Great Lakes Large Grant Final Report Form
Please submit your completed report as a word document.

PI Name: David Karpovich (Saginaw Valley State University), Joseph DePinto (LimnoTech), and Scott Sowa (The Nature Conservancy)

Project Team: Chelsie Boles, Dan Rucinski, Derek Schlea, and Ed Verhamme (LimnoTech); Gust Annis, Mary Fales, Doug Pearsall, Jared Ross (The Nature Conservancy); Vicki Anderson, Jon Bartholic, Glenn O'Neil (Institute for Water Research, MSU); Bretton Joldersma (Michigan Office of the Great Lakes), Kyle Cissell, Lee Koski, Arthur Martin, Andrew Miller, and Rhett Mohler (SVSU).

Project Title: Saginaw Bay Optimization Decision Tool: Linking Management Actions to Multiple Ecological Benefits via Integrated Modeling

Project Period: September 1, 2013 – November 30, 2015

Date of Report: January 14, 2016

A. Project Approach

A-1. State the problem and/or issue the project sought to address and briefly summarize the project approach (250 words or less).

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* includes 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.

B. Project Outputs

Output – a specific product or item that is developed during or upon project completion; there are likely several outputs associated with your project. (Hover over definition to view output examples.)

B-1. Provide a brief description of each of the key project outputs developed for the project. When possible, provide links to or submit copies of described outputs.

B-2. Explain the extent to which you were able to achieve the project outputs outlined in your full proposal. Provide an explanation for proposed outputs you were unable to produce and identify those you had not anticipated producing. ACTION: Address B1-B2 for each Output.

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 (Appendix A). We developed this conceptual model (Appendix A) using Miradi project management software (https://www.miradi.org/, which is specifically designed to support the Open Standards for Conservation (OS) process (see Appendix A). The OS process represents a comprehensive adaptive management decision process. The conceptual model in Appendix A 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).

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.

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/)).

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

As Appendix B 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 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.

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 (Appendix C) 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. The third workshop/meeting is planned to take place at the Saginaw Bay RC&D's Celebration of Success event on 2/25/16.

  This third workshop/meeting is being held later than originally planned due in part to the grant extension and the fact that the workshop/meeting was intended to provide end-uses with a retrospective of the project and a more comprehensive view of the *Realized SagODM*. While the Saginaw Bay RC&D's Celebration of Success falls a couple months outside of the grant period, it was decided that this event provides an excellent opportunity to engage both end-users and ecosystem-users and helps reduce meeting fatigue by minimizing the number of meetings within a short timeframe. For these reasons, the project team decided to delay the final workshop/meeting until the Saginaw Bay RC&D's Celebration of Success.

- *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 Appendix D.)

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.

B-3. Who is using the outputs of your research and how? Based on current users, who else do you anticipate using your project outputs in the future?

Outputs of our project are just being released as of this report so they are currently not being used. However, there are several groups that we have been communicating and working with throughout this project that expressed an interest in using the results of our optimization analyses to help them establish conservation action goals and strategically target conservation practices. The first group is the Saginaw Bay Regional Conservation Partnership Program (RCPP). https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/michigan/projects/Documents/RCPP%20supporters%20and%20partners.pdf The Saginaw Bay RCPP is currently using components of the ODM toolkit to strategically place agricultural BMPs to help achieve ecological goals in Saginaw Bay tributaries. However, the RCPP partners are also interested the health of the Bay and would like to work with us to incorporate our analyses into their decision tools.

The Upper Midwest/Great Lakes LCC Coastal Conservation Working Group http://greatlakeslcc.org/group/coastal-conservation-working-group has recently launched a coastal visioning project that extends from Saginaw Bay through the Detroit River. They have expressed an interest in the results of our optimization analyses for Saginaw Bay and also an interest in our methods and the potential for extending the analyses beyond Saginaw Bay.

We anticipate targeting many other users with outreach materials that will be developed in partnership with the Water Center. In particular, Saginaw Bay coastal communities like Bay City, Linwood, Pinconning, Au Gres, Tawas, Bay Port, Caseville, Port Austin, and Sebawaing should find the result of our work extremely valuable to their planning and policy development related to maintaining and improving beach health, source water quality, access to harbors and marinas, and general tourism. Similarly, we anticipate a variety of natural resource managers will be using the results of our analyses including: fisheries managers focused on reef restoration in Saginaw Bay, state park managers, and federal, state, and local wetland restoration managers.

Results from our retrospective analyses (see Section D-1) of the likely benefits of agricultural BMPs funded through the Great Lakes Restoration Initiative (GLRI) and/or certified through the Michigan Environmental Assurance Program (MAEAP) will be of significant interest and value to these two programs. These analyses provide quantitative estimates of the benefits of their programs to improving water quality. We can also show the marginal contributions of these programs to achieving larger goals required to improve the conditions of a variety of biological and socioeconomic valued features of the Bay. This information will help these programs communicate benefits in more familiar and valued "currencies" like beach health, fisheries, etc., which will help key audiences like legislators and the public more clearly understand the value of these programs to Great Lakes citizens.

Finally, results from our gap analyses will certainly be of interest to researchers and funders interested in advancing the science behind our efforts to address agricultural non-point source pollution in the Great Lakes. This includes the Water Center as well as other private funders like the Joyce Foundation and Mott Foundation, among others.

B-4. List project-relevant publications and presentations to date, and planned. For completed publications, include citations. For presentations, include title, date, and meeting details such as sponsoring organization and location. Include any project-related photos and/or visuals that you are willing to share as appendices to the final report. Please note any forthcoming outputs and when you anticipate being able to share them with the Water Center.

There are no current publications, but we plan on submitting at least two complementary manuscripts on this work to high impact journals. One manuscript will focus primarily on the innovative analytical and modeling methods developed in this project with a few results to illustrate the potential applications. We anticipate submitting this manuscript to PNAS or PlosOne. The second manuscript will focus mostly on the results of the optimization analyses. Specifically, it will focus on a comparative assessment of the results from the different optimization analyses, their potential use, and hopefully also highlight at least one real application of the results. This manuscript is suited to a variety of journals and we have yet to identify which journals we will target for publication.

List of Presentations:

1. "Saginaw Bay Environmental Science Institute." Presented by David Karpovich. Partnership for the Saginaw Bay Watershed Annual Meeting and Speaker Series. SVSU. October 23, 1013.
2. "Saginaw Bay Environmental Science Institute." Presented by David Karpovich. House Democrats' Great Lakes and Conservation Task Force meeting at SVSU. September 23, 2013.
3. "Saginaw Bay Optimization Decision Model: Linking Management Actions to Multiple Ecological Benefits via Integrated Modeling." Presented by David Karpovich and Scott Sowa. The Saginaw Bay Annual Celebration of Success. Saginaw Bay RC&D. Bay City, MI. February 27, 2014.
4. "Development and application of SWAT models to support the Saginaw Bay Optimization Decision Model." Co-Author. Presented by Joe DePinto of LimnoTech. Great Lakes SWAT modeling workshop. UM Water Center, Ann Arbor, MI. March 18, 2014.
5. "Saginaw Bay Optimization Decision Model: Linking Management Actions to Multiple Ecological Benefits via Integrated Modeling." Presented by David Karpovich and Joe DePinto. to the Kawkawlin River stakeholders in Bay City Michigan and Pigeon/Pinnebog River stakeholders in Caseville, MI. March 24, 2014.
6. "Working Toward Strategic Implementation of Soil Conservation Practices in the Saginaw Bay Watershed." Presented by David Karpovich. Great Lakes Sedimentation Workshop, Ann Arbor, MI. June 5, 2014
7. "Targeting Implementation of BMPs in Kawkawlin and Pigeon/Pinnebog Watersheds." Presented by David Karpovich. 2014 Saginaw Bay Watershed Conference, SVSU, June 12, 2014.
8. "Strategic Conservation in the Saginaw Bay Watershed." Presented by David Karpovich. Bay City Rotary Club in Bay City, MI on February 17, 2015.
9. "Saginaw Bay Optimization Decision Model: Linking Management Actions to Multiple Ecological Benefits via Integrated Modeling." Presented by David Karpovich. Kawkawlin Watershed Summit in Auburn, MI on February 18, 2015.
10. "Strategic Conservation in the Saginaw Bay Watershed." Presented by David Karpovich. Pinconning-Standish Rotary Club in Standish, MI on April 30, 2015.
11. "Saginaw Bay Optimization Decision Model: Linking Management Actions to Multiple Ecological Benefits via Integrated Modeling." Presented by Doug Pearsall. Lake Huron Restoration Regional Meeting in Port Huron, MI on May 12, 2015.
12. "Strategic Conservation in Saginaw Bay." Presented by David Karpovich. Special session at the 11th Annual Great Lakes Restoration/Healing Our Waters Conference, Chicago, IL, September 30, 2015.
13. "An Overview of the Saginaw Bay Optimization Decision Toolkit." Presented by Scott Sowa. Special session at the 11th Annual Great Lakes Restoration/Healing Our Waters Conference. Chicago, IL. September 30, 2015.
14. "Linking Watershed and Bay Models to support the Saginaw Bay Optimization Decision Model." Presented by Derek Schlea. Special session at the 11th Annual Great Lakes Restoration/Healing Our Waters Conference. Chicago, IL. September 30, 2015.
15. "Linking of model outputs to optimization." Presented by Doug Pearsall. Special session at the 11th Annual Great Lakes Restoration/Healing Our Waters Conference. Chicago, IL. September 30, 2015.
16. "SagODM Retrospective." Presented by Bretton Joldersma. Special session at the 11th Annual Great Lakes Restoration/Healing Our Waters Conference. Chicago, IL. September 30, 2015.
17. "Strategic Conservation in the Saginaw Bay Watershed." Presented By David Karpovich. Kawkawlin River Watershed Summit. SVSU, October 28, 2015.
18. "Strategic Conservation in Saginaw Bay." Presented by David Karpovich. Saginaw Bay Watershed Conservation Training for MAEAP Technicians. SVSU, December 21, 2015.

C. Project Outcomes

Outcome – the consequences of the application of the output(s) associated with your project. (Hover over definition to view outcome examples.)

We recognize that project outcomes may not coincide precisely with project completion as they often require time and the action of others within decision-making contexts (e.g. management, policy) beyond the control of the project team. With this in mind, we ask that you report on both realized and anticipated project outcomes.

C-1. Provide a brief description of each of the key project outcomes as outlined in your proposal, as well as any unexpected but valuable outcomes.

C-2. Explain the extent to which the above outcomes have occurred, identify those that you anticipate will occur in the near future (next 3 years), and evidence that they may occur.

This project aimed for a series of short, medium and long term outcomes as shown in Appendix E. As we developed the ODM toolkit, we gathered information and received feedback from stakeholders, which gave us better information on which to predict outcomes. Accordingly, our outlook and expectations for the short and medium term outcomes changed somewhat. This is evident when comparing Appendix E with the order and descriptions of the outcomes given here. The status of each outcome is described below beginning with those realized during the project.

Outcome #1: Strengthened relationships and communication among Saginaw Bay stakeholders;

Status of Outcome #1: The initial idea for the project grew out of conversations between researchers and resource managers. At this early project concept phase, additional stakeholders were contacted and brought into the project. Many of these additional stakeholders joined the project team and provided information and knowledge from their area of expertise. This early communication and collaboration helped to strengthen both the project and relationships from the very start of the project.

In addition, through a robust stakeholder engagement strategy, the project team was able to solicit stakeholder input that: 1) helped to inform and provide strategic direction to the project; 2) helped to better define the SagODM framework; 3) helped to better define the intended use of the *Realized SagODM*; and 4) helped the project team identify important ecological and socioeconomic endpoints. As a result of this stakeholder engagement effort, the project team was able to develop a *Realized SagODM* that reflects the needs and priorities expressed by local stakeholders. By soliciting and being responsive to stakeholder input, the project team was able to build support for the project and it helped to further strengthen relationships and communications between local stakeholders.

Outcome #2: Key stakeholders/end-users (e.g., MDARD, MDEQ, NRCS, Drain Commissioners, Soil Conservation Districts) will be informed on the ODM and its utility at informing the development of projects at multiple scales, including restoration and conservation practices at the farm field, sub-watershed and Saginaw Bay Watershed scales.

Status of Outcome #2: Over the course of the project significant progress was made to engage and inform key stakeholders (i.e. end-users) about the goals and utility of the SagODM. As detailed in the stakeholder engagement strategy, the project team implemented specific activities that were targeted at engaging and soliciting end-user feedback. During a two year period (2014 -2015), the project team hosted five targeted end-user meetings. These meetings were hosted on 2/27/14, 10/8/14, 2/18/15, 3/5/15 & 3/12/15 and were intended to: 1) introduce end-users to the project and provide a vision for how the SagODM could be used to inform future implementation decisions; 2) solicit end-user input on the project, including feedback to help shape the strategic direction of the project and better define the framework and intended use of the SagODM; 3) provide end-users with project updates; and 4) help to facilitate and maintain a feedback loop between end-users and the project team. In addition, it should be noted that members of the project team included several key end-users including MDARD, MDEQ, NRCS, and TNC.

