Institute of Water Research
Annual Technical Report
FY 2015

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: http://www.iwr.msu.edu

The IWR 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 IWR 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 IWR works with MSUs AgBio Research and closely with the Cooperative Extension Service to conduct outreach and education. Outreach activities are detailed in the Information Dissemination section of this report. USGS support of this Institute as well as others in the region enhances the IWR credibility and facilitates partnerships with other federal agencies, universities, and local and state government agencies. The IWR 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 IWR's staff works half-time in facilitating MSU-WATER activities so the IWR enjoys a close linkage with this project. The following provides a more detailed explanation of the IWR'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 Introduction

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 policy, 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 IWR’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 guide sustainable water use plus secure and protect the future of water quality and supplies in the Great Lakes Basin, across the country and the world—with management strategies based on an understanding of the uniqueness of each watershed.

IWR Advisory Team The Water Resources Research Act supports the development of an Advisory Committee that has broad representation for each of the 54 Water Institutes located at Land-Grant Universities.

The IWR at Michigan State University (MSU) has assembled an Advisory Team consisting of five key individuals each with major responsibilities in different realms of water research, management and outreach education assuring a wide diversity of perspectives. The characteristics of the team incorporate a vision of future needs, technologies, and approaches that the IWR should consider including into our present and future planning and strategies.

Specific responsibilities include: (1) provide informative and broad guidance/direction for the director and personnel of IWR for the present and future; (2) provide guidance for IWR operations; (3) advise on diffusion and linkages of research, information technologies, and their use in operationalizing IWR activities; (4) serve as an important interface with AgBio Research, MSU Extension, and the University.

The Advisory Team will meet three times per year. On an ongoing basis, key IWR activities and planning will be provided to the Advisory Team and they will assist the IWR in its mission to assure a continued high level of productivity, creativity, and impact.

Advisory Team Members

Mr. Jon Allan, Director, Office of the Great Lakes Michigan Department of Environmental Quality

Mr. Scott Piggott, Chief Operating Officer Michigan Farm Bureau

Dr. Pat Doran, Associate State Director/Conservation Director for Michigan The Nature Conservancy, Michigan

Ms. Lisa Brush, Executive Director Stewardship Network, Michigan

Dr. Michael Jones, Assistant Director of Natural Resources Programs AgBio Research, and Professor, Department of Fisheries & Wildlife Michigan State University

Natural Resources Integrated Information System

Basic Information

Title:	Natural Resources Integrated Information System
Project Number:	2015MI232B
Start Date:	3/1/2015
End Date:	2/29/2016
Funding Source:	104B
Congressional District:	8
Research Category:	Water Quality
Focus Category:	Management and Planning, Water Quality, Water Quantity
Descriptors:	None
Principal Investigators:	Jon Bartholic

Publications

1. Wolfson, L., A. Lewandowski, J. Bonnell, J. Frankenberger, F. Sleeper, and J. Latimore. 2015. Developing Capacity for Local Watershed Management: Essential Leadership Skills and Training Approaches. Universities Council on Water Resources, Journal of Contemporary Water Research and Education. July 2015. Issue 156, Pages 86-97, December 2015. USDA-NIFA Supported.
2. Bartholic, J. 2015. Bridging Over Water Troubles: Water Wonderful World. On-line publication International Innovation-Disseminating Science, Research and Technology: Leaving Footprints; Issue 192, Pages 52-54. http://www.internationalinnovation.com/leaving-footprints/
3. Wolfson, Lois. 2015. Developing Local Watershed Capacity: Four Approaches to Training Watershed Leaders, UCOWR/NIWR/CUAHSI Conference, June 16-18, 2015, Henderson, NV. USDA-NIFA Supported.
4. Thomas, M., J. Piwarski. 2015. “Mid-Michigan Health Impact Assessment Tool”. Innovative Governance of Large Urban Systems. East Lansing, MI.
5. Piwarski, J. 2015. “Great Lakes Clean Communities Network”. ANR Week Luncheon Poster Reception in East Lansing, MI.
6. Young, L. 2015. Go Green Help Keep Our Water Clean. Flint River GREEN Student Summit. May 15 in Flint, MI.
7. Young, L. 2015. CrowdHydrology. Michigan Water Environment Association (MWEA) Watershed Summit. March 25 in Bath, MI.
8. Young, L. 2015. Great Lakes: Opportunities and Challenges presented to Senator Debbie Stabenow's Office on May 11, 2015 via meeting with web conferencing.
9. Young, L. 2015. Water Quantity and Quality Research Programs presented to State Extension and AgBioResearch Council on June 3, 2015 via meeting with web conferencing
10. O’Neil, Glenn, Jeremiah Asher, Jason Piwarski, Phanikumar Mantha, James Duncan, Jon Bartholic, and Stephen Gasteyer. 2015. An Integrative Decision Support System for Managing Water Resources Under Increased Climate Variability. 70th Annual Soil and Water Conservation Society Conference, Greensboro, NC (Poster). USDA-NIFA Supported Published
11. Asher, Jeremiah, Laura Young, Ken Freestone, Lois Wolfson, Jason Piwarski and Glenn O’Neill. The Great Lakes Clean Communities Network, www.glccn.org
12. Piwarski, J., Thomas, M., Asher, J. 2015. “Mid-Michigan Health Impact Assessment Toolkit”. URL: http://hiatoolkit.weebly.com/index.html
13. Cowles, F., J. Piwarski 2015. Middle Grand River Heritage Water Trail Guidebook. Lansing, MI.

Published by the Middle Grand Organization of Watersheds. Published guidebook for distribution.
14. Curell, Christina, Lois Wolfson, Steve Miller, Bruce MacKeller, Marilyn Thelen, Paul Gross, Shelby Burlew, Lina Rodrigues, Phil Kaatz. 2015. Phosphorus runoff: A large contributor to problems in Western Lake Erie Basin. MSU Extension News. May. Published
15. Thomas, M., J. Mitra, K. Rose, J. Piwarski, T. Yuting. 2015. Analysis of the Impacts of Increased Interconnections of Renewable Generation Resources Across the Midcontinent Independent System Operator's (MISO) Zone 7 Footprint in Michigan's Lower Peninsula. Funded by Midcontinent Independent System Operator, Inc.
16. Ruswick, F. 2015. The Status and Future of Water Conservation in Michigan. A Water White Paper Series Prepared for Michigan's Office of the Great Lakes.
17. Seedang, Saichon, Jon Bartholic, and Frank Lupi. 2015. The Potential for Incorporating Economics into Decision Support Tool. White Paper. Institute of Water Research. May 2015. 23 pages. Supported by U.S. Army Corps of Engineers (USACE) and U.S. Geological Survey (USGS)
18. Seedang, Saichon. 2015. Estimating the Economic Value of Ecosystems Services for Supporting the Implementation of Payment for Environmental Services and Bio-carbon Financial Mechanisms in Thailand Watershed Pilot Sites. Under Project "Integrated Community-based Forest and Catchment Management Through an Ecosystem Service Approach". Technical Report (Inception Report). June 2015. 112 pages. Supported by Global Environmental Facility (GEF), Thailand Ministry of Natural Resources and Environment (MONRE), United Nations Development Programme (UNDP)
19. Seedang, Saichon. 2015. Estimating the Economic Value of Ecosystems Services for Supporting the Implementation of Payment for Environmental Services and Bio-carbon Financial Mechanisms in Four Watershed Pilot Sites. Under Project "Integrated Community-based Forest and Catchment Management Through an Ecosystem Service Approach". Technical Report (Progress Report). August 2015. 70 pages. Supported by Global Environmental Facility (GEF), Thailand Ministry of Natural Resources and Environment (MONRE), United Nations Development Programme (UNDP)
20. Allman, S., C. Lampe, L. Young, and R. Atwood. 2015. Great Lakes Clean Communities Network Social Media Video Series [Online video series]. Available from: https://www.youtube.com/playlist?list=PLQTu4Il8pwiSPkzIa7Xqgfe8fC1MwRGZy. Funding agency: Great Lakes Protection Fund.
21. IWR developed a High Impact Targeting (HIT) model (measuring erosion and sedimentation risk) for the River Raisin Watershed in southeast Michigan, and incorporated that model into on-line Great Lakes Watershed Management System (GLWMS). May 2015. Development for HIT was funded by the U.S. Army Corps of Engineers and the U.S. Department of Agriculture Natural Resources Conservation Service. http://www.iwr.msu.edu/hit2/
22. IWR using the Soil and Water Assessment Tool (SWAT), developed models of ground water recharge for the Saginaw Bay Watershed, allowing users to evaluate potential field-scale changes to ground water hydrology resulting from land cover change and/or best management practices. Users can store these modeled results on a database, and report on cumulative recharge results across projects. June 2015. This effort was supported by The Nature Conservancy.
23. Latimore, Jo, Jane Herbert, Lois Wolfson, Bindu Bhakta, and Paige Filice. Introduction to Lakes Series. October – November, 2015.
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25. Wolfson, Lois. Investigating Lake Ecology Workshop, Independence Oaks, Oakland County, July 2015
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32. Young, L. 2015. Demonstration of the Great Lakes Watershed Management System with an emphasis on calculating nutrient loss change. The Stewardship Network Grand-Raisin Cluster Conference. June 19 in Adrian, MI.
33. Young, L. 2015. ELUCID Tool Demonstrations for the Cooling the Hotspots Engagement Meeting. March 5 in Adrian, MI.
34. IWR developed a High Impact Targeting (HIT) model (measuring erosion and sedimentation risk) for the River Raisin watershed in southeast Michigan, and incorporated that model into on-line Great Lakes Watershed Management System. May 2015.
35. IWR developed Soil and Water Assessment Tool (SWAT) models of ground water recharge for the Saginaw Bay watershed, allowing users to evaluate potential field-scale changes to ground water hydrology resulting from land cover change and/or best management practices. Users can store these modeled results on a database, and report on cumulative recharge results across projects. June 2015. This effort was supported by The Nature Conservancy.

