

Implementation Plan for the Muskegon Lake Habitat Focus Area

National Oceanic and Atmospheric Administration

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I. Executive Summary

Muskegon Lake covering 4,232 acres on the west shoreline of Michigan's Lower Peninsula is the drowned river mouth of the Muskegon River and is connected to Lake Michigan by an Army Corps of Engineers-maintained, deep-draft navigation channel. The lake has long been a regional industrial center, including lumber, chemical and petrochemical companies, foundries, a coal-fired power plant, and a paper mill. This has contributed to the area's contemporary environmental challenges. Water quality concerns and habitat degradation from extensive shoreline filling, loss of wetland habitat, deposition of mill debris, untreated sewage, and sediment contamination from compounds such as heavy metals, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) led to its designation as an Area of Concern (AOC) under the Great Lakes Water Quality Agreement in 1985.

Despite its environmentally troubled history, Muskegon Lake was selected as one of NOAA's Habitat Focus Areas (HFA) because of the strong track record of federal, state, and local collaboration in the area; the long term research by federal and academic scientists that provides a comprehensive baseline of environmental data; and the active history of NOAA involvement in efforts to restore habitat for fish and wildlife. The agency's presence in the area is anchored around the NOAA Lake Michigan Field Station located right on the Muskegon navigation channel and the more than \$30 million NOAA provided in grants through the American Recovery and Restoration Act and the Great Lakes Restoration Initiative.

This Implementation Plan for Muskegon Lake incorporates a suite of specific projects to complete the work of an AOC remedial action plan to remove degraded benthos and the fish and wildlife-related beneficial use impairments (BUIs) leading to the delisting of the Muskegon Lake AOC. However, we do not see delisting of an AOC an end but rather a milestone in a process of stewardship that includes post-restoration management. Thus, the plan's key purpose is to encourage NOAA to invest in needed capacity to fill science information gaps to support ongoing and planned habitat restoration and management activities, in particular, monitoring of the effectiveness of the restoration work and its impact on Muskegon Lake, the Muskegon River and the Lake Michigan nearshore. To this end, we propose creating a framework for engagement in the area of restoration and research that will extend well beyond the Habitat Blueprint Plan's five-year timeframe and the delisting of the AOC. Long-term stewardship is essential to ensure that both restored areas are managed effectively post-restoration to prevent a return to degraded state and that remaining natural areas are adequately protected. The plan also considers that although NOAA is heavily invested in the Muskegon Lake region, the agency's work most often goes unrecognized. Therefore, we also propose that NOAA invest in a formal

effort to communicate NOAA accomplishments to the relevant stakeholders in the Muskegon Lake HFA.

This plan is intended to provide a strategic approach to guide NOAA **research, restoration, monitoring, and outreach** activities in the Muskegon Lake HFA. It outlines both ongoing habitat related efforts in Muskegon and recommendations to bring new NOAA resources and expertise to the Muskegon Lake HFA. If implemented, we expect increased collaboration across the diverse NOAA programs and initiatives focused on Muskegon Lake and an enhancement of NOAA's engagement as a partner agency within the wider Muskegon community. We propose to achieve this goal through the four following objectives:

- Continue to direct available NOAA and regional resources toward implementing all management actions necessary to delist Muskegon Lake as an AOC by 2018.
- Continue to direct available NOAA and regional resources towards the long-term stewardship of the Muskegon Lake ecosystem post-delisting.
- Develop new, and strengthen existing, research partnerships with academic, agency, and NGO scientists working on issues that affect Muskegon Lake.
- Develop and implement an outreach and communication strategy to effectively engage the Muskegon Lake stakeholder community.

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III. Foreword

A. What is Habitat Blueprint?

Habitat Blueprint is a nationwide initiative that provides a framework for the National Oceanic and Atmospheric Administration (NOAA) to better focus internal programs and expertise in addressing habitat loss and degradation. Habitat Blueprint is designed to help NOAA prioritize our habitat related projects and activities. Ultimately, this initiative will allow NOAA to maximize our impact in supporting healthy habitats that contribute to resilient and thriving coastal communities and economies.

Because healthy habitats sustain resilient and thriving marine and coastal resources, communities, and economies, NOAA leadership has established these core outcomes for the Habitat Blueprint initiative at the national level:

- Sustainable and abundant fish populations
- Recovered threatened and endangered species
- Protected coastal and marine areas and habitats at risk
- Resilient coastal communities
- Increased coastal/marine tourism, access, and recreation

B. What are Habitat Focus Areas?

An essential component of Habitat Blueprint is the selection of regional Habitat Focus Areas (HFAs). These HFAs are specific geographic sites where NOAA intends to direct agency resources, expertise and on-the-ground conservation efforts through the Habitat Blueprint initiative to maximize the impacts of NOAA's investments and benefits to coastal communities. Habitat Focus Areas were selected based on a number of criteria including:

- Restoration activities in the area which have the potential to demonstrate long-term impacts.
- There is a high likelihood of measurable progress towards Habitat Blueprint goals and objectives within a three to five year timeframe.
- There is strong potential for involvement of multiple NOAA programs and offices in the area.

Policy Drivers for Environmental Restoration in the Great Lakes

Great Lakes Water Quality Agreement Amended 2012 – is a binational agreement between Canada and the U.S. first signed in 1972 that provides direction for programs focused on restoring the chemical, physical, and biological integrity of the Great Lakes. It formalized the concept of Areas of Concern.

Great Lakes Restoration Initiative – is a multi-agency federal government effort designed to prioritize U.S. restoration in the Great Lakes. First launched in 2010, GLRI has provided over \$2.3 billion dollars that have helped support almost 3000 projects to date.

- Local stakeholders and leaders in the area are actively engaged in habitat restoration efforts.
- There are significant current or planned investments of NOAA resources (monetary, research, personnel, etc.) in the area.

For each HFA, NOAA and local partners will develop an Implementation Plan to guide NOAA’s habitat research, restoration, and conservation efforts in the area over a five-year time period. These plans will ultimately result in a place-based strategic approach to NOAA’s habitat research and restoration efforts, increased collaboration across NOAA programs, and enhanced interactions with external partners and local stakeholders. Focusing NOAA expertise and resources in the area would be consistent with and build upon regional habitat initiatives.

C. Habitat Blueprint in the Great Lakes Region

The Great Lakes are unique in their level of regional collaboration on place-based habitat restoration. With major restoration successes under the American Recovery and Reinvestment Act, the Great Lakes Restoration Initiative and the Great Lakes Water Quality Agreement, the NOAA Great Lakes region has a strong history of cooperative restoration partnerships. Habitat Blueprint presents a new opportunity to highlight the Great Lakes region as a leader in habitat restoration and showcase the strong cooperation between NOAA programs, external partners, and the local stakeholders. A core priority of Habitat Blueprint in the Great Lakes was selecting HFAs that build on and advance the restoration projects and partnerships in which NOAA already participates.



Map of Great Lakes Areas of Concern (AOC) as identified in the Binational Great Lakes Water Quality Agreement. Inset shows location of the Muskegon Lake AOC with respect to Lake Michigan and the entire basin.

D. Selection of Muskegon Lake as a Habitat Focus Area

Muskegon Lake is a 4,232 acre drowned river mouth of the Muskegon River located on the west shoreline of Michigan’s Lower Peninsula and is connected to Lake Michigan by an Army Corps

of Engineers-maintained, deep-draft navigation channel. Since the late 1800s, when Muskegon Lake was a center of the regional lumber industry, several other industries located to the area including chemical and petrochemical companies, foundries, a coal-fired power plant, and a paper mill. Muskegon's historic status as a regional industrial center contributed to the area's contemporary environmental challenges. Water quality concerns and habitat degradation have resulted from extensive shoreline filling, loss of wetland habitat, deposition of mill debris, untreated sewage, and sediment contamination from compounds such as heavy metals, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs).

This historic degradation led to Muskegon Lake being designated an Area of Concern (AOC) under the Great Lakes Water Quality Agreement in 1985. Because of this designation, Muskegon Lake has been subject to numerous coordinated habitat restoration and conservation efforts under a locally driven action plan.

Developed in partnership by the Michigan Department of Environmental Quality and the Muskegon Lake Watershed Partnership, the Remedial Action Plan¹ aims to bring the AOC to target environmental conditions set forth in the plan. Steinman et al. (2008) and Larsen et al. (2013) provide recent assessments of the state of the Muskegon Lake ecosystem. Once this is attained, the AOC is removed from the list of degraded "hot spots." The HFA encompasses the entire AOC, which includes Muskegon Lake, Bear Lake, portions of the Muskegon River, Ryerson Creek, Ruddiman Creek, Green Creek, Four Mile Creek, Bear Creek and the Bear Lake channel.

The Muskegon Lake HFA was selected because of the strong track record of federal, state, and local collaboration in the area, the availability of comprehensive baseline data (*e.g.*; Bhagat and Ruetz 2011; Dila and Biddanda 2015; Gillet and Steinman 2011; Nelson and Steinman 2013), and the active history of NOAA involvement in efforts to restore habitat for fish and wildlife that also benefit coastal communities. There also have been significant NOAA investments in and around Muskegon Lake such as the NOAA Lake Michigan Field Station located on the Muskegon navigation channel and more than \$30 million NOAA provided in grants through the American Recovery and Restoration Act and the Great Lakes Restoration Initiative.

NOAA's involvement in the area, both as a science and service provider, as well as our partnerships with local government and non-governmental entities, further promoted the selection of this area. The Muskegon Lake AOC is on track to be delisted as early as 2018.

¹ Michigan Department of Environmental Quality. 2011. Stage 2 Remedial Action Plan Muskegon Lake Area of Concern.

E. Vision for Habitat Blueprint in Muskegon Lake

Muskegon Lake has been subject to numerous coordinated habitat restoration and conservation projects under a locally driven action plan since its designation as an AOC in 1985. This Implementation Plan for Muskegon Lake presents a list of specific projects that would complete the work specified in the AOC remedial action plan to remove degraded benthos and the fish and wildlife-related beneficial use impairments (BUIs), which would lead to the delisting of the Muskegon Lake AOC. However, delisting of an AOC is not an end but rather a milestone in a process of stewardship that includes post-restoration management.