While significant progress was made during the grant period, additional work is still needed to engage and demonstrate the utility of the realized SagODM to end-users. At this time, members of the project team are actively pursuing opportunities to continue this stakeholder engaged effort. Within the next couple of months, members of the project team are anticipating giving presentations at the Saginaw Bay RC&D's Celebration of Success event on 2/25/16 and the Natural Resources Working Group meeting in February/March. Moving forward, it is anticipated that this engagement effort will continue and hopefully increase the use of the realized SagODM and help to inform future implementation efforts in targeted areas that have high ecological and socioeconomic benefits.

Outcome #3: Shared priorities where conservation efforts will be most effective and will maximize the suite of benefits to ecosystem services to both riverine and nearshore systems.

Status of Outcome #3: This project reached out to a broad range of stakeholders in the Saginaw Bay Watershed as described in Appendix C. The outreach by the project team led to many collaborative discussions among the variety of stakeholders. Communication across stakeholder groups is an important first step in developing shared priorities. We anticipate this to develop further as end-users employ the results from this project and communicate with ecosystem users. This outcome will take time to be fully realized, and the SagODM will help this realization as the first tool of its kind.

Outcome #4: Facilitate the development of agricultural ecosystem service market(s).

Status of Outcome #4: As the project team moves forward, the intent is to integrate results from the SagODM into the Great Lakes Watershed Management System (see section C-4 below), which is used by NRCS and soil conservation districts to evaluate land for BMP implementation in several programs, including the Saginaw Bay RCPP. This is a longer term outcome that is not yet realized.

Outcome #5: Increase the likelihood that producers will participate in MAEAP to meet shared ecological and socioeconomic goals.

Status of Outcome #5: Progress on this outcome is likely to parallel Outcomes 3 and 4. Moving forward, the results of the SagODM can be used by MAEAP technicians as they encourage MAEAP verification by showing more specifically how BMPs can help meet ecological and socioeconomic goals.

Outcome #6: More effective, science-based policies and programs that foster strategic conservation to protect and restore ecological and associated socioeconomic conditions of Saginaw Bay and the watershed.

Status of Outcome #6: This is a long term outcome due to the slow evolution of policies. The SagODM is a tool that can be used to form a scientific basis for setting policies and developing strategic conservation programs for Saginaw Bay.

Outcome #7: Shared ecological and socioeconomic vision and goals for Saginaw Bay and the watershed with policies and programs in place to ensure these goals are being met in a sustainable manner.

Status of Outcome #7: Some initial progress has been made to develop a shared ecological and socioeconomic vision for Saginaw Bay. Through the stakeholder engagement strategy, the project team solicited stakeholder input on priority ecological and socioeconomic endpoints. This stakeholder input was used by the project team to inform the ecological and socioeconomic endpoints that were important to incorporate into the Marxan model and *Realized SagODM*.

While the models reflect a shared ecological and socioeconomic vision for Saginaw Bay, additional work is still needed. Building a shared vision to shape policies and programs is a long term effort that wasn't intended to be completed within the timeframe of the grant. As stakeholder engagement continues, the project team believes that the SagODM can be used as a tool to help build support for a shared ecological and socioeconomic vision. Further, the project team is hopeful that *Realized SagODM* can be used by key stakeholders to inform future programmatic, policy, and BMP implementation decisions.

C-3. Looking ahead, please describe how this project has positioned you to pursue future, related research (e.g., by providing critical data, helping you establish or strengthen collaborative partnerships, helping you identify information gaps, etc.)?

The innovative approach we developed to link agricultural BMPs to ecological and socioeconomic targets in nearshore and open waters of the Great Lakes has truly advanced our ability to assess past and forecast potential future benefits of BMPs. Our approach should be extended to other regions of the Great Lakes and beyond to help inform bi-national, federal, state and local management programs and policies. In fact there is already interest to extend this approach to Western Lake Erie, so members of this project team are uniquely positioned to pursue funding to advance this work within Great Lakes.

The breadth of this project has provided the members of our project team with unique insight and perspective on the key data, knowledge, and decision tool gaps that must be addressed in order to advance our ability to model, assess, and strategically place agricultural BMPs for the benefit of multiple ecological and socioeconomic endpoints. This insight is not only applicable for Saginaw Bay, but the entire Great Lakes Basin and beyond. Therefore, members of our project team would be valuable members of any effort focused on prioritizing science needs to better address agricultural non-point source pollution.

The *Realized ODM* was developed from available data, models, and knowledge. In order to track down this information, the project team had to engage a broad range of stakeholders, including potential end users, ecosystem users, resource managers, and research groups. The connections and relationships that formed throughout this process will be key to advancing the ODM beyond its current scope. Gaps in data, models, and knowledge that currently limit the ODM will only be filled by many people of a wide variety of expertise communicating and working together. This is because the major gaps are much broader in scope than one field of work can address. For example, there are major gaps in associating ecosystem end points with socioeconomic features and benefits. Defining the gaps and guiding research priorities will be crucial for researchers and funding agencies, and people from both of those groups are involved in the network that formed during this project. Our next goal is to make the Saginaw Bay ODM more comprehensive in its ecological and socioeconomic breadth as well as its geographic coverage and precision. Our ultimate expectation is that the Saginaw Bay ODM and the process to develop it will be a basis on which to replicate ODM toolkits around the Great Lakes Basin to effect strategic conservation for multiple ecological and socioeconomic benefits.

C-4. Are there specific next steps for moving this work forward for which it would be useful to have help or support from the Water Center? If so, please identify and describe.

There are several areas in which we believe it would be valuable to have help and support from the Water Center. The first and most immediate need is providing assistance with outreach about our project outputs to help with the uptake and maximizing the use of these outputs. Fortunately, we already have funding from Water Center to help prepare a variety of communication materials to help with outreach efforts to multiple audiences and look forward to working with the Water Center staff on this important endeavor.

The Water Center could also support our efforts to more formally integrate and more effectively deliver the analytical products from this project and other key elements of the Saginaw Bay ODM Toolkit. Specifically, there is a need to incorporate the results of the optimization runs and the Agricultural to Non-Agricultural Threat Index into the Great Lakes Watershed Management System (GLWMS). There is also the need to develop an online interactive mapping application and/or story map (using and hosted by ESRI Map Applications) that will allow end users to efficiently view, interact, and use the resulting analytical outputs from the optimization runs in a flexible manner. There is also an urgent need to support collaboration among key stakeholders to address some of the obstacles (e.g., lack of data and goals, issues of ownership and sustained funding, lack of systematic long term collaborative assessment and planning) that hinder the integration of the various data, models, and decision tools that are currently included in the ODM toolkit (see Appendix B).

For this project, we were able to develop fine-scale SWAT models for our focus watersheds, which represent just three of the 24 Saginaw Bay subwatersheds. These more detailed models provided us with more accurate information for forecasting and retrospective assessments in these three watersheds. However, for the rest of the subwatersheds we had to rely on simplified models and assumptions in order to estimate effects on ecological and socio-economic goals. Consequently, one of the highest priorities for developing a fully operational Saginaw Bay ODM toolkit is to develop and incorporate a fine-scale SWAT model for the entire Saginaw Bay Watershed. This project provided a blueprint and a collaborative team to accomplish that effort.

It is important to complete the full complement of optimization analyses for Saginaw Bay Watershed because it will significantly increase the number of planning, management, and policy decisions that can use the results of this new information. Specifically, we believe it is important to complete separate optimization analyses for;

- Each of the individual ecological and socioeconomic targets, as this would provide both a sensitivity analysis and data to inform decisions of specific end user groups (e.g., fisherman vs. water treatment operators)
- Each of the 6 individual Bay zones as we were only able to complete analyses for two zones in the current project. This would provide specific information for all of the coastal communities that surround Saginaw Bay.
- Each of the 24 individual subwatersheds as we were only able to complete analyses for three subwatersheds in the current project. This would provide data to local communities and watershed management groups to help prioritize BMP placement within these specific watersheds.

We believe our innovative optimization analyses and the ODM toolkit should be expanded to other geographies like Western Lake Erie, Green Bay, and other parts of the Great Lakes. Finally, our innovative approach could and should be applied to create complimentary optimization analyses and priorities for citing of green infrastructure through the Saginaw Bay Watershed or other watersheds in the Great Lakes.

D. Research Findings

D-1. Report your most significant research results/findings (up to 5 pages including figures and tables as appropriate).

Optimization Analyses:
To identify optimal catchments for placement of agricultural BMPs to achieve multiple ecological and socioeconomic benefits in Saginaw Bay, we completed three major steps. We first built on prior plans and stakeholder input to identify ecological targets and socioeconomic values and compiled data to spatially represent them. We then attributed those data to 1km2 grid developed as part of the SAGEM3 model. Then we calculated the contribution of sediments and total phosphorus from every NHD+ catchment in the Saginaw Bay Watershed to each 1km2 grid cell (and thus to each ecological and socioeconomic value in each grid cell) by:

a. Using HIT and LTHIA models to determine export of sediments and total phosphorus from each catchment;
b. Estimating delivery ratios for sediments and total phosphorus for each catchment and using those to determine the contribution of sediments and total phosphorus to the Bay at each of 24 tributary river mouths;
c. Simulating a conservative tracer with the SAGEM3 model to calculate the proportional contribution of each of the 24 tributaries to each 1km2 grid cell.

Finally, we incorporated the values from the first two steps into conservation planning software (Marxan) to optimize a suite a catchments to achieve goals for all the ecological targets and socioeconomic value at the least cost (e.g., acres of agricultural BMP implementation). We ran different scenarios in Marxan to compare optimal catchments for benefits from sediment reductions vs. total phosphorus reductions and to explore the effect of setting goals for the entire Bay vs. setting goals for each of six 'zones' within the Bay and also the four inner Bay 'zones'. Each of these scenarios was run at two goal levels; a lower benefit/lower cost level and a higher benefit/higher cost level. Finally, we optimized BMP placement within three focal watersheds: the Kawkawlin River, Pigeon River, and Pinnebog River. Data sources used for this portion of the assessment are included in Appendix F.

One assessment that we conducted was to run the Marxan optimization for goals established independently for each of the six Bay zones (Figure 1.A.) for both sediments and total phosphorus using a 0.5 impact reduction factor to Bay targets. Results indicate that sediment goals can be achieved by implementing BMPs in a relatively limited geography within five primary watersheds that contain approximately 14% of the row crop agriculture within the Saginaw Bay Watershed (Figure 1.B. and Table 1). Implementing BMPs on the agricultural lands within these areas has the potential to reduce sediment entering Saginaw Bay between 27,300 and 34,100 tons/year which is 17-21% of the total Saginaw Bay Watershed load (Table 1). With the exception of the Rifle and Au Gres drainages in the north, most areas are dominated by agricultural land uses and are nearer the bay in areas with high sediment delivery ratios. The Rifle and Au Gres drainages are comprised of both agricultural and forest land uses, but these areas have higher sloping lands than many other places in the Saginaw Bay Watershed which likely are more susceptible to erosion thus contributing more sediments to the streams.

Achieving goals for total phosphorus require a much larger footprint or proportion of the Saginaw Bay Watershed including much of the Saginaw River drainage (Figure 1.C). This area represents nearly 64% of the total row crop acres in the Saginaw Bay Watershed (Table 1). Implementing BMPs on the agricultural lands within this footprint will reduce total phosphorus from between 237,900 and 297,400 lbs/year which is 30-37% of the Saginaw Bay Watershed load (Table 1).

We also set goals with respect to Saginaw Bay as a single unit (i.e. no 'zones') for sediments. Comparing the results of this run (Figure 1.D.) with the results from setting sediment goals for each of the six Bay zones, as described above and depicted in Figure 1.B., indicate that most agricultural BMPs should be implemented in the northern portion of the Saginaw Bay Watershed in portions of the Rifle, Au Gres, and other adjacent drainages. Taking this approach could reduce sediments reaching the Bay by 23,300 to 29,200 tons/year which represents 14-18% of the load from the Saginaw Bay Watershed (Table 1).

Another interesting analysis was to compare the results of increasing the impact reduction factor for sediments from 0.5 to 0.75 using goals established independently for Bay zones 1-4 (Figure 1.A.) which represent the inner Bay. The results are presented in Figures 1.E. and 1.F. and indicate that increasing the reduction factor from 0.5 to 0.75 does not significantly change the focal geographies other than to expand those same general areas. The results presented in Table 1 indicate that sediment reductions increase from an average of 24,700 tons/year and 15% of the Saginaw Bay Watershed load at the 0.5 reduction level to an average of 46,300 tons/year and 28% of the total load at the 0.75 reduction level.

