# Institute of Water Research Annual Technical Report FY 2012

# Introduction

## Program Introduction

The Institute of Water Research (IWR) at Michigan State University (MSU) continuously provides timely information for addressing contemporary land and water resource issues through coordinated multidisciplinary efforts using advanced information and networking systems. The IWR endeavors to strengthen MSU's efforts in nontraditional education, outreach, and interdisciplinary studies utilizing available advanced technology, and partnerships with local, state, regional, and federal organizations and individuals. Activities include coordinating education and training programs on surface and ground water protection, land use and watershed management, and many others. We also encourage accessing our web site which offers a more comprehensive resource on IWR activities, goals, and accomplishments: <a href="http://www.iwr.msu.edu">http://www.iwr.msu.edu.

The Institute has increasingly recognized the acute need and effort for multi-disciplinary research to achieve better water management and improved water quality. This effort involves the integration of research data and knowledge with the application of models and geographic information systems (GIS) to produce spatial decision support systems (SDSS). These geospatial decision support systems provide an analytical framework and research data via the web to assist individuals and local and state government agencies make wise resource decisions. The Institute has also increasingly become a catalyst for region wide decision-making support in partnership with other states in EPA Region 5 using state-of-the-art decision support systems. The Institute works closely with the MSU Cooperative Extension Service to conduct outreach and education. USGS support of this Institute as well as others in the region enhances the Institute credibility and facilitates partnerships with other federal agencies, universities, and local and state government agencies. The Institute also provides important support to MSU-WATER, a major university initiative dealing with urban storm water issues with funding from the university Vice President for Finance. A member of the Institute's staff works half-time in facilitating MSU-WATER activities so the Institute enjoys a close linkage with this project. The following provides a more detailed explanation of the Institute's general philosophy and approach in defining its program areas and responsibilities.

## General Statement

To deal successfully with the emergence of water resource issues unique to the 21st century, transformation of our knowledge and understanding of water for the protection, conservation, and management of water resources is imperative. Radically innovative approaches involving our best scientific knowledge, extensive spatial databases, and "intelligent" tools that visualize wise resource management and conservation in a single holistic system are likewise imperative. Finally, holistic system analysis and understanding requires a strong and integrated multi-disciplinary framework.

## Research Program

The management of water resources, appropriate policies, and data acquisition and modeling continue to be at the forefront of the State, Regional, and National Legislatures agenda and numerous environmental and agricultural organizations. Our contribution to informing the debate involved numerous meetings, personal discussions, and most importantly, the enhancement of web-based information to aid in the informed decision-making process.

## Unique Capabilities: Decision Support Systems as the Nexus

IWR, with its “extended research family,” is exceptionally well-positioned to integrate research conducted within each of the three principal water research domains: hydrologic sciences, water resources, and aquatic ecosystems. Integrated decision support both reflects and forms the nexus of these three research domains. Expanding web accessibility to the decision support system nexus (formed by the intersection of the three research domains) will facilitate broad distribution of science-based research produced in these domains. A special emphasis is being placed on facilitation of science-based natural resource state and national policy evolution. Fundamentally we are addressing the Coupled Human and Natural System (CHANS).

The Institute’s extensive experience in regional and national networking provides exceptional opportunities for assembling multi-agency funding to support interdisciplinary water research projects and multi-university partnerships.

## Using a Multi-Disciplinary Framework

Using a multi-disciplinary framework facilitates dynamic applications of information to create geospatial, place-based strategies, including watershed management tools, to optimize economic benefits and assure long-term sustainability of valuable water resources. New information technologies including GIS and computational analysis, enhanced human/machine interfaces that drive better information distribution, and access to extensive real-time environmental datasets make a new “intelligent reality” possible. This is our way of addressing the "CHANS."

Effective watershed management requires integration of theory, data, simulation models, and expert judgment to solve practical problems. Geospatial decision support systems meet these requirements with the capacity to assess and present information geographically, or spatially, through an interface with a geographic information system (GIS). Through the integration of databases, simulation models, and user interfaces, these systems are designed to assist decision makers in evaluating the economic and environmental impacts of various watershed management alternatives.

The ultimate goal of these new imperatives is to secure and protect the future of water quality and supplies in the Great Lakes Basin and across the country and the world—with management strategies based on an understanding of the uniqueness of each watershed.

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# Natural Resources Integrated Information System

## Basic Information

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| **Title:** | Natural Resources Integrated Information System |
| **Project Number:** | 2012MI200B |
| **Start Date:** | 3/1/2012 |
| **End Date:** | 2/28/2013 |
| **Funding Source:** | 104B |
| **Congressional District:** | 8 |
| **Research Category:** | Water Quality |
| **Focus Category:** | Management and Planning, Water Quality, Water Use |
| **Descriptors:** | Management and Planning, Water Quality, Water Use |
| **Principal Investigators:** | Jon Bartholic |

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27. Bartholic, J., Y. Shi., J. Asher. 2012. Co-Creation and Adaptation of Tools for New Purposes and Audiences-Great Lakes, Gulf, Upper Mississippi, presented at the Midwest Spatial Decision Support System Partnership Conference in Chicago, IL, July 9-10.
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**Title:** Natural Resources Integrated Information System
**Project Number:** 2012MI200B
**Start:** 03/01/12 (actual)
**End:** 02/29/13 (actual)
**Funding Source:** USGS 104(B)
**Congressional District:** eighth
**Research Category:** Water Quality
**Focus Categories:** Management and Planning, Water Quality, Water Use
**Descriptors:** Management and Planning, Water Quality, Water Use
**Primary PI:** Jon F. Bartholic, Director, Institute of Water Research, Michigan State University, East Lansing, MI 48823, bartholi@msu.edu
**Project Class:** Research

## Problem and Research Objectives

### Nature and Importance to the Problem and Relevance to the Mission

Water is replacing oil as one of the single most important resources upon which policy and, in fact, human existence in many portions of the globe will depend. Political power, economics, and civilization's development will be critically impacted by our ability to sustainably manage and optimally utilize the planet's water resources. Because of the United States' relative advantage from a water resource standpoint, this country's role will be increasingly significant in food production and industrial production requiring significant quantities of water, and in developing sustainable approaches to maintain waters' ecological services. Specifically, the Great Lakes region will have tremendous opportunities to capitalize in numerous ways on the potential of its vast water resources. But water resources management always occurs in a social context involving multiple stakeholders. Stakeholders can have radically different perceptions of the problems and potential trade-offs associated with finding solutions because of dynamic social, economic, and political factors as well as biophysical complexities of water resources issues. This complex nature of water resource management and other related issues, such as global climate change and health care, is often referred to in the scientific community as "wicked." Research on wicked-type problems suggests that a comprehensive knowledge system sustained by a boundary organization is essential. Boundary organizations act as intermediaries between science and policy because they fulfill or possess (see Figure 1): 1) specialized roles within the organization for managing the boundary; 2) clear lines of responsibility and accountability to distinct social arenas on opposite sides of the boundary; and 3) a forum in which information can be co-created by research and interested parties. Since its very beginning and long history of existence, the Institute of Water Research (IWR) has been functioning as a boundary organization to tackle wicked water resources management issues. Through a history of extensive knowledge generation, engagement and facilitation, and working experience with local, state, and basin-wide organizations, IWR has a solid base of success to build upon in creating innovative knowledge systems for sustainable management of water resources.

## Previous Work and Present Outlook

Three current IWR projects illustrate approaches to solving wicked problems. The first project involves a nearly six-year experience in the co-creation, facilitation, and support for the State of

Michigan's Water Withdrawal Assessment Process to meet the requirements of the Great Lakes Basin Water Resources Compact (Steinman, et al. 2010) The assessment process integrates surface and groundwater hydrology and fisheries resource models to predict potential adverse resource impacts from water withdrawals. The role of IWR was to provide key input to state legislators and convene a science advisory committee. Also, IWR was assigned the task of developing the legislatively-designated web-based tool that is currently being used to assess potential water withdrawals. The second example, in place for the last seven years encompasses work with non-point source pollution reduction with the support of numerous agencies including the U.S. Army Corps of Engineers, EPA, MDA, USDA_NRCS, MAES, MSUE, and several foundations including The Nature Conservancy (TNC) and C.S. Mott Foundation. As part of this large effort, IWR developed a model to evaluate sediment contributions to the tributaries of the Great Lakes and its harbors. The model was used by IWR to identify and map the agricultural areas contributing the greatest sediment loadings. This enabled the Corps to begin targeting its sediment reduction efforts at a macro scale. More recently, IWR worked with MDA and USDA NRCS to refine this targeting approach at the local level in three Michigan watersheds. These watershed projects allowed IWR to complete development of a more refined High Impact Targeting (HIT) decision support system.

The HIT system is designed to aid federal, state, and local decision makers with prioritizing their sediment reduction efforts (O'Neil, Bartholic and Shi 2010; O'Neil, Theller, et.al. 2010). A third example involves IWR collaborating internationally with three Borlaug Fellows from India and the MSU Institute of International Agriculture (Bartholic, Shi, Maredia, et.al. 2010). The joint international effort included an Indo-U.S. Workshop on "Emerging Issues in Water Management for Sustainable Agriculture in South Asia Region," December 2009, in Tamil Nadu, India. This event was jointly organized by the Central Soil & Water Conservation Research & Training Institute (Indian Council of Agricultural Research) and Michigan State University. MSU was represented by the Institute of International Agriculture and IWR. The workshop was attended by top level representatives from over ten major water management programs. As a result of this workshop, a South Asia Water Knowledge and Innovation Network was formed, and IWR will be a major player in the expansive new efforts initiated at this workshop. An additional follow-on workshop entitled "Indo-US Workshop on the Critical Global Challenge: Managing Water Resources for Food Security and Sustainability" which took place March 2011, was jointly organized by the M.S. Swaminathan Foundation and University of Nebraska Water for Food Institute.

Our vision is to create an institute that effectively links science and technology for the sustainable management of water resources. There is a great need for local, state, national and international water resources management decisions and policies to be based on thorough scientific research and multidisciplinary expertise. IWR works across multiple units within the University and with numerous external partners. As water resources issues become more complex, IWR will embrace and strive to enhance its service as a boundary organization by advancing the understanding of wicked problems related to water issues among academia, state partners, NGOs, citizens of Michigan, and the global community and through the research and development of new decision support systems that help address these complex problems.

## Methodology

### Research Methods/Experimental Procedures

The manner in which we have engaged in team efforts with the scientific community from across campus, the state and region has been effective and provides an approach upon which we can build. As previously mentioned, we have an evolving process which will help us to transform our institute to more effectively address "wicked" problems. The advisory body will be critical in guiding the re-creation of our activities, which will lead to more holistic and effective approaches to addressing "wicked" problems. This transformation may be aided through support and input from various internal individuals and entities, including departments and units within CANR such as the proposed new Department of Natural Resources Ecology and Management, Department or focal area of Sustainable Studies and Biosystems Engineering. In addition, Dr. Hiram Fitzgerald, Director of University Outreach and Engagement, and colleagues, are refining a community-based systems approach for affecting change in social systems, which IWR may incorporate as a component of this new strategy. These various inputs will guide our initial activities. In addition to its staff members who have expertise in a broad array of water resources management topics, including database development and information systems, GIS, aquatic ecology and community-based water management programming, IWR has historically worked with many diverse faculty members representing a broad cross section of water resources expertise across MSU colleges. A listing of the faculty members and students who have recently worked with and received support from IWR on various water resources management projects was included in a recent report compiled for the Water Resources Partnership, a jointly funded agreement with the Michigan Department of Environmental Quality and MSU.

Our first achievement strategy is to build on and transform current IWR strengths, partnerships, and reputation. By working in a co-creative framework with individuals, policymakers and organizations to integrate the science and knowledge base, IWR is generating adaptive and dynamic systems for management of critical water resources that includes ecological, social and economic components.

(1) Reorganize IWR to more effectively link knowledge with action, i.e., connecting knowledge generation and local applications by becoming an appropriately structured boundary organization. The structure depicted in Figure 1 shows that IWR will not only serve as a critical link between the research and knowledge generated by the scientific community (i.e., entities at the University) and the user community, but will also serve to facilitate the co-creation of knowledge (middle column, Figure 1) by working with the end users (right column) and the scientific community (left column).

(2) Actively be involved in facilitating, leading, demonstrating and evaluating the co-creation process through numerous specific activities involving "wicked" problems. Water resources management with consideration for economic development is a complex or "wicked" problem because it often demands organizations/stakeholders at all levels to come together and find acceptable solutions to issues. Such solutions may also evolve over time when agreed upon by the parties involved. Integrating sciences into this dynamic social process and utilize modern technologies to facilitate communications and problem solving is the grand challenge we face as university researchers and technology transfer professionals. As a boundary organization, our objective is to be uniquely positioned to work across disciplinary boundaries and bring advanced sciences and technologies into decision makers' hands. Since

there is a large gap between academic research and real world operational applications, bridging this gap and streamlining research and the technology transfer process is a major task for IWR as a boundary organization. The efficient and effective utilization of modern technologies such as advanced Information and Communication Technology (ICT), GIS and numerical modeling is the key to achieve this objective.

(3) Develop decision support systems that provide support for knowledge users to make more informed decisions based on input from the knowledge generators. As we move from traditional PC-based computing era to a new Internet-based cloud computing age with millions of mobile computing devices coming online at an accelerated rate, we need to conduct further detailed research on how we can develop a new generation of water resources decision support and knowledge systems that can take advantage of recent advances in cyber infrastructure, social networking, geospatial technologies and numerical modeling and associated scientific visualization technologies. To implement this new generation of systems, we need to analyze the needs of different target audiences such as federal, state and local government agencies, NGOs, various environmental organizations and the general public. As a boundary organization, it's critically important that we bring environmental knowledge producers and consumers together under the same overarching umbrella and provide tools for them to work together in a mutually beneficial manner. We need to understand their needs and concerns and address them appropriately.

(4) Guide development of this new bridging structure through an external advisory body, representing a cross-section of users and scientific groups. This advisory body will have integrative and dynamic roles in providing guidance and ideas to communities of users. The scientists involved will provide connections to clusters of water expertise from the following: multiple units within CANR, such as the Center for Water Sciences and Department of Biosystems and Ag Engineering; other colleges, such as Natural Science and Civil and Environmental Engineering; and, external partners including the USGS Great Lakes Science Center, the Nature Conservancy and others.

(5) Provide an inclusive environment to facilitate a sense of trust among the knowledge users so they can effectively interact with the knowledge generators, creating an atmosphere and functionality where there is successful communication, translation, mediation, and adaptive process outcomes.

(6) Actively inform and partner with NGOs (with emphasis on TNC) and other funding agencies such as EPA, GLPF (Great Lakes Protection Fund), US Army Corps of Engineers, etc., to aid in acquiring support of IWR activities. These partnerships will help to add new funding sources to IWR's existing broad portfolio of funders to facilitate an expanding base of fiscal support.

## Literature Review

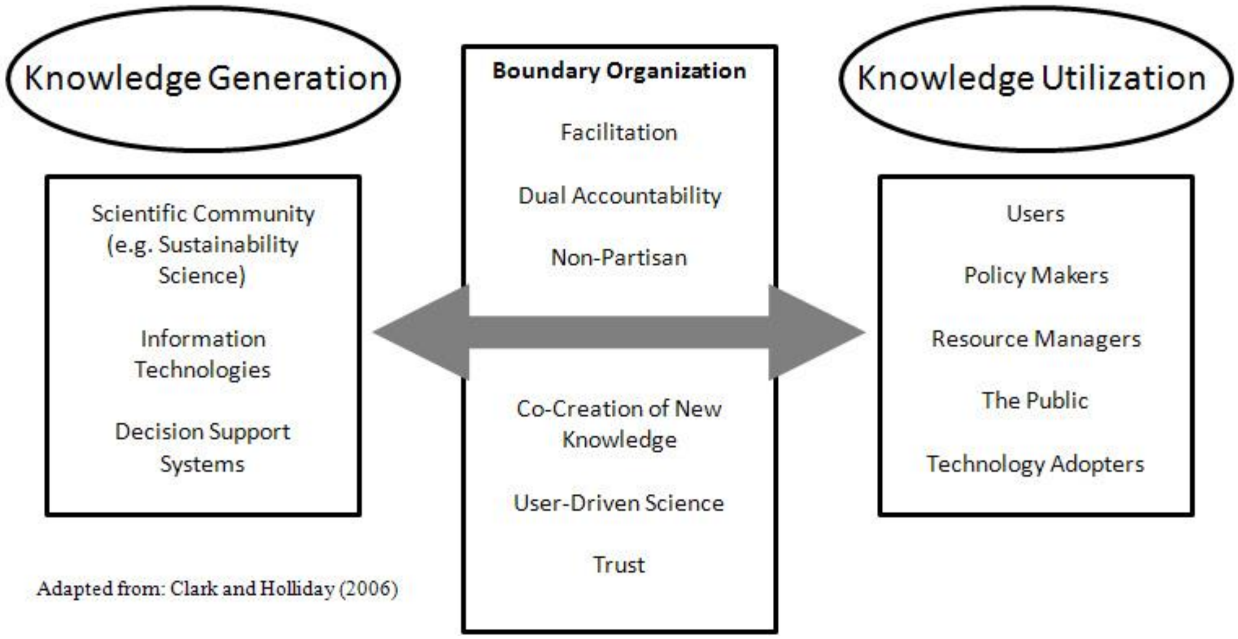


Figure 1. Boundary organization: Linking knowledge with action

All social, economic and environmental factors in a watershed need to be considered in a holistic approach to determine proper actions to manage water resources (Heathcote 1998; Gregersen et al., 2008). Watershed management often involves multiple stakeholders with conflicting interests. These stakeholders can have radically different perceptions of the problems and potential trade-offs associated with finding solutions because of dynamic social, economic, and political factors as well as biophysical complexities of water resources issues. This complex nature of water resource management and other related issues, such as global climate change or health issues, is often referred to in the scientific community as wicked problems (Batie 2008). These types of problems are so named because they are usually difficult to solve due to their complexities and changing nature and often may create other problems as the initial ones are being addressed.

Research on wicked-type problems suggests that a comprehensive knowledge system sustained by a boundary organization is essential (Cash et al., 2003). Boundary organizations act as intermediaries between science and policy because they fulfill or possess: 1) specialized roles within the organization for managing the boundary; 2) clear lines of responsibility and accountability to distinct social arenas on opposite sides of the boundary; and 3) a forum in which information can be co-created by interested parties (Cash et al., 2003). Ingram and Bradley (2006) define boundary organizations as those situated between different social and organizational worlds, such as science and policy. Guston (2001) list three conditions often attributed to successful boundary organizations. "First, they must provide incentives to produce boundary objects, such as decisions or products that reflect the input of different perspectives. Second, they involve participation from actors across boundaries. Third, they have lines of accountability to the various organizations spanned by the boundary organization." According to Batie (2008), adaptive and inclusive management practices are essential to the functioning of boundary organizations, and Ruttan et al. (1991) suggests that boundary organizations serve as a bridging institution and help to link suppliers and users of knowledge.

One way to further the efforts of boundary organizations, particularly with wicked problems, is to provide tools to assist with good decision-making using science-based data. Spatial Decision Support Systems (SDSS) are a type of computer system that combine the technologies of Geographic Information Systems (GIS) and DSS to assist decision-makers with problems that have spatial dimensions (Walsh 1993). SDSS are developed to integrate data, knowledge, and modeling results to identify, evaluate, and recommend alternative solutions to spatially distributed problems (Djokic, 1996; Prato and Hajkowicz, 1999). A SDSS focuses on a limited problem domain, utilizes a variety of data, and brings analytical and statistical modeling capabilities to solve the problems. It further depends on graphical displays to convey information to the users. It can be adapted to decision-maker's style of problem solving, and can easily be extended to include new capabilities as needed (Densham et al. 1989, Armstrong et al. 1990).

In natural resource management, SDSS have proven to be effective in a variety of applications such as flood prediction (Al-Sabhan et al., 2003) and conservation program management and best management practices assessment (Rao et al., 2007). Al-Sabhan et al. (2003) argued that a web-based hydrologic modeling SDSS can help solve problems such as limited accessibility by non-experts and the public; lack of collaboration support; and costly data acquisition and communications. They further indicated such system can offer openness, user friendly interface, transparency, interactivity, flexibility, and fast communication and be directly accessible to a broad audience including decision makers, stakeholders and the general public.

## Objectives

(1) Reorganize IWR to more effectively link knowledge with action, i.e., connecting knowledge generation and local applications by becoming an appropriately structured boundary organization.
(2) Actively be involved in leading, demonstrating and evaluating the co-creation process through numerous specific activities involving "wicked" problems.
(3) Develop decision support systems that provide support for knowledge users to make more informed decisions based on input from the knowledge generators.
(4) Guide development of this new bridging structure through an external advisory body, representing a cross-section of users and scientific groups.
(5) Provide an inclusive environment to facilitate a sense of trust among the knowledge users so they can effectively interact with the knowledge generators, creating an atmosphere and functionality where there is successful communication, translation, mediation, and adaptive process outcomes.
(6) Actively inform and partner with NGOs and other funding agencies to aid in acquiring support of IWR activities. These partnerships will help to add new funding sources to IWR's existing broad portfolio of funders to facilitate an expanding base of fiscal support.

## Plans to Disseminate Information from Stated Research

IWR has effectively worked with a variety of organizations and audiences. This has allowed IWR to build a diverse network of partners. As a complicated and wicked problem, effective water resource management requires solutions from the broad economic sectors it affects. With partners from the university, government, non-government, and private sectors, IWR will receive the input needed to reorganize itself as a boundary organization, bridging the gaps between each of the sectors. IWR will work with its partners and internally to co-create solutions to the complex problems posed by water resource management and disseminate this information through its well established technology transfer program, as well as through its decision support systems, regional networking, social networks and facilitation capabilities. Advisory body inputs will be critically important in defining targets, timelines, and expected impacts. This reorganization can evolve largely within our existing financial and personnel structures.

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## Principle Findings and Significance

Extensive investigation and research is needed to achieve effective coupling of human management needs with geospatial databases and decision support systems to assist better decision-making. Multiple research funding opportunities exist to support linking understanding of various phases of the hydrologic cycle with impacts on water use, management, and conservation. As a result, outstanding opportunities to develop scientific water management skills and techniques for the 21st Century are clearly within reach.

**Research and Development:** The *Water Resources Partnership* is a major effort with support and involvement from units across the University campus with the Michigan Department of Environmental Quality as the key external funding partner. At this time the project is a four year effort funded at 1.5 million dollars. [This project is inclusive in nature relative to Michigan's Department of Environmental Quality (MDEQ) partners and clients interested in the products.] Campus partners provide fundamental inputs relative to new frontiers such as computational thinking which is dependent on new computational capabilities, web technologies, and advanced GIS web-based delivery systems. Also, MSU's Extension and Outreach and Engagement units are involved. Fundamentally this project facilitates the discovery of new approaches for integrating advanced multi-scale modeling with intuitive visual and interactively enhanced outputs. Products from this activity are also used in other active projects, with those projects in turn providing general feedback into the Water Resources Partnership.

# An Overview of Activities:

**<u>Outputs</u>**

*General Background*: The IWR at MSU is responsible for coordinating research and educational programs on surface water and ground water quality and quantity. Established in 1961 the Institute addresses multi-disciplinary issues arising from the dynamic interaction of land and water resources and strengthens MSU's commitment to finding effective solutions to contemporary water resource Problems. The Institute has developed water-related programs across a wide spectrum of issues. Ongoing support from the USGS, Department of interior, Michigan Ag-Bio Research and MSU Extension helps fund important research and outreach on water issues with regional land national significance. The Institute's goal is to provide the most accurate and complete information on contemporary land and water issues to citizens, stakeholders, government agencies, and resource managers. To achieve this goal, the Institute consistently collaborates and forges partnerships with other research and resource conservation organizations and agencies. The result of these collaborations is the development of science-based information for use by decision makers faced with complex water issues. The increasing use of information technologies and decision-making is a fundamental part of the Institute's mission in the 21st Century.

*Programs*: The Institute functions in a coordinating role to support education, research, and outreach through partnerships with University departments, agencies, and organizations in the board water arena. Efforts focus on three major areas: (1) integrated watershed systems including both surface and ground-water; (2) extended education and outreach; (3) networking infrastructure.

*Integrated Watershed Systems*: The Institute continues to development decision support systems that utilize data, models, and spatial analysis to provide an increased understanding of land-water relationships. These systems are made available through interactive web based GIS/graphic tools.

Some examples are highlighted below.

*General Programs*: We believe the above brief description of the Institute's program makes it clear that our operation, with a budget in excess of $1 million a year, continually works on developing innovative tools using new technologies to assist with improved understanding and assessment of how human activities on the landscape can influence the natural system with emphasis on water quality and quantity. Several examples to highlight these programs follow.  We currently have a $225,000 three-year active project funded by the C.S. Mott Foundation (MOTT) through The Nature Conservancy (TNC) to work in the Saginaw Bay developing a variety of tools to enhance ecological services from the landscape. This GLRI proposed project is of particular importance as it will be a companion effort with the TNC/MOTT project but more importantly, we can tap into a whole array of understanding ecological outcomes from improved water quality resulting from better land-use practices. It is critically important to realize that farmers and other owners of land are likely more motivated to make improvements that will impact the environment; i.e. fish habitat, birds, and recreational use, etc. Thus we can incorporate knowledge from the TNC/MOTT project along with spatial system products, into the education and outreach components of this proposed project. Other examples of IWR work involves an NRCS CIG grant in which we partnered with the Michigan Department of Agriculture and supported half of three conservation technician salaries at three different County Conservation Offices. They were an integral part of the CIG project both at the state and local levels which led to the successful development and subsequent use of the High Impact Targeting (HIT) system now recommended by MDEQ and used by NRCS in many of their activities including prioritization of Farm Bill financial and technical assistance dollars. We have also worked on multiple projects with the Great Lakes Protection Fund. These projects facilitated the early conceptualization and development of the now highly successful Water Withdrawal Assessment Tool developed by IWR in cooperation with many others. This web-based tool is utilized throughout the state for on-line registering of new high-capacity wells. More recently the Great Lakes Protection Fund funded IWRs Networked Neighborhoods project that incorporates new social networking concepts and web-based interactive technologies allowing individual homeowners to easily upload their BMPs (rain barrels, rain gardens, etc.). Since the BMPs are all geo-position by the homeowners as they enter the data, the impact that these multiple practices have in any given watershed can be summarized within sub-watersheds providing feedback to the citizens on the combined positive impact they have had in reducing runoff and nutrient loads.

These are but a few of IWRs more recent activities each having their own components of outreach and dissemination incorporated into the Institutes ongoing technology transfer and outreach efforts.

*Programs Federal*: The following are specific examples of federal programs for which IWR has been funded. Multiple grants from the same agency are emphasized as over time we have developed successful partnerships by consistently meeting their expectations and effectively reported both on the program and fiscal responsibility.

A key series of federal grants to the IWR have been from the U.S. Geologic Survey with several consecutive five-year grants each approximately $500,000. Nearly half of these funds were provided for external grants to faculty at MSU and universities around the state. A significant portion of funds of roughly 30% went for technical assistance plus outreach and education.