Objectives

(1) IWR continues its restructuring to more effectively link knowledge with action, i.e., connecting knowledge generation and local applications by becoming an appropriately structured boundary organization.
(2) Continues its active involvement in leading, demonstrating and evaluating the process through numerous specific activities involving "wicked" problems.
(3) Enhance current and develop new decision support systems that provide support for knowledge users to make more informed decisions based on input from the knowledge generators.
(4) Augment development of this new bridging structure through an external advisory body, representing a cross-section of users and scientific groups.
(5) Enrich the evolving 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) Continue to actively inform and partner with NGOs and other funding agencies to aid in acquiring support of IWR activities. These partnerships help to add new funding sources to IWR's existing broad portfolio of funders to facilitate an expanding base of fiscal support.

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 IWR to more effectively address "wicked" problems. The advisory body, described below, will be critical in guiding the re-creation of IWR activities, which will lead to more holistic and effective approaches for addressing "wicked" problems. These various inputs will guide our initial activities. In addition to its staff members who have expertise in a broad array of water resource 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 resource 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 resource 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 resource management with consideration for economic development is a complex 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 . 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 the 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 have tapped into developing a new generation of water resource 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 must analyze the needs of different target audiences such as federal, state and local government agencies, NGOs, various environmental organizations and the general public. It is 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

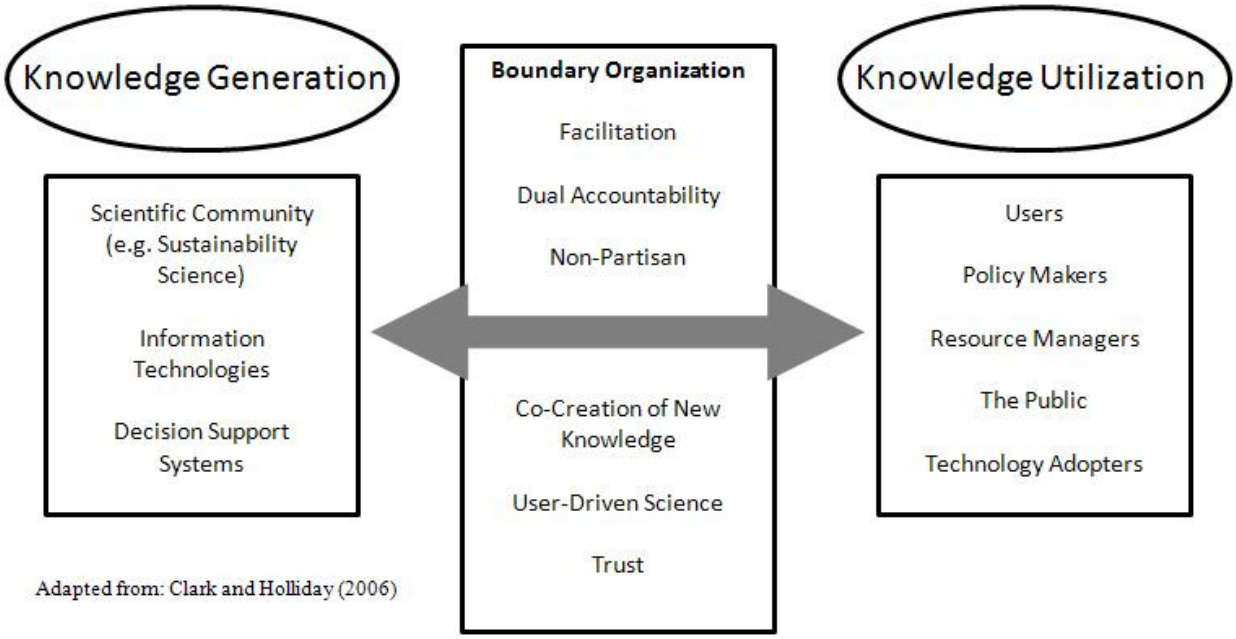

Figure 1. Boundary organization: Linking knowledge with action

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 resource 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.

Principal Findings and Significance

Previous Work and Present Outlook

- Broad Guidance: Impact Support
- Research Projects

- Spatial Decision Support Systems (SDSS)
- Building a Great Lakes Basin-Wide IT/Decision Support/Networking System

Broad Guidance: Impact Support
To guide our discovery, integrative activities and outreach, we actively and continually interact with numerous diverse organizations, government agencies, and individuals.

Water Use Advisory Council Support
The Michigan Department of Environmental Quality (MDEQ) convened the Water Use Advisory Council, made up of roughly 30 members, for a two-year appointment in early 2013 to advise MDEQ Director Dan Wyant on Michigan's Water Use Program. The Council concluded its work in December of 2014. A final report consisting of 69 recommendations was submitted to Director Wyant. Diverse interests were represented on the Council, including those from government, non-profit organizations, and those representing agricultural, industrial, commercial, or environmental interests. The MSU-IWR had ex-officio membership on the Council and Frank Ruswick served as a co-chair of the Water Conservation and Use Efficiency work group.

Through an MOU with the MDEQ, the MSU-IWR also provided administrative support to the Council. The IWR was responsible for preparing meeting summaries and coordinating all meeting logistics. In addition, the IWR compiled the Council's final report, which included a recommendations matrix outlining all 69 recommendations and their respective implementation considerations. The final report, meeting summaries and other materials are available at www.michigan.gov/wateruse. Being intimately involved with Council activities allowed the IWR to understand emerging needs relating to water use within the state and directly align certain project activities with major issues identified through the Council. For example, a major focus of the USDA-NIFA funded project at the IWR is the development of decision support tools to assist water users committees outlined in the legislation that dictates requirements of MDEQ's Water Use Program. We will continue to work on implementing Advisory Council guidance.

White paper per request the Michigan Office of the Great Lakes for inclusion in the Michigan Water Strategy: The Water Cycle: Wise Use of Michigan's Water Cycle – Resources - Prepared March 2014

The IWR prepared a white paper for inclusion in the Michigan Water Strategy regarding wise use of Michigan's water cycle and resources. A main goal covered in the paper emphasized that Michigan's water resources need to be maintained with a goal that optimizes community and human health, and natural, recreational, economic, and cultural uses and values. Addressing this goal requires a water resource perspective that begins with an overview and understanding of Michigan's water cycle and how its components interact. We are now involved in the early stages of the refining and implementation of the States' Water Strategy.

White Paper per request of the Michigan Office of the Great Lakes for inclusion in the Michigan Water Strategy: The Status and Future of Water Conservation in Michigan – Prepared February 2015

A conservation perspective that marries economic drivers and a desire and obligation for care and stewardship should be the foundation for Michigan's water management policy. As the fundamental basis for holding on to water in the Great Lakes, it would place Michigan and the region in a strong position to demand conservation performance by those who may covet the water riches of the Great Lakes. This White Paper examined Michigan's approach to water conservation and stressed that it need not be based on the exigencies of immediate or widespread scarcity. It called for the development of an integrated system of water conservation driven by deep respect and care for water as the basis of life. We are now involved with the co-creation of the Water Conservation Strategy.

Michigan Natural Resources Working Group

Background

The Michigan Natural Resources Working Group (NRWG ~ initiated and facilitated by MSU-IWR) is a partnership of federal, state and local agencies and organizations with an interest in conserving Michigan's natural resources. Partners include the Great Lakes Commission, Michigan Department of Agriculture and Rural Development, Michigan Department of Environmental Quality, Michigan Farm Bureau, The Nature Conservancy, US Geological Survey, USDA Natural Resources Conservation Service, US Fish and Wildlife Service, Shiawassee Conservation District, Lenawee Conservation District and Michigan State University (Institute of Water Research; Department of Sociology; Michigan State Extension; Department of Community Sustainability; Land Policy Institute).