Finally, we ran an analysis focused on three focal watersheds consisting of the Kawkawlin, Pigeon, and Pinnebog drainages for both sediments and total phosphorus using goals established independently for each of the six Bay zones at the 0.5 impact reduction level. The maps depicted in Figure 1.G. (sediments) and 1.H. (total phosphorus) show the results of this assessment. All three of these watersheds are dominated by row crop agriculture and are geographically close to the Bay and therefore have relatively high delivery ratios for both sediments and total phosphorus. Similar to the analysis described above for the entire watershed, total phosphorus reductions required a larger footprint for BMP practice implementation. As expected, total reductions in loads are much reduced from what would be achieved working across the entire Saginaw Bay Watershed as presented in Table 1.

In addition to determining the optimal catchments for achieving goals and quantifying the sediment and total phosphorus load reductions from the BMP implementation needed to achieve those goals, the total cost of implementing the BMPs was estimated for each assessment described above using an assumed installation cost of $123.16 per acre (Sowa et al. 2011). Due to the large geographic footprint required to achieve the total phosphorus reduction goals established independently for each of the six Bay zones, the scenario depicted in Figure 1.C. required the largest cost investment at over $145 million (Table 1). The various sediment reduction scenarios conducted for the entire Saginaw Bay Watershed resulted in BMP implementation costs ranging from $23 million to $65 million (Table 1). Across all scenarios presented, the cost ranges per unit reduction were $780-1600/ton sediment and $280-610/lb. total phosphorus.

Although we are presenting just a small sample of the various analyses conducted, results indicate that the best or optimal places for both sediment and total phosphorus reductions for Saginaw Bay can be identified using specific ecological and human well-being endpoints and using different reduction setting levels. The results can be used to quantify specific anticipated load reductions and estimates of the costs for implementing BMPs (Table 1) in these areas.

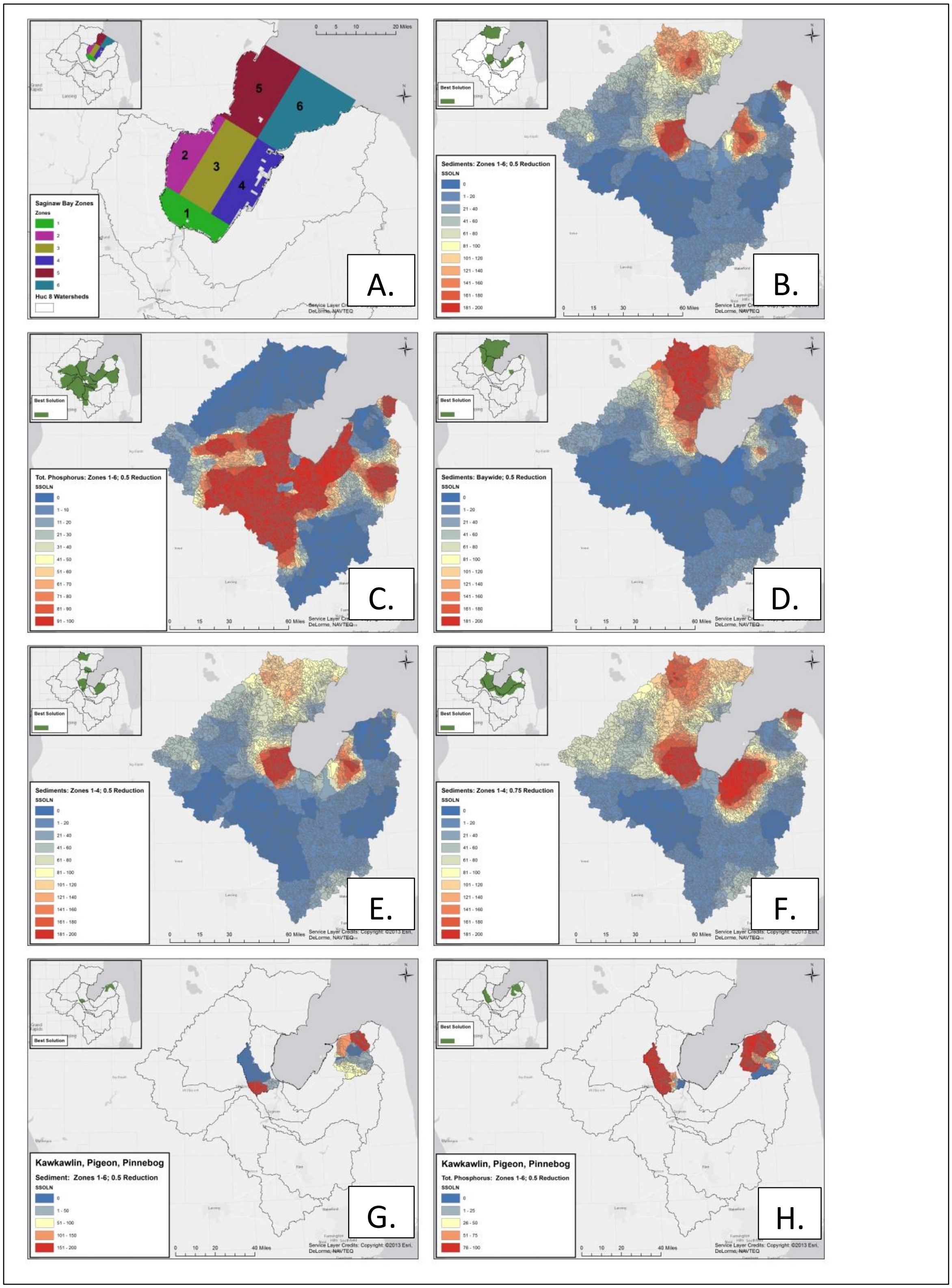


Figure 1. Maps depicting optimized Marxan outputs for various combinations of sediments, total phosphorus, goals, and Saginaw Bay zones. Map A: Saginaw Bay zones; Map B: Sediments, Zones 1-6, 0.5 reduction factor; Map C: Total phosphorus, Zones 1-6, 0.5 reduction factor; Map D: Sediments, Bay-wide (no zones) 0.5 reduction; Map E: Sediments, Zones 1-4, 0.5 reduction factor; Map F: Sediments, Zones 1-4, 0.75 reduction factor; Map G: Sediments, select tributaries, Zones 1-6, 0.5 reduction factor; Map H: Total phosphorus, select tributaries, Zones 1-6, 0.5 reduction factor.

Table 1. Post-facto calculations of sediment and total phosphorus reductions achieved if BMPs were placed within Best Solution catchments in SagODM.

	Marxan Run	Impact Reduction Factor [1]	Percent (%) of total Saginaw Bay row crop agriculture	Total amount reduced with BMP implementation		Percent (%) reduced relative to load from entire Saginaw Bay Watershed [4,5]		Estimated total cost ($) of implementing BMPs[6]
				Lower BMP efficiency[2]	Upper BMP efficiency[3]	Lower BMP efficiency	Upper BMP efficiency	
Sediment (tons/yr)	Baywide	0.50	9.96	23,300	29,200	14	18	$22,811,000
	Zones 1-6	0.50	13.93	27,300	34,100	17	21	$31,888,000
	Kawkawlin	0.50	1.05	1,500	1,900	0.9	1.2	$2,398,000
	Pigeon	0.50	1.60	2,500	3,200	1.5	1.9	$3,666,000
	Pinnebog	0.50	1.44	2,400	3,000	1.4	1.8	$3,289,000
	Zones 1-4	0.50	13.37	22,000	27,500	13	17	$30,606,000
	Zones 1-4	0.75	28.33	41,200	51,500	25	31	$64,868,000
Total Phosphorus (lbs/yr)	Zones 1-6	0.50	63.51	237,900	297,400	30	37	$145,411,000
	Kawkawlin	0.50	2.62	12,900	16,100	1.6	2.0	$5,997,000
	Pigeon	0.50	2.97	19,500	24,400	2.4	3.1	$6,794,000
	Pinnebog	0.50	2.93	17,400	21,800	2.2	2.7	$6,717,000

[1] Impact reduction factor refers to the impact reduction applied to each of the 11 Saginaw Bay targets.

[2] Lower combined BMP efficiency: Sediment = 60%; Total Phosphorus = 40%

[3] Upper combined BMP efficiency: Sediment = 75%; Total Phosphorus = 50%

[4] Total sediment reaching the bay from entire watershed (tons/yr) = 164,900

[5] Total phosphorus (lbs/yr) reaching the bay from row crop agriculture in the entire watershed (lbs/yr) = 795,900

[6] Estimated total cost ($) assumes all row crop acres in Best Solution catchments would have BMP implementation with installation costs averaging $123.16 per acre (Sowa et al. 2011).

Retrospective analyses:
The SWAT models developed for the Kawkawlin, Pigeon, and Pinnebog river watersheds were used to estimate the benefits of agricultural BMPs implemented in the watersheds between 2012-2014. LimnoTech was provided with two sources of agricultural BMP information: (1) GLRI-funded projects in Huron and Bay counties and (2) MAEAP-verified projects across the Saginaw Bay Watershed. The GLRI-funded BMP information listed individual projects including sufficient geographical information to link the projects to individual SWAT subbasins. The MAEAP-verified BMP information was condensed at the HUC-12 level, so BMP implementation could not be linked to individual SWAT subbasins. Because nearly all projects in the Huron County spreadsheet were located in the Pigeon River watershed, the SWAT model for the Pinnebog River watershed was not used to estimate benefits of BMPs implemented between 2012-2014.

Management scenarios were constructed using the SWAT models to analyze three types of BPMs: cover crops, no-till, or reduced tillage/residue management. The results of the BMP scenarios were compared to the baseline model predictions of sediment, nitrogen, and phosphorus yields to compute a relative reduction (%) for all agricultural hydrologic response units (HRUs) in the watershed. Then, for the GLRI-funded projects which could be linked to individual SWAT subbasins, an average BMP reduction from representative HRUs within that subbasin could be computed. Finally, the cumulative impact of the individual GLRI-funded projects at the watershed outlet could then be computed by multiplying: (1) the given acreage; (2) the baseline SWAT yield (e.g. tons sediment/acre/year); (3) the edge-of-field % reduction from the BMP scenario results; and (4) the delivery ratio from the subbasin to the watershed outlet for each individual project and then adding the results for all projects implemented in a given year. Table 2 summarizes the estimated benefits of GLRI-funded projects in the Kawkawlin and Pigeon watersheds.

Table 2: Estimated benefits of GLRI-funded projects in the Kawkawlin and Pigeon watersheds

Watershed	Year	Number Projects	Acres	TSS reduction, MT (% of 2001-2013 baseline)	TN reduction, kg (% of 2001-2013 baseline)	TP reduction, kg (% of 2001-2013 baseline)
Kawkawlin	2012	0	0	-	-	-
	2013	67	2,616	101 (3.7%)	4,788 (0.7%)	1,178 (2.3%)
	2014	242	8,330	239 (8.8%)	8,812 (1.2%)	2,531 (5.0%)
Pigeon	2012	38	1,902	190 (1.6%)	3,969 (0.5%)	1,081 (1.0%)
	2013	63	3,509	383 (3.3%)	7,223 (0.9%)	2,208 (2.1%)
	2014	144	7,056	615 (5.2%)	12,534 (1.5%)	3,543 (3.3%)

Information on the MAEAP-verified management practices was at a much coarser level of detail than the GLRI-funded projects, and therefore the retrospective analysis of BMP performance using the SWAT models was done at a relatively coarse level. The approach used to estimate the benefits of the MAEAP-verified projects followed the approach described above for the GRLI-funded projects except estimations of average BMP reduction from representative HRUs were aggregated at the HUC-12 level instead of the subbasin level. Table 3 summarizes the estimated benefits of MAEAP-verified projects in the Kawkawlin, Pigeon, and Pinnebog watersheds.

Table 3: Estimated benefits of MAEAP-verified projects in the Kawkawlin, Pigeon, and Pinnebog watersheds

Watershed	Years	Acres (each year)	TSS reduction, MT (% of 2001-2013 baseline)	TN reduction, kg (% of 2001-2013 baseline)	TP reduction, kg (% of 2001-2013 baseline)
Kawkawlin	2012-2014	3,144	193 (7.1%)	4536 (0.6%)	1756 (3.5%)
Pigeon	2012-2014	28,593	4,037 (34.2%)	58,872 (7.2%)	19,604 (18.2%)
Pinnebog	2012-2014	29,225	5,048 (34.1%)	57,596 (6.3%)	16,142 (15.7%)

E. Additional Questions

E-1. Estimate the percentage of your project budget and time that were allocated for activities related to end user engagement (e.g., travel, team meetings, conference calls, workshop planning, development of communications materials, etc.). If you found that you lacked sufficient time and/or resources for these activities, please specify and comment on how you and/or the Water Center might have helped you to plan differently.