Our strong research base is enhanced by our involvement in regional/national USDA Hatch/multi-state research projects. One such project, MICLO4064/W2190 entitled *Water Policy and Management Challenges in the West* (from W1190), addresses water policy and economic research and involves researchers across the U.S. Another Hatch/multi-State research project, MICLO4052/S1042 *Modeling for TMDL Development and Watershed Based Planning and Management and Assessment*, involves hydrologic and non-point source (NPS) modelers with a specific focus on total maximum daily loading (TMDL's) and general NPS reduction strategies. In January 2012 an additional project, MICL02236/Hatch, *Using a Decision Support System to Guide Practices and Summarize Multiple BMP Benefits in Watersheds*, addresses risk mapping technology and support to technicians accelerating reduction of soluble phosphorus loads and other nutrients and sediment to streams in the Saginaw Basin.

**Outcomes/Impacts**

The results of this three year project yielded what is now termed the High Impact Targeting (HIT) tool to calculate the highest eroding fields and watersheds. This system is now available throughout the Great Lakes Basin. Michigan Department of Environmental Quality's 319 program is suggesting the HIT system for use in the development of 319 watershed management plans and the system is being used by NRCS for prioritizing higher payments for practices to be placed in the highest risk locations determined with the HIT system. The Army Corps of Engineers through their 516(e) program have funded five projects from 2004 through the present to guide the development of modeling techniques for predicting soil erosion (sediment) loads to the Great Lakes. Subsequently they supported making this information available via the web for users throughout the basin. Because of the project success and providing timely reports, the work continues. Another project that has received multiple funding in this case is from EPA to MDEQ as part of the 319 program for a Social Indicators project. Three phases of this project was funded over a three-year period. This program is now being utilized by all states in the EPA Region 5 area and across the U.S. Over 100 watershed organizations are using this program to help inform their watershed planning and implementation organizations. After a webinar in August 2012 highlighting the system, over 50 new watershed groups requested permission to use the system in their watersheds. Additionally, a more formal training hosted by University of Wisconsin Extension with training materials developed by IWR-MSU took place in October 2012. Future training events are anticipated and being planned.

## Specific Projects Conducted

1. 2/3 to 3/4 of our support ($800,000 to $1 million annually) is for more specific projects. These projects can then be interwoven to maximize the effect. A list of projects organized by Research, Supporting tool development, Outreach, and Assessment follows.

### Table of Contents

## A. Regional Research/Ag BioResearch Projects

# Modeling for TMDL Development and Watershed Based Planning, Management and Assessment: S-1042 ~ 2012 Annual Report

## Output

Like many ecologically-significant Midwestern rivers, the Paw Paw River watershed is heavily impacted by agriculture, and as a result conservationists have prescribed conservation practices to improve hydrologic conditions and water quality. Implementing these strategies cost-effectively is difficult because one rarely knows where practices will be most effective, nor how to accurately predict the effects from a given practice. To address these gaps, several existing models were combined to identify and prioritize the most effective locations for improving water quantity and quality at the field scale. This research project was conducted and funded cooperatively with The Nature Conservancy (TNC). The investigation provides a means for quantifying the anticipated benefits for groundwater recharge based on practices applied at a field scale. Models Utilized - In the first phase, the outputs of 3 models were generated and merged to identify priority areas at the field scale for specific conservation practices. These 3 models include - (a) Sediment Delivery (High Impact Targeting) - The HIT model is a product of two underlying models, the Revised Universal Soil Loss Equation (RUSLE), and the Spatially Explicit Delivery Model (SEDMOD) to estimate at a 30-m resolution the percentage of soil from any given location entering the stream system. (b) Infiltration and Groundwater Recharge (SWAT Modeling) - SWAT was used to estimate the hydrologic water balance under both current and circa 1800 land cover, and then to estimate groundwater recharge for broad soil types under different land practices. (c) Sensitivity to Groundwater Withdrawal (WWAT Modeling) - WWAT is a tool that estimates the amount of flow of a river or stream that could be reduced (e.g. through groundwater pumping) before the species abundance of fish would be adversely impacted. To reach the goal of identifying priority locations where conservation practice implementation could optimize ground water recharge and minimize sediment loading, data was combined from the three models (HIT, SWAT, WWAT) and the results mapped, including only lands in the watershed with active row-crop agriculture. The highest priority was assigned to agricultural lands where HIT estimated sediment loading as high, the WWAT indicated a low amount of available groundwater as baseflow to streams, and on soils suitable to promote groundwater recharge modeled in SWAT. The various input layers were re-classified into numeric classes from 1-4 at natural breaks, with 4 having the highest priority. Sedimentation risk received highest priority because the HIT modeling provides the most site-specific information. WWAT results were given the lowest consideration in the model because of legal protections in Michigan and because specific conditions within tributaries were of lower concern than contributions to the Paw Paw River main stem. SWAT modeling demonstrated that soil-type played a strong influence on the benefits of tillage practices, so relatively moist type-C soils were prioritized and mapped separately from drier A-soils.

## Outcomes/Impacts

Collectively across the six practices, the prioritized scenarios provide an increase in groundwater recharge of between 23 and 36 percent over the historic scenario. Results for sediment reduction were more variable, but prioritized scenarios showed more than a 100 percent improvement in focusing on agricultural lands at risk for producing the highest sediment volumes. Prioritized areas and the groundwater recharge tool are now being used to inform implementation of conservation practices. Because of this projects success, TNC is expanding the effort to the Saginaw Bay with support from the C.S. Mott Foundation - Using Science to Target Conservation Practices in Critical Great Lakes Watersheds. This project is an example of The Nature Conservancys expanded conservation approach from site to systems. To implement this approach, Conservancy scientists are joining with key partners to address some of the most fundamental issues and challenges facing Great Lakes health today. The added value the Conservancy hopes to bring to the current body of conservation work is to develop an understanding, based on science, of the collective impact of conservation actions across these systems and to generate the tools and analyses that allow targeting of conservation practices that have been identified by science as having the potential to yield the greatest return on conservation investment. To this end, and in partnership with Michigan State University water scientists, Conservancy scientists are helping to develop ecological models that will tell us both where in the watershed to implement agricultural Best Management Practices (BMPs) and how much of a given BMP needs to be applied to achieve a measureable positive impact on the watershed and maximize return on conservation investment. TNC is also working with MSU to develop models that tell where sediments and nutrients originate on the land, and to quantify the amount of sediments and nutrients entering the waterway. The tool may also contribute to developing new funding models for support of conservation practice implementation. Coca-Cola North America (CCNA) operates their largest company-owned bottling plant in the Paw Paw watershed. CCNA is pursuing a goal of water neutrality in its global operations, defined as mitigating its use of water in production through on-site conservation and support of off-site watershed improvements. Based on this analysis, CCNA has provided support for targeted outreach, recruiting priority landowners for enrollment in USDA-funded cost-share programs to implement conservation practices. The analysis combined with the field-scale groundwater recharge calculator tool allow CCNA to correlate recharge benefits with practices initiated through their support. In the future, other institutions using large volumes of water may want to support similar projects to demonstrate progress toward offsetting their water use through sponsorship of activities that replenish water quantity and/or quality.

## Publications

ONeil, G., A. Shortridge. 2012. Quantifying local flow-direction uncertainty. International Journal of Geographic Information Science. In press.

Bartholic, J. 2012. Navigating a new course for water resource policy and management, Michigan State University Futures Magazine, MSU Global Water Initiative, volume 30 Nos 1 & 2. pg 21-26

Wolfson, L. 2012. Multiple Impacts on Michigan Waters Possible Due to Climate Change. Lake Effect. Michigan Chapter, North American Lake Management Society. June, Pages: 2, 6.

Legge, J., P.J. Doran, M. Herbert, J. Asher, G. ONeil, S. Mysorekar, S. Sowa and K. Hall. 2012. Prioritizing locations for implementing agricultural best management practices in a Midwestern watershed. Journal of Soil and Water Conservation. In press.

ONeil, G. 2011. Sediment Modeling for the Manitowoc and Twin Rivers Watersheds (Wisconsin), July 2010 – Jun 2011. Final Report prepared for U.S. Army Corps of Engineers, Detroit District, 477 Michigan Avenue, Detroit, MI 48226-2523.

**PRESENTATIONS**

Bartholic, J. 2012. Invited speaker at Great Lakes Decision Support Systems on Steroids, Presented at the Minnesota River Integrated Watershed Study Workshop, University of Minnesota – St. Paul Campus, MN, Jan. 16-17.

Bartholic, J. 2012. Environmental Decision Support Systems on Steroids: An Overview of Several Systems Being Developed by Groups on Campus, Center for Water Sciences, Natural Resource Bldg., MSU, Jan. 25.

Wolfson, L., J. Asher, C. Lampe, J. Grabill, Y. Shi, J. Bartholic and G. ONeil. 2011. Networked Neighborhoods to Encourage Adoption of Green Practices: Using social networking and mapping technology to improve the environment. Poster Session, NIFA National Water Conference, Washington, DC, February.

Bartholic, J. 2012. Farm Conservation/Environmental Credit Calculator (CCC), Webinar Presentation, March 22.

Kline-Robach, R., L. Wolfson, and J. Asher. 2012. Development of a Web-based Program to Encourage Adoption of Green Practices. Land Grant and Sea Grant National Water Conference, Portland, OR, May.

Bartholic, J. 2012. Productivity and Conservation Enhancement: Mapping, Assessing and Tracking, Natural Resource Working Group, East Lansing, MI, May 10.

Bartholic, J. 2012. Web-based Model Development-Agricultural Land Uses, presented at the Great Lakes Sedimentation Workshop in Ann Arbor, MI, May 31.

Bartholic, J. 2012. Watershed Targeting Program, USDA Technology Workshop, East Lansing, MI, June 25.

Bartholic, J., Y. Shi., J. Asher. 2012. Co-Creation and Adaptation of Tools for New Purposes and Audiences-Great Lakes, Gulf, Upper Mississippi, presented at the Midwest Spatial Decision Support System Partnership Conference in Chicago, IL, July 9-10.

Shi, Y. 2012. Mobil Technologies presented at the Midwest Spatial Decision Support System Partnership Conference in Chicago, IL, July 9-10.

Bartholic, J. (presenter), Y. Shi, J. Asher. 2012. Tools and Techniques for Watershed Management and Decision Support-Decision Support Systems for Water, Energy, and Food in an Uncertain World, presented at the UCOWR/NIWR Annual Conference: Managing Water, Energy & Food in an Uncertain World, Santa Fe, New Mexico, July 17-19.

Bartholic, J. 2012. Focused Practice Application to Reduce Soluble Reactive Phosphorus presented at the Regional Project Meeting S-1042, Gainesville, FL, Oct 26.

Bartholic, J. 2011. Watershed Targeting Program, USDA Technology Workshop. Washington, DC, November 3.

## Participants

Individuals, organizations, etc. are incorporated in the Outcomes section of this report.

## Target Audiences

State, Federal, County, Local, Extension, Environmental Organizations, Farmers, Schools, Township-County Officials - all are incorporated in the Outputs and Outcomes sections of this report.

## Project Modifications

Project nearing completion

# Water Policy and Management Challenges in the West: W-2190 ~ 2012 Annual Report

## Water Policy and Management Challenges in the West: W-2190 ~ Annual Report 2012

**Outputs**

A Special Message that guides our research from Gov. Rick Snyder-Ensuring our Future - Energy and the Environment. Excerpt - In Michigan, we care about energy and the environment because we care about our kids and their future. These areas do not lend themselves to quick fixes. But the rewards of the right decisions are tremendous. How do we know what the right decisions are? What we need to do is identify those actions or decisions that are adaptable. Water Use - Water is in demand by farmers for irrigation use, and by Michigan residents and businesses who want clean, safe water, 100 percent of the time. Michigan has created an innovative and simple-to-use system for water withdrawal as part of its obligations under the regional water management compact. We need to take the next steps regarding the states surface water use (lakes, rivers and streams). We will establish a Water Use Advisory Council to refine the Water Withdrawal Assessment Tool and to evaluate situations where large quantity water withdrawals adversely affect other users or the health of the aquatic system. We also need to make sure that any conflict resolution system that works for surface water users takes into account groundwater users. End Excerpt   The Institute of Water Researchs current activity that provides insights plus management and policy options is through an agreement with Ottawa County - (a) Since 2005, there have been instances where aquifers in certain areas of the County have not had the capacity to support new development, (b) Increased demand for groundwater has generated discussions regarding the impacts of water withdrawal from aquifers on surface waters and whether withdrawals are exacerbating brine, nitrate, and other contaminate-levels in domestic wells, (c) There is also concern regarding the potential for widespread, elevated water table levels that result from record rainfall and snowfall events, (d) In response, the County Planning Commission (CPC) developed the Comprehensive Water Resource Study (CWRS), (e) The CPC prepared a RFP to obtain professional consulting services for the Ottawa County CWRS. The Ottawa County Selection Committee recommended that the IWR conduct the CWRS. In order to accomplish the objectives of the Study the IWR proposed to develop an interactive web-based decision support system (IWDSS) that can be utilized by county and local officials. The IWDSS will enable users to see into the earth in a WebGIS-based environment by displaying interactive plan-view maps, and selected cross-sectional views of portions of the county where sufficient well-data exist. Also, Countywide Groundwater Data Analysis Products to - (a) determine the aerial extent and large-scale variation in thickness of the clay layer, (b) characterize at least three aquifer types, (c) provide a depiction of the general groundwater flow regime (direction and rate), (d) map the concentrations of sodium (Na), chloride (Cl), nitrate ($NO_3$), and Arsenic (As) within water well samples, (e) determine the fluctuations of water table depth, (f) graph the generalized decadal trend in mean static groundwater level.

**Outcomes/Impacts**:

Ottawa Water Resources Project Q2 Progress Report - August 22, 2012. Very important preliminary findings from the data analysis indicate some disturbing trends in Ottawa County groundwater quality and quantity. These present trends are under further investigation at this time. Following is a summary of the hydrogeological results from Drs. Li and Liao - (1) There is a really extensive, thick clay layer throughout most of central Ottawa county. Numerous, thinner clay confining layers extend under the eastern townships of the county, (2) We are unable to map a lower glacial aquifer anywhere in the county since the bottom of the thick clay layer is very close to bedrock surface in most places, (3) Increasing withdrawals from both the glacial aquifer package and the bedrock aquifer system has resulted in a lowering of the static water levels (SWL) in both aquifers. The decline in SWL for both aquifer types displays a strong spatial pattern (i.e., larger declines in some focal areas, less decline elsewhere), (4) The groundwater in the bedrock aquifer is becoming more saline (i.e., increasing chloride concentrations) through time. The spatial pattern of the chloride concentration increases clearly shows that the majority of it is NOT a surface contamination problem (e.g., road salt), but is coming from below within the bedrock aquifer. It is likely that the increasing withdrawals from the bedrock aquifer have caused saline groundwater from deeper in the bedrock aquifer system to migrate upward toward the top of the Marshall Formation beneath central Ottawa County, (5) Nitrate concentrations are elevated (greater than 3 mg/L) in many areas of the county and have been increasing through time. There are numerous hotspots throughout the county, especially in the areas just east of Ferrysburg and Grand Haven, in the area south and SE of Zeeland, in central and western Allegan Twp, in central Georgetown Twp, and in SW Jamestown Twp. In many of these hotspots, the nitrate concentrations are 5 - 10 times the drinking water standard of 10 mg/L. Update by Dr. Yi Shi on the development of the Interactive Web-based Distribution Support System (IWDSS). A scenario based DSS prototype system has been developed. It is based on jQuery and jQuery Mobile front end. This system adopts the so-called mobile first strategy so the system can be run on any device including tablets, smartphones and desktop PCs. The flexible interface also offers tight integration with tutorial information that is critical for this project. Users can also click on the map to query for specific values of certain scenarios. An address locator is also available for use on top of other common interactive mapping capabilities.

## Publications

ONeil, G., A. Shortridge. 2012. Quantifying local flow-direction uncertainty. International Journal of Geographic Information Science. In press.

Bartholic, J. 2012. Navigating a new course for water resource policy and management, Michigan State University Futures Magazine, MSU Global Water Initiative, Volume 30 Nos 1 & 2, pg 21-26.

Wolfson, L. 2012. Multiple Impacts on Michigan Waters Possible Due to Climate Change. Lake Effect. Michigan Chapter, North American Lake Management Society. June, Pages: 2, 6.

**PRESENTATIONS**

Bartholic, J. 2012. Water Resource Study Kick-Off Meeting, Ottawa County Water Study Project presentation , West Olive, MI, Jan. 11.

Bartholic, J. 2012. Invited speaker at Great Lakes Decision Support Systems on Steroids, Presented at the Minnesota River Integrated Watershed Study Workshop, University of Minnesota-St. Paul Campus, MN, Jan. 16-17.

Bartholic, J. 2012. Environmental Decision Support Systems on Steroids: An Overview of Several Systems Being Developed by Groups on Campus, Center for Water Sciences, Natural Resource Bldg., MSU, Jan. 25.

Bartholic, J., Y. Shi., J. Asher. 2012. Co-Creation and Adaptation of Tools for New Purposes and Audiences-Great Lakes, Gulf, Upper Mississippi, presented at the Midwest Spatial Decision Support System Partnership Conference in Chicago, IL, July 9-10.

Shi, Y. 2012. Mobile Technologies presented at the Midwest Spatial Decision Support System Partnership Conference in Chicago, IL, July 9-10.

Bartholic, J. (presenter), Y. Shi, J. Asher. 2012. Tools and Techniques for Watershed Management and Decision Support-Decision Support Systems for Water, Energy, and Food in an Uncertain World, presented at the UCOWR/NIWR Annual Conference: Managing Water, Energy & Food in an Uncertain World, Santa Fe, New Mexico, July 17-19.

Bartholic, J., S. Li, D. Lusch, Y. Shi, K. Schindler. 2012. Ottawa County Planning Commission Water Study Project, presentation of Case Study, IWDSS, and Data Analysis. October 29.

Bartholic, J., D. Lusch, Y. Shi, K. Schindler. 2012. Ottawa County Water Resources Study: An Update-Background, Water Quantity/Quality Analysis, Interactive Web Decision Support System, and Planning and Policy Perspectives presented at the Ottawa County Seventh Annual Water Quality Forum in West Olive, MI, Nov. 1.

**Participants**

Organizations, agencies, etc. are incorporated into the Outcomes section of this report.

**Target Audiences**

State and Federal Agencies, Policy Makers, Natural Resource Organizations. All are incorporated into the Outputs and Outcomes sections of this report.

**Project Modifications**

# Using a Decision Support System to Guide Practices and Summarize Multiple BMP Benefits in Watersheds

## Using a Decision Support System to Guide Practices and Summarize Multiple BMP Benefits in Watersheds

### Hatch MICL02236-CRIS Report 2012

### Outputs

This research evaluates and integrates the DSS process by utilizing an actively supported project in the Flint River Watershed. The project provides risk mapping technology and support to technicians accelerating reduction of soluble phosphorus loads and other nutrients and sediment to streams in the Saginaw Basin. Conservation practice implementation is focused on fields with the greatest potential to improve water quality and include BMPs generally recommended by NRCS plus practices not widely used such as cover crops, and management of nutrients and drainage water. New technology will also support school and 4-H water quality related projects.

Components have been addressed and effectiveness evaluated including (1) identifying specific sites that have the greatest potential to impact lowering nutrient levels in streams (2) influence land managers actions with education, technical support and financial assistance (3) developing an improvement action plan to reduce losses (4) facilitate and support for implementing practices contained in the improvement action plan (5) evaluate implemented practices environmental and economic benefits (6) assist local schools in their water quality projects by linking to landscape characteristics and (7) report benefits to the broader agricultural community. Key components of the DSS to guide practices and summarize multiple BMP benefits include integration of numerous models/techniques/tools being made operational with local spatial data, and distributed using fully developed, supported, and proven information technologies, web-based systems, and web services. Six (6) individual tools/models are being partially or entirely integrate into the DSS for strengthening organized networks of technical experts and their capabilities. (1) Digital Watershed (DW) www.iwr.msu.edu/dw, (2) The High Impact Targeting (HIT) www.iwr.msu.edu/hit2, (3) The Soil and Water Assessment Tool (SWAT), (4) The SWAT recharge component designed for TNC and Coca-Cola for developing a water neutral footprint, (5) Developed methods to identify ephemeral gully locations, (6) Networked Neighborhoods for Eco-Conservation Online (NECO) is a web-based tool that helps link individuals together in the Great Lakes region to map and share green practices they have put in place or are interested in implementing, www.iwr.msu.edu/neco. Each of these tools/models functions are being integrated into a process that will result in a series of physical and digital maps that are web accessible and interactive. The system will assist landowners and technicians in identifying and addressing critical areas related to soluble phosphorus and sediment delivery. Through existing technology (NECO), practices can be mapped and reported at various scales providing a method to track their beneficial impacts.

## Outcomes/Impacts

The improved efficiency and effectiveness of existing organizations (many partially funded from the Great Lakes Restoration Initiative) is a major evolving outcome of the DSS and related technical assistance. This is an ideal time to evaluate the impacts of the increased technical expertise in these two watersheds while maintaining connections for future expansion to the entire Saginaw Basin. Local organizations in the watersheds have been active for several years and there are fully developed watershed plans for both watersheds. Additionally, there are numerous Great Lakes Restoration Initiative, MI Dept of Ag and Rural Development, Nat Resource Conservation Service, and local projects supported in these watersheds. The increasing rate that a variety of practices leading to potentially reduced nutrient and sediment loads to streams and the Great Lakes, are being evaluated. The percent of these practices in the highest risk areas are being calculated with concurrent estimates of reduced loads. With this system in place along with integrated communication networked organizations, programs are being enhanced and more effectively executed to meet water quality improvement goals. The EPA Program STEP-L spreadsheet results are being augmented and made more relevant to water quality outcomes with the priority mapping and water quality assessment system in place. Evaluation is both normative and summative throughout the duration of this project, and ongoing analysis of the various components are also being obtained via feedback from our Advisory Committee. This project is designed to have ongoing feedback from users of the DSS and social networking. The feedback is vital as the systems design characteristics are tweaked to enhance understandability and ease-of-use. The evaluation will lead to changes and improvements throughout the project and aid with any design changes that may be required. Broad expansion of the system across priority watersheds and the Great Lakes is anticipated following completion of this research project.

## Publications

ONeil, G., A. Shortridge. 2012. Quantifying local flow-direction uncertainty. International Journal of Geographic Information Science. In press.

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Bartholic, J. 2012. Environmental Decision Support Systems on Steroids: An Overview of Several Systems Being Developed by Groups on Campus, Center for Water Sciences, Natural Resource Bldg., MSU, Jan. 25.

Wolfson, L., J. Asher, C. Lampe, J. Grabill, Y. Shi, J. Bartholic and G. ONeil. 2011. Networked Neighborhoods to Encourage Adoption of Green Practices: Using social networking and mapping technology to improve the environment. Poster Session, NIFA National Water Conference, Washington, DC, February.

Wolfson, L., K. Stepenuck, J. Iles, B. Liukkonen, and T. Grant. 2011. Building Volunteer Capacity and Comparing Methods for *E. coli* Monitoring in Streams: A Multi-State Effort. Poster Session, NIFA National Water Conference, Washington, DC, February.

Bartholic, J. 2012. Farm Conservation/Environmental Credit Calculator (CCC), Webinar Presentation, March 22.

Bartholic, J. 2012. MSU's Virtual Watershed Program-An Internet-based Academic Credit or Professional Certificate Program in Watershed Management Online, East Lansing, MI, March 0.

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Bartholic, J. 2012. Productivity and Conservation Enhancement: Mapping, Assessing and Tracking, Natural Resource Working Group, East Lansing, MI, May 10.

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Bartholic, J. 2012. 54$^{th}$ Annual Regulatory Studies Program CAMP, Water Resource Management, presented at the Institute of Public Utilities Conference, MSU Kellogg Center , Michigan State University, East Lansing, MI August 14.

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**Participants**

State, Federal, County, Local, Extension, Environmental Organizations, Farmers, Schools, Township-County Officials

**Target Audiences**

State, Federal, County, Local, Extension, Environmental Organizations, Farmers, Schools, Township-County Officials

**Project Modifications**

Not Applicable

# Ottawa County Comprehensive Water Resource Study

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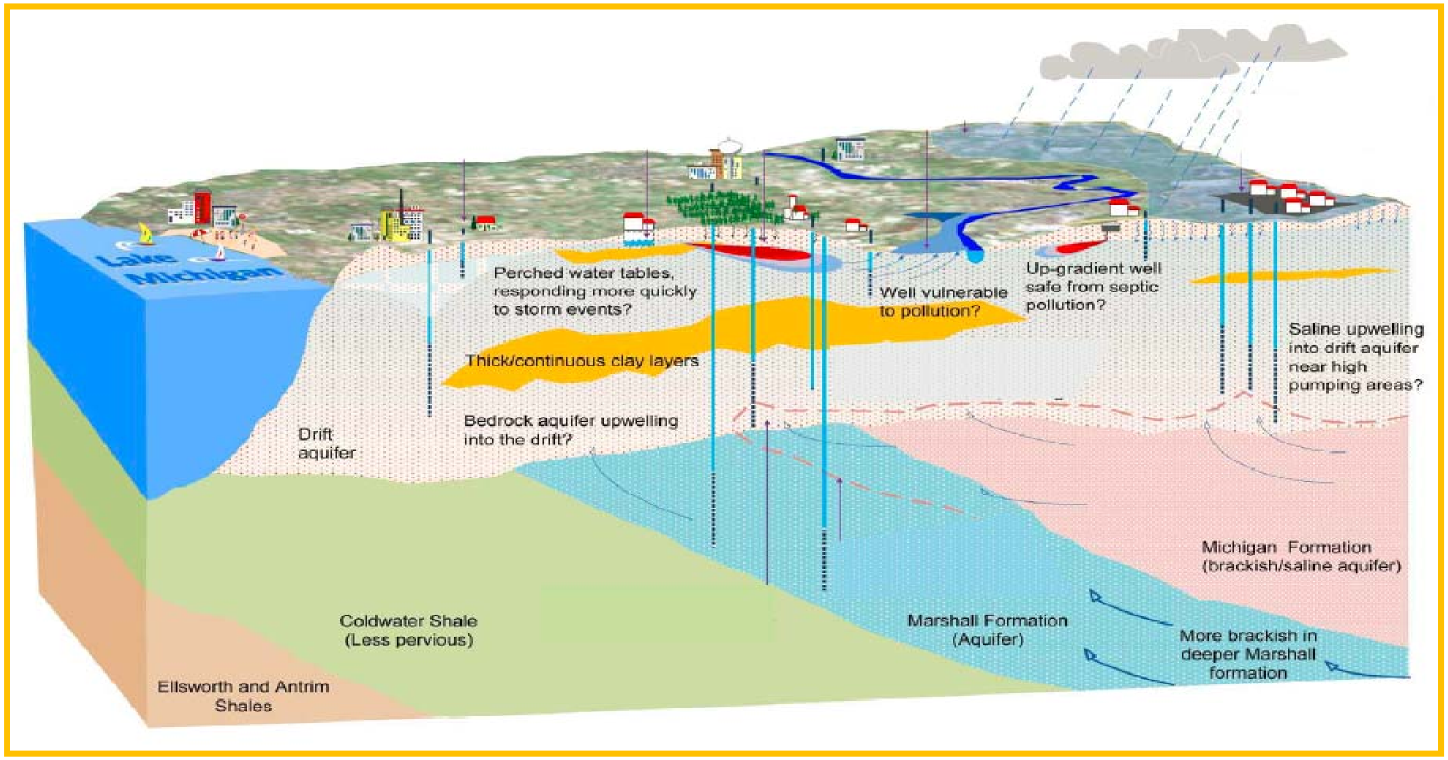
# EXECUTIVE SUMMARY

## Introduction

In recent years, several groundwater resource issues occurred in Ottawa County, Michigan that caused concern by both citizens and their local, elected officials. These problems included unreliable groundwater availability (quantity) in certain areas of the county, impaired groundwater quality (high brine and nitrate concentrations) in certain areas of the county and basement flooding (thought to be due to an elevated water table level).