The partners first met in November 2011 and have since been meeting regularly. The goal of the initial meeting was for each member organization to identify challenges and goals that they are currently facing. Two were found in common among all members of the partnership. The first was a need to measure accomplishments in terms of outcomes in addition to outputs (e.g., output of acres under conservation treatment and an outcome based on improvements in fish populations). The second was a need to find more effective ways to get residents to make desired changes (e.g., looking at other approaches besides farm bill programs to encourage farmers to make changes in their farming practices). The partners decided to use a "results chain" approach in order to understand the current strategies that are being used to address natural resource conservation and identify a future direction.

During the past reporting year, the Natural Resources Working Group (NRWG) has continued to serve as a forum for information exchange and collaboration of natural resource related groups and agencies in Michigan. Topics discussed and supported through the NRWG include
- the GLRI project "Cooling the Hot Spots" in the Western Lake Erie Basin
- the Great Lakes Clean Communities Network
- Collective Impacts

- The Nature Conservancy Projects in the Saginaw Bay Area (RCPP, Pay for Performance, Groundwater Recharge)
- Saginaw Optimization Decision Model
- training on Edge of Field Monitoring for NRCS, Conservation District, State of Michigan, and others

Assessment of Collaborative Capacity
IWR worked with Dr. Stephen Gasteyer (MSU Department of Sociology) to assess the motivations and causal models of NRWG members for participation in periodic meetings and coordinated actions. The rationale is that this group has the potential to provide coordinated leadership in addressing longstanding problems of surface water quality impairment in key watersheds: River Raisin; Western Lake Erie; Shiawassee/Saginaw Bay.

This research assessed the collaborative capacity of a multi-institutional collaboration to address disproportionality 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.

Strategic Doing
In order to take action to address our common challenges and goals, the NRWG enlisted the assistance of Robert Brown, Associate Director of University-Community Partnerships, Michigan State University Outreach and Engagement. Mr. Brown led the NRWG through a process based on Strategic Doing. According to the Purdue Center for Regional Development, Strategic Doing is "a set of principles, practices and disciplines for implementing strategy in a network." (Strategic Doing: The Art and Practice of Strategic Action in Open Networks, Staff Publication 2010-1, Ed Morrison, Purdue Center for Regional Development, February 2010). The NRWG started with a framing question: *How do we use our assets and resources to develop innovative ways to change behavior on rural lands within the River Raisin and Shiawassee River watersheds resulting in improved water quality, benefiting human health and fish communities?*

After identifying assets that each member of the NRWG is willing to share, the group developed seven outcomes that should be accomplished together. These include:

1. Develop guiding system for decision making/process
2. Use results chain to determine additional data layers that would be pertinent to this analysis
3. Select, prioritize and depict specific rural geographic areas for action
4. Engage farmers and land owners as partners to change land practices
5. Increase knowledge of available sources of funding for activities at hand
6. Engage stakeholders that can either encourage or inhibit practice change (supply chain stakeholders and policy stakeholders) as partners to change land practices
7. Identify and disseminate existing and new knowledge

Current actions
After completing actions 1 and 2 during the previous year, the NRWG proceeded to complete action number 3 within the Shiawassee and River Raisin watersheds in Michigan in the following months. The geographic units used in the prioritization were watersheds, specifically at the HUC-12 level, and were presented to the group toward the end of 2014.

The NRWG was been able to efficiently work toward completing actions 4 and 5 in the last year as well. While reviewing results of the prioritization analysis, several members of the NRWG realized that these efforts would couple well with a proposed Great Lakes Restoration Initiative project, titled "*Cooling the Hot Spots*." This proposed project involved a pay-for-performance process for reducing phosphorus and the creation of a farmer advisory council in the River Raisin watershed, to engage farmers to join the program and raise awareness about water quality issues within the Western Lake Erie Basin. This grant was awarded by the EPA to the Stewardship Network at the end of 2014 and is currently underway. The MSU-IWR is providing technical and decision support expertise to the *Cooling the Hotspots* project.

Research Projects

The following projects represent activities supported with over $2 million dollars from our partners. USGS 104b projects are covered in other sections of this report. To the maximum extent possible and appropriate, we work on harmonizing project to enhance the coupling of activity pieces on the landscape.

<u>Great Lakes Restoration Initiative (GLRI) - Flint River Nutrient Reduction: Focusing Action</u>
The "Flint River Nutrient Reduction: Focusing Action" Project, funded through EPA by the Great Lakes Restoration Initiative, provided enhanced mapping technology, technical assistance and outreach efforts to agricultural conservation technicians in the Saginaw Basin. The project, which concluded in September 2014, sought to achieve a larger beneficial impact on agricultural non-point source (NPS) pollution using conservation prioritization tools that would be attained using traditional approaches. The eWatershed (formerly ELUCID) decision support system, described later in this report, was developed with stakeholder input and used by field technicians to identify and target farm fields prone to nonpoint source pollution.

The following five recommendations were included in the project's final report to improve the decision support tools:

Recommendation #1 – expand the availability of ELUCID beyond the Saginaw Basin. There is interest in doing this as evidenced by the inquiry from MSU-E for use of the tool in Southeast Michigan.

Recommendation #2 - integrate tools such as GLWMS with ELUCID to provide technicians and other users with the ability to move seamlessly from watershed scale analysis to local treatment.

Recommendation #3 – procure missing or incomplete data layers, especially LiDAR. LiDAR was used to identify areas of concentrated flow and likely areas of ephemeral gully erosion. This analysis was of great interest to the field technicians since ephemeral gullies, by definition, are not present at all times. The gullies can occur in standing crops which makes them hard to locate on site and they may be located in remote areas that are time consuming to physically investigate. LiDAR is currently not widely available in Michigan.

Recommendation #4 – test and refine the algorithms for identifying concentrated flow and ephemeral gully locations.

Recommendation #5 - look for opportunities to work with additional conservation organizations (such as the Flint River Watershed Coalition) and Conservation Districts, and help them access and utilize the tools built, demonstrated and utilized in this GLRI project.

<u>USDA-NIFA Grant</u>

An Integrative Decision Support System for Managing Water Resources under Increased Climate Variability

The goal of this project is to develop and disseminate a Decision Support System (DSS) that incorporates outputs from a diverse set of hydrologic systems models, analytical tools and processes which examine future climatic scenarios. Using the DSS, policy-makers, water resource managers, and agricultural producers will be able to consider varying climatic conditions while developing sustainable water strategies within communities and planning for agricultural water uses. Significant components of this project are the assessment of water users to determine and understand their capacity to accept and make behavioral modifications regarding water use as well as the involvement of key individuals and groups that represent the policy-makers, managers and water users during the various stages of the project. Modeling is ongoing during this phase of the project and water user assessments will begin in 2015.

A major outcome of the project will be to assess the implication of these scenarios on Michigan's legislated Water Withdrawal Assessment Tool and process. Furthermore, public engagement and dissemination of the knowledge gained from the project's efforts through enhanced educational programs to be develop and offered by Michigan State University and the expertise provided by Michigan State University Extension.

During this reporting year, development of the Decision Support System (termed WaterWays) continued as modeling of the hydrologic systems was completed and outputs from the various models compared, analyzed, and integrated with future climatic scenarios. Two meetings were held with stakeholders in southwest Michigan (location of the watersheds studied) to demonstrate potential outputs and uses of WaterWays and to solicit their feedback. One stakeholder group consisted of agricultural producers; the other stakeholder group consisted of planners and conservationists from local government, resource management, and tribal organizations. The goal of WaterWays remains to support these stakeholders as they develop sustainable water strategies within communities and plan for agricultural water uses, while taking varying climatic conditions into consideration. Completion and delivery of the initial

WaterWays system is scheduled to occur by Fall 2016. Supplemental to this effort was the completion and initial analyses of the survey conducted of local stakeholders: agricultural producers, to determine and understand their capacity to accept and make behavioral modifications regarding water use, and government and conservation water use policy-makers and managers, to understand factors involved in their decision-making.

Application of Michigan's legislated Water Withdrawal Assessment Tool (WWAT) and process continues to be a topic of much concern amongst agricultural producers. Through preliminary conversations with WWAT regulators it is hopeful that WaterWay outcomes can be used to help assess the implication of the climate scenarios on the WWAT and process. Also, the knowledge gained from the project's efforts will be disseminated through enhanced educational programs being developed and offered by Michigan State University, with the expertise provided by Michigan State University Extension.