We propose here that NOAA invest in needed capacity to fill science information gaps to support ongoing and planned habitat restoration and management activities, in particular, monitoring of the effectiveness of the restoration work and its impact on Muskegon Lake, the Muskegon River and the Lake Michigan nearshore. To this end, we propose creating a framework for engagement in area restoration and research that will extend well beyond the originally intended Habitat Blueprint five-year timeframe. A long-term framework is necessary to ensure that restored areas are managed effectively post-restoration and that remaining natural areas are adequately protected. We also propose that NOAA invest in a formal communication and outreach effort to communicate NOAA accomplishments to the relevant stakeholders in the Muskegon Lake HFA.

The overarching goals of this plan are to provide a strategic approach to guide NOAA **research, restoration, monitoring, and outreach** activities in the Muskegon Lake HFA. The plan outlines NOAA's involvement in ongoing habitat related efforts in Muskegon and provides recommendations for future opportunities to bring new NOAA resources and expertise to bear in the Muskegon Lake HFA. The expected results include an increase in collaboration across diverse NOAA programs and initiatives and enhancement of NOAA's effectiveness as an engaged partner agency within the wider Muskegon community.

In order to achieve this goal, NOAA has established four objectives:

1. continue to direct available NOAA and regional resources toward implementing all management actions necessary to delist Muskegon Lake as an AOC by 2018;
2. continue to direct available NOAA and regional resources towards the long-term stewardship of the Muskegon Lake ecosystem post-delisting;
3. develop new, and strengthen existing, research partnerships with academic, agency, and NGO scientists working on issues that affect Muskegon Lake; and
4. develop and implement an outreach and communication strategy to effectively engage the Muskegon Lake stakeholder community.

IV. Introduction

A. Description of the Habitat Focus Area

Drowned river mouths are one of the most common estuary types found along the eastern coast of Lake Michigan, an area renowned as the largest assemblage of freshwater sand dunes in the world. Long ago, rivers carved deep valleys into the bluffs along the Great Lakes coastline. These ancient river valleys were then flooded or “drowned” with the rise in Great Lakes water levels, creating inland lakes (Albert 2003). Drowned river mouths support highly productive aquatic and wetland habitats. Historically, they also have served as natural harbors for commercial and recreational vessels, attracting significant manufacturing and commercial development (see Larsen et al 2013).

Muskegon Lake is a 4,232 acre drowned river mouth located where the Muskegon River drains into the east end of the lake. On the western end, the lake is connected to Lake Michigan by a maintained deep water navigation channel. The lake is 5.5 miles long and 2.5 miles wide with a maximum depth of 79 feet. The north and south shores of Muskegon Lake are different with respect to the historic development that occurred there.

Macrophyte surveys conducted in 1995 and 2005 by the Annis Water Resources Institute (AWRI) indicated that the historically debris-filled south shore (see next section) had very little aquatic

vegetation compared to the predominantly residential north shore of the lake, where the lake is shallower and the shoreline is more natural and less altered (Ogdahl and Steinman, 2014). The sediments of Muskegon Lake also were classified in a 2012 acoustic study where four distinct bottom types were determined including a silty-deep habitat, a shallower sandy habitat, a shallower silty-sandy habitat and a vegetated shallow habitat (Lozano and Birkett, 2012).



Aerial view of Muskegon Lake looking east from Lake Michigan in the foreground toward the Muskegon River where it enters the lake at the west end. (Image: Marge Beaver, www.photography-plus.com.)

The Muskegon River watershed which flows into Muskegon Lake stretches across the state of Michigan covering an area of 2,725 square miles with three sub-watersheds (Cedar Creek, Mosquito Creek, and Four Mile Creek) further divided into 40 distinct sub-basins.² In addition, several smaller tributaries feed into Muskegon Lake including Ryerson Creek, Ruddiman Creek, Green Creek, and the Bear Lake channel. The Muskegon Lake HFA is part of the largest freshwater dune system in the world and is home to a highly productive recreational fishery. See Appendix A for a list of key fish and wildlife populations impaired by loss of habitat in Muskegon Lake.



Picture of a sawmill built at the foot of Fourth St. at Muskegon Lake by L.G. Mason in 1865 (From the Collection of the Lakeshore Museum Center; Muskegon, Michigan)

B. Historical Development and Habitat Change in Muskegon

Muskegon hosts the largest natural deep water port in eastern Lake Michigan and the surrounding habitat has been shaped by historic development related to Great Lakes shipping and industry. In the 1800s, the lumber boom resulted in the first major wave of habitat disturbance to Muskegon Lake and its system of wetlands, marshes, riparian forests, and sand dunes. With easy access to Chicago lumber markets, Muskegon attracted thousands of lumber speculators and laborers from the East. At the height of the lumber era, 47 mills had been established on the shores of Muskegon Lake, upwards of 2,800 lumber schooners passed through the port annually, and the city of Muskegon boasted more millionaires per capita than any other town in the United States.³ While the Muskegon economy thrived, the environmental impacts of the lumber boom were less positive. Nearly the entire Muskegon River Watershed was clear cut and large portions of open water and wetlands around the lake were filled in with sawdust, slab wood, and other mill debris.

By the turn of the century, the lumber industry was in decline and the Muskegon economy began to transition to a manufacturing base. During World War II, Muskegon was a major center of production for aircraft and tank components and the site of several foundries. Muskegon's

² Muskegon Lake Watershed Management Plan developed by the Muskegon Area Storm Water Committee, 2005, 14 pp.

³ <http://www.co.muskegon.mi.us/history.htm> and http://www.mlive.com/news/muskegon/index.ssf/2014/09/recent_influx_of_salties_marks_1.html (accessed on December 19, 2014).

industrial growth brought with it continued hardening of the shoreline, filling and fragmentation of wetland habitat, declining water quality, and sediment contamination.⁴

By the late 1900s, nearly 800 acres of shallow water and wetland habitat in Muskegon Lake had been filled in with slab wood, saw dust, coal ash, broken concrete, asphalt, foundry slag, and scrap metal, reducing the lake from its original size.

Approximately 84 percent of the shoreline was hardened leading to loss of habitat, restricted public access and recreational opportunities, and changes in the hydrodynamics of the lake (see Steinman et al. 2008). These changes resulted in significant degradation of benthic communities in the lake, local fish and wildlife populations as well as their habitat. Negative health impacts associated with drinking water restrictions, undesirable algae, restrictions on fish and wildlife consumption and economic consequences for Muskegon residents were also documented in the remedial action plan for the AOC.



Satellite picture of Muskegon Lake, with Bear Lake just to the north. Areas in yellow depict sections of the shoreline that were filled in to accommodate industrial and commercial use. (Image: GVSU Annis Water Research Institute, Muskegon, Michigan)

C. Restoration Efforts

The first major step towards improving water quality and habitat in Muskegon Lake was taken in 1973 with the construction of the Muskegon County Wastewater Management System which diverted municipal and industrial wastewater away from the lake. In the 1980s the city of Muskegon and the surrounding county supported a number of shoreline brownfield redevelopment projects.

A new turning point for restoration efforts came in 1985 when Muskegon Lake was listed as an Area of Concern (AOC), one of 43 sites across the Great Lakes basin designated under the Great Lakes Water Quality Agreement (GLWQA) as having especially high levels of environmental damage. Muskegon Lake was selected as an AOC based on a number of specific impairments to beneficial uses of the area's natural resources. The AOC designation brought new regional and national attention to the environmental concerns in Muskegon Lake as well as new resources to address those concerns. In collaboration with several federal and state agencies, local

⁴ Muskegon Lake Area of Concern: Fish and Wildlife habitat Restoration and Beneficial use Impairment Removal Strategy, prepared by the Muskegon lake Watershed Partnership Habitat Committee, 2008, 4 pp.

stakeholders and leadership began developing a series of action plans to remove the beneficial use impairments (BUI). The Muskegon Lake Watershed Partnership (originally the Muskegon Lake Public Advisory Council) was established to identify targets and indicators for BUI removal and coordinate with local, state, and federal partners to develop and implement plans for achieving those targets (see Appendix B).

Habitat restoration in Muskegon Lake began in 2006 as part of the remediation work in Ruddiman Creek under the Great Lakes Legacy Act (GLLA). Working with the Michigan Department of Environmental Quality (MDEQ) Clean Michigan Initiative, the EPA provided \$10.6 million for the removal of 204,000 lbs of chromium, 126,000 lbs of lead, 2,800 lbs of cadmium, 320 lbs of PCBs and 260 lbs of benzo (a) pyrene. Additional contaminated sediments were removed from the Division Street Outfall area of Muskegon Lake under the GLLA in 2011. In this location, 41,000 cubic yards of sediment containing mercury and PAHs were removed, a sand cover was placed and aquatic habitat was restored. Remedial activities are underway at the former Zephyr Oil Refinery site near the mouth of the Muskegon River with additional cleanup currently being planned there and at the mouth of Ryerson Creek in Muskegon Lake.

Greats Lakes Legacy Act

Authorized by Congress in 2002, the GLLA targeted funding to address the issue of contaminated sediments in the Areas of Concern. During its implementation, \$338 million federal funds were leveraged by \$227 million from non-federal sponsors to remove over 4 million yds³ of sediments.

A second wave of habitat restoration in Muskegon Lake was initiated in 2008 with funds provided by NOAA's Restoration Center and further supported by two major federal actions, the American Recovery and Reinvestment Act (ARRA) and the Great Lakes Restoration Initiative (GLRI). NOAA's Restoration Center awarded several large habitat restoration grants. The first of the large grants was awarded through ARRA in partnership with the Great Lakes Commission and a local group, the West Michigan Shoreline Regional Development Commission (WMSRDC), to restore and protect fish and wildlife habitat within Muskegon Lake. The original goals included removing 182,862 metric tons of unnatural fill, and restoring 23.6 acres of aquatic habitat and 10,007 linear feet of shoreline at 10 sites in Muskegon Lake.