A conceptual sketch illustrating some key water resources issues facing Ottawa County.

To gain a better understanding of the groundwater resource status in the entire county and provide preliminary decision support tools for county and township officials, Ottawa County contracted with the MSU Institute of Water Research (IWR) to carry out a comprehensive groundwater resource study and develop an interactive, on-line, water resources decision support system. A team of experts from the Department of Civil and Environmental Engineering, the Department of Geography and IWR were assembled to accomplish all the objectives specified in the contract.

The core objectives of the study were to:

- Describe the aquifers beneath Ottawa County and evaluate their ability to sustain current and future water withdrawal demands.
- Map the static water levels in the aquifers of Ottawa County and their change across the period of the available well records.
- Evaluate the recharge areas to the aquifers of Ottawa County in terms of size, location and relative recharge rates.
- Characterize the groundwater quality in the aquifers of the county, especially regarding their salinity and nitrate concentrations.

The MSU team conducted a comprehensive groundwater resource study based solely on existing data in state databases such as Wellogic, GWIM and WaterChem. In order to stay within the allocated budget, no new data were collected in the field nor developed from laboratory analyses.

# Aquifers

The Phase-1 study has documented that there are two, areally extensive aquifers in Ottawa County: a shallow, unconfined aquifer in the glacial deposits and a deep, confined aquifer in one of the bedrock formations beneath the county. In most places within Ottawa County, these two aquifer systems are separated by an extensive, thick clay layer. The upper, glacial aquifer is thickest and most areally extensive along the coastal margin of the county. It thins and becomes less extensive inland, essentially pinching out on the west side of the Grand River valley near the common borders of Allendale, Tallmadge and Georgetown townships.

The only productive bedrock aquifer beneath Ottawa County is the Marshall Formation, a very fine- to coarse-grained sandstone. The Marshall sandstone subcrops diagonally beneath the center of Ottawa County, trending from Spring Lake and Crockery townships in the NW to Jamestown Township in the SE. Stratigraphically, the Marshall Formation overlies the Coldwater Shale and in overlain by the Michigan Formation. Along its subcrop contact with the Coldwater Shale, the Marshall Formation is thin; it thickens considerably to the east and southeast. The Coldwater Shale unit is a master confining unit with the Michigan Basin. The Michigan Formation is dominantly shale, but also includes discontinuous beds of sandstone, limestone, dolostone, gypsum, and anhydrite. In some places, the Michigan Formation is a marginal aquifer, but generally serves as a partially confining layer.

# Static Water Levels

The static water levels (SWL) for both the glacial and bedrock aquifers were mapped for two periods (1960-1999 and 2000-2012). Since 1999, the static water levels in both the glacial and the bedrock aquifer have modestly declined in the central region of Ottawa County. The decline in the glacial aquifer SWL in south-central Blendon Township appears to be one of the most significant in the county. Such declines suggest that the current volume of withdrawals from the glacial aquifer in this part of Ottawa County may not be sustainable in the long run.

In south-central Allendale Township and north-central Blendon Township, the decline in the SWL within the bedrock aquifer appears to be one of the most significant SWL changes in the county, suggesting that the current volume of groundwater withdrawals from the Marshall Sandstone may be unsustainable in the long run.

Mapping the temporal trends in static water levels is problematic in areas with temporally variable data densities. Interpolating across each of two point data sets with notably different spatial distributions of sample points can cause significant spatial variations in the estimation uncertainty.

Further study will be necessary in order to forecast the sustainability of groundwater withdrawals from either aquifer.

# Recharge

The master recharge areas for the unconfined, glacial aquifer occur in Chester and Wright townships in northeastern Ottawa County and in Jamestown Township in the southeast corner of the county. Due to the heterogeneous nature and generally finer textures of the glacial sediments in both of these areas, recharge to the unconfined glacial aquifer is limited. Groundwater replenished by the recharge area in Chester and Wright townships discharges primarily to the Grand River. Thus, the NE master recharge flow does not contribute groundwater to the areas south of the Grand River, where groundwater withdrawal needs are the greatest. Groundwater replenished by the Jamestown Township recharge area discharges, in part, to the Macatawa River and Rush Creek. As a result, this recharge also does not appreciably help the central county region.

The master recharge area for the confined, bedrock aquifer occurs in Jamestown Township in the southeast corner of the county. Due to the heterogeneous nature and generally finer textures of the glacial sediments in this area, however, recharge to the confined, bedrock aquifer from this landscape is limited. It is most likely that the majority of recharge to the Marshall Formation occurs outside of Ottawa County to the northeast, east and southeast.

# Groundwater Quality

The groundwater in the glacial aquifer, but especially in the bedrock aquifer, is becoming more saline as shown by increasing chloride concentrations through time. Prior to 2000, generally less than 4% of all the groundwater quality samples in Ottawa County showed chloride concentrations above 250 mg/l (the recommended water quality standard). In the 2000 – 2010 period, however, 6 – 10% of the samples showed chloride concentrations above 250 mg/l.

A depth *vs.* concentration analysis showed that the chloride concentrations in both the glacial and bedrock aquifers are not a surface contamination problem (*e.g*., road salt). In both aquifers, chloride concentrations increase with depth indicating a deep, subsurface source. Evaluation of a small-scale map of generalized groundwater heads in the Marshall Formation suggests that hypersaline groundwater is upwelling within the Marshall Formation and discharging beneath Ottawa and Muskegon counties. It is likely that increasing withdrawals from the bedrock aquifer over time have allowed hypersaline groundwater from deeper in the Marshall Formation to migrate upward at an increased rate beneath central Ottawa County.

The WaterChem data also show that nitrate concentrations are elevated (*i.e*., > 3 mg/l) in many areas of the county. There are numerous hotspots throughout the county, especially in the areas just east of Ferrysburg and Grand Haven, south and southeast of Zeeland, in central and western Allegan Township, in central Georgetown Township, and in southwest Jamestown Township. In many of these hotspots, the nitrate concentrations in groundwater are 2 - 5 times the drinking water standard of 10 mg/l. There is no strong temporal trend of variation in the nitrate concentrations, however, suggesting that the nitrogen sources are persistent and prevalent. at least in and near the hotspot areas.

Although there are some natural sources of nitrogen that can pollute groundwater with nitrates, anthropogenic sources are most often the cause of high nitrate concentrations in groundwater. Sites used for disposal of human and animal sewage; industrial wastes related to food processing; and facilities handling and storing nitrogenous materials are all potential sources. Many areas of the United States and other countries have reported significant contamination of groundwater from septic systems in densely populated areas without sanitary sewers. However, in less populated areas, properly constructed and well maintained septic systems do not pose a threat to groundwater contamination.

Another potentially large source of nitrogen pollution of groundwater is the overuse of nitrogen-rich fertilizers on residential and commercial turfgrass. The land application of nitrogen fertilizer and manure in agricultural is also a potential source of nitrate pollution of groundwater. Irrigation of land that receives of nitrogen-rich fertilizers may also increase the chances of nitrate pollution, especially where the soils over the aquifer are sandy. Poorly constructed or maintained manure storage facilities at confined animal feeding operations are also potential sources of nitrate leaching to the groundwater.

# Decision Support System

Utilizing the results from the MSU groundwater study, together with numerous, public , geospatial data gathered from the State and Ottawa County, the MSU team developed the Ottawa County Interactive Web-based Water Resources Decision Support System (IWDSS). The IWDSS uses a state-of-the-art, web-based environment with GIS capabilities and provides interactive plan-view maps and cross-sectional plots of portions of the county to: (a) determine the aerial extent and large-scale variation in aquifer characteristics, (b) provide a depiction of the general groundwater flow regime (direction and rate), (c) map the concentrations of sodium, chloride, nitrate, and arsenic from water well samples, and (d) determine the fluctuations of water table depth.

The system includes five inquiry scenarios that assist users in exploring selected groundwater issues in Ottawa County:

- Glacial Aquifer Water Quantity
- Basement Flooding Assessment
- Salinity
- Nitrate
- Impervious Surface/Recharge Area.

The system also contains an on-line manual and tutorials, so that users can easily familiarize themselves with the various tools and thematic layers within the IWDSS.

## A. Decision System Support Tools Development

# Development of the Great Lakes Watershed Management System

## Introduction

As part of an ongoing relationship with the U.S. Army Corps of Engineers (USACE), the Institute of Water Research at Michigan State University (IWR) and Purdue University's Agricultural and Biological Engineering Department, in support of USACE's Great Lakes Tributary Modeling Program – 516(e), has developed The Great Lakes Watershed Management System (GLWMS). The system is an on-line decision support tool that allows users to analyze non-point source pollution (NPS) data at watershed and field scales. The system is an update and expansion of similar USACE-funded collaborations for the Burns Ditch-Trail Creek Watershed of northern Indiana, and the Swan Creek Watershed of northwest Ohio. Whereas those prior collaborations created systems that more loosely coupled IWR's sediment loading prioritization model High Impact Targeting (HIT) and Purdue's surface runoff model Long Term Hydrologic Impact Assessment (L-THIA) for relatively small study areas, the Great Lakes Watershed Management System more seamlessly integrates the tools over a much larger geographic area. This report describes the key steps in the development of the GLWMS, and discusses future expansion and updates.

## Study Area

Because the funding for the development of the GLWMS originated from the Environmental Protection Agency's Great Lakes Restoration Initiative (GLRI), the system's development was targeted in the priority areas identified in GLRI (Figure 1). To broaden engagement across the Great Lakes Basin a tributary to Lake Ontario was added to the study area, yielding the final targeted watersheds (Figure 2):

- The Fox River Watershed of Lake Michigan (6,600 square miles, 36% agriculture, 15% urban)
- The Genesee River Watershed of Lake Ontario (2,500 square miles, 45% agriculture, 7% urban)
- The Maumee River Watershed of Lake Erie (8,300 square miles, 77% agriculture, 12% urban)
- The Saginaw River Watershed of Lake Huron (8,700 square miles, 45% agriculture, 13% urban)
  *(land cover percentages based on 2006 National Land Cover Dataset)*

Agriculture is the dominant land cover in each watershed, making the agricultural-based HIT model a suitable analysis tool for the analyzing sediment loading to streams in the study areas. L-THIA complements HIT by providing nutrient loading estimates in both agricultural and urban environments, effectively creating a suite of water quality analysis tools for all land cover types in the study areas.

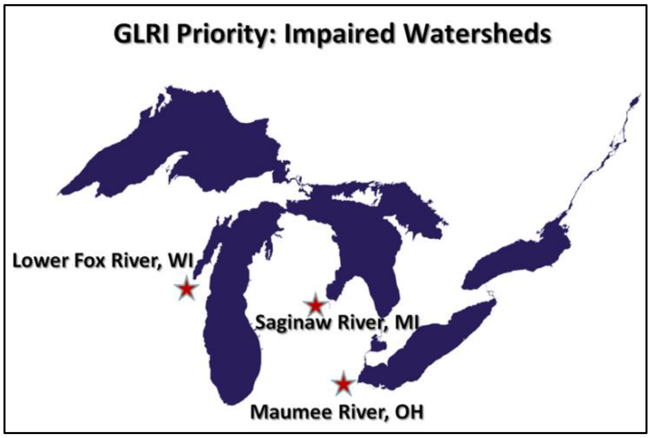



**Figure 1: GLRI priority areas. Figure courtesy of EPA (http://glri.us/priorities.html).**


**Figure 2: Study area for the GLWMS.**

## Background

In 2007 IWR and Purdue developed the Burns Ditch / Trail Creek Watershed Management System (Figure 3) with support through 516(e). This system created a link between IWR's Digital Watershed mapping interface and Purdue's L-THIA for use in the northern Indiana watershed. Users could view Digital Watershed's numerous environmental data layers and link directly to L-THIA for more in-depth water quality analysis. In 2009 USACE supported an expansion to northern Ohio with the Swan Creek Watershed Management System (Figure 4). In this system, the Burns Ditch / Trail Creek interface was extended to include links to IWR's HIT system for agricultural sediment loading analysis and sub-watershed prioritization.


**Figure 3: Burns Ditch / Trail Creek Watershed Management System.** **https://engineering.purdue.edu/mapserve/www/lthia_bdin/**

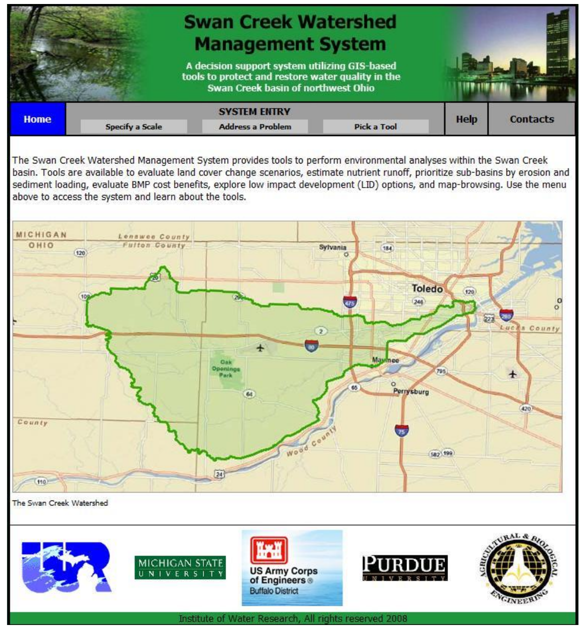



**Figure 4: Swan Creek Watershed Management System.** **www.iwr.msu.edu/swancreek**

The initial plan for the current project was to continue the refinement and integration of IWR's and Purdue's systems, and broaden their geographic scope. IWR and Purdue proposed developing a highly sophisticated and dynamic prototype system for the Fox River Watershed in Wisconsin, and what would essentially be duplicates of the Swan Creek Watershed Management System for each of the Genesee, Maumee, and Saginaw River watersheds. The Fox River system would link HIT and L-THIA analyses within a single mapping interface, as opposed to sending users to separate websites for analysis, which is how the previous systems functioned (and how the proposed systems for the Genesee, Maumee, and Saginaw river watersheds would function). The Fox River system would also allow users to conduct dynamic field-scale modeling of water quality impacts from land-cover change and best management practices (BMPs). Users would be able to draw areas of change on the map and re-run HIT or L-THIA on-the-fly to analyze results, as opposed to the static data that users could access in the other systems.

However, as IWR and Purdue progressed in the development of the Fox River Watershed Management System it became evident that utility of the new analysis tools should not be limited to just one area. To best empower decision makers on issues of water quality management across the Great Lakes Basin, these tools should be made available to as many users as possible. Therefore, IWR and Purdue decided to extend the design for the more enhanced Fox River Watershed Management System to the other three study area watersheds, and build an initial version of a Great Lakes Watershed Management System (GLWMS). Dynamic land cover change and BMP modeling within a single mapping interface would be available for all four of the watersheds in Figure 2.

## Model Development

In order to populate the GLWMS with the best available data IWR developed new HIT models for the study area watersheds. HIT is a combination of two sub-models; the Revised Universal Soil Loss Equation (RUSLE) for estimating agricultural soil erosion, and the Spatially Explicit Delivery Model (SEDMOD) for estimating eroded soil delivery to the stream network. HIT is applied within a GIS raster environment, so annual estimates of erosion and sediment loading are produced on a pixel-by-pixel basis. The size of the pixel is a function of the resolution of the digital elevation model used to simulate surface water flow characteristics in the HIT model. IWR developed an on-line HIT system (www.iwr.msu.edu/hit2) where users can prioritize watersheds by annual sediment loading, and view fields at high risk for erosion and sediment loading for any area in the Great Lakes Basin. Unlike the proposed GLWMS, all the data within the HIT system is static, users cannot conduct dynamic land cover change modeling. In order to produce data for such a large area, IWR utilized relatively coarse model resolutions of 30-meters for the majority of Great Lakes Basin; therefore each calculated value of sediment loading risk for a pixel corresponded to an area of $900m^2$ on the ground. For the HIT models that would serve the GLWMS IWR employed 10-meter resolution DEMs which, based on field studies in previous projects, improved the ability of soil conservationists to better identify in-field erosion features such as gullies and areas of concentrated flow.

The HIT models for the GLWMS also included a superior representation of land cover than IWR had utilized in previous projects. One of RUSLE's key inputs is the crop-management factor (C-factor), which describes the relationship between vegetative cover and soil erosion. C-factor values vary by crop type, region, time of planting, tillage practice, and crop rotation cycle. In previous HIT model projects, IWR represented C-factor by linking agricultural locations in the 2001 National Land Cover Dataset (NLCD) to crop and tillage survey data from the Conservation Technology Information Center (CTIC) at Purdue (http://www.ctic.purdue.edu/) and to NRCS RUSLE field guides. However, CTIC survey data was only available at county-level resolution, meaning that each agricultural pixel in the NLCD within a particular county was treated the same by HIT. The new HIT models developed for the GLWMS employed the 2006 NLCD and the USDA's Cropland Data Layer (CDL) to pinpoint crop-type and crop rotation to a specific pixel. Like the NLCD, the CDL is a satellite-based product; unlike the NLCD it represents specific crop-types on a pixel-by-pixel basis, and is produced annually. Therefore IWR was able to represent C-factor at a more spatially explicit resolution, and use the CDL's temporal resolution to factor crop-rotation into the representation. Figure 5 illustrates how IWR employed the CDL to represent RUSLE's C-factor.

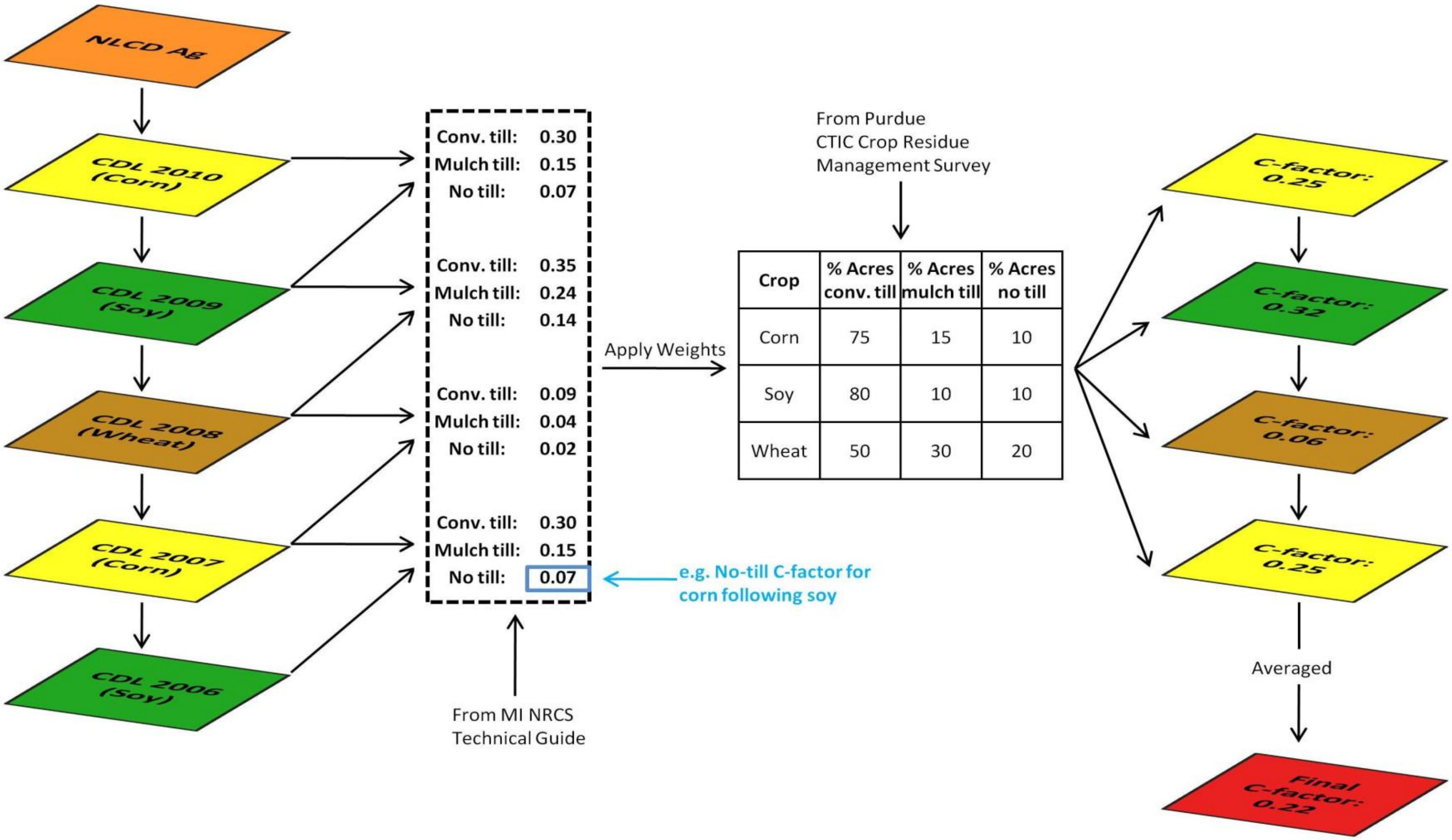



**Figure 5: HIT C-factor representation through NLCD, CDL, CTIC, and NRCS Field Guide.**

## The Great Lakes Watershed Management System

The on-line system is built on top of an ArcGIS Server back end, with a custom front-end developed using the ArcGIS JavaScript API. When loaded, the system initially shows a map of the basins for which data and analysis tools are available (Figure 6). The left hand side of the page contains the map, whereas the right hand side contains collapsible panels providing information on the system's background, access to the map's layers, and links to the analysis functions.

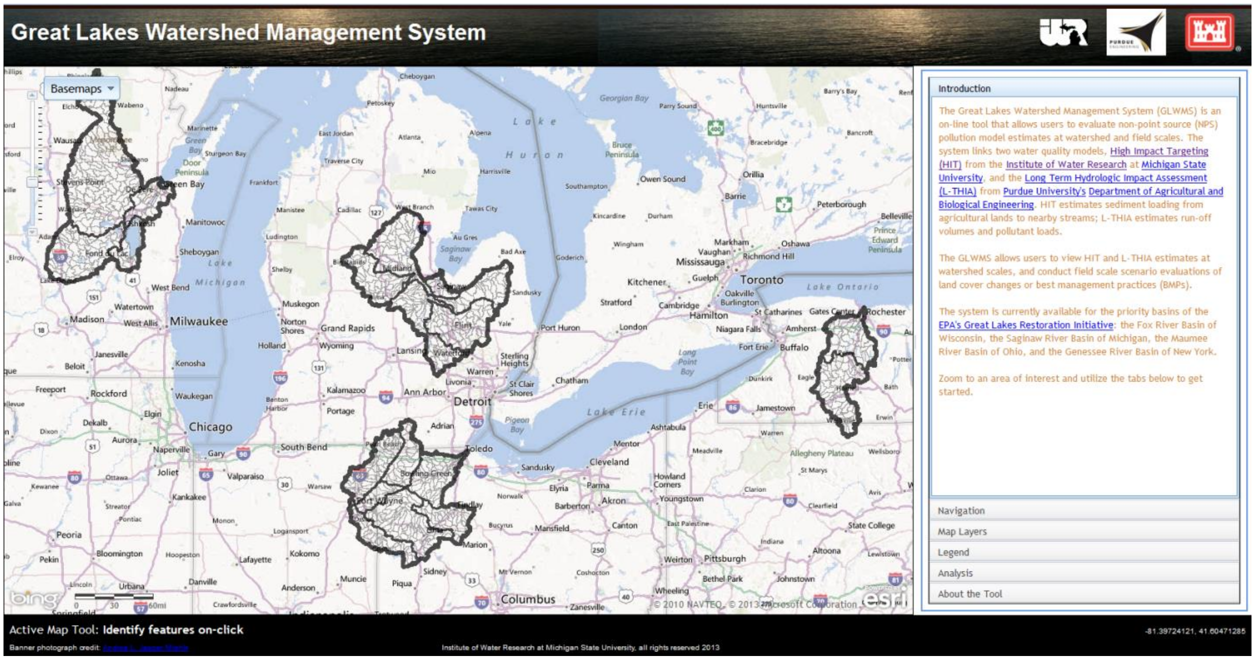



**Figure 6: GLWMS initial view.**

### *Watershed-scale Analysis*

There are two scales of analysis that can be performed within the GLWMS, watershed or field scale (Figure 7). At the watershed scale users can view erosion and sediment loading data at 8, 10, or 12-digit watershed scales, as modeled through HIT. Users start by selecting watersheds of interest and then choosing particular HIT outputs to evaluate. These outputs include annual sediment loading totals or rates, and reductions from hypothetical BMP targeting scenarios, such as installing no-till on the worst sediment loading areas of each selected sub-watershed. The users are then presented with a table listing data for each selected watershed (Figures 8 and 9). In Figure 9, results were generated for a hypothetical scenario of targeting no-till on the worst

25% of sediment loading areas in each 12-digit watershed of the Saginaw River Watershed, at a cost of $24/acre[1]. Both the targeting percentage and BMP cost can be customized by the user. The far right column of the table lists the cost benefit (dollars spent per ton of sediment reduction) of the targeted no-till program in each sub-watershed. The table of 193 records can quickly be sorted to identify the sub-watersheds where such targeting would yield the greatest cost benefits. These sorted results can also be mapped spatially by applying a legend based on the cost-benefit attribute (Figure 10). Any numeric tabular attribute can be mapped with a legend. Such an analysis can quickly guide the efforts of a state agency, conservation district, or watershed group to effectively prioritize conservation activities within in a watershed. At present the GLWMS only supports such an analysis for HIT data; but future updates will include L-THIA estimates allowing users to view watershed-scale nutrient data, such as Phosphorus and Nitrogen.

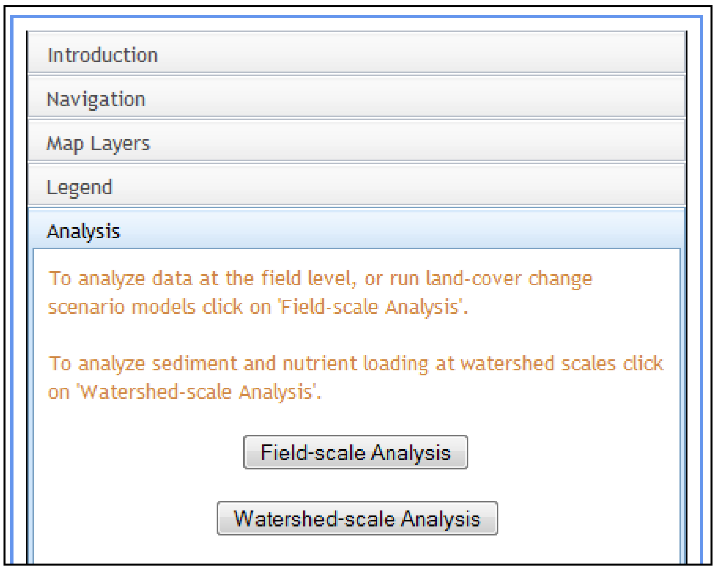



**Figure 7: GLWMS analysis scales.**

[1] Based on cost/acre of no-till in Michigan NRCS' Environmental Quality Incentives Program (EQIP) payments.

