Muskegon Lake
Ruddiman Creek
Ecological Restoration Master Plan

Muskegon Lake, Ruddiman Creek and nearby shoreline

Ecological Restoration Master Plan

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Glossary

area of concern (AOC) A geographic area that fails to meet the objectives of the Great Lakes Water Quality Agreement [between Canada and the United States] and where such failure has caused or is likely to cause impairment of beneficial uses of the area's ability to support aquatic life.

aquatic Living or growing in or on water.

aquatic nuisance species Water-borne plants or animals that pose a threat to humans, agriculture, fisheries, and/or wildlife resources.

assemblage A group of species found together in a particular area. An assemblage differs from a community in that an assemblage may not be a repeating pattern of species found together in similar habitat conditions.

base flow The sustained dry-weather, flow of a stream.

benthic Pertaining to the bottom of a water body.

benthos Community of organisms living on the bottom

beneficial use impairment (BUI) A positive or valued trait of an area that is compromised by current ecological conditions.

best management practice (BMP) An agreed-upon set of actions designed to reduce negative consequences and optimize benefits from a certain activity. For example, stormwater BMPs are designed to reduce water quality degradation from uncontrolled runoff. BMPs include the structural and non-structural controls and operation and maintenance procedures.

cadmium A naturally occurring inorganic element which is frequently generated as a byproduct from mining and smelting operations. It is identified in the Lake Michigan LaMP as one of 11 pollutants of concern.

chromium A naturally occurring inorganic element. It is identified in the Lake Michigan LaMP as one of 11 pollutants of concern and has many uses in industry, such as in steel making and metal finishing.

community An association of interacting organisms occupying a particular area. A community typically demonstrates a repeating pattern of associations in similar environmental conditions.

conservation target Rare or common plant or animal species, plant associations, aquatic habitats, or ecological systems of concern on which conservation activities are focused.

corridor A connection between two patches of habitat that permits the movement of plant and animal species between the otherwise isolated patches.

delisting Removal of the AOC designation for a location after it has been sufficiently restored. Delisting requires removing the BUI targets.

ecological function A role or service provided to the ecosystem. For example, primary production is an ecological function provided by green plants as they turn solar energy (an ecological component) into chemical energy (another ecological component).

ecological process Describes changes in, actions by, or interactions between ecological components. For example, erosion is an ecological process that carries sediment or soil from one location to another.

ecological restoration The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.

ecosystem A system made up of all the organisms in a given area together with the non-living components (e.g., climate, geology, etc.) and the interactions between them. A group of organism associations that (1) occur together on the landscape; (2) are linked by ecological processes, underlying environmental features (e.g., soils, geology, topography), or environmental gradients (e.g., elevation, precipitation, temperature); and (3) form a robust, cohesive, and distinguishable unit on the ground.

ecoregion A geographic area defined by a shared set of physical and ecological characteristics including climate, geology, and vegetation.

ecotype A population or group of populations distinguished by morphological and/or physiological characteristics, interfertile with other ecotypes of the same species but usually prevented from interbreeding by ecological barriers.

emergent Used to describe vegetation that is rooted on the bottom of a river or lake and has leaves that float on the surface or protrude above the water.

exotic species Species found beyond their natural ranges or natural zone of potential dispersal. Also referred to as non-native or non-indigenous species.

geographic information system (GIS) Geographic Information System; a computer-based system used to store and manipulate geographic information. A GIS is designed for the collection, storage, and analysis of objects and data where geographic location is an important characteristic or is critical to the analysis.

Great Lakes Legacy Act This act, adopted in 2002, provides funding to take the necessary steps to clean up contaminated sediment in "Areas of Concern located wholly or partially in the United States," including specific funding designated for public outreach and research components.

Great Lakes National Program Office (GLNPO) A federal EPA office created in 1978 to oversee the U.S. fulfillment of its obligations under the Great Lakes Water Quality Agreement with Canada.

Great Lakes Water Quality Agreement An international agreement between the U.S. and Canada signed in 1978 and amended in 1987. Its purpose is to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin ecosystem. The Agreement seeks to restore and maintain full beneficial uses of the Great Lakes system.

habitat An identifiable area where a particular species or group of species successfully live; a given habitat can be described by either physical features (such as water depth) or biological features (such as plant associations) or a combination of both.

herpetofauna Reptiles and amphibians.

International Joint Commission (IJC) An international organization formed by Canada and the United States in 1909 as a result of the Boundary Waters Treaty to assist in preventing disputes and resolving issues involving all water bodies shared by the U.S. and Canada and to make recommendations about their management, particularly water quality issues and the regulation of water levels.

lacustrine Pertaining to, or living in, lakes or ponds.

Lakewide Management Plan (LaMP) A binational program for the Great Lakes that provides a process for coordinating and prioritizing activities designed to reduce loadings of critical pollutants. The emphasis is on identifying the major sources of these pollutants and concentrating regulatory efforts where they will have the most impact.

lead A heavy metal that can be hazardous to health if inhaled or swallowed. Lead can bioaccumulate in fish and wildlife.

macroinvertebrates Animals without backbones and larger than ½ millimeter (the size of a pencil dot). Examples include crayfish, mollusks, aquatic worms and the immature forms of aquatic insects such as stonefly and mayfly nymphs. They are often a component of benthos.

palustrine Pertaining to, or living in, wet or marshy habitats.

polychlorinated biphenyl (PCB) Polychlorinated biphenyls; PCBs are a group of over 200 nonflammable compounds formerly used in heating and cooling equipment, electrical insulation, hydraulic and lubricating fluids, and various inks, adhesives, and paints. These compounds are highly toxic to aquatic life, persist in the environment for

long periods of time, and are bioaccumulative. PCBs are suspected carcinogens and are linked to infant development problems.

pre-settlement Pre-settlement is not a precise term, but it is widely used and understood to describe conditions before large-scale human alterations of the landscape. This term is commonly used to describe vegetation maps derived from land surveys conducted under the jurisdiction of the United States Public Land Survey. In many areas, it is believed Native Americans influenced vegetation structure and composition through setting fires. And some of the surveys were not complete before Euro-Americans had settled and also started to alter the landscape.

phytoremediation The use of plants to take up chemicals, and binding some of the material in an inert form with the plant, or converting some of it to other substances, and possibly breaking it down into the normal end product of a plant's chemical processes.

remedial action plan (RAP) A plan developed and implemented to protect and restore beneficial uses in Great Lakes areas of concern, as required under the Great Lakes Water Quality Agreement. Often referred to as a RAP, its purpose is to restore all beneficial uses to the area.

remediate To improve or restore a contaminated site involving enclosure, encapsulation, capping or removal of the material.

riverine Formed by a river or situated along the banks of a river

submerged aquatic vegetation (SAV) Rooted aquatic vascular plants that grow under the water surface.

seiche A tidal-like rise and fall of water in large lakes, which occurs after water is piled up on one side of the lake by wind or high barometric pressure; when this force diminishes, the water rocks back and forth from one shore to the other with decreasing amplitude.

species of greatest conservation need (SGCN) Aquatic and terrestrial wildlife species with small or declining populations or other characteristics that make them vulnerable.

stress Processes or events, both direct and indirect, that cause negative ecological or physiological impacts on conservation targets.

succession Generally predictable and orderly changes in composition and structure of an ecological community

target: See conservation target.

terrestrial Living or growing on land.

threat Factors that have a direct and negative impact on the health of conservation targets or that negatively impact the ecological systems and processes that support and maintain the conservation targets.

total maximum daily load (TMDL) An allocation of the maximum amount of a pollutant that may be introduced into a water body and still assure attainment and maintenance of water quality standards.

tributary A stream that flows into a larger body of water; larger stream, river, lake or ocean.

turbidity Cloudiness or reduced clarity of water due to the presence of suspended matter.

United States Environmental Protection Agency (U.S. EPA) Federal agency whose primary goal is to prevent or mitigate the adverse impacts of pollution on human health and the environment.

United States Fish and Wildlife Service (USFWS) Federal agency whose mission is to conserve, protect, and enhance the Nation's fish and wildlife and their habitats for the continuing benefit of people.

viability The overall health of a conservation target in a given location and it ability to persist over a long period of time.

watershed An area of land that drains into a lake, bay, river system or other body of water.

Biohabitats, Inc. and the United States Environmental Protection Agency, Great Lakes National Program Office, in collaboration with the multiple stakeholders have created a restoration master plan for Ruddiman Creek and the nearby shoreline of Muskegon Lake, in Muskegon Michigan. This ecological restoration master plan provides a suite of restoration actions and management recommendations for the restoration of fish, wildlife, benthos and wetland habitats; and human uses in the project area. Guiding principles of the restoration project include building resiliency and diversity of natural habitats, establishing reproducing populations of indigenous species, using reference ecosystems, ecologically-compatible recreation, protecting ecologically-sensitive areas, and reducing threats to ecosystems, while addressing Beneficial Use Impairments (BUIs) in the project area. This plan is the outline for addressing Beneficial Use Impairments within the project area and can be used as a template for restoring degraded habitats in the Muskegon Area of Concern as well as the Great Lakes region.

The Ruddiman Creek and adjacent Muskegon Lake shoreline project area, is located near the western boundary of Michigan, at the mouth of the Muskegon River in Muskegon County. Muskegon Lake is one of several drowned river mouths scattered along the Lake Michigan shoreline. Ruddiman Creek flows north into Muskegon Lake, which flows west, through sand dunes, into Lake Michigan. Ruddiman Creek and Muskegon Lake are within the Southern Lower Peninsula ecoregion. This region is characterized by dunes, rolling hills and flat lake plains. The climate is generally moderated by the large water mass of Lake Michigan. It influences local temperature during much of the year and delivers precipitation during the Spring and Fall.

In the last 200 years, the landscape in and around Muskegon Lake has changed dramatically at the hand of humans. Natural Resource extraction and industrial activity relied on the local environment to support the economy. The industrial legacy left Muskegon Lake with degraded ecological conditions due to the accumulation of industrial wastes associated with foundries, metal finishing facilities, petrochemical production and shipping. As a result, in 1985 the international Great Lakes Water Quality Board designated Muskegon Lake and its tributaries as one of 42 Great Lakes Areas of Concern (AOC); which identified the area as a major source of pollution in the Great Lakes. In an effort to coordinate multiple restoration efforts throughout the Muskegon Lake AOC, a Remedial Action Plan (RAP) was written in 1987 and subsequently updated in 1994 and 2002. The RAP identified the Ruddiman Creek watershed as a high priority remediation and restoration site, due to historic sediment contamination, fish and wildlife habitat loss and degradation of fish and wildlife populations.

Remediation Efforts

In 2002 the Great Lakes Legacy Act was signed into law to provide funding for remediation of contaminated sediment in AOCs. The implementation of the Legacy Act is coordinated by the United States Environmental Protection Agency's, Great Lakes National Program Office (GLNPO). From 2005 to 2006, through the efforts of the local community and local officials, GLNPO, and the Michigan Department of Environmental Quality (MDEQ), approximately 90,000 cubic yards of contaminated sediment were removed from the mainstem of Ruddiman Creek, and the Ruddiman Lagoon.

MDEQ is responsible for monitoring the site by conducting sediment analyses and toxicity testing on samples randomly collected from various dredge sites to determine the short- and long-term success of the project.

The three remediation objectives were:

- Reduce Relative Risks to Humans, Wildlife, and Aquatic Life in the AOC: Remove contaminated sediment.
- Restore Beneficial Uses: Improve the condition and stability of the aquatic habitat, particularly for benthos.
- Source Control: Reduce further contamination of Ruddiman Creek

Although the major source of contamination has been removed from Ruddiman Creek, the stream corridor and nearby Muskegon Lake shoreline still suffer from habitat loss, and degraded fish and wildlife populations. Signs along the creek and its tributaries warn against contact with the water due to high levels of bacteria. Furthermore, past and recent fish and macroinvertebrate inventories indicate poor communities and aquatic habitat. Though the project area has significant ecological problems; it also includes three of the six natural areas identified along the Muskegon Lake south shoreline (Day and Associates, 1995). Thus, restoration efforts will build on existing fragments of somewhat healthy and functional habitat. Another supportive element is that local interest and concern is strong and residents support the restoration efforts within the project area.

This Ecological Restoration Master Plan has been created to help guide and focus the local restoration efforts so that the area can reach its full ecological potential. In doing so, the major Beneficial Use Impairments (BUIs) of the site will be addressed, while creating a more ecologically viable and appealing landscape.

Muskegon Lake Beneficial Use Impairments (BUIs)

The international Great Lakes Water Quality Agreement listed 14 BUIs associated with the Great Lakes AOCs, and nine of them were identified for the Muskegon Lake AOC. The BUIs in bold type are specifically related to the Ruddiman Creek and Nearby Shoreline project area.

1. Restrictions on human consumption of fish and wildlife
2. **Loss of fish and wildlife habitat**

3. **Degradation of fish and wildlife populations**
4. **Degradation of benthos** (bottom dwelling organisms)
5. Restrictions on dredging
6. Degradation of aesthetics
7. Beach closings (health advisories)
8. Eutrophication or Undesirable algae
9. Restrictions on Drinking water Consumption (groundwater)

Addressing BUIs through Ecological Restoration

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. The previously implemented sediment remediation project specifically addressed sediment contamination. However, other ecological components including water quality and quantity, cover/shelter, food, corridors and space are in need of ecological restoration. A primary focus of this ecological restoration plan is to address fish and wildlife habitat. Thus, a major portion of the Plan focuses on restoring the aquatic, wetland and terrestrial habitats in the project area. Each habitat type will have different restoration trajectories, defined by their reference ecosystems and standard indices, and so the benchmarks for this progression will be distinct for each community. The "success" of restoration actions can be determined through the evaluation of post-project monitoring data, and the use of ecological reference information to determine if ecosystem succession is occurring along the desired trajectory. Feedback from monitoring efforts will inform decisions on adjusting restoration actions and even the trajectories depending on the response of the system.

The restoration of a particular ecosystem component is completed when it has been determined that the desired restoration trajectory has been fulfilled. Following this plan will result in addressing the target BUIs in the project area and restoring fish and wildlife habitat.

Developing the Ecological Restoration Master Plan

Restoration strategies have been determined as a result of stakeholder input at the first public workshop, including the vision and guiding principles, as well as specific restoration opportunities and constraints recognized by the workshop participants. Key elements of the guiding principles include the restoration of natural landscapes to attain self-sustaining, reproducing, native communities, ecosystem resiliency, biodiversity, and the mitigation of threats to these ecosystems. The Biohabitats team translated and developed stakeholder ideas into a hierarchy of Goals, Objectives, and Actions, adding details and articulating specific strategies according to their professional expertise in ecological restoration. The major restoration goals presented in this plan are designed to address the BUIs identified above, build upon the recent remediation efforts and contribute to delisting the Muskegon Lake AOC.

Goal A: Improve water quality and hydrology in Ruddiman Creek.

Goal B: Restore fish and wildlife habitat within the project area.

Goal C: Restore fish and wildlife populations within the project area.

Goal D: Permanently protect and conserve existing and restored habitats.

Goal E: Increase opportunities for recreation, education, and stewardship.

The final prioritization of objectives and actions was performed at the second Public Workshop held on November 29, 2007. During the workshop, stakeholders were encouraged to provide direct input on the restoration framework described in the following sections. The final set of actions was evaluated and refined, and a collaborative and adaptive framework has been developed to ensure that all stakeholders are involved in the continued development and implementation of the restoration initiatives.

Additional meetings with key stakeholders were held on February 11 through 13, 2008 to ensure that specific and complex comments and concerns not fully addressed during the second workshop would be addressed in the final plan. These meetings were important to continue the dialogue and guarantee buy-in by these stakeholder groups. Specific comments and concerns were discussed, so they could be included in final master plan.

The Muskegon Lake Watershed Partnership (MLWP) endorsed the Plan at its March 13, 2008 meeting. The primary focus of the MLWP will be to implement the goals and objectives in the Plan that contribute to reaching BUI removal targets. They are

currently creating a Muskegon Lake Fish and Wildlife Restoration Plan through consultation with the Michigan Department of Environmental Quality. This plan will set the BUI targets for the project area, as well as the entire Muskegon AOC. The group will also work to accomplish additional plan objectives to the greatest practical extent. The Habitat Committee of the MLWP will act as the central coordinator to plan new habitat restoration projects that meet the BUI targets. The Habitat Committee will oversee the implementation of projects identified in the Plan and coordinate related monitoring programs. The West Michigan Shoreline Redevelopment Commission will assist the MLWP Habitat Committee by facilitating meetings and providing staff support to ensure that planning and writing proposals for future restoration projects continue.

1.0 Regional Context

The Ruddiman Creek and Nearby Shoreline project area is important to the people who live in and around the project area. Further, it plays an important role in the health of Lake Michigan and the Great Lakes Region. This combination of local support and ecological significance makes this location ideal for restoration.

1.1 Great Lakes Initiative – Lake Michigan Lakewide Management Plan

Under the Great Lakes Water Quality Agreement (GLWQA), the United Sates and Canada agreed "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes basin ecosystem." To achieve this objective, the parties agreed to develop and implement Lakewide Management Plans (LaMPs) for open waters. The Lakewide Management Plan for Lake Michigan (2000), provides a status report on the health of the Lake Michigan ecosystem and a summary of related activities based upon the vision, goals and subgoal of the Plan. The goal of the Lake Michigan LaMP is *to restore and protect the integrity of the Lake Michigan ecosystem through collaborative, place-based partnerships*. As of 2000, the status of achieving the goals is mixed; a combination of improvement and deterioration. Efforts have been undertaken to gather data on wetlands, beaches, stream buffers, and other items that will ensure that the goal status changes from mixed to mixed/improving by 2010 and to good by 2020. (Lake Michigan LaMP Fact sheet, MDEQ, 2000).

1.2 Area of Concern and Beneficial Use Impairments

Under the GLWQA, the International Joint Commission (IJC) is required to monitor progress by Canada and the United States as the two countries implement the goals and objectives of the Agreement. As part of this Agreement the IJC has identified Areas of Concern (AOCs) in the Great Lakes as having serious water pollution problems requiring remedial action and the development of a Remedial Action Plan. An AOC is an area that "fails to meet the objectives of the Great Lakes Water Quality Agreement and where such failure has caused or is likely to cause impairment of beneficial use or of the areas ability to support aquatic life". The tool used to describe the effects of the contamination in an AOC is called a Beneficial Use Impairment (BUI). The scope of the AOC program is based on the concept that each AOC has at least one BUI that is a significant problem.

The international Great Lakes Water Quality Board identified 42 AOCs throughout the five Great Lakes and ten of them, including the Muskegon Lake AOC, are located around the perimeter of Lake Michigan. In 1985 Muskegon Lake and its tributaries were designated as an

Lake Michigan Drainage Basin

AOC because of degraded ecological conditions due to the accumulation of industrial wastes associated with foundries, metal finishing facilities, petrochemical production and shipping. During the 1980s and into the 2000s, the Lake shoreline reflected more commercial and recreational uses as heavy industry moved out of the area. Muskegon Lake remains an AOC because of water quality, sediment and habitat problems associated with urban run-off, dredging and filling along the shoreline, and localized groundwater contamination moving toward the Lake and its tributaries. These problems have the potential to harm not only the Muskegon Lake ecosystem, but the Lake Michigan ecosystem as well (Muskegon Lake Community Action Plan, 2002). In contrast to these impacts, historical discharges of polluted wastewater have been stopped and improvements in lake water quality have been observed over the last 30 years (A. Steinman, personal communication).

The Great Lakes Water Quality Agreement also called for the development of Remedial Action Plans (RAPs) for specific AOCs such as the Muskegon Lake AOC. As prescribed by the Agreement, a RAP is developed using an ecosystem approach to focus on a specific embayment or stretch of river within a single watershed and relies on a structured public involvement process. Linking RAPs to the Lake Michigan Lakewide Management Plan is essential in order to remove impairments affecting the health of Lake Michigan while restoring the ecological integrity of the local watershed. (LaMP summary and Muskegon RAP, 2002).