Other goals of the habitat restoration project were to improve public access to the shoreline, create and retain jobs during the project period, and achieve long-term socioeconomic benefits related to the improved habitat for fish and wildlife populations within Muskegon Lake, the Muskegon River and Lake Michigan. Ultimately, the initial goals of the restoration work were exceeded when 208,620 metric tons of unnatural fill were removed, and 32.3 acres of aquatic habitat and 13,073 linear feet of shoreline were restored at 15 sites. Employment created during the project was exceeded by 13,897 hours and a Grand Valley State University socioeconomic study funded under the grant concluded that the initial \$10 million investment in the restoration work will conservatively generate more than \$66 million in economic benefits over 10 years to

the local economy (Isely et al. 2011). This 6.6:1 return on investment has since been vetted by the professional economics community and has been used as a standard throughout the country.

In addition to the work completed in Muskegon Lake under the ARRA grant, NOAA also has funded through GLRI a range of highly successful restoration projects that have been completed or are in design through a partnership with the GLC and WMSRDC. Since 2011, GLRI funding has supported the design, engineering and implementation of a project to restore former celery farmland and reconnect the aquatic habitat to Bear Creek, and has completed a project to remove excessive mill debris from the lake. Other projects currently underway through the existing partnership are to locate and remove additional mill debris from the lake and to complete the design, engineering and implementation of restoration projects at Veteran's Memorial Parkway and the lower Muskegon River.

With four out of nine BUIs successfully removed or scheduled for removal, Muskegon Lake is expected to be officially delisted as an AOC by as early as 2018. Remediation and restoration of coastal and aquatic habitat in Muskegon Lake and the Muskegon River have not only improved the HFA's status as an AOC but also have led to tangible benefits for the local economy. The city of Muskegon and the surrounding region was hit hard by the Great Recession of 2009. Unemployment rates in Muskegon County peaked at 15.9 percent in July of 2009. This economic hit exacerbated the area's depressed economic activity that began earlier with the closing of the shoreline foundries and the paper mill. Additional economic hardship is likely with the closing of the coal power plant in 2016. Habitat related projects have brought major investments to Muskegon and lead to increased property values and recreational appeal as indicated in the Grand Valley State University economic study (see Isely et al. 2011).

D. Partner and Stakeholder Engagement

The high level of stakeholder engagement in habitat restoration and conservation was one of the primary motivations behind Muskegon's selection as an HFA. In order to take full advantage of this asset NOAA invited local leaders representing major stakeholder groups to participate in the Planning Team. Kathy Evans, the Environmental Planning Program Manager with the West Michigan Shoreline Regional Development Commission, represents the perspectives of local community organizations and provides an invaluable liaison to a range of local stakeholders. Al Steinman, Director of the Grand Valley State University Annis Water Resources Institute, represents the perspective of the local academic research community.

To further solicit stakeholder input early on during the implementation planning process, NOAA conducted a series of one-on-one interviews with stakeholders from economic development organizations, government agencies, nonprofit organizations, and education and research institutions. Stakeholders were asked a series of questions related to ongoing and planned habitat related projects, connections between habitat restoration and economic development,

opportunities and gaps in habitat projects or research, and the long-term vision for the Muskegon Lake HFA. In total, 40 individuals from 29 different organizations, agencies and businesses were interviewed during this process. The results of those interviews were summarized in a report (see Appendix C) which the Planning Team used to inform the goals, objectives, and recommendation outlined in the Muskegon Lake HFA Implementation Plan.

Throughout the implementation planning process, NOAA staff attended public meetings to discuss Habitat Blueprint and solicit public feedback from the Muskegon community. In particular, the Muskegon Lake Watershed Partnership hosted the Habitat Blueprint co-leads during one of their monthly meetings for an hour long discussion forum on HFAs and the Habitat Blueprint Initiative.

V. Goals and Objectives

Prior to the designation of Muskegon Lake as a HFA, NOAA was already heavily engaged with its partners to achieve the habitat related objectives identified under the current Muskegon lake AOC Remedial Action Plan, namely to **delist Muskegon as AOC**. In this Habitat Blueprint plan, NOAA reinforces its commitment to support its ongoing and planned projects focused on delisting, particularly since they are, and will be, implemented independently. However, rather than focus solely on activities that will occur regardless, the true goal of this plan is to set forth a strategy that will instead guide NOAA and local partners in **the long-term stewardship of Muskegon Lake**.

To achieve this goal, NOAA will look at directing efforts towards **creating a collaborative research framework** that will advance the Habitat Blueprint goals and objectives for the Muskegon Lake HFA by strengthening the value of ongoing and future restoration by measuring the success of past restoration activities. The framework will work at establishing new internal and external partnerships and providing additional resources and expertise where appropriate to advance the impact of existing partnerships and NOAA activities. Finally, NOAA will also look to develop ways to **communicate more effectively** to both stakeholders and NOAA leadership the impact of NOAA activities in achieving delisting and the need for supporting stewardship post-delisting.

To accomplish the plan's goals, we have established four main objectives as listed next:

A. Objective 1

Contribute to the delisting of the Muskegon Lake Area of Concern (AOC) by supporting implementation actions necessary to remove the four remaining beneficial use impairments as specified in the AOC's Remedial Action Plan:

- BUI 3: degradation of fish and wildlife populations
- BUI 6: degradation of benthos
- BUI 8: eutrophication and undesirable algae
- BUI 14: loss of fish and wildlife habitat

B. Objective 2

Continue to improve the ecosystem health of Muskegon Lake and its watershed following the delisting from AOC status by implementing or otherwise supporting work in the following areas:

- coastal resiliency
- socio-economic research (e.g., coastal tourism, public access, and recreation)
- ecosystem research

C. Objective 3

Develop and implement collaborative research partnerships with relevant academic institutions and resource agencies in order to carry on the work necessary to provide long-term stewardship of Muskegon Lake and its watershed during and after delisting as an AOC.

D. Objective 4

Develop and implement outreach and communication strategies to identify and incorporate research and restoration needs into future planning of the Muskegon Lake Watershed Management framework. In addition, continue to communicate NOAA's involvement in Muskegon Lake to local stakeholders through the utilization of the Lake Muskegon Field Station (LMFS), as a base for community engagement related to the long term stewardship of the Muskegon Lake ecosystem. The Lake Michigan Field Station could serve as a base for crafting a structured outreach and communications strategy for the LMFS.

VI. Current Activities

Muskegon Lake is often cited as a success story of local, state, and federal partners coming together to achieve major habitat improvements in a short time period. This success is due to the combination of many highly engaged partners and local expertise in the area, who have invested a great deal of time in strategic planning and coordination of projects. Our aim with Habitat Blueprint is not to distract from those efforts but rather to offer recommendations for how NOAA can be an even more effective and engaged partner in the Muskegon Lake HFA. In

particular, how NOAA can leverage its programs and resources to complement ongoing habitat related efforts to achieve delisting of the AOC and help advance other relevant GLRI initiatives.

Next, is a summary of ongoing NOAA-led or sponsored restoration, research, and outreach activities in the Muskegon Lake HFA that were deemed by the planning team to be contributing to the proposed goals and objectives of this plan. It is not intended to be an exhaustive account of ongoing efforts surrounding habitat relevant research, restoration, and outreach in Muskegon but rather an outline of the work that the Planning Team has determined to be most compatible with Habitat Blueprint objectives and timeline.

A. Restoration

The Muskegon Lake HFA Implementation Plan has identified several restoration projects in Muskegon Lake that have been or are planned to be implemented by NOAA's Restoration Center with funds provided by the GLRI. Implementation of the projects will be done through a regional partnership with the Great Lakes Commission and local sub recipients. Table 1 summarizes current restoration activities which have been completed in Muskegon Lake including future work, the primary partners involved in the project, the outcomes expected from the restoration, funding details, as well as the status of on-going restoration work.

1. Bear Creek Hydrologic Reconnection

One of the most pervasive threats to habitat quality within the HFA are high levels of phosphorus in Bear Lake and Bear Creek, which result in issues of eutrophication and undesirable algae. One possible source of this nutrient loading may be the phosphorous laden sediments of abandoned celery flats such as those near Bear Creek. This GLRI-funded project will remove phosphorus rich sediment and the existing dike to hydrologically reconnect the flooded celery flats with Bear Creek. This work includes the restoration of emergent and submerged wetland and streambank which will provide fish access to new nursery and spawning habitat as well as improve water quality. This will increase nutrient and sediment filtration in the watershed and help address one of the suspected root causes of eutrophication in Bear Lake. Completion of this project will result in measurable progress toward this plan's first objective of helping in the removal of the following BUIs: degradation of fish and wildlife populations, loss of fish and wildlife populations, and eutrophication and undesirable algae. This effort also addresses elements of the Habitat Blueprint goals in the Muskegon Lake HFA to increase coastal tourism, access and recreation leading to a resilient coastal community. The abandoned celery farms were purchased by Muskegon County through funding by the NOAA National Ocean Service AOC Land Acquisition Program with funds provided by the GLRI.

2. Mill Debris Removal

Thick layers of slab wood, sawdust and other mill debris were deposited along the shoreline and in open waters of Muskegon Lake during the 1800s lumber boom. Although a certain amount of woody debris is beneficial as habitat, excessive amounts of mill debris inhibits the health of benthic invertebrate communities and aquatic vegetation leading to negative impacts higher up the food chain. An important aspect of the project is to assess benthic communities in areas with varying amounts of woody debris to further refine at what level mill debris is harmful.

Monitoring of the benthic community before and after removal of the mill debris will also evaluate the success of the project. Successful mill debris removal projects already have been conducted in the Muskegon Lake HFA along the south side of the lake. This GLRI-funded project will remove mill debris from additional areas within Muskegon Lake where excessive amounts of mill debris have been identified. Local partners are currently investigating and mapping sites for future mill debris removal throughout the rest of the lake.

This effort will result in measurable progress toward the first objective of removing the following BUIs: degradation of benthos, loss of fish and wildlife habitat, and degradation of fish and wildlife populations.