Red Cedar River Watershed

The IWR led the development of a watershed plan for the Red Cedar River Watershed, located in Ingham and Livingston Counties, Michigan. The Red Cedar River Watershed Management Plan (WMP) represents the culmination of a two and a half year collaborative process designed to address existing and potential pollutants in the Red Cedar River. The process included data collection and analysis, an extensive watershed inventory effort and stakeholder involvement. The WMP describes the watershed and water quality issues within it, including the existing TMDLs that have been established for *E. coli* bacteria and dissolved oxygen. Subwatersheds within the Red Cedar are described in detail, and best management practices for addressing nonpoint sources of pollutants within subwatersheds are included as a critical component. The subwatersheds are prioritized using a scoring system to focus implementation activities in the next phase of the watershed planning process.

Regional Conservation Partnership Program (RCPP)

The Regional Conservation Partnership Program (RCPP) is a new program being implemented by the United States Department of Agriculture (USDA) under the 2014 Farm Bill. The RCPP intends to make $1.2 billion in federal funding available over 10 years to address critical conservation concerns across the country. Already, the Saginaw Bay Watershed Conservation Partnership, co-led by The Nature Conservancy and the Michigan Agri-Business Association, is earning national attention and is considered by the USDA, U.S. Secretary of Agriculture Tom Vilsack, and others as a leading candidate to address water quality resource concerns. The Saginaw Bay Watershed Conservation Partnership will provide a total investment of $20 million including $8 million in direct financial assistance and $12 million in technical assistance, to growers in the watershed to implement conservation.

The Saginaw Bay Watershed Conservation Partnership project will utilize the Great Lakes Watershed Management System (GLWMS), a new online tool developed by Michigan State University's Institute of Water Research (MSU-IWR), to model, map, and track implementation progress and water quality benefits. We will use this tool to quantify the annual increase in groundwater recharge (in gallons) and the amount of sediment (in tons) and phosphorus (in

pounds) reduced for each conservation practice implemented. Long-term water quality improvement will ultimately be measured by examining trends in the biological health of riverine systems throughout the watershed. (A portion of this RCPP write-up was secured from the Saginaw Bay Watershed Conservation Partnership TNC fact-sheet.)

River Raisin Watershed

Several IWR research teams are playing major roles in the Cooling the Hot Spots project, a GLRI collaboration with The Stewardship Network, University of Michigan, Winrock International, MSU Extension, MSU Department of Sociology, Heidelberg University, Adrian College, Michigan Department of Agriculture and Rural Development, River Raisin Watershed Council, and countless other partners. The main objective of this project is developing a pay-for-performance program to incentivize farmers in the Western Lake Erie Basin's River Raisin Watershed in Southeastern Michigan to adopt best management practices on their agricultural land. The goal is a reduction in phosphorus lost in water runoff from farmland, which contributes to the harmful algal blooms (HABs) in Lake Erie.

The IWR has been working with Dr. Stephen Gasteyer in the MSU Department of Sociology to better understand the motivations for farmers to become involved in conservation efforts. In order to study this question, IWR researchers have worked closely with the Farmers Advisory Committee (FAC), a farmer-led watershed group in the River Raisin watershed. The project aims to learn what brings farmers to this group and why they participate. Information was collected through participant observation at field day events and in-depth interviews with FAC participants. In addition, the IWR facilitated a multi-state collaborative workshop on April 8th, 2016 with guest speakers from two successful farmer-led watershed groups, one in Iowa and the other in Wisconsin. The data will be used to develop surveys that will seek information about farmer opinions on best management practices. Ultimately this section of the project will inform the pay-for-performance program, tailoring the efforts to major motivators for agricultural producers.

In an effort to better understand the health of the River Raisin watershed and to create a baseline for the pay-for-performance program's progress, the IWR has collaborated with Adrian College, the River Raisin Watershed Council, and the Michigan Agricultural Environmental Assurance Program to form a stream monitoring program. All stream samples are collected by Adrian College students and analyzed in a well-equipped biology lab. This is done under the supervision of Dr. Jim Martin, who is very familiar with the history and landscape of this area. Sampling is currently being conducted at six stream sites and six farm sites throughout the south branch of the River Raisin watershed. Sampling at certain sites has been done since October 2015, and the majority of sites have been sampled since April 2016. Sampling is scheduled to continue through the end of October 2016.

Spatial Decision Support Systems (SDSS)

eWatershed

eWatershed (formerly ELUCID), developed by the Michigan State University Institute of Water Research (IWR), is a web-based geographic information system (GIS) available at

http://ewatershed.iwr.msu.edu/. This interactive mapping environment was piloted in the Flint River Watershed and has subsequently been developed for the River Raisin Watershed, Chippewa River Watershed, and Ottawa County (MI). One of eWatershed's greatest assets is its ability to engage and inform different user groups and address multiple issues in one system. Each customized eWatershed system is organized into varying themes such as water quality and land protection and can be linked to existing systems to enhance its analytical capabilities.

The recently developed River Raisin eWatershed system is being utilized in a GLRI supported project to help facilitate the implementation of BMPs in the watershed. Furthermore, water quality monitoring data collected through a USGS 104(b) funded project will be uploaded into the system and made available to the public in a form that protect farmer's privacy. This will allow the public to gain a better understanding of the real-time conditions that exist in their watershed. The system was also used in the selection of sites for water quality monitoring in the River Raisin watershed.

Great Lakes Watershed Management System (GLWMS)

IWR has made several key enhancements to the GLWMS based upon feedback from from key user groups and continued collaboration with The Nature Conservancy (TNC) and Michigan State University Extension (MSU-E). Within the Saginaw Bay Watershed the GLWMS is being utilized by conservation district staff and crop consultants as part of the Regional Conservation Partnership Program (RCPP) to electronically store BMP locations and model anticipated reductions in sediment loading. TNC is coordinating the effort and identified several additions to GLWMS functionality that would assist the RCPP users. IWR accommodated these requests by allowing users to upload BMP locations from their own GIS files and generate sediment modeling results in batch mode, as opposed to individually hand-digitizing each BMP and running sediment models one at a time. This system enhancement allowed the RCPP project to quickly evaluate a large number of prospective BMPs (roughly 1,200 covering almost 38,000 acres) that would have been otherwise impossible given the resources available to the project. IWR also added the ability to create detailed reports in PDF format, which provided the project with a standardized format to store model results, in addition to a means by which conservation staff or crop consultants could share model results with farmers in situations when internet connectivity might be spotty or nonexistent, such as during a field visit.

In support of other TNC conservation efforts in the Saginaw Bay Watershed, IWR expanded the GLWMS' groundwater recharge analysis capabilities to include the effects of tile drainage. IWR worked with a Andrey Guber, a scientist at MSU's Department of Plant, Soil, and Microbial Science, to estimate potential changes in groundwater recharge in the presence of tiles. Dr. Guber utilized the three-dimensional HYDRUS model to generate groundwater models of the Saginaw Bay Watershed. These models were able to more accurately simulate groundwater flows around tiles than IWR's initial efforts with the SWAT model. IWR utilized the HYDRUS outputs to augment the SWAT-derived estimates of groundwater recharge, and incorporated them into the analysis capabilities of the GLWMS.

IWR also expanded GLWMS functionality in support of an MSU-E project to implement a pay-for-performance (PFP) phosphorus reduction program in Michigan's River Raisin Watershed. First, IWR expanded the GLWMS geographic availability to include the watershed, allowing users to analyze estimates of sediment loading through HIT, and nutrient loading through L-THIA. Next, IWR modified the GLWMS to accept and display more detailed Phosphorus loading estimates from SWAT. A team of modelers at the Graham Sustainability Institute at the University of Michigan developed a detailed and phosphorus-calibrated SWAT model for the River Raisin Watershed. The GLWMS now allows users to view field-scale estimates of phosphorus loadings from that model. As that project advances, IWR will enhance the GLWMS to allow for the evaluation of BMP impacts on phosphorus, based upon simulations by the team at the Graham Center. IWR will also incorporate economic analyses by other project partners to produce estimates of payments for phosphorus reductions through various BMP adoption options.

Train the Trainer - High Impact Targeting (HIT)

In 2012, the US Army Corps of Engineers (USACE) worked with the IWR and Purdue University to develop training materials (e.g., manuals, tutorials, fact sheets, powerpoints and a 10-part video tutorial series) for the High Impact Targeting (HIT) and Long-term Hydrologic Impact Analysis (L-THIA) online systems. These systems were originally developed by the IWR and Purdue University for the USACE Great Lakes Tributary Modeling 516e Program. This collaboration was an effective and efficient method to further disseminate the online tools throughout the Great Lakes and educate end users. The USACE Buffalo District recently incorporated the train-the-trainer materials into their Sediment Transport Analysis and Regional Training (START) program, launched in early 2015, which offers free trainings to stakeholders across the Great Lakes. They conducted 31 trainings by the end of the 2015 fiscal year and anticipate training 500 individuals in the coming year, demonstrating the far-reaching impact of this initial project.