1.3 Muskegon Lake AOC Remedial Action Plan

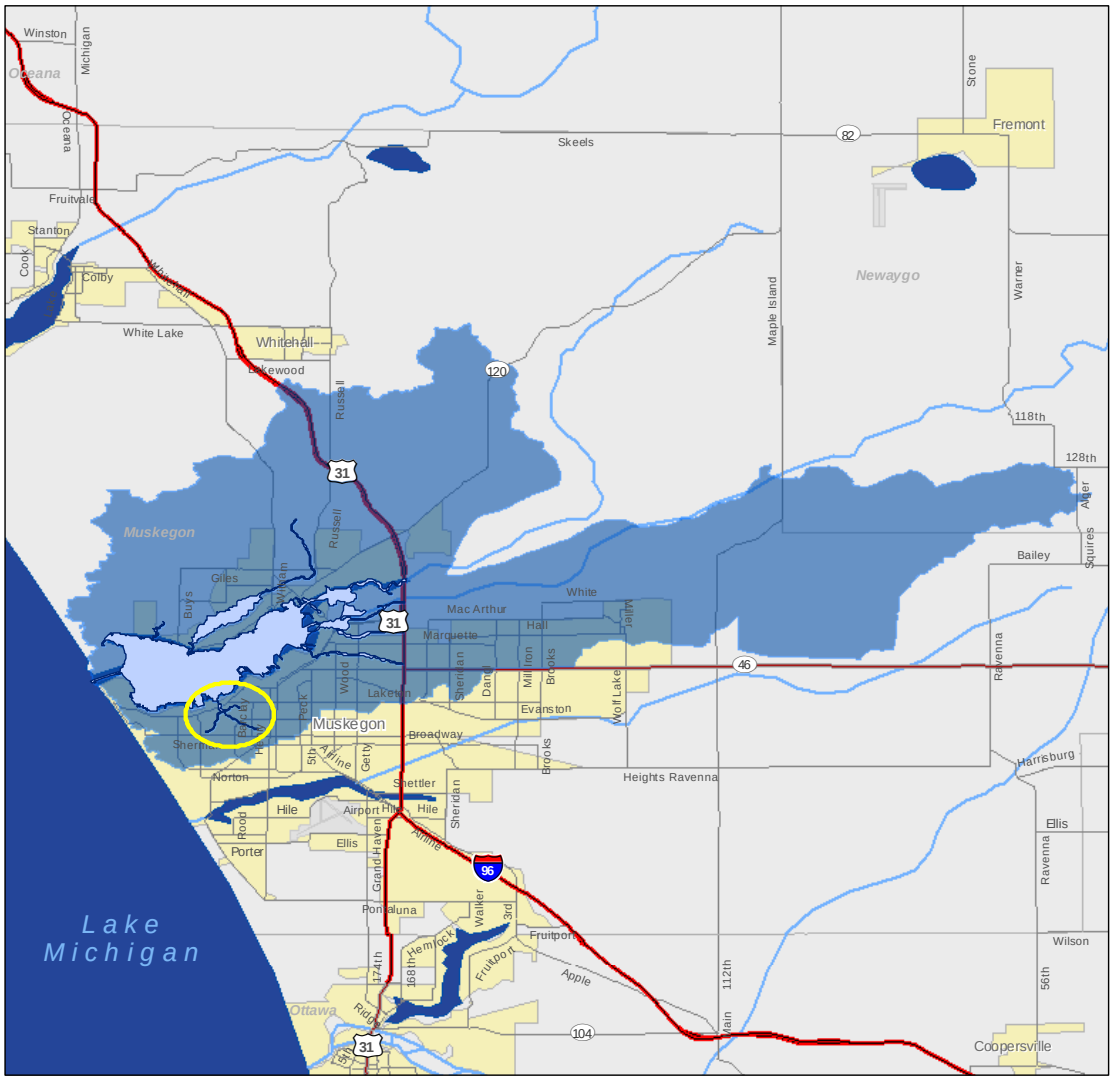
Muskegon Lake is a 4,149 acre inland coastal lake located along the east shore of Lake Michigan in Muskegon County, Michigan. The Muskegon Lake AOC boundary includes a 52 square mile immediate watershed with several tributaries including Ruddiman Creek. In 1987 a RAP was developed for the Muskegon Lake AOC. The RAP was subsequently updated in 1994 and 2002. The RAP process is designed to bring partners together to coordinate restoration activities within the AOC for the purpose of delisting the Muskegon Lake AOC. Delisting is based on removing BUIs from the AOC thus, the RAP identifies targets for restoration, reviews indicators of success and outlines actions designed to remove BUIs. Additionally it summarizes the status of each BUI. All Muskegon Lake watershed community members are encouraged to use the 2002 RAP Update to plan and carry out ecosystem improvement projects in the Muskegon Lake AOC watershed.

The International Great Lakes Water Quality Agreement listed 14 BUIs associated with the Great Lakes AOCs and 9 of them were identified for the Muskegon Lake AOC. BUIs inside

the box are top priorities established by the Muskegon Lake Watershed Partnership and the MDEQ. The BUIs highlighted with bold text are specifically associated with the Ruddiman Creek and Nearby Shoreline project area.

1. Restrictions on human consumption of fish and wildlife
2. **Loss of fish and wildlife habitat**
3. **Degradation of fish and wildlife populations**
4. **Degradation of benthos (bottom dwelling organisms)**
5. Restrictions on dredging
6. Degradation of aesthetics
7. Beach closings (health advisories)
8. Eutrophication or Undesirable algae
9. Restrictions on Drinking water Consumption (groundwater)

Although the Beach closings BUI is not associated with Ruddiman Creek, it is documented that the stream does not meet water quality standards for human contact due to bacteria (MDEQ, 2006). A Total Maximum Daily Load (TMDL) is required for this stream and is slated to go into effect in 2010.



1.4 Ruddiman Creek and Nearby Shoreline Project Area

Ruddiman Creek is identified in the RAP as a major contributor to the degradation of Muskegon Lake due to historic causes of fish and wildlife habitat loss and degradation. The Muskegon Lake AOC RAP takes a sub-watershed approach to organize and facilitate restoration activities and public involvement. Local interest in restoring Ruddiman Creek is high because it flows through back yards and recreation areas in the neighborhoods of Glenside, Lakeside, Nims, and Campbell. The Ruddiman Creek Task Force was formed and supported the development of the Ruddiman Creek Strategic Plan to guide local sub-watershed efforts toward the removal of Muskegon Lake BUIs. Sediment remediation work was completed in 2006 and made a major contribution toward addressing contamination in the stream corridor. Water contamination due to stormwater runoff continues to be addressed by the City of Muskegon Department of Public Works and through municipal partnerships at the local level. In addition, restoration efforts are necessary to address the habitat related BUIs in the project area.

The Muskegon Lake and Ruddiman Creek project area exists mostly within the Ruddiman Creek watershed. Ruddiman Creek watershed covers approximately 3,500 acres and is one of seven sub-watersheds included in the AOC boundary. Most of the watershed is within the City of Muskegon, but portions extend into the Cities of Norton Shores, Muskegon Heights, and Roosevelt Park. As a result, Ruddiman creek carries water from storm sewers located in all four cities. Land ownership within the project area includes public and private parcels. The majority of the land use is residential (mostly low with some high density). Open space areas include McGraft Park located in the middle of the Project area, Muskegon Catholic Central High School located at the headwaters of the north branch, the former AMOCO tank farm, and areas associated with the bike path located along the shoreline.

Several roads traverse the site including Lake Shore Drive, Glenside Boulevard and Barclay Street. A commercial railway follows the shoreline of Muskegon Lake, crossing Ruddiman Creek just before the confluence with the Lake. The railway is active and transports goods daily to and from the SAPPI paper mill located west of the project area.

The project area was defined to include highly degraded areas in need of restoration, as well as healthy, but fragmented areas. Habitat components in need of restoration include, but are not limited to wetlands, in-stream habitat, invasive species, water quality, shoreline habitat, and vegetative enhancement. The remainder of the boundary was drawn to include the riparian and upland forested areas associated with the main stem of Ruddiman Creek and its tributaries. The headwaters of the east tributary are included in the boundary while culverts associated with road crossings delineate the extent of the boundary along the other two waterways.

Ruddiman Creek and Muskegon Lake Project Area Map

2.0 Plan Development Process

VISION:

"Muskegon Lake, Ruddiman Creek and nearby shoreline: a healthy place for all living things, where people interact with nature through stewardship and recreation."

This Master Plan compliments years of work by the Muskegon Lake Watershed Partnership and recent remediation efforts. The Plan framework is a result of previous work with Great Lakes National Program Office (GLNPO); the federal agency tasked with administering funds for sediment remediation projects associated with AOCs. The planning process comprises a series of stakeholder workshops, data collection and analysis, and continual feedback between stakeholders about the directions and components of the Plan, ultimately resulting in an ecological restoration master plan that will be used to address the habitat-related BUIs identified in the Ruddiman Creek and Nearby Shoreline project area.

2.1 Project Kick-off

This project has its roots in efforts led by local individuals and agencies to remediate the AOC. The environmental restoration component began with a project kickoff meeting hosted by Biohabitats, Inc. and the USEPA at the Grand Valley State University (GVSU) Michigan Alternative and Renewable Energy Center (MAREC) in Muskegon, MI on April 23, 2007. Here, Biohabitats, Inc. and the USEPA identified and explained the project goals and gathered preliminary information from stakeholders, including members of the Muskegon Lake Watershed Partnership, the City of Muskegon, local business owners, and citizens.

2.2 Data Collection and Analysis

Following the project kickoff, Biohabitats gathered multiple sources of information to aid in developing the Master Plan. Local, state and federal records of fish and wildlife species, topography, and hydrology were consulted. Other sources of information included, remediation reports, Muskegon County GIS data, habitat studies, aquatic vegetation reports, and material compiled by the Muskegon Lake Watershed Partnership.

Biohabitats conducted a three-day site reconnaissance to assess the general ecological and physical conditions of the site. This research included identifying vegetation communities including invasive species, reference ecosystem identification and photo documentation. The site visit was used to corroborate existing database and report information, identify where discrepancies existed, and identify some initial opportunities and constraints for ecological restoration within project area.

After the field reconnaissance the collected information was reviewed in light of the information gathered during the literature review. The following physical and biological parameters were reviewed:

- geology,
- soils,
- upland, wetland, shoreline, and riparian vegetation communities,
- invasive species,

- Ruddiman Creek channel conditions,
- fish, bird, and wildlife communities,
- rare, threatened, and endangered species,
- land use and zoning,
- recreational features and amenities,
- site history,
- potential threats to ecological integrity, and
- ecological reference conditions.

A summary of this ecological information was compiled into a series of posters for the first public workshop.

2.3 First Public Workshop

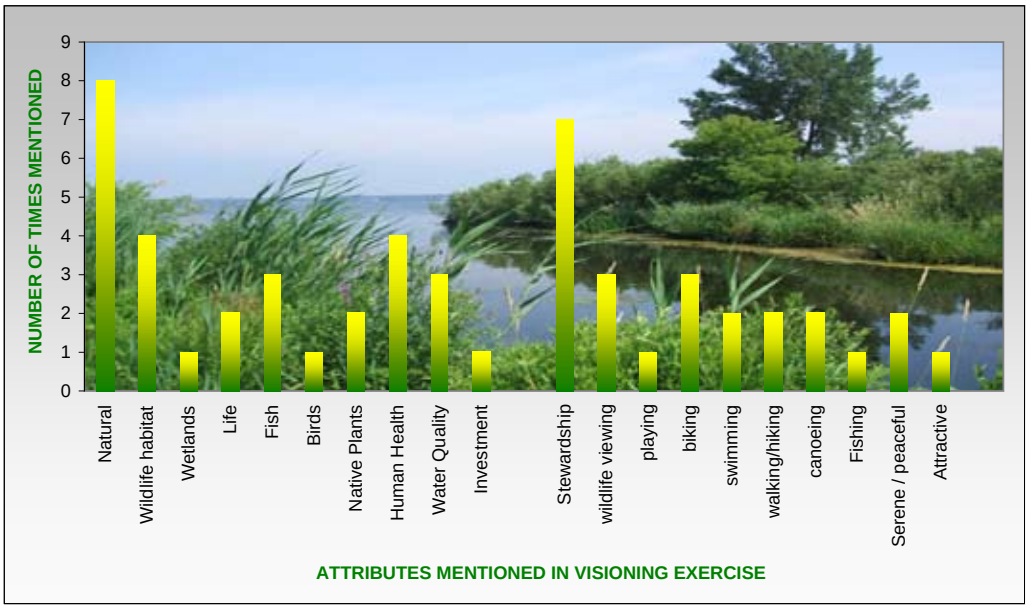
The first public workshop was a full-day meeting held on September 11, 2007 in Muskegon, MI. (Please see Appendix A for attendee list and agenda). The purpose of the meeting was multi-pronged: gather stakeholders to get their perspectives and concerns about the ecological restoration; present the data collected thus far about the site; and work collaboratively to develop a vision and guiding principles for Ruddiman Creek and Nearby Shoreline.

An active group of stakeholders (Appendix A) met for the day's activities. Following an overview of the purpose of the ecological restoration and the role EPA would play in supporting steps towards restoration, participants began the process of defining a vision for the site. This vision statement is a collective representation of what stakeholders ultimately want the site to become. Describing the essence of a future site succinctly – particularly when its recent history has been one of contamination – requires not only a sense of imagination and possibility, but also word economy. Each participant made at least one "bumper sticker" that summarized in a few words what a future Ruddiman Creek and Nearby Shoreline would look like, feel like, or be used for. The graph below gives a visual summary of the words and ideas expressed during the bumper sticker activity.

As shown on the graph below, key words from the visioning exercise included Nature (natural), Health and Stewardship. From these key words the following vision statement was crafted. This serves as a personal and unique signature for this restoration.

"Muskegon Lake, Ruddiman Creek and nearby shoreline: a healthy place for all living things, where people interact with nature through stewardship and recreation."

In addition to participating in the visioning exercise, participants at the workshop also communicated their preferences regarding the restoration and use of the project site. A wide range of statements were provided to determine



agreement or disagreement per statement. The table on page 21 summarizes the responses and ranks them in order of highest percentage of agreement to lowest percentage of agreement.

Statements with at least 80% of the responses clustered in the "I mostly agree" and the "I strongly agree" columns were included as guiding principles. Additionally, statements that received at least 80% in the "I mostly disagree" and "I strongly disagree" columns were re-worded to communicate the opposite intent and included as guiding principles. Statements that fell in between the two extremes are not included in the final list of guiding principles.

The following list of guiding principles is a result of this analysis.

Restoration

Sustain necessary species to achieve goals.

- Support indigenous species to the greatest extent possible.
- Eliminate or reduce potential threats.
- Support self-sustaining systems in likeness to a reference system.
- Monitor site through completion.
- Maximize involvement of volunteers and provide educational opportunities.
- Incorporate species assemblages typical of reference system.
- Seek permanent protection for important habitat areas.
- Explore opportunities for active recreation in addition to passive recreation.
- Take a watershed based approach to ecosystem restoration.
- Pursue active restoration to achieve restoration goals.

Management Planning

- Incorporate short term milestones.
- Create a plan that is flexible and can be updated easily to incorporate new information and stakeholder interests.
- Survey community to assess changes in values as a result of restoration.

2.4 Master Plan Development

Through the remainder of September and October, 2007, Biohabitats integrated the materials generated at the first public workshop with the ecological analyses previously performed. From the Vision and guiding principles, a distinct set of restoration goals, objectives, and actions were derived and further developed by the Biohabitats technical team.

A second public workshop was held on November 29, 2007 at the MAREC building in Muskegon Michigan to solicit general comments from the workshop participants. The Goals, Objectives and Actions proposed in the Draft Plan were discussed and feedback was incorporated into the Plan.

2.5 Second Public Workshop

The main focus of the second workshop was to discuss stakeholders' reactions to the Draft Ecological Restoration Master Plan created after the first public workshop. Nearly thirty participants

Restoration Attribute from Slider Board	I strongly disagree	I mostly disagree	I'm not sure	I mostly agree	I strongly agree
Able to sustain necessary species to achieve goals	0%	0%	0%	0%	100%
Indigenous species to the greatest extent possible	0%	0%	0%	8%	92%
Potential threats should be eliminated or reduced	0%	0%	0%	45%	55%
Self-sustaining in likeness to reference system	0%	0%	0%	73%	27%
There should be short term milestones	0%	0%	8%	8%	83%
Monitor site through completion	10%	0%	0%	0%	90%
Maximize the use of volunteers, and provide educational opportunities	0%	0%	10%	20%	70%
Characteristic assemblages of species that occur in a reference ecosystem	0%	0%	8%	25%	67%
Planning and design process should remain flexible, to allow for the integration of new information and stakeholder interests	0%	0%	10%	50%	40%
Judge impact of restoration on community values	0%	0%	8%	33%	58%
Permanent protection through direct acquisition, conservation easement, or other conservation methods	0%	10%	10%	30%	50%
Signs of ecological or physical dysfunction should be absent	8%	0%	17%	67%	8%
Integrated into a larger ecological matrix or landscape	25%	0%	0%	17%	58%
Active recreation and human access should be maximized	8%	8%	17%	17%	50%
Revise plan every other year	36%	0%	18%	9%	36%
Should be restored to its original, pre-development morphology	30%	40%	10%	20%	0%
Only passive recreation	30%	50%	0%	10%	10%
Riparian restoration only - do not include watershed-wide strategies	80%	20%	0%	0%	0%
No active restoration initiatives need to be performed	91%	9%	0%	0%	0%
	Daily	monthly	annually	2-5 yrs	never
Visitation before restoration	22%	22%	11%	33%	11%
Visitation after restoration	10%	20%	50%	20%	0%

	1 yr	10 yrs	15 yrs	20 yrs	35 yrs	50+
Timeframe for the realization of the VISION	0%	17%	58%	8%	0%	17%

I mostly agree + I strongly agree = 80%-100%
I mostly agree + I strongly agree = 20%-75%
I mostly disagree + I strongly disagree = 80%–100%

Number of respondents = 12

again met in the MAREC building on November 29, 2007 to discuss the specific Goals, Objectives and Actions presented in the Draft Plan (see Appendix A for agenda, attendee list and initial list of proposed goals and actions). The meeting began with a field walk with visits to key locations in the project area. After returning to MAREC, the meeting included recap of the first workshop, discussion of the process behind the creation of the Vision, Goals, Objectives and Actions (which came from discussions and suggestions in the first public meeting), editing the Vision, and a discussion about local ownership of the Plan, funding opportunities and the delisting process for the site.

After the initial discussion, the remainder of the meeting was dedicated to evaluating the Goals and all of their components. Comments on any part of the Plan were welcomed and several stakeholders submitted these in writing during the afternoon. To focus the meeting on the proposed Draft Plan strategies, large posters with each Goal and its associated Objectives and Actions were posted around the conference room, participants were encouraged to review each poster and mark it up with their suggestions for wording, additions and deletions. This process enabled people to go through at their own pace, make sure that everyone participating in the conversation was familiar with the proposed strategies, and let stakeholders view and respond to others' edits.

After the "board tour" concluded, each board was discussed with the entire group. The aim in this portion of the meeting was to achieve consensus about which Goals, Objectives and Actions to include in the Final Plan, how they were to be worded and what information should be added or removed. The discussion was intense and fast-paced, as the group had much material to cover in a short period of time. Despite time constraints, members were responsive and worked respectfully with one another even in the face of disagreement, to edit the Draft Plan. At the conclusion of this segment, the group worked out a timeline for preparing and receiving minutes from the meeting, an updated version of the Draft Plan based on recommendations from the second workshop, and providing feedback and recommendations on the revised and most current Draft Plan.

In addition to the edits, two notable topics

emerged relating to the future implementation of the Plan. The first was the discussion of possible funding for the restoration from grants and public agencies. The second was a concern about the current level of ownership of the Draft Plan. The group, while making suggestions for strategies, was not yet invested enough in the Draft Plan to be in a position to implement it. Most recognized that Plan endorsement and implementation needed to be addressed.

Meetings with Individual Stakeholders

Additional meetings with key stakeholders were held on February 11 through 13, 2008 to ensure that specific and complex comments and concerns not fully addressed during the second workshop would be addressed in the final plan. These meetings were important to continue the dialogue and guarantee buy-in by these stakeholder groups. The meetings included personnel from the City of Muskegon, private landowners, scientists from Grand Valley State University (GVSU), and individuals from the Muskegon Lake Watershed Partnership (MLWP), the West Michigan Shoreline Regional Development Commission (WMSRDC), the Muskegon Conservation District, and the Greater Muskegon Catholic Schools. Specific comments and concerns were addressed during each meeting, so they could be included in final master plan.

3.0 Ecological Restoration Master Plan

The Ruddiman Creek and Nearby Shoreline Ecological Restoration Master Plan is intended to guide future restoration efforts in the project area, in accordance with the vision and guiding principles outlined below. Key elements of the Master Plan include the restoration of natural landscapes to attain self-sustaining, reproducing, native populations of species and assemblages, ecosystem resiliency, biodiversity, and the mitigation of threats to these ecosystems. Restoration will be done in accordance with the goals of the Muskegon Lake Remedial Action Plan (RAP). Reference ecosystems are used to determine species assemblages and desired ecosystem function. The restoration strategies will integrate reference system data to enhance existing ecological communities, in accordance with the range of human uses in the project area. Finally, the Ecological Restoration Master Plan will leverage and enhance recreational, educational, and stewardship opportunities that are compatible with these ecological principles.

It is acknowledged that the full restoration of ecosystem function for natural areas along Ruddiman Creek and the Muskegon Lake shoreline is a process that will take many years or decades to evolve. The natural succession of restored areas will allow habitat to mature and diversify over time. Many of the restoration actions proposed in this Master Plan will take many years to become fully developed. Further, they will require active monitoring and adaptive management to ensure that habitat complexes and desired species assemblages remain intact.

To provide an adequate planning framework, it is intended that this document serve as a "living plan" that will guide these long-term restoration and management actions. In addition, the Master Plan is structured to be adaptive to new information, stakeholder needs, and management objectives.

The vision and guiding principles, as well as specific restoration opportunities and constraints were identified at the first public workshop. The Biohabitats team translated and developed these ideas into a hierarchy of Goals, Objectives, and Actions, adding details and articulating specific strategies according to their professional expertise in ecological restoration. The Goals are broad statements about what should be accomplished in the area. Each Objective includes a measurable trajectory. Individual Actions include a procedure for implementation, reference ecosystems, planning level cost estimates for the design, implementation, and management of each action, a timeline of the restoration process, notes on any permitting requirements, and any pre-implementation requirements. The Objectives and Actions presented in this document should be further developed during the Plan execution and the ongoing monitoring process.

The final prioritization of objectives and actions was completed at the second Public Workshop held on November 29th, 2007. During the workshop, stakeholders were encouraged to provide direct input on the restoration framework described in the following sections.

3.1 Restoration Goals / Objectives / Actions

Goal A: Improve hydrology and water quality and in Ruddiman Creek	
Objective A1)	**Reduce flashy flows within Ruddiman Creek.**
	Action 1. Review existing hydrologic analysis and determine data gaps and needs for additional research.
	Action 2. Identify properties and areas in the watershed where stormwater Best Management Practices (BMPs) would be practical and beneficial, including retrofits of existing outfalls, where feasible.
	Action 3. Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1:2 above.
	Action 4. Educate landowners about stormwater BMPs to reduce overland flow of stormwater.
Objective A2)	**Improve water quality of Ruddiman Creek.**
	Action 1. Continually monitor, identify and eliminate illicit discharges.
	Action 2. Install BMPs that facilitate water quality treatment, and where feasible, infiltration.
	Action 3. Educate homeowners about water quality BMPs
Goal B: Restore fish and wildlife habitat within the project area.	
Objective B1)	**Enhance physical aquatic habitat features in the project area.**
	Action 1. Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.
	Action 2. Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.
	Action 3. Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.
	Action 4. Reconfigure the Glenside Boulevard culvert for improved fish passage when it is near the end of its useful life.
Objective B2)	**Protect and enhance native aquatic vegetation along the Muskegon Lake shoreline.**
	Action 1. Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots, for species expansion.
Objective B3)	**Enhance terrestrial habitat including riparian buffers and corridors in the project area.**
	Action 1. Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Boulevard.
	Action 2. Expand the riparian and upland buffers along the Muskegon Lake shoreline, and along the bike path.
	Action 3. Reconfigure the Glenside Boulevard culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.
Objective B4)	**Restore and enhance existing wetlands throughout the project area.**
	Action 1. Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.
	Action 2. Explore opportunities for wetland creation at the former AMOCO tank farm site.
	Action 3. Encourage private landowners to establish native wetland vegetation where it is compatible with current zoning, future development plans, and where proper hydrology and soils exist.
Objective B5)	**Reduce the abundance of invasive plant species in the project area.**
	Action 1. Conduct invasive species management in project area.
	Action 2. Provide information to homeowners about invasive species management and the use of native plants in the landscape.