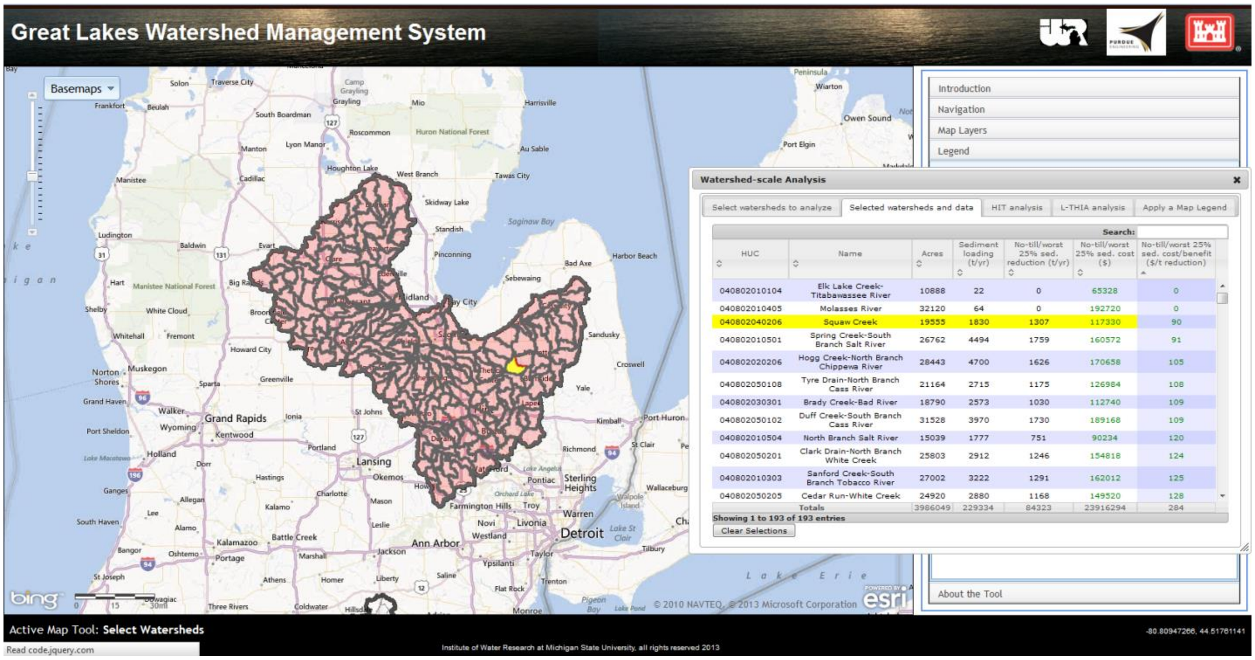
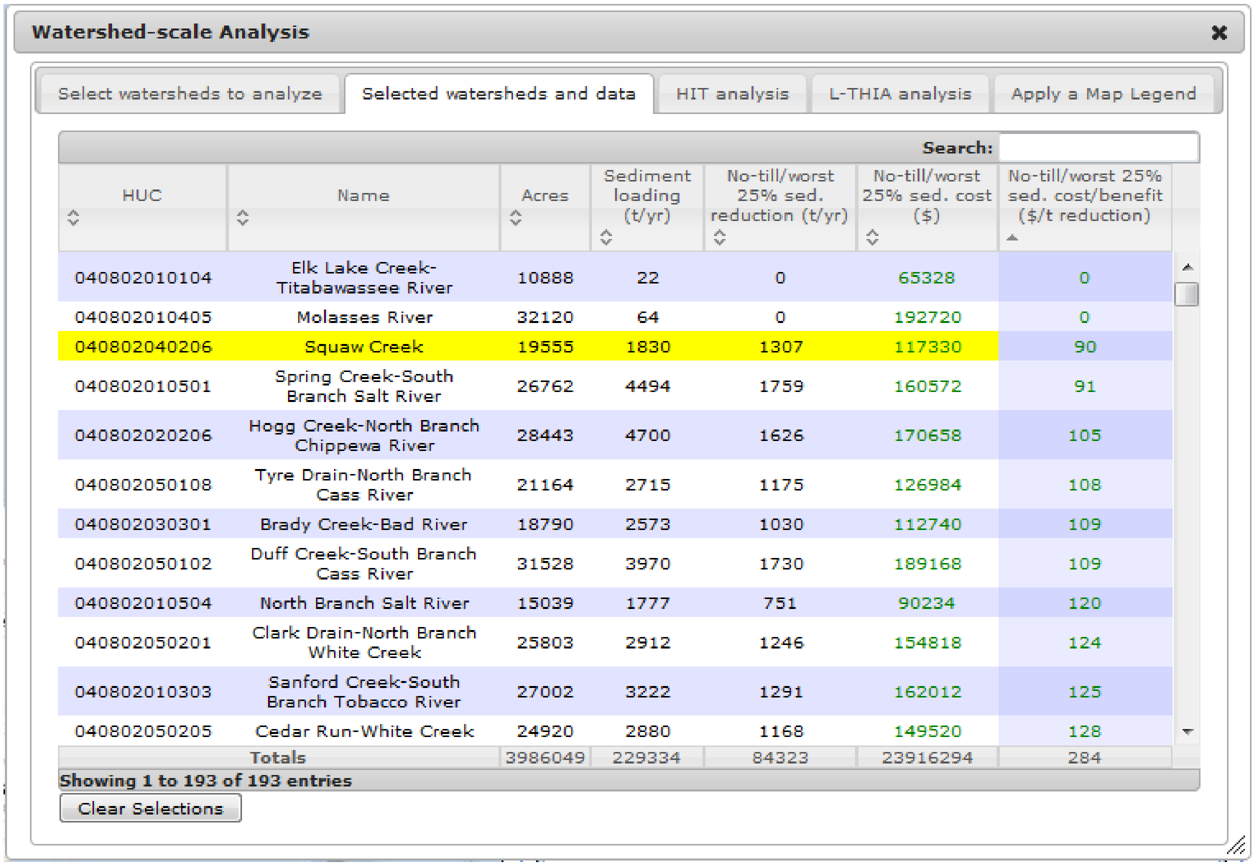



**Figure 8: Watershed-scale analysis in the GLWMS. Saginaw River Basin 12-digit watersheds and corresponding HIT data.**




| HUC | Name | Acres | Sediment loading (t/yr) | No-till/worst 25% sed. reduction (t/yr) | No-till/worst 25% sed. cost ($) | No-till/worst 25% sed. cost/benefit ($/t reduction) |
|---|---|---|---|---|---|---|
| 040802010104 | Elk Lake Creek-Titabawassee River | 10888 | 22 | 0 | 65328 | 0 |
| 040802010405 | Molasses River | 32120 | 64 | 0 | 192720 | 0 |
| 040802040206 | Squaw Creek | 19555 | 1830 | 1307 | 117330 | 90 |
| 040802010501 | Spring Creek-South Branch Salt River | 26762 | 4494 | 1759 | 160572 | 91 |
| 040802020206 | Hogg Creek-North Branch Chippewa River | 28443 | 4700 | 1626 | 170658 | 105 |
| 040802050108 | Tyre Drain-North Branch Cass River | 21164 | 2715 | 1175 | 126984 | 108 |
| 040802030301 | Brady Creek-Bad River | 18790 | 2573 | 1030 | 112740 | 109 |
| 040802050102 | Duff Creek-South Branch Cass River | 31528 | 3970 | 1730 | 189168 | 109 |
| 040802010504 | North Branch Salt River | 15039 | 1777 | 751 | 90234 | 120 |
| 040802050201 | Clark Drain-North Branch White Creek | 25803 | 2912 | 1246 | 154818 | 124 |
| 040802010303 | Sanford Creek-South Branch Tobacco River | 27002 | 3222 | 1291 | 162012 | 125 |
| 040802050205 | Cedar Run-White Creek | 24920 | 2880 | 1168 | 149520 | 128 |
| | Totals | 3986049 | 229334 | 84323 | 23916294 | 284 |



**Figure 9: GLWMS tabular output of watershed scale-analysis, sorted by BMP cost-benefit.**

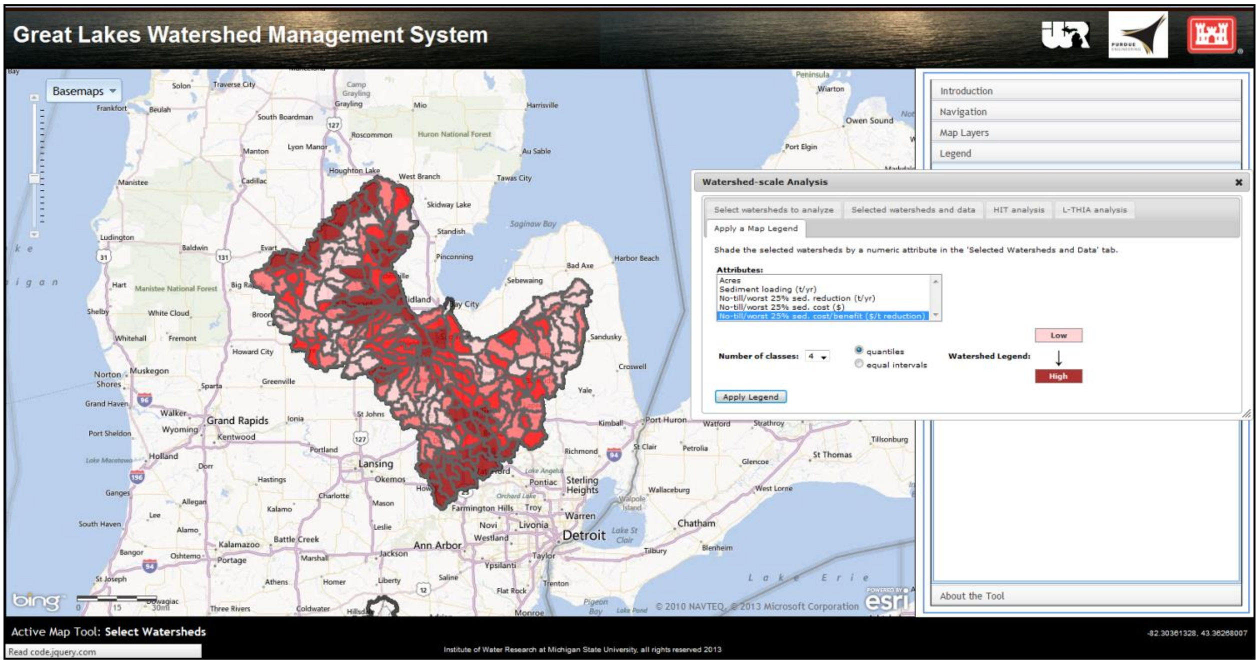



**Figure 10: Users can apply a legend to view the spatial distribution of watershed-scale tabular outputs.**

## *Field-scale Analysis*

The watershed-scale analysis tools allow users to prioritize conservation activities at a macro level; but once a particular priority watershed has been identified, the next logical question is upon which fields the conservation should be applied. The GLWMS field-scale analysis tools were designed to aid in such decision making. First, users can use the HIT Sediment map layer within the GLWMS to identify priority fields (Figures 11 and 12). Next, users can open up the Field-scale Analysis window to run land cover change and BMP simulations. Users can digitize an area of interest and generate HIT and L-THIA baseline estimates within that polygon, estimates of sediment and nutrient load changes based on a land cover change or BMP, and sediment and nutrient load changes between two user-defined scenarios. In Figure 13, a polygon was drawn around an area of relatively high sediment loading risk, as modeled by HIT, and ran a simulation where that area was converted from agriculture to pasture. Figure 14 displays the results of that simulation. HIT and L-THIA estimates are presented separately, but within one common result window. Note the blue feature, around the digitized polygon, added to the map in Figure 14. This polygon defines the upland area affected by the change to pasture; it represents all the lands that flows through the user-defined polygon, and would therefore have its loadings diminished by a conversion to pasture within the yellow area.

HIT and L-THIA have separate land-cover / BMP drop-down menus within the Field-scale Analysis dialog window shown in Figure 13. Though the two models complement each other through HIT's more spatially explicit focus and L-THIA's more detailed nutrient estimates, their model parameters are fundamentally different. As a mainly agricultural-based model HIT supports fewer land cover change and BMP scenarios than L-THIA; which, as a curve number


**Figure 11: Field-scale imagery from Microsoft Bing.**

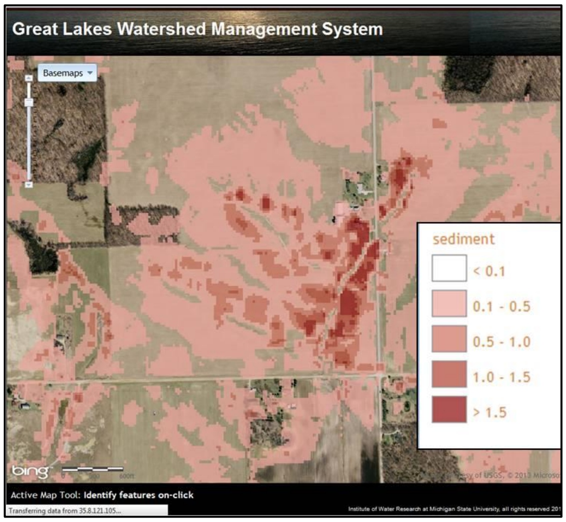



**Figure 12: HIT sediment loading risk applied to Figure 11.**

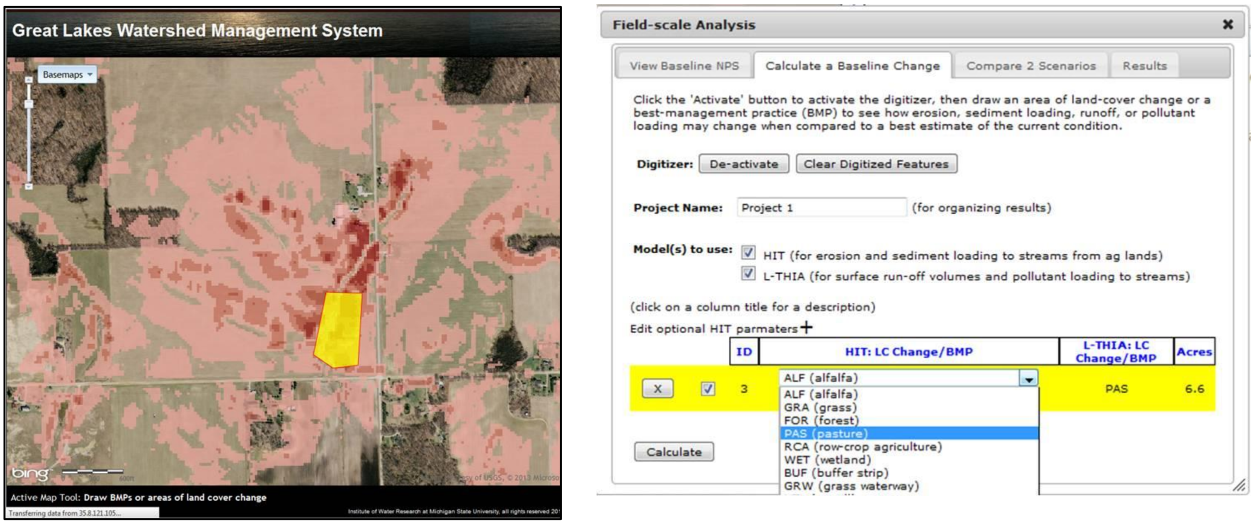



**Figure 13: User-defined land cover change simulation.**

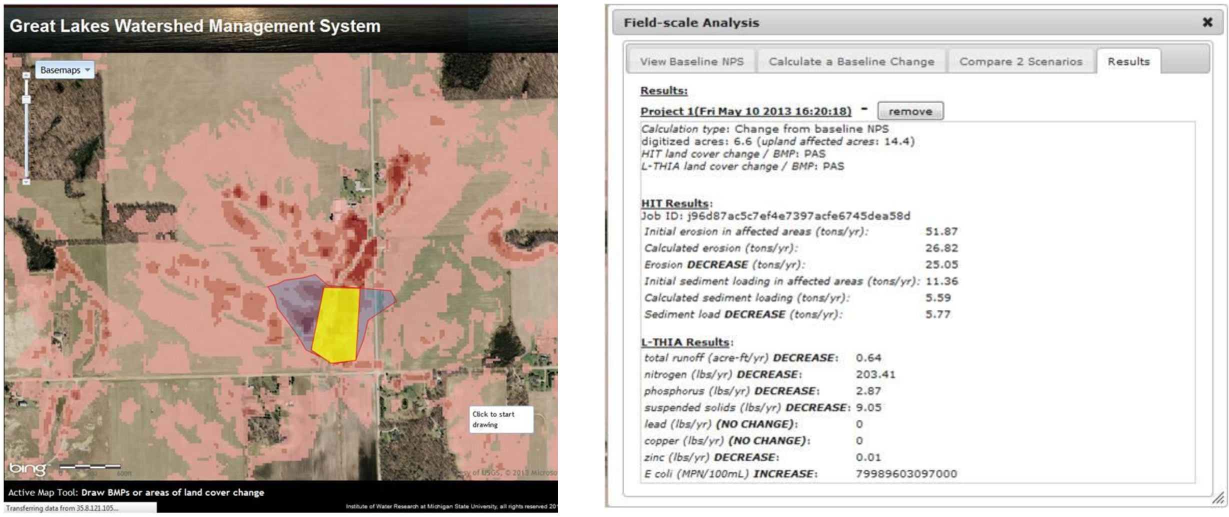



**Figure 14: User-defined land cover change simulation.**

based runoff model, can simulate agricultural, forested, and urban land covers and BMPs. Table 1 lists the land cover change scenarios modeled by HIT for the GLWMS, and Table 2 lists those modeled by L-THIA. Though HIT's scenario options are limited, users familiar with HIT's parameters can manually specify them to suit a particular simulation (Figure 15).

The combined utility of the watershed and field-scale analysis functions of the GLWMS enable decision makers to quickly and effectively prioritize sensitive areas for water quality management, and to evaluate land management options for an individual field in terms of sediment and nutrient loading to streams. Though similar functionality was available in earlier Corps-funded, IWR and Purdue developed watershed management systems, those applications did not link these capabilities in a single mapping interface as with the GLWMS; nor were users able to run HIT models dynamically at field scales, or simulate as many land cover change scenarios, in those earlier systems.

| |
|---|
| - Alfalfa |
| - Grass |
| - Forest |
| - Pasture |

| |
|---|
| - Row-crop agriculture |
| - Wetland |
| - Buffer strip |
| - Grass waterway |
| - No-till |
| - Mulch-till |
| - Conventional-till |
| - No-till with cover crop |
| - Mulch-till with cover crop |
| - Conventional-till with cover crop |

**Table 1: HIT land-cover/BMP scenarios available in the GLWMS.**

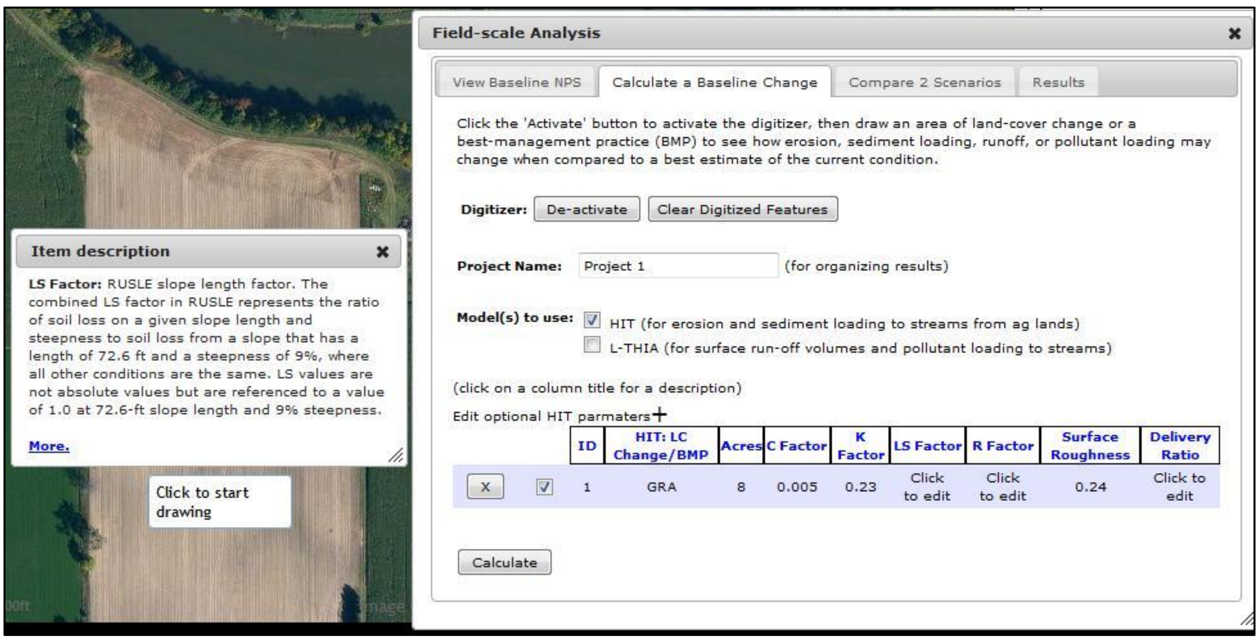



**Figure 15: Optional HIT parameter specification in GLWMS.**

| Agricultural | Industrial/Urban |
|---|---|

- No Till (100 %)
- Conservation Tillage (30%)
- Reduced Till
- Mulch Till
- 30 ft grass buffer
- Riparian Buffer Strip
- Detention Basin
- Grass swale
- Cropland generalized
- Row Crops (5-20% residue)
- Small Grain (5-20% residue)
- Small Grain straight rows
- Close Seeded legumes
- Row Crops (5-20% residue and contour)
- Small Grain (5-20% residue and contour)
- Close Seeded legumes contour
- Pasture/Hay

**Forest**

- Forest/Woods
- Trees/Orchard
- Woods fair
- Woods good
- Woods poor

**Residential**

- Commercial
- Commercial/Industrial/Transportation
- Industrial
- Parking lot
- Parking lot with porous pavement good
- Parking lot with porous pavement fair
- Parking lot with porous pavement poor
- Paved street with curbs and gutters and storm sewers
- Paved Surface Driveway or Parking lot
- Street/Road
- Street with curbs and gutters and porous pavement
- Street with swales
- Street with swales and porous pavement
- Streets / other
- Roof cistern
- Green roof

**Impervious surfaces**

- Impervious surface-10%
- Impervious surface-20%
- Impervious surface-30%
- Impervious surface-40%
- Impervious surface-50%
- Impervious surface-60%
- Impervious surface-70%
- Impervious surface-80%

| | |
|---|---|
| - High-density Res. (townhomes - 1/4 ac lots) | |
| - Low-Density Residential (general 1/3 - 2 ac lots) | **Open space** |
| - Residential - 1 ac lots | - Grass land |
| - Residential - 1/2 ac lots | - Open space-dirt or grass cover < 50% |
| - Residential - 1/3 ac lots | - Open space-gravel or grass cover 50%-75% |
| - Residential - 1/4 ac lots | - Open space-wooded or grass cover > 75% |
| - Residential - 1/8 ac lots | - Open Space/Park |
| - Residential - 2 ac lots | - Open space with bioretention |
| - Driveway with porous pavement | - Other Open/Unused Land |
| - Permeable patio | - Barren Land |
| - Roof | |
| - Roof rain barrel | **Water** |
| - Sidewalk | - Open Water |
| - Sidewalk with porous pavement | - Perennial ice or snow |
| | **Wetlands** |
| | - Emergent Wetlands (marsh) |
| | - Woody Wetlands (swamp) |

**Table 2: L-THIA land-cover/BMP scenarios available in the GLWMS.**

## Stakeholder Engagement

Throughout the development of the GLWMS, IWR has sought to gather input and feedback from stakeholders in the project's study areas. IWR gathered this information through webinar demonstrations and face-to-face meetings with state and local decision makers.

Early in 2010 IWR met with conservation district staff from Clinton County, MI to observe technician workflows and identify the technical needs of the office. Though this particular conservation district office was outside of this project's study area, IWR had a prior working relationship with the district's staff. This familiarity provided ready access to a user audience that would be very similar those served by this project. This initial meeting helped identify features that conservation district staff wanted in an on-line watershed management system. IWR followed up this county-level meeting with state-level meetings at Michigan NRCS to gather more input on desired system features, and to see how NRCS was currently integrating watershed prioritization into its activities.

IWR held similar meetings later in 2010 in Madison, WI with officials from Wisconsin NRCS and Wisconsin Department of Natural Resources. Through this effort, IWR was able to identify group of potential users from county conservation districts in Wisconsin to include in an information-gathering webinar, held in May 2011. Feedback from that session helped to further refine the scope of the future system, and make potential users aware that a decision support system was under development for their area. As part of a separate project, in June 2011 IWR met in person with conservation district staff from Calumet and Manitowoc counties of northeast WI. Though the development of the GLWMS was not the focus of these meetings, IWR took advantage of the opportunity and gathered additional input and feedback on the workflows and technical needs of conservation district staff in Wisconsin.

In 2012 IWR participated in two webinars hosted by the Great Lakes Commission to share project updates and solicit feedback from NRCS staff in the Great Lakes Basin. The first webinar was in February and engaged staff from across the Basin. The second took place in November and was focused on staff in the western region of New York State. These meetings provided further opportunities for IWR to preview some of the system's functionality to potential users, and also to gather input on necessary refinements. Also in 2012, IWR met with officials from Michigan's Department of Environmental Quality to discuss how the proposed system could aid in the state's management of EPA 319 Watershed Management projects.

Though this report solely provides an update on IWR activities, it should be noted that Purdue hosted similar meetings with stakeholders, particularly in Ohio, that provided input into the system's design and functionality.

**Next Steps**

*Technology Transfer*

After addressing issues identified in an initial user-testing, IWR will jointly host a series of webinars with Purdue University to promote the GLWMS to stakeholders in the project's study areas. The target audiences for those webinars will comprise both state-level managers and local conservation district staff, including those who provided feedback during the system's development. IWR will also coordinate a formal training of the system for users in the Saginaw River Basin.

*Future System Updates*

As mentioned earlier, the watershed scale analyses illustrated in Figures 8-10 will be extended to include L-THIA outputs. Users will be able to prioritize watersheds by phosphorus and nitrogen loading estimates, among other pollutants modeled by L-THIA. However, watershed-scale BMPs and cost benefits, such as HIT's no-till targeting on the worst X% of a watershed will not be available for L-THIA.

Cost-benefit analysis capabilities will be integrated into the GLWMS' field-scale analysis tools. Similar to the cost-benefit options in HIT's watershed-scale analyses, users will be able to specify a cost of a particular BMP or land cover change and compare it to the modeled changes in sediment and nutrient loading.

Users will be able to create individual accounts to save field-scale simulations. For example, a user could digitize the location of a BMP and estimate a potential change in sediment loading, then save the coordinates of the BMP and the estimated change to her GLWMS account. The user could then revisit the simulation at a later time to adjust model parameters or create an entirely new simulation. Users could utilize the GLWMS to store a number of BMPs and analyze the cumulative benefits that those practices are providing. For example, a conservation district technician may oversee the installation of a number of BMPs as part of an EPA-funded watershed management project. If those practices are simulated and stored within the GLWMS he will be able to report back to EPA their cumulative reductions in sediment loading over time. Users will be able to distinguish actual BMP installations from simply hypothetical simulations, so that such cumulative reporting would not include practices that were not actually implemented.