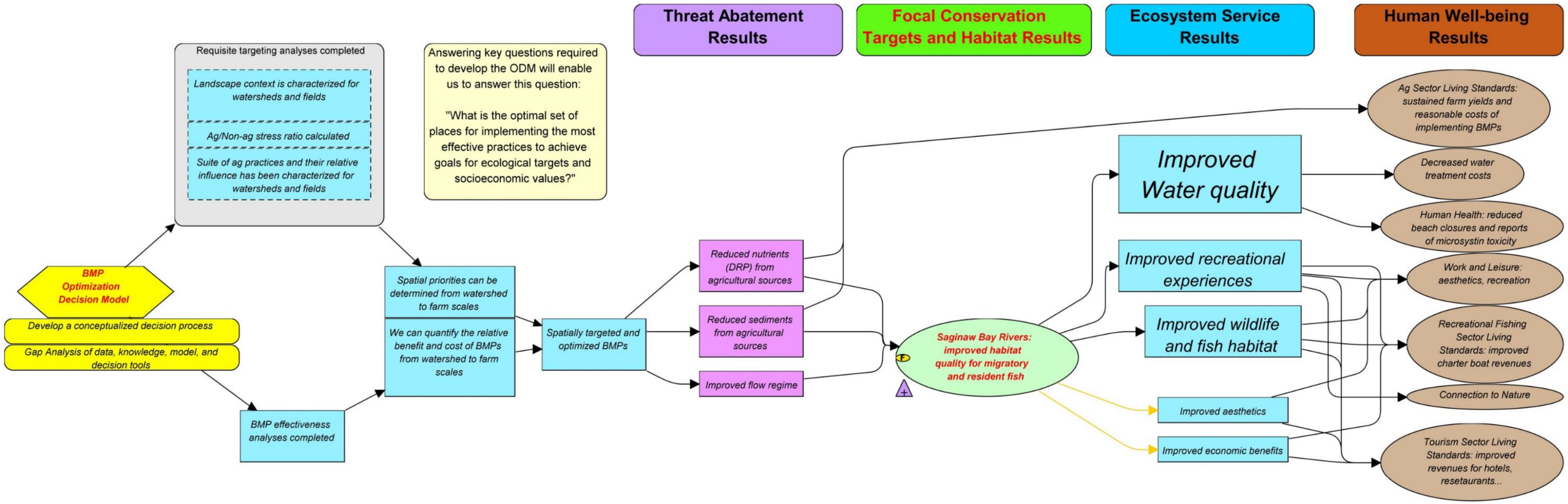
Overall, we estimate that approximately 8.5% of the project budget was spent on end-user engagement. However, funded project team members (TNC and LimnoTech) estimated that about 10% of time was spent in this area. Additionally, SVSU personnel spent considerable unfunded time during the academic year on end-user engagement, and this effort was accompanied by the help of staff from Michigan's Office of the Great Lakes, who also contributed their time (unfunded by the grant). The effort was considered necessary to accomplish project goals and better anticipate the effort needed to avoid any further budget shortfalls. But as described in Section E2 below, our challenges with end-user engagement are more associated with the limited project duration and timing rather than budget.

E-2. Reflect on your experience as a Water Center grantee. In particular, please consider the Water Center's efforts to help support end user-driven research, foster collaborative relationships and learning among project teams, and adaptively respond to project team feedback. We are interested in knowing what has worked well and how we can improve the support we provide to project teams in the future to help ensure the success and broader impacts of each project.

The project PIs and the team had a positive experience with the UM Water Center. The user-driven research aspect was unique from other funders. It is a much needed approach for effective water resource restoration because it facilitates buy-in beyond the researchers and resource management communities. This directive from the UM Water Center kept our project team focused on end-users' needs. We appreciated the forums that were facilitated by the UM that enabled communication not just across Tier II projects and UMWC staff, but also with scientists and other stakeholders from a variety of agencies and organizations. These opportunities for communication and collaboration expanded our network of expertise which was key to achieving our project goals. Overall, our team found the UM Water Center great to work with. Reporting requirements were clear and not overly burdensome. The staff was always accessible, and they welcomed our questions and inquiries. They displayed more than sufficient flexibility with project direction and minor adjustments. We especially appreciate that the UM Water Center kept the project's needs a priority over the process.

There were a few challenges cited by the team members with the project duration, end-user engagement, and overall stakeholder engagement. The project duration enabled us enough time to develop the Saginaw Bay ODM toolkit and evaluate the proposed retrospective and forward scenarios. End-user engagement began early in the project and occurred several times, but the most beneficial engagement with them will be with a completed *SagODM* toolkit and tangible results in the form of maps and scenarios that they can use. We are now just getting to that point. Likewise, while the emphasis on stakeholder engagement was viewed as beneficial, it was incorporated after conception of the project plan and budget, and it was difficult at key times to divert from the technical needs and activities of the team to engage stakeholders. A project duration of three to five years would enable us to engage stakeholders more effectively and have time to follow up after results are complete.

Appendix A. Conceptual Model



Open Standards Step			Questions
1. Conceptualize and Analyze	1A. Define Planning Purpose and Project Team	1.A	**What is the optimal set of places for implementing the most effective practices to achieve goals for ecological targets and socioeconomic values?**
	1B. Define Scope, Assessment Framework, and Gaps in data, knowledge, models, and decision tools	1.B.1.a	What is the geographic scope of our project?
		1.B.2.a	What is the ecological scope of our project? (Major Ecosystems., Habitats, and Taxonomic Groups*). Our Ecological Targets*
		1.B.2.b	What are the most relevant and information rich stream community indicators?
		1.B.3.a	What is the socioeconomic scope of our project? *Our Socioeconomic Targets*
		1.B.3.b	What are the most relevant and information rich socioeconomic indicators?
		1.B.4.a	What is the human disturbance/source of stress scope of our project?
		1.B.4.b	What are the most relevant and information rich human disturbance indicators?
		1.B.4.c	Do we have the data, knowledge, and tools needed to model the effects of human disturbances on our stream community indicators?
		1.B.5.a	What is the conservation practice scope of our project?
		1.B.5.b	What are the most relevant and information rich conservation practice indicators?
		1.B.5.c	Do we have the data, knowledge, and tools needed to model the effects of conservation practices on our stream community indicators?
		1.B.1.b	Given the purpose and scope, what geographic framework(s) should we use?
		1.B.1.c	Given the purpose and scope, what scales/spatial grains of assessment should we use?

Open Standards Step			Questions
1. Conceptualize and Analyze	1C. Assess Condition of Targets, Limiting Factors, and Sources of Disturbance	1.C.1	**What is the status of our Targets and Likely Source(s) of Impairments?**
		1.C.1.a	What is the status of our stream community indicators?
		1.C.1.b	If impaired, what human disturbances are likely limiting the stream community indicators?
		1.C.1.c	Where is row-crop AG likely contributing to the impairments of our stream community indicators?
		1.C.1.d	Where is row-crop AG likely the dominant source of the stream community impairments?
		1.C.1.e	What is the status of our socioeconomic indicators (targets)?
		1.C.1.f	If impaired, what human disturbances are likely limiting socioeconomic indicators?
		1.C.1.g	Where is row-crop AG likely contributing to the impairments of our socioeconomic indicators?
		1.C.1.h	Where is row-crop AG likely the dominant source of the socioeconomic impairments?
		1.C.2	**What activities are contributing most to impairments of ecological and socioeconomic indicators/targets?**
		1.C.2.a	*Poor land use planning*
		1.C.2.a.1	Direct conversion/loss of stream habitat
		1.C.2.a.2	Altered Landscape Pattern and Structure of stream community Habitats
		1.C.2.b	*Poor Management Practices on Agricultural Lands*
		1.C.2.b.1	Altered/impaired stream and riparian habitat (physical, chemical, hydrological)
		1.C.2.b.2	Altered/impaired Ecosystem Services provided by stream communities
	1D. Analyze the Conservation Situation	1.D	This is one of the steps in the Open Standards process that entails constructing a conceptual diagram, which we have already done.

Open Standards Step			Questions
2. Plan Your Actions and Monitoring	2A. Develop a Formal Action Plan: Goals, Strategies, Assumptions, and Objectives	2.A.3	**What are the best places and practices for achieving conservation goals?**
		2.A.3.a	What are the costs and benefits of implementing practices in different places at different scales?
		2.A.3.b	What specific conservation practices can most effectively abate impairments of stream community targets?
		2.A.3.c	What is the cost per unit benefit to stream communities of different conservation scenarios?
		2.A.3.d	What is the cost per unit benefit of conservation scenarios when benefits to other ecological goals are considered?
		2.A.3.e	What is the cost per unit benefit when benefits to socioeconomic/ecosystem service goals are considered?
	2B. Develop a Formal Monitoring Plan		
	2C. Develop an Operational Plan		
3. Implement Actions and Monitoring	3A. Develop a Detailed Short-Term Work Plan and Timeline		
	3B. Develop and Refine Your Project Budget		
	3C. Implement Your Plans		
4. Analyze, Use, Adapt	4A. Prepare Your Data for Analysis		
	4B. Analyze Results	4.B.1	Are the selected practices leading to the desired outcomes to stream communities?
		4.B.1	Were the outcomes of management actions predictable by our models (i.e., Model Post-audit)?
	4C. Adapt Your Strategic Plan		
5. Capture and Share Learning	5A. Document What You Learn		
	5B. Share What You Learn		
	5C. Create a Learning Environment		

Appendix B: Current Data, Models, and Decision Tools essential to the Realized Saginaw Bay Optimization Decision Model (ODM) Toolkit.

Saginaw Bay ODM Core Questions and Decisions	**Within or For Saginaw Bay**	**Within or For the Saginaw Bay Watershed and Tributaries**	**Comments**
What ecological features and socioeconomic conditions do people value?	Data: Results of Stakeholder Surveys and research http://www.nemw.org/wp-content/uploads/2015/06/GLEconVal.pdf http://ns.umich.edu/new/releases/22137-pollution-top-concern-for-u-s-and-canadian-citizens-around-great-lakes Models and Decision Tools: None that we know of	Data: Results of Stakeholder Surveys and research http://www.nemw.org/wp-content/uploads/2015/06/GLEconVal.pdf http://ns.umich.edu/new/releases/22137-pollution-top-concern-for-u-s-and-canadian-citizens-around-great-lakes Models and Decision Tools: None that we know of	We conducted stakeholder surveys specifically for this project and there are many scattered surveys that obtain data on the values of Great Lakes citizens. However, these represent distinct and highly fragmented efforts. There is an urgent need for more systematic long-term monitoring of social values associated with our water resources to complement our efforts to monitoring ecological and socioeconomic indicators.
What are our goals for these ecological and socioeconomic conditions (indicators)?	Lake Huron or Basinwide Scale: Lake Management Plans (LaMPs) and Biodiversity Management Plans: http://www.ijc.org/en_/GLWQA_2012_Annexes http://www.epa.gov/greatlakes/lake-huron-lamps https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/michigan/Documents/LHBCS-Technical-Report.pdf Saginaw Bay: http://www.ijc.org/en_/GLWQA_2012_Annexes http://www.pscinc.com/Portals/0/Publications/Saginaw_Bay/2000_Measures_Success/report.PDF Local Scale (distinct zone of Saginaw Bay): None that we know of	Lake Huron or Basinwide Scale: Binational and Federal Water Quality Criteria as administered under the GLWQA and US Clean Water Act http://www.ijc.org/en_/Great_Lakes_Water_Quality http://www.epa.gov/cleanwaterrule Saginaw Bay Watershed: State water quality criteria http://www.michigan.gov/documents/deq/wrd-swas-ir2014-final_455859_7.pdf The Saginaw Bay Regional Conservation Partnership Program (RCPP) https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/michigan/projects/Pages/Regional-Conservation-Partnership-Program.aspx Local Subwatershed Scale: Saginaw Bay RCPP https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/michigan/projects/Pages/Regional-Conservation-Partnership-Program.aspx	Explicit, measureable, shared goals are rare for ecological indicators and even rarer for socioeconomic indicators. Thankfully there is a growing interest in and emphasis on socioeconomic indicators as evidence by the work of several groups in the Great Lakes and beyond like the; • IJC http://ijc.org/en_/AOP/Human_Health • State of Michigan http://www.michigan.gov//documents/deq/deq-ogl-Table_1._Water_Strategy_Priority_Recommendations_and_Measures_of_Success_491269_7.pdf • ICSU http://www.icsu.org/publications/reports-and-reviews/socioeconomic-data-in-relation-to-the-integrated-global-observing-strategy-partnership-2004/Socio_Eco_Data_Report