Goal C: Restore fish and wildlife populations in the project area.	
Objective C1)	**Track the abundance and diversity of avian, fish, herpetofauna and macroinvertebrate species in the project area.**
	Action 1. Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities within the project area
Goal D: Permanently protect and conserve existing and restored habitats.	
Objective D1)	**Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.**
	Action 1. Work with the City of Muskegon to consider stronger protection of 50 acres designated as open space recreation, including the former AMOCO Tank Farm Site, and land on the east side of Ruddiman lagoon.
	Action 2. Propose and enact conservation zoning for 7 acres of shoreline between the former AMOCO Tank Farm Site, and Lakeshore Yacht Club.
Objective D2)	**Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.**
	Action 1. Initiate discussions with private landowners to determine the types of conservation measures that could increase property value and enhance future development plans.
	Action 2. Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.
Goal E: Increase opportunities for recreation, education, and stewardship.	
Objective E1)	**Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing.**
	Action 1. Explore the feasibility of placing an observation platform within the lagoon.
Objective E2)	**Encourage opportunities for active recreation along, and in Ruddiman Creek and the Nearby Shoreline of Muskegon Lake.**
	Action 1. Explore the feasibility of placing a boardwalk in the lagoon area.
	Action2. Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.
Objective E3)	**Promote local stewardship and education opportunities.**
	Action 1. Elicit support from adjacent schools to have students implement and monitor restoration measures.
	Action 2. Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.
	Action 3. Maintain and promote research opportunities through Grand Valley State University (GVSU).
	Action 4. Hold seasonally relevant seminars on the ecology, history, environmental stewardship, or function of the area.
	Action 5. Encourage construction of informational signage describing local history vegetation and wildlife.

Goal A) Improve hydrology and water quality in Ruddiman Creek

Overview

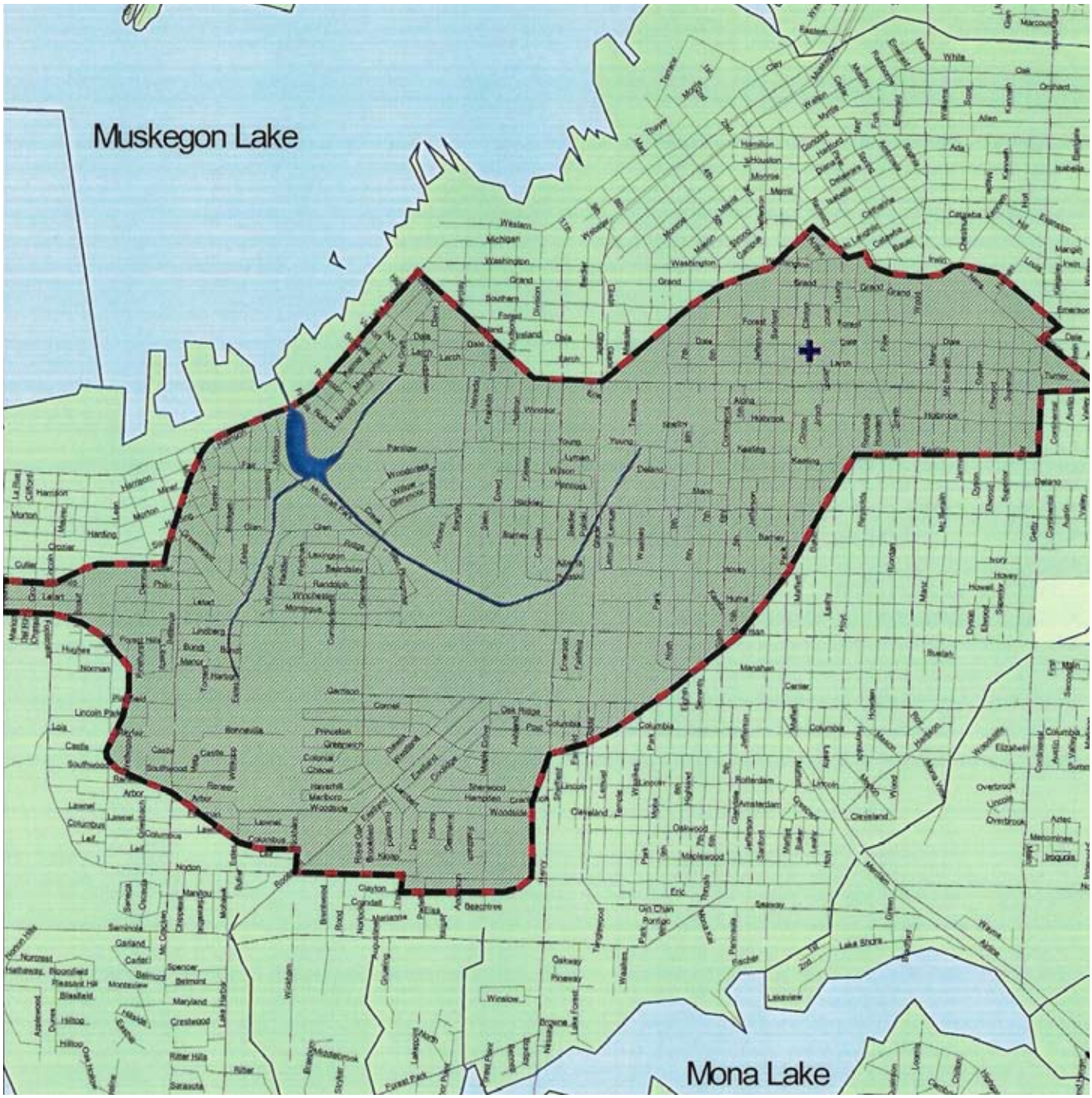
Sediment remediation efforts have successfully removed contaminated sediments from within the Ruddiman Creek channel and subsurface areas of the lagoon to levels that comply with federal and state standards. However, Ruddiman Creek is still subject to the impacts from an urbanized watershed, including pollutants, bacteria, flashy hydrology and reduced infiltration.

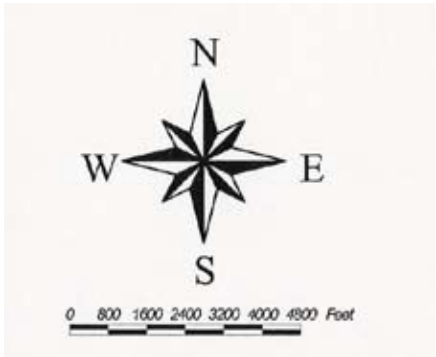
To ensure the health of a restored aquatic system, and provide for sustained use by plant, invertebrate, fish, bird, wildlife, and human inhabitants, it is necessary to maintain water conditions so that they do not limit ecological function and biodiversity, or be continual sources of ecological stress.

Objectives

A1) Reduce flashy flows within Ruddiman Creek

A2) Improve water quality of Ruddiman Creek





SEG
A CDZ Company
Michigan - Ohio - Indiana

Ruddiman Creek Watershed

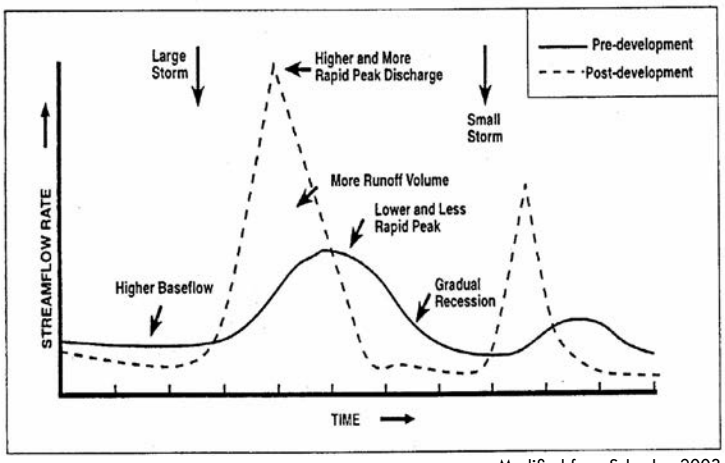
Phase II Draft Sampling and Analysis Plan
Ruddiman Creek / Muskegon, Michigan
Revision 00 / May 2000

Objective A1) Reduce flashy flows within Ruddiman Creek

Restoration Trajectory: *Restore the discharge of Ruddiman Creek to resemble the annual discharge regime observed in a less urbanized watershed.*

Overview

Approximately two thirds of the Ruddiman Creek watershed has been culverted and/or placed in storm sewers. When rain water hits the parking lots streets and driveways in the watershed, it is rapidly transported to the storm sewers, which quickly deliver it to the stream channel. Rain water has little opportunity to infiltrate into the ground, and instead, enters the stream channel with erosive velocities and flooding volumes. The Cities of Muskegon, Norton Shores, Muskegon Heights and Roosevelt Park are undertaking programs to address pollution and impacts associated with stormwater runoff (see Section 5.4). Additional efforts that should be considered are described below.



Modified from Schueler, 2003

Above, typical stormwater hydrograph; opposite page, stormflows increased from impervious surfaces in the watershed

Actions

1) Review existing hydrologic analysis and determine data gaps and needs for additional research.

2) Identify properties and areas in the watershed where stormwater BMPs would be practical and beneficial, including retrofits of existing outfalls, where feasible.

3) Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1:2 above.

4) Educate landowners about stormwater BMPs to reduce overland flow of stormwater.

Action A1:1) Review existing hydrologic analysis and determine data gaps and needs for additional research.

Procedure

A) Review and, if necessary, build upon the existing HEC-HMS model (computer model used to estimate the relationship between rainfall and run-off) for Ruddiman Creek to analyze the existing hydrologic regime and to identify problem areas within the watershed. Problem areas may include those impacted by overbank flows or flooding during storms of different return intervals.

B) Identify flow-related targets for the watershed based on this analysis. These may include a variety of objectives, such as reduced flooding at road crossings during the 10-year storm event, increased summer baseflows to enhance habitat, reduced overbank or nuisance flooding during small storms, etc.

C) Coordinate with local municipalities and state agencies to implement actions that facilitate and support current efforts.

Field reconnaissance to verify existing data

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide

Implementation Timeline: 0 to 2 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

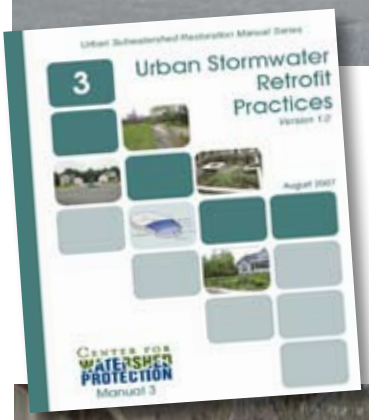
Range of estimated costs: $25,000 - $40,000

Permitting requirements: None

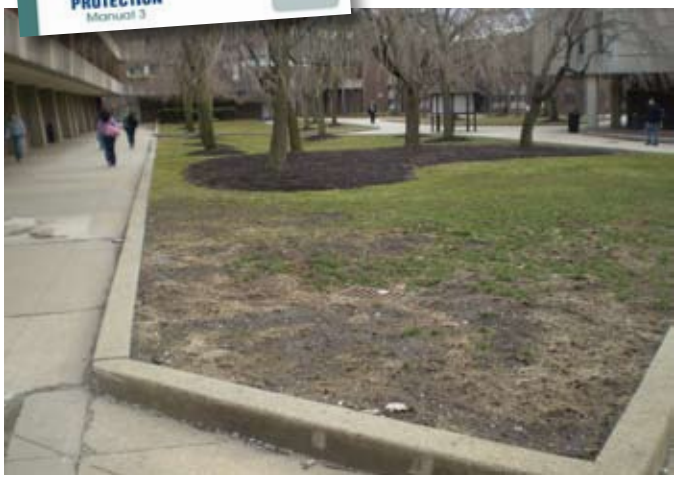
Pre-implementation needs: GIS layers including soils, land use and watershed topography, and existing storm drain network.

Goal A) Improve hydrology and water quality in Ruddiman Creek
Objective A1) Reduce flashy flows within Ruddiman Creek

Action A1:2) Identify properties and areas in the watershed where stormwater BMPs would be practical and beneficial, including retrofits of existing outfalls, where feasible.



Above, identifying potential BMP; at left, stormwater report cover; below, potential BMP



Procedure

A) Perform a GIS analysis of publicly held properties that would make potential candidates for the installation of stormwater retrofits and BMPs.

B) Conduct a windshield survey to verify the desktop analysis and identify additional potential BMP sites.

C) Use the information above and the hydrologic information from Action 1 to create a watershed-specific stormwater management plan including feasibility and priority analysis of proposed BMP sites, and policies for new development and infill development. This stormwater management plan should both draw from and support relevant actions undertaken by the cities as part of their Stormwater Pollution Prevention Initiatives.

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

Implementation Timeline: 0 to 2 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $20,000 - $70,000

Permitting requirements: None

Pre-implementation needs: GIS layers including soils, land use and geo-referenced aerial photography.

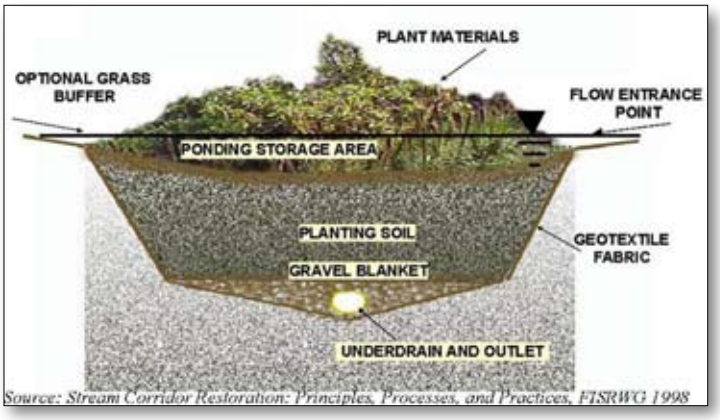
Action A1:3) Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1:2 above.

Procedure

A) Create concepts and final construction plans for the prioritized BMPs from the Stormwater Master Plan.

B) Bid and construct the selected BMPs.

C) Monitor and maintain BMPs.



BMP diagram

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

Implementation Timeline: 3 - 10-years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $700,000 - $2,100,000 (for full implementation of the Plan).

Permitting requirements: Local, state and federal permits will be required for work in and around waterways, and for any development, redevelopment, or retrofit stormwater credit to be received.

Pre-implementation needs: Results of Actions 1 and 2 above.

Action A1:4) Educate landowners about stormwater BMPs to reduce overland flow of stormwater.

At top, BMP example; above, parking lot bioretention

Procedure

A) Coordinate with existing programs designed for landowners, add a stormwater BMP (rain gardens, rain barrels, porous pavement, etc.) component and increase educational opportunities in the Ruddiman Creek Watershed.

B) Provide workshops, forums, networks and incentives associated with community organizations.

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

Implementation Timeline: 3 to 10 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $1,000 - $2,000 (efforts to be repeated annually).

Permitting requirements: N/A

Pre-implementation needs: N/A

Objective A2) Improve water quality of Ruddiman Creek.

At top and bottom, exmples of outfalls; center, sign warning of pollution at Ruddiman Creek

Restoration Trajectory: *Ensure that Ruddiman Creek does not receive untreated water from illicit discharges, cross connections, or stormwater drainage features.*

Overview

Runoff from parking lots and roadways carries chemical byproducts of petroleum combustion, nutrients, road grit, bacteria from pet waste and sewer mammals, and other pollutants into the stream channel, reducing water quality. Conversely, during dry weather there is little groundwater discharge to the channel. This results in extremely low flows in the channel that concentrate the deposited pollutants and stress aquatic fauna. Other contamination of the creek occurs from leaks and cross connections to the sanitary sewer system into the storm sewers.

Actions

1) Continually monitor, identify and eliminate illicit discharges.
2) Install BMPs that facilitate water quality treatment, and where feasible, infiltration.
3) Educate homeowners about water quality BMPs

Action A2:1) Continually monitor, identify and eliminate illicit discharges.

Examples of discharges

Procedure

A) Ensure that existing illicit discharge elimination programs administered by the Cities of Muskegon, Norton Shores, Muskegon Heights and Roosevelt Park monitor all potential sources of illicit discharges to Ruddiman Creek.

B) Identify illicit connections and discharges, and report them to the governing agencies for corrective action.

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

Implementation Timeline: Continuous

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $5,000 - $10,000 (annually)

Permitting requirements: None

Pre-implementation needs: None

Action A2:2) Install BMPs that facilitate water quality treatment, and where feasible, infiltration.

Procedure

A) Concurrent with Objective A1 above, identify locations for BMPs that focus on water quality benefits as well as quantity control.

B) Educate private and commercial property owners about BMPs that can be installed on site.

C) Develop a ranking system to prioritize BMPs for implementation. This ranking system should take into account both technical information and public concerns.

D) Design, bid and construct BMPs

E) Monitor and maintain BMPs

Examples of BMPs

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

Implementation Timeline: 3 to 10 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: See Objective A1, Action 3, above

Permitting requirements: Likely that local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: See Objective A1 above.

Action A2:3) Educate homeowners about water quality BMPs.

At top and right, examples of residential BMP action; above signs encouraging individual action.

Procedure

A) Coordinate with existing programs designed for landowners, add a water quality BMPs (fertilizer application, low phosphorus soaps, car washing, pet waste, etc.) component and increase educational opportunities in the Ruddiman Creek Watershed.

B) Provide consistent and frequent reminders of what homeowners can do to improve water quality.

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

Implementation Timeline: 3 to 10 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $500 - $1,000.

Permitting requirements: N/A

Pre-implementation needs: N/A

Goals, objectives and actions where hydrolaulic analyses are useful and/or necessary

Goal	Objective	Action	BUI	H&H Needs
Goal A: Improve hydrology and water quality in Ruddiman Creek.	Objective A1) Reduce flashy flows within Ruddiman Creek.	Action A1:1 - Review existing hydrologic analysis and determine data gaps and needs for additional research.	√	
		Action A1:2 - Identify properties and areas in the watershed where stormwater BMPs would be practical and beneficial, including retrofits of existing outfalls, where feasible.	√	
		Action A1:3 - Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1:2 above.	√	
		Action A1:4 -Educate landowners about stormwater BMPs to reduce overland flow of stormwater.		
	Objective A2) Improve water quality of Ruddiman Creek.	Action A2:1 -Continually monitor, identify and eliminate illicit discharges.		
		Action A2:2- Install BMPs that facilitate water quality treatment and where feasible, infiltration.	√	
		Action A2:3- Educate homeowners about water quality BMPs.	√	
Goal B: Restore fish and wildlife habitat within the project area.	Objective B1) Enhance physical aquatic habitat features in the project area.	Action B1:1 - Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.	√	
		Action B1:2- Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.	√	
		Action B1:3 - Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.	√	
		Action B1:4 - Reconfigure the Glenside Boulevard culvert for improved fish passage when it is near the end of its useful life.	√	
	Objective B2) Protect and enhance native submerged aquatic vegetation along the Muskegon Lake shoreline.	Action B2:1 - Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots.	√	
	Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.	Action B3:1 - Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Blvd.		
		Action B3:2 - Expand the riparian and upland buffers along the Muskegon Lake shoreline, and along the bike path.		
		Action B3:3 - Reconfigure the Glenside Avenue culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.	√	
	Objective B4) Restore and enhance existing wetlands throughout the project area.	Action B4:1 - Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.	√	
		Action B4:2 - Explore opportunities for wetland creation at the former AMOCO tank farm site.		
		Action B4:3 - Encourage private landowners to establish native wetland vegetation where it is compatible with future development pland and where proper hydrology and soils exist.		
	Objective B5) Reduce the abundance of invasive plant species in the project area.	Action B5:1 - Conduct invasive species management in the project area.		
		Action B5:2 - provide information to homeowners about invasive species management and the use of native plants in the landscape.		
Goal C: Restore fish and wildlife populations in the project area.	Objective C1) Track the abundance and diversity of native avian, fish, herpetofauna, and macroinvertebrate species in the project area.	Action C1:1 - Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities in the project area.		
Goal D: Permanently protect and conserve existing and restored habitats.	Objective D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.	Action D1:1 – Work with the City of Muskegon to consider stronger protection of 50 acres designated as open space recreation, including the former AMOCO Tank Farm Site, and land on the east side of Ruddiman lagoon.		
		Action D1:2 – Propose and enact conservation zoning for 7 acres of shoreline between the former AMOCO Tank Farm Site, and Lakeshore Yacht Club.		
	Objective D2) Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.	Action D2:1 – Initiate discussions with private land owners to determine the types of conservation measures that could increase property value and enhance future development plans.		
		Action D2:2 – Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.		
Goal E: Increase opportunities for recreation, education, and stewardship.	Objective E1) Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing.	Action E1:1 - Explore the feasibility of placing an observation platform within the lagoon.	√	
	Objective E2) Encourage opportunities for active recreation along, and in Ruddiman Creek and the nearby shoreline of Muskegon Lake.	Action E2:1 - Explore the feasibility of placing a boardwalk in the lagoon area.	√	
		Action E2:2 - Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.		
	Objective E3) Promote local stewardship and education opportunities.	Action E3:1- Elicit support from adjacent schools to have students implement and monitor restoration measures.		
		Action E3:2 - Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.		
		Action E3:3 - Maintain and promote research opportunities through GVSU.		
		Action E3:4 - Hold seasonally relevant seminars on the ecology, history, environmental stewardship andr function of the area.		
		Action E3:5 - Encourage construction of informational signage describing local history vegetation and wildlife.		

Goal B) Restore fish and wildlife habitat within the project area.

Overview

As presented in the Exiting Conditions section of this plan, the Muskegon Lake shoreline, Ruddiman Lagoon, and Ruddiman Creek contain a variety of habitat complexes which support, or can support a high degree of biodiversity. Many locations in the project area are not in need of wholesale, ecological restoration actions and may only require minor enhancement to improve habitat conditions.