3. Veteran's Memorial Park

Veteran's Memorial Park is a historic memorial to veterans of World War II. The pond, central to the park, was once connected to the Muskegon River. This project will reconnect the pond and restore wetlands in the park to the north branch of the Muskegon River, improve native plant buffer, stabilize shoreline with native vegetation, and construct woody fish habitat. The Muskegon River habitat restoration at Veteran's Memorial Park will improve habitat for fish and wildlife and re-establish fish passage for juvenile, adult and spawning life stages.

Completion of this project will result in measurable progress towards the plan's first objective for removing the following BUIs: degradation of fish and wildlife populations, loss of fish and wildlife habitat, and eutrophication and undesirable algae. This effort also addresses elements of the Habitat Blueprint goals in the Muskegon Lake HFA to increase coastal tourism, access, and recreation, leading to a resilient coastal community.

4. Lower Muskegon Habitat Restoration

The LMR project will remove the dike system from the former Bosma celery farm to restore a natural, native wetland habitat and floodplain by allowing hydrologic reconnection with the adjacent North Branch of the Muskegon River. Restoration will involve the removal of three dikes composed of artificial fill including broken concrete, soil and tree stumps. One dike separates the Muskegon River from the former, 95-acre floodplain wetland that is pumped and

farmed for hay and used for passive recreation. Two internal dikes will also be removed. Design work involves topographic surveys and soil/sediment sampling. Additionally, laboratory trials will be run to predict the probability of phosphorus release under artificially replicated 'wetted' conditions (i.e., to mimic hydrologic reconnection). A Phase I and Phase II environmental assessment and a Draft Due Care Plan were completed to assist with engineering and design for habitat restoration. The property was purchased by Muskegon County with funds from the NOS AOC Land Acquisition Program.

Completing this project will advance the plan's objective to remove the BUIs identified for this AOC including the degradation of fish and wildlife populations, loss of fish and wildlife habitat, and eutrophication and undesirable algae. This effort also addresses elements of the Habitat Blueprint goals in the Muskegon Lake HFA to increase coastal tourism, access and recreation as part of the Muskegon River segment of the Lake Michigan Water Trail, leading to a resilient coastal community.

Table 1. Active Restoration Projects in the Muskegon Lake Habitat Focus Area

Project Name	Project Outcomes	Primary Partners	Objectives* and Goals Addressed	Funding	Status
Bear Creek Hydrologic Reconnection	<ul style="list-style-type: none"> ◆ Excavate approximately 182,735 tons of phosphorus rich sediment; ◆ Remove 500 feet of existing dike to hydrologically reconnect the flooded celery flats with Bear Creek; ◆ Restoration of 36 acres of wetland; ◆ Restore 2,000 linear feet of streambank; ◆ Provide fish access to new nursery and spawning habitat as well as improved water quality. ◆ Measurable progress toward removing BUIs 3, 8, 14 	Great Lakes Commission, West Michigan Shoreline Regional Development Commission, United States Geological Survey, Grand Valley State University Annis Water Resources Institute, Muskegon Lake Watershed Partnership, Muskegon County and the NOAA Office for Coastal Management.	<p>Meets Objective 1.</p> <p>Addresses elements of the HFA IP goals to increase coastal tourism, access and recreation leading to a resilient coastal community.</p>	\$8 million GLRI funded	<p>In progress</p> <p>Project is complete with some monitoring and planting continuing.</p>
Mill Debris Removal	<ul style="list-style-type: none"> ◆ Investigation of Mill Debris removal locations with survey and probing; ◆ Development of design implementation plans; ◆ Removal of mill debris from identified locations totaling 12-20 acres of bottom land within Muskegon Lake; ◆ Evaluate the benthic community before and after mill debris removal; ◆ Use results to determine success; ◆ Inform future restoration work involving marine debris removal. ◆ Measurable progress toward removing BUIs 3, 6, 14 	Great Lakes Commission, West Michigan Shoreline Regional Development Commission, Grand Valley State University Annis Water Resources Institute, Muskegon Lake Watershed Partnership, Michigan Department of Natural Resources and Michigan Department of Environmental Quality.	Meets Objective 1.	\$4.7 million GLRI Funded (includes Veteran’s Memorial Park funds)	<p>In progress</p> <p>Local partners have mapped sites for future mill debris removal at three locations: Lakeshore Trail, Water Sports Park and Snug Harbor. Work to begin at Lakeshore Trail fall 2017 or spring 2018.</p>

Table 1. Active Restoration Projects in Muskegon Lake (continued)

<p>Veteran’s Memorial Park</p>	<ul style="list-style-type: none"> ◆ Restore 3,645 feet of shoreline with native vegetation; ◆ Restore 8.6 acres of wetland; ◆ Remove 19,000 tons of fill; ◆ Install fish habitat structures within the ponds; ◆ Hydrologically reconnect the ponds to the Muskegon River (North Branch). ◆ Measurable progress toward removing BUIs 3, 8, 14 	<p>Great Lakes Commission, West Michigan Shoreline Regional Development Commission, the Grand Valley State University Annis Water Resources Institute, Michigan Department of Environmental Quality, Muskegon Lake Watershed Partnership, Muskegon County and Michigan Department of Transportation.</p>	<p>Meets Objective 1. Addresses elements of the HFA IP to increase coastal tourism, access, and recreation, leading to a resilient coastal community.</p>	<p>\$4.7 million GLRI funded (includes Mill Debris Removal funds)</p>	<p>In Progress Final design plans have been completed and construction summer 2017.</p>
<p>Lower Muskegon Habitat Restoration</p>	<ul style="list-style-type: none"> ◆ Restoration of wetland hydrology; ◆ Restore 95 acres of floodplain wetland; ◆ Remove 4,385 linear feet of dike; ◆ Soften more than 3,000 feet of Muskegon River shoreline; ◆ Measurable progress toward removing BUIs 3, 8, 14 	<p>Great Lakes Commission, West Michigan Shoreline Regional Development Commission, Grand Valley State University Annis Water Resources Institute, Muskegon County, Muskegon Lake Watershed Partnership, Michigan Department of Environmental Quality, and Ducks Unlimited.</p>	<p>Meets Objective 1. Addresses elements of HFA IP to increase coastal tourism, access and recreation as part of the Muskegon River segment of the Lake Michigan Water Trail, leading to a resilient coastal community.</p>	<p>\$8 million GLRI funded</p>	<p>In progress Preliminary design plans underway with final plans and construction coordinated with an EPA led remediation project on the adjacent property.</p>

*HFA Objectives: 1.) direct available NOAA and regional resources toward implementing all management actions necessary to delist Muskegon Lake as an AOC by 2018; 2.) direct available NOAA and regional resources towards the long-term stewardship of the Muskegon Lake ecosystem post-delisting; 3.) develop new, and strengthen existing, research partnerships with academic, agency, and NGO scientists working on issues that affect Muskegon Lake; and 4.) develop and implement an outreach and communication strategy to effectively engage the Muskegon Lake stakeholder community.

B. Research

The restoration work outlined above is geared towards the removal of BUIs and reflects the path to delisting for the Muskegon Lake AOC. However, the lake, its watershed, and the adjacent nearshore waters of Lake Michigan are also subject to ongoing NOAA scientific research. The work is performed, often in collaboration, by NOAA, academic, and state scientists. Some of this research is relevant to Habitat Blueprint because it provides NOAA with a picture of the state of Muskegon Lake's ecosystem and acts as the baseline from which to monitor the effectiveness of the restoration work and evaluate progress towards delisting. A summary of this research is presented below.

1. Ecosystem Research

Muskegon is home port to NOAA's vessels in the Great Lakes as well as the site of the NOAA Lake Michigan Field Station. As a result, NOAA has a very active research presence in the area. Key NOAA research activities in the Muskegon Lake HFA related to the goals and objectives of Habitat Blueprint include:

Microbial Food Web in Changing Lake Michigan

This project measures biomass, taxonomic composition, and growth/loss rates for phytoplankton in the open waters of Southern Lake Michigan.

Fish Early Life History and Recruitment

NOAA researchers have examined salmon and walleye recruitment in the lower watershed, Muskegon Lake, and Lake Michigan. They also look at common stressors and models, such as land use change and climate change impacts.

Great Lakes Food Web Modeling

GLERL researchers are employing a variety of approaches including ATLANTIS ecosystem models, individual community based models, and incorporating uncertainty and socio-economic links. This is part of a larger effort to model food webs in several of the Great Lakes.

2. Monitoring and Assessment

NOAA also engages in extensive observation and monitoring throughout the Muskegon Lake HFA. In order to provide critical information to evaluate the current conditions and determine changes in the state of Lake Michigan and Muskegon Lake, NOAA has four long-term monitoring programs that regularly collect data throughout the ice-free season.

Lake Michigan Long-Term Research Program

Since the mid-1990s, NOAA scientists have conducted annual sampling of several parameters including temperature, chlorophyll, zooplankton, *Mysis*, mussels, and nutrients. Long-term research on planktivore diet and feeding ecology is also conducted as resources are available.

Muskegon Lake Long-term Monitoring Project

AWRI is a key partner in the Muskegon Lake Habitat Blueprint. The institute also has a long-term monitoring program in Muskegon Lake that complements NOAA's monitoring program of the Lake Michigan nearshore off Muskegon. Their program samples six sites in Muskegon Lake for water quality three times a year including measurements of nutrients, dissolved oxygen, temperature, light transmittance, and biological measurements on algal, benthic invertebrate (including dreissenid mussels), and fish communities. The focus of this monitoring program is on gathering data that meets the needs of both the community and the Muskegon AOC. Data are communicated to the public through an online dashboard. During the ice-free months AWRI also deploys a buoy in Muskegon Lake. A range of parameters is measured including temperature, oxygen, nutrients, light, pH, conductivity, algal pigments, bacterial pigments, and current speed and direction. Data from the buoy are open to the public in an interactive platform that allows users to plot variables over time and against other variables.

