centers/oki-water/science/flood-inundation-mapping-ohio-kentucky-and-indiana?qt-science_center_objects=0#qt-science_center_objects.

For more information: *Moon Kim, U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center (mkim@usgs.gov).*

Valparaiso University – Department of Biology

Biomonitoring of headwater streams in Northwest Indiana, Salt Creek watershed

Twice a year, once in mid-April and once in mid-October, students from Valparaiso University biology courses gather data on aquatic macroinvertebrates in the headwater streams of Meadowbrook Nature Preserve. Using protocols from Hoosier Riverwatch for biomonitoring by citizen scientists, students collect samples using D-nets from all habitats within the streams and identify organisms to significant taxonomic categories. Pollution Tolerance Indices are calculated and all data is provided to the Shirley Heinz Land Trust, the owners of the Meadowbrook preserve. The data is used to monitor changes in ecosystems that could indicate how land based restoration activities impact the Salt Creek Watershed.

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

Biomonitoring of storm water receiving waters for MS4 compliance requirements in Valparaiso, Indiana.

Five sites along the upper reaches of Salt Creek, in the city of Valparaiso (Figure 47) are sampled each Fall at the end of October/early November by students from Valparaiso University. Students, working in groups, collect data in the same way each year and make comparisons across years for changes in biotic indices. Hoosier Riverwatch protocols are used as the base of monitoring protocols for this project (Figure 48). The

City of Valparaiso collects physical data (dissolved oxygen, COD, nutrients, temperature, etc.) on the waterways at the same five sites and provides the data to students for further comparisons and analysis. Sample results are available upon request.

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

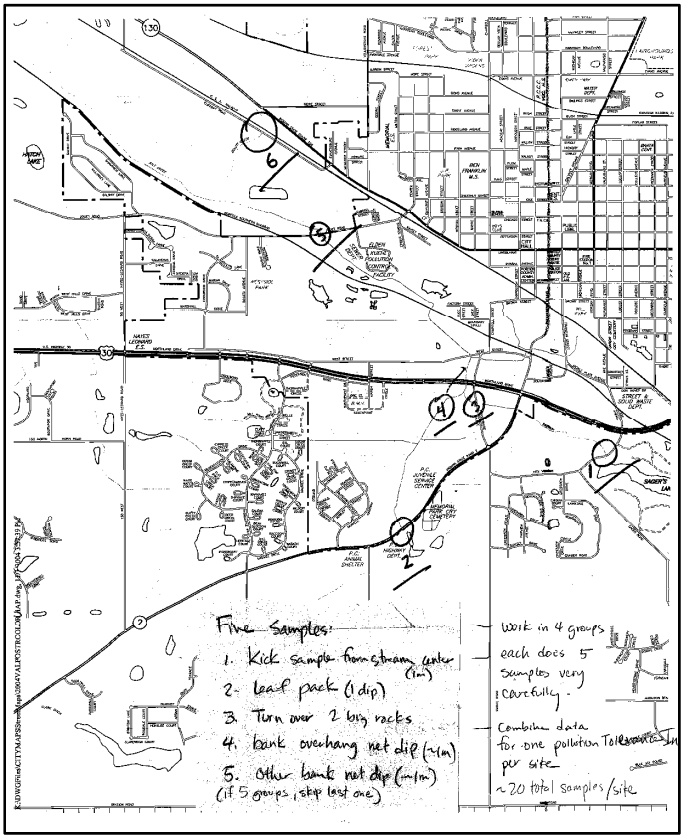

Figure 47. *Sampling sites along the upper reaches of Salt Creek, in the city of Valparaiso.*

Figure 48. *Valparaiso University students in headwater stream at Meadowbrook Nature Preserve after an afternoon of collecting aquatic macroinvertebrates.*

Valparaiso University – Department of Chemistry

Integrating microplastics pollution into traditional water quality monitoring protocol in the Salt Creek Watershed in Porter County, Indiana