The Ruddiman Creek corridor contains a range of habitats that are in a state of active succession as vegetation communities and soils recover from the past remediation. Here, focused restoration strategies have been proposed to enhance specific habitat elements (e.g. woody debris enhancement) that will improve ecosystem function. Full restoration is proposed in the more degraded habitats including, the former AMOCO Tank Farm, and the hardened shoreline areas and lacustrine wetlands along Muskegon Lake. These locations contain degraded habitats, or present excellent opportunities for expanding existing natural areas, and re-establishing native species diversity and natural communities.

Objectives

B1) Enhance physical aquatic habitat features within the project area.

B2) Protect and enhance native aquatic vegetation along the Muskegon Lake Shoreline.

B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.

B4) Restore and enhance existing wetlands throughout the project area.

B5) Reduce the abundance of invasive plant species in the project area.

Habitat Enhancements that Target Fish and Benthic Communities

Goal B) Restore fish and wildlife habitat within the project area.

Objective B1) Enhance physical aquatic habitat features in the project area.

Restoration Trajectory: *Provide suitable aquatic habitats including woody debris and naturally sloped, vegetated shorelines to support diverse aquatic wildlife.*

Overview

The general aquatic habitat types that exist in the project area include the Muskegon lakeshore and littoral zone, the shallow open water marsh of the Ruddiman lagoon, and the headwater stream habitats found in Ruddiman Creek. As described in the Existing Conditions section of this plan, each of these areas have suffered from human impacts and will require some habitat enhancement to again support diverse aquatic fauna.

Actions

1) Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.

2) Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.

3) Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.

Concrete Rubble near the mouth of Ruddiman Creek.

Goal B) Restore fish and wildlife habitat within the project area.
Objective B1) Enhance physical aquatic habitat features in the project area.

Action B1:1) Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.

Procedure

A) Explore the feasibility of concrete removal and shoreline recontouring, including permitting, and potential contaminant release.

B) Develop concepts, and construction documents for each area of impacted shoreline that account for wave energy, and ice scour.

C) Bid and construct these projects.

Implementation details

Reference conditions: The Duck Lake and Pentwater Lake shorelines provide good reference for slope and vegetation. Additional engineering measures may be required to maintain stability along the Muskegon Lake shoreline.

Affected area/size: Roughly 4,000LF of concrete shoreline exist in the project area.

Implementation Timeline: 2 to 10 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $420,000 - $1,200,000 (Planning level costs assume no contamination in the fill and no additional remediation requirement.)

Permitting requirements: Local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: Assessment of the lateral extents of concrete fill and analysis of the potential release of contaminants will be required.

Examples of concrete fill and woody debris at Muskegon Lake

Goal B) Restore fish and wildlife habitat within the project area.
Objective B1) Enhance physical aquatic habitat features in the project area.

Action B1:2) Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.

At top, existing debris; above and left, examples of grade control

Procedure

A) Explore the feasibility of debris removal at the Ruddiman mouth, including permitting, and potential contaminant release.

B) Perform engineering studies to determine the appropriate water level to be maintained in the lagoon while considering public opinion and wildlife passage.

C) Develop concepts, and construction documents for a more natural step, cascade, riffle or vane structure that will improve fish passage into Ruddiman lagoon.

Implementation details

Reference conditions: N/A

Affected area/size: 2,500 square feet

Implementation Timeline: 0 to 2 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $10,000 - $40,000
(Planning level costs assume no contamination in the fill and no additional remediation requirement.)

Permitting requirements: Local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: Assessment of the extents of debris and the potential release of contaminants will be required.

Action B1:3) Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.

Procedure

A) Survey the frequency of woody debris along the forested sections of Ryerson Creek and relatively unimpacted reaches of similar size in the Muskegon River watershed.

B) Identify potential locations for placement of woody debris and perform analytical tests of the soils and sediment in these locations.

C) Locate and incorporate woody debris for habitat variability within the remediated areas of the Ruddiman channel, and in the Ruddiman lagoon downstream from Glenside Boulevard.

Examples of large woody debris used for wetland (above) and stream (left) habitat

Implementation details

Reference conditions: Ryerson Creek and tributaries to the Muskegon River

Affected area/size: Ruddiman Corridor

Implementation Timeline: 0 to 2 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $10,000 - $20,000- (Planning level costs assume no contamination identified and no additional remediation requirement.)

Permitting requirements: Local, state and federal permits may be required for work in and around waterways.

Pre-implementation needs: None.

Goal B) Restore fish and wildlife habitat within the project area.
Objective B1) Enhance physical aquatic habitat features in the project area.

Action B1:4) Reconfigure the Glenside Boulevard culvert for improved fish passage when it is near the end of its useful life.

At right, Glenside culvert; above and below, culverts created for improved fish passage

Procedure

A) Explore the feasibility of redesigning the culvert as a bottomless arch, and or bridge over the stream and floodplain.

B) Develop concepts, and construction documents for a structure that will improve fish and wildlife passage within the stream corridor.

C) Bid and construct this structure.

Implementation details

Reference conditions: N/A

Affected area/size: Approximately 4,000 square feet

Implementation Timeline: 20 to 50 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $200,000 - $500,000

Permitting requirements: Local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: Hydrologic study of Ruddiman watershed per Goal A and a study of the local hydraulics at the culvert.

Objective B2) Protect and enhance native littoral and emergent wetland vegetation along the Muskegon Lake shoreline.

Examples of emergent wetland test plot

Restoration Trajectory: *Increase the aerial coverage and diversity of littoral and emergent wetland vegetation.*

Overview

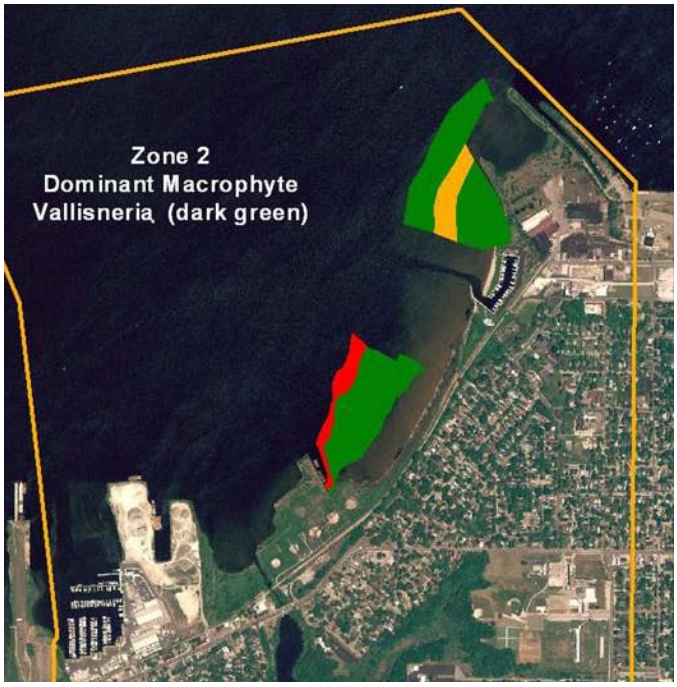
Emergent wetland provides diverse microhabitats for a wide variety of species. Their presence is necessary to support all wildlife, especially a strong fishery. Studies of the Muskegon Lake littoral zone indicate that submerged plant growth has generally decreased during the past ten years. Efforts to increase the aerial coverage and diversity of this vegetation along the lake shoreline should be initiated.

Actions

1) Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots.

Goal B) Restore fish and wildlife habitat within the project area.
Objective B2) Protect and enhance native littoral and emergent wetland vegetation along the Muskegon Lake shoreline.

Action B2:1) Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots.



Site areas for emergent wetland vegetation

Procedure

A) Identify areas suitable for vegetative enhancement.

B) Reconfigure lake sediments and shoreline areas for desired species assemblages.

C) Plant and monitor test plots in each location with a mix of species suitable for each location.

D) Broaden coverage of native aquatic vegetation through expanded plantings.

Implementation details

Reference conditions: Marsh habitats in Duck Lake and Pentwater Lake

Affected area/size: Approximately 56 acres

Implementation Timeline: 3 **to** 5 years

0 1 2 3 4 5 10 15 20+

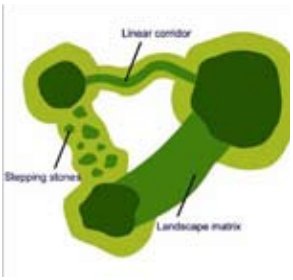
Years from Master Plan adoption

Range of estimated costs: $60,000 - $120,000

Permitting requirements: Local, state and federal permits will be required if lake sediments are reconfigured.

Pre-implementation needs: None.

Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.



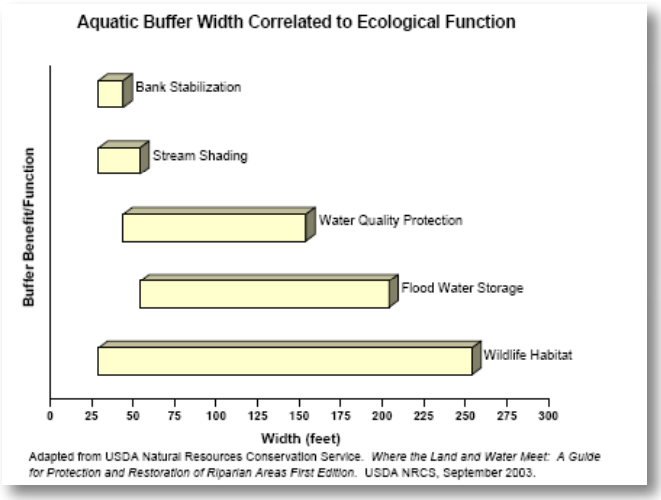
Above, ecological corridor graphic; below, buffer width recommendations

Restoration Trajectory: *Expand all corridors in the project area to meet their full potential for water quality, flood protection, and wildlife habitat.*

Overview

Restoring and expanding riparian buffers in the project area presents a great opportunity to expand and improve terrestrial habitat in the project area. It will also provide the potential to increase biodiversity of wildlife populations by maximizing the width and continuity of vegetative riparian corridors.

Along Ruddiman Creek, riparian buffer enhancement should concentrate on attaining an ecologically-optimal width within McGraft Park, while reducing the acreage of maintained turf grass and gravel parking pad. A filter strip of low meadow vegetation along the lagoon shoreline would slow water flow and filter run-off entering the lagoon. It would also make the area less appealing for nuisance waterfowl like Canada geese. Native vegetation should provide cover to facilitate wildlife migration in the corridor, and human access should be controlled to minimize disturbance. While the gravel parking pad is necessary for large vehicle and overflow parking in the park, small portions of the parking lot could be reconstructed as raingardens to promote infiltration. Greater public education/opinion must also be considered before moving forward with these actions.



Along the Muskegon Lake shoreline and the bike path corridor, native forest plantings should be incorporated where the corridor and lakeside forests are dominated by invasive species, as well as where they are in an early state of succession. Opportunities for forest enhancement exist on the high slopes leading to residential properties, south of the bike path.

Actions

1) Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Boulevard.

2) Expand the riparian and upland buffers along the Muskegon Lake shoreline and along the bike path.

3) Reconfigure the Glenside Boulevard culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.

Ruddiman corridor riparian buffers

Goal B) Restore fish and wildlife habitat within the project area.
Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.

Action B3:1) Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Boulevard.

Procedure

A) Conduct public opinion and education sessions to determine the need for extensive turf grass and parking along Ruddiman Creek and lagoon, and identify areas where the riparian buffer may be expanded.

B) Determine ecological objectives and desired buffer/corridor width.

C) Refer to riparian reference communities along Ryerson Creek and within the Muskegon River watershed for applicable native plant species.

D) Determine the appropriate recreational uses of the area and control access accordingly.

E) Coordinate riparian enhancement efforts with other water quality (Goal A) and habitat improvements (Goal B).

Implementation details

Reference conditions: Riparian and upland habitats along less disturbed portions of Ruddiman Creek, Ryerson Creek and within the Muskegon River watershed.

Affected area/size: Approximately 3 acres

Implementation Timeline: 1 to 5 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $15,000 - $200,000

Permitting requirements: None

Pre-implementation needs: Establish reference sites for the appropriate riparian and upland communities. Coordinate plans with the City Parks Board.

At top, turf grass buffer at Ruddiman Creek; above right, Ruddiman Corridor parking lot; above left, example of pond edge buffer

Goal B) Restore fish and wildlife habitat within the project area.
Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.

Action B3:2) Expand the riparian and upland buffers along the Muskegon Lake shoreline and along the bike path.

Above, existing lake shoreline and Bike path buffer; right, example of nice greenway buffer with bike path

USDA NRCS

Procedure

A) Concurrent with other shoreline habitat improvements in Goal B install selected upland woodland vegetation along the Muskegon Lake shoreline and the bike path.

B) Assess the feasibility for forest buffer enhancement on the high slopes leading to residential properties, south of the bike path.

C) Conduct public opinion and education sessions to promote the benefits forested buffers along private properties.

Implementation details

Reference conditions: Upland habitats along the less disturbed portions of Ruddiman Creek, the Duck Lake shoreline and Pentwater Lake.

Affected area/size: 6 acres

Implementation Timeline: 1 to 5 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $60,000 - $220,000

Permitting requirements: None

Pre-implementation needs: Establish reference sites for the appropriate riparian and upland communities.

Goal B) Restore fish and wildlife habitat within the project area.
Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.

Action B3:3)

Reconfigure the Glenside Boulevard culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.

Procedure

A) Explore the feasibility of redesigning the culvert as a bottomless arch, and or bridge over the stream and floodplain.

B) Develop concepts, and construction documents for a structure that will improve fish and wildlife passage within the stream corridor.

C) Bid and construct this structure.

Example of re-established pond buffer at two years

Implementation details

Reference conditions: N/A

Affected area/size: Approximately 4,000 square feet

Implementation Timeline: 20 to 50 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $200,000 - $500,000

Permitting requirements: Local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: Hydrologic study of Ruddiman watershed per Goal A and a study of the local hydraulics at the culvert.

Objective B4) Restore and enhance existing wetlands throughout the project area.

At top, east side of Ruddiman Lagoon; above and center, examples of wetland enhancement and construction

Restoration Trajectory: *Increase the amount and diversity of wetlands in the project area by restoring "Great Lakes Marsh" wetlands in areas covered by concrete fill and rehabilitating lacustrine wetlands along the shore of Muskegon Lake and within the former AMOCO tank farm site. Other known wetlands should be protected and/or enhanced.*

Overview

Wetlands have long been recognized as essential habitat for many species of fish and birds that utilize these areas for forage and cover, resting and breeding. In addition, wetlands provide natural "cleansing" of waters through the process of denitrification and nutrient uptake.

Historically, the Muskegon Lake shoreline and littoral zone were likely one of many Great Lakes Marsh habitats. Once the concrete debris has been removed, much of the area along the shoreline would be ideal for re-introducing this type of habitat. There are also large wetlands between the former AMOCO tank farm and the Lakeshore Yacht Club. These are largely a mosaic of common reed, and cattail. Restoring and enhancing these wetlands according to the other objectives in Goal B will greatly improve wildlife habitat and ecological function.

The feasibility of expediting the remediation of the former AMOCO tank farm site must be explored. A large wetland complex would provide the greatest habitat benefit in this area. The stakeholders and general public must determine whether it is more important to remediate this area and provide wetland enhancements, or to conduct surface remediation (capping) and focus habitat restoration efforts in other areas.

Phytoremediation offers great potential to remediate the remaining BTEX/PAH, cadmium, chromium, PCBs and lead which may be occurring along the Muskegon Lake shoreline in the area of the former AMOCO tank farm. Phytoremediation is the process of using plants to stabilize and/or remove low-moderate level contaminants from water and soils. Phytoremediation can and also provide direct habitat benefits during the remediation process that are not possible with other methods.

This technique consists of a collection of four different mechanisms of action for the remediation of polluted soil or water.

- **Phytovolatilization:** Plants take up water and organic contaminants through the roots, transport them to the leaves, and release the contaminants as a reduced mixture of detoxified vapor into the atmosphere.

- **Phytostabilization:** Plants prevent contaminants from migrating by reducing runoff, surface erosion, and ground-water flow rates. "Hydraulic pumping" can occur when tree roots reach ground water, take up large amounts of water, control the hydraulic gradient, and prevent lateral migration of contaminants within a ground water zone.

- **Phytoaccumulation/extraction:** Plant roots can remove metals from contaminated sites and transport them to

leaves and stems for harvesting and disposal or metal recovery through smelting processes.

- **Phytodegradation by plants:** Organic contaminants are absorbed inside the plant and metabolized (broken down) to non-toxic molecules by natural chemical processes within the plant. **Indirect microorganism stimulation:** Plants excrete and provide enzymes and organic substances from their roots that stimulate growth of microorganisms such as fungi and bacteria. The microorganisms in the root zone then metabolize the organic contaminants.

Phytoremediation has been used successfully for remediation in many locations and it is generally considered to be a cost-effective, environmentally friendly method of remediating low-moderate level contaminated areas. It is an alternative to more aggressive techniques such as sediment excavation. For example, the cost of cleaning up one acre of sandy loam soil at a depth of 50cm with plants is estimated at $60,000-$100,000 compared to $400,000 for the conventional excavation and disposal method.

The phytoextraction of heavy metals such as Cadmium (Cd), Chromium (Cr) and Lead (Pb) is a viable option of remediating metal-laden soils. Addition of chelators such as organic acids to alter soil pH, fertilizing appropriately with NH4, K and P, investigating mycorrhizal and microbe roles and perhaps utilizing biotechnology to increase biomass of plants and/or increase accumulation in high-biomass species are all proven methods of improving heavy metal-phytoextraction.

The phytoremediation of BTEX/PAH occurs through volatilization through the processes of evapotranspiration within the plant, hydraulic control and uptake of liquid contaminant, degradation of compounds within the plants metabolic processes, and decomposition by microbial populations feeding on plant root byproducts. Phytoremediation of BTEX/PAH contamination in shallow groundwater areas (-5 ft) are some of the most feasible phytotechnologies available.

After the former AMOCO tank farm site has been remediated, the feasibility of establishing a larger wetland complex between the Ruddiman Creek mouth and Lakeshore Yacht Club should be explored. Two emergent species of plants potentially targeted for re-establishment are American lotus (*Nelumbo lutea) and wild rice (Zizania palustris);* however, opportunities for establishing other native species should be explored.

Wild Rice

The historically important emergent macrophyte wild rice (*Zizania aquatica*) was a characteristic wetland plant species found in the region. Declines in this species have been due to human habitat manipulation, perturbations from carp and Canada geese, increased turbidity, contaminant impacts, and displacement by invasive non-native species such as purple loosestrife. It is a vital food source for migratory waterfowl. It is found in sheltered, shallow water (1.5-3 feet deep), low energy wetland systems with a silty substrate (Eggers and Reed, 1997).

Actions

1) Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.

2) Explore opportunities for wetland creation at the former AMOCO tank farm site.

3) Encourage private landowners to establish native wetland vegetation where it is compatible with current zoning, future development plans, and where proper hydrology and soils exist.

Goal B) Restore fish and wildlife habitat within the project area.
Objective B4) Restore and enhance existing wetlands throughout the project area.

Action B4:1)

Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.

Procedure

A) Remove concrete shoreline according to Objective B1, Action 1.

B) Remove invasive species according to Objective B5.

C) Plant and monitor test plots in each location with a mix of species suitable for each location.

D) Plant native emergent littoral vegetation according to Objective B2:1, and other native wetland vegetation in existing wetland areas.

Above, Ruddiman marsh area; right, example of healthy marsh

Implementation details

Reference conditions: Marsh and wetland habitats in Duck Lake and Pentwater Lake

Affected area/size: Approximately 7 acres

Implementation Timeline: 3 to10 years and ongoing

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $70,000 - $140,000

Permitting requirements: Local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: All pre-implementation tasks in Goal B (e.g. concrete removal and invasive species management).

Goal B) Restore fish and wildlife habitat within the project area.
Objective B4) Restore and enhance existing wetlands throughout the project area.

Action B4:2) Explore opportunities for wetland creation at the former AMOCO tank farm site

Examples of healthy wetlands

Procedure

A) Conduct a feasibility study to determine the most appropriate remediation measure for the site (e.g. phytoremediation, excavation and disposal, or capping).

B) Discuss costs and timelines with stakeholders and representatives from the City of Muskegon.

C) Determine the feasibility of creating a contiguous wetland complex from the mouth of Ruddiman Creek to the Lakeshore Yacht Club.

Implementation details

Reference conditions: Marsh and wetland habitats in Duck Lake and Pentwater Lake

Affected area/size: Approximately 30 acres

Implementation Timeline: 3 to 20 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $2.0 - $10.0 million

Permitting requirements: Hazardous disposal permits, local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: Remediation of the former AMOCO tank farm site.

Goal B) Restore fish and wildlife habitat within the project area.
Objective B4) Restore and enhance existing wetlands throughout the project area.

Action B4:3)

Encourage private landowners to establish native wetland vegetation where it is compatible with current zoning, future development plans, and where proper hydrology and soils exist.

Established wet swale at private residence

Procedure

A) Continue dialogue with the owners of R.C. Productions and the Lakeshore Yacht Club, Michigan Steel, Coles Marina, and the Achterhoff family to encourage them to explore options for establishing and/or enhancing wetland habitat on their properties.

B) If approved, establish and/or enhance wetland habitats according to landowner expectations.

Implementation details

Reference conditions: Marsh and wetland habitats in Duck Lake and Pentwater Lake

Affected area/size: 17 acres

Implementation Timeline: 1 to 5 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $35,000 - $75,000

Permitting requirements: Local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: Landowner buy-in.

Objective B5) Reduce the abundance of invasive plant species in the project area.

Restoration Trajectory: *Reduce the threat from exotic invasive plant species and restore target assemblages of native plant communities in Ruddiman Creek and Nearby Shoreline.*

Overview

Invasive plant species are a major threat to the long term ecosystem sustainability across most habitats in the project area. Prior to restoration activities in the project area, it is imperative to undertake a comprehensive invasive species inventory and create an invasive species management plan that accounts for continued adaptive management of invasive species in the project area. This includes baseline assessment, monitoring, active control, passive control, and the combination of invasive species management with other projects such as wetland restoration, and reforestation.