Real-time Coastal Observation Network

The Real-Time Coastal Observation Network (RECON) is a national network of low cost coastal buoys capable of seabed to sea-surface observations. These observation systems are deployed at numerous sites in and around the Great Lakes basin. Each system collects meteorological data and provides sub-surface measurements of chemical, biological, and physical parameters. The observation network is designed to provide real-time environmental data through the internet to state, federal, and university researchers, educators, and resource managers. These data are especially useful for ecosystem forecasting and model validation. The RECON network includes buoys and fixed observation sites in Muskegon Lake (AWRI operated and NOAA supported) and the nearshore of Lake Michigan (NOAA operated and supported) off Muskegon.

Mussel Watch

The Mussel Watch program helps inform delisting by using zebra mussels and quagga mussels to provide time-integrated observation of contamination in AOCs. Valuable information can be determined about the effectiveness of remediation and pollution regulation efforts from these mussels. Muskegon is a key site in the program.

C. Outreach and Education

The presence of NOAA's Lake Michigan Field Station (LMFS) in Muskegon offers a prime opportunity for engagement with the local community. The primary focus of the Field Station to this point has been to act as a home base for Great Lakes vessels and a center for scientific research. Field Station staff participates in special events in the community when possible and occasionally offer expertise and technical support to partner institutions in the HFA. For example, NOAA participates in the local Grand Haven Coast Guard Festival and the Muskegon Blessing of the Boats festival annually. NOAA vessels assist AWRI with buoy deployment in Muskegon Lake and recently have been coordinating with WMSRDC to supply technical support for studying mill debris in deep water areas of Muskegon Lake. In recent years, NOAA Great Lakes Regional Collaboration Team has made outreach in Muskegon a priority and in the summer of 2014 hosted a Cooperative Institute for Limnology and Ecosystem Research (CILER) summer fellow at LMFS.

While extremely valuable, these efforts are primarily the result of a few individual staff members taking special initiative. There is no coordinated outreach strategy guiding NOAA efforts in Muskegon, no personnel dedicated to communications and education, and very few resources available. Because of the smaller size of the local community and the highly engaged stakeholder base, the LMFS is uniquely positioned to become a major asset in the Muskegon community. A more organized and structured approach to outreach and education that utilizes the LMFS as a focal point for coordinated outreach would help advance NOAA's strategic goals and objectives and the more targeted goals and objectives of Habitat Blueprint in the Muskegon Lake HFA. More detailed recommendations are provided in the next section.

VII. Recommended Future Considerations

In addition to the ongoing NOAA and partner activities listed above, there are future efforts that have been identified as essential to achieving the goals of delisting Muskegon Lake as an AOC. While the bulk of these efforts are restoration projects supported through GLRI funding to NOAA and implemented through regional partnerships with local partners, there also are opportunities for NOAA to expand its portfolio of activities in Muskegon Lake to further the goals of the agency and this plan.

A. Restoration

1. Continued Support of AOC Delisting Efforts

A core focus of NOAA's planned habitat restoration activities in Muskegon Lake are to continue to support delisting of the Muskegon Lake AOC. A clear timeline of project implementation necessary to remove the BUIs and achieve delisting is already established in the Muskegon Lake Remedial Action Plan. NOAA will continue to provide technical expertise and financial support through the GLRI to the projects identified above in collaboration with the Great Lakes Commission, the West Michigan Shoreline Regional Development Commission, and numerous other partners.

2. New Opportunities with Changing Shoreline

A number of significant shoreline property changes will be taking place in the Muskegon Lake HFA over the next five years, namely the decommissioning of a large paper mill and coal fired power plant. Future ownership and use of these properties is still uncertain and will have a major impact on coastal habitat, public access and recreation, and commercial port development in the Muskegon Lake HFA. As part of the Habitat Blueprint implementation process, NOAA should seek to remain informed of future plans for these properties and explore opportunities to lend support and expertise to any habitat restoration activities included in those plans.

Another potential habitat restoration effort that may be undertaken in the next five years is the removal of industrial fill from Ruddiman Creek. A number of restoration efforts have already been completed in Ruddiman Creek as part of the series of projects funded through the Great Lakes Legacy Act. New woody habitat was installed and a vegetative buffer was established around Ruddiman Creek and in the Ruddiman Creek pond under the NOAA ARRA Habitat Restoration Project. At this stage, there is still a need to remove industrial fill and restore wetlands in Muskegon Lake at the mouth of the creek. However, this work is not listed as a priority project required for delisting the AOC. If a sediment removal project does move forward in the future there may be some potential for NOAA involvement in the subsequent habitat restoration work.

3. Coastal Resiliency and Green Infrastructure

One area that is an opportunity for NOAA engagement within the Muskegon Lake HFA is coastal resiliency. There are a number of innovative GLRI funded green infrastructure projects underway by state agencies and local stakeholders in Muskegon Lake to restore wetlands and implement best management practices for stormwater control and nutrient reduction in the Bear Creek Watershed.

We recommend that the Habitat Blueprint Implementation Team help build connections between NOAA resiliency expertise and programs and stakeholders and facilitate future NOAA involvement in coastal resiliency efforts in the Muskegon Lake HFA. This is also a key interest of the Michigan Coastal Zone Management Program, a state-NOAA partnership. NOAA support of comprehensive monitoring across the Muskegon Lake HFA also would contribute valuable information toward understanding the full impacts of changing temperatures and precipitation patterns on habitat conditions.

B. Research

1. Science Collaboration Framework

One of the major NOAA objectives of the Muskegon Lake Habitat Focus Area Implementation Plan is the provision of scientific research to fill critical information gaps in our understanding of the Muskegon Watershed ecosystem, including its connection to the adjacent Lake Michigan nearshore area. This objective can be accomplished more effectively through strategic partnerships with other research entities focused on Muskegon. A key activity for NOAA to achieve this objective under this plan is identifying the challenges to develop and maintain a coherent, interdisciplinary and integrated science program, as well as ideas to overcome these challenges. In particular, emphasis should be given to development and implementation frameworks that will promote collaboration and coordination between scientists, managers, and stakeholders.

Historically, NOAA research in the Muskegon Lake HFA has focused primarily on nearshore and offshore Lake Michigan. However, in recent years NOAA scientists have begun exploring opportunities for increased collaboration with other research projects in Muskegon Lake and Muskegon River. One of the most promising developments in this effort is the development of a Muskegon Science Collaborative. Spearheaded by NOAA and Grand Valley State's Annis Water Resources Institute, the Science Collaborative will bring together researchers from the various academic institutions, government agencies, and NGOs active in the Muskegon River, Muskegon Lake, and Lake Michigan. While the Muskegon River, Muskegon Lake, and Lake Michigan are part of a complex interconnected system, traditionally researchers have often focused their efforts on distinct parts of this system. The Science Collaborative seeks to connect these disparate research efforts by developing a coordinated long-term research partnership that links Muskegon River, Muskegon Lake, and nearshore/offshore Lake Michigan. As part of this effort, NOAA and AWRI organized a series of workshops that brought together researchers, resource managers, and stakeholders to share information about their work in the Muskegon River,

Muskegon Lake, and Lake Michigan and identify essential research gaps and priorities for this interconnected system. Summaries of these workshops are provided in appendices D and E.

The goals of this Science Collaborative are closely aligned with those of Habitat Blueprint in Muskegon, in particular bringing to managers timely, actionable, scientific information. By bringing together NOAA and academic researchers with resource managers and stakeholders to support an integrated approach to science planning in Muskegon, the Science Collaborative opens up opportunities for NOAA to develop new partnerships and strengthen existing partnerships. As an example, AWRI engages in a number of research and monitoring initiatives that closely align with NOAA efforts and priorities, including the study of macrophytes, microbenthic invertebrates, and fish populations to assess long-term restoration impacts, evolutionary response of aquatic invasive species to management, ecosystem response to hypoxia, the hydrology of coastal wetlands, and impacts of water level fluctuation on sediment-water nutrient release.

As such, we propose that NOAA continue to support the development of a Muskegon Science Collaborative by tracking its progress, providing personnel assistance in organizing workshops and deliverables, and working to connect new NOAA research efforts that emerge in the next five years to the Science Collaborative. The Habitat Blueprint Implementation Team also should seek to formalize a NOAA-AWRI led research collaboration framework over the next five years through a memorandum of understanding. As the other major science entity in Muskegon, AWRI research and monitoring activities are compatible with NOAA goals and priorities on several fronts. Coordinating NOAA and AWRI monitoring efforts across the Muskegon River, Muskegon Lake, and Lake Michigan will allow for a comprehensive watershed to nearshore monitoring strategy that leverages resources from both AWRI and NOAA. This will provide more comprehensive data on a broad suite of parameters and advance several research priorities. These include monitoring the long-term effects of habitat restoration, potential ecosystem impacts of climate change, and the development of a hydrodynamic model for Muskegon Lake.

2. Potential Research Topics

Ecosystem Research

A major research gap identified by both scientists and managers in the workshops held as part of the scoping process for the Science Collaborative is the lack of ecosystem models and predictive tools for Muskegon Lake. Of particular importance is a hydrodynamic model of the lake that could be coupled with an existing model of the Muskegon River Watershed. The coupled models will help both in understanding how Muskegon Lake functions as an ecosystem and in evaluating the effectiveness of the restoration which has been implemented. Muskegon Lake would serve as a test model for similar efforts in coastal zones elsewhere that are facing anthropogenic and climate change-driven stress. Other knowledge gaps and needs besides the hydrodynamic model include the impact of the Muskegon Lake plume on Lake Michigan, high frequency and event

response sampling, role of satellite remote sensing, and the need to expand work that occurs in Lake Michigan to Muskegon Lake.

Socio-Economic Research

Muskegon Lake is often cited as a prime example of the significant economic benefits that can result from habitat restoration. Remediation and restoration efforts along the shores of Muskegon Lake have significantly increased the recreational appeal of the area and led to high property values for the entire community. Past studies of these impacts conducted by Grand Valley State University economists, in collaboration with AWRI staff, frequently are cited both within the academic community and by elected officials as support for habitat restoration efforts across the Great Lakes. At the local level these studies have led to increased interests and participation from local landowners and businesses in restoration programs. There are significant opportunities for continued research into the social and economic aspects of habitat restoration work, and in particular the economic benefits of restoration in the Muskegon Lake HFA. Local partners and the general public understand and appreciate the value of this research. We recommend that the Implementation Team coordinate with researchers at partner institutions and within NOAA to support further investment in social science projects and integrated assessment efforts in the Muskegon Lake HFA.