Science faculty at Valparaiso University are working with undergraduate science research students and 8th grade science teachers and students at Willowcreek Middle School in Portage, Indiana in a watershed monitoring project to advance water quality research. Monitoring and sampling are taking place in the Salt Creek Watershed (part of the Lake Michigan Watershed), and research is being conducted to quantify microplastic pollution, mainly microfibers. The project team tasks consist of 1) collecting traditional water quality data, 2) quantifying and studying the transport and fate of microplastic pollutants, and 3) investigating the sources and destinations for synthetic microfiber pollution. A main project objective is to improve the procedure to integrate the detection of microplastics into traditional water quality monitoring. This large assemblage of water quality data will be useful for assessing the health of the watershed, and is necessary for future microplastic pollution mitigation strategies.

For more information: *Julie Peller (Principal Investigator), Valparaiso University, Department of Chemistry (julie.peller@valpo.edu); Laurie Eberhardt, Valparaiso University, Department of Biology; Chris Iceman and Robert Clark, Valparaiso University, Department of Chemistry (chris.iceman@valpo.edu; robert.clark@valpo.edu).*

Table 1. *Summary of water projects described in this report.*

Summary of Water Projects Described in this Report									
Organization	***Contact***	***Email***	***Project Title***	***Project Period***	***Focus***	***Domain***	***Project Scope***	***Congressional District***	***Page of Project Summary in this Report***
					Q = Water Quality A = Water Availability H = Water Hazard	**G = Groundwater S = Streams P = Precipitation O = Other**	**L = Local R = Regional or Multi-County S = Statewide N = Nationwide**	**1–9, All**	
Ball State University – Department of Natural Resources	Bangshuai Han	bhan@bsu.edu	Water Quality of Prairie Creek Reservoir	2018 – Present	Q	O	L	6	9
Center for Earth and Environmental Science at Indiana University – Purdue University (IUPUI)	Pierre-Andre Jacinthe	pjacinth@iupui.edu	Starkey Farms Edge of Field Sampling Project	2006 – Present	Q	S	L	4	9
Ecosystems Connections Institute, LLC in collaboration with Manchester University	Jerry Sweeten Herb Manifold	jesweeten@ecosystemsconnections.com jesweeten@manchester.edu hfmanifold@manchester.edu	Stream Response to Holistic Restoration Strategies Through Innovative Conservation Partnerships	2009 – Undetermined	Q, H	S, O	R	2	6
Grace College – Lilly Center for Lakes and Streams	Adrienne Funderburg	lakes@grace.edu	Water monitoring and research in Koskiosko County	2007 – Present	Q	S, O	R	2, 3	10