There are privacy concerns that must be considered when storing the locations and impacts of BMPs. Federal conservation programs, such as CRP, require that land owner records remain confidential. Therefore any BMPs stored on the GLWMS will default to a private setting whereby only the user (author) that digitized the BMP, or an authorized administrator of the GLWMS, will be able to see it on the system. The author will then be able to specify whether a BMP and its results should be visible to other users of the system, perhaps after securing permission from the land owner.

At a macro-scale, users with sufficient privileges, such as a state-level or federal administrator, will be able to view cumulative benefits across users and for a defined area. For example, a program manager at MI-NRCS would be able to view cumulative benefits of installed BMPs within Michigan, whereas an administrator at EPA could view total load reductions across the multi-state Maumee River Basin.

Lastly, as the system's name implies, IWR will seek funding to expand the system's coverage throughout the Great Lakes Basin[2]. The GLWMS was born from IWR and Purdue collaborations for the individual watersheds of Swan Creek and Burns Ditch/Trail Creek. Though the original intention of this project was to create three systems (one for each of the

[2] IWR is currently leveraging support from The Nature Conservancy to expand the system's coverage to rest of Saginaw Bay and Michigan's Paw Paw River Watershed.

Genesee, Maumee, and Saginaw river basins) in the style of Swan Creek and one advanced system (for the Fox River Basin), IWR recognized that an expanded advanced system would better equip a broader audience to address water quality issues in the Great Lakes. Furthermore, the expansion would create a single tool to by which state and federal administrators could conduct water quality analyses across the Basin, and perhaps better rally support for the addition of new watersheds than four separate systems could. The Swan Creek and Burns Ditch/Trail Creek systems tended to exist in isolation, used only by decision makers within those watershed boundaries. But the GLWMS could serve as a standardized platform for free and readily accessible water quality decision support across the Great Lakes Basin. As users and administrators realize the utility of the system, particularly its ability to track benefits across watersheds, support will grow to fill the current gaps in its geographic scope.

The prototype of the GLWMS can be accessed at www.iwr.msu.edu/glwms.

# The Paw Paw River Watershed Water Quantity and Quality GIS Modeling Report

## 2.D. The Paw Paw River Watershed Water Quantity and Quality GIS Modeling Report

# PROJECT STATUS REPORT

### PROJECT SUMMARY

| REPORT DATE | PROJECT NAME | PREPARED BY |
|---|---|---|
| 7/27/2012 | TNC/Mott Saginaw Bay Watershed Project | Jeremiah Asher |

### STATUS SUMMARY

The second quarter of 2012 has been spent planning and collecting required data and information for the project deliverables. The overall project is moving forward as scheduled with the following tasks in progress: Tasks 2A.1, 2A.2, 2.B1, and 2.C4.

### PROJECT OVERVIEW

| TASK | % DONE | DUE DATE | STATUS |
|---|---|---|---|
| 2A.1 | 10% | 9/30/2012 | NFHAP and NHD data has been downloaded. We recently received some documentation and will be meeting with Scott Sowa to discuss how the threat indexes are created. |
| 2A.2 | 10% | 9/30/2012 | 8,10,12 HUC data has been downloaded and is ready for processing. This task is dependent on the completion of task 2A.1. |
| 2B.1 | 30% | 12/31/2012 | Pre-processing is complete, the data must be run through the HIT process to produce the final deliverables. |
| 2C.4 | 20% | 12/31/2013 | The framework and modeling proceedures have been developed for the sediment calcuator. Saginaw data will need to be pre-processed and brought into the framework. |
| 2D.2 | 5% | 3/31/2014 | We have started initial planning of the web interface. However, the interface design and structure is tied closely to the other tool development and should progress in step. |

### RISKS AND BARRIERS

Current risk to completing project deliverable 2A.1 on time is receiving instructions from TNC for creating the threat indexes. The completion of this task also affects task 2A.2. No other immediate risks are identified.

## B. Outreach

## Implementing LaMP Priorities Through Enhanced Public Forum

## Lake Erie Forum Website Project Report

### Introduction

The Ohio Environmental Council (OEC) is funded by EPA under Great Lakes Restoration Initiative to implement Lakewide Management Priorities for Lake Erie through an enhanced public forum. A key part of the project is to develop and maintain an interactive web portal that will contain current information, research and analysis regarding a variety of stressors to the Lake Erie ecosystem, as well as educational video segments by experts, PowerPoint presentations and factsheets etc. The Institute of Water Research (IWR) at Michigan State University is charged by OEC to develop and maintain the interactive web portal. The IWR has built the site based on open source content management system Drupal. IWR also built a general watershed mapping system for Lake Erie basin and included it on the web portal site. A customized mobile accessible website was also developed to enable better site browsing experience by users on their mobile devices.

### Site Development & Content

In order to construct the site based on Lake Erie Forum members' needs, the IWR team attended both the face to face Forum meetings and online webinar discussions to gather inputs from users. The team also engaged with individual forum members to flesh out many details for the site structure and content. During the development of the site, IWR received enthusiastic supports and insightful inputs for the site from a variety of forum members. A survey prepared by IWR was also employed to let users provide further comments and suggestions regarding all aspects of the site development. Currently IWR team has gone through much iteration to develop the site. The figure 1 shows the site design and structure.

The main menu of the site contains Home, Facts, LaMP, Science, Policies, Projects, Tools, Community and About tabs. The Facts tab has Economy, Tourism, Geography, Geology, History and Lake Environment submenu items. The LaMP tab provides detailed information on EPA Lake Erie LaMP and has links to all related reports over the years. The Science tab includes Research and Nutrients submenu items and provides information on research entities and their ongoing Lake Erie related research activities. The Policies tab provides links to all Lake Erie related environmental policies. The Projects tab links to Great Lakes Restoration Initiative site. The Tools tab contains links to a number of mapping and decision support tools related to Lake Erie, including the general Lake Erie mapping tool developed by IWR for this project. The Community tab has Environmental Organizations, Mailing List, Public Forum and Blogs submenu items, which are intended to provide a comprehensive online communication mechanism for forum members as well as the general public. The About tab describes introductory information


Figure 1. Lake Erie Forum Site

about Lake Erie Forum. A news section was added to show aggregated news around Great Lakes. A video gallery was also developed to display educational YouTube videos. These videos were well received by forum members during the past stakeholders meetings. Forum charter member Terry Martin agreed to start a blog named "Lake Erie Futures" and has since wrote and published two articles on the site. The mobile version of the site has Facts, LaMP, Videos and Tweets sections and its interface is shown in figure 2.


Figure 2. Lake Erie Forum Mobile Site

# Train the Trainer Development of a Web-Based Tools Workshop

# Train the Trainer Development of a Web-Based Tools Workshop

By Purdue University and Michigan State University

## Introduction

Over the past decade, the U.S. Army Corps of Engineers (USACE) has developed a strong working relationship with Michigan State University (MSU) and Purdue University through the Great Lakes Tributary Modeling Program. This relationship has yielded research on sediment loadings at multiple scales, GIS models for erosion and sediment loading risk, new and advanced modeling algorithms, multi-scaled prioritization maps, and on-line decision support systems to help users maintain and restore water quality in their watersheds. These achievements have been published in scientific journals, presented at numerous conferences, and disseminated through hands-on workshops. These decision tools have been well received by stakeholders. The expansion of these tools will improve decision making within the Great Lakes Basin, which will help keep sediment on the land and out of the Great Lakes.

## Project Description

In FY12 and in future fiscal years, a series of workshops will be conducted throughout the Great Lakes educating the use of the web-based tools developed by MSU and Purdue University (primarily the L-THIA and HIT tools). This Scope of Work consists of MSU and Purdue University developing the materials that will be used in these workshops.

## Tasks

In general, this Scope of Work (SOW) will educate individuals in the use of High Impact Targeting, L-THIA, and other web-based tools developed under previous grants to MSU and Purdue. Specifically, this will involve the development of 3 training manuals, (one for Buffalo, Chicago, and Detroit), and a joint workshop that will be given by MSU and Purdue Universities.

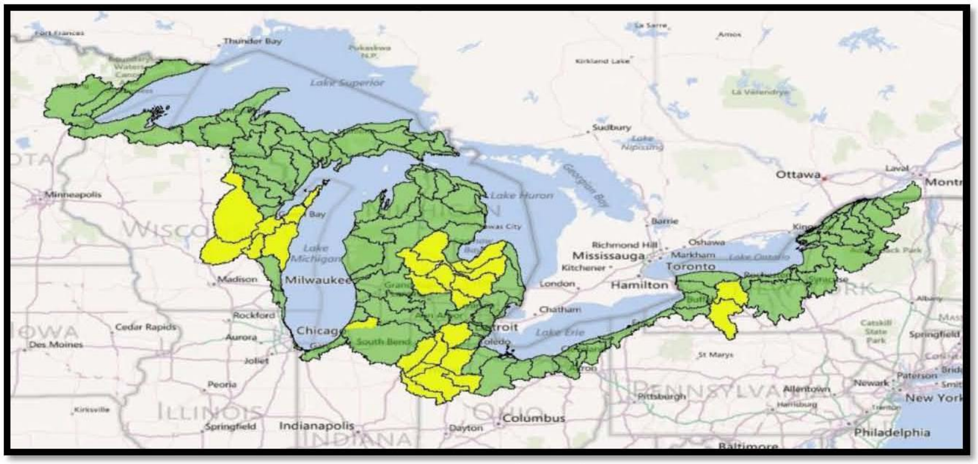



**Figure 1.2: 10-meter resolution HIT model availability (yellow) by the end of 2012, 30-meter resolutions (green).**

# On-line Decision Support Tools for Watershed Management:

**High Impact Targeting (HIT)**
**Long-term Hydrologic Impact Assessment and Low Impact Development (LTHIA-LID)**
**Digital Watershed**

A training manual in support of the U.S. Army Corps of Engineers
Great Lakes Tributary Modeling Program

Developed by:

The Institute of Water Research – Michigan State University

Biological and Agricultural Engineering – Purdue University

July 2012

## Task 1 - Develop Training Manual with 3 District Specific Tutorials

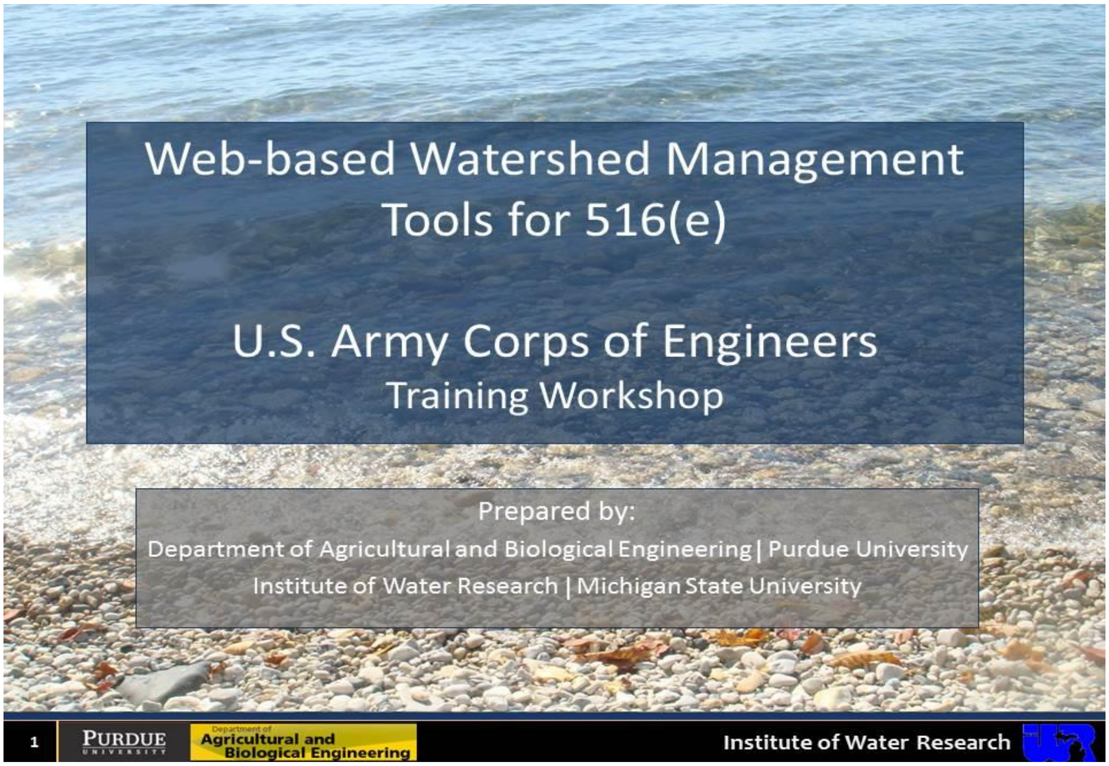
Purdue University, Michigan State University (MSU), USACE Buffalo, Chicago, and Detroit staff, and the Great Lakes Commission (GLC) will have a kick-off conference call to coordinate specific details of this scope of work. Following the kick-off call Purdue University and MSU will jointly prepare manuals to educate watershed groups throughout the Great Lakes on how to use the web-based tools developed by MSU and Purdue University. The training manuals' appendices will consist of a tutorial for each of the following three watersheds:

1 Upper Blanchard River, Ohio
2 Burns Ditch and/or Trail Creek, Indiana
3 River Raisin Watershed, Michigan

**Task 2 – Conduct Workshop**

MSU and Purdue Universities will jointly prepare a workshop. This workshop will be for one-day coordinated by the GLC. The workshop will be designed such that stakeholders can be educated on the HIT, L-THIA, and other web-based tools. The workshop will include a PowerPoint presentation that will be used to educate local watershed stakeholders. The one-day workshop will be approximately 8 hours of instruction.

Following the training, staff will provide comments on the PowerPoint presentations. MSU and Purdue Universities will incorporate comments into three (3) versions of a PowerPoint presentation which includes specific watershed tutorials (one for each of the listed watersheds).




**Task 3 – On-Line Instructional Videos**

MSU and Purdue Universities will develop instructional videos, to be posted on-line, for the respective tools. These videos will be based on the materials developed for the training manual and include the following: background, theory, and limitations; walkthroughs of each tool's functions; and applied scenarios. The ready accessibility of these videos will allow engagement of individuals who may not be able to attend the workshop, empower educators and allow workshop participants to readily review steps in tool use.

http://35.8.121.111/usace/jun212012.aspx

# Focused Practice Application To Reduce Soluble Reactive Phosphorous

**Focused Practice Application To Reduce Soluble Reactive Phosphorous**

## USEPA-Great Lakes Restoration Initiative Projects

Grant or IA Number: **00E01155-0-GL**
Project Title: **Locating and Targeting High-Impact Farm Fields to Reduce Phosphorus Discharges**
Reporting Period Covered: **10/01/2012 – 03/31/2013**
Principal Investigator: **Dr. Jon Bartholic**

1. What work was accomplished for this reporting period? Report should quantify results as measurable products, i.e. numbers, acres, contacts, improvements in water quality, habitat, etc.

- Advisory Team meeting conducted 2/19/2013
- Developed web page available to the public for the project www.iwr.msu.edu/flintriver. Also developed a secure link on that webpage for information to be accessed by the Advisory Team (Resources Tab > Advisory Committee -- password is action).
- Obtained water quality data from multiple sources and added them to our GIS-based system
- Contacted NRCS and obtained documentation on how to conduct appropriate cost/benefit analysis for BMP implementation
- Developed a prototype web-based mapping system (Environmental Learning Using Computer Interactive Decisions “ELUCID”) depicting information related to water quality. Discussed with the advisory team and at project meetings which other topics (e.g., land protection), that could be included in the web-based mapping system.
- Attended school water quality monitoring workshop in Flint and presented project information. Working with Flint River Watershed Coalition to examine the need for incorporating components of ELUCID into existing school monitoring programming.
- Developed a QAAP for the project.

2. What, if any, changes were made from the Object Class Categories listed in Sec. B of the SF 424A or Box 29 of the IA, as applicable? **None needed.**

3. If a problem was encountered, what action was taken to correct it? **None encountered.**

4. What work is projected for the new reporting period activity?

- Develop and post maps of phosphorus high risk areas on the web.
- Conduct detailed assessment of preliminary product (ELUCID). This will be done through focus group meetings with technicians and associates to test the prototype ELUCID. We will use the learning from these assessments to refine the ELUCID interface and functionality.
- Finalize subcontract with the Flint River Watershed Coalition including the position description for the one-half time facilitator position to be hired by the Coalition.
- Conduct second Advisory Team meeting.

5. Is the project work on schedule? List activities from the Work Plan, and any required Quality System Documentation, and report as percent completed.

(a) This reporting period

1) **Form an Advisory Team and meet quarterly:** Held Advisory Team meeting on February 19, 2012. (100% for this reporting period) On schedule.
2) **Subcontract with a local organization for one-half time local facilitator:** Developed a scope of work for the position which will form the basis for the subcontract. Currently working with the Flint River Watershed Coalition to develop and finalize the specific terms of the subcontract and the position description. (100% for this reporting period ) On schedule.
3) **Detailed assessment of preliminary products and specify refinements:** Collected input from Advisory Team and project team. Incorporated into ELUCID as appropriate. (100% for this reporting period) On schedule.
4) **Have High Risk maps and related products available on the Web:** High risk erosion and sediment maps have been produced and made available online via the initial version of the tool. The sediment risk map is being used as a surrogate to produce phosphorus risk maps on the 12-digit watershed basis for purposes of initial testing of the tool. (100% for this reporting period) On schedule.
5) **Fully assess the success of the integration of web support (maps, products, guidance) into local networks technical operations:** not applicable to this project period since the products have not yet been made available to the technicians
6) **Assess the success of all phases of the project and emphasize evaluation of activities and results relating to reduction of SRP:** not applicable to this project period since the products have not yet been made available to the technicians

(b) For the project

1) **Form an Advisory Team and meet quarterly:** Held Advisory Team meeting on February 19, 2012. (25% for the project) On schedule.
2) **Subcontract with a local organization for one-half time local facilitator:** Developed a scope of work for the position which will form the basis for the subcontract. Currently working with the Flint River Watershed Coalition to develop and finalize the specific terms of the subcontract and the position description. (50% for the project ) On schedule.
3) **Detailed assessment of preliminary products and specify refinements:** Collected input from Advisory Team and project team. Incorporated into ELUCID as appropriate. (50% for the project) On schedule.
4) **Have High Risk maps and related products available on the Web:** High risk erosion and sediment maps have been produced and made available online via the initial version of the tool. The sediment risk map is being used as a surrogate to produce phosphorus risk maps on the 12-digit watershed basis for purposes of initial testing of the tool. (50% for the project) On schedule.
5) **Fully assess the success of the integration of web support (maps, products, guidance) into local networks technical operations:** not applicable to this project period since the products have not yet been made available to the technicians
6) **Assess the success of all phases of the project and emphasize evaluation of activities and results relating to reduction of SRP:** not applicable to this project period since the products have not yet been made available to the technicians

## C. Assessment

## Social Indicators Data Management and Analysis

[www.iwr.msu.edu/sidma](www.iwr.msu.edu/sidma)


Water quality problems have accumulated over many decades and may take decades to amend. Confirming that awareness and attitudes are changing and behaviors are being adopted in a watershed is one way that projects can demonstrate progress toward water quality goals. Social indicators provide consistent measures of social change within a watershed and can be used by managers at local, state, and federal levels to estimate the impacts of their efforts and resources. As part of the Social Indicators Planning and Evaluation System (SIPES) project, the Michigan State University Institute of Water Research developed a web-based project management aid that support SIPES watershed projects. The Social Indicator Data Management and Analysis (SIDMA) system organizes, analyzes, and visualizes social indicators, related to nonpoint source (NPS) management efforts through statistical and spatial relationships. To date, the system has 105 SIDMA projects on the website. Ninety-six of these projects are in Illinois, Indiana, Michigan, Minnesota, Ohio and Wisconsin. After a recent webinar featuring this system, 50 additional watershed organizations from across the US requested permission to use this system tool in their watershed.

# 1. "Water Policy and Management Challenges in the West" for IWR's part contrasts Water Law/Management between the Eastern and Western United States. This is annual report of progress.

Nonpoint source pollution poses particular challenges to tracking water quality improvements in watersheds. Demonstrating improvements through traditional measures have not proven successful due to complex variables within watersheds and delays in response to applied management strategies. Social data can be used as a surrogate to traditional monitoring to identify changes in peoples behavior and attitudes that lead to improved water quality. However, due to the need for consistent measures and indicators for summarizing social data, using a practical framework and system to manage these indicators is crucial. The Social Indicator Data Management and Analysis (SIDMA) system was developed to provide a practical means for project management and administration to easily build and standardize social surveys, track progress, and summarize results in targeted watersheds.

In support of Coca-Cola and The Nature Conservancys (TNC) desire to protect Michigans Paw Paw River and remain water neutral, we developed a suite of maps and modeled outputs that display optimal locations for protection and improvement of water quality and quantity in the Paw Paw River watershed.

Previous work by Michigan TNC staff and Michigan State University (MSU) partners has resulted in a tool to quantify the impacts of groundwater pumping and surface land use on a groundwater aquifer. This framework allows for groundwater recharge (replenishment) to be calculated through spatial land use changes (e.g. conversion of conventional tillage to no-till, conversion of agricultural land to grassland or wetland restoration). Here we propose to apply this tool to the Paw Paw River Watershed, with the specific outcome of more efficiently targeting our outreach efforts to farmers, for the benefit of water quantity and quality within the watershed.

The optimization maps are the product of three tool outputs; Michigans Water Withdrawal Assessment Tool (WWAT); High Impact Targeting (HIT); and Soil and Water Assessment Tool (SWAT). The idea behind the optimization maps is to individually identify and map areas of particular interest within the watershed such as: high sediment loadings, agricultural row crops, water withdrawal, and groundwater recharge by soil groups. Once areas were modeled and identified, they were assigned weighting within a 30x30 meter grid cell. The weightings were summarized to provide rankings for priority location specific mapping of the key water balance factors. In this project we used the USDA-ARS SWAT and the USDA-NASS Cropland Data Layer to estimate the amount of annual irrigation water that could be used for irrigated agriculture (maize) across current row crop agriculture in the state of Michigan. The model was run on all row crop soil types across the state using site specific long term weather data from five locations. The results were aggregated to the watershed level that is used by the WWAT managed by the MI Department of Natural Resources and Environment.

## Outcomes/Impacts

The SIDMA website is the first system created to both manage social data related to water quality improvement and offer tools for users to build standardized social surveys. These functions allow project managers and administrators funded through the EPAs 319 program to demonstrate improvements in watersheds in new and innovative ways. In addition, administrators can easily search and report on the status of any of these projects across a region, reducing time and resources typically involved in facilitating these requests.

Online Groundwater Recharge Calculator: The online groundwater recharge calculator estimates the change in recharge to an aquifer based on land use/cover change and acres of land converted. The interface utilizes a map section and calculator section. The map section is built on Microsoft Bing Maps and displays the 12 digit HUC watershed boundaries, streams, and soil groups. The map interface works best with Mozilla FireFox. The user can zoom into parcel of land they are interested in and click the Create New Parcel button at the top map. The user can then single click on the corners of the property for which they wish to make land use/cover changes (double click when finished). The map will automatically calculate the size the parcel and soil type(s), and then open the calculator interface.

In the calculator interface, the user can enter the current land use/cover and the proposed land use/cover. If the soil type from the selected parcel is a single soil type, and not comprised of multiple soils, the interface will select that soil group; if there are multiple soils groups, the user will have to choose a dominant type. Once these parameters are all chosen, the user clicks the Calculate button. This sends the parameters to a recharge look up table produced by the SWAT model. The results are displayed in graphical and numeric form displaying the change in groundwater recharge.

A project titled Refining the Water Needs and Availability for Michigans Agriculture, provides broader yet location specific mapping of the key water balance factors. Never before has a thorough statewide assessment been conducted and presented of water balance factors with specific emphasis on water availability and needs at a water catchment level. This information is critically important and being utilized by the irrigation industry, seed corn growers, plus other agricultural producers. The information generated supports both broader statewide conceptual planning and detailed local consideration of water availability related to present and growing irrigation demands. We have used the results of this study to educate staff from the state agencies on irrigation and groundwater recharge in an agricultural setting. The study has given a good indication of what the long term irrigation demands are spatially across the state and where new irrigation demands are likely to occur.

## Publications

Bartholic, J., W. Northcott, S. Miller, J. Asher, S. Seedang, S. Gasteyer, and J. Andresen. 2010. Refining the Water Needs and Availability for Michigans Agriculture from a Spatial and Temporal Perspective, Institute of Water Research, Michigan State University, 5 pp.

Isely, E, P. Isely, S. Seedang, K. Mulder, A. Steinman, and K. Thompson. 2010. Addressing the Information Gaps Associated with Valuing Green Infrastructure in West Michigan: Integrated Valuation of Ecosystem Services Tool (INVEST). Journal of Great Lakes Research 36(3):448-457

Seedang, S. and P. Norris. 2010. Water Use in Michigan. Technical paper. Michigan Agricultural Experimental Station.

Adelaja, S. Y. Hailu, A. Tekle and S. Seedang. 2010. Evidence of Land Hoarding Behavior in U.S. Agriculture. Agricultural Finance Review 70(3) 377-398.

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Seedang, S , P. Norris, and J. Bartholic. 2010. The Role of Water Conservation Technology, Economics, and Institutions for Reducing Water Use Conflicts, Michigan Case Study (Proceedings abstract). The American Water Resources Association Annual Conference, Seattle, WA, November 9-12, 2009.

Bartholic, J., Y. Shi, K. Maredia, S. Seedang, J. MacDonagh-Dumler. 2010. Institute of Water Research and Institute of International Agriculture, Michigan State University, Characteristics of an Action Plan for Addressing Emerging Issues in Water Management for Sustainable Agriculture in South Asia Region. Submitted to the Central Soil & Water Conservation Research & Training Institute Research Centre, India for inclusion in Proceedings from the Indo-US Workshop on Emerging Issues in Water Management for Sustainable Agriculture in South Asia Region, December 10-12, 2009, in Udhagamandalam, Tamil Nadu, India.

ONeil, G., L. Theller, Y. Shi, J. Bartholic, B. Engel. 2010. The Swan Creek Watershed Management System, presented by ONeil at the TMDL 2010: Watershed Management to Improve Water Quality ASABE Conference, Nov. 14-17 in Baltimore, MD.

Shi, Y., J. Bartholic. 2010. Institute of Water Research, Michigan State University, .Managing Water Resources through Virtual Organizations. Proceedings from the Indo-US Workshop on Emerging Issues in Water Management for Sustainable Agriculture in South Asia Region, December 10-12, 2009, in Udhagamandalam, Tamil Nadu, India.

Shi, Y., J. MacDonald-Dumler, J. Bartholic, G. ONeil, J. Asher. 2010. Institute of Water Research, Michigan State University. Decision Support Tools for Watershed Management . A United States Experience. Proceedings from the Indo-US Workshop on Emerging Issues in Water Management for Sustainable Agriculture in South Asia Region, December 10-12, 2009, in Udhagamandalam, Tamil Nadu, India.