Priority invasive species targeted for control are common reed (*Phragmites australis*), narrow-leaf cattail (*Typha angustifolia*), Japanese knotweed (*Polygonum cuspidatum*), and tartarian honeysuckle (*Lonicera tartarica*). Other infestations of purple loosestrife (*Lythrum salicaria*) and glossy buckthorn (*Rhamnus frangula*) should be monitored. Stands of common reed and narrow-leaf cattail dominate the wetlands between the former AMOCO tank farm site and Lakeshore Yacht Club, while Japanese knotweed is common in the upstream portions of Ruddiman Creek near Barclay Avenue. Tartarian honeysuckle is a common shrub in all upland areas and on the edge of the Ruddiman Creek floodplain.

Actions

1) Conduct invasive species management in the project area.

2) Provide information to homeowners about invasive species management and the use of native plants in the landscape.

Goal B) Restore fish and wildlife habitat within the project area.
ObjectiveB5) Reduce the abundance of invasive plant species in the project area.

Action B5:1) Conduct invasive species management in the project area.

Procedure

A) Perform invasive species inventory and mapping using field surveys.

B) Create an invasive species management plan that details the control method for each species, is compatible with the restoration goals of each area, and includes monitoring and adaptive management including maintenance treatment where necessary.

C) Educate maintenance workers about invasive species and practices that can limit their proliferation.

Common invasive species clockwise from top: japanese knotweed, reed canary grass and purple loosestrife

Implementation details

Reference conditions: N/A

Affected area/size: Project area

Implementation Timeline: 1 to 5 years and ongoing

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $7,000 - 10,000 for the inventory

$10,000 for the invasive species management plan

$1,200 - $5,000 / acre for control

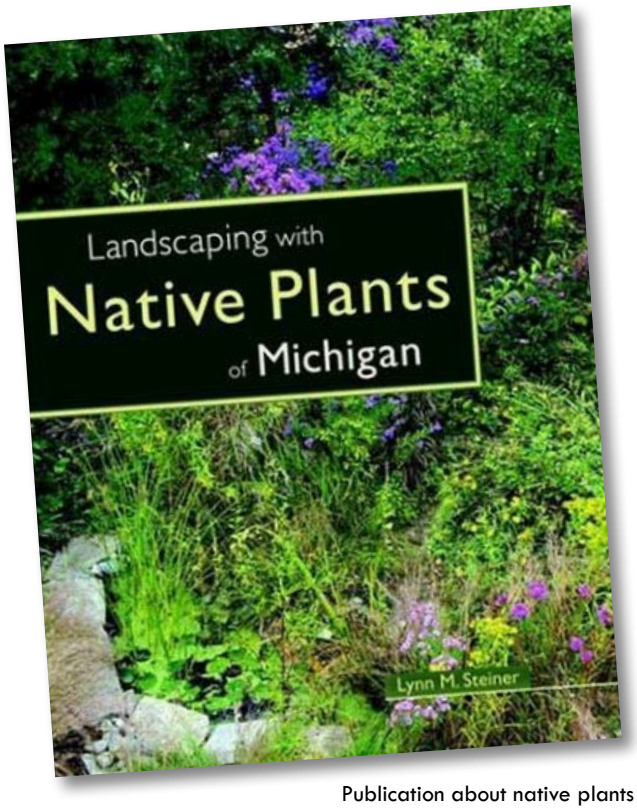
Total Cost is Approximately $50,000

Permitting requirements: Proper applicator licenses of contractor.

Pre-implementation needs: None.

Goal B) Restore fish and wildlife habitat within the project area.
ObjectiveB5) Reduce the abundance of invasive plant species in the project area.

Action B5:2) Provide information to homeowners about invasive species management and the use of native plants in the landscape.



Publication about native plants that could be made available to homeowners for educational purposes

Procedure

A) Create a pamphlet about the invasive species that occur in the project area and include specific management recommendations that homeowners could implement on their property.

B) Host an annual native plant sale in the Ruddiman Creek watershed to promote the use of native plants.

C) Work with local nurseries to provide native plants and assistance for landowners.

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

Implementation Timeline: 3 to 10 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $500 - $1,000

Permitting requirements: N/A

Pre-implementation needs: N/A

Goal C) Restore fish and wildlife populations according to the established vision and guiding principles.

Overview

It is common for ecological restoration plans to include objectives associated with specific fish and/or wildlife species (e.g. rare, threatened, endangered, species of concern, etc.). In this case management actions would be implemented and monitored to track specific population goals. Conversations with local wildlife biologists and stakeholders and, review of existing data did not produce any restoration recommendations for specific populations. Therefore, a primary goal of the Plan is to restore habitat to increase biodiversity and ultimately meet the benthos, and fish and wildlife delisting targets being created by the MLWP. As a result, Goal C is directly focused on monitoring the communities targeted in Goals A and B. Rather than repeat those objectives, the objective below focuses on tracking changes in the associated communities that result from habitat improvements. The data collected from the inventories will be helpful in assessing the impacts of all of the management actions on fish and wildlife populations.

Monitoring should be incorporated into every restoration Action that is implemented, potentially including quantitative indices of vegetation, benthic macroinvertebrate, fish, amphibian and avian communities, qualitative measures of stream and wetland habitat, and monitoring for threats, such as invasive species, and chemical water quality. This information will be reported to the Master Plan managers as the Plan is implemented.

Objectives

C 1) Track the abundance and diversity of avian, fish, herpetofauna and macroinvertebrate species in the project area.

Actions

1) Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities within the project area

Goal C) Restore fish and wildlife populations according to the established vision and guiding principles.

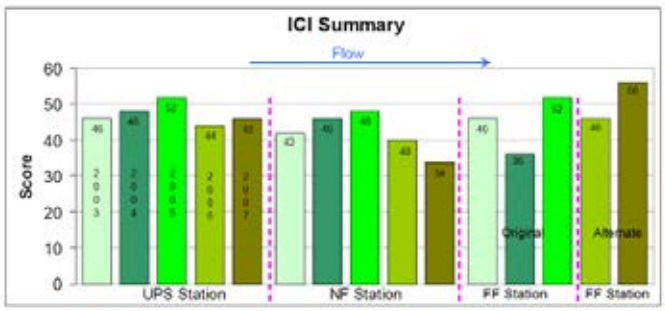
Objective C1)

Track the abundance and diversity of avian, fish, herpetofauna and macroinvertebrate species in the project area.

Restoration Trajectory: *Monitoring results indicate that these communities are meeting established performance criteria for the region.*

Action C1:1)

Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities within the project area.



At top sampling stream communities; mallard; spring peeper; and monitoring results.

Procedure

A) Establish suitable habitats according to Goals A & B.

B) Consult with USFWS and Michigan DNR and Michigan DEQ to identify performance standards for each community that will lead to delisting benthos, and fish and wildlife BUIs.

C) Coordinate with groups mentioned in Goal E below to establish a monitoring program.

Implementation details

Reference conditions: Biocriteria established and agreed upon by the governing agencies and stakeholders.

Affected area/size: the project area

Implementation Timeline: 3 to 10 years with ongoing monitoring

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: Based on Goals A, B, and E

Permitting requirements: Scientific collecting permit.

Pre-implementation needs: Identify leadership for a monitoring program per Goal E below.

Goal D) Permanently protect and conserve existing and restored habitats.

Overview

Within the Ruddiman Creek and Nearby Shoreline project area; there are many areas of open space that are either programmed as parkland, or unprogrammed and not officially used by the public. Many of these areas have a high degree of ecological value, and provide essential habitats for a diverse array of plant and animal species. The continued ecological function of these areas is dependent upon the conservation of these as open spaces to protect the natural communities from direct and indirect disturbance from conversion to urban, suburban, or industrial land uses. In addition, the longevity of areas that are programmed for restoration will be contingent upon the future conservation status of those areas.

There are five zoning categories in the project area. These are General Industrial, Open Space Conservation, Open Space Recreation, Lakefront Recreation, and Waterfront Marine. The rules and requirements of these zoning categories are included as Appendix F. This Goal proposes measures that will enable the long term protection of valuable natural areas that are currently in private ownership, or lands in public ownership that could be subject to future development actions.

Objectives

D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.

D2) Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.

Objective D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.

Restoration Trajectory: *Provide permanent conservation protection for publicly-owned open spaces on the east side of Ruddiman lagoon, and vacant land along the Muskegon Lake shoreline.*

Overview

Approximately 100 acres of land are in the project area are owned by the City of Muskegon and zoned as open space recreation. This zoning designation provides some protection including a 75 foot setback from the ordinary high watermark of waterbodies, it may not provide adequate protection to preserve many natural features. Approximately 30 acres of this land are located on the former AMOCO tank farm site. It is an area identified in Goal B as a potentially important habitat area where a large wetland complex could be created between the Ruddiman mouth and Lakeshore Yacht Club. In addition, there is approximately 20 acres of intact upland forest designated as Open Space Recreation on the east side of the Ruddiman lagoon. Measures to re-designate these areas as more restrictive, Open Space Conservation should be explored in the future.

An additional 7 acres of land along the Muskegon Lake shoreline between the tank farm site, and Lakeshore Yacht Club are not zoned. As further described in section 5.3, this land exists as an emergent wetland that is choked with invasive plant species. It may become completely inundated during cyclical water level fluctuations in Lake Michigan and Muskegon Lake, but has been more exposed in the past few years due to lower lake water levels. If lake water levels continue to decrease, as predicted by global climate models, it is foreseeable that, future development could occur on this land. The City of Muskegon might also consider zoning this land as Open Space Conservation to preserve the natural communities on this land.

Actions

1) Work with the City of Muskegon to consider stronger protection of 50 acres designated as open space recreation, including the former AMOCO Tank Farm Site, and land on the East side of Ruddiman lagoon.

2) Propose and enact conservation zoning for 7 acres of shoreline between the former AMOCO Tank Farm Site, and Lakeshore Yacht Club.

Goal D) Permanently protect and conserve existing and restored habitats.
Objective D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.

Action D1:1)

Work with the City of Muskegon to consider stronger protection of 50 acres designated as open space recreation, including the former AMOCO Tank Farm Site, and land on the east side of Ruddiman lagoon.

Procedure

A) Engage city planning departments and the general public to explore and enact protection.

Implementation details

Reference conditions: N/A

Affected area/size: The former AMOCO Tank Farm Site and east side of Ruddiman lagoon (50 acres).

Implementation Timeline: 0 to 3 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $20,000 - $120,000

Permitting requirements: None

Pre-implementation needs: Public notifications and administrative procedures.

Above, land on the east side of Ruddiman lagoon in need of more restrictive zoning; left, bike path winding through former AMOCO property

Goal D) Permanently protect and conserve existing and restored habitats.
Objective D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.

Action D1:2)

Propose and enact conservation zoning for 7 acres of shoreline between the former AMOCO Tank Farm Site, and Lakeshore Yacht Club.

7 acres of shoreline between the former AMOCO Tank Farm Site and Lakeshore Yacht Club

Procedure

A) Engage city planning departments and the general public to explore and enact protection.

Implementation details

Reference conditions: N/A

Affected area/size: 7 acres

Implementation Timeline: 0 to 3 years

Range of estimated costs: $5,000 - $15,000

Permitting requirements: None

Pre-implementation needs: Public notifications and administrative procedures.

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Objective D2) Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.

Restoration Trajectory: *Provide permanent easements along privately-owned open spaces in the project area.*

Overview

Approximately 34 acres of ecologically-valuable floodplain and forest along Ruddiman Creek both upstream and downstream of Barclay Street are either owned by private residents, and/ or commercial and industrial ventures. These areas provide a wide buffer for Ruddiman Creek, and a corridor for the migration of animals through the open woodland, wetland. Their protection will ensure the continued viability of these habitats, and protection from future development or development-related infrastructure.

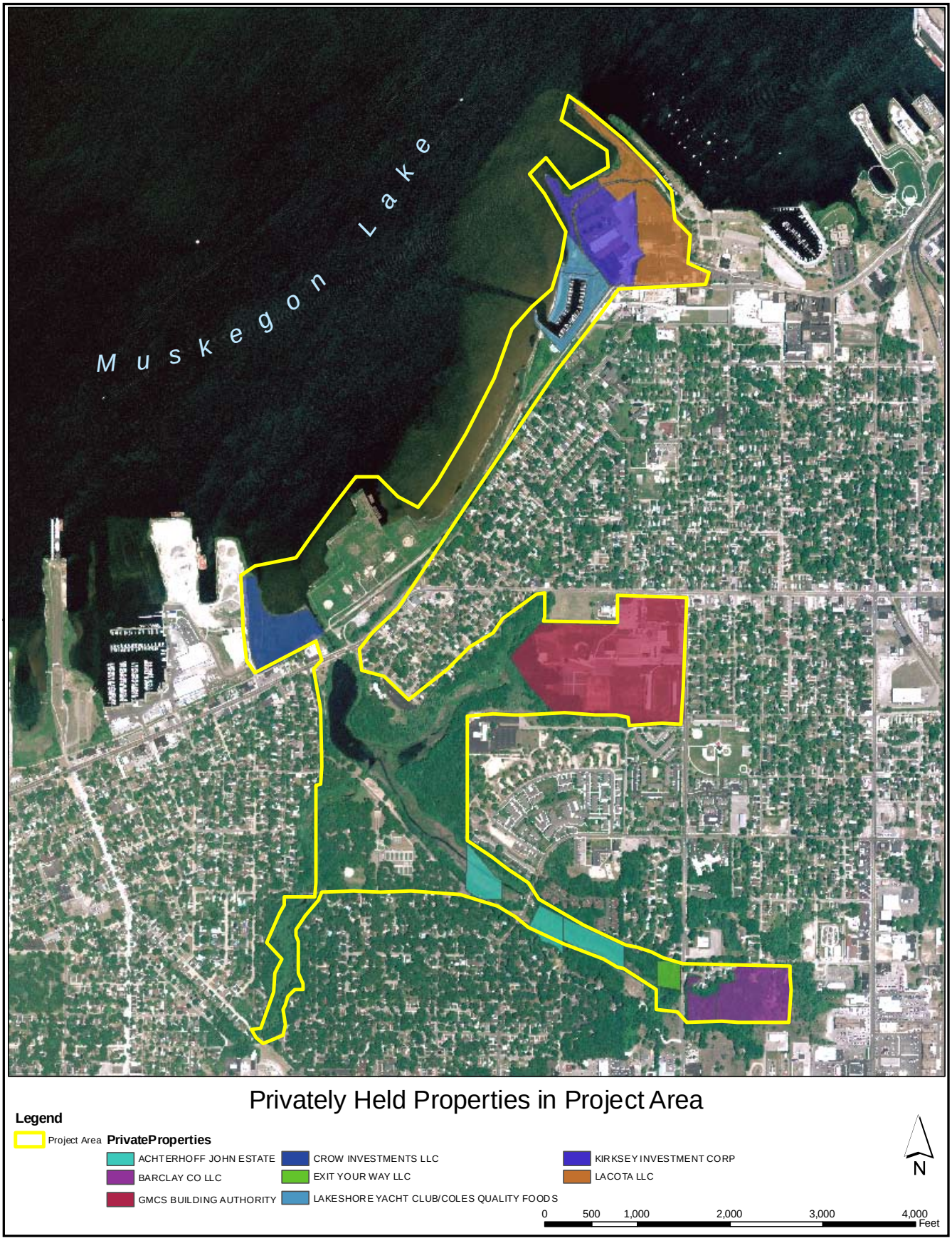
Potentially viable natural areas on privately-owned lands along the Muskegon Lake shoreline include approximately 7 acres on the west side of the Ruddiman Creek mouth, and approximately 10 acres extending from the lakeshore Yacht Club to the eastern land spit associated with Michigan Steel. Discussions with current landowners must be initiated and continue through the life of the master plan to maintain relationships and foster open communication regarding site development plans and potential conservation opportunities. Discussions should focus on conservation measures that could enhance property value and promote sustainable activities on the properties.

Land conservation strategies such as direct acquisition, conservation easement, and land transfers, can be used to facilitate the proposed restoration actions and ultimately place these parcels into permanent protection, without threat of careless development. The Land Conservancy of West Michigan may be able to help facilitate the conservation and protection of these private lands.

Actions

1) Initiate discussions with private landowners to determine the types of conservation measures that could increase property value and enhance future development plans.

2) Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.



Goal D) Permanently protect and conserve existing and restored habitats.
Objective D2) Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.

Action D2:1)

Initiate discussions with private landowners to determine the types of conservation measures that could increase property value and enhance future development plans.

Procedure

A) Begin and maintain a dialogue with existing landowners to foster open communication regarding future site development plans.

B) Educate landowners of sustainable site activities that can improve ecological value and enhance future site development plans.

Above, stakeholder input

Implementation details

Reference conditions: Existing sustainable and regenerative developments.

Affected area/size: West side of the Ruddiman Creek mouth, and parcels on the Muskegon Lake shoreline. Approximately 51 acres.

Implementation Timeline: 0 to 10 years and ongoing

Years from Master Plan adoption

Range of estimated costs: $2,000 - $5,000 annually

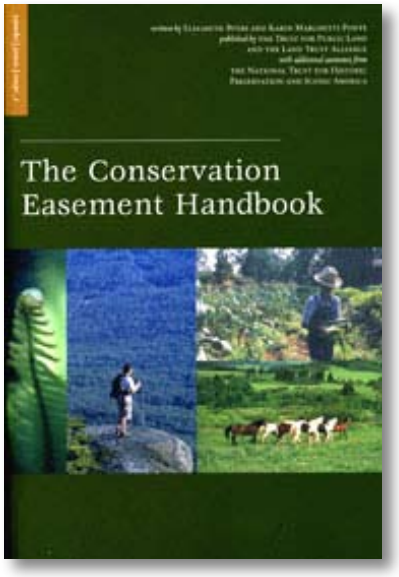
Permitting requirements: None

Pre-implementation needs: None

Goal D) Permanently protect and conserve existing and restored habitats.
Objective D2) Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.

Action D2:2)

Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.



A resource for conservation easements

Procedure

A) Work with the Land Conservancy of West Michigan to educate landowners and facilitate land protection.

B) Purchase lands where possible.

Implementation details

Reference conditions: N/A

Affected area/size: Ruddiman Creek near Barclay Street, and parcels on the Muskegon Lake shoreline. Approximately 51 acres

Implementation Timeline: 0 to 10 years and ongoing

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $25,000 - $70,000 / acre

Permitting requirements: None

Pre-implementation needs: Assessment of property values and discussions with landowners.

Goal E) Increase opportunities for recreation, education, and stewardship.

Overview

Ruddiman Creek and Nearby Shoreline have a history of human use for biking, walking, bird watching, fishing and canoeing/kayaking. Supporting and these activities is a critical element of a successful ecological restoration, as these actions encourage residents to gain knowledge of how their everyday actions affect water quality, human health, and the ecological processes of the landscape in which they live, develop a sense of caring for that environment, prioritize environmental health, and voluntarily modify their behaviors and practices toward more ecologically sustainable options. Long-term ecological sustainability is directly linked to the actions and attitudes of the people that live, work, and play in the landscape. The concept of environmental stewardship is that residents understand the value, care for, and interact meaningfully with their environmental resources, and thus are motivated to make decisions that improve the health of Ruddiman Creek and Nearby Shoreline.

Supporting the existing uses of Ruddiman Creek and Nearby Shoreline and fostering new interaction with the area that encourages education, stewardship and sustainable decisions requires several elements. City of Muskegon citizens are already visiting the area and an established interest in this place as a site for recreation and relaxation exists. The next step is to expand awareness of the area, provide passive and active educational opportunities, expand options for engagement with the area, and plan for the site so that it can meet the vision of its residents.

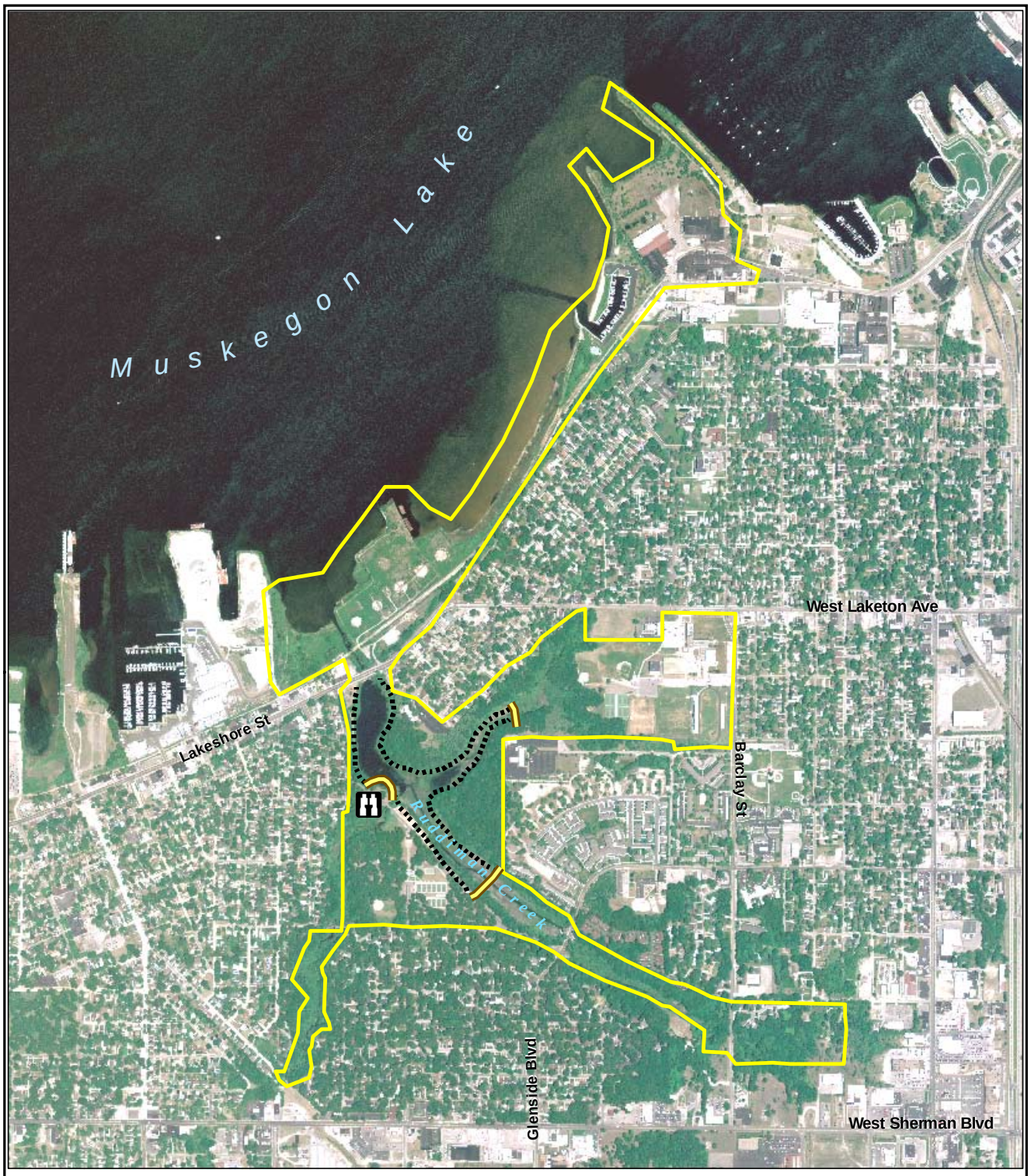
An effective public education and stewardship program includes both informative and interactive techniques of teaching. To be most successful, these educational experiences should be supplemented by opportunities for interaction with the natural environments that the Ecological Restoration Master Plan endeavors to protect and restore. To ensure widespread application and complete information throughout the watershed, the effort needs a coordinated approach in which the programs and activities of different providers are integrated. Ultimately, these educational and stewardship efforts aim to both harness the existing knowledge of local stakeholder and also increase their "capacity" to effectively advocate for the restoration of the area. By implementing the full suite of recommendations in this Master Plan, the future of the Muskegon lake and Ruddiman Creek can be one that is ecologically, culturally, and economically beneficial.