Hamilton County Soil and Water Conservation District	Ginger Davis	ginger.davis@hamiltoncounty.in.gov	Private Well Water Monitoring and Maintenance Initiative	2017 – Present	Q, H	G	L	5	11
Hamilton County Health Department	Morgan Bennett	morgan.bennett@hamiltoncounty.in.gov	Hamilton County Health Department Water Quality Program	2004 – Present	Q	S, O	L	5	11
Hoosier Environmental Council	Indra Frank	ifrank@hecweb.org	The Impact of Coal Ash on Indiana Groundwater	2016 – Present	Q	G, O	S	All	13
Indiana Department of Environmental Management	Jim Sullivan	jsulliva@idem.in.gov	Statewide Ground Water Monitoring Network	2008 – Present	Q	G	S	All	13
	Marylou Renshaw	mrenshaw@dem.in.gov	Fixed Station Monitoring		Q	S	S	All	13
	Marylou Renshaw	mrenshaw@dem.in.gov	Probabilistic Monitoring		Q	S	R	1, 2, 3	14
	Marylou Renshaw	mrenshaw@dem.in.gov	Reference Site Monitoring		Q	S, O	R	6, 8, 9	15
	Marylou Renshaw	mrenshaw@dem.in.gov	Contaminants Monitoring Program		Q	S, O	L, R	All	15
	Marylou Renshaw	mrenshaw@dem.in.gov	Blue-Green Algae Beach Sampling		Q	O	S	All	15
	Marylou Renshaw	mrenshaw@dem.in.gov	Performance Measures Monitoring		Q	S	S	3	16
	Marylou Renshaw	mrenshaw@dem.in.gov	Thermal Verification Projects		Q	S	S	8	17
	Marylou Renshaw	mrenshaw@dem.in.gov	Watershed Characerization Monitoring Projects		Q	S, O	R	8	17
	Marylou Renshaw	mrenshaw@dem.in.gov	Hoosier Riverwatch Volunteer Stream Monitoring		Q	S, O	S	All	17
Indiana Department of Natural Resources – Division of Reclamation	Peter Burch	pburch@dnr.in.gov	Monitoring of Streams Impacted by Past Coal Mining Activities in Southwestern Indiana	1994 – Present	Q	S	R	8	19
Indiana Department of Natural Resources – Division of Water	Mark Basch or Bill Davis	mbasch@dnr.in.gov wdavis@dnr.in.gov	Indiana's Water Shortage Plan	Continuous	A	G, S, P	S	All	19
	Bill Davis	wdavis@dnr.in.gov	Indiana Water Resource Updates	Continuous	A	G, S, P, O	S	All	19
	Mark Basch	mbasch@dnr.in.gov	Great Lakes-St. Lawrence River Basin Resources Compact	Continuous	Q, A	H, G, S, O	R	1, 2, 3	19
	Bill Davis	wdavis@dnr.in.gov	Voluntary Monitoring Program	Continuous	A	G	S, N	All	20
	Bill Davis	wdavis@dnr.in.gov	Potentiometric Surface Mapping	Continuous	A	G	S	All	20
	Mark Basch	mbasch@dnr.in.gov	Emergency Regulation of Groundwater Rights and of Surface Water Rights	Continuous	Q, A	G, S, O	S	All	21
	Mark Basch	mbasch@dnr.in.gov	Water Use Reporting	Continuous	A	G, S, O	S	All	21
	Mark Basch	mbasch@dnr.in.gov	Significant Water Withdrawal Registration	Continuous	A	G, S, O	S	All	21
	Mark Basch	mbasch@dnr.in.gov	Water Well Driller and Pump Installer Licensing, Continuing Education, Water Well Record Submittal, Well and Pump Installation Standards	Continuous	A	G	S	All	21
Indiana Geographic Information Council	Mike Martin	mmartin@dnr.in.gov	The IGIC Waters Workgroup	2007 – Present	A, H	S, O	S	All	22