Wolfson, L. G. 2010. Rain Barrels, Rain Gardens, Green Roofs, and Porous (Permeable) Pavement. Fact Sheet Series. Networked Neighborhoods for Eco-Conservation Online. Accessible at: http://www.networkedneighbors.org/

**<u>Participants:</u>**

Individuals, organizations, etc. are incorporated in the Outcomes section of this report.

**Target Audiences:**

Individuals, organizations, etc. are incorporated in the Outputs and Outcomes sections of this report.

**Project Modifications:**

Nothing significant to report during this reporting period.

# 2. "Modeling for TMDL Development and Watershed Based Planning, Management and Assessment" Research Report incorporates recent progress on a variety of IWR's research projects.

Develop Tools: Nonpoint source pollution poses particular challenges to tracking water quality improvements in watersheds. Demonstrating improvements through traditional measures have not proven successful due to complex variables within watersheds and delays in response to applied management strategies. Social data can be used as a surrogate to traditional monitoring to identify changes in peoples behavior and attitudes that lead to improved water quality. However, due to the need for consistent measures and indicators for summarizing social data, using a practical framework and system to manage these indicators is crucial. The Social Indicator Data Management and Analysis (SIDMA) system was developed to provide a practical means for project management and administration to easily build and standardize social surveys, track progress, and summarize results in targeted watersheds.

Decision support systems for optimally managing the landscape of our Great Lakes watersheds have advanced significantly in recent years. Several approaches have been used in specific case studies. One such system known as High Impact Targeting (HIT) has evolved over the past several years and can now provide guidance to resource/watershed managers across the basin. With assistance and support from the Army Corps of Engineers 516e program and the USDA-NRCS-CIG program, this systematic approach toward identification and prioritization of highest contributing sediment locations (watershed down to sub-field scales) has been evaluated and enhanced. The HIT plus system is now available across the Great Lakes Basin. The system utilizes a spatially explicit sediment loading model that combines a soil-erosion model called RUSLE (Revised Universal Soil Loss Equation) and a sediment delivery ratio model called SEDMOD (Spatially Explicit Delivery Model). The system has been extensively evaluated at the County Conservation District office level and system outputs have been incorporated locally into the NRCS county level Tool Kit analysis system.

Gully erosion is an important sediment source in the environment. Gullies provide effective links for transporting runoff and sediment from uplands to valley bottoms and stream channels. Many damages done to watercourse and properties by runoff from agricultural land are related to gully erosions. In the past, the Institute of Water Research (IWR) sediment modeling tool was mostly focused on sheet erosion over agricultural landscapes. To enhance our capabilities for comprehensive sediment modeling, IWR recently applied technique developed by USDA-ARS to the Root River watershed in MN for a pilot study. This method uses a Compound Topographic Index (CTI) as a predictor of ephemeral gullying potential. CTI can be calculated in a GIS environment and is also programmed into the latest version of the AnnAGNPS software. The results we got for potential gully erosions in Root River watershed show this is a promising technique and can be utilized in the Great Lakes region based on high resolution DEMs(2-4 meters).

**Outcomes/Impacts**

A suite of decision support and learning web-based tools have been developed that are being used throughout the state and within the Great Lakes region to enable agencies and users to make more informed decisions concerning key environmental issues or practices. The State Department of Environmental Quality has recommended their use with watershed planning grants, and the Michigan NRCS is using one of these systems to guide their process in developing priority watersheds. Included are High Impact Targeting (HIT) (www.iwr.msu.edu/hit2) which prioritizes areas, at multiple scales, for optimal soil erosion and sediment loading reduction; Social Indicators Data Management and Analysis system (SIDMA) (www.iwr.msu.edu/sidma), a part of a larger multi-state project to measure social indicators as proxies for water quality; and Networked Neighborhoods for Eco-Conservation (www.networkedneighbors.org) which uses social networking and mapping technology to link people together with common goals of improving the environment in the Great Lakes Basin or their watershed.

The Social Indicators Data Management and Analysis (SIDMA) website is the first system created to both manage social data related to water quality improvement and offer tools for users to build standardized social surveys. These functions allow project managers and administrators funded through the EPA 319 program to demonstrate improvements in watersheds in new and innovative ways. In addition, administrators can easily search and report on the status of any of these projects across a region, reducing time and resources typically involved in facilitating these requests.

The High Impact Targeting (HIT) system is being utilized in watershed planning funded by the EPA 319 watershed program. The HIT system has aided in watershed planning by defining problematic agricultural areas in the watershed. Also, the system aids in the prioritization of actions to be taken in the implementation portion of the watershed improvement process. Estimates of sediment reduction from BMP implementation can be calculated and accumulated from field to watershed to sub-basin levels.

Facilitate Usability: These new technologies are allowing local users access to field level interactive intelligent guidance for conservation planning and practice selection. These systems can greatly improve efficiency and effectiveness for field technicians and land owners with identifying problematic fields, assessing BMPs, and simultaneously recording subsequent actions. One such system currently being adapted for hand-held and tablet technology delivery is High Impact Targeting (HIT), which is an action support tool at the watershed and field level for aiding conservation decisions. This hand-held and tablet technology delivery tool can provide greater cost-effective decisions to reduce the levels of sediment and nutrients reaching streams and lakes.

## Publications

Bartholic, J., W. Northcott, S. Miller, J. Asher, S. Seedang, S. Gasteyer, and J. Andresen. 2010. Refining the Water Needs and Availability for Michigans Agriculture from a Spatial and Temporal Perspective, Institute of Water Research, Michigan State University, 5 pp.

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Bartholic, J., Y. Shi, K. Maredia, S. Seedang, J. MacDonagh-Dumler. 2010. Institute of Water Research and Institute of International Agriculture, Michigan State University, Characteristics of an Action Plan for Addressing Emerging Issues in Water Management for Sustainable Agriculture in South Asia Region. Submitted to the Central Soil & Water Conservation Research & Training Institute Research Centre, India for inclusion in Proceedings from the Indo-US Workshop on Emerging Issues in Water Management for Sustainable Agriculture in South Asia Region, December 10-12, 2009, in Udhagamandalam, Tamil Nadu, India.

ONeil, G., J. Bartholic, Y. Shi. 2010. Institute of Water Research, Michigan State University. High Impact Targeting Decision Support System for BMPs to Most Effectively Reduce NPS Pollution, presented at the 18th National Nonpoint Source Monitoring Workshop held in Milwaukee, Wisconsin November 16-18. Nov. 17, Session 5-03, In Proceedings on CD, 33 pp.

Shi, Y., J. Bartholic. 2010. Institute of Water Research, Michigan State University. Managing Water Resources through Virtual Organizations. Proceedings from the Indo-US Workshop on Emerging Issues in Water Management for Sustainable Agriculture in South Asia Region, December 10-12, 2009, in Udhagamandalam, Tamil Nadu, India.

Shi, Y., J. MacDonald-Dumler, J. Bartholic, G. ONeil, J. Asher. 2010. Institute of Water Research, Michigan State University. Decision Support Tools for Watershed Management. A United States Experience. Proceedings from the Indo-US Workshop on Emerging Issues in Water Management for Sustainable Agriculture in South Asia Region, December 10-12, 2009, in Udhagamandalam, Tamil Nadu, India.

Stepenuck, K., L. Wolfson, B. Liukkonen, J. Iles, and T. Grant. 2011. Volunteer Monitoring of E. coli in Streams of the Upper Midwestern United States: A Comparison of Methods. Environmental Monitoring and Assessment 174:625-633.

Wolfson, L. 2010. Harmful Algal Blooms on the Rise. 2010. Lake Effect: Vol. 2. February 2010. Michigan Chapter, North American Lake Management Society. Pages: 69.

Wolfson, L. G. 2010. Rain Barrels, Rain Gardens, Green Roofs, and Porous (Permeable) Pavement. Fact Sheet Series. Networked Neighborhoods for Eco-Conservation Online. Accessible at: http://www.networkedneighbors.org/

**Participants:**

Individuals, organizations, etc. are incorporated in the Outcomes section of this report.

**Target Audiences:**

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**Project Modifications:**

Nothing significant to report during this reporting period.

# Water Quality and Nonpoint Source Disproportionality: Addressing the Structural Factors

## Basic Information

| | |
|---|---|
| **Title:** | Water Quality and Nonpoint Source Disproportionality: Addressing the Structural Factors |
| **Project Number:** | 2012MI202B |
| **Start Date:** | 3/1/2012 |
| **End Date:** | 2/28/2013 |
| **Funding Source:** | 104B |
| **Congressional District:** | 8 |
| **Research Category:** | Social Sciences |
| **Focus Category:** | Water Quality, Management and Planning, Non Point Pollution |
| **Descriptors:** | None |
| **Principal Investigators:** | Stephen Gasteyer |

## Publications

1. Gasteyer and Benveniste. In Development. Assessing Collaborative Capacity: Identifying Common Ground to Achieve Water Quality Goals.
2. Contributed to the USDA NC 1190 Regional Research Report on Disproportionality (forthcoming).

**Title:** Water Quality and Nonpoint Source Disproportionality: Addressing the Structural Factors
**Project Number:** 2012MI202B
**Start:** 03/1/2012
**End:** 02/28/13 (actual)
**Funding Source:** USGS ("104B")
**Congressional District:** eighth
**Research Category:** Social Sciences
**Focus Categories:** WQ, M&P, NPP
**Descriptors:** water quality; watershed management; civic environment; disproportionality; community capitals
**Primary PI:** Stephen Gasteyer

**Project Class:** Research

**Introduction:** There has been increasing concern about how to address the problem of disproportionality of contribution to water quality impairment. Disproportionality as a concept refers to the recognition that certain land holdings bear a greater responsibility for contribution to water impairment. The implications of disproportionality are that addressing water quality impairment requires: a) identifying the main culprits of impairment; b) creating processes to reach the culprits and implement the practices that will mitigate impairment. In Michigan, significant progress has been made in identifying the spatial distribution of impairment. The collaborative processes to address impairments and, ergo, remediate impairment. This research project studied the collaborative process of interagency collaboration to address disproportionality in two watersheds.

## General Statement

<u>Problem/Demand</u>

Development of interagency collaboration to address disproportionality, requires the creation of long standing collaborative processes – which the literature refers to as collaborative capacity. Collaborative capacity assessments are a reflexive process for identifying possible policy goals, actions and indicators of success in a multi-stakeholder collaboration. These assessments help to identify common ground between group stakeholders as well as clarify key differences in perspectives and policy orientations, both of which facilitate collaboration. We attempt to answer the question: what are the potential capacities for collaboration to impact disproportionate contribution to water quality impairment?

<u>Methodology</u>

To conduct this assessment, we carried out telephone and/or face to face interviews with member organization representatives using an interview tool that would use a concept mapping approach to assess:

1. the motivations of the group
    a. what individuals partners want out of the meetings
    b. how their organizations benefit from better water quality

2. the causal model of what actions would lead to improved water quality and mitigation of water quality impairments
3. goals in policy development to mitigate water quality impairments
    a. key policies and policy changes that should be considered
4. key developments in the effort to mitigate water quality impairments that they would see as problematic
5. key indicators that should be used to indicate the impacts of actions to improve water quality

All in all, we interviewed 14 organizational representatives. Interviews lasted between 30 minutes and an hour. We also analyzed agency reports and papers, and were participant observers at 4 meetings of the NRWG. Notes were content analyzed by the research assistant and PI, and additionally subjected to a preliminary content analysis using Nvivo.

We used the "socio-ecological activity pyramid" analysis framework (Morton, et al. 2010) to illustrate how different group member perspectives influence the group from program development to outcome. The socio-ecological activity pyramid categorizes the ways that social institutions try to convince people to take actions in the common interest: specifically through force, economic incentive; social pressure; and internalization. Overlaid on this will be a modified advocacy coalition framework (Gasteyer, 2008) that will be used to demonstrate how groups of representatives cluster around desired policies, actions, outcomes, and indicators; and the community capitals framework (Flora 2008) to analyze the kinds of actions desired by members.

<u>Problem and Research Objectives</u>

This project assessed the collaborative capacity assessment proceedings of a natural resources working group that included members from state and federal agencies, environmental organizations, and industry leaders. This group formed out of a recognized need for better coordination of activities aimed at reducing agricultural pollution impacts on MI watersheds. Though it is too early to know if the assessment facilitated much collaboration, an analysis of the assessment process does locate power within the group, and may help to explain why certain watershed management strategies are adopted over others.

<u>Principle Findings and Significance</u>

Members of the NRWG recognize that opportunities for collaboration exist within the group, and agree that ecosystem improvements is the indicator of success for pollution mitigation interventions. However, members of this group expressed differences in their motivations and perspectives that can potentially undermine future collaboration if left unacknowledged. Differences in preferred group goals and actions exist, and serve as an indicator of how much the group is willing to engage in collaborative actions. And though group members prefer non-regulatory approaches to reducing agricultural pollution, several identify a need to adjust how voluntary programs like MAEAP are implemented.

Differences in group goals and actions indicate how much various members of the group are willing to engage in collaboration. For some, sharing information was the desired goal of the group, while others sought coordinating efforts for improved operational efficiency. Members who sought collaborative partnerships as the group goal indicated the greatest willingness for collaborative engagement. The actions members identified as achieving group goals also reflected this spectrum for collaborative engagement; with regular meetings and network building at the low end, and identifying opportunities for collaborative proposals at the high end. The distinctions in desired policy implications are also worth noting, though all members identified non-regulatory preferences to reducing agricultural impacts on watersheds. Several members suggested modifying the implementation of voluntary programs, either by expanding their authority or by including water quality goals. Recognizing that regulatory approaches can result in a splintering of the coalition will be something to consider at the group moves ahead. Integrate this point about "Social Capital as Improving Collaborative Capacity"

> "I don't see this group as being a driving force in better implementation and on the land conservation; that's several steps beyond what this group may be doing. But this group may be better able to facilitate that"
>
> "One of the things that would be a great indicator of the success of the group, is if there are relationships between individuals sitting around the table today that are long-lasting over and above and beyond what we do at the meetings. You know, are we going to call one another when there's something that comes up between meetings, or even if this group were to go away, will we be talking with one another long after this group disbanded, about opportunities to move forward in a positive way to address these risks"

Having said that, the NRWG expresses significant common ground around goals, actions, desired outcomes and willingness to participate.

Concern for collaboration's public support: "the big challenge would be to demonstrate to tax payers that the work that's being done by all these organizations in a collaborative way is actually changing that body of water and an entire watershed, so that people can use it for recreational purposes, for drinking purposes, for all of those things that people typically think about living within a watershed they can do: fishing, hunting, swimming."

Why collaborative capacity is important:
- Identifying common ground to work with positional players who will support policies for reducing NPS agricultural pollution.

There's going to be significant challenges in making sure that local level stakeholders are pulled into the decision-making process when we start sharing data and implementing BMPs. Partnerships being about communication, data sharing, collaboration, join proposals, and partnerships being about sharing of work. So it's important to tease out what kind of collaboration do people want to do. What will keep people and organizations continuing to collaborate?

Each of these organizations have an ideal type of collaboration -- "There were a range of responses about the type of collaboration that might viewed as ideal"

If you are going to move from discussions at the high level to particular watersheds, you do need to think about who are the partners on the ground you need to include, both producers as well as local government. What we do know is that there are partners in this room who are going to be deeply opposed to moving towards regulation.

## Notable Achievements

**Title:** Water Quality and Nonpoint Source Disproportionality: Addressing the Potential for Collaborative Approaches

**Brief:**
This research assessed the collaborative capacity of a multi-institutional collaboration to address disproporationality in water quality impairment in Michigan watersheds. The key finding was that 1) there is real interest in collaboration, 2) there is diversity in interest in collaboration, 3) the challenge of maintaining the collaboration will necessitate a continued focus modeling and intensification of voluntary approaches to land management.

**Funding Agency: USGS**

## Publications

Gasteyer and Benveniste. In Development. Assessing Collaborative Capacity: Identifying Common Ground to Achieve Water Quality Goals.

Contributed to the USDA NC 1190 Regional Research Report on Disproportionality (forthcoming).

# Landscape and lake characteristics driving the genetic and species diversity of aquatic plants

## Basic Information

| | |
|---|---|
| **Title:** | Landscape and lake characteristics driving the genetic and species diversity of aquatic plants |
| **Project Number:** | 2012MI203B |
| **Start Date:** | 3/1/2012 |
| **End Date:** | 2/28/2013 |
| **Funding Source:** | 104B |
| **Congressional District:** | 8 |
| **Research Category:** | Water Quality |
| **Focus Category:** | Ecology, Conservation, Acid Deposition |
| **Descriptors:** | Macrophytes, lake connectivity, landscape genetics, species diversity, genetic differentiation, Inter sequence simple repeats (ISSR) |
| **Principal Investigators:** | Kendra Spence Cheruvelil, Joseph K. Bump |

## Publications

1. De Palma-Dow, A. and and K.S. Cheruvelil. Drivers of macrophyte richness in undisturbed lakes: an Isle Royale Case Study. Oral presentation at the Midwest Aquatic Plant Management Society Annual Conference, Cleveland, OH. March 2013.
2. De Palma-Dow, A. and and K.S. Cheruvelil. The roles of connectivity and abiotic lake and landscape features for understanding variation in macrophyte richness among undisturbed lakes. Poster presentation at the American Society of Limnology and Oceanography Aquatic Sciences Meeting, New Orleans, LA. February 2013.

**Title:** Landscape and lake characteristics driving genetic and species diversity of aquatic plants.
**Project Number:** 2012MI203B
**Start:** 03/1/2012
**End:** 02/28/13 (actual)
**Funding Source:** USGS ("104B")
**Congressional District:** eighth
**Research Category:** Water Quality
**Focus Categories:** Ecology, Conservation, Invasive Species
**Descriptors:** Macrophytes, lake connectivity, landscape genetics, species diversity, genetic differentiation, Inter sequence simple repeats (ISSR)
**Primary PI:** **1)** Dr. Kendra Cheruvelil, Associate Professor, Lyman Briggs College and the Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI 48823, ksc@msu.edu, 517-353-9528 **2)** Dr. Joseph Bump , Assistant Professor, School of Forest Resources & Environmental Science, Michigan Technological University, 1400 Townsend Drive, Houghton, MI 49931, jkbump@mtu.edu (906) 487-1093.
**Project Class:** Research

## Introduction

Diversity is essential for species, community, and ecosystem survival. For example, the higher genetic and species diversity that is present in a population and community, respectively, the better equipped that population or community will be to respond to various environmental stressors such as invasive species introduction and human-induced environmental change (Lande & Shannon 1996, Thum & Lennon 2010). These stressors, through competition for resources (invasive species) and selection (drastic changes in environmental conditions), can induce local or regional extinctions of species (Lande & Shannon 1996). Therefore, to best prioritize where to assign research and conservation focus, we have to understand the extent of diversity that is currently present in both disturbed and undisturbed systems.

In aquatic environments, species composition is often driven by a combination of factors that influence the introduction, abundance and diversity of individual species in communities. Our research aims to identify the important role that dispersal potential (i.e. connectivity) and the local environment (physical and chemical) play in determining macrophyte (i.e. aquatic plant) diversity across multiple unconnected lakes and connected, chains of lakes. We do so by conducting a field survey of lakes located on an undisturbed freshwater island, Isle Royale National Park (ISRO). These study lakes present an ideal study site for this research because they are shielded from most anthropogenic factors, have few macrophyte immigration and emigration possibilities, and have a naturally constraining physical and political boundary.

## General Statement

Problem/Demand

In general, scientists know little about the influence that lake connectivity and landscape characteristics have on macrophyte diversity. Moreover, a majority of landscape ecology research, as well as research on ISRO, has been traditionally terrestrial in nature. Today, a majority of aquatic systems in our nation have been altered. For example, many have decreased connectivity because of dams and levees, leading to genetic bottlenecks, loss of diversity and decreased ecosystem production (Rahel 2007; Karburg & Gale 2006). Simultaneously, human expansion has also increased species dispersal through corridor alteration or creation and the physical transport of organisms across the land, resulting in the artificial linkage of previously isolated patches in the landscape (Rahel 2007; Karburg & Gale 2006; Pringle 2003). Study on human-induced connectivity among water bodies has been great (e.g., Rahel 2007; Lodge et al. 2006; Karberg & Gale 2006), particularly since the advent of watershed-scale management planning. However, little is known about the effects of natural connections on macrophyte populations in relatively natural and unaltered freshwater ecosystems, such as those found on ISRO.

ISRO is also home to several rare, Michigan special concern or threatened macrophyte species, such as alternate-leaved watermilfoil (*Myriophylum alterniflorum*), aquatic lake cress (*Armoracia lacustris*), Farwell's milfoil (*Myriophyllum farwellii*) (Meeker et al. 2007), and pygmy water lily (*Nymphaea tetragona*) (A. De Palma Dow, personal observation 2011). Invasive macrophyte species, such as Eurasian milfoil (*Myriophylum spicatum*), purple loose-strife (*Lythrum salicaria*) and curly leaf pondweed (*Potomogeton crispus*) are routinely found in lakes on the mainland of Michigan. If introduced and established on ISRO, these species could negatively affect these threatened and special concern species as well as overall macrophyte genetic and species diversity, thus leading to a decrease in community resistance and resilience to human-induced stressors.

Our study provides important baseline data about the macrophytes on ISRO that will meet goals of the National Park Invasive Species Strategic plan (2008-2012). Specifically, this document calls for a 'Prevention, Early Detection and Eradication' research priority to 'Quantify genetic, ecological, and evolutional relationships among the species and ecosystems where they occur and…[the] ecological, social, and economic impacts of invasive species'. Therefore, by characterizing the ISRO lakes and landscape (e.g., connectivity) features and relating them to macrophyte richness and diversity on ISRO; these data can inform ecology as well as aquatic plant management and restoration on the island and in the surrounding regions.

Problem and Research Objectives

Objectives of this project include: 1) classify all ISRO lakes as either physically connected or isolated, 2) for a subset of those lakes, determine the physical and chemical lake features, 3) relate these features to aquatic plant species richness and diversity, and 4) determine whether these relationships differ for connected vs. isolated lakes.

Methodology

During summer 2012, we conducted a field survey to determine the main driver of macrophyte diversity among lakes on ISRO. GIS was used to select 12 inland ISRO lakes that were either isolated (not within the same watershed) or connected (within the same watershed and sharing water sources with another lake). All lakes also had a surface area size greater than 10 hectares, which increases the probability of most accurately-representing macrophyte diversity (Van Geest et al. 2003, Squires et al. 2002, Vestergard & San Jenson 2000). In the field, we measured the number and relative abundance of each macrophyte species using the Capers (2009) and Titus (1993) sampling protocols. We collected physical and chemical abiotic lake data (i.e. lake area, perimeter and depth, watershed size, alkalinity, water column and sediment nutrients, clarity and water color) to quantify the relationships of these environmental features with macrophyte diversity.

During the academic 2012-2013 year, we processed all lab samples, entered field data into a database, and conducted statistical analyses in R. We used multiple regression models to identify which environmental predictor variables had the most influence on macrophyte species richness (richness is used here as a diversity surrogate measure because abundance analysis, which is needed for diversity metrics, is still being completed at the time of this report). In these models, species macrophyte richness is the response variables and physical and chemical lake and landscape factors are predictor variables. For the best model selection, we transformed non-normally distributed variables, used only predictor variables that had weak correlations with other predictor variables ($r < 0.50$) and variables with wide variability in their range (i.e. information contributed meaningful ecological inference). ANOVA was also used to identify if species richness varied by lake type (connected vs. isolated) or lake chain type (two or three lake chain).

## Principal Findings and Significance

*Results for Objective 1: Create a Geodatabase to determine hydrologic connectivity of ISRO lakes.* Using watershed boundary (Kraft et al. 2010), NHD stream flow (USGS) and topographical layers, we produced an interactive map describing the general flow of water across the island. We identified which lakes are connected to other lakes and share aquatic corridors, even if they are seemingly geographically separated (Figure 1a-b). We also used this information to identify lakes that were truly isolated from any other lakes, conforming to the selection requirements of our sample lakes (i.e. ‘isolated’ lakes may be connected to a neighboring beaver pond or steam, but are isolated if connected to another lake > 10 hectares in area) To our knowledge, such a geodatabase did not previously exist, and it will help park managers determine overall aquatic landscape connections across ISRO.

*Results for Objective 2: Determine physical and chemical lake features for 12 connected and isolated lakes on ISRO.* Samples taken during Summer 2012 and processed during the academic 2012-2013 year provide us with the following information about our 12 study lakes:

| Lake Name | Connected (Y or N) | Surface Area (ha) | Perimeter (m) | Watershed area (ha) | Max depth (m) | Alk - water ($CaCO_3$) | Alk - sediment ($CaCO_3$) | color (Pt-Co units) | Secchi depth (m) | $NH_4$ - water (ug/L) | $NH_4$ - sediment (ug/L) | TP - water (ug/L) | TP - sediment (ug/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ahmik | Y | 10.3 | 2600.7 | 35.4 | 3.4 | 91.5 | 143.5 | 168.8 | 1.5 | 29.6 | 915.9 | 6.9 | 89.7 |
| Angleworm | Y | 49.8 | 73331.4 | 495.6 | 8.4 | 54.3 | 54.0 | 50.0 | 2.7 | 46.2 | 51.9 | 32.6 | 53.4 |
| Beaver | Y | 20.4 | 3110.1 | 258.3 | 5.2 | 75.5 | 93.3 | 137.5 | 2.2 | 515.4 | 278.5 | 86.2 | 50.0 |
| Benson | N | 23.8 | 3209.1 | 83.0 | 3.8 | 62.3 | 90.0 | 93.8 | 1.7 | 15.6 | 519.7 | 29.0 | 80.1 |
| Chickenbone | Y | 91.0 | 8903.8 | 1556.4 | 6.4 | 76.0 | 97.3 | 75.0 | 1.3 | 14.3 | 42.1 | 20.6 | 38.2 |
| LaSage | Y | 44.8 | 5845.9 | 933.0 | 6.4 | 52.5 | 83.0 | 100.0 | 1.8 | 83.5 | 183.6 | 7.9 | 47.8 |
| Livermore | Y | 29.8 | 3729.4 | 168.8 | 5.5 | 74.0 | 107.0 | 87.5 | 2.2 | 16.7 | 13.9 | 19.9 | 71.9 |
| McDonald | Y | 15.1 | 2346.4 | 104.9 | 4.0 | 76.8 | 127.0 | 143.8 | 1.9 | 1176.8 | 1102.4 | 70.2 | 61.0 |
| Ojibway | N | 15.0 | 3659.5 | - | - | 31.0 | 42.5 | 112.5 | 0.9 | 26.5 | 227.8 | 34.5 | 169.0 |
| Otter | N | 20.3 | 2858.6 | 96.3 | 4.3 | 67.0 | 75.8 | 75.0 | 1.9 | 33.4 | 22.3 | 25.7 | 61.3 |
| Patterson | Y | 10.3 | 2018.3 | 43.3 | 3.6 | 71.8 | 85.5 | 237.5 | 0.9 | 22.9 | 370.1 | 21.7 | 40.4 |
| Richie | Y | 200.0 | 15671.7 | 2080.2 | 10.7 | 63.0 | 73.5 | 81.3 | 2.2 | 48.5 | 97.3 | 23.8 | 60.6 |

***Table 1.*** Physical and chemical attributes for 12 lakes sampled on Isle Royale National park during summer 2012. Values represent averages calculated from four stratified random sample locations for each lake used to capture whole lake conditions. Surface area, perimeter, watershed size and maximum depth were provided by the National Park Service. Alk = alkalinity, water = water column, and – means no data available.