Sensitive Areas Identification System (SAIS)

The IWR is developing a Sensitive Areas Identification System (SAIS) for the USDA Natural Resources Conservation Service, Michigan Office. This system is an online mapping and reporting tool that identifies and maps sensitive areas on farm fields. It is anticipated that this kind of tool may attract new clients to the agency. During the reporting period, a beta-version of the system was developed with input from the Michigan NRCS Office and several farmers. The beta-version assesses a given field's physical characteristics (e.g., soils, slope) and asks users to fill out a brief and optional questionnaire about management practices. Users may generate a report that summarizes potential resource issues (e.g., soil erosion, phosphorus runoff) on a field and describes conservation practices that would help reduce these issues. A final version of the system will be ready in 2016. An initial rollout will begin at that time.

Building a Great Lakes Basin-Wide Networking System

Great Lakes Clean Communities Network (GLCCN) | www.glccn.org
The Great Lakes Clean Communities Network (GLCCN) is a free online network for water, natural resources and environmental professionals working in the Great Lakes Basin, seeking to connect and empower individuals and organizations that strive to make the Great Lakes greater. The Network, funded by the Great Lakes Protection Fund, is a place for practitioners to build new and stronger partnerships, translate innovative ideas into powerful outcomes, and discover game-changing tools and resources.

The online Network provides a space for users to connect with one another through an interactive directory map and group forums. Users are able to explore and add to a database of over 100 interactive tools (e.g., calculators, web-based GIS, crowdsourcing apps) that address various Great Lakes issues. Through the GLCCN's EcoScore, members can also evaluate and track ecological health in Great Lakes communities.

The Network was released through a soft launch in January 2016. At the end of February 2016, 113 users had registered on the site. The GLCCN continues to grow, and as of May 2016, there are 179 users. Members are sharing resources as well as creating and joining groups. The GLCCN is being utilized at the IWR to further disseminate research, decision support tools and other resources to stakeholders across the Great Lakes.

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. IWRs Advisory Team plays a significant role in helping with dissemination strategies.

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Microbial Water Pollution Source Characterization and Quantification at Sloan Creek

Basic Information

Title:	Microbial Water Pollution Source Characterization and Quantification at Sloan Creek
Project Number:	2015MI234B
Start Date:	3/1/2015
End Date:	2/29/2016
Funding Source:	104B
Congressional District:	8
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Surface Water, Water Quality
Descriptors:	None
Principal Investigators:	Irene Xagoraraki, Ruth Kline-Robach

Publication

1. Xagoraraki, Irene and Ruth Kline-Robach.2016.(In process): Microbial Pollution Source Identification at a TMDL Subwatershed in Michigan under varying hydrological conditions

General Statement

Problem/Demand

A significant portion of the Red Cedar River Watershed, located in Ingham and Livingston Counties, Michigan, is impaired due to elevated bacteria levels. The Sloan Creek is a tributary of the Red Cedar River. Its subwatershed (HUC 040500040502) contains 19 square miles of land and about 26 miles of stream channel. Based on data in the 2014 draft Michigan Department of Environmental Quality (MDEQ) Integrated Report, 13 miles of stream channel in the subwatershed are impaired due to elevated E. coli levels, and were added to the Total Maximum Daily Load (TMDL) for portions of the Red Cedar River Watershed. The MDEQ ranked this subwatershed as a top priority subgroup in the TMDL area based on a stressor analysis. A draft watershed management plan has been developed for the Red Cedar River Watershed with input from multiple stakeholders. The plan identified the Sloan Creek subwatershed as a high priority for additional water quality analyses and implementation efforts. Suspected sources of bacteria in the subwatershed include human, agricultural and wildlife inputs. Additional sampling in this subwatershed will assist the watershed planning team in better characterizing pollutant sources and causes, and ultimately will help to target future implementation efforts.

Methodology

Methods:

The proposed work will include quantitative qPCR and Illumina next generation sequencing, and, will result in quantification of human and bovine pollution source and identification of multiple microbial pollution sources, including human, multiple farm animal, and wildlife. E-coli will be measured for comparison purposes.

Problem and Research Objectives

Objectives:

The goal of this project is to better characterize the microbial pollution sources in Sloan Creek. Our specific objectives are to:

1. Quantify the contribution of the major expected pollution sources (septic systems, bovine waste) using host-specific quantitative qPCR assays.

2. Characterize the effect of spring first-flush and summer dry periods on the creek pollution load using daily sampling for E.coli and qPCR, over two 10-day periods

3. Identify the presence of other potential microbial pollution sources (farm animal, wildlife) using molecular microbial community analysis (Illumina HiSeq) in two samples over the two sampling periods.

Principle Findings and Significance

A comprehensive long term sampling scheme was designed to collect samples at least twice per week and following each rain event during spring and summer 2015, from March 22 to August 26 at three sampling sites on two tributaries, Sloan Creek and Button Drain, within the Sloan Creek Subwatershed of the Red Cedar River. Samples were analyzed for *E. coli* and *Bacteroides*. A total of 192 samples (64 from each sampling location) were collected. The base flow conditions for *E. coli* and *Bacteroides* and water discharge were recorded for samples collected in March, three weeks before the study was started.

Out of 192 total sampling events 147 occurred during wet weather, defined for this study as measurable rainfall on the same morning as the sampling event.

The detection of *Bacteroides* specific markers compared to culturable *E. coli* levels at the confluence with the Red Cedar River. Results showed a significant correlation between two markers (B.theta and BoBac) and *E.coli* ($P<0.05$). On average, the levels of the human (B.theta) and bovine (BoBac) *Bacteroides* genetic makers showed large differences among sites, however, these differences were not statistically significant ($P>0.05$). A total of 64 samples at each sampling site were tested for human and bovine *Bacteroides* markers of which 49 were collected during rainfall runoff periods and the remaining during base flow conditions. Human *Bacteroides* (B. theta) were present in 25% of Sloan, 27% of Meridian, and 14% of Every samples. Overall average concentrations of B.theta human marker at the Sloan site were the highest among the three sites with an average of 1.1×10^{7} genomic copies/100mL. At the Meridian site the average of the B.theta human marker concentration was 1.87×10^{5} genomic copies/100mL, while the Every site was the lowest among the three with an average concentration of 2.5×10^{1} genomic copies/100mL. BoBac was detected in 28% of Sloan, 22% of Meridian, 11% of Every samples. BoBac concentrations ranged from not detected to 7.6×10^{9} genomic copies/100mL in runoff event samples at Sloan Creek, and 7.52×10^{7} genomic copies/100 mL at Meridian, and 5.3×10^{3} at Every. At the mouth of the Sloan Creek, the difference in runoff events compared to base flow occurrence was dominated by bovine *Bacteroides*.

Seasonal differences in *Bacteroides* markers over the watershed were compared for the three sites. Wet weather had a significant effect on *Bacteroides* marker levels. Concentrations of B.theta and BoBac markers were greater in runoff samples than in samples collected during base flow periods. There were conclusive seasonal trends in the *Bacteroides* markers for the three sites. Human and bovine markers were elevated in the wet season at the Sloan site ($p < 0.04$, $r=0.58$ for B. theta, $P <0.027$, $r=0.76$ for BoBac). The same trend was observed at the Meridian site; both human and bovine *Bacteroides* markers were significantly higher in the wet season when the flowrate was high ($p < 0.032$, $r=0.46$ for B. theta, $P <0.045$, $r=0.69$ for BoBac). There was no significant difference for both B.theta and BoBac during base flow and storm flow at the Every site.

Numerous *Bacteroides* species were detected by MG-RAST, with one of the most common being human *Bacteroides* fragilis, which accounted for 33% of all *Bacteroides* sequences for one sampling event, and Bovine *Bacteroides* (Mycobacterium bovis) was present with 117 hits in the

same sample. Several *E.coli* wild-type strains were detected in the three analyzed samples such as *E.coli* B, *E.coli* W, *E.coli* K12.

During the study period Sloan Creek continuously delivered water with high concentrations of *E. coli* to the Red Cedar River. Time series graphs show that rainfall, and flowrate were significantly related to *E. coli* concentration at the creek. The *E. coli* concentration fluctuate between base flow and storm flow, with a sharp increase following each rain event. Late season storms had a greater frequency of water quality exceedances compared to early season storm events, possibly because in early spring the soil temperature is still low, possibly affecting *E. coli*. MST marker loading rates also increased with rain events at the three sites.

In June, during heavy rain events, it is suspected that runoff carried manure from the surface to the creek, and similarly in August, high *E.coli* and high BoBac were detected, with no human marker detected. The human marker was detected and had the potential to impact *E. coli* concentrations mainly in June within the heavy rain season, which indicate potential leakage from septic systems. Human B.theta were detected more frequently at the Meridian site, which is located within a more urban setting.

Results of the monitoring study will be used to inform implementation activities. Best management practices pertaining to agricultural operations and septic system maintenance will be identified in order to reduce bacterial loading within the Sloan Creek Subwatershed.