Objectives

E1) Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing.

E2) Encourage opportunities for active recreation along, and in Ruddiman Creek and the Nearby Shoreline of Muskegon Lake.

E3) Promote local stewardship and education opportunities.



Objective E1) Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing

Restoration Trajectory: *Increase number and quality of passive recreation opportunities along the Ruddiman Creek and Nearby Shoreline area that inspire stewardship.*

Overview

During the initial stakeholder meetings, the importance of viewing wildlife and habitat in the area was clear: People enjoy the area to look at the water, watch the birds that migrate through and simply appreciate the beauty of the area. Now that the area has been remediated, ensuring that the Ecological Restoration Master Plan provides continued opportunity for passive recreation is critical.

The existing bike trail serves as a key pathway along which passive recreation opportunities can be expanded via observation decks, benches and interpretative signage. While the lagoon is currently not part of the bike trail, creating opportunities for viewing the wildlife off the trail can encourage visitors to interact with a larger portion of the Ruddiman Creek and Nearby Shoreline project area in a sustainable manner. Providing a combination of methods to enable passive recreational activities throughout the area will encourage connection between the restored areas, appreciation for the location, and access for a variety of human and wildlife populations.

Actions

1) Explore the feasibility of placing an observation platform within the lagoon.
2) Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.

Goal E) Increase opportunities for recreation, education, and stewardship.
Objective E1) Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing

Action E1:1) Explore the feasibility of placing an observation platform within the lagoon.

Passive recreation and observation opportunities

Procedure

A) Work with local stakeholders and Fish & Wildlife Service members to identify best location for a platform that will allow for minimally invasive and disruptive viewing.

B) Work with City of Muskegon officials to determine necessary permits and permissions.

Implementation details

Reference conditions: N/A

Affected area/size: Ruddiman Lagoon

Implementation Timeline: 0 to 3 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $4,000 - $8,000

Permitting requirements: Local, state and federal permits may be required for work in and around waterways.

Pre-implementation needs: None

Goal E) Increase opportunities for recreation, education, and stewardship.

Objective E2) Encourage opportunities for active recreation along and in Ruddiman Creek and the Nearby Shoreline of Muskegon Lake.

Restoration Trajectory: *Work with local stakeholders to increase the variety and quality of active recreation opportunities such as biking, canoeing, kayaking,, hiking and general play along and in Muskegon lakeshore.*

Overview

People appreciate this area not only for the passive and reflective opportunities it provides, but also but for the chance to get outdoors and actively engage in their environment. The more opportunities for recreational activities that are sustainable, responsible and promote stewardship, the more people who will come to Ruddiman Creek and Nearby Muskegon Lake Shoreline, appreciate what it has to offer, and have a vested interest in maintaining its vitality.

The existing bike and pedestrian greenway link is both a solid example of one of the many ways people enjoy the area and a launching point from which to explore other options for recreation. Additional hiking/walking trails and wildlife observation areas could be established within the public property of Ruddiman lagoon and the Ruddiman corridor.

Actions

A) Explore the feasibility of placing a boardwalk in the lagoon area.

B) Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.

Opportunities for active recreation like fishing can be encouraged in certain areas.

Goal E) Increase opportunities for recreation, education, and stewardship.
Objective E2) Encourage opportunities for active recreation along and in Ruddiman Creek and the Nearby Shoreline of Muskegon Lake.

Action E2:1) Explore the feasibility of placing a boardwalk in the lagoon area.

Boardwalk example

Procedure

A) Engage local stakeholders and Fish and Wildlife Service to consider appropriate location, width and sustainable materials.

B) Evaluate how construction can avoid compromising habitat or wildlife movement.

Implementation details

Reference conditions: N/A

Affected area/size: Ruddiman Creek Lagoon and potentially along Ruddiman Creek

Implementation Timeline: 3 to 5 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $50,000 - $200,000

Permitting requirements: Local, state and federal permits may be required for work in and around waterways.

Pre-implementation needs: None

Goal E) Increase opportunities for recreation, education, and stewardship.
Objective E2) Encourage opportunities for active recreation along and in Ruddiman Creek and the Nearby Shoreline of Muskegon Lake.

Action E2:2)

Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.

Existing path on Ruddiman west Branch

Procedure

A) Coordinate with stakeholders, USFWS and Michigan DNR to establish location and size of trails that are minimally invasive and disruptive.

B) Educate maintenance workers about proper trail and boardwalk maintenance.

Implementation details

Reference conditions: N/A

Affected area/size: 1 to 2 miles

Implementation Timeline: 3 to 5 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $200,000 - $1,200,000

Permitting requirements: Construction permits required.

Pre-implementation needs: None

Objective E3) Promote local stewardship and education opportunities.

Examples of community stewardship and education opportunities

Restoration Trajectory: *Throughout the duration of the ecological restoration and beyond, create a tradition of student and public involvement with and education about the Ruddiman Creek and Nearby Shoreline areas.*

Overview

The drive to remediate and restore this area flows from many different sources. One of them is the desire to have a natural area in which children can play and from which students can learn. Much enthusiasm for a place can arise from casual interaction with it. A deeper sense of understanding, interest in stewardship and curiosity about ecological processes comes from classroom and life experiences that integrate learning, problem solving, and service activities with students' natural surroundings. Incorporating local knowledge of the area into classroom science and service curricula can be a meaningful way to learn about the shaping and preservation of landscapes.

Actions

1) Elicit support from adjacent schools to have students implement and monitor restoration measures.

2) Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.

3) Maintain and promote research opportunities through GVSU.

4) Hold seasonally relevant seminars on the ecology, history, environmental stewardship, or function of the area.

5) Encourage construction of informational signage describing local history vegetation and wildlife.

Goal E) Increase opportunities for recreation, education, and stewardship.
Objective E3) Promote local stewardship and education opportunities.

Action E3:1) Elicit support from adjacent schools to have students implement and monitor restoration measures.

The White Pine Partnership (Muskegon Area Intermediate School District, Muskegon Conservation District, the Muskegon Chamber of Commerce, and the Odawa Native Americans, Little River Band) has developed education and stewardship programs that incorporate native teachings, local history, including the movement of humans along the landscape, and their impacts and cultural interactions. They have also developed curricula for educating about local natural resources and their influence on the economy. Once restored, the Ruddiman corridor and Muskegon lakeshore bike path make excellent backdrops for programs developed by the White Pine Partnership that teach these principles and help the students develop relationships with their community and the natural world.

The Greater Muskegon Catholic Schools have also expressed interest in education and stewardship activities. Muskegon Catholic Central High School and the surrounding property cover 44 acres on the northeast side of the watershed. The teachers currently use the property for environmental education, and teachers and administrators have discussed the possibility constructing a science, math and education facility near the stream. Such a facility would provide a "hands on" experience for exploration of renewable energies, impact on the environment and green principles. It would be available to all for study, and for education and meeting purposes. Greater Muskegon Catholic Schools' prominent location in the watershed makes them ideal leaders in developing education and outreach programs based in science education and watershed stewardship. The schools' teachers and administrators can play an important role in demonstrating and guiding the local community toward upland activities have a direct positive impact on the condition of Ruddiman Creek, the lagoon, the water quality of Muskegon Lake, and the quality of life in Muskegon.

Local businesses can also fund education programs through internships and scholarships based in community involvement and environmental awareness.

Procedure

A) Identify coordinator to run student programs.

B) Identify restoration opportunities and attributes that students could implement and monitor.

C) Categorize opportunities into age-appropriate groupings.

Implementation details

Reference conditions: N/A

Affected area/size: the project area

Implementation Timeline: 1 to 10 years and ongoing

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $20,000 - $50,000/year (number will increase depending on the scope and complexity of the activities)

Permitting requirements: None

Pre-implementation needs: None

Students assisting in stewardship activities

Goal E) Increase opportunities for recreation, education, and stewardship.
Objective E3) Promote local stewardship and education opportunities.

Action E3:2) Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.

There are groups poised to monitor the restoration of Ruddiman Creek and the Muskegon Lake shoreline. Currently, avian and amphibian communities are being monitored using methodologies created by Bird Studies Canada's, Great Lakes Volunteer Marsh Monitoring Program. Scientists at Grand Valley State University (GVSU) are monitoring fish and macroinvertebrate communities in the project area and an Environmental Biology Course aimed at monitoring restoration projects has been launched at Muskegon Community College. The Great Lakes Coastal Wetlands Consortium can also provide support for these monitoring efforts, including funding, research leadership, and database management to track restoration efforts and guide maintenance activities.

Stream monitoring

Procedure

A) Make use of any and all contacts with fellow environmental groups, local experts and volunteers.

B) Coordinate activities with the Great Lakes Coastal Wetlands Consortium and local monitoring programs affiliated with the Muskegon Lake Watershed Partnership.

C) Identify leaders and select features to be collaboratively monitored.

Implementation details

Reference conditions: N/A

Affected area/size: the project area

Implementation Timeline: 0 to 10 years and ongoing

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $10,000 - $80,000 annually

Permitting requirements: Scientific collections permits

Pre-implementation needs: Identify leadership for a monitoring program.

Goal E) Increase opportunities for recreation, education, and stewardship.
Objective E3) Promote local stewardship and education opportunities.

Action E3:3) Maintain and promote research opportunities through GVSU.

The Grand Valley State University, Annis Water Resources Institute

University students are a particularly important group to involve in local restoration efforts. They are at the age to better understand a range of influences on current conditions of an area. Furthering the influential role a hands-on project can play in developing their academic and career interests is one benefit of connecting students with restoration efforts. There is a great need for individuals trained in the prevention, remediation, restoration, and monitoring of contaminated sites.

Procedure

A) Continue partnerships with GVSU departments and faculty.

B) Coordinate efforts between faculty, student and restoration stewards to develop and maintain projects that can facilitate restoration measures (e.g. hydrologic studies and vegetative assessments).

Implementation details

Reference conditions: N/A

Affected area/size: the project area

Implementation Timeline: 0 to 10 years and ongoing

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $5,000 - $10,000 annually

Permitting requirements: None

Pre-implementation needs: None

Goal E) Increase opportunities for recreation, education, and stewardship.
Objective E3) Promote local stewardship and education opportunities.

Action E3:4)

Hold seasonally relevant seminars on the ecology, history, environmental stewardship, or function of the area.

Procedure

A) Contact exiting nature centers and State Parks in the area to discuss existing programs and ideas, partnering if appropriate.

B) Identify coordinator to design and lead seminars/hikes.

C) Identify sponsors and create a program calendar.

Workshop seminar

Implementation details

Reference conditions: N/A

Affected area/size: Muskegon County and outside areas.

Implementation Timeline: 1 to 10 years and ongoing

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $2,500 - $10,000

Permitting requirements: None

Pre-implementation needs: None

Goal E) Increase opportunities for recreation, education, and stewardship.
Objective E3) Promote local stewardship and education opportunities.

Action E3:5) Encourage construction of informational signage describing local history vegetation and wildlife.

Educational signage

Procedure

A) Designate potential locations for signs

B) Determine number of signs desired

C) Draft verbiage and graphics for signs

D) Create signs out of sustainable material and secure in minimally invasive manner

Implementation details

Reference conditions: N/A

Affected area/size: Locations along Bike Trail and Ruddiman Creek

Implementation Timeline: 0 to 3 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: $5,000 - $20,000

Permitting requirements: None

Pre-implementation needs: None

3.2 Alleviating Threats to Ecological Integrity

Currently, the project area exists in an extremely altered ecological condition compared to what occurred in pre-industrial times. Despite these changes and influences, diverse natural communities exist, while still others can be established in the current landscape matrix. Maintaining the stability and viability of the natural communities in the project area will depend on managing ongoing threats to ecological sustainability.

The goals, objectives and actions previously described in this plan have been created to address the BUIs, as well as to minimize future threats to ecological integrity and ecosystem viability.

Potential ecological threats in the project area identified in section 5.8 include:

- Impacts from urban hydrology (high discharge, erosion, and pollutants)
- Fluctuating lake levels and wave action
- Invasive vegetation and wildlife
- Impacts from recreational use
- Poorly planned development
- Global climate change

The table below demonstrates how threats will be minimized by following the actions presented in this master plan.

Threats to Ecological Integrity

Stressor	Potential Ecosystem Impact	Proposed Objectives for Mitigating Threats
Impacts from urban hydrology	Higher flood levels, discharges and velocities. Increased pollution and decreased water quality Stress to aquatic organisms	A1) Reduce flashy flows within Ruddiman Creek. A2) Improve water quality within Ruddiman Creek
Fluctuating lake levels and wave action	Habitat alteration from reduced access to water Displacement of wetland communities Wind and boat induced waves	B1) Enhance physical aquatic habitat features in the project area. B2) Protect and enhance native aquatic vegetation along the Muskegon Lake shoreline. B4) Restore and enhance existing wetlands throughout the project area.
Invasive vegetation and wildlife	Loss of habitat variability/diversity Displacement of native species Direct destruction and consumption of native species Altering natural processes (hydrology nutrients)	B1) Enhance physical aquatic habitat features in the project area. B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area. B4) Restore and enhance existing wetlands throughout the project area. B5) Reduce the abundance of invasive plant species in the project area. E3) Promote opportunities for stewardship and education.
Impacts from recreational use	Litter and debris Light and noise pollution Pet predation / disturbance Erosion from trail usage	D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat. D2) Encourage major private landowners to establish permanent easements. E3) Promote opportunities for stewardship and education.
Poorly Planned Development	Direct displacement of natural communities. Alteration of watershed hydrology. Degradation of stream channel conditions. Increase in potential pollution sources.	A1) Reduce flashy flows within Ruddiman Creek. A2) Improve water quality within Ruddiman Creek D1) Place publicly held properties into permanent easements that protect and conserve restored and existing wildlife habitat. D2) Encourage major private landowners to establish permanent easements that protect and conserve restored and existing wildlife habitat.
Global climate change	Increased air temperatures Decreased precipitation Decreased lake levels Alteration of vegetation community composition and distribution Stress to aquatic organisms	The impact of all the restoration objectives and actions in the Plan serve to improve water quality, increase habitat complexity, and species diversity. Such a community may be better able to contend with climate change.

Goal	Objective	Action	BUI		
			Loss of fish and wildlife habitat	Degradation of fish and wildlife populations	Degradation of benthos
Goal A: Improve hydrology and water quality in Ruddiman Creek.	Objective A1) Reduce flashy flows within Ruddiman Creek.	Action A1:1 - Review existing hydrologic analysis and determine data gaps and needs for additional research.	√		
		Action A1:2 - Identify properties and areas in the watershed where stormwater BMPs would be practical and beneficial, including retrofits of existing outfalls, where feasible.	√		
		Action A1:3 - Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1:2 above.	√		√
		Action A1:4 -Educate landowners about stormwater BMPs to reduce overland flow of stormwater.	√		√
	Objective A2) Improve water quality of Ruddiman Creek.	Action A2:1 -Continually monitor, identify and eliminate illicit discharges.	√		
		Action A2:2- Install BMPs that facilitate water quality treatment and where feasible, infiltration.	√		√
		Action A2:3- Educate homeowners about water quality BMPs.	√		√
Goal B: Restore fish and wildlife habitat within the project area.	Objective B1) Enhance physical aquatic habitat features in the project area.	Action B1:1 - Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.	√	√	√
		Action B1:2- Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.	√	√	√
		Action B1:3 - Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.	√	√	√
		Action B1:4 - Reconfigure the Glenside Boulevard culvert for improved fish passage when it is near the end of its useful life.	√	√	
	Objective B2) Protect and enhance native submerged aquatic vegetation along the Muskegon Lake shoreline.	Action B2:1 - Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots.	√		√
	Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.	Action B3:1 - Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Blvd.	√	√	
		Action B3:2 - Expand the riparian and upland buffers along the Muskegon Lake shoreline, and along the bike path.	√	√	
		Action B3:3 - Reconfigure the Glenside Avenue culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.	√	√	
	Objective B4) Restore and enhance existing wetlands throughout the project area.	Action B4:1 - Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.	√	√	√
		Action B4:2 - Explore opportunities for wetland creation at the former AMOCO tank farm site.	√	√	
		Action B4:3 - Encourage private landowners to establish native wetland vegetation where it is compatible with future development pland and where proper hydrology and soils exist.	√	√	
	Objective B5) Reduce the abundance of invasive plant species in the project area.	Action B5:1 - Conduct invasive species management in the project area.	√		
		Action B5:2 - provide information to homeowners about invasive species management and the use of native plants in the landscape.	√		
Goal C: Restore fish and wildlife populations in the project area.	Objective C1) Track the abundance and diversity of native avian, fish, herpetofauna, and macroinvertebrate species in the project area.	Action C1:1 - Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities in the project area.	√	√	√
Goal D: Permanently protect and conserve existing and restored habitats.	Objective D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.	Action D1:1 – Work with the City of Muskegon to consider stronger protection of 50 acres designated as open space recreation, including the former AMOCO Tank Farm Site, and land on the east side of Ruddiman lagoon.	√		
		Action D1:2 – Propose and enact conservation zoning for 7 acres of shoreline between the former AMOCO Tank Farm Site, and Lakeshore Yacht Club.	√		
	Objective D2) Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.	Action D2:1 – Initiate discussions with private land owners to determine the types of conservation measures that could increase property value and enhance future development plans.	√		
		Action D2:2 – Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.	√		
Goal E: Increase opportunities for recreation, education, and stewardship.	Objective E1) Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing.	Action E1:1 - Explore the feasibility of placing an observation platform within the lagoon.			
	Objective E2) Encourage opportunities for active recreation along, and in Ruddiman Creek and the nearby shoreline of Muskegon Lake.	Action E2:1 - Explore the feasibility of placing a boardwalk in the lagoon area.			
		Action E2:2 - Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.			
	Objective E3) Promote local stewardship and education opportunities.	Action E3:1- Elicit support from adjacent schools to have students implement and monitor restoration measures.	√		
		Action E3:2 - Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.		√	√
		Action E3:3 - Maintain and promote research opportunities through GVSU.	√	√	√
		Action E3:4 - Hold seasonally relevant seminars on the ecology, history, environmental stewardship andr function of the area.			
		Action E3:5 - Encourage construction of informational signage describing local history vegetation and wildlife.			

3.3 Addressing the Beneficial Use Impairments

There are nine recognized BUIs for the Muskegon AOC. This Ecological Restoration Master Plan directly addresses three habitat-related BUIs, including "loss of fish and wildlife habitat", "degradation of fish and wildlife populations", and "degradation of benthos" in the Ruddiman Creek and Muskegon Lakeshore project area.

The table below demonstrates the linkages between ecological restoration activities recommended within Ruddiman Creek, along the shoreline of Muskegon Lake, and the BUIs they address. Quantitative delisting criteria for the habitat-related BUIs are currently being developed.

3.4 Ecological Benchmarks and the Adaptive Management Framework

Because natural communities undergo a process of maturation, succession, and diversification over time, it will take some years between initial ecosystem restoration efforts and the final development of resilient, diverse ecosystems that contain the full suite of attributes expressed in the "guiding principles". Continual post-project monitoring by qualified restoration ecologists will allow the measurement, documentation and ranking of this progression over time. Each habitat type will have different restoration trajectories, defined by their reference ecosystems and standard indices, and so the benchmarks for this progression will be distinct for each community. The "success" of restoration actions can be determined through the evaluation of post-project monitoring data, and the use of ecological reference information to determine if ecosystem succession is occurring along the desired trajectory. Feedback from monitoring efforts will inform decisions on adjusting restoration actions and even the trajectories depending on the response of the system. Monitoring data can also be used to modify the timing of restoration actions, using adaptive management as necessary to maintain a logical sequence of restoration activities (e.g. invasive species must be treated before native plants are established).

The restoration of a particular ecosystem component is completed when it has been determined that the desired restoration trajectory has been fulfilled, including:

- The quantity or extent of the desired ecosystem element has been established.
- The restored ecosystem has similar species assemblage and distribution as the reference ecosystem.
- The "guiding principles" of ecosystem restoration are achieved.

The Master Plan is structured such that when all restoration Actions under a particular Objective are fulfilled, then that Objective is completed. Similarly, when all Objectives of a Goal are achieved, then that Goal is realized. Finally, when all Goals are achieved, then the Vision of a restored Ruddiman Creek and Muskegon Lake Shoreline will become a reality. Following this plan will result in addressing the target BUIs in the project area. This may occur before all of

the objectives of each goal have been completed.