C. Outreach and Education

Our primary recommendation for future NOAA outreach and education in the Muskegon Lake HFA is to utilize the LMFS as a base for community engagement related to the long term stewardship of the Muskegon Lake ecosystem. The Lake Michigan Field Station could serve as a base for crafting a structured outreach and communications strategy for the LMFS.

NOAA should focus on the following:

- Building connections across habitat related research, restoration and outreach efforts in the Muskegon Lake HFA through the formation of the Science Collaborative.
- Stay up-to-date on partner activities and provide support to local partners at the regional and local level relevant to habitat restoration work in the Muskegon Lake HFA. NOAA should also look for opportunities to contribute expertise and resources to these activities, and coordinate with the appropriate entities to take advantage of those opportunities.
- Providing support to the Science Collaborative as needed (*e.g.*, drafting documents, organizing workshops, and serving as the point of contact for participating researchers).
- Working with GLERL communications staff and LMFS staff to design a comprehensive strategy for communications and outreach at the LMFS and managing communication and outreach efforts for the LMFS according to the plan.
- Coordinating NOAA outreach and education efforts with the work of local partners.

- Quantifying the recreation and aesthetic amenity values for Muskegon Lake to complement, and build upon, the work done between 2009 and 2011. This includes coordinating the use of the traveling museum exhibit on mill debris impacts to the Great Lakes, created under a Preserve America Initiative grant, to educate the public on this issue.
- At the local level, outreach and education efforts in the Muskegon Lake HFA should build on the existing partnerships established through the LMFS and Habitat Blueprint. A likely opportunity is partnering with the AWRI vessel education program, and other national NOAA education programs. The LMFS is the oldest NOAA facility in the entire country so part of NOAA outreach efforts in the Muskegon Lake HFA should include preserving this historic landmark

VIII. Monitoring and Performance Measures

Many of the ongoing project activities described in this plan are part of established research and restoration funding programs. As such, they already are tracked through their established programmatic performance metrics. Therefore, it is proposed that NOAA use data gathered and conduct additional monitoring as needed to evaluate the overall impact of NOAA and our partners' activities on the social, economic, and environmental conditions of Muskegon Lake. Program evaluations will be performed, according to the reporting schedule required by NOAA for all HFAs. The evaluation will address the following general questions:

1. Did program activities contribute to the delisting of the Muskegon Lake AOC by
 - a. restoring or preserving critical habitat,
 - b. restoring or protecting fish and wildlife populations,
 - c. restoring or protecting the benthos, or
 - d. reducing eutrophication and undesirable algae?

2. Did program activities contribute to improving the social and economic environments of the Muskegon area by
 - a. increasing the resiliency of its coastal communities to future environmental stressors,
 - b. increasing recreational use of the natural environment, or
 - c. increasing the understanding of the interaction between socioeconomic factors and natural resource management?

Program assessment will use, as appropriate, performance metrics related to NOAA's Habitat Blueprint as well as other relevant Agency mandates (*i.e.*, Government Performance and Results Act) and program requirements (*i.e.*, GLRI, and GLWQA).

IX. Next Steps

HFAs are intended to focus NOAA expertise and resources in targeted sites to maximize the impacts of NOAA investments and the benefits to coastal resources and communities. In line with this goal, NOAA staff in the Great Lakes invested a great deal of time and effort in selecting regional sites that have the strongest potential for long-term NOAA involvement in habitat research and restoration and successful partnerships with area stakeholders. In order to take full advantage of that potential and maintain NOAA's reputation as an effective collaborator in the larger scope of Great Lakes habitat efforts, it is essential that we commit appropriate resources to implementing Habitat Blueprint for the Muskegon lake HFA.

With the location of a field station and the significant investments in habitat restoration in the Muskegon Lake HFA, it is especially important that NOAA develop and maintain strong connections with Muskegon stakeholders. Also, the time and effort necessary to effectively implement this plan and other long-term efforts after delisting of the AOC is beyond the capacity of existing personnel at the LMFS or any single NOAA Line Office staff currently involved in Muskegon work. As such, we recommend that NOAA perform a capacity assessment as it pertains to the Muskegon Lake HFA and consider adding or reassigning staff as appropriate, particularly with respect to increasing the level of partner and stakeholder engagement. We also recommend the formation of a Muskegon Lake Habitat Focus Area Implementation Team to oversee the implementation of this plan within its expected five year horizon and the implementation of a long-term strategy to continue NOAA's involvement in the environmental stewardship of the Muskegon Lake Ecosystem.

A NOAA-led standing implementation team is essential for the successful implementation of the Habitat Blueprint concept in Muskegon Lake, ensuring commitment of the NOAA Line Offices whose staff conduct or oversee work in the Muskegon area. It is important that the team include external partners so that NOAA activities are fully integrated with those of others also working to restore and ultimately conserve the ecosystems of Muskegon Lake, its watershed and Lake Michigan's nearshore and coastline.

Functions of the Muskegon Lake Habitat Focus Area Implementation Team would include:

- Overseeing the implementation of this plan within its five year horizon
- Supporting the development of a science collaboration framework to facilitate the integrations of research and restoration activities
- Setting long-term priorities for NOAA activities in Muskegon
- Providing guidance to the Habitat Blueprint Coordinator
- Reviewing and revising the Habitat Focus Area Implementation Plan as appropriate to ensure it achieves the plan's goals and objectives.

X. References Cited

Albert, D.A. *Between Land and Lake: Michigan's Great Lakes Coastal Wetlands*. Michigan State University: Michigan Natural Features Inventory, 2003, 15 pp.

Bhagat, Y., and C.R. Ruetz III. 2011. Temporal and fine-scale spatial variation in fish assemblage structure in a drowned river mouth system of Lake Michigan. *Transactions of the American Fisheries Society* 140:1429-1440.

Dila, D.K., and B.A. Biddanda. 2015. From land to lake: Contrasting microbial processes across a Great Lakes gradient of organic carbon and inorganic nutrient inventories. *Journal of Great Lakes Research*.

Gillett, N., and A.D. Steinman. 2011. An analysis of long-term phytoplankton dynamics in Muskegon Lake, a Great Lakes Area of Concern. *Journal of Great Lakes Research* 37: 335-342.

Isely, P., E.S. Isely, and C. Hause. 2011. Muskegon Lake Area of Concern Habitat Restoration Project: Socio Economic Assessment. On-line
Address: ftp://geoportal.wri.gvsu.edu/awri_website/final%20socio%20economic%202.pdf.

Larsen, J.H., A. Trebitz, A.D. Steinman, M. J. Wiley, M. Carlson-Mazur, V. Pebbles, H. Braun, and P. Seelbach. 2013. Great Lakes rivermouth ecosystems: scientific synthesis and management implications. *Journal of Great Lakes Research* 39: 513-524.

Lozano, S. and K. Birkett. 2012. Muskegon Lake Sediment Classification and Habitat Mapping. Unpublished NOAA GLERL Technical Memorandum. 26 pp.

Nelson, W., and A.D. Steinman. 2013. Changing trends in benthic communities in a coastal drowned river mouth lake, a Great Lakes Area of Concern. *Journal of Great Lakes Research* 39: 7-18.

Ogdahl, M.E., and A.D. Steinman. 2014. Factors influencing macrophyte growth and recovery following shoreline restoration activity. *Aquatic Botany* 120: 363-370.

Steinman, A.D., M. Ogdahl, R. Rediske, C.R. Ruetz III, B.A. Biddanda, and L. Nemeth. 2008. Current status and trends of Muskegon Lake, Michigan. *Journal of Great Lakes Research* 34:169-188.

XI. Appendices

A. List of Fish and Other Wildlife Impacted by Habitat Loss in Muskegon Lake

Appendix A. List of fish and other wildlife species known to be present in Muskegon and likely to be impacted by loss of habitat. (Data source: joint GLC and WMSRDC Muskegon Lake AOC Factsheet dated April 2010)

Fish	Reptiles	Amphibians	Birds	Mammals
Lake Sturgeon ¹	Spotted Turtle ¹	Bull Frog	Black-crowned Night Heron ²	Mink
White Bass	Wood Turtle ²	Green Frog	Sedge Wren	Otter
Muskellunge	Blanding's Turtle ²	Wood Frog	Common Moorhen	Muskrat
Northern Pike	Eastern Box Turtle ^{2,4}	Spring Peepers	American Bittern ²	Fox
Yellow Perch	Snapping Turtle	Northern Leopard Frog	Black Tern ^{2,4}	
Brown Trout	Painted Turtle	American Toad	Caspian Tern ¹	
Rainbow Trout	Musk Turtle	Salamander	Green Heron	
Black Crappie	Red-eared Slider	Skink	Great Blue Heron	
Bluegill	Map Turtle		Belted Kingfisher	
Walleye	Spiny Soft-shell Turtle		Spotted Sandpiper	
Smallmouth Bass			American Coot	
Largemouth Bass			Trumpeter Swan ¹	
Flathead Catfish			Peregrine Falcon ^{3,5}	
			Canvas backs	
			Blue-winged Teal	
			Lesser Scaup ⁶	

1 = Michigan Threatened, 2 = Michigan Special Concern, 3 = Michigan Endangered, 4 = USFWS Rare/Declining, 5 = Federal Endangered Federal Trust Species, 6 = Continental Concern

B. Muskegon Lake AOC Fish and Wildlife Habitat Projects and BUI Removal Target Criteria

APPENDIX B. Muskegon Lake AOC Fish and Wildlife Habitat Projects and BUI Removal Target Criteria - Muskegon Lake AOC Fish and Wildlife Habitat and BUI Removal Strategy, 2008