Integration of Additional Models into the Development of an Optimization Decision Model (ODM) for Strategically Allocating Resources and Conservation Practices to Benefit Multiple Ecological and Socioeconomic Endpoints

Basic Information

Title:	Integration of Additional Models into the Development of an Optimization Decision Model (ODM) for Strategically Allocating Resources and Conservation Practices to Benefit Multiple Ecological and Socioeconomic Endpoints
Project Number:	2015MI235B
Start Date:	3/1/2015
End Date:	2/29/2016
Funding Source:	104B
Congressional District:	8
Research Category:	Climate and Hydrologic Processes
Focus Category:	Management and Planning, Water Quality, Water Quantity
Descriptors:	None
Principal Investigators:	Jon Bartholic, Vicki Anderson, James O Duncan, Glenn A O'Neil

Publication

1. For a list of presentations and description of planned publications, please see the SagODM final report at http://www.svsu.edu/sbesi/saginawbayodmupdates/

General Statement

Problem/Demand

Problem: Unfortunately, for BMP implementation focused programs there does not exist a science-based, system-wide integrated framework to help guide investments of BMPs and other restoration projects on the basis of optimizing ecological benefits in a way that will not adversely impact social values and economic opportunities.

Methodology

Methods: An integrated restoration framework is being developed at SVSU; it is called an optimization decision model (ODM). Integrating the individual research and management products of Saginaw Bay into a set of tools can quantitatively connect conservation and BMP actions in the watershed with ecological responses of concern in the system such as fish health and community integrity in the watershed stream network and cyanobacteria (e.g.,Microcystis) blooms and nuisance benthic algae (e.g., Cladophora) growth in the river mouth and nearshore regions of the bay. This project will facilitate the incorporation of models, developed as part of the Michigan State University (MSU) Institute of Water Research (IWR) program, into the ODM integrated framework plus support application of the ODM strategy. Note: IWR models include the Great Lakes Watershed Management System (GLWMS) http://35.8.121.111/glwms/map.aspx, High Impact Targeting (HIT) http://www.iwr.msu.edu/hit, Environmental Learning Using Computer Interactive Decisions (ELUCID) elucid.iwr.msu.edu.

Problem and Research Objectives

Objectives:

Objective a: The Phase I overall objective of the ODM is to support a more objective, science driven, decision process for establishing;

- sets of related biological, water quality, and conservation action goals for both riverine and nearshore habitats across Saginaw Bay and its watershed.
- priorities on where and which BMPs will be most effective to maximize benefits to ecological endpoints and ecosystem services for both riverine and nearshore systems.

Objective b: In Phase II of the project, the realized functional ODM will be utilized to conduct a retrospective assessment of the Great Lakes Restoration Initiative (GLRI) and Michigan Agriculture Environmental Assurance Program (MAEAP) projects implemented since 2010 for the GLRI and MAEAP projects in the Kawkawlin and Pigeon/Pinnebog sub-watersheds.

Objective c: Phase III. The third objective will involve application of the ODM to the two focus watersheds in an adaptive mode to assess future actions (both location and type) in those watersheds in terms of their relative benefits to ecological endpoints in the tributaries and nearshore habitats of the bay.

Principle Findings and Significance

Over the past several decades there have been major investments in the development of information, models, and decision tools to support effective ecological restoration of Saginaw Bay and its watershed. Recent investments have funded projects establishing linkages between conservation actions and a variety of ecological endpoints across inland, coastal, and open water habitats. Since 2010, the Great Lakes Restoration Initiative (GLRI) has allocated millions of dollars for best management practice (BMP) implementation for reducing nutrient inputs to Saginaw Bay. Similarly, the Michigan Agriculture Environmental Assurance Program (MAEAP) of the MDARD encourages voluntary BMP implementation.

This project integrated tools, models, and information to guide future BMP implementation and inform strategic use of restoration funds to achieve multiple ecological benefits. This project addressed the needs with a phased approach. *Phase I* included the development of an Optimization Decision Model (ODM) for strategically allocating resources and conservation practices to benefit multiple ecological and socioeconomic endpoints. The ODM includes both an *idealized* version and *realized* (or functional) version of the model based on actual data availability. Using the *realized* ODM, *Phase II* involved a retrospective assessment of GLRI-funded and MAEAP-verified projects within the Kawkawlin River and Pigeon/Pinnebog River sub-watersheds. *Phase III* included the development of an optimized set of nested priorities to guide conservation practice selection and location to most efficiently achieve multiple sets of ecological and socioeconomic goals. Through all phases, we worked with key stakeholders to incorporate the *realized* ODM into guiding strategic investments of restoration funds through their programs.

The SVSU subcontract was used to employ undergraduate students and an adjunct faculty/staff member to support their field sampling and laboratory analysis of samples from the target subwatersheds (Kawkawlin, Pigeon, and Pinnebog Rivers); the results of their analyses were used for model calibration and validation. Their activities also included work with the soil conservation district offices (Bay and Huron) to gather detailed information on land use and BMP implementation resulting from recent GLRI programs. This information was used to inform the ODM and also for retrospective analyses as described in the report.

The project outputs are described below. The descriptions are taken from the final report for the overall SagODM project submitted to the UM Water Center. Detailed findings are available in that final report which is available at this following website: http://www.svsu.edu/sbesi/saginawbayodmupdates/

B. Project Outputs

The first step of our project involved developing a conceptual model linking agricultural conservation actions (BMPs) to riverine and bay ecological endpoints and associated ecosystem services and human values. This is illustrated in Appendix A of the SagODM final report (http://www.svsu.edu/sbesi/saginawbayodmupdates/). We developed this conceptual model

using Miradi project management software (https://www.miradi.org/), which is specifically designed to support the Open Standards for Conservation (OS) process. The OS process represents a comprehensive adaptive management decision process. The conceptual model in illustrates the relations between project activities, intermediate outcomes including reductions of key stressors and ultimate outcomes which include benefits to ecological targets, ecosystem services, and human well-being values. The size of the ecosystem service boxes in the model reflects their relative importance, as determined through surveys of ecosystem users (Output #5 below). We completed the model as planned, and it provided the basis for the subsequent Gap Analysis (Output #3 below).

Output #1: An idealized ODM decision process and tool kit will be developed that can be evaluated and used by federal, state, and regional stakeholders to guide strategic allocation of resources and conservation practices for the benefits of multiple ecological and socioeconomic endpoints. The project team will work to develop the appropriate format and distribution method for the ODM.

To develop the ODM decision process, we used the conceptual model to help flesh out specific agricultural non-point source management questions/decisions related to the five main steps of the OS process: 1) Conceptualize and Analyze; 2) Plan Your Actions and Monitoring; 3) Implement Actions and Monitoring; 4) Analyze, Use, Adapt; and 5) Capture and Share Learning. These five steps of the OS process represent the core elements of adaptive management (https://www.miradi.org/open-standards/). All of these represent a subset of questions and decisions that must be addressed in order to answer the overarching question of: "What is the optimal set of places for implementing the most effective agricultural BMPs to achieve goals for ecological targets and socioeconomic values associated with Saginaw Bay and its tributaries?" This ODM decision process represents the idealized set of questions that should be comprehensively and objectively answered through scientific data, knowledge, models, and decision tools. Although we will never be able to achieve this "Holy Grail," it should serve as a constant aspiration of the natural resource managers, policy makers, and scientists.

Output #2: A gap analysis of data, knowledge, models and decision tools needed to support the *idealized* ODM.

We used the ODM decision process as the framework for identifying available data, knowledge, models and decision tools that could be incorporated into realized ODM toolkit and also help identify key gaps. We started with a very detailed and comprehensive gap analysis process that turned out to be too ambitious for the time and resources available. However, this comprehensive gap analysis framework proved to be useful for our alternative gap analysis processes. For the alternative gap analysis we decided to use a combination of a literature review and expert judgement for the analysis. The literature review resulted in a Saginaw Bay Watershed bibliography (http://www.svsu.edu/sbesi/saginawbayodmupdates/). Expert judgement was based on input provided by the project team through group polling and associated discussions as well as input from key experts involved with the development of models and decision tools that were identified as important components of the ODM Toolkit (e.g., Dana Infante from MSU and PI on the development of the National Fish Habitat Assessment Results

viewer (http://ecosystems.usgs.gov/fishhabitat/assessment_viewer.jsp) and Dave Allan from UM and PI on the development of the Great Lakes Environmental Assessment and Mapping (GLEAM) tool (http://www.greatlakesmapping.org/)).

Output #3: A functional, *realized* ODM decision process and tool kit based on available data, knowledge, models and decision tools.