Saginaw Bay ODM Core Questions and Decisions	Within or For Saginaw Bay	Within or For the Saginaw Bay Watershed and Tributaries	Comments
		Several 319 watershed management plans http://www.michigan.gov/documents/deq/wrd-nps-approved-watershed-plans_431188_7.pdf	
Where are ecological and socioeconomic valued conditions impaired (goals not being met)?	Data: Status and trends from federal, state, and local monitoring and academic research http://www.ijc.org/files/tinymce/uploaded/Publications/16thBE_internet%2020130509.pdf http://www.michigan.gov/deq/0,4561,7-135-3313_3681_3686---,00.html http://www.glerl.noaa.gov/res/projects/multi_stressors/ http://glahf.org/ Models and Decision Tools: SAGEM2 http://www.limno.com/pdfs/2011_Verhamme_IAGLR.pdf	Data: Status and trends from federal, state, and local monitoring and academic research http://www.michigan.gov/deq/0,4561,7-135-3313_3681_3686---,00.html http://www.glerl.noaa.gov/res/projects/multi_stressors/ Models and Decision Tools: Sowa et al. 2011 and Sowa et al. In Review	There is limited information for ecological indicators and even less for socioeconomic indicators As mentioned in the cell just above there is a growing interest in socioeconomic indicators and goals. However, we need to move beyond the identification and talking about socioeconomic indicators related to ecosystem services and begin focusing more addressing the logistics of developing long term monitoring programs for such metrics. Thankfully the University of Michigan Water Center recently created a new work group focused on the possible development of a Social Observing System for the Great Lakes.
What human disturbances are likely causing these impairments?	Data: Status and trends from federal, state, and local monitoring and academic research http://www.glerl.noaa.gov/res/projects/multi_stressors/ http://www.michigan.gov/documents/deq/sagbayphosrep_283289_7.pdf Models and Decision Tools: Great Lakes Environmental Assessment and Mapping Tool http://www.greatlakesmapping.org/ Great Lakes Environmental Indicators Project http://glei.nrri.umn.edu/default/default.htm	Data: Status and trends from federal, state, and local monitoring and academic research http://www.glerl.noaa.gov/res/projects/multi_stressors/ Models and Decision Tools: NFHAP National Assessment Data Viewer http://ecosystems.usgs.gov/fishhabitat/assessment_viewer.jsp	There has been a significant amount of monitoring, mapping and research focused on human disturbances and stressors relative to other components of the ODM toolkit.
Where is AG NPS likely contributing and/or a major contributor to these impairments?	Data: Status and trends from federal, state, and local monitoring and academic research http://www.glerl.noaa.gov/res/projects/multi_stressors/	Data: Status and trends from federal, state, and local monitoring and academic research http://www.glerl.noaa.gov/res/projects/multi_stressors/	Not having data or models to accurately answer this question is often a barrier to addressing non-point source pollution because it does not allow discussions and management efforts to get beyond the “finger-pointing” stage.

Saginaw Bay ODM Core Questions and Decisions	Within or For Saginaw Bay	Within or For the Saginaw Bay Watershed and Tributaries	Comments
	http://www.michigan.gov/documents/deq/sagbayphosrep_283289_7.pdf Models and Decision Tools: Great Lakes Environmental Assessment and Mapping Tool http://www.greatlakesmapping.org/ Great Lakes Environmental Indicators Project http://glei.nrri.umn.edu/default/default.htm	NFHP Data Download and Map Services http://ecosystems.usgs.gov/fishhabitat/nfhap_download.jsp Models and Decision Tools: NFHP National Assessment Data Viewer http://ecosystems.usgs.gov/fishhabitat/assessment_viewer.jsp	
Where are the best places to focus our AG NPS management efforts?	Data: Marxan optimization outputs from this project Models and Decision Tools: High Impact Targeting tool http://www.iwr.msu.edu/hit2/ The Great Lakes Watershed Management System http://35.8.121.111/glwms/ Many others	Data: See Sowa et al. 2011 and Sowa et al. In Review Models and Decision Tools: High Impact Targeting tool http://www.iwr.msu.edu/hit2/ The Great Lakes Watershed Management System http://35.8.121.111/glwms/ Many others	This prioritization and targeting of BMPs must be done at multiple scales for multiple ecological and socioeconomic outcomes and that is the focus of these data and tools provided here. However, there are many other data sources, models and decision tools that also help answer this question at different scales and this often leads to confusion among decision makers.
What are the best practices to address AG NPS impacts?	Data: Minnesota Ag BMP Handbook http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf *The UofM Water Center Ensemble Modeling Project http://graham.umich.edu/water/events/swat-modeling-workshop Models and Decision Tools: The Great Lakes Watershed Management System http://35.8.121.111/glwms/	Data: Minnesota Ag BMP Handbook http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf *The UofM Water Center Ensemble Modeling Project http://graham.umich.edu/water/events/swat-modeling-workshop Models and Decision Tools: The Great Lakes Watershed Management System http://35.8.121.111/glwms/	*The ensemble modeling project being led by the Water Center grew out of the SWAT modeling workshop they hosted and is focused on identifying the best practices and management scenarios (multiple practices) needed to achieve Phosphorous reduction goals that have been established for Western Lake Erie. We need a similar effort for Saginaw Bay and Green Bay.
How much of these practices are needed to address AG NPS and achieve goals for our ecological and socioeconomic valued conditions?	Data: Results of the Marxan optimization analyses completed in this project Models and Decision Tools: Integration of Saginaw Bay SWAT model, SAGEM2, and MARXAN analyses completed in this project	Data: See Sowa et al. 2011 and Sowa et al. In Review *The UofM Water Center Ensemble Modeling Project http://graham.umich.edu/water/events/swat-modeling-workshop	*The ensemble modeling project being led by the Water Center is also attempting to answer this question for Western Lake Erie. Again, we need a similar effort for Saginaw Bay and Green Bay.

Saginaw Bay ODM Core Questions and Decisions	Within or For Saginaw Bay	Within or For the Saginaw Bay Watershed and Tributaries	Comments
		Models and Decision Tools: See Sowa et al. 2011 and Sowa et al. In Review	
What are our watershed goals for AG BMPs?	Lake Huron or Basinwide Scale: None that we know of Saginaw Bay Scale: None that we know of Local Scale (to affect individual zones of Saginaw Bay): None that we know of	Lake Huron or Basinwide Scale: None that we know of Saginaw Bay Watershed: The Saginaw Bay Regional Conservation Partnership Program (RCPP) https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/michigan/projects/Pages/Regional-Conservation-Partnership-Program.aspx Local Subwatershed Scale: Saginaw Bay RCPP https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/michigan/projects/Pages/Regional-Conservation-Partnership-Program.aspx Some 319 watershed management plans http://www.michigan.gov/documents/deq/wrd-nps-approved-watershed-plans_431188_7.pdf	There is a significant need to bring together the many stakeholders that are interested in and critical to addressing AG NPS to establish a shared vision and goals for Agricultural BMPs across Saginaw Bay watersheds and subwatersheds. Without a shared vision and goals efforts to address agricultural non-point source pollution will continue to be significantly less efficient and effective than they can be even with the best scientific data, knowledge, and tools.
How are we progressing toward goals for our conservation actions (AG BMPs) and ecological and socioeconomic valued conditions?	Data: Not applicable because we lack goals Models and Decision Tools: Not applicable because we lack goals	Data: The Great Lakes Watershed Management System http://35.8.121.111/glwms/ Models and Decision Tools: The Great Lakes Watershed Management System http://35.8.121.111/glwms/	Our lack of conservation action goals to meet ecological and socioeconomic outcomes within Saginaw Bay must be addressed. Much more attention must also be given to tracking progress towards these goals. The Saginaw Bay RCPP is using the GLWMS to track progress towards such goals and to our knowledge this is the only effort to do this outside of the Chesapeake Bay watershed http://www.chesapeakestat.com/

Appendix C. Stakeholder Engagement Strategy.

Background and Approach

Engaging key federal, regional and local stakeholders is an overarching priority throughout the entire Saginaw Bay Optimization Decision Tool project. Identified stakeholders have been categorized into two groups: 1) "end-users; and, 2) "ecosystem-users." The "end users" include individuals at local, state and federal agencies that might actually use the decision tool to help select targeted areas and/or conservation practices for future implementation projects. The "ecosystem users" describe broad categories of people or groups who use or benefit from water resources throughout the Saginaw Bay Watershed.

The role of the end-user group will be multifaceted, including providing strategic direction, input and feedback on various aspects of the project development and the format of the final product. Members of the project team include several key end-users: MDARD, MDEQ, MDNR, USGS, NRCS, and TNC. These organizations have been actively working in the Saginaw Bay region through the MAEAP; the NOAA Saginaw Bay Multiple Stressors project; and other federal, state, and local natural resources initiatives. Other end-user organizations have been identified and are listed in the Stakeholder List table in the Appendix.

The role of the "ecosystem-users" will be to inform the overall project model or results chain. Specifically, input from the "ecosystem-users" will be used to identify all of the ecological and socioeconomic endpoints most important to incorporate into the realized ODM. "Ecosystem-users" include the interested general public, municipalities, riparian landowners, boaters, swimmers, producers, and others that use and/or manage the resource. As part of this Engagement Strategy, the project team will identify additional ecosystem-users using the pre-existing steering committees from recently funded watershed projects in the Kawkawlin and Pigeon/Pinnebog sub-watersheds, and other committees that are active in these subwatersheds that would have an interest in the project.

Goals

The overall goal of the Engagement Strategy is to develop a feedback loop between stakeholders and the project team to ensure that the outcomes of the project address the needs, where applicable, of the end-users and ecosystem-users. The following five sub-goals will be used to guide the strategy:

1. **Create Project Awareness -** Inform stakeholders of the project and ways they can engage and/or provide input.
2. **Receive Feedback:** Create opportunities for stakeholders to provide valuable input to the project tasks.
3. **Communicate Progress -** Develop a strategic system for updating stakeholders about developments, progress, challenges and opportunities during the 2013-15 project timeframe.
4. **Communicate Successes -** Report on completed project elements to key stakeholders.
5. **Demonstrate Use and Applicability -** Provide examples and materials that enable key stakeholders to understand the utility of the realized ODM for development of future projects.

Outcomes of Stakeholder Engagement Strategy

A) Relationships and communication among Saginaw Bay stakeholders are strengthened to achieve the shared ecological and socioeconomic vision and goals of the project;
B) Ecological and socioeconomic endpoints most important to stakeholders are incorporated into the realized ODM;
C) End-users and ecosystem-users understand the utility of the realized ODM for informing the planning and implementation of BMP practices.

Activities and Distribution Methods

There will be specific activities targeting end-users and ecosystem-users, see below descriptions. In addition to face-to-face meetings, project communications will be developed to share through a variety of communication outlets. Information and input gleaned from the meetings and communication feedback will be used to develop both the idealized and realized ODM (where applicable). The following table describes the major activities that will be conducted to implement the engagement strategy to key stakeholder groups.

Table 1. Engagement Activities and Distribution Methods.

Activity	Appropriate Interest Group	Associated Outcomes	Timeframe	Distribution Method	Status
Conduct first end-user workshop	End Users	A, B, C	Quarter 2	Email and mail invitation, face to face facilitated meeting	Complete: Saginaw Bay RC&D Celebratio
Develop email listserv	End Users	A	Quarter 2	Email	Complete
Conduct first end-user conference call	End Users	A, B, C	Quarter 3	Email invitation, Conference Call	Complete (10/8/14)
Conduct end-user webinar/meeting	End Users	A, B, C	Quarter 5	Email invitation, Webinar	Complete (10/8/14)
Stakeholder Survey	Both		Quarter 3 - 5	Email, meetings, local watershed meetings, etc.	Complete: survey was open from 6/14 until 10/14
Conduct second end-user conference call	End Users	A, B, C	Quarter 6	Email invitation, Conference Call	Complete: face-to-face meetings held 2/18/15,
Conduct second end-user workshops	End Users	A, B, C	Quarter 9	Email invitation, face to face	Scheduled for 2/25/16
Conduct four stakeholder engagement meetings (two meetings in Caseville Twp. and two meetings Bangor Twp.)	Ecosystem Users	A, B, C	Quarter 2, 9	Email and mail invitations, newspapers, websites*	Complete: meetings held 3/24/14
Develop and pitch story ideas to local press and schedule interviews for PIs to discuss project	Both	A	Quarter 2, 4, 6, 8	Newspapers, websites*	Complete: several news stories, presentatio ns to Pigeon Rotary Club, Bay City
Engage in local watershed meetings	Both	A, B, C	Ongoing	Project Team In person	Complete
Develop term sheet, talking points and a fact sheet	Both	A	Quarter 2	Post on partners' websites*	Complete: project fact sheet and webpage
Develop PowerPoint slides with key messages and imagery that can be used by	Both	A	Quarter 3	Project Team oral presentations	Complete
Schedule presentations at various outside meetings	Both	A	Ongoing	Project Team oral presentations	Complete: presented info. about the project and engaged with other Sag. Bay projects

***** e.g., governmental sites, local municipal sites –OGL-Lake Notes, local municipal and/or DEQ, MDARD, conservation districts.