*Results for Objective 3: Relate physical and chemical lake features to aquatic plant species diversity.* Of all the environmental variables (see **Table 1** above), only nitrogen concentration was significantly related to macrophyte richness (**Figure 2**). It was surprising that lake size and water clarity (measured as Secchi disk depth) were not related to macrophyte richness because previous research has found such relationships. This surprising result may be partly because of the relatively small number of lakes we sampled during Summer 2012. Therefore, we plan to sample additional lakes during Summer 2013.

*Results for Objective 4: Determine whether species richness or relationships between the environment and richness differ between connected vs. isolated lakes*. ANOVA results showed that lake chain type did not have a significant effect on macrophyte richness. However, species richness was found to be higher in isolated lakes then connected lakes (**Figure 2**, F= 7.07, P=0.024). This result is contrary to our expectation of higher richness in connected lakes because connections allow for species introductions. Our result may be due to species-specific interactions in the connected lakes or the fact that they share very similar environmental characteristics, leading to homogenization in those lakes. Nitrogen concentration was negatively related to macrophyte richness for all lakes (**Figure 3**, n=12, R= 0.24, P=0.09), and this relationship was even stronger for connected lakes only (**Figure 4**, n=9, R= 0.46, p=0.04).

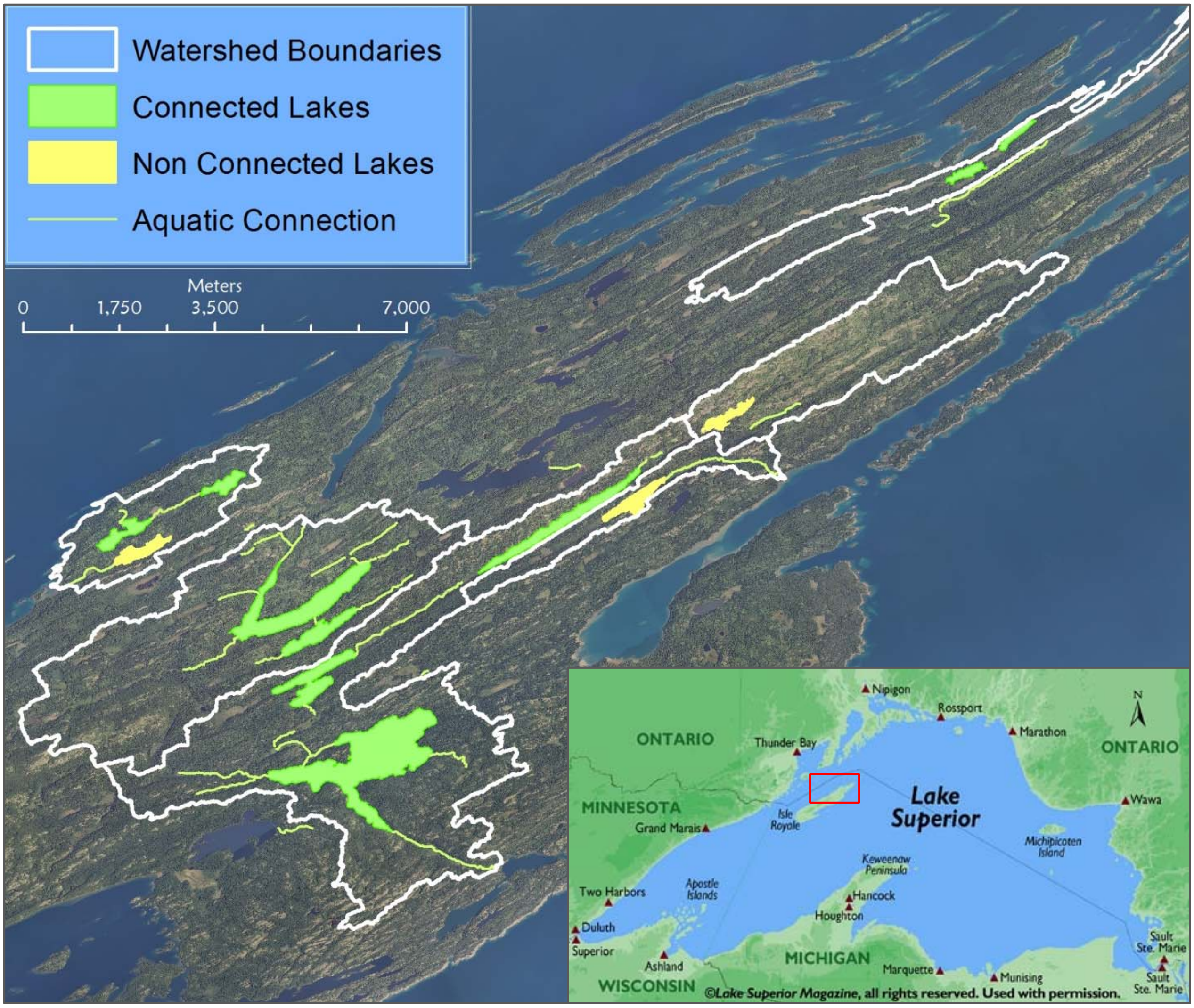
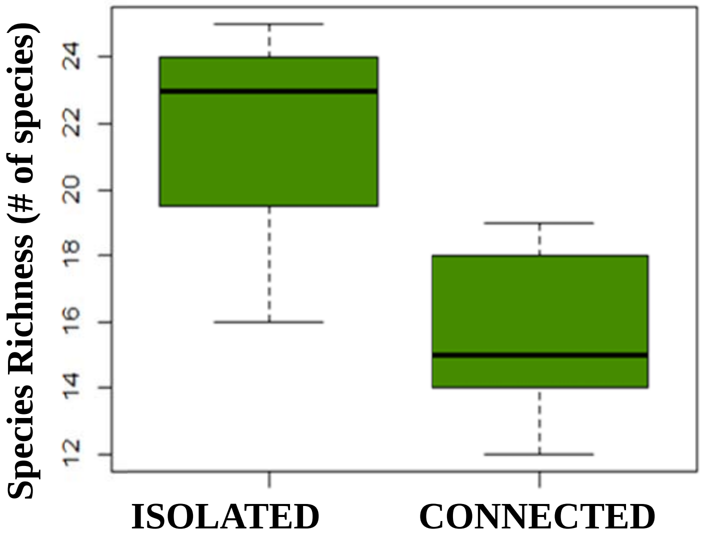



**Figure 1a-b.** Map of Study location a) Lake Superior with Isle Royale National Park (ISRO) study site boxed in red. b) Eastern portion of Isle Royale National Park where sample lakes are located. Connected and isolated sample lakes are highlighted along with aquatic connections and watershed boundary layers. Made with GIS 1m resolution aerial orthoimagery from the USGS NHD, other layers courtesy of ISRO NPS and Dave Mechenich (UW-Stevens Point).



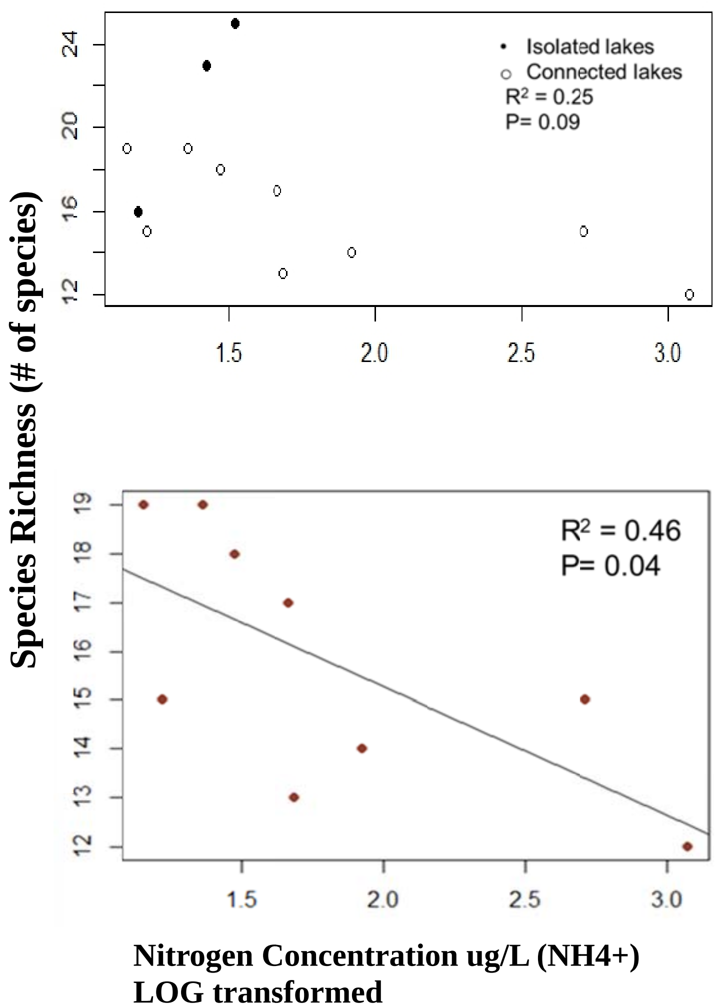




**Figure 3 (left)** Relationship shown between species richness and NH4 concentration for all 12 lakes (for all n=12 Nitrogen concentration ranges from 1.16 to 3.07 LOG transformed ug/L). Although for all lakes this relationships is not significant at the α=0.05 level, generally, lower nitrogen concentrations are related to higher richness in ISRO lakes, indicating a potential preferred NH4 nutrient range for a diverse macrophyte community.

**Figure 4 (left)** Scatterplot of macrophyte richness against NH4+ concentration for connected lakes (n=9) only on ISRO. Regressions with connectivity type and nitrogen concentration included produced a reasonably significant negative relationship (p=0.04, $R^2$ = 0.46 at α=0.05) to richness. Nitrogen (by NH4+) concentration predicts macrophyte richness in connected lakes.

Results of our study thus far provide: 1) Important baseline ISRO aquatic plant data that will meet goals of the National Park Invasive Species Strategic plan (2008-2012), complement terrestrially-focused research on the island, and provide restoration ecologists with location of potential native and rare plant seed banks that are most likely to be successful in the Great Lakes region, especially the Lake Superior Basin. 2) Important geospatial ISRO connectivity information to help predict aquatic invasive species introduction and establishment. Aquatic plants travel to new locations through aquatic corridors or rely on human/animal or man-made vectors. Our geospatial database of aquatic connections for ISRO can help predict invasion susceptibility on the island, both for macrophytes and for other species that cannot rely on wind or air-mediated transport to reproduce or disperse (e.g., zebra mussel, spiny water flea and sea lamprey larva).

## Notable Achievements

**Title:** Significant Training
**Brief:** Significant training potential was satisfied by the completion of this project. Angela De Palma-Dow, a Masters Graduate Student in the Department of Fisheries and Wildlife at Michigan State University, is basing her Master's Thesis on the data collected during Summer 2012. She is expected to be lead author on at least one scientific article about this research. Kimberly Schoch, an undergraduate student (currently a Junior) and Professorial Assistant through the Lyman Briggs College and the Honors College at MSU was a research assistant for Angela and contributed to the success of this project by formulating laboratory protocols, collecting field data, and helping to organize and train volunteers. Kim developed her own tangentially-related research project and presented the theory and development in poster form at the 2012 Lyman Briggs Undergraduate Research Symposium. Angela and Dr. Cheruvelil also recruited a new freshman undergraduate Professorial Assistant through Lyman Briggs, Stephen Rivard, in September 2012. He used alkalinity data collected from the ISRO 2012 summer season to complete his own methods-inquiry research and presented his poster at the 2013 Lyman Briggs Undergraduate Research Symposium. Due to the heavy requirement of field work for this project, Angela successfully recruited and trained four female undergraduate volunteer field assistants from the department of Fisheries and Wildlife and the Lyman Briggs College who accompanied her and Kim to ISRO during summer 2012. They carried equipment, collected samples, organized materials and provided feedback on environmental conditions and project structure.
**Funding Agency:** USGS104 (B)

## Publications

Results from this research were presented in two external forums:

*De Palma-Dow, A.* and and K.S. Cheruvelil. Drivers of macrophyte richness in undisturbed lakes: an Isle Royale Case Study. Oral presentation at the Midwest Aquatic Plant Management Society Annual Conference, Cleveland, OH. March 2013.

*De Palma-Dow, A.* and and K.S. Cheruvelil. The roles of connectivity and abiotic lake and landscape features for understanding variation in macrophyte richness among undisturbed

lakes. Poster presentation at the American Society of Limnology and Oceanography Aquatic Sciences Meeting, New Orleans, LA. February 2013.

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# Spatially distributed modeling of water and pollutant transport in the Great Lakes watersheds

## Basic Information

| | |
|---|---|
| **Title:** | Spatially distributed modeling of water and pollutant transport in the Great Lakes watersheds |
| **Project Number:** | 2012MI205B |
| **Start Date:** | 3/1/2012 |
| **End Date:** | 2/28/2013 |
| **Funding Source:** | 104B |
| **Congressional District:** | 8 |
| **Research Category:** | Water Quality |
| **Focus Category:** | Water Quality, Hydrology, Models |
| **Descriptors:** | Nonpoint source pollution, hydrological modeling, Distributed Large Basin Runoff, Saginaw River Basin |
| **Principal Investigators:** | Chansheng He |

## Publications

1. He, C., C. DeMarchi, W. Tao, and T.H. Johengen. 2012. Modeling Distribution of Point and Nonpoint Sources Pollution Loadings in The Saginaw Bay Watersheds, Michigan. In: Lawrence, P.L. edited book: Geospatial Tools for Urban Water Resources. Springer, New York, p97-113.
2. He, C. 2012. Water Resource Management and Watershed Science. Advances in Earth Science , 27(7):705-711 (in Chinese).
3. He, C., X. Zhang, and S. Eslamian. 2013. Chapter 86: Water Security: Concept, Measurement, and Operationalization. In: Saeid Eslamian (ed): Handbook of Engineering Hydrology, Vol. 3: Environmental Hydrology and Water Management (Taylor and Francis ) (in press).
4. He, C. and T.E. Croley. 2012. Modeling the Nonpoint Source Pollution in the U.S. Great Lakes Watersheds. The Institute of Geographical Resources and Natural Resources Research (IGSNRR), The Chinese Academy of Sciences, Beijing, May 14.

**Title:** Spatially distributed modeling of water and pollutant transport in the Great Lakes watersheds
**Project Number:** 2012MI205B
**Start:** 03/1/2012
**End:** 02/28/13 (actual)
**Funding Source:** USGS ("104B")
**Congressional District:** eighth
**Research Category:** Water Quality
**Focus Categories:** Water Quality, Hydrology, Models
**Descriptors:** Nonpoint source pollution, hydrological modeling, Distributed Large Basin Saginaw River Basin
**Primary PI:** Chansheng He, Professor, Department of Geography, Western Michigan University, Kalamazoo, MI 49008-5424, chansheng.he@wmich.edu

**Project Class:** Research

## Introduction

Contaminated sediments, urban runoff and storm sewers, and agricultural nonpoint sources have been identified as the primary sources of pollutants that impair Great Lakes shoreline waters by the U.S. Environmental Protection Agency (EPA 2002). Up until recently, however, there are no integrated, spatially distributed, physically-based watershed-scale hydrological water quality models available to evaluate movement of materials (sediments, animal and human wastes, agricultural chemicals, and nutrients, etc.) in both surface and subsurface waters in the Great Lakes watersheds. As a result, little comprehensive research has been done to systematically model the spatial and temporal distributions of point and nonpoint source pollution of water quality in Great Lakes watersheds. In recent years, the Great Lakes Environmental Research laboratory (GLERL) and Western Michigan University (WMU) have been working together to develop a spatially distributed, physically-based watershed model, the Distributed Large Basin Runoff Model (DLBRM) to simulates both point and nonpoint source pollution in the Great Lakes watersheds. We propose in this study to use DLBRM to simulate the transport and distributions of those materials and evaluate their impacts on water quality in Great Lakes watersheds to support water resources and ecosystem management.

## General Statement

Problem/Demand

Agricultural nonpoint source contamination of water resources by pesticides, fertilizers, animal wastes, and soil erosion is a major problem in much of the Great Lakes Basin. Point source contaminations, such as combined sewer outflows (CSOs), also add wastes to water flows. Improper management of fertilizers, pesticides, and animal and human wastes can cause increased levels of nitrogen, phosphorus, and toxic substances in both surface water and groundwater. Sediment, waste, pesticide, and nutrient loadings to surface and subsurface waters can result in oxygen depletion (BOD and COD loadings) and eutrophication in receiving lakes, as well as secondary impacts such as harmful algal blooms (HABs) and beach closings due to viral and bacterial and/or toxin delivery to affected sites. The U.S. Environmental Protection Agency (U.S. EPA 2002) has identified contaminated sediments, urban runoff and storm sewers, and agriculture as the primary sources of pollutants that impair Great Lakes shoreline waters. Effective management of Great Lakes water quality requires estimation of both point and nonpoint source material transport through a watershed by hydrological processes and prediction of various ecological system variables or consequences (such as beach closings) to ensure the health of ecosystems and the safety of the general public. Up until recently, however, there are no integrated, spatially distributed, physically-based watershed-scale hydrological water quality models available to evaluate movement of materials (sediments, animal and human wastes, agricultural chemicals, nutrients, etc.) in both surface and subsurface waters in the Great Lakes watersheds. Subsequently, little comprehensive research has been done to systematically model the spatial and temporal distributions of point and nonpoint source pollution of water quality in the Great Lakes watersheds. In recent years, the Great Lakes Environmental Research laboratory (GLERL) and Western Michigan University (WMU) have been working together to develop a spatially distributed, physically-based watershed model, the Distributed Large Basin Runoff Model (DLBRM) to simulates both point and nonpoint source pollution in the Great Lakes watersheds. We propose in this study to use DLBRM to simulate the transport and distributions of those materials and evaluate their impacts on water quality in Great Lakes watersheds to support water resources and ecosystem management.

Methodology

In regards to objective 1 [Acquire, process, and analyze multiple databases of land use, soil, digital elevation model (DEM), and agricultural management practices to develop dynamic input parameters for the revised universal soil loss equation (version 2) (RUSLE2) for the Saginaw River Watersheds]:

Application of the RUSLE2 requires input variables of precipitation (for estimating erosivity), soil erodibility, topography (slope and slope length), crop management and support practices over multiple temporal (e.g. monthly or weekly) and spatial scales. We will acquire and reduce databases for the study watersheds at 1 $km^2$ resolution of elevation (from available USGS 30-m digital elevation models), slope, flow direction (from the digital elevation database), soil parameters (from the USDA State Soil Geographic Database including: texture, upper and lower soil zone thickness, water holding capacity, and permeability), land use and land cover (from the USGS national land cover characterization databases), crop management practices (from the USDA National Agricultural Statistical Services and surface and channel flow roughness by methods of He (2003) and He and Croley (2007b). (Note: Meteorology databases for these watersheds are available at the NOAA GLERL and will be used in this study).

In regards to objective 2 [Survey and contact different governmental agencies and institutions to collect, process, and analyze the real-world information on water quality including nutrients (N and $P_2O_5$, sediment, and toxic materials) to support calibration of the DLBRM simulations of documented cases of chemical and sediment movement in the study watersheds]:

We will survey and contact relevant agencies and institutions such as Michigan Departments of Agriculture, Michigan Department of Environmental Quality, U.S. Geological Survey, U.S. Environmental Protection Agency, and relevant universities to acquire in-situ measurements of water quality including nutrients, sediment, and toxic materials in the study watersheds. These data will be processed and analyzed to support calibration of the DLBRM simulations of documented cases of chemical and sediment movement in the study watersheds.

In regards to objective 3 [Map DLBRM-water quality outputs over the watersheds and support visualization of the results for spatial and temporal analysis of the watershed hydrology and water quality]:

The DLBRM simulation results include watershed hydrology (precipitation, infiltration, evapotranspiration, surface runoff, groundwater, river flow etc.) and quality (sediment, nutrients, pesticides, and CSOs and SSOs etc.) over multiple years at daily intervals for each of the grid cells that comprise the study watersheds. We will process these outputs and convert them into both map format and animated series for spatial and temporal analysis of the watershed hydrology and water quality and for transferring the results to ecosystem researchers and resource managers.

Problem and Research Objectives

The overall goal of this research is to use the DLBRM to evaluate loadings of sediment and nutrients from runoff and erosion, at the watershed level in the Great Lakes Basin. The specific objectives are to:

1) Acquire, process, and analyze multiple databases of land use, soil, digital elevation model (DEM), and agricultural management practices to develop dynamic input parameters for the revised universal soil loss equation (version 2) (RUSLE2) for the Saginaw River Watersheds.

2) Survey and contact different governmental agencies and institutions to collect, process, and analyze the real-world information on water quality including nutrients (N and $P_2O_5$, sediment, and toxic materials) to support calibration of the DLBRM and simulations of documented cases of chemical and sediment movement in the study watersheds.

3) Map DLBRM-water quality outputs over the watersheds and support visualization of the results for spatial and temporal analysis of the watershed hydrology and water quality.

## Principle Findings and Significance

**Objective 1**. [Acquire, process, and analyze multiple databases of land use, soil, digital elevation model (DEM), and agricultural management practices to develop dynamic input parameters for the revised universal soil loss equation (version 2) (RUSLE2) for the Saginaw River Watersheds]:

**Status**: Completed. Multiple databases have been compiled, processed, and analyzed to derive the relevant input parameters (C-cover management factor, P- support practice factor, SL – slope and slope length factors, K- soil erodibility factor) for all the study watersheds over different periods (monthly values for C and P). Analysis of the sediment distribution is currently underway in the study area.

**Objective 2**. Survey and contact different governmental agencies and institutions in Michigan to collect, process, and analyze the real-world information on water quality including nutrients (N and $P_2O_5$, sediment, and toxic materials) to support calibration of the DLBRM and simulations of documented cases of chemical and sediment movement in the study watersheds.

**Status**: Completed. A number of water quality information including STORET files and documents have been collected from different agencies for the study watersheds.

**Objective 3**. Map DLBRM-water quality outputs over the watersheds and support visualization of the results for spatial and temporal analysis of the watershed hydrology and water quality.

**Status**: Completed. The DLBRM water quality results have been put into map format for the study watersheds. Animation files have also been created to demonstrate the changes of the hydrological variables over both space and time.

**Additional Task**: Division of the Saginaw, AuGres-Rifle, Kawkawlin-Pine, and Pigeon-Wiscoggin Watersheds into 2,000 by 2,000 m and 4,000 by 4,000 m to explore the impact of cell size (scaling) on hydrological simulations.

**Statu**s: Completed. We have processed the multiple databases at different cell sizes and are writing a manuscript to assess the impacts of scales on the hydrological simulations at present.

Summary

In collaboration with the NOAA's Great Lakes Environmental Research Laboratory and Case Western Reserve University, we are developing a spatially distributed, physically-based watershed-scale water quality model to estimate movement of materials through point and nonpoint sources in both surface and subsurface waters to the Great Lakes watersheds. This study estimates loading potential of nutrients from animal manure and fertilizers and point sources in the Saginaw Bay Basin. Annually, about 140,000 tons of N are applied in the Saginaw Bay Basin, with livestock manure and fertilizer applications and atmospheric deposition accounting for about 20, 70, and 10 percent, respectively. Livestock manure and fertilizers contribute approximately 20 and 80 percent of the total phosphate applications (53,000 tons) per year. While total fertilizer applications declined during the period of 1987 and 2002, fertilizer applications on nonfarmland increased significantly during the same period. Point sources contribute about 25 percent of the TP load entering the bay, indicating municipalities, industrial and business entities as a large contributor of the TP loading. Thus expansion and enhancement of the current water quality programs in both farmland and urban areas is essential for achieving the targeted nutrient load in the bay. Current efforts are focusing on the refinement of the distributed large basin runoff water quality model for simulating pollutant transport in both surface and subsurface water in the Saginaw Bay Watersheds to help management agencies and ecosystem researchers for identifying critical pollution areas to target implementation of the water quality control programs.

Long term, comprehensive water quality databases with adequate spatial and temporal coverage are critical for both modeling point and nonpoint source pollutions and assessing the effectiveness of water quality programs. A coordinated network should be established among governmental agencies, research institutions, and private organizations to collect and tabulate relevant agricultural chemical application data at finer scale (the township or zip code level) and to monitor water quality with adequate spatial and temporal resolution to aid water resources planning and management.

## Notable Achievements

Ecosystem Context. This project estimates the loadings and pathways of sediment, nutrients, and chemicals from both agricultural and urban nonpoint and point sources at the watershed level to the Great Lakes. The results would help ecosystem researchers and resource managers better understand the impacts of land use activities on aquatic and human health in the Great Lakes Basin.

New Technologies. Up until recently, there are no integrated spatially distributed physically-based watershed-scale hydrological water quality models available to evaluate movement of materials (sediments, animal and human wastes, agricultural chemicals, nutrients, etc.) in both surface and subsurface waters in the Great Lakes watersheds. This research is utilizing the multiple databases of climate, soil, topography, land use, agricultural statistics, and management to develop an integrated, spatially distributed, physically-based water quality model to evaluate both nonpoint and point source loadings to the Great Lakes. This simulation model with predictive capabilities will lead to improved understanding of mechanisms and processes that govern Great Lakes health threats.

Chemical Pollutants. This research quantifies the spatial and temporal distribution of sediments, and nutrients from erosion and agricultural chemical applications from Great Lakes watersheds. The results help ecosystem researchers with better understanding of the effects of chemical pollutants and nutrients on the dynamics of Great Lakes ecosystems and enable management agencies to target those critical areas for implementation of water quality programs.

Additional support is also provided by NOAA Center for Sponsored Coastal Ocean Research (NA07NOS4780198)

**Title:** Understanding Multiple Stressors in Coastal Ecosystems: Advancing Adaptive Management in Saginaw Bay
**Brief:** Targeting Saginaw Bay , a system with a history of multiple stressor impacts and existing management policies to mitigate their consequences, this project uses coupled modeling, observational, and experimental studies that focuses on the development of approaches that can be widely applied across coastal and estuarine settings. An adaptive management system will be developed to forecast how different management actions, including modified P loading and landscape practices, in the presence of invasive species and climate change scenarios, affect fishery and water quality endpoints in the study area.
**Funding Agency:** NOAA Center for Sponsored Coastal Ocean Research (NA07NOS4780198)

**<u>Publications</u>**

He, C., C. DeMarchi, W. Tao, and T.H. Johengen. 2012. Modeling Distribution of Point and Nonpoint Sources Pollution Loadings in The Saginaw Bay Watersheds, Michigan. In: Lawrence, P.L. edited book: *Geospatial Tools for Urban Water Resources*. Springer, New York, p97-113.

He, C. 2012. Water Resource Management and Watershed Science. *Advances in Earth Science* , 27(7):705-711 (in Chinese).

He, C., X. Zhang, and S. Eslamian. 2013. Chapter 86: Water Security: Concept, Measurement, and Operationalization. In: Saeid Eslamian *(ed): Handbook of Engineering Hydrology, Vol. 3: Environmental Hydrology and Water Management (Taylor and Francis ) (in press).*

**<u>Invited Presentation</u>**

He， C. and T.E. Croley. 2012. Modeling the Nonpoint Source Pollution in the U.S. Great Lakes Watersheds. The Institute of Geographical Resources and Natural Resources Research (IGSNRR), The Chinese Academy of Sciences, Beijing, May 14.