Appendix B of the SagODM final report (http://www.svsu.edu/sbesi/saginawbayodmupdates/) shows many of the key data, models and decision tools needed to help address the core questions and decisions of the ODM Decision Process do exist. However, there are also significant gaps particularly as discussed above, particularly with regard to collaborative assessment and planning efforts that lead to shared socioeconomic and conservation action goals. There are also key gaps related to socioeconomic indicators and associated long-term monitoring of such indicators. However, the biggest obstacles to full integration of the data, models and decision tools listed in Appendix B (http://www.svsu.edu/sbesi/saginawbayodmupdates/) are largely logistical and political in nature but also surmountable in our opinion. Some components, like the data being developed by the Great Lakes Aquatic Habitat Framework (GLAHF), are simply not yet available for distribution. The more daunting obstacle to integration pertains to issues of ownership and long-term sustained funding of datasets and online mapping and decision tools such as the National Fish Habitat Plan (NFHP) National Assessment, Great Lakes Environmental Assessment and Mapping (GLEAM), and the Great Lakes Watershed Management System (GLWMS). Each of these online tools support both distinct and overlapping information needs that must be integrated in order to fully address the questions presented in the ODM decision process. The discussions for how these valuable tools could maintain their autonomy but also have certain components become integrated to provide a suite of information to more comprehensively address agricultural non-point source pollution impacts to Great Lakes aquatic resources was beyond the scope of this project. However, there is definitely the need for and interest in beginning these conversations.

Output #4: Through stakeholder involvement, the *realized* ODM will be applied to develop a set of conservation and BMP actions in the focus sub-watersheds that will most efficiently achieve benefits of multiple sets of ecological (e.g., GLRI Action Plan Measures of Progress, Harmful Algal Blooms [HABs], fish communities, water quality) and related socioeconomic (e.g., full-cost accounting) endpoints throughout Saginaw Bay and its watershed will be developed.

Building project awareness, seeking stakeholder input, and ultimately gaining stakeholder buy-in was an overarching priority for the SagODM project. To guide this effort, a multifaceted stakeholder engagement strategy (see Appendix C in the SagODM final report, http://www.svsu.edu/sbesi/saginawbayodmupdates/) was developed with the goal of developing a feedback loop between stakeholders and the project team to ensure that the outcomes of the project address stakeholders' needs.

To achieve this goal, the project team implemented a stakeholder engagement strategy targeted at two stakeholder groups identified as "end-users" and "ecosystem-users". End-users refers to the

set of stakeholders that are actively involved with the implementation of agricultural conservation practices and therefore could use the SagODM to help inform and target future implementation efforts in areas that would optimize ecological and socioeconomic outcomes. This group of stakeholders includes non-governmental organizations, watershed groups, conservation districts, and other local, state, and federal agencies. Ecosystem-users on the other hand describe a broader set of stakeholders who use or benefit from water resources throughout the Saginaw Bay Watershed. This broad stakeholder group includes the general public, municipalities, farmers/producers, riparian property owners, hunters, anglers, boaters, swimmers, and others that use and/or manage the resource.

Over the course of the project, the project team was able to implement all of the stakeholder engagements activities outlined in the proposal including a stakeholder survey that was added over the course of the project. Information on these stakeholder engagement activities are detailed below:

- *End-user Workshops/Meetings:* The project team proposed hosting three formal stakeholder workshops/meetings (two in-person workshops & one webinar) to engage and solicit stakeholder input.
  Status: During the course of the project, the project team decided to replace the webinar with a third in-person meeting. Two of the end-users workshops/meetings were held on 2/27/14 and 10/8/14.

- *End-user Conferences Calls*: Two conference calls with interested stakeholders were proposed to further facilitate stakeholder input and engagement.
  Status: During the course of the project the project team decided to replace the conference calls with four in-person meetings which were held on 10/8/14, 2/18/15, 3/5/15 & 3/12/15.

- *Ecosystem-user/General Public Meetings*: The project team proposed hosting two ecosystem-users meetings to help build project awareness and solicit stakeholder input.
  Status: The project team ended up having three information sessions for ecosystem-users and the general public. Two of the meetings were held on 3/24/14 and the third meeting was held on 10/28/15.

- *Local Watershed/Stakeholder Meetings*: The project team proposed identifying additional opportunities to engage stakeholders through participation in meetings and events hosted by local stakeholder groups and watershed organizations.
  Status: Over the course of the project, members of the project team frequently participated in local watershed/stakeholder meetings. As a result of this engagement effort, members of the project team were able to provide approximately 15 presentations to local watershed/stakeholder groups.

- *Stakeholder Survey*: The original project proposal did not include or mention the possibility of conducting a stakeholder survey. The stakeholder survey was added to the project to help

the project team gain an understanding of the perceptions that stakeholders have on the conditions and uses of the water resources within the Saginaw Bay Watershed.

Status: An online survey was developed and completed by 53 participants. The survey was intended to target stakeholders within Kawkawlin River and Pigeon/Pinnebog River watersheds. Results from the stakeholder survey were used to inform many aspects of the SagODM. Information and insight gained by the survey was used to inform the overall SagODM model and helped to better define the SagODM framework. In addition, the survey results helped the project team identify important socioeconomic endpoints to incorporate into the *Realized SagODM*. Survey results are included in the SagODM final report (http://www.svsu.edu/sbesi/saginawbayodmupdates/), Appendix D.

Output #5: Endpoint priorities identified can be used to guide future GLRI funding decisions to efficiently restore the ecological health of Saginaw Bay. This will include a retrospective assessment of the benefits derived from GLRI-funded and MAEAP-verified projects within the Kawkawlin River and Pigeon/Pinnebog River sub-watersheds of the Saginaw Bay Watershed will be conducted using the ODM framework. Knowledge gained through this process is expected to identify the best project areas to leverage larger-scale restoration and protection.

Optimization Analyses:

Endpoint priorities identified can be used to guide future GLRI funding decisions to efficiently restore the ecological health of Saginaw Bay. The products of our spatial optimization analyses include a suite of maps depicting the most cost effective catchments for siting agricultural BMPs. We provide maps for optimizing reduction of sediment or nutrients based on how those reductions benefit spawning sites, beaches, drinking water intakes, commercial and recreational fishing, and other values while reducing cyanobacteria, chlorophyll-a, and harmful algal blooms. Each optimization analysis achieved goals for the selected values, some employing goals for the Bay as a whole and others – at higher spatial resolution – using goals for each of six 'zones' within the Bay. We explored two different levels of goals; one that would achieve greater benefits than the other but at higher cost. Finally, we optimized BMP placement within three focal watersheds: the Kawkawlin River, Pigeon River, and Pinnebog River. These maps and associated data can be used to guide GLRI investment in placement of BMPs to restore Saginaw Bay. In addition, we compiled datasets for all the ecological and socioeconomic values and associated costs. These products exceed our anticipated outputs as outlined in the proposal.

Retrospective Analyses:

Another project output described in the proposal was a retrospective assessment of the benefits derived from GLRI-funded and MAEAP-verified projects within the Kawkawlin River and Pigeon/Pinnebog River sub-watersheds using the ODM framework. It was envisioned that the assessment would result in three tiers of output for the conservation practices: (1) estimations of local sediment and nutrient loading reductions, cumulative impacts, and cost effectiveness; (2) whether or not projects were optimally placed; and (3) estimation of the marginal footprint on ecological endpoints. Although the outputs described in the first tier were achieved as part of this project, the outputs described in the second and third tiers were not. A lack of sufficient geospatial information for the MAEAP-verified projects prevented a more thorough evaluation

of benefits. While the GLRI funded projects had sufficient geospatial information to evaluate placement, time and budget constraints prevented the full output from being generated.

Notable Achievements

N/A

Information Transfer Program Introduction

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The objectives of the program are to develop and present educational programs designed to increase awareness, knowledge and appreciation of the water quality and quantity problems in Michigan, to stress the environmental and economic alternatives required to solve complex and sometimes contentious water related problems, to address high priority and emerging issues and to promote transformational education that leads to positive changes for the environment and people of the state. The IWR also coordinates and develops multidisciplinary projects with Michigan State University Extension, faculty on campus, state and local agencies, environmental organizations, and other Universities, particularly those in the Great Lakes and North Central regions.

To meet the needs of these diverse audiences, programs are developed in the format of conferences, seminars, training workshops, demonstrations, computer models and decision support systems, web-based programs, and printed material with the goal of transferring science based water-related information and data for educational purposes, more informed decision making, and improved management of water resources.

Some programs are targeted at specific groups while others are suitable for diverse audiences. Much of the work is collaborative with colleagues and organizations, and many programs are created in a co-creative manner with other entities. Several of the activities have been ongoing for many years. In other cases, the programs are part of a much larger initiative, which includes other educational opportunities. Evaluations of programs are used to assess the value of the programs, learning outcomes by participants, priority issue areas and programming/training needs for future years.