	579.1 - Muskegon Lake average elevation 577.7-581 - elevation used for emergent wetland <i>Fill criteria includes restored, upland transitional shoreline buffer</i>	Shoreline Softening linear feet	Emergent Wetland acres	Open Water Wetlands acres	Fill Removed/Improved acres
NOAA Coastal Marine and ARRA, 2009-2013		Achieved	Achieved	Achieved	Achieved
Grand Trunk Shoreline Wetland & Native Transitional Buffer		2034	1.8	1.5	3.8
Grand Trunk Marine Debris Open Water Aquatic Habitat				4.8	4.8
Grand Trunk Shoreline					0.1
South Branch of Muskegon River - Richards Park		395	0.0	0.0	8.6
Edgewater		64	0.02	0.01	0.1
Centerpointe Bay - Kirksey		1314	1.3	0.0	2.3
Michigan Steel and Hartshorn Marina/City of Muskegon		2,377	1.9	0.0	4.0
Hartshorn Marina Peninsula/City of Muskegon		1000	0.1	0.8	1.0
Ruddiman Creek Mouth Shoreline		1400	1.1		2.3
Ruddiman Creek Mouth Marine Debris				4.0	4.0
Amoco Peninsula		650	0.5	1.0	2.0
Heritage Landing Circle		615	0.3	0.1	0.7
Heritage Landing Scrap Bay		725	0.3	0.7	1.2
Ryerson Creek Fish Passage Wetland Corridor		271	0.4		0.6
GL&V Marine Debris and Shoreline		335	0.06	5.5	5.8
Lakeshore Bike Path		0	5.5		7.0
Heritage Landing II / Rotary Park		460	0.1		0.5
Pointe Marine		1,433	0.54		1.4
BUI Criteria Met Under NOAA ARRA		13,073.0	13.9	18.4	50.2
NOAA Great Lakes Restoration Habitat Partnership 2009-2012		Achieved	Achieved	Achieved	Achieved
Muskegon Lake Nature Preserve, Phragmites Control					3.6
Ruddiman Creek Upstream, Lagoon & Riparian Corridor		540	0.3	1.8	2.1
Ryerson Creek Fish Passage/Wetland/Riparian Corridor		1,975	2.7		3.6
BUI Criteria Met under NOAA Great Lakes Partnership		2,515.0	0.0	3.0	0.0
Great Lakes Legacy Act (GLLA)		Achieved	Achieved	Achieved	Achieved
YMCA at Division Street Outfall GLLA Site		1,068	0.8		1.0
BUI Criteria Met under EPA Great Lakes Legacy Act		1,068	0.8		1.0
Habitat Restored Prior to 2009 (est.)		Achieved	Achieved	Achieved	Achieved
GVSU-AWRI native landscape above seawall					1
LaFarge native landscape above seawall					0.5
Muskegon Lake Nature Preserve (MERES)			3		3
YMCA Shoreline at DSO Storm Outfall		300	0.3		0.3
Edgewater Street at Salorifous Property					0.1
BUI Criteria Met under Prior Restored		300	0	3.3	0
NOAA GLC WMSRDC Regional Partnership 2015-2018		Shoreline Softening Underway	Emergent Wetland Underway	Open Water Wetlands Underway	Fill Removed/Improved Underway
Bear Creek Hydrologic Reconnect/Wetland Restoration		2015.0		4.5	31.9
Muskegon River Veterans Park		2257.0		2.3	6.3
Mill Debris - 5 Sites:					
Upper Bear Lake, Site #5				2.0	2.0
Lakeshore Trail, Site #2				0.4	0.4
Block 58/Water Sports Park, Site #4				3.0	4.0
Snug Harbor, Site #3				2.0	2.0
GL&V, Site #1				3.0	3.0
BUI Criteria to be Met under Current NOAA GLC Regional Partnership		4272.0	11.8	44.6	20.6
NOAA GLC WMSRDC Regional Partnership Proposed, 2016-2018					
Lower Muskegon River Hydrologic Reconnection/Wetland Restoration		2739.0		33.5	3.3
BUI Criteria to be Met under Proposed NOAA GLC Regional Partnership		2739.0	33.5		3.3
Totals		23967.0	0.0	86.3	0.0
BUI Target Criteria / AOC Habitat Restoration Goals		24,086	73.11	19	123.1
Work Remaining to Reach AOC Goals (Once All Past, Current and Proposed Work Is Complete)		119.0	0.0	-13.2	0.0

C. Habitat Blueprint Muskegon Lake Stakeholder Interviews Summary of Results

(Note: A full version of the results of this survey including individual interviews is available upon request. Some content may need to be edited to protect the identity of the interviewees.)

HABITAT BLUEPRINT MUSKEGON LAKE

AUGUST 6, 2014



Photo Credit: Marge Beaver

STAKEHOLDER INTERVIEWS
SUMMARY OF RESULTS

INTERVIEW PROCESS

Over the course of two months we conducted interviews with 40 individuals from 29 different organizations, agencies, and businesses. These outreach efforts encompassed stakeholders from across the Muskegon Lake and Muskegon River watersheds, as well as representatives from the private, public, and nonprofit sectors. Stakeholders were identified through consultation with NOAA staff active in the Muskegon area and local partner organizations including the West Michigan Shoreline Regional Development Commission and Grand Valley State University’s Annis Water Resource Institute. [See **Appendix B** for a complete list of individuals interviewed and summary notes on their responses.]

PARTICIPATING STAKEHOLDER GROUPS

Education & Research	Nonprofit	Government	Economic Development
<ul style="list-style-type: none"> • Grand Valley State University • Lakeshore Museum Center • Michigan Great Lakes Stewardship Initiative • Michigan Sea Grant • Michigan State University • Muskegon Community College • Muskegon Environmental Education and Research Society • University of Michigan 	<ul style="list-style-type: none"> • Community Foundation for Muskegon County • Great Lakes Commission • Land Conservancy of Western Michigan • Muskegon Area Sustainability Coalition • Muskegon Conservation District • Muskegon Lake Watershed Partnership • Muskegon River Watershed Alliance • Community enCompass 	<ul style="list-style-type: none"> • Cedar Creek Township • City of Muskegon • Laketon Township • Muskegon County Sustainability Office • Muskegon Office of Planning, Zoning, and Recreation. • Michigan Department of Community Health • Michigan Department of Environmental Quality • Michigan Department of Natural Resources • City of North Muskegon 	<ul style="list-style-type: none"> • Downtown Development NOW • Muskegon Area First • Muskegon Lakeshore Chamber of Commerce • West Michigan Shoreline Regional Development Commission

QUESTIONS

Interview questions were tailored to fit the expertise and experience of each individual stakeholder but broadly covered five major topic areas 1) the ongoing and planned projects of the stakeholder group 2) ties between economic development and habitat restoration in Muskegon and the surrounding region 3) obstacles to effective habitat restoration and conservation 4) opportunities and gaps in ongoing projects or research 5) long-term vision for Muskegon Lake and the watershed.

ANALYSIS

Detailed notes were taken for each of the interviews. We then used those notes to identify trending ideas and topics that were mentioned by multiple stakeholders in relation to a theme. The resulting analysis gives a broad view of community concerns and priorities that will inform the design and implementation of Habitat Blueprint in Muskegon Lake. [See **Appendix A** for a more detailed breakdown of trending topics and how frequently they were mentioned during stakeholder interviews.]

RESULTS

ECONOMIC DEVELOPMENT & HABITAT

- City, county, and regional leadership highlighted maintaining Muskegon's status as a deep water port as their top priority.
- Many stakeholders talked about the need to strike a balance between recreational use and public access to the lake and commercial or industrial use of the lake. However, perceptions of what that balance should look like varied widely based on the individual stakeholder.
- Some stakeholders perceived a tension between the goals of port development and effective habitat restoration and conservation efforts. The most common concern among these individuals was that further industrial growth would perpetuate Muskegon's reputation as a polluted factory city.
- It was common for stakeholders, particularly those with connections to economic development organizations or government, to emphasize strong ties between the resources of the watershed and economic vitality in Muskegon.

OBSTACLES

- Often stakeholders felt that the predominance of private property along the lakefront increases uncertainty about future use and makes cohesive large scale planning for water resources difficult.
- Several stakeholders mentioned a lack of community awareness about green spaces along the lakefront, especially residents living further inland or in east Muskegon. In some cases, stakeholders were concerned that the image of Muskegon Lake as unsafe or polluted persists among these residents.
- Many stakeholders, both within and outside of local government, felt that leadership was supportive of habitat efforts undertaken by others. However, leadership clearly prioritized jobs and development over all other issues. The quick turnover of elected officials was also mentioned as an obstacle to engaging leadership in long-term restoration and conservation efforts.
- Stakeholders from every sector discussed the absence of a clear plan for land use in the watershed. They felt that land use decisions were inconsistent and lacking in direction. However, stakeholders were also skeptical about the usefulness of developing such a plan. They feared that the process of developing a plan would stir up unnecessary tension and conflict and would not result in significant long-term changes or concrete action.

OPPORTUNITIES/GAPS

- The opening up of the Cobb and SAPPI sites either for new development or for restoration projects was mentioned by nearly every individual interviewed as a major opportunity.
- Green infrastructure was also singled out as an issue of importance.
- A few stakeholders felt that too much focus has been placed on habitat projects in Muskegon Lake and important opportunities exist for future projects in the region's smaller tributaries including Ryerson Creek, Ruddiman Creek, and Four Mile Creek.

FUTURE VISION

- Many stakeholders had a vision of the Muskegon Lake watershed that emphasized mix use with a balance of commerce and recreation. Several individuals mentioned efforts to segregate these different

uses spatially with the east side of the lake dedicated to commercial use and the west side to recreation.

- Many stakeholders emphasized the need to continue restoration efforts in future years. Some were concerned that after delisting the community would slip back into undervaluing habitat resources.
- Others expressed the idea that Muskegon has a unique opportunity to reinvent itself and stand out as an example of what successful ecological restoration efforts can accomplish.

GOALS & OBJECTIVES

HABITAT BLUEPRINT PURPOSE

The Habitat Blueprint provides a forward-looking framework for NOAA to think and act strategically across programs and with partner organizations to address the growing challenge of coastal and marine habitat loss and degradation. We will increase the effectiveness of our efforts to improve habitat conditions for fisheries, and coastal and marine life, along with other economic, cultural, and environmental benefits our society needs and enjoys.