If, according to post-project monitoring data, a restoration action is not succeeding, additional studies or surveys will need to be performed to evaluate the source(s) of ecological stress, and the strategy adjusted accordingly. This Master Plan is intended to be dynamic and flexible, a "living document" that can be adjusted to account for new information and changing environmental conditions.

3.5 Monitoring and Maintenance

A restoration monitoring program will enable the successes and lessons learned in this Plan to be tabulated and communicated to Master Plan managers. The Managers will then use the information to direct maintenance and resource management activities to maintain the trajectory of each restoration Objective in the Plan. The information can also be used to guide the development of future restoration projects with similar objectives. The restoration monitoring and maintenance program should begin with existing conditions and document initial post-restoration conditions and continue for the life of the project. Funding for a monitoring and maintenance plan is a requirement for the success of each restoration project. This should include money set aside for training and education for the employees maintaining and managing natural habitats, and adequate funds for continued monitoring and reporting. A sound monitoring and maintenance plan will provide cost effective measures for monitoring and maintenance of all restoration activities.

Monitoring will be incorporated into every restoration Action that is implemented, potentially including quantitative indices of vegetation, benthic macroinvertebrate, fish, amphibian and avian communities, qualitative measures of stream and wetland habitat, and monitoring for threats, such as invasive species, and chemical water quality. This information will be reported to the Master Plan managers as the Plan is implemented. This way the

timing of Actions can be modified using adaptive management as necessary to maintain a logical sequence of restoration activities (e.g. invasive species must be treated before native plants are established).

Active monitoring specified in the Plan should be coordinated by the managers of the Plan and may be conducted by volunteers, university scientists, state agencies, and or private consultants, depending on funding and the need for technical expertise. The Great Lakes Coastal Wetlands Consortium can also provide support for these monitoring efforts, including funding, research leadership, and database management to track restoration efforts and guide maintenance activities. All monitoring must be coordinated to ensure that:

- monitoring efforts are not duplicated,
- the data are useful for the ultimate determination of BUI status, and
- the data can be efficiently summarized and communicated to the Master Plan managers.

Once the monitoring plan is implemented, it will provide the link between the active monitoring and the mangers of the Master Plan. This will ensure adaptive management is incorporated into ecosystem restoration in the project area.

3.6 Phasing of Restoration Actions

The restoration of Muskegon Lake, Ruddiman Creek, and the nearby Shoreline will occur incrementally. To provide an organized framework for implementation, it is recommended that work occur in four distinct phases. Phasing will enable the stakeholders to recognize the completion of key milestones in the restoration process. It also allows for flexibility where stakeholder needs change, or where unforeseen obstacles require adaptive management and phasing adjustments.

PHASE 1 0-2 years from Master Plan adoption:

- Hydrologic, hydraulic and GIS/field studies of the Ruddiman Creek watershed (A1:1, A1:2);
- Ongoing monitoring for illicit discharges. (A2:1);
- Remove debris and reconstruct the outlet of Ruddiman Creek (B1:2);
- Select areas and provide large woody debris habitat in and along Ruddiman Creek and lagoon (B1:3);
- Initiate the restoration and expansion of riparian buffers along Ruddiman Creek and the bike path (B3:1, B3:2);
- Begin invasive species surveys and invasive species management plan (B5:1);
- Initiate dialogue with the City of Muskegon, and private/commercial landowners regarding land conservation and wetland enhancement (B4:3, Goal D).
- Explore the feasibility for physical amenities such as wildlife blinds, informational kiosks, boardwalks, and hiking trails (E1:1, E1:2, E2:1, E2:2);
- Continue and expand public outreach, environmental stewardship, monitoring and education programs (E3:1, E3:4, E4:1, E4:2);

PHASE 2 3-5 years from Master Plan adoption:

- Initiate stormwater management, in the Ruddiman Creek watershed (A1:3, A2:2);
- Ongoing monitoring for illicit discharges. (A2:1);
- Begin removing concrete debris along Muskegon Lake, including regrading, and revegetating the shoreline (B1:1, B2:1, B4:1);
- Initiate the feasibility of reconfiguring the Glenside Blvd culvert (B3:3, B1:4);
- Investigate the expedited remediation of the former AMOCO tank farm site and explore opportunities for wetland creation (B4:2);
- Continued coordination with the City of Muskegon, and private/commercial landowners regarding land conservation and wetland enhancement (B4:3, Goal D).
- Continue restoration and expansion of riparian buffers along Ruddiman Creek and the bike path (B3:1, B3:2);
- Begin invasive species management in key areas (B5:1);
- Install some physical amenities such as wildlife blinds, informational kiosks, boardwalks, and hiking trails (E1:1, E1:2, E2:1, E2:2);
- Continued public outreach and education, expand monitoring efforts for fish and wildlife communities (Goal C, E3:2, E3:3, E3:4, E4:1, E4:2);

PHASE 3 6-10 years from Master Plan adoption:

- Continue stormwater management projects, in the Ruddiman Creek watershed (A1:3, A2:2);
- Ongoing monitoring for illicit discharges. (A2:1);
- Continue removing concrete debris along Muskegon Lake, including regrading, and revegetating the shoreline (B1:1, B2:1, B4:1);
- Begin the reconstruction of the of the Glenside Blvd culvert (B3:3, B1:4);
- Remediation of the former AMOCO tank farm site prior to wetland creation (B4:2);
- Finalize coordination with the City of Muskegon, and regarding land conservation and wetland enhancement (D1:1, D1:2);
- Continue coordination with private/commercial landowners private/commercial landowners regarding land conservation and wetland enhancement (D2:1);
- Complete the restoration and expansion of riparian buffers along Ruddiman Creek and the bike path (B3:1, B3:2);
- Complete major invasive species management efforts and begin invasive species monitoring according to the invasive species management plan (B5:1);
- Compete installation of approved physical amenities (E1:1, E1:2, E2:1, E2:2);
- Expanded public outreach and education, expand monitoring efforts for fish and wildlife communities (Goal C, E3:1, E3:2, E3:3, E3:4, E4:1, E4:2);

PHASE 4 11 years through completion of ecosystem restoration efforts:

- Complete all major stormwater management projects, in the Ruddiman Creek watershed (A1:3, A2:2);
- Ongoing monitoring for illicit discharges. (A2:1);
- Complete removal of concrete debris along Muskegon Lake, including regrading, and revegetating the shoreline (B1:1, B2:1, B4:1);
- Complete reconstruction of the of the Glenside Boulevard culvert (B3:3, B1:4);
- Complete remediation of the former AMOCO tank farm site and wetland creation (B4:2);
- Continue coordination with private/commercial landowners private/commercial landowners regarding land conservation and wetland enhancement (D2:1);
- Conduct invasive species monitoring according to the invasive species management plan (B5:1);
- Expanded public outreach and education, expand monitoring efforts for fish and wildlife communities (Goal C, E3:1, E3:2, E3:3, E3:4, E4:1, E4:2);

Certain strategies must be performed prior to full scale restoration actions. Ecological threats should be assessed and mitigated prior to habitat restoration efforts, to ensure that the investment in ecological restoration is not compromised by ongoing or future disturbances. Priority land protection actions should be initiated prior to restoration, to assure that entities responsible for implementing the proposed actions have the legal jurisdiction to proceed. Finally, the collection of additional necessary baseline information, including invasive species surveys, reference condition surveys, and discharge data should be performed to inform restoration design.

These initial steps are critical efforts to the restoration design process, providing essential data and defining the extent of these projects. For example: it will be inadvisable to design the shoreline buffer proposed in Action B4:1 without reference survey information obtained from Duck Lake, Pentwater Lake, or a similar system, and without negotiations with private landowners and the City of Muskegon about potential shoreline restoration.

Phase 2 includes the initiation of most ecological restoration efforts detailed in Goals A and D, and the continuation of ecosystem conservation and public outreach efforts in Goal B and Goal E.

The final phases are defined by the continuation and completion of ongoing restoration efforts. Active post-project monitoring should begin at the completion of the restoration efforts. This will facilitate the adaptive management process by determining if the trajectories of each restoration Objective are being met. Expanded environmental stewardship, education, and outreach programs are also a large part of the final phases of the Plan.

Phasing of Goals, Objectives, and Restoration Actions

MUSKEGON LAKE, RUDDIMAN CREEK AND NEARBY SHORELINE ECOLOGICAL RESTORATION MASTER PLAN			Years from Master Plan Adoption
Goal	**Objective**	**Action**	0 1 2 3 4 5 6 7 8 9 10 11+
Goal A: Improve hydrology and water quality in Ruddiman Creek.	Objective A1) Reduce flashy flows within Ruddiman Creek.	Action A1:1 - Review existing hydrologic analysis and determine data gaps and needs for additional research.	
		Action A1:2 - Identify properties and areas in the watershed where stormwater BMPs would be practical and beneficial, including retrofits of existing outfalls, where feasible.	
		Action A1:3 - Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1:2 above.	
		Action A1:4 -Educate landowners about stormwater BMPs to reduce overland flow of stormwater.	
	Objective A2) Improve water quality of Ruddiman Creek.	Action A2:1 -Continually monitor, identify and eliminate illicit discharges.	
		Action A2:2- Install BMPs that facilitate water quality treatment and where feasible, infiltration.	
		Action A2:3- Educate homeowners about water quality BMPs.	
Goal B: Restore fish and wildlife habitat in the project area.	Objective B1) Enhance physical aquatic habitat features in the project area.	Action B1:1 - Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.	
		Action B1:2- Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.	
		Action B1:3 - Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.	
		Action B1:4 - Reconfigure the Glenside Boulevard culvert for improved fish passage when it is near the end of its useful life.	
	Objective B2) Protect and enhance native submerged aquatic vegetation along the Muskegon Lake shoreline.	Action B2:1 - Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots.	
	Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.	Action B3:1 - Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Blvd.	
		Action B3:2 - Expand the riparian and upland buffers along the Muskegon Lake shoreline, and along the bike path.	
		Action B3:3 - Reconfigure the Glenside Avenue culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.	
	Objective B4) Restore and enhance existing wetlands throughout the project area.	Action B4:1 - Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.	
		Action B4:2 - Explore opportunities for wetland creation at the AMOCO tank farm site.	
		Action B4:3 - Encourage private landowners to establish native wetland vegetation where it is compatible with future development pland and where proper hydrology and soils exist.	
	Objective B5) Reduce the abundance of invasive plant species in the project area.	Action B5:1 - Conduct invasive species management in the project area.	
		Action B5:2 - provide information to homeowners about invasive species management and the use of native plants in the landscape.	
Goal C: Restore fish and wildlife populations in the project area.	Objective C1) Track the abundance and diversity of native avian, fish, herpetofauna, and macroinvertebrate species in the project area.	Action C1:1 - Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities in the project area.	
Goal D: Permanently protect and conserve existing and restored habitats.	Objective D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.	Action D1:1 – Work with the City of Muskegon to consider stronger protection of 50 acres designated as lakefront recreation and open space recreation, including the AMOCO Tank Farm Site, and land on the east side of Ruddiman lagoon.	
		Action D1:2 – Propose and enact conservation zoning for 7 acres of shoreline between the AMOCO Tank Farm Site, and Lakeshore Yacht Club.	
	Objective D2) Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.	Action D2:1 – Initiate discussions with private land owners to determine the types of conservation areas that could increase property value and enhance future development plans.	
		Action D2:2 – Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.	
Goal E: Increase opportunities for recreation, education, and stewardship.	Objective E1) Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing.	Action E1:1 - Explore the feasibility of placing an observation platform within the lagoon.	
	Objective E2) Encourage opportunities for active recreation along, and in Ruddiman Creek and the nearby shoreline of Muskegon Lake.	Action E2:1 - Explore the feasibility of placing a boardwalk in the lagoon area.	
		Action E2:2 - Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.	
	Objective E3) Promote local stewardship and education opportunities.	Action E3:1 - Continue working with adjacent schools for assistance with implementing restoration measures.	
		Action E3:1- Elicit support from adjacent schools to have students implement and monitor restoration measures.	
		Action E3:2 - Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.	
		Action E3:3 - Maintain and promote research opportunities through GVSU.	
		Action E3:4 - Hold seasonally relevant seminars on the ecology, history, environmental stewardship andr function of the area.	
		Action E3:5 - Encourage construction of informational signage describing local history, and different plants and wildlife that appear in the area throughout the year.	

Approximate Cost Range for each Restoration Action

MUSKEGON LAKE, RUDDIMAN CREEK AND NEARBY SHORELINE ECOLOGICAL RESTORATION MASTER PLAN			Cost Meter
Action	**Size**	**Cost**	≤ $1K · $5K · $10K · $20K · $50K · $100K · $150K · $200K · $300K · $400K · $500K · $1M · $2M · $5M +
Action A1:1 - Review existing hydrologic analysis and determine data gaps and needs for additional research.	watershed-wide	$25,000 to $40,000	
Action A1:2 - Identify properties and areas in the watershed where stormwater BMPs would be practical and beneficial, including retrofits of existing outfalls, where feasible.	watershed-wide	$20,000 - $70,000	
Action A1:3 - Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1:2 above.	watershed-wide	$700,000 to $2,100,000	
Action A1:4 -Educate landowners about stormwater BMPs to reduce overland flow of stormwater.	watershed-wide	$1,000 to $2,000 (annually)	
Action A2:1 -Continually monitor, identify and eliminate illicit discharges.	watershed-wide	$5,000 to $10,000 (annually)	
Action A2:2- Install BMPs that facilitate water quality treatment and where feasible, infiltration.	watershed-wide	See Action A1:3 above.	
Action A2:3- Educate homeowners about water quality BMPs.	watershed-wide	$500 tp $,1000 (annually)	
Action B1:1 - Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.	Approx 4,000 LF	$420,000 to $1,200,000	
Action B1:2- Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.	2,500 square feet	$10,000 to $40,000	
Action B1:3 - Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.	N/A	$10,000 to $20,000	
Action B1:4 - Reconfigure the Glenside Boulevard culvert for improved fish passage when it is near the end of its useful life.	4,000 square feet	$200,000 to $500,000	
Action B2:1 - Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots.	6 acres	$60,000 to $120,000	
Action B3:1 - Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Blvd.	3 acres	$15,000 to $200,000	
Action B3:2 - Expand the riparian and upland buffers along the Muskegon Lake shoreline, and along the bike path.	6 acres	$60,000 to $220,000	
Action B3:3 - Reconfigure the Glenside Avenue culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.	See Action B1:4 above.	See Action B1:4 above.	
Action B4:1 - Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.	7 acres	$70,000 to $140,000	
Action B4:2 - Explore opportunities for wetland creation at the AMOCO tank farm site.	30 acres	$2,000,000 to $10,000.000	
Action B4:3 - Encourage private landowners to establish native wetland vegetation where it is compatible with future development pland and where proper hydrology and soils exist.	17	$35,000 to $70,000	
Action B5:1 - Conduct invasive species management in the project area.	15 acres	$40,000 to $75,000	
Action B5:2 - provide information to homeowners about invasive species management and the use of native plants in the landscape.	watershed-wide	$500 to $1,000	
Action C1:1 - Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities in the project area.	project area	Based on Goals A & B above.	
Action D1:1 – Work with the City of Muskegon to consider stronger protection of 50 acres designated as lakefront recreation and open space recreation, including the AMOCO Tank Farm Site, and land on the east side of Ruddiman lagoon.	50 acres	$20,000 to 120,000	
Action D1:2 – Propose and enact conservation zoning for 7 acres of shoreline between the AMOCO Tank Farm Site, and Lakeshore Yacht Club.	7acres	$5,000 to $15,000	
Action D2:1 – Initiate discussions with private land owners to determine the types of conservation resources that could increase property value and enhance future development plans.	watershed-wide	$2,000 to $5,000 (annually)	
Action D2:2 – Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.	51 acres	$25,000 to $70,000/acre	
Action E1:1 - Explore the feasibility of placing an observation platform within the lagoon.	minimal	$2,000 to $5,000	
Action E2:1 - Explore the feasibility of placing a boardwalk in the lagoon area.	60 to 200LF	$500/LF	
Action E2:2 - Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.	1 to 2 miles	$120/LF	
Action E3:1- Elicit support from adjacent schools to have students implement and monitor restoration measures.	project area	$20,000 to $50,000/year	
Action E3:2 - Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.	project area	$10,000 to $80,000/year	
Action E3:3 - Maintain and promote research opportunities through GVSU.	project area	$5,000 to $100,000	
Action E3:4 - Hold seasonally relevant seminars on the ecology, history, environmental stewardship andr function of the area.	N/A	$2,500 to $10,000	
Action E3:5 - Encourage construction of informational signage describing local history, and different plants and wildlife that appear in the area throughout the year.	project area	$5,000 to $20,000	

3.7 Funding the Ecological Restoration Management Actions

The Ruddiman Creek and Nearby Shoreline Ecological Restoration Master Plan assesses the ecological health of a small part of the Muskegon AOC and details actions to improve that health. The actions, some costly, will require federal, state, and local financial support to implement. The Muskegon Lake Watershed Partnership has stepped forward to adopt and begin implementation of several of those actions. The U.S. EPA Great Lakes National Program Office is committed to helping find funding. Conversations with the National Oceanic and Atmospheric Administration and U.S. Army Corps of Engineers regarding their grant programs look promising. In addition, the funding programs listed below, although not comprehensive, offer a range of grant opportunities for the community to explore.

- Grants from Federal Agencies: http://www.grants.gov
- Great Lakes Protection Fund: http://www.glpf.org/
- Great Lakes Watershed Restoration Grant Program: http://www.nfwf.org/AM/Template.cfm?Section=Browse_All_Programs&CONTENTID=5337&TEMPLATE=/CM/ContentDisplay.cfm
- Lake Michigan Coastal Management Program: http://www.michigan.gov/deq/0,1607,7-135-3313_3677_3696-11188--,00.html
- National Oceanic and Atmospheric Administration (NOAA): http://www.nmfs.noaa.gov/habitat/restoration/funding_opportunities/funding_ner.html
- U.S. Army Corps of Engineers Habitat Initiative: http://www.glhi.org/
- U.S. EPA Great Lakes National Program Office (GLNPO) Funding Program: http://www.epa.gov/glnpo/fund/glf.html
- U.S. Fish and Wildlife Service: http://www.fws.gov/grants/

The costs associated with the proposed restoration strategies are provided in the fold out table. Note that these are planning level cost estimates for design, engineering, construction, and maintenance. Actual costs may vary depending on the nature and degree of implementation and cost escalation over time.

4.0 Site History

Prior to European settlement, the Potowatomi and Odawa Tribes inhabited the area known as Michigan. The First Peoples numbered in the thousands, with some population estimates reaching as high as 14,000 in Michigan's Lower Peninsula. The Muskegon area was first explored by Europeans in the 1600s, and fur trading was the primary economic activity. Muskegon River first appeared on early French maps and the mouth of the river was referred to as the "great marsh." In the early 1800s the Erie Canal opened, providing passage into the Great Lakes Region, and immigrants flooded into Michigan. This migration sparked the rise of modern day Michigan (Muskegon Chronicle, 5/17/07).

1800s- Logging

The Muskegon River extended far into prime white pine country and the timber was easily transported downriver and across Lake Michigan to Chicago. White pines as tall as 175 feet lined the Muskegon River. By 1830 the lumber industry had become the local economic engine. While the industry provided employment for thousands of workers, the character of Muskegon Lake was substantially changed due to the increase in population and the construction of lumber mills along the shoreline. It was common practice to discard slab wood into the lake and the marshy areas around the lake were built up to support factories, shipping docks, boom areas and piles of wood chips. Wood debris is still present today along the shoreline. The sawdust and debris clogged the wetlands around the lake. Part of the lumber industry went to support paper production. Central Paper Co. (now Sappi Fine Paper) opened on Muskegon Lake in 1899. The continued presence of industry on the shoreline dramatically affected the water quality and natural shoreline (Day & Associates, 1995; Muskegon Chronicle, 5/17/07)

Early 1900s - Factories

By the end of the 19th century, 95% of the virgin forests in Michigan had been harvested. The sprawling white pine forest that had defined the lumber industry had been reduced to a collection of stumps. Lumbering ended in Muskegon and a group of lumber barons remained behind and initiated a "factory" fund to promote industrial growth in the Muskegon area. This enterprise was eventually successful, and Muskegon became a leader in manufacturing. In the 1920s, there was an oil boom as petroleum that had been previously discovered in the area, became a profitable enterprise to support the budding automobile industry. Muskegon became the Port City in the late 1920s and eventually rose to become the seventh busiest port on the Great Lakes. The activity included filling in more of the soft, marshy edges of the lake and building factories, train yards, tank farms, stock pile areas and docking facilities. In 1928, the sand dunes along Lake Michigan gained industrial attention. Known for their unique particle size, sand dunes hundreds of feet tall vanished over the next thirty years as they were mined (Day & Associates, 1995).

The Great Depression and World War II

From the 1920s through the 1930s, the local industries made the financial and physical infrastructure of Muskegon (banks, hotels and department stores) possible. The City rebounded a decade later after the depression. During World War II, the industrial foundation of the city ushered in one of the lowest unemployment rates in history as the need for defense work surged. Despite the dangerous and grueling work in the factories and foundries, Muskegon was at its economic and employment peak during World War II. (Muskegon Chronicle, 5/17/07).