Technology Transfer Training, Dissemination and Program Development

Basic Information

Title:	Technology Transfer Training, Dissemination and Program Development
Project Number:	2015MI233B
Start Date:	3/1/2015
End Date:	2/29/2016
Funding Source:	104B
Congressional District:	8
Research Category:	Water Quality
Focus Category:	Surface Water, Water Quality, Education
Descriptors:	None
Principal Investigators:	Lois Wolfson

Publications

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Conferences

The 25th annual Great Lakes conference, **The Great Lakes: Advancing Knowledge and Improvement** focused on critical issues that affect the Great Lakes ecosystem and Michigan's well-being. Topics included the future of agriculture, harmful algal blooms, potential aquatic plant invasions and risk to habitats, clean-up efforts and impacts on the Great Lakes, fisheries, and conservation issues. Conference evaluations indicated that 93% of those filling out the evaluation form found the overall conference very good or excellent. Many indicated that they are returning participants, have direct connections with the Great Lakes, either through their work or through teaching, and that they will use the information gained from the conference in their current work. The conference had a near capacity crowd of 275, the highest recorded in its 25 year span. Partners with the Institute for this conference were Michigan Sea Grant Extension, MSU Department of Fisheries and Wildlife, and the Office of the Great Lakes, Michigan Department of Environmental Quality (MDEQ).

The biennial conference, the **Shallow and Shoreline Conference: Challenges and Successes** looked at other states' successes with implementing statewide natural shoreline programs. The program also featured talks on lake and river differences and challenges for installing natural shorelines; plant design processes for shorelines and stream banks; estimating costs associated with shoreline installations; and case studies. The conference was jointly sponsored by IWR and the Michigan Department of Environmental Quality (MDEQ), and led by the Michigan Natural Shoreline Partnership. Several other NGOs also assisted. The conference offered CEU credits to certified shoreline professionals attending the meeting. Approximately 135 people attended. The evaluation survey included before and after assessments of learning and confidence levels in certain topics. For example, confidence in addressing river versus stream restoration increased 41% based on a before and after self-evaluation of participants. Approximately 95% of those participants returning evaluation forms found the conference to be very good or excellent.

Two **Source Water Conferences** were held for Public Water Supply Operators, who are responsible for public drinking water supplies from groundwater sources. The focus of these conferences was on source water assessment and protection along with wellhead protection area delineation. The conference was co-sponsored by the MDEQ Office of Drinking Water and Municipal Assistance. Each conference drew nearly 100 people.

The goal of the **Assuring Sustainable Food Production with Information Technologies** conference (originally titled *How Information Technologies are Transforming Agricultural Conservation*) was to start an ongoing dialogue about evolving and cutting edge technologies and approaches that define agriculture, food production, and conservation over the 21st century. Approximately 35 people attended the session. Speakers represented Agro-Culture Liquid Fertilizers, Michigan Agri-Business Association, The Nature Conservancy, and Michigan Farm Bureau, and a local Conservation District. Highlights and a list of presentations are available at: https://www.youtube.com/watch?list=PLQTu4Il8pwiTbtI3j_QB4jmjtTUc4Wgxj&v=yqxxB3zD6t4

Training Programs

Lake and Stream Leaders Institute

The Lake and Stream Leaders Institute (LSLI) ran from May through October in 2015. The LSLI consisted of five sessions of intensive on-site training on leadership and water issues. Topics over the five sessions included process skills such as engaging public participation, communications, and conflict resolution; assessment skills for watershed planning and management, storm water management and wetlands identification; science skills such as lake and stream sampling, identification of biota, and fisheries; and legal issues. Twenty people enrolled and 17 graduated. All participants were required to attend all sessions, complete homework assignments, and develop a project within their community or watershed. The IWR is a co-developer of the LSLI, along with the MSU Department of Fisheries and Wildlife, MSU Extension and the nonprofit Michigan Lake and Stream Associations, Inc.

In relation to the above program, IWR worked with three other state's Watershed and Leadership Academies in the Great Lakes region (IN, OH, and MN) to learn from one another on each of the state's programs and share more about successes and challenges in presenting these in-depth intensive programs. Results from this project included a presentation at the annual UCOWR/ NIWR conference held in Henderson, NV in 2015, and a published paper in UCOWR's Water Research and Education Journal.

Summer Parks Program

The IWR, in coordination with Oakland County Parks and MSU Extension helped develop and run a half-day lake ecology workshop. The session offered an interactive training on aquatic plant and macroinvertebrate identification, proper monitoring protocols, and chemical analyses. Approximately 30 individuals attended the workshop.

Online Courses, Webinars, and Internet Based Programs

Watershed Courses for Credit

Four courses developed by IWR and partners on Watershed Management utilize interdisciplinary expertise at MSU to create an intensive web based training opportunity for both students and watershed managers. Classes are available for academic credit or for certification of completion. All classes are offered year-round and include Watershed Concepts; Building and Implementing Watershed Management Plans; Watershed Assessment and Tools; and Legal, Financial, and Institutional Frameworks for Watershed Management. IWR staff members have been and are continuing to update and enhance the courses by adding new tools, links, models, and narrative. A new video on the course was produced by students with IWR input, and is now housed on the IWR's Watershed Management web page.

Climate Change Webinar Series

The Climate Outreach Team made minor headway in the development of an online climate webinar. The team, however, is continuing the effort into 2016, with the goal of having the course ready to view by fall of 2016. IWR staff members are working with the team to teach Extension educators and other outreach personnel about climate change and variability, and impacts of climate on ecological and human health.

Decision Support Tools

Multiple sources of funding are used to continue support, development, training and dissemination of a variety of decision support systems. Those being developed in 2015 include a climate-water availability tool, a networking tool that includes an ecological scorecard for assessing a community's ecological footprint, a water use calculator, and several apps. The purpose of these online systems is to assist users with making more informed science based decisions through the aid of computer models, GIS, extensive data, networking, and visual scenarios. The outcomes include savings in time and money, increased networking among groups, and estimations of the reductions in pollutants as a result of changes in practices. Staff employees are continually upgrading the software, incorporating new models, and writing code to enable seamless entry to these systems.

The IWR recently redesigned its website for easier navigation and access to its multiple programs. Included on the website is IWR's on-line newsletter, *The Watershed Post.* This electronic newsletter provides current information on Institute activities as well as general articles of interest, and links to other pertinent programs or materials. Contributions are made by faculty, staff, and students.

Lake Erie Western Basin

In coordination with MSU Extension, a web site was developed on "Agriculture's Role in Lake Erie" to deal with issues concerning the drinking water problems, harmful algal blooms, and hypoxia in Lake Erie. A series of webinars were planned, and IWR produced the first one titled, "Understanding the Lake Erie Ecosystem." The narrated power point presentation was completed in 2015, however, the project organizers were waiting until others were produced before posting the series online.

Exhibits and Demonstrations

A variety of University sponsored events are offered annually, and IWR participated in several of them. This year, IWR held a program at the MSU Science Festival, an event that explores multiple aspects of science and how it affects people within the state. Two classes were held focusing on water issues and lake stratification. IWR also participated in MSU Grandparents' University teaching 50 grandparents and their grandchildren about river water quality. IWR also took part in MSU Autumn Fest, and talked with approximately 200 people about watersheds, water quality and groundwater issues.

Lectures and Seminars

In 2015, IWR staff presented multiple lectures in classes, presentations at other conferences, and meetings. These included lectures on stream and lake ecology, crowd hydrology, invasive species, wellhead protection, Great Lakes watershed management system, pond management, water withdrawals and water use, and harmful algal blooms. Class size ranged from approximately 25 to over 100 for each presentation.

IWR staff working on portions of the Information Dissemination program include Dr. Lois Wolfson (PI) along with Ruth Kline-Robach, Laura Young, Jason Piwarski, and Jeremiah Asher.

Notable Achievements

Title: Introduction to Lakes Online Course

Brief: In September of 2015, **The Introduction to Lakes,** a new online course was launched. The course was a joint effort by MSU Extension, Department of Fisheries and Wildlife, and the IWR. The course utilized a cohort-based structure, encouraging participants to communicate with and learn from each other. Three online "chat" sessions offered participants the opportunity to ask questions. The course consisted of a series of eight recorded and narrated power point presentations, including (1) lake ecology; (2) lakes and their watersheds; (3) shorelines; (4) Michigan water law; (5) aquatic plant management; and (6) citizen involvement in lake stewardship; homework assignments, quizzes, interactive blogs, and a live chat session. Ninety-nine students registered for the course and 83 completed it. Approximately 89% of those taking the evaluation survey described their level of satisfaction with the content presented in the course as high or very high and 91% said that they would use the information they learned in the course in local lake management efforts. The course will be offered again in 2016.

Funding Agency: MSU Extension, USGS Water Resources Program and Student Fees

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	1	0	0	0	1
Masters	2	0	0	0	2
Ph.D.	3	0	0	0	3
Post-Doc.	0	0	0	0	0
Total	6	0	0	0	6

Notable Awards and Achievements