Ecosystem-User/General Public Engagement (Quarter 2 & 9) - We will hold two formal information sessions that will target potential ecosystem-users and general public in the Kawkawlin and Pigeon/Pinnebog sub-watersheds. The first meeting (quarter 2) will focus on informing stakeholders about the project and soliciting stakeholder input on important values and issues related to ecosystem services. The second meeting (quarter 8) will be used to solicit stakeholder input, provide a retrospective of the project, and to helpstakeholders understand the linkages among ecosystem issues (e.g. muck, algal blooms), ecosystem uses (e.g. hunting, fishing), and conservation practices. The Kawkawlin stakeholder meetings will be held at the Bangor Twp. Hall and the Pigeon/Pinnebog meetings will be held at the Caseville Twp. Hall. Each meeting will be facilitated by the project P.I. (Karpovich), a representative of MDEQ (Bauer and/or Joldersma), a representative from TNC (Sowa, Fales, or Pearsall), and LimnoTech (DePinto). ***Status: Complete*** *(meetings held 3/24/14 (Quarter 2) and 10/28/15 (Quarter 9))*

End-User Stakeholder Meeting 1 (Quarter 2) - The first meeting will introduce the project goals, provide an overview of the use of the ODM in its application in implementing conservation practices, and solicit stakeholder input on important values and issues related to ecosystem services. The purpose of the meeting is to clarify and better define the necessity and framework and intended use of the ODM. The objectives of the workshop will be to: 1) briefly describe the current set of data tools and models available; 2) discuss possible sources of additional data and tools; 3) solicit inputs from end-user groups on key needs and conservation priorities; 4) define the importance of end-user engagement in the project and beyond; 5) identify data gaps; and, 6) identify additional economic data regarding costs and impacts of NPS and nutrient abatement programs currently being implemented under GLRI and MAEAP. The information gathered from this workshop will help inform the development of ODM and the next steps for the project, particularly the development of the Gap Analysis and the retrospective assessment components. ***Status: Complete*** *(meeting was held on 2/27/14 after the Saginaw Bay RC&D's Celebration)*

Stakeholder Survey (Quarter 3 – 5) – A survey will be developed (using SurveyMonkey or a similar program) for the purpose of gathering stakeholder input and gaining an understanding of stakeholders perceptions of the conditions and uses of their local water resources. The survey will be distributed to stakeholders via the project's listserv and by the project team at local watershed and/or other stakeholder meetings (e.g.

Conservation District meetings, local NGO meeting, etc.). ***Status: Complete*** *(survey was open from June – October 2014)*

End-User Stakeholder Meeting 2 (Quarter 8 or 9) - The second meeting will present a retrospective of the project designed to help stakeholders understand the linkages among: 1) socioeconomic values (e.g. reduced incidence of beach closures, reduced cost to drinking water treatment, prime fishing and hunting opportunities);

2) ecosystem targets (e.g., health and status of migratory fish); 3) ecosystem stressors (e.g. nutrients, sediment algal blooms); and, 4) conservation practices. During the second meeting, the evolving nature of the ODM will be evident as further stakeholder input will be invited. This workshop will present an analysis of the retrospective review of GLRI and MAEAP verified farm conservation practices using the realized ODM, will summarize the overall project findings, and provide an opportunity for the stakeholders to gain a comprehensive view of the realized ODM. The outcome of this final workshop is to identify invested federal, state, and local stakeholders who will use the realized ODM to address future needs (e.g., make funding decisions) and implement targeted conservation actions within the Kawkawlin River and Pigeon/Pinnebog River sub-watersheds. ***Status: Scheduled*** *(information will be presented at the Saginaw Bay RC&D's Celebration of Success on 2/25/16 in Frankenmuth, MI)*

End-User Webinar or Meeting (Quarter 5) - A Webinar or meeting will be convened to provide an overview of the modeling effort. The invitation will be communicated to key end-user stakeholders engaged during the first end-user workshop held in Quarter 2, as well as others who have expressed an interest in the project outcomes. The webinar/meeting will: 1) summarize project findings to date, including the results of the Gap Analysis; 2) provide the opportunity for stakeholders to comment on a draft set of nested priority conservation values based on feedback from the first workshop; and, 3) gather comments on the format and distribution method of the final realized ODM product. ***Status**: **Complete*** *(meeting held on 10/8/14 at SVSU)*

Local Watershed/Stakeholder Meetings (Quarter 2 – 8) – The project team will identify additional project stakeholder engagement opportunities such as Soil Conservation District Meetings (farmers), stakeholder meetings from ongoing GLRI groups (multiple ecosystem and end-users), farmers, and agribusinesses.

Last Updated: 12/29/2015

Participating in these additional ecosystem-user and/or end-user meetings/events will help to raise the profile of the project, increase the exchange of information between the project team and stakeholders, and increase the opportunity to receive feedback from ecosystem-users and end-users. ***Status**: **Complete*** *(see list below):*

1. *"Saginaw Bay Environmental Science Institute."* Partnership for the Saginaw Bay Watershed Annual Meeting and Speaker Series. Presented at SVSU. October 23, 1013.
2. *"Saginaw Bay Environmental Science Institute."* House Democrats' Great Lakes and Conservation Task Force meeting held at SVSU. September 23, 2013.
3. *"Saginaw Bay Optimization Decision Model: Linking Management Actions to Multiple Ecological Benefits via Integrated Modeling."* The Saginaw Bay Annual Celebration of Success. Saginaw Bay RC&D. Bay City, MI. February 27, 2013.
4. *"Development and application of SWAT models to support the Saginaw Bay Optimization Decision Model."* Co-Author. Presented by Joe DePinto of LimnoTech. Great Lakes SWAT modeling workshop. UM Water Center, Ann Arbor, MI. March 18, 2013.
5. *"Saginaw Bay Optimization Decision Model: Linking Management Actions to Multiple Ecological Benefits via Integrated Modeling."* Presented to Kawkawlin River stakeholders in Bay City Michigan and Pigeon/Pinnebog River stakeholders in Caseville, MI. March 24, 2013.
6. Exchanged information with UofM Water Center's "Stuck in the Muck" Project. May 21, 2014
7. *"Working Toward Strategic Implementation of Soil Conservation Practices in the Saginaw Bay Watershed."* Presented at the Great Lakes Sedimentation Workshop, at NOAA GLERL, Ann Arbor, MI. June 5, 2014
8. *"Targeting Implementation of BMPs in Kawkawliin and Pigeon/Pinnebog Watersheds."* Presented at the 2014 Saginaw Bay Watershed Conference, SVSU, June 12, 2014.
9. Exchanged information with the MI Sea Grant's Saginaw Bay Integrated Assessment Project. August 22, 2014
10. *"Strategic Conservation in the Saginaw Bay Watershed."* Presented to the Bay City Rotary Club in Bay City, MI on February 17, 2015.
11. *"Saginaw Bay Optimization Decision Model: Linking Management Actions to Multiple Ecological Benefits via Integrated Modeling."* Presented at the Kawkawlin Watershed Summit in Auburn, MI on February 18, 2015.
12. *"Strategic Conservation in the Saginaw Bay Watershed."* Presented to the Pinconning-Standish Rotary Club in Standish, MI on April 30, 2015.
13. *"Saginaw Bay Optimization Decision Model: Linking Management Actions to Multiple Ecological Benefits via Integrated Modeling."* Presented at the Lake Huron Restoration Regional Meeting in Port Huron, MI on May 12, 2015.
14. *"Strategic Conservation in the Saginaw Bay Watershed."* Presented at the Healing Our Waters Conference in Chicago, IL on September 30, 2015.
15. *"Strategic Conservation in the Saginaw Bay Watershed."* Presented at the Kawkawlin River Watershed Summit held at SVSU on October 28, 2015.
16. *"Strategic Conservation in Saginaw Bay."* Presented at the Saginaw Bay Watershed Conservation Training for MAEAP Technicians. SVSU, December 21, 2015.

End-User Conference Call Updates (Quarter 3 & 6) – In between face-to-face meetings, at least two conference calls will be held with the PIs and end-users. Participants will be invited via the stakeholder listserve created for the project. ***Status*: *Complete*** *(Quarter 3 call was replaced with a face-to-face meeting on 10/8/14 at SVSU; the Quarter 6 call was replaced with face-to-face meetings with Bay County Soil Conservation District on 2/18/15 at the Kawkawlin Watershed Summit and with the Huron Conservation District on 3/5/15 & 3/12/15 at the HCD's office).*

Internal Project Team Communication

Regular, organized and efficient internal communication among the project team members will be essential to timely completion of tasks and project success. To facilitate internal project communication, a collaborative website was developed via SVSU's intranet (V-Space). All project team members have been issued a user name and password. All project related documents and scheduled events will be posted on this website. In addition, we have identified a need for regular conference calls, face-to-face meetings and the development of subcommittees. Currently a Communication Subcommittee and a Modeling Subcommittee have been developed.

Conference Calls - At a minimum, hold quarterly conference calls to update the Project Team on progress and any issues that have arisen.

Face-to-face Meetings – The Project Team will hold at least one face-to-face meeting per year.

Water Center Communication – In addition to quarterly reporting, the Project Team will correspond and/or provide the Water Center with updates on an as needed basis, and will invite the Water Center staff to participate at all meetings and conference calls.

Project Team Calendars - The 2014 and 2015 calendars will be maintained on the SVSU VSpace website under Resources Tab for approximate dates of stakeholder workshops and meetings, conference calls, reporting deadlines and face-to-face meetings.

Appendix

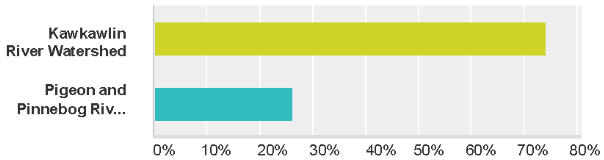
Stakeholder List

Interest Group	Stakeholder Group	Identified Entities (Lists developed with specific contact information)	Project Team Contact
Potential End-Users	MDARD	Stewardship	Brown
	MDEQ	Water Resources Division Office of the Great Lakes	Joldersma, Bauer
	MDNR	Fisheries P&R Stewardship	Caroffino, Joldersma
	NRCS	District Conservationist	Shaffer
	USGS	Michigan Water Science Center	Evans
	USEPA	EPA Bad Axe Creek contractor (Pinnebog) GLs National Program Office	Bauer, Joldersma
	Corps of Engineers	Detroit District	Joldersma
	Drain Commissioners	Michigan Assoc. of County Drain	Bauer
	Soil Conservation Districts	Conservation Districts RC&D	Karpovich, Joldersma
	Education	Universities Colleges Local Schools	Joldersma, Bartholic, Karpovich
	Watershed Groups	Friends of Groups Watershed Councils Watershed-based Organizations	Karpovich, Bauer, Joldersma, Fales
	Environmental Organizations	Land Conservancies Natural Resource Organizations Master Gardners	Karpovich, Bauer, Joldersma, Fales
Ecosystem Users	Municipalities	Townships, Villages, Cities	Karpovich, Bauer, Joldersma
	Local Elected Officials		Karpovich
	Farmers/Producers	Farm Bureau Crop Services	Brown, Karpovich, Fales
	Property Owners	Property Owners Associations	Karpovich, Bauer, Fales
	Recreation Users	Field & Stream Clubs Marinas, Yacht Clubs & Harbors Bait & Tackle Shops Boating/Swimming	Karpovich, Bauer, Joldersma, Fales
	Recreation Oriented Businesses/Organizations	Charters Restaurants Lodges	Karpovich, Bauer, Joldersma, Fales
	Other	Economic Development Tourism Councils Tribal Lakeshore Groups County Parks State Parks	Karpovich, Bauer, Joldersma, Fales

Appendix D. Stakeholder Survey Results.

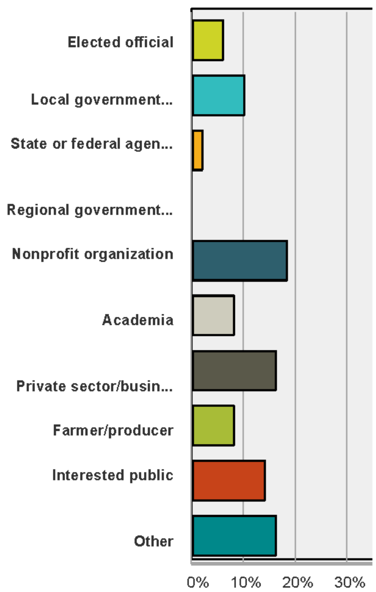
SagODM Stakeholder Survey Results

Q1) Which local water body do you identify with most? (see map above for reference)



Answer Choices	Responses (Answered: 50 Skipped: 3)	
Kawkawlin River Watershed	74.00%	37
Pigeon and Pinnebog River Watershed	26.00%	13
Total		50

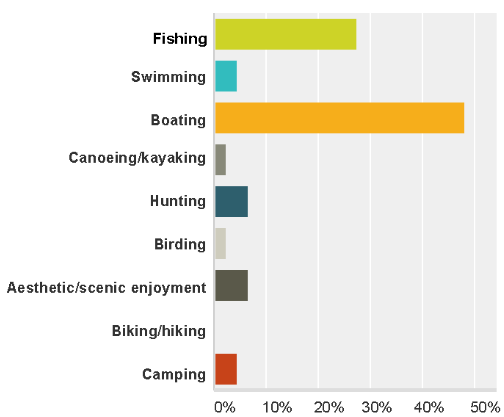
Q2) Select the answer that best describes your profession or interest?