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Indiana Geological and Water Survey	Shawn Naylor	snaylor@indiana.edu	Bedrock topography (BRT) of Indiana and the Continentally Glaciated U.S.	2010 – Present	A	O	S	All	23
	Shawn Naylor	snaylor@indiana.edu	The National Groundwater Monitoring Network: Contributions from IGWS	2017 – Present	A	G	S	All	23
	Bob Autio	rjautio@indiana.edu	Unconsolidated Sediment Database Description Tool	2018 – Present	A	O	S	All	23
	Bob Autio	rjautio@indiana.edu	Long-term monitoring of an urban/forest interface	2004 – Present	A	S, G	L	9	23
	Tracy Branam	tbranam@indiana.edu	Groundwater geochemistry of Indiana aquifers	1986 – Present	Q	G	S	All	24
	Kevin Ellett	kmellett@indiana.edu	Integrating Hydrogeological Studies with U.S. Geological Survey-Funded Mapping Projects	2018 – Present	A	G	S	All	24
	Lee Florea	lflorea@indiana.edu	Indiana Karst Observatory	2018 – Present	A, Q	G	R	8, 9	24
	Lee Florea	lflorea@indiana.edu	Indiana Dye Trace Database	2018 – Present	A, Q	G	R	All	24
	Lee Florea	lflorea@indiana.edu	Delineating the Harrison-Crawford Karst Aquifer	2018 – Present	A, H	G	R	9	25
	Adam Kuban	ajkuban@bsu.edu	Water Quality Indiana	2018 – Present	A, Q	S	L	R	25
	Shawn Naylor	snaylor@indiana.edu	The Indiana Water Balance Network	2011 – Present	A	G, P, O	S	All	25
	Shawn Naylor	snaylor@indiana.edu	Evaluating Tillage Practices on Near-Surface Groundwater Recharge: School Branch Watershed, Hendricks County, Indiana	2016 – Present	A	G	L	4	26
Indiana State Department of Agriculture	Julie Harrold	jharrold@isda.in.gov	Highlighting Indiana's Commitment to Enhance Water Quality through the use of GIS Story Maps of the Major River and Lake Basins in Indiana	2017 – Present	Q	S, O	S	All	26
Indiana State Department of Health	Mike Sutton	Msutton@isdh.in.gov	Monitoring of Environmental Public Health Division	2015 – Present	Q, H	G, S	S	All	27
Indiana University – Department of Geography	Sally Letsinger	sletsing@indiana.edu	Spatial analysis of significant water withdrawal facilities in Indiana	2015 – 2018	A	S, G	S	All	27
	Sally Letsinger	sletsing@indiana.edu	Geological investigations to understand the distribution of arsenic in groundwater	2015 – Present	Q	G	S	All	27
	Sally Letsinger	sletsing@indiana.edu	Indiana School Lead Sampling Program	2017 – Present	Q	S, G	S	All	5, 28
	Sally Letsinger	sletsing@indiana.edu	An Assessment of the Persistence of Chloride from Source Water to Tap and its Implications for Potential Corrosion of Metal Pipes: A Pilot Study	2017 – 2018	Q	S, G	S	All	28
Indiana University Northwest	Erin Argyilan	eargyilan@iun.edu	Great Lakes Innovative Stewardship Through Education Network (GLISTEN)		Q	S	R	1	28
Marion County Public Health Department	Gretchen Quirk	gquirk@marionhealth.org	Marion County Public Health Department Monitoring	1995 – Undetermined	Q	G, S	L	7	29
Mundell & Associates, Inc.	Paul Seymour	paul.sgc44@gmail.com	Groundwater Monitoring for Lawrenceburg Conservancy District	2018 – Present	A	G	L	6	29
National Oceanic and Atmospheric Administration / National Integrated Drought Information System	Molly Woloszyn	molly.woloszyn@noaa.gov	Midwest Drought Early Warning	2018 – Present	A	G, S, P, O	S	All	29
The Nature Conservancy	Brad Smith	bsmith@tnc.org	Promotion of NRCS Easements Through a WREP Agreement Focused on the Lower White and Lower Wabash River Floodplain	2017 – 2022	Q	G, S	R	8	30
Purdue University – Department of Agricultural and Biological Engineering	Margaret Gitau	mgitau@purdue.edu	Land Use, Land Management, and Climate Trends and Impacts on Hydrology and Water Quality		Q	G, S	L	All	30
	Keith Cherkhauer	cherkaue@purdue.edu	Statewide Hydrologic Modeling Efforts		A	S, O	S	All	31