HABITAT BLUEPRINT VISION

Healthy habitats that sustain resilient and thriving marine and coastal resources, communities, and economies.

HABITAT BLUEPRINT OUTCOMES

- Sustainable and abundant fish populations
- Recovered threatened and endangered species
- Protected coastal and marine areas and habitats at risk
- Resilient coastal communities
- Increased coastal/marine tourism, access, and recreation

MUSKEGON LAKE HABITAT BLUEPRINT GOALS & OBJECTIVES

1. NOAA will make contributions to the measurable improvement of BUIs as specified in the area's Remedial Action Plan:
 - a. loss of fish and wildlife habitat
 - b. degradation of fish and wildlife populations
 - c. degradation of benthos
2. NOAA will take a coordinated, cross-line office approach to the implementation of projects and the demonstration of impacts in the following areas:
 - a. climate coastal resiliency technical support to implement priority actions identified by the Muskegon Lake Watershed Partnership.
 - b. resilient coastal communities
 - c. increased coastal tourism, access and recreation
 - d. socio-economic research

D. Lake Michigan – Muskegon Lake Connectivity Workshop [Executive Summary]

(Note: A full version of this report including meeting notes and presentations is available upon request.)

Lake Michigan – Muskegon Lake Connectivity Workshop

Report for Workshop I

April 28 – 29, 2014

Annis Water Resources Institute, Grand Valley State University
Muskegon, MI



Photo Credit: Marge Beaver, www.photography-plus.com



Executive Summary

The Lake Michigan-Muskegon Lake Connectivity workshops are a series of three workshops designed to develop a collaborative and coordinated long-term research program that links the watershed, Muskegon River, Muskegon Lake, and nearshore/offshore Lake Michigan (MUSkegon Interconnected eCosystem, MUSIC). Emphasis is on an integrated and interdisciplinary approach that includes hydrodynamics and hydrology, chemistry, biology and ecology, and socioeconomics across the MUSIC. The workshops are designed to bring together researchers, resource managers, and stakeholders to construct a framework with an overall goal to understand and predict the role of environmental stressors on ecosystem services, human health, and societal needs. The end product will be an Implementation Plan to guide this effort.

The first workshop, reported here, brought together governmental and academic researchers to inform one another about ongoing research, identify scientific needs, and begin the dialog for developing a long-term research program. The second workshop will bring together resource managers and stakeholders toward the general goals of information exchange, identifying management and public needs, and engaging participants in the process. The last workshop will provide a forum for discussion and for providing final comments. Following these workshops, a writing team will be established to draft the Implementation Plan.

This report summarizes the results of the first workshop, which was held on April 28-29, 2014 at the Annis Water Resources Institute Grand Valley State University (AWRI-GVSU) in Muskegon, MI. The workshop was organized and convened by NOAA Great Lakes Environmental Research Laboratory (GLERL) and AWRI-GVSU. Presentations of research were organized into 4 sessions: food web and fisheries; water quality and wetlands; hydrology, hydrodynamics, observing systems and remote sensing; and integrated assessment. Open discussion followed each session. There were also presentations on the NOAA Habitat Blueprint and the habitat restoration completed in Muskegon Lake. Muskegon Lake has recently been designated by NOAA as a Habitat Blueprint site. Discussion notes are provided following each session in the agenda, found in this report. All presentations are included in the appendix. Some key points from the workshop were:

- The generality of the MUSIC as a dynamic estuarine zone of intense productivity and biogeochemical cycling, lends itself as a test model for similar efforts in coastal zones elsewhere that are facing anthropogenic and climate change-driven stress.
- There is a rich history of long-term monitoring and research within MUSIC.
- Muskegon Lake is an Area of Concern (AOC) and represents a microcosm of Great Lakes restoration.
- Examples of some of the knowledge gaps and needs included: development of a hydrodynamic model (biophysical model) for Muskegon Lake that is coupled with the river and Lake Michigan, impact of Muskegon Lake plume on Lake Michigan, high frequency and event response sampling, role of satellite remote sensing, need to expand work that occurs in Lake Michigan to Muskegon Lake.
- Identified a strong need for clear and regular interactive communications with stakeholders and resource managers.
- Challenges to develop and maintain a coherent, interdisciplinary and integrated program were identified and ideas were presented to overcome these challenges.
- Need to develop a conceptual framework to guide the remaining workshops and the program, and to facilitate integration and communication amongst group members.

APPENDIX A

Theme	Comment	Frequency	
Economic Development & Habitat	Maintaining Muskegon's status as a deep water port is a major priority for city, county, and regional leadership	8	
	Would like to see a balance between recreational use and commercial use in Muskegon Lake.	7	
	See very close ties between habitat quality and economic growth in Muskegon.	6	
	Saw there being tension between port development and effective restoration. Expressed concerns that increased commercial development would perpetuate Muskegon's reputation as a contaminated watershed.	5	
	Would prefer that recreation and green space be prioritized over more development	5	
	Need to attract more businesses that rely heavily on water in their production process to increase use of the wastewater treatment plant	4	
	Need for more connections between the downtown and the lakefront.	4	
	Socioeconomic concerns and income inequality need to be addressed more directly in both environmental efforts and economic development plans.	2	
	Obstacles	The predominance of private property increases uncertainty about plans for lakefront land use and makes public access to water resources a challenge.	9
		Lack of community awareness of green spaces along the lakefront especially among those residents that live further inland. A need for more education and outreach among the general public. Safety concerns are also a barrier to use. Often people still fear pollution and poor water quality and many people in the African American community don't know how to swim.	7
Low involvement from local government in habitat related projects. They generally leave that work to community organizations that are established in the field. Leadership is supportive once restoration projects are proposed but they are primarily reactionary rather than active partners. Part of the problem is a two year term limit that results in a quick turnover in leadership. Continually the trend is to prioritize jobs and development over all else.		5	
There is no real cohesive plan or vision for land use along the waterfront. No clear direction or consistency in decisions on land use. There is a City of Muskegon plan but it is vague at best. Wider regional development plans often don't include a clear vision for the water front		5	
Large scale problems with hydrology upstream in the Muskegon River contribute to sediment concerns and erosion further downstream.		3	
Opportunities /Gaps		Expressed concern about future development plans for the SAPPI and Cobb sites.	15
		Need for more work on green infrastructure. They understand the gaps and opportunities but little concrete action is being taken.	4
		Need for more restoration efforts in some of the smaller tributaries in the area such as Ryerson creek, Ruddiman Creek, 4 mile Creek.	4
		Need for more valuation of health impacts of restoration.	2
		Need for more understanding of decision making and social science research in area as well as forming linkages between natural science and social science research. Integrated view of costs and benefits in management/restoration efforts.	2
Future Vision	Need for more data and focus on climate resiliency.	2	
	Balanced mixed use with industry on the east side of the lake and recreation and residential on the west side.	7	
	Blue infrastructure as a community asset.	5	
	Emphasis on continuing restoration work. A fear that over time especially post AOC delisting the community will forget all of the effort invested in restoration and begin to slip back into devaluing the natural resources.	3	
	Continue to develop the greenway around the lake.	3	
	Muskegon has an opportunity to reinvent itself and remake its reputation. Muskegon as the "poster child" for successful ecological restoration.	2	

E. Muskegon Research and Restoration Connectivity Workshop [Executive Summary]

(Note: A full version of this report including meeting notes, presentations, and participant survey is available upon request.)

Muskegon Research and Restoration Connectivity Workshop

Summary Report

November 13, 2014

Grand Valley State University Annis Water Resources Institute
Muskegon, MI



Photo Credit: Marge Beaver, www.photography-plus.com



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Executive Summary

The Lake Michigan-Muskegon Lake Connectivity workshops are a series of three workshops designed to develop a collaborative and coordinated long-term research program that links the watershed, Muskegon River, Muskegon Lake, and nearshore/offshore Lake Michigan (MUSkegon Interconnected eCosystem, MUSIC). Emphasis is on an integrated and interdisciplinary approach that includes hydrodynamics and hydrology, chemistry, biology and ecology, and socioeconomics across the MUSIC. The workshops are designed to bring together researchers, resource managers, and stakeholders to construct a framework with an overall goal to understand and predict the role of environmental stressors on ecosystem services, human health, and societal needs.

This summary focuses on Workshop II, which brought together resource managers, restoration specialists, and stakeholders from across the MUSIC. Workshop II was designed to ensure that the long-term research program engages diverse stakeholders and is responsive to the needs and priorities of those working on the ground in the MUSIC in habitat restoration and resource management.

Workshop II was held on November 13, 2014 at Grand Valley State University's Annis Water Resources Institute (AWRI) in Muskegon, MI. The workshop was organized and convened by AWRI, the NOAA Great Lakes Environmental Research Laboratory (GLERL), and the West Michigan Shoreline Regional Development Commission (WMSRDC). Representatives from federal, state, and local resource management and restoration organizations presented information on their unique management and restoration priorities and the research that guides management decisions and project design. These presentations were followed by an open discussion on what research is needed to advance management and restoration priorities in the MUSIC. Further discussions evaluated the state of communications between researchers, resource managers, and restoration specialists in the MUSIC in order to identify barriers to communication, exchange information on priority projects, and discuss options for future improvements in face-to-face and virtual communication pathways. There was also a presentation summarizing results from a pre-workshop survey of both researchers and management/restoration specialists working in the MUSIC.

Overall, workshop participants felt that the priorities of researchers, restoration specialists, and resource managers working in the MUSIC are well matched but that there is a need for improved communication between these groups. A number of potential actions were proposed. However, addressing barriers to communication in a manner that uses resources and time efficiently and avoids redundancy continues to present a major challenge. Particularly in the case of the proposed three dimensional hydrodynamic model for the MUSIC there needs to be an effort on the part of both researchers and management/restoration specialists to engage in two-way communication as a means of ensuring that 1) the model's design and outputs are relevant to habitat restoration and resource management efforts; and 2) stakeholders understand the inherent value of the model.

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