Answer Choices	Responses (Answered: 49 Skipped: 4)	
Elected official	6.12%	3
Local government staff	10.20%	5
State or federal agency staff	2.04%	1
Regional government staff	0.00%	0
Nonprofit organization	18.37%	9
Academia	8.16%	4
Private sector/business owner	16.33%	8
Farmer/producer	8.16%	4
Interested public	14.29%	7
Other	16.33%	8
Total		49

#	Other (please specify)	Date
1	Landlord and Master Gardener	8/5/2014 4:05 PM
2	Consumers Energy volunteer	6/7/2014 8:30 PM

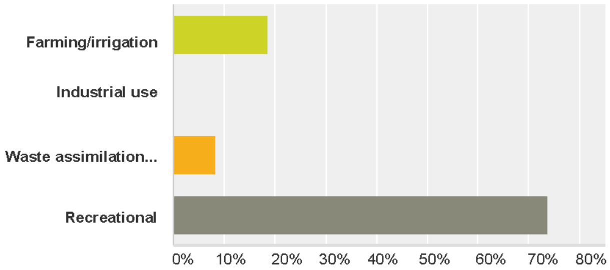
Q3) Which recreational activity is the most important to your local economy?



Answer Choices	Responses (Answered: 48 Skipped: 5)	
Fishing	27.08%	13
Swimming	4.17%	2
Boating	47.92%	23
Canoeing/kayaking	2.08%	1
Hunting	6.25%	3
Birding	2.08%	1
Aesthetic/scenic enjoyment	6.25%	3
Biking/hiking	0.00%	0
Camping	4.17%	2
Total		48

SagODM Stakeholder Survey Results

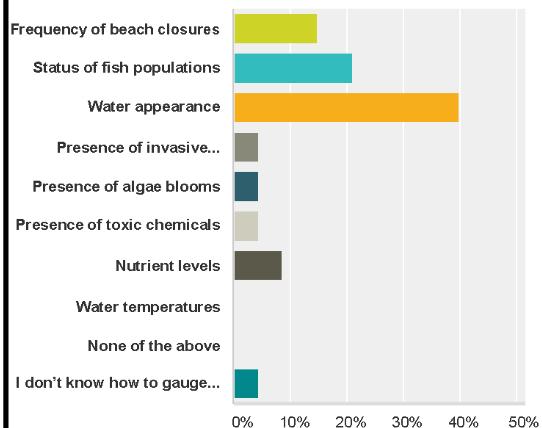
Q4) Other than drinking water, what water use is most important to you?



Answer Choices	Responses (Answered: 49 Skipped: 4)	
Farming/irrigation	18.37%	9
Industrial use	0.00%	0
Waste assimilation/disposal	8.16%	4
Recreational	73.47%	36
Total	49	

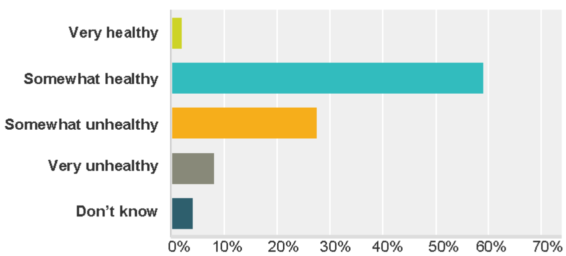
#	Other (please specify)	Date
1	Other	6/11/2014 1:50 PM
2	Other	6/11/2014 1:09 PM

Q5) How do you generally gauge whether a water body is healthy or not?



Answer Choices	Responses (Answered: 48 Skipped: 5)	
Frequency of Beach closures	14.58%	7
Status of fish populations	20.83%	10
Water appearance	39.58%	19
Presence of invasive species	4.17%	2
Presence of algae blooms	4.17%	2
Presence of toxic chemicals	4.17%	2
Nutrient levels	8.33%	4
Water temperatures	0.00%	0
None of the above	0.00%	0
I don't know how to gauge water quality health	4.17%	2
Total		48

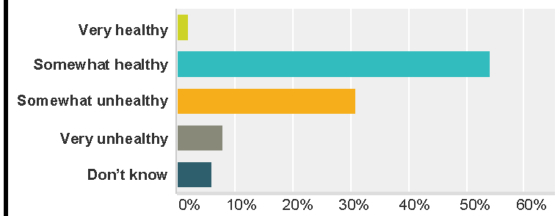
Q6) Overall, how healthy do you think the water quality is in Saginaw Bay?



Answer Choices	Responses (Answered: 51 Skipped: 2)	
Very healthy	1.96%	1
Somewhat healthy	58.82%	30
Somewhat unhealthy	27.45%	14
Very unhealthy	7.84%	4
Don't know	3.92%	2
Total		51

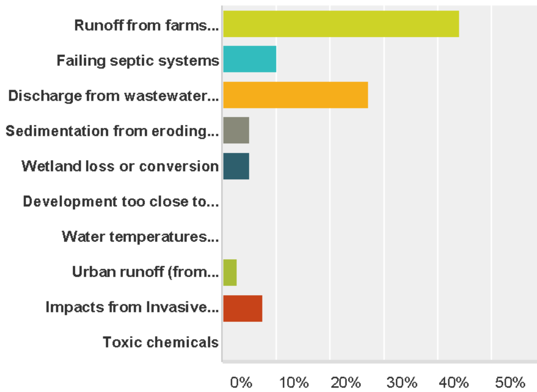
SagODM Stakeholder Survey Results

Q7) Overall, how healthy do you think the water quality is in the Kawkawlin or Pigeon/Pinnebog watershed? (Answer for whichever water body you most identify with)



Answer Choices	Responses (Answered: 52 Skipped: 1)	
Very healthy	1.92%	1
Somewhat healthy	53.85%	28
Somewhat unhealthy	30.77%	16
Very unhealthy	7.69%	4
Don't know	5.77%	3
Total		**52**

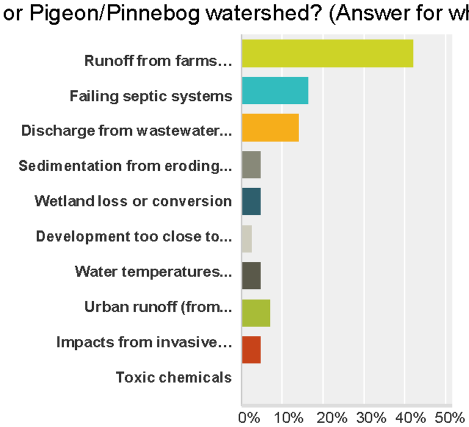
Q8) What do you think is the most important natural resource or environmental issue impacting Saginaw Bay?



Answer Choices	Responses (Answered: 41 Skipped: 12)	
Runoff from farms (chemicals, nutrients, manure)	43.90%	18
Failing septic systems	9.76%	4
Discharge from wastewater treatment plants	26.83%	11
Sedimentation from eroding streambanks	4.88%	2
Wetland loss or conversion	4.88%	2
Development too close to the water	0.00%	0
Water temperatures that are too warm	0.00%	0
Urban runoff (from roads/parking lots)	2.44%	1
Impacts from Invasive species	7.32%	3
Toxic chemicals	0.00%	0
Total		**41**

#	Other (please specify)	Date
1	+low lake levels	8/5/2014 1:52 PM
2	All	6/11/2014 1:58 PM
3	Don't Know	6/11/2014 1:19 PM

Q9) What do you think is the most important natural resource or environmental issue impacting the Kawkawlin or Pigeon/Pinnebog watershed? (Answer for whichever water body you most identify with)

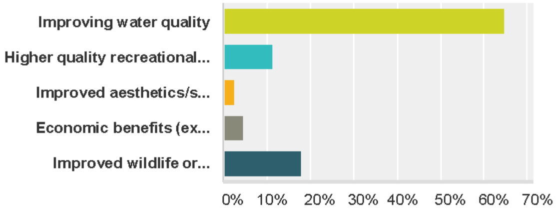


Answer Choices	Responses (Answered: 43 Skipped: 10)	
Runoff from farms (chemicals, nutrients, manure)	41.86%	18
Failing septic systems	16.28%	7
Discharge from wastewater treatment plants	13.95%	6
Sedimentation from eroding streambanks	4.65%	2
Wetland loss or conversion	4.65%	2
Development too close to the water	2.33%	1
Water temperatures that are too warm	4.65%	2
Urban runoff (from roads/parking lots)	6.98%	3
Impacts from invasive species	4.65%	2
Toxic chemicals	0.00%	0
Total		**43**

#	Other (please specify)	Date
1	+low lake levels	8/5/2014 1:52 PM

SagODM Stakeholder Survey Results

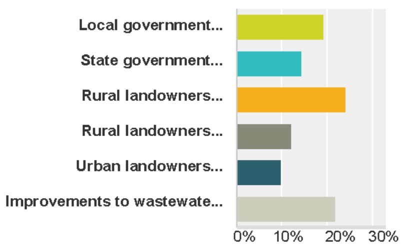
Q10) What benefits of conservation actions are most important to you?



Answer Choices	Responses (Answered: 45 Skipped: 8)	
Improving water quality	64.44%	29
Higher quality recreational opportunities	11.11%	5
Improved aesthetics/scenic quality	2.22%	1
Economic benefits (ex. increase in property values or soil health)	4.44%	2
Improved wildlife or aquatic habitat	17.78%	8
Total		45

#	Other (please specify)	Date
	There are no responses.	

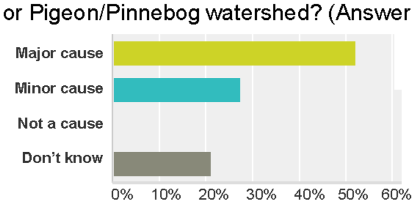
Q11) Where can the greatest gains be made in terms of improving water quality?



Answer Choices	Responses (Answered: 42 Skipped: 11)	
Local government policy (ex. master planning, ordinances)	19.05%	8
State government policy and regulation development	14.29%	6
Rural landowners voluntarily implementing conservation practices	23.81%	10
Rural landowners getting more technical assistance/government funding	11.90%	5
Urban landowners implementing conservation practices (ex. reducing runoff, lawn care)	9.52%	4
Improvements to wastewater treatment or septic systems	21.43%	9
Total		42

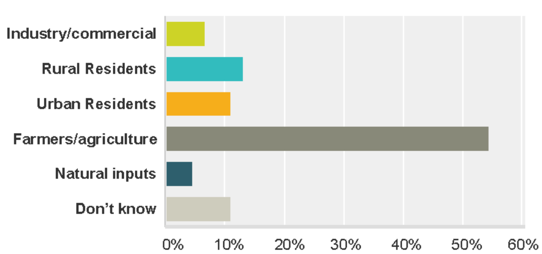
#	Other (please specify)	Date
1	All	6/11/2014 1:58 PM

Q12) To what extent is nutrient runoff (nitrogen and phosphorous) causing water quality problems in Kawkawlin or Pigeon/Pinnebog watershed? (Answer for which ever water body you most identify with)



Answer Choices	Responses (Answered: 48 Skipped: 5)	
Major cause	52.08%	25
Minor cause	27.08%	13
Not a cause	0.00%	0
Don't know	20.83%	10
Total		48

Q13) Who do you think contributes the most to nutrient runoff in the Kawkawlin or Pigeon/Pinnebog watershed? (Answer for whichever water body you most identify with)

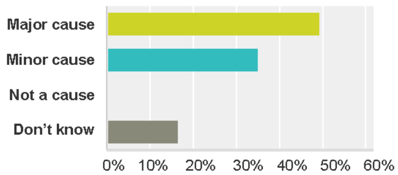


Answer Choices	Responses (Answered: 46 Skipped: 7)	
Industry/commercial	6.52%	3
Rural Residents	13.04%	6
Urban Residents	10.87%	5
Farmers/agriculture	54.35%	25
Natural inputs	4.35%	2
Don't know	10.87%	5
Total		46

#	Other (please specify)	Date
1	with farmers/agriculture running a close second.	8/5/2014 4:11 PM

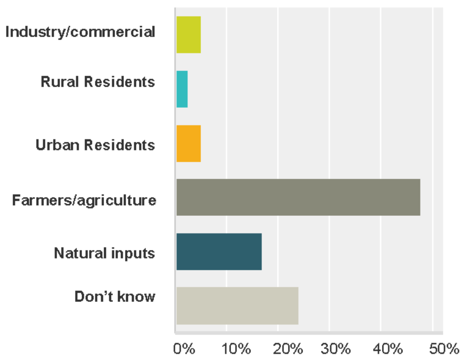
SagODM Stakeholder Survey Results

14) To what extent is sediment runoff causing water quality problems in the Kawkawlin or Pigeon/Pinnebog watershed? (Answer for which ever water body you most identify with)



Answer Choices	Responses (Answered: 49 Skipped: 4)	
Major cause	48.98%	24
Minor cause	34.69%	17
Not a cause	0.00%	0
Don't know	16.33%	8
Total		**49**

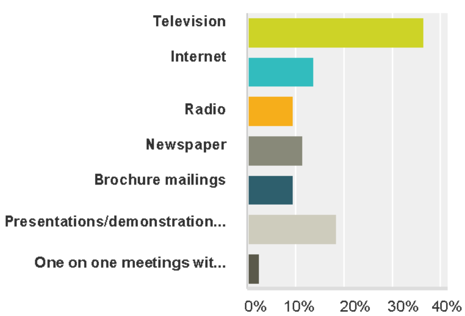
Q15) Who do you think contributes the most to sediment runoff in the Kawkawlin or Pigeon/Pinnebog watershed? (Answer for which ever water body you most identify with)



Answer Choices	Responses (Answered: 42 Skipped: 11)	
Industry/commercial	4.76%	2
Rural Residents	2.38%	1
Urban Residents	4.76%	2
Farmers/agriculture	47.62%	20
Natural inputs	16.67%	7
Don't know	23.81%	10
Total		**42**

#	Other (please specify)	Date
1	Untiled fields and cleaning vegetation from existing or expanding ditches and drains	8/5/2014 4:13 PM
2	Other	6/11/2014 1:51 PM

Q16) What is the most effective way to provide information regarding water quality and ways to protect water quality in your community?