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Purdue University – Department of Agronomy	Sanoar Rahman	rahman17@purdue.edu	Naturalized Streamflow for the Wabash River	2014 – Present	A, H	S	R	2, 3, 4, 5	31
	Laura Bowling	bowling@purdue.edu	Evaluation of Best Management Practices (BMPs) for Water Quality in Elliot Ditch, Indiana		Q	S	L	4	31
University of Notre Dame – Department of Biological Sciences	Jennifer Tank	jtank@nd.edu	Preventing Nutrient Loss From Indiana Farms With Watershed-Scale Pairing of Cover Crops and the Two Stage Ditch	2015 – 2019	Q	G, S	R	4, 2	32
University Of Southern Indiana – Department of Geology	Paul K. Doss	pdoss@usi.edu	Groundwater Monitoring Lab at USI	2002 – Present	Q, A	G, P	L, R	8	32
U.S. Army Corps of Engineers	Jade L. Young	Jade.L.Young@usace.army.mil	U.S. Army Corps of Engineers 2017 Water Quality Sampling	2017	Q	S, O	S	2-9	33
U.S. Department of Agriculture – Agricultural Research Service	Dennis Flanagan	Dennis.Flanagan@ars.usda.gov	USDA-ARS National Soil Erosion Research Laboratory	1954 – Present	Q	S, P, O	N	All	33
U.S. Geological Survey	Jeff Woods	jwoods@usgs.gov	USGS Streamgages in Indiana		A, H	S	S	All	34
	Randy Bayless	ebayless@usgs.gov	USGS Groundwater Network in Indiana		A	G	S	All	34
	Travis Cole	tcole@usgs.gov	Indiana Periodic Groundwater Networks	1970's – Present	Q, A, H	G	L, R	1, 2, 5	34
	Tim Lathrop	trlathro@usgs.gov	USGS Super Gages Monitor Continuous Water Quality at Streamflow Gages	2010 – Present	Q	S	S	All	35
	Gary Martin	grmartin@usgs.gov	Estimated Water Use in the United States	1950 – Present	A	G, S	N	All	35
	Travis Cole	tcole@usgs.gov	Evaluation of Restoration Efforts at Urban Beaches on Southern and Western Lake Michigan Networks	2015 – Present	Q, H	G, S, P, O	R	1	36
	Megan Shoda	meshoda@usgs.gov	National Assessment of Pesticides in Streams, Rivers, and Groundwater	1992 – Present	Q	S	N	All	36
	Jeff Frey	jwfrey@usgs.gov	National Water Quality Network for Rivers and Streams	1991 – Present	Q	S, O	N	All	37
	David Lampe	dclampe@usgs.gov	Monitoring and Quantifying the Impacts of Green Infrastructure on Storm Water Flows in Urban Environments	2016 – 2021	A, Q	G, S, O	L	1	37
	Edward Dobrowolski	edobrowo@usgs.gov	Edge of Field Monitoring in Black Creek Watershed in Northeastern, Indiana	2015 – Present	Q	S, O	R	3	38
	Edward Dobrowolski	edobrowo@usgs.gov	Hydraulic and Water Quality Evaluations of Invasive Carp	2013 – Present	O	O	N	All	38
	Edward Dobrowolski	edobrowo@usgs.gov	Monitoring Water Quality in the St. Mary's Watershed	2017 – Present	Q	S	R	3	38
	Kayla Christian	kmchristian@usgs.gov	Contaminants of Environmental Concern	2010 – 2018	Q	S	R	1	39
	Leslie Arihood	larihood@usgs.gov	Comparison of Water Quality Characteristics Between a Natural and a Managed Wetland	1997 – Present	Q	G, S	L	1	39
	Leslie Arihood	larihood@usgs.gov	New approach to groundwater model construction	2007 – Present	A	G	N	2	40
U.S. Geological Survey	Moon Kim	mkim@usgs.gov	USGS Flood Inundation Mapping Program of Indiana		H	S	S	All	40
Valparaiso University – Department of Biology	Laurie Eberhardt	laurie.eberhardt@valpo.edu	Biomonitoring of Headwater Streams in Northwest Indiana, Salt Creek Watershed		Q	S	L	1	40
	Laurie Eberhardt	laurie.eberhardt@valpo.edu	Biomonitoring of Storm Water Receiving Waters for MS4 Compliance Requirements in Valparaiso, Indiana	2004 – Present	Q	S	L	1	40
Valparaiso University – Department of Chemistry	Julie Peller	julie.peller@valpo.edu	Integrating microplastics pollution into traditional water quality monitoring protocol in the Salt Creek Watershed in Porter County, Indiana	2015 – Present	Q	S	L, R	1	41