# USGS Award No. G12AP20087 Modeling the Impacts of Chicago River on Lake Michigan: Dynamics of Dissolved Oxygen, BOD, Suspended Solids, Chloride and Temperature in the Nearshore Region

## Basic Information

| | |
|---|---|
| **Title:** | USGS Award No. G12AP20087 Modeling the Impacts of Chicago River on Lake Michigan: Dynamics of Dissolved Oxygen, BOD, Suspended Solids, Chloride and Temperature in the Nearshore Region |
| **Project Number:** | 2012MI219S |
| **Start Date:** | 4/1/2012 |
| **End Date:** | 3/31/2013 |
| **Funding Source:** | Supplemental |
| **Congressional District:** | |
| **Research Category:** | Water Quality |
| **Focus Category:** | Water Quality, Solute Transport, Nitrate Contamination |
| **Descriptors:** | Chicago River on Lake Michigan: Dynamics of Dissolved Oxygen, BOD, Suspended Solids, Chloride and Temperature |
| **Principal Investigators:** | Jon Bartholic, Phanikumar S Mantha |

## Publications

There are no publications.

**Title:** USGS Award No. G12AP20087 Modeling the Impacts of Chicago River on Lake Michigan: Dynamics of Dissolved Oxygen, BOD, Suspended Solids, Chloride and Temperature in the Nearshore Region
**Project Number:** 2012MI219S
**Start:** 04/1/2012
**End:** 03/31/4 (No Cost Extension)
**Funding Source:** USGS ("104B")
**Congressional District:** eighth
**Research Category:** Water Quality
**Focus Categories:** Water Quality, Solute Transport, Nitrate Contamination
**Descriptors:** Chicago River on Lake Michigan: Dynamics of Dissolved Oxygen, BOD, Suspended Solids, Chloride and Temperature
**Primary PI:** Phanikumar S. Mantha, Michigan State University

**Project Class:** Research

## Introduction

As described in the proposal, the objective of the present study is to model dissolved oxygen, biochemical oxygen demand (BOD), temperature and chloride transport in the southwest corner of Lake Michigan. In particular, the focus of the study is on quantifying the impacts of inputs from the North Shore Channel, the Chicago River, and/or the Calumet River on water quality near drinking water intakes in the nearshore areas of Lake Michigan. Two scenarios will be modeled: (1) baseline conditions representing water quality under present conditions and (2) water quality under future conditions should the river controlling works at or near these locations be removed.

## General Statement

Problem/Demand

River plumes in southern Lake Michigan often change direction depending on local conditions including wind direction and magnitude. To simulate current and future conditions and how the behavior of river plumes might change, it is important to test hydrodynamic and transport models using field data.

Methodology

We have collected extensive field data during the summer of 2012 to test our numerical models. We have also made significant progress in setting up an unstructured-grid, three-dimensional numerical model for the nearshore areas of Chicago. The model was tested against the observations and the various scenarios identified in our proposal have been simulated using high-performance computing platforms. At present, model outputs are being analyzed and we are working on a final report for the USACE. The final report will be submitted by the end of June 2013.

## Problem and Research Objectives

## Principle Findings and Significance

All final results including the major findings and the significance of those results will be included in the final report that will be submitted to the US Army Corps of Engineers before June 2013.

## Notable Achievements

**N/A**

## Publications

There are no publications at this point.

# Information Transfer Program Introduction

## Introduction

Surrounded by four of the five Great Lakes, more than 11,000 inland lakes, 36,000 miles of streams, and a vast groundwater supply, Michigan has ready access to an abundant water supply much of which is of good to excellent quality. However, because the demand for water from a multitude of activities, including agriculture, industry, and recreation, is high, the water resources of the state are often stressed and are susceptible to degradation, ecosystem changes, and water use conflicts. Problems associated with nonpoint source pollutants, invasive species, habitat degradation, climate change, water withdrawals and wetland loss are some of the more prominent environmental issues that Michigan residents and decision makers face. Addressing these issues, whether as a riparian, decision-maker, educator, or agency representative, requires good science based information, appropriate data, and good analysis and interpretation. Universities, such as Michigan State University (MSU), have earned positive reputations for providing dependable, accurate and unbiased information to its clientele and partners, by providing the needed science-based data and results from research. However, because information is now easily accessible over the internet from a variety of sources, some of which are unverified or biased, it is critical for Universities to continue providing current, reliable, and readily transferable information to multiple audiences in a variety of formats that are easily understood and easily accessible. An effective information dissemination program encompasses the transfer of research-based information and a variety of alternative solutions, where available, to problems being assessed. The MSU Institute of Water Research (IWR) has developed and expanded upon its information dissemination and training program to address the needs of multiple groups and individuals. The objectives of the program are to develop and present educational programs, demonstrations, and materials designed to increase the public's awareness, knowledge and appreciation of the water quality and quantity problems in Michigan, change practices or behaviors that lead to environmental improvement, and help provide science based information to help solve real world water related problems that will lead to positive changes for the environment and the people of the state.

# Dissemination and Technology Transfer Training Programs

## Basic Information

| | |
|---|---|
| **Title:** | Dissemination and Technology Transfer Training Programs |
| **Project Number:** | 2012MI201B |
| **Start Date:** | 3/1/2012 |
| **End Date:** | 2/28/2013 |
| **Funding Source:** | 104B |
| **Congressional District:** | 8 |
| **Research Category:** | Water Quality |
| **Focus Category:** | Surface Water, Water Quality, Invasive Species |
| **Descriptors:** | None |
| **Principal Investigators:** | Lois G Wolfson |

## Publications

1. Bartholic, J. 2012. Navigating a new course for water resource policy and management, Michigan State University Futures Magazine, MSU Global Water Initiative, volume 30 No’s 1 & 2. pg 21-26
2. ONeil, G. and A. Shortridge. 2012. Quantifying local flow-direction uncertainty. International Journal of Geographic Information Science. In press.
3. Wolfson, Lois. 2012. Multiple Impacts on Michigan Waters Possible Due to Climate Change. Lake Effect, June Issue. Michigan Chapter, North American Lake Management Society. Pages: 2, 6.
4. Wolfson, Lois. 2012. Invasive Species and Lake Research Highlights, Lake Effect, November Issue. Michigan Chapter, North American Lake Management Society. Pages: 2-3.

**Title:** Dissemination and Technology Transfer Training Programs
**Project Number:** 2012MI201B
**Start:** 03/1/2012
**End:** 02/28/13
**Funding Source:** USGS ("104B")
**Congressional District:** eighth
**Research Category:** Water Quality
**Focus Categories:** SW, WQL, INV
**Descriptors:** Water Quality; Natural Shorelines, Great Lakes, Watershed Management; Invasive Species; Lake and Stream Monitoring; Interactive Web-based Systems; Climate Outreach
**Primary PI:** Lois Wolfson, Institute of Water Research, Michigan State University, East Lansing, MI 48823-5243, wolfson1@msu.edu

**Project Class:** Information Transfer

## Introduction

Surrounded by four of the five Great Lakes, more than 11,000 inland lakes, 36,000 miles of streams, and a vast groundwater supply, Michigan has ready access to an abundant water supply much of which is of good to excellent quality. However, because the demand for water from a multitude of activities, including agriculture, industry, and recreation, is high, the water resources of the state are often stressed and are susceptible to degradation, ecosystem changes, and water use conflicts. Problems associated with nonpoint source pollutants, invasive species, habitat degradation, climate change, water withdrawals and wetland loss are some of the more prominent environmental issues that Michigan residents and decision makers face. Addressing these issues, whether as a riparian, decision-maker, educator, or agency representative, requires good science based information, appropriate data, and good analysis and interpretation. Universities, such as Michigan State University (MSU), have earned positive reputations for providing dependable, accurate and unbiased information to its clientele and partners, by providing the needed science-based data and results from research. However, because information is now easily accessible over the internet from a variety of sources, some of which are unverified or biased, it is critical for Universities to continue providing current, reliable, and readily transferable information to multiple audiences in a variety of formats that are easily understood and easily accessible. An effective information dissemination program encompasses the transfer of research-based information and a variety of alternative solutions, where available, to problems being assessed. The MSU Institute of Water Research (IWR) has developed and expanded upon its information dissemination and training program to address the needs of multiple groups and individuals. The objectives of the program are to develop and present educational programs, demonstrations, and materials designed to increase the public's awareness, knowledge and appreciation of the water quality and quantity problems in Michigan, change practices or behaviors that lead to environmental improvement, and help provide science based information to help solve real world water related problems that will lead to positive changes for the environment and the people of the state.

**Brief description of the information transfer activity for each project**

*Conferences*
Several conferences are held yearly to address key state environmental issues. These conferences reach large audiences and often address multiple issues. For the last 22 years, the IWR has run a Great Lakes conference to present current research and discuss emerging issues relating to the management and protection of this unique and valuable resource. The 2012 conference was titled, "The Dynamic Great Lakes: Anticipating and Adapting to Change," and featured talks on the renaissance of the Great Lakes; tribal fisheries; invasive species, including the spiny water flea and potential invasion of Asian carp; freshwater estuaries; and the delisting of some Areas of Concern and concerns and consequences associated with those de-listings. IWR partners for this conference included, Michigan Sea Grant Extension, MSU Department of Fisheries and Wildlife, and the Office of the Great Lakes, Michigan Department of Environmental Quality (MDEQ). For the last several years the conference has continually grown by attracting state and local agency personnel, researchers and educators, environmental organizations, and interested citizens. The conference was near capacity and included state and local agency personnel, researchers and educators, environmental organizations, and interested citizens. Evaluations rated the conference very highly, and many participants indicated that they would use the information gained at the conference in their classrooms or in their work.

A second conference grew out of a new partnership among Universities, state agencies, and non-governmental organizations. The Michigan Natural Shoreline partnership is providing information and training on bio-engineering of shorelines, their benefits for reducing erosion, protecting the shoreline, and providing good habitat for aquatic species. As part of the effort, a research conference titled, "Climate Change and Lakeshore Landscaping" was led by the IWR and the Partnership. Several NGOs and businesses contributed to the conference, both in-kind and financially. The conference focused on climate change and plant species, local ordinances and a variety of case studies, including the selection of plants to enhance and stabilize shorelines and uplands; experiences with small scale shoreline restoration; and restoration of a severely eroded bluff on a large lake. The conference offered CEU units to 50 certified shoreline professionals attending the meeting and approximately 150 people attended the meeting.

A third conference was sponsored by the Michigan Chapter, North American Lake Management Society, and co-coordinated and co-sponsored by the IWR. "Taking Charge: Aquatic Invasive Species and Other Current Lake Research" focused on inland lake issues including emerging issues for permitting the chemical treatment of invasive aquatic plant species in Michigan; invasive species such as Cabomba, Phagmites, Euasian watermilfoil; landscape limnology; Canada geese; and harmful algal blooms. Approximately 75 people attended the conference.

*Lake and Stream Leader's Institute Alumni Program*
The IWR has played an important role in the programming and development of the Lake and Stream Leader Institute since its beginning in the early 2000s. The program focuses on the development of leadership skills and understanding of local water resource management planning and program implementation. This year, alumni were invited to join in activities offered by the statewide volunteer monitoring program, MiCorps. However, the year's activities were mainly devoted to revamping the program and developing an agenda for the program in 2013.

Changes were made to the format, an agenda was developed and publicity was increased. The next class will be offered at three different times of the year at three different locations. Attendees are expected to attend all sessions, develop and present a project, and take part in all activities.

*Aquatic Ecology Training and Groundwater Workshops*
The IWR helped develop and take part in the Conservation Stewards Program, Oakland County water programs and Pond Management workshops. These sessions assisted local decision makers, agency personnel, riparians, farmers and other interested citizens with tools and information on lake and stream ecology and hands-on activities. IWR staff assisted in the sessions through lectures, interactive sessions, and training on aquatic plant and macroinvertebrate identification, proper monitoring protocols, and chemical analyses. IWR also helped in the revamping of the MSU Extension Inland Lakes Program and played a prominent role in revitalizing and updating the program to include more current and emerging issues and writing script for the module dealing with aquatic plants.

IWR staff helped develop and participate in various workshops and training sessions on groundwater. These included Protecting Groundwater with Innovative Tools: Michigan Groundwater Management Tool in coordination with the Michigan Department of Environmental Quality (90 participants); Water Fundamentals for MAEAP and Conservation District Technicians in coordination with the Michigan Department of Agriculture and Rural Development (17 participants); and Source Water Protection Planning for Municipal Groundwater Supplies with the Michigan Rural Water Association (15 people).

*Climate Outreach and Water*
IWR was involved in two events related to climate change and its impact on water quality and availability. One event was a series of five webinars called Climate, Water and Agriculture. IWR helped in the planning and development of the series and took the lead on one of webinars to address water availability, water quality, and effects of climate change on these resources. Another program was part of a multi-state initiative with funds mainly from another source. IWR played a key role in the planning, production, and presentation of a series of webinars. One of the programs, Climate Tools Café, featured tools that could be used in helping to address water and climate change in urban settings. The other focused on sustainable communities and options people could take to deal with water issues relating to climate changes. Audiences for these two events include Extension personnel, watershed managers, and local decision makers. Approximately 500 participants attended one or more of these climate-related events.

*Invasive Aquatic Plant Species Manual*
In coordination with MSU Extension, the IWR took the lead role in the development of a companion piece to the booklet “A Citizen’s Guide for the Identification, Mapping and Management of the Common Rooted Aquatic Plants of Michigan Lakes, 2nd Ed. WQ-55.” The new book to be released in mid-spring of 2013, is titled, “A Michigan Boater’s Guide to Selected Invasive Aquatic Plants, and features the identification and treatment of invasive aquatic plant species either already in Michigan or with the potential to invade Michigan waters. The booklet will be available through the MSU Extension Bulletin Office.

*Internet-Based Programs Using Decision Support Tools*

The IWR has built upon it array of decision support tools and has made many of them available over the web. Multiple funding sources have contributed to their development, updating, and maintenance. The purpose of these programs is to assist citizens, agency personnel, farmers, and others with making more informed science based decisions through the aid of computer models, GIS, extensive data, and visual programs. Staff employees are continually upgrading the software, incorporating new models, and writing code to enable seamless entry to other web programs such as Bing maps, Google Earth, and social networks. Tools developed by IWR and other entities can be accessed at: http://www.iwr.msu.edu/Tools-Data/index.asp. In addition, the IWR also produces and maintains an on-line newsletter, *The Watershed Post*. This electronic newsletter provides current information on Institute activities as well as general articles of interest. Contributions are made by faculty, staff, and students.

*Exhibit, Demonstrations and Competitions*

MSU's Ag Expo, an agricultural oriented exposition is held annually during summer to highlight MSU research, publications, and activities. With the multiple Decision Support Systems being developed, the IWR featured two programs – Networked Neighborhoods for Ecosystems Online and the "Mapping Your Home or Watershed" program. The exhibit, housed in the College of Agriculture and Natural Resources (CANR) tent was viewed by over 1000. The IWR also participated in a variety of University-sponsored or on campus one day events that showcased the University's role in science based education. These included Grandparents' University for children and their grandparent(s); Autumn Fest, sponsored by CANR for friends and alumni of MSU; FFA days, a competition for high school students in the FFA program; the Quiet Water Symposium, a one-day exhibit directed towards canoers, kayakers, and those interested in non-motorized recreational vehicles; and the Michigan Science Olympics, an event for junior and high school students from across the state. All of these programs draw hundreds to thousands of people to campus. In most cases, only a portion of the total participants attend the IWR events.

*Presentations, Webinars, Seminars*

Guest lectures and seminars are routinely provided by IWR staff members throughout the year to outside groups on issues relating to stormwater and LID practices, invasive aquatic species, water withdrawals and the water withdrawal assessment tool, wellhead protection, volunteer monitoring, lake and stream ecology, pond management, and indicator species for water quality testing. Staff members also give class lectures in the Departments of Fisheries and Wildlife, Community Sustainability, Journalism, and Lyman Briggs. Audience or class participation ranged from approximately 25 to over 100 for each presentation.

*Personnel and Facilities*

The Institute of Water Research maintains a variety of computer workstations and servers for its growing web based decision support systems. In addition to computer-related supplies and equipment, the IWR also has video editing and photographic equipment, color printers, and field supplies for its Information Dissemination Program. The IWR's technology transfer program is under the direction of Principal Investigator Dr. Lois Wolfson, with several IWR personnel contributing to the project, including Dr. Jon Bartholic, Director, Ruth Kline-Robach, Outreach Specialist, Stephanie Smith, Web Designer, and Jeremiah Asher, Laura Young, Glen O'Neill and Yi Shi, Information Technology Specialists.

**Publications**

Bartholic, J. 2012. Navigating a new course for water resource policy and management, Michigan State University Futures Magazine, MSU Global Water Initiative, volume 30 No's 1 & 2. pg 21-26

ONeil, G. and A. Shortridge. 2012. Quantifying local flow-direction uncertainty. International Journal of Geographic Information Science. In press.

Wolfson, Lois. 2012. Multiple Impacts on Michigan Waters Possible Due to Climate Change. Lake Effect, June Issue. Michigan Chapter, North American Lake Management Society. Pages: 2, 6.

Wolfson, Lois. 2012. Invasive Species and Lake Research Highlights, Lake Effect, November Issue. Michigan Chapter, North American Lake Management Society. Pages: 2-3.

# USGS Award No. G12AP20091 Proposal for the Development of a Web-Based Tools Workshop

## Basic Information

| | |
|---|---|
| **Title:** | USGS Award No. G12AP20091 Proposal for the Development of a Web-Based Tools Workshop |
| **Project Number:** | 2012MI217S |
| **Start Date:** | 5/1/2012 |
| **End Date:** | 9/30/2012 |
| **Funding Source:** | Supplemental |
| **Congressional District:** | 8th |
| **Research Category:** | Not Applicable |
| **Focus Category:** | Education, Management and Planning, None |
| **Descriptors:** | Training, Management and Planning |
| **Principal Investigators:** | Jon Bartholic |

## Publications

There are no publications.

**Title:** USGS Award No. G12AP20091 Proposal for the Development of a Web-Based Tools Workshop
**Project Number:** 2012MI217S (extended to FY2012)
**Start:** 05/01/12 (actual)
**End:** 09/30/2012 (actual)
**Funding Source:** Summplemental
**Congressional District:** eighth
**Research Category:** Not Applicable
**Focus Categories:** Education, Management and Planning,
**Descriptors:** Training, Management and Planning
**Primary PI:** Jon F. Bartholic, Director, Institute of Water Research, Michigan State University, East Lansing, MI 48823, bartholi@msu.edu
**Project Class:** Information Transfer

# Train the Trainer Development of a Web-Based Tools Workshop

## Train the Trainer Development of a Web-Based Tools Workshop

By Purdue University and Michigan State University

### Introduction

Over the past decade, the U.S. Army Corps of Engineers (USACE) has developed a strong working relationship with Michigan State University (MSU) and Purdue University through the Great Lakes Tributary Modeling Program. This relationship has yielded research on sediment loadings at multiple scales, GIS models for erosion and sediment loading risk, new and advanced modeling algorithms, multi-scaled prioritization maps, and on-line decision support systems to help users maintain and restore water quality in their watersheds. These achievements have been published in scientific journals, presented at numerous conferences, and disseminated through hands-on workshops. These decision tools have been well received by stakeholders. The expansion of these tools will improve decision making within the Great Lakes Basin, which will help keep sediment on the land and out of the Great Lakes.

### Project Description

In FY12 and in future fiscal years, a series of workshops will be conducted throughout the Great Lakes educating the use of the web-based tools developed by MSU and Purdue University (primarily the L-THIA and HIT tools). This Scope of Work consists of MSU and Purdue University developing the materials that will be used in these workshops.

### Tasks

In general, this Scope of Work (SOW) will educate individuals in the use of High Impact Targeting, L-THIA, and other web-based tools developed under previous grants to MSU and Purdue. Specifically, this will involve the development of 3 training manuals, (one for Buffalo, Chicago, and Detroit), and a joint workshop that will be given by MSU and Purdue Universities.

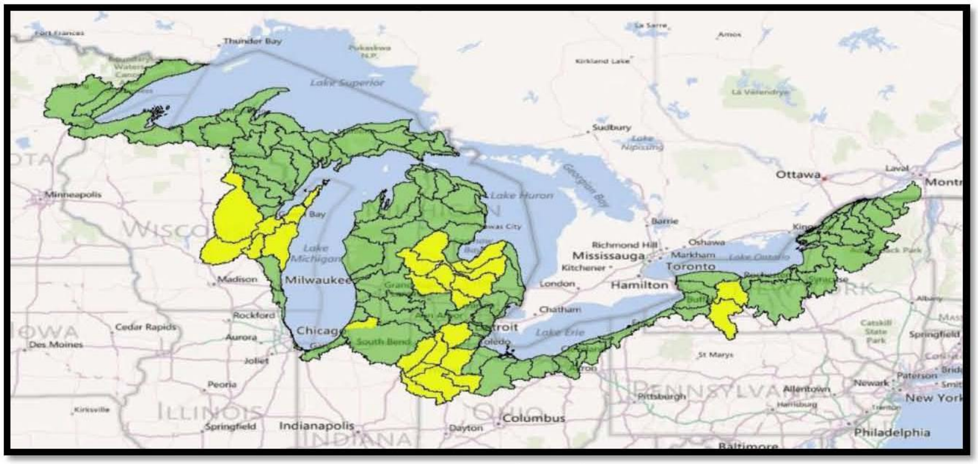



**Figure 1.2: 10-meter resolution HIT model availability (yellow) by the end of 2012, 30-meter resolutions (green).**

# On-line Decision Support Tools for Watershed Management:

**High Impact Targeting (HIT)**
**Long-term Hydrologic Impact Assessment and Low Impact Development (LTHIA-LID)**
**Digital Watershed**

A training manual in support of the U.S. Army Corps of Engineers
Great Lakes Tributary Modeling Program

Developed by:

The Institute of Water Research – Michigan State University

Biological and Agricultural Engineering – Purdue University

July 2012

## Task 1 - Develop Training Manual with 3 District Specific Tutorials

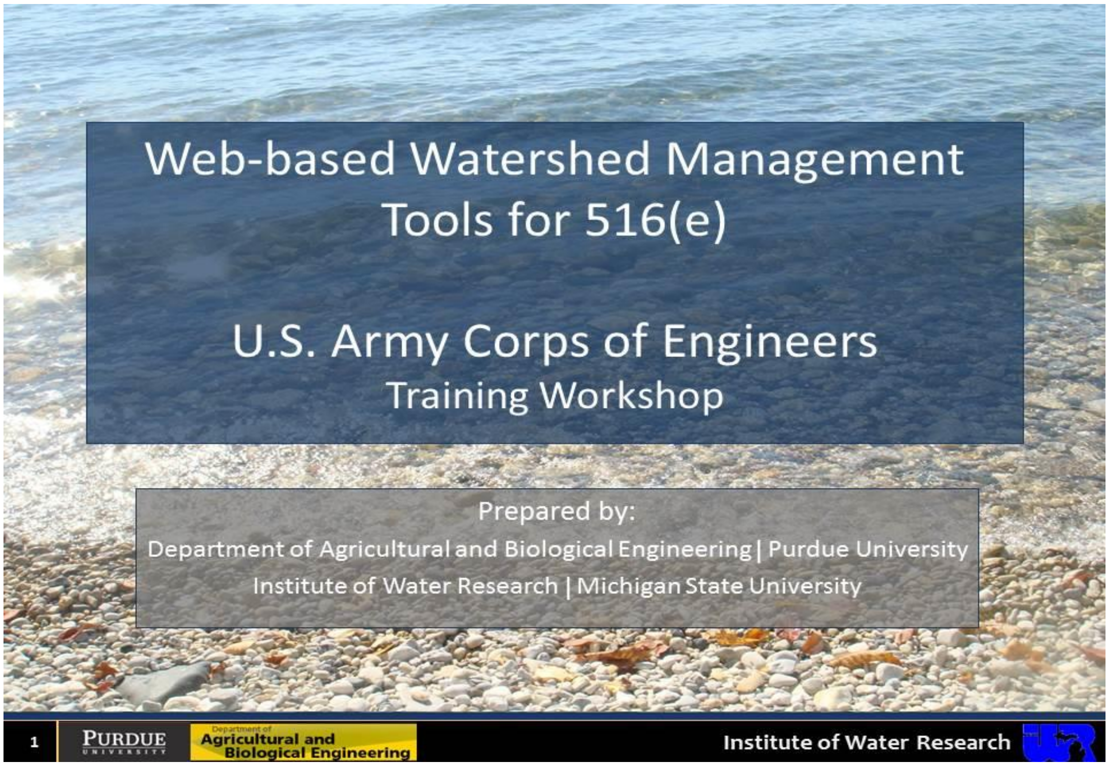
Purdue University, Michigan State University (MSU), USACE Buffalo, Chicago, and Detroit staff, and the Great Lakes Commission (GLC) will have a kick-off conference call to coordinate specific details of this scope of work. Following the kick-off call Purdue University and MSU will jointly prepare manuals to educate watershed groups throughout the Great Lakes on how to use the web-based tools developed by MSU and Purdue University. The training manuals' appendices will consist of a tutorial for each of the following three watersheds:

1 Upper Blanchard River, Ohio
2 Burns Ditch and/or Trail Creek, Indiana
3 River Raisin Watershed, Michigan

**Task 2 – Conduct Workshop**

MSU and Purdue Universities will jointly prepare a workshop. This workshop will be for one-day coordinated by the GLC. The workshop will be designed such that stakeholders can be educated on the HIT, L-THIA, and other web-based tools. The workshop will include a PowerPoint presentation that will be used to educate local watershed stakeholders. The one-day workshop will be approximately 8 hours of instruction.

Following the training, staff will provide comments on the PowerPoint presentations. MSU and Purdue Universities will incorporate comments into three (3) versions of a PowerPoint presentation which includes specific watershed tutorials (one for each of the listed watersheds).




**Task 3 – On-Line Instructional Videos**

MSU and Purdue Universities will develop instructional videos, to be posted on-line, for the respective tools. These videos will be based on the materials developed for the training manual and include the following: background, theory, and limitations; walkthroughs of each tool's functions; and applied scenarios. The ready accessibility of these videos will allow engagement of individuals who may not be able to attend the workshop, empower educators and allow workshop participants to readily review steps in tool use.

http://35.8.121.111/usace/jun212012.aspx

# USGS Summer Intern Program

None.

| Student Support | | | | | |
|---|---|---|---|---|---|
| Category | Section 104 Base Grant | Section 104 NCGP Award | NIWR-USGS Internship | Supplemental Awards | Total |
| Undergraduate | 3 | 0 | 0 | 0 | 3 |
| Masters | 2 | 0 | 0 | 0 | 2 |
| Ph.D. | 1 | 0 | 0 | 0 | 1 |
| Post-Doc. | 1 | 0 | 0 | 0 | 1 |
| Total | 7 | 0 | 0 | 0 | 7 |

# Notable Awards and Achievements

2011; Dr. Lois G. Wolfson was the distinguished recipient of the Michigan Extension Specialist and State Staff (MESSSA) Award for her outstanding work in Outreach and Extension through Michigan State University. The award was presented to her at MESSSA's ceremony in October.