Answer Choices	Responses (Answered: 44 Skipped: 9)	
Television	36.36%	16
Internet	13.64%	6
Radio	9.09%	4
Newspaper	11.36%	5
Brochure mailings	9.09%	4
Presentations/demonstration events	18.18%	8
One on one meetings with experts	2.27%	1
Total		**44**

#	Other (please specify)	Date
	There are no responses.	

Appendix E. Logic diagram for Saginaw Bay ODM project.

INPUTS	ACTIVITIES	OUTPUTS	SHORT TERM OUTCOMES	MEDIUM TERM OUTCOMES	LONG TERM OUTCOMES
In order to accomplish our goal will need the following resources	*Accomplishing the following activities will result in the following measurable outputs*	*Producing these outputs will result in the following outcomes*	*We expect the following measurable changes within the life of the grant*	*We expect the following measurable changes within the following one to three years after the grant*	*We expect the following impacts/trends within the following five to seven years or more*
UM Water Center Grant Leveraged Funds and resources from recent and ongoing projects from Applicant and partners Stakeholder input on ecosystem services, conservation issues, conservation strategies, and collaborative opportunities from this project and previous assessment and planning efforts (e.g., L. Huron BCS) Existing Field and Geospatial Data on From: GLEAM, GL CEAP, Multistressor Project, MDEQ, USGS, NOAA, and others Current Models and Decision Tools: - Soil and Water Assessment Tool (SWAT); - SAGEM2 - High Impact Targeting system (HIT); - Etc.	Team meetings Stakeholder workshops to identify common goals, strategies and priorities Develop idealized decision process for optimizing the placement of AG BMPs A gap analysis of data, knowledge, models, & tools needed to achieve the idealized decision process Compile available data, models and decision tools needed to develop realized Optimized Decision Model (ODM) toolkit Link Saginaw Bay SWAT models to SAGEM2 to relate sub-watershed actions to bay-wide and local nearshore responses Retrospective assessment of GLRI projects and placement of BMPs (MAEAP) 2 sub-watersheds Apply Realized ODM to future placement of BMP projects in subwatersheds Presentation to Saginaw Bay stakeholders on outputs/outcomes of project and training on use of ODM	Project work plans and communication strategy Conceptual models linking conservation actions to riverine and nearshore ecological endpoints and associated ecosystem services and human values (Fig 3) An idealized decision process for optimizing the placement of AG BMPs Gap analysis summary of data, knowledge, model, & decision tools needed to support idealized decision process Realized ODM with an associated set of available data, models and decision tools (Tool Kit)(Fig 2) Watershed & sub-watershed priorities and online field scale tools for optimizing ecological and socioeconomic benefits to Riverine and Nearshore systems Proposed riverine and nearshore indicators and recommendations to existing monitoring programs to help improve the ODM and also assess the effectiveness of targeted conservation actions resulting from the application of the ODM	Strengthened relationships and communication among Saginaw Bay stakeholders Increase the likelihood that producers will participate in MAEAP to meet shared ecological and socioeconomic goals Shared priorities where conservation efforts will be most effective and will maximize the suite of benefits to ecosystem services to both riverine and nearshore systems	Increased stakeholder engagement in conservation More effective science-based policies and programs that foster strategic conservation to protect and restore ecological and associated socioeconomic conditions of Saginaw Bay and the Watershed Facilitate the development of agricultural ecosystem service market(s) that further incentivize strategic placement of BMPs	Shared ecological and socioeconomic vision and goals for Saginaw Bay and the Watershed with policies and programs in place to ensure these goals are being met in a sustainable manner.

GOAL: Develop integrated watershed & sub-watershed priorities and online decision tools for simultaneously optimizing ecological and socioeconomic benefits to Riverine and Nearshore systems

Appendix F. Data sources used in the Marxan optimization analysis.

Data Set	Units	Data Source	Data reference
NLCD Land Cover	Land cover classes	NLCD	U.S. Geological Survey, 20140331, NLCD 2011 Land Cover (2011 Edition): None None, U.S. Geological Survey, Sioux Falls, SD.
Stream catchments	NA	NHD Plus v2	U.S. Environmental Protection Agency (USEPA) and the U.S. Geological Survey (USGS), 2012, NHDPlus version 2; (http://www.horizon-systems.com/NHDPlus/NHDPlusV2_home.php)
Water intakes	# of people served	Digitized from NOAA Navigational Charts; modified based on communication with Michigan Department of Environmental Quality (MDEQ) staff	NOAA Seamless Raster Nautical Chart Web Service
			Berndt, J. MDEQ Active surface water intakes from Saginaw Bay. Data received on 9/9/2015
Recreational fishing effort	Mean annual angler hours	Michigan Department of Natural Resources (DNR)	Fielder, D.G., T.L. Kolb, T.M. Goniea, D.L. Wesander, and K.S. Schrouder. 2014. Fisheries of Saginaw Bay, Lake Huron 1986-2010. Michigan Department of Natural Resources, Fisheries Report 02, Lansing.
Commercial fishing harvest	Mean annual round pounds	Michigan Department of Natural Resources (DNR)	Fielder, D.G., T.L. Kolb, T.M. Goniea, D.L. Wesander, and K.S. Schrouder. 2014. Fisheries of Saginaw Bay, Lake Huron 1986-2010. Michigan Department of Natural Resources, Fisheries Report 02, Lansing.
eBird visits (2010-2014)	eBird "hotspots" # unique visits per day	Cornell Lab of Ornithology	Sullivan, B.L., C.L. Wood, M.J. Iliff, R.E. Bonney, D. Fink, and S. Kelling. 2009. eBird: a citizen-based bird observation network in the biological sciences. Biological Conservation 142: 2282-2292.
			eBird. 2015. eBird: An online database of bird distribution and abundance [web application]. eBird, Ithaca, New York. Available: http://www.ebird.org. (Accessed: February 2015).
Recreational boating	# of marina slips & parking spaces	Great Lakes Environmental Assessment and Mapping Project (GLEAM)	Allan, J.D., P.B. McIntyre, S.D.P. Smith, B.S. Halpern, G.L. Boyer, A. Buchsbaum, G.A. Burton, L.M. Campbell, W.L. Chadderton, J.J.H. Ciborowski, P.J. Doran, T. Eder, D.M. Infante, L.B. Johnson, C.A. Joseph, A.L. Marino, A. Prusevich, J.G. Read, J.B. Rose, E.S. RUTHERFORD, S.P. Sowa, and A.D. Steinman. Joint analysis of stressors and ecosystem services to enhance restoration effectiveness. Proceedings of the National Academy of Sciences 110:372-377
Beach use	# of Flickr photo uploads	Great Lakes Environmental Assessment and Mapping Project (GLEAM)	Allan, J.D., P.B. McIntyre, S.D.P. Smith, B.S. Halpern, G.L. Boyer, A. Buchsbaum, G.A. Burton, L.M. Campbell, W.L. Chadderton, J.J.H. Ciborowski, P.J. Doran, T. Eder, D.M. Infante, L.B. Johnson, C.A. Joseph, A.L. Marino, A. Prusevich, J.G. Read, J.B. Rose, E.S. RUTHERFORD, S.P. Sowa, and A.D. Steinman. Joint analysis of stressors and ecosystem services to enhance restoration effectiveness. Proceedings of the National Academy of Sciences 110:372-377
Coastal wetlands	Presence/absence	Great Lakes Coastal Wetland Inventory	Great Lakes Coastal Wetland Inventory dataset (2004) developed by the Great Lakes Coastal Consortium. (http://glc.org/projects/habitat/coastal-wetlands/)
Total Phosphorus	Concentration (µg/L)	Saginaw Bay Multiple Stressor	Stow, Craig A. "The Continuing Effects of Multiple Stressors in Saginaw Bay" Journal of Great Lakes Research; Volume 40

Data Set	Units	Data Source	Data reference
		Project	Supplement 1, Pages 1-204 (2014). [Digital Data]
Cyanobacteria density	Cell count (cells/L)	Saginaw Bay Multiple Stressor Project	Stow, Craig A. "The Continuing Effects of Multiple Stressors in Saginaw Bay" Journal of Great Lakes Research; Volume 40 Supplement 1, Pages 1-204 (2014). [Digital Data]
Spawning reef locations	Presence/absence	Great Lakes Aquatic Habitat Framework (GLAHF); DNR-IFR; Goodyear spawning atlas	Wang, L., C.M. Riseng, L.A. Mason, K.E. Wehrly, E.S. Rutherford, J.E. McKenna, Jr., C. Castiglione, C., L.B. Johnson, D.M. Infante, S. Sowa, M. Robertson, J. Schaeffer, M. Khoury, J. Gaiot, T. Hollenhorst, C. Brooks, and M. Coscarelli, 2015. A Hierarchical Spatial Classification and Database for Management, Research, and Policy Making: the Great Lakes Aquatic Habitat Framework. J. of Great Lakes Res, Accepted.
			Goodyear, C.S., Edsall, T.A., Ormsby Dempsey, D.M., Moss, G.D., and Polanski, P.E. 1982. Atlas of the spawning and nursery areas of Great Lakes fishes. 14 vols. U.S. Fish and Wildlife Service, Washington, DC. FWS/OBS-82/52
Chlorophyll-a	Concentration (µg/L)	Saginaw Bay Multiple Stressor Project	Stow, Craig A. "The Continuing Effects of Multiple Stressors in Saginaw Bay" Journal of Great Lakes Research; Volume 40 Supplement 1, Pages 1-204 (2014). [Digital Data]
Cladophora (SAV)	Presence/absence	Michigan Tech Research Institute (MTRI)	Brooks, C., Grimm, A., Shuchman, R., Sayers, M., & Jessee, N. (2015). A satellite-based multi-temporal assessment of the extent of nuisance Cladophora and related submerged aquatic vegetation for the Laurentian Great Lakes. Remote Sensing of Environment, 157, 58-71.
			Shuchman, R. A., Sayers, M. J., & Brooks, C. N. (2013). Mapping and monitoring the extent of submerged aquatic vegetation in the Laurentian Great Lakes with multi-scale satellite remote sensing. Journal of Great Lakes Research, 39(S1), 78-89.
Long Term Hydrologic Impact Assessment (LTHIA)	Total phosphorus load (lbs/yr)	Purdue University; Long Term Hydrologic Impact Assessment (LTHIA)	Lim, K.J., B. Engel, Y. Kim, B. Bhaduri, and J. Harbor. 2001. Development of the Long Term Hydrologic Impact Assessment (LTHIA) WWW Systems. In D.E Stott, R.H. Mohtar and G.C. Steinhardt (eds.) Sustaining the Global Farm: Selected Papers from the 10th International Soil Conservation Organization Meeting. May 24-29, 1999 at Purdue University and the USDA-ARS National Soil Erosion Research Laboratory.
High Impact Targeting (HIT)	Sediment load (tons/yr)	MSU IWR; High Impact Targeting (HIT)	O'Neil, G. 2010. Conservation Innovation Grant final report, Impact Targeting: Applying conservation tools to the worst areas for maximum sediment/nutrient reductions. http://www.hydra.iwr.msu.edu/iwr/cv/proposals/ publications/documents/2009/CIG-FinalReport.pdf. Ouyang, D., J. Bartholic, and J. Selegean. 2005. Assessing sediment loading from agricultural croplands in the Great Lakes Basin. The Journal of American Science 1(2):14-21. The Great Lakes Watershed Management System. Version 2.5. The Institute of Water Research – Michigan State University. Web. www.iwr.msu.edu/glwms. 11/1/2015.