Aftermath

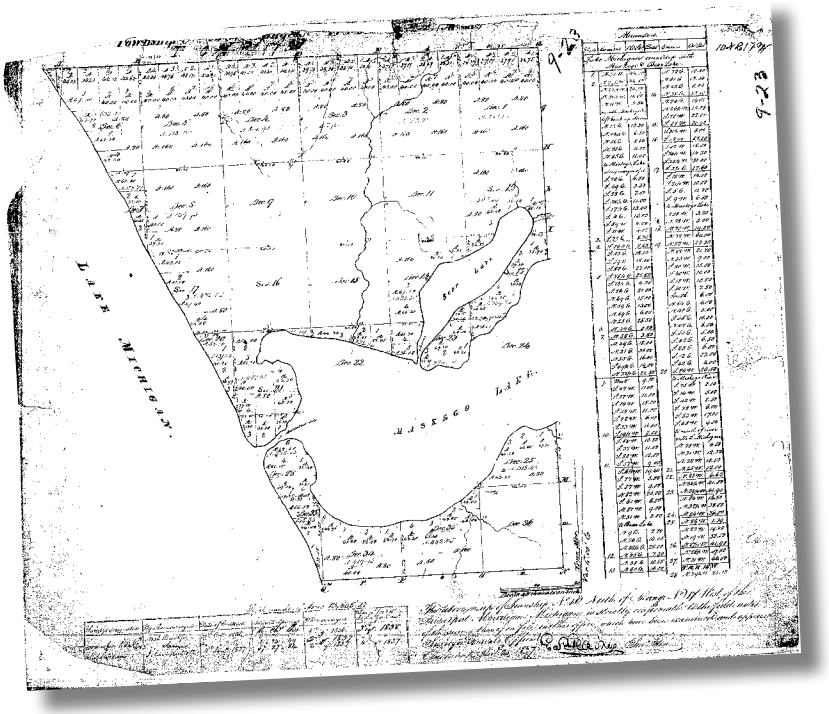
The Korean War and growing auto industry kept Muskegon's factories bustling through the 1950s. Beginning in the 1960s, the Muskegon economy took another downturn as local factory jobs subsided. Thousands left during the '60s and '70s in search of work elsewhere. One surviving foundry, Campbell Company, is located in the Ruddiman Creek watershed. The economic challenges compounded as the cross-lake passenger ferry the Milwaukee Clipper ended its service to Muskegon in 1971. Ferry service from Milwaukee to Muskegon was not restored until 2004 with the arrival of the Lake Express (Muskegon Chronicle, 5/17/07).

Chemical Industry

As a result of efforts of the Muskegon Industrial Fund, Ott Chemical began its operations in the area in the late 1950s. In the coming years, half a dozen more chemical companies emerged nearby. Though they brought job opportunities and money into the local economy, the consequences of their practices gained attention. A combination of spills, explosions, dumping, contaminated surface and ground water, poisoned local wells, altered aquatic communities and injuries required stronger oversight and cleanup. While improvements began in the 1970s, the consequences of the environmental degradation are still visible today (Muskegon Chronicle, 5/17/07).

Environmental Recovery

Since Muskegon Lake received the AOC designation in 1985, efforts have improved environmental quality. The Muskegon County wastewater system and industrial pretreatment programs were central to improving water quality in the area. After the AOC designation, the 1987 RAP was developed and Ruddiman Creek was identified as a major source of contamination. With Ruddiman Creek now clearly identified as a cause of contamination, action to help the creek recover began. By 1993, interested citizens created the Muskegon Lake Public Advisory Council and a year later the RAP was updated. To help guide the clean-up efforts, Wildlife Habitat and Aquatic Vegetation Assessments were completed for Muskegon Lake during 1995. In 1996 the Ruddiman Task Force



was formed to further assist recovery activities for the creek. The Glenside Neighborhood Association (GNA) and the Muskegon Lake Public Advisory Council helped to support this group and together they spearheaded the development of the Ruddiman Creek Strategic Plan. The Task Force and GNA hosted what came to be the first of annual Earth Week Clean-ups later that same year.

Over the next decade, the steps to environmental recovery continued with the case against Ott Chemical (one of the major polluters of the area) moving to the Supreme Court in 1998, the MDEQ identifying Ruddiman Creek as a priority for contaminated sediment investigation, and the US Army Corps of Engineers identifying fourteen sites that threaten the creek. A major setback came in 2001, with 5.86 million gallons of sewer system overflow spilling into the creek.

The removal of contaminated sediment began in 2005. Within the following year nearly 90,000 cubic yards of contaminated sediment were extracted from Ruddiman Creek. The improved sediment conditions met the prerequisite for additional habitat restoration. In 2007, habitat restoration planning began among local and national stakeholders. That same year the Muskegon Lake Advisory Council (MLPAC) became The Muskegon Lake Watershed Partnership and continues to facilitate the restoration efforts associated with the Muskegon shoreline and Ruddiman Creek and other restoration sites throughout the Muskegon AOC.

The name "Muskegon" is derived from the Ottawa Indian term "Masquigon" meaning "marshy river" or "swamp."

- Daniel J. Yakes, Muskegon Community College and the Muskegon County Museum

Muskegon map circa 1868

Muskegon map circa 1874

Logging in the Muskegon watershed (painting by Victor Casenelli)

Lumber mill on Muskegon Lake (painting by Victor Casenelli)

#10 Chicago to Muskegon Passenger Ship (painting by Victor Casenelli)

Montgomery Champagne Mill near Ruddiman Creek

Muskegon's lumber era (late 1800's)

MUSKEGON AREA INHABITED BY POTAWATOMI AND OTTAWA TRIBES

EXPLORATION | **FUR TRADING** | **LUMBER INDUSTRY** | **RAILROADS** | **INDUSTRIALIZATION**

1600

1600: In the future state of Michigan, pre-European settlement wetland acreage is 11 million acres (approximately 30% of the total land area in Michigan). The Native American population at the time is 6,000–8,000 people.

1620

1620: French exploration of Great Lakes.

1650

1700

1750

1800

1796: U.S. takes possession of territory that will become Michigan.

1850

1837: Muskegon Township established as part of Ottawa County.

1837: Lumber industry flourishes in Muskegon.

1869: Muskegon and Ferrysburg Railway Company begins.

1870s: 27 sawmills in operation in Muskegon.

1900

1880: Muskegon known as "Lumber Queen of the United States."

1889: 95% of virgin forests in Michigan have been harvested.

1897: Michigan lumbering boom ends.

1950

1940s: Muskegon labeled as "Arsenal of Democracy" after bouncing back from Great Depression and World War II.

1950s & 60s: Muskegon Industrial Fund brings chemical companies to the region.

1960s: Muskegon economy suffers, many businesses close or consolidate.

1975

1970s to present: The Muskegon industrial community diversifies in order to cope with an ever changing economy.

1971: Mobil Oil spills 50,000 gallons of gasoline into Ruddiman Creek; soils and groundwater are contaminated with lead and BTEX.

1971: Milwaukee Clipper ends ferry service.

1974: The Muskegon County Wastewater Management System begins operation.

1980

1985

1985: Muskegon Lake identified as an AOC.

1987: Ruddiman Restoration Action Plan (RAP) released.

1990

1990: 5.5 million acres of wetland remain in Michigan, a decline of about 50% from presettlement conditions.

1995

1994: RAP updated by the Muskegon Lake Public Advisory Council (PAC).

1996: Ruddiman Creek Task Force formed.

1996: First of annual Earth Week cleanups.

1998: MDEQ identifies Ruddiman Creek as priority for contaminated sediment investigation.

2000

2000: Army Corps of Engineers identify 14 sites that threaten Ruddiman Creek.

2001: Largest sewer system overflow in Ruddiman Creek history: 5.86 million gallons.

2003: The "Imagine Muskegon" community design workshop.

2004: Lake Express re-establishes ferry service to Milwaukee.

2005

2005: Sediment removal begins.

2005: Muskegon Area-Wide Plan unveiled.

April / May 2006: Last dredging activities completed. Habitat restoration begins at Ruddiman Creek.

2010

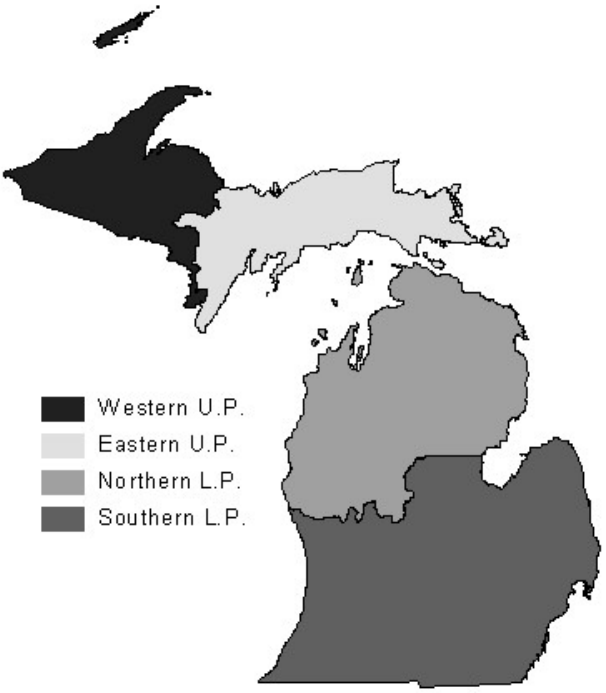
Muskegon Lake Ruddiman Creek Ecological Restoration Master Plan

MUSKEGON SOUTH LAKESIDE AND RUDDIMAN CREEK REGIONAL HISTORY

This ecological restoration master plan aims to restore and/or enhance the form and function of aquatic and terrestrial habitat along the shoreline of Muskegon Lake and throughout the riparian corridors associated with Ruddiman Creek. Understanding the past and current physical, biological and cultural conditions is an inherent prerequisite for prescribing actions to direct ecological change and measuring those changes over time. The following site description is a summary of existing assessments, data and reports, and three days of field reconnaissance in July 2007.

5.1 Southern Lower Peninsula Ecoregion

Michigan contains a broad diversity of terrestrial ecosystems that are differentiated by variations in regional climate, physiography (glacial landform and geologic parent material), soils and vegetation (Albert 1995). The ecoregional classification provides a framework for understanding broad patterns of natural community and species occurrences, natural disturbance regimes, and land-use patterns across the State (Albert et al. 1986, Albert 1995). These ecoregions are a useful tool for integrated resource management, planning, and biological conservation. The four major ecoregions in Michigan are the Southern Lower Peninsula, Northern Lower Peninsula, Eastern Upper Peninsula, and Western Upper Peninsula (Albert 1995).



The project area is located near the boundary of the Southern Lower Peninsula and Northern Lower Peninsula Ecoregions and exhibits characteristics of both regions. There are rolling hills and flat lake plains. High levels of agriculture and urban development have increased habitat fragmentation. Landcover in this ecoregion is primarily agriculture (50%) and forested (23%). Wetlands cover 8% and urban landscapes cover approximately 9% of the land area (Michigan DNR, 2006). In contrast, the land north of the study area remains predominantly forested with northern hardwoods, early successional aspen forest, pine systems, and lowland conifer forests.

5.1.1 Climate

The weather station office is located at Muskegon County Airport, four miles south of Muskegon Lake. The lake effect (weather associated with large expanses of inland water) caused by Lake Michigan heavily influences the climate of Muskegon throughout much of the year. Prevailing westerly winds travel across Lake Michigan increasing cloudiness and snowfall during the fall and winter. Furthermore the large water mass of Lake Michigan moderates the temperature most of the year. The prevailing wind is south-south-westerly, averaging 11 mph. Summers are dominated by moderately warm days with temperatures rarely exceeding 90° F. The highest average monthly maximum temperature is 87°F in July. During winter months temperatures rarely fall below 0°F and the

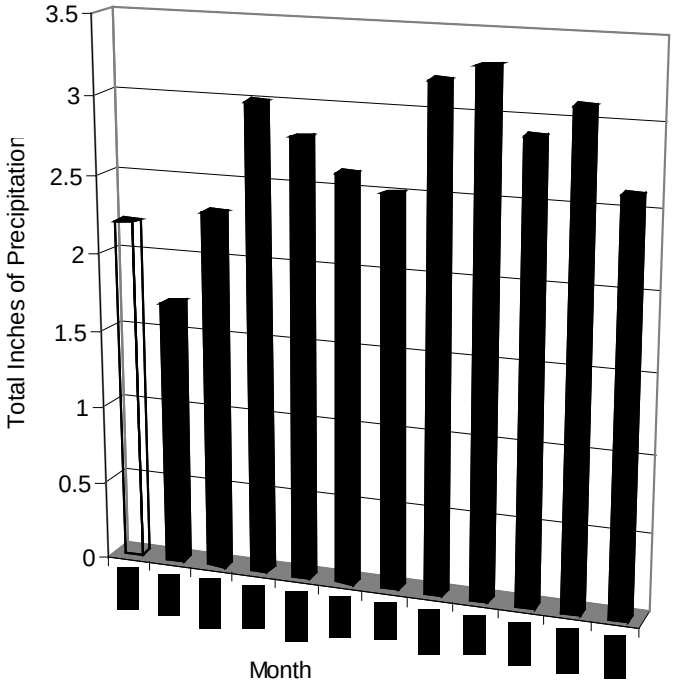
lowest average monthly minimum temperature is 6.8°F. The average date of the last freezing temperature in the spring is May 7th while the average date for the first freezing date in the fall is October 11th which creates an average annual freeze-free period is 156 days.

Average annual precipitation is approximately 32 inches and is distributed evenly throughout the year. April, August, September and November are the wettest months with precipitation levels at 3 inches or more while the average driest month is February with 1.65 inches. Afternoon showers and thunderstorms are the main sources of summer precipitation. Between 1950 and 1987 five tornadoes occurred in Muskegon County. Average seasonal snowfall is 109.3 inches. While drought occurs periodically, the Palmer Drought Index indicated drought conditions reached extreme severity only 1% of the time (Michigan Department of Agriculture, Climatology Program, 2007).

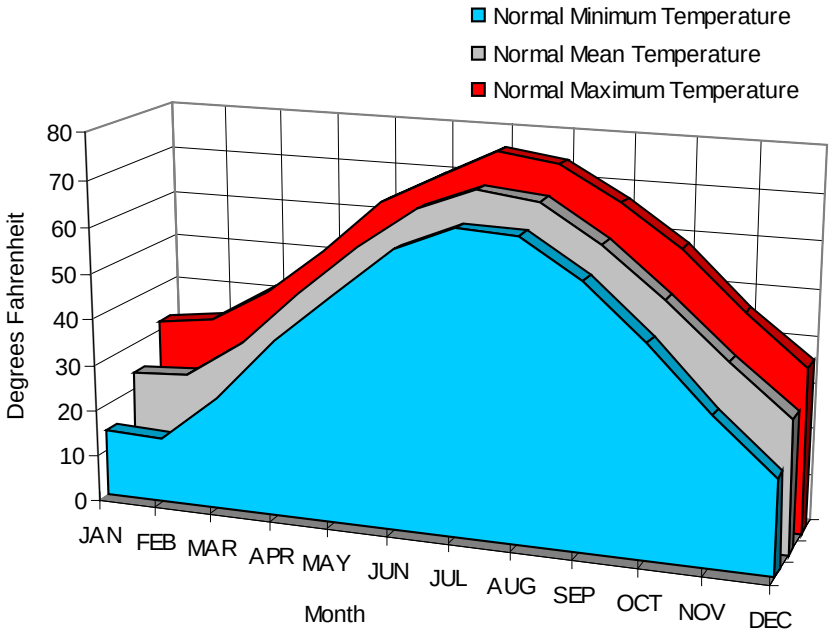
5.1.2 Physiography

The entire Lower Peninsula of Michigan is made up of Paleozoic and Mesozoic sedimentary rocks of Cambrian to Jurassic age. The undulating topography of gently dipping rock formations constitute a large regional geological structure known as the Michigan basin. Repeated advances by continental glaciers eroded the rocks, broke down soil and redeposited the material sediments covering most of Michigan with gravel, sand and clay (http://websoilsurvey.nrcs.usda.gov/app). Broad lacustrine plains occur along all of the Great Lakes; these lake plains extend more than 20 miles inland along Lake Michigan and more than 50 miles inland along the Lake Huron shoreline at Saginaw Bay. Postglacial sand dunes form a 1-5 mile band along much of the Lake Michigan shoreline. The interior of the region consists of a relatively low plain of ground and end moraines, with narrow outwash channels throughout (Michigan DNR, 2006).

Muskegon Co Monthly Normal Precipitation 1948-2001



Muskegon Co Monthly Normal Temperatures 1948-2001



Graphs created from data within NOAA/National Climatic Data Center, 2002

5.1.3 Soils

Most of the soils of the region are calcareous and loamy, derived from underlying limestone, shale, and sandstone bedrock. Till deposits are primarily loams, silt loams and clay loams. Fertile lacustrine soils occur on the lake plain along the east and west edges of the region. These lacustrine soils are primarily dominated by silt and clay. Where sandy soils occur on the lake plains, they are often banded with silt or clay. The outwash plains are sands, often containing abundant gravel (Michigan DNR, 2006).

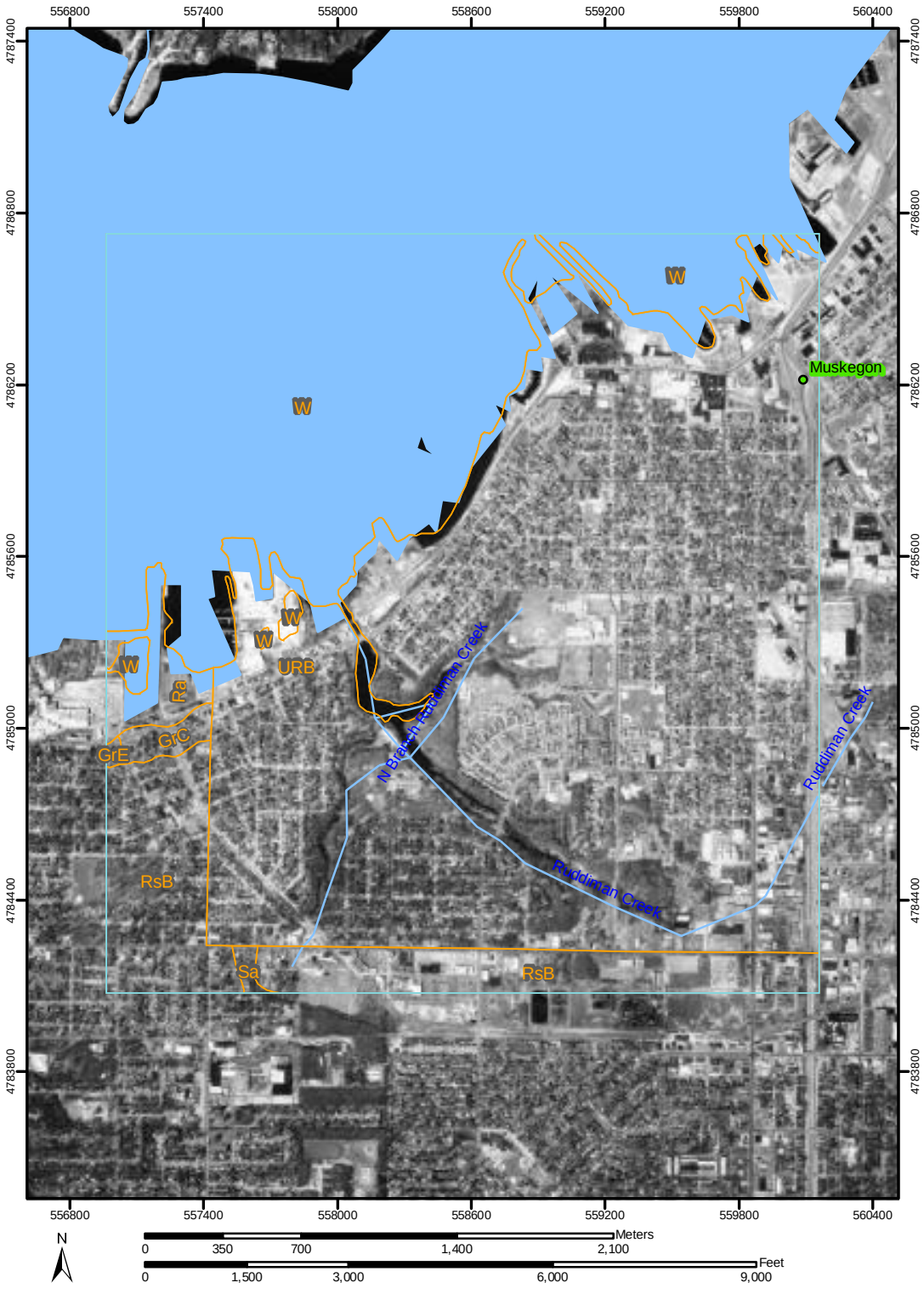
Soils within the project area have not been surveyed, however soil information is available for soils along the west and south boundaries. The dominant soil type is Rubicon sand which is an excessively drained sandy soil. Permeability is rapid and the available water capacity is very low. Surface runoff is slow and the natural fertility is low. Grayling-Rubicon sands, characteristically very similar to Rubicon sand, Sarcanac loam and Roscommon/Au Gres sands are also present near the project area. The latter two soils are poorly drained (http://websoilsurvey.nrcs.usda.gov/app/).

5.1.4 Vegetation

Michigan's pre-settlement Vegetation, as Interpreted from the General Land Office Surveys 1816-1856 shows historic vegetation cover as white pine-white oak forest along the south shoreline of Muskegon Lake. The northern portion of the region was likely dominated by northern hardwoods and Jack pine, along with northern pin oak. Forests of white pine and red pine were common with conifer swamps covering large portions of the northern lake plains. Fire-dependent savanna and forest systems likely dominated other portions of the Southern Lower Peninsula Ecoregion. Oak savanna was probably the most prevalent cover type, followed by oak-hickory forest (Albert 1995). Beech/sugar maple forest was also important on areas of lake plain and fine-textured moraines (Comer et al. 1995). Numerous broad floodplain forests occurred along the rivers of this region.

Most of the Southern Lower Peninsula Ecoregion is now farmed for row crops; this is the most heavily farmed region in Michigan. Furthermore, the heaviest urban, industrial and residential development has occurred in this region, especially along the Great Lakes shoreline. The enduring forest has become fragmented. The remaining floodplain forests provide important habitat for songbird migration and breeding, especially as adjacent upland forests are increasingly fragmented for further agricultural or residential development. Most of the oak savannas have been eliminated or converted to closed-canopy forests as a result of fire suppression. The remaining marshes and wetlands along Great Lakes shorelines are critical for maintaining migratory waterfowl, shore birds, and the Great Lakes fisheries. Rare plant communities found near the project area include coastal plain marshes, which occur in sandy depressions in outwash plains and glacial lake beds (Michigan DNR, 2006).

Soil Map–Muskegon County, Michigan
(South Muskegon Lake & Ruddiman Creek)



5.2 Regional Ecological Connections

The Ruddiman Creek and Nearby Shoreline project area is ecologically connected to the surrounding landscape primarily through aquatic and avian migration routes. Fish and other aquatic organisms that inhabit Lake Michigan or Muskegon River have access to the shore of Muskegon Lake and Ruddiman Creek. These waters also support spawning runs of potamodromous salmonids (primarily steelhead and Chinook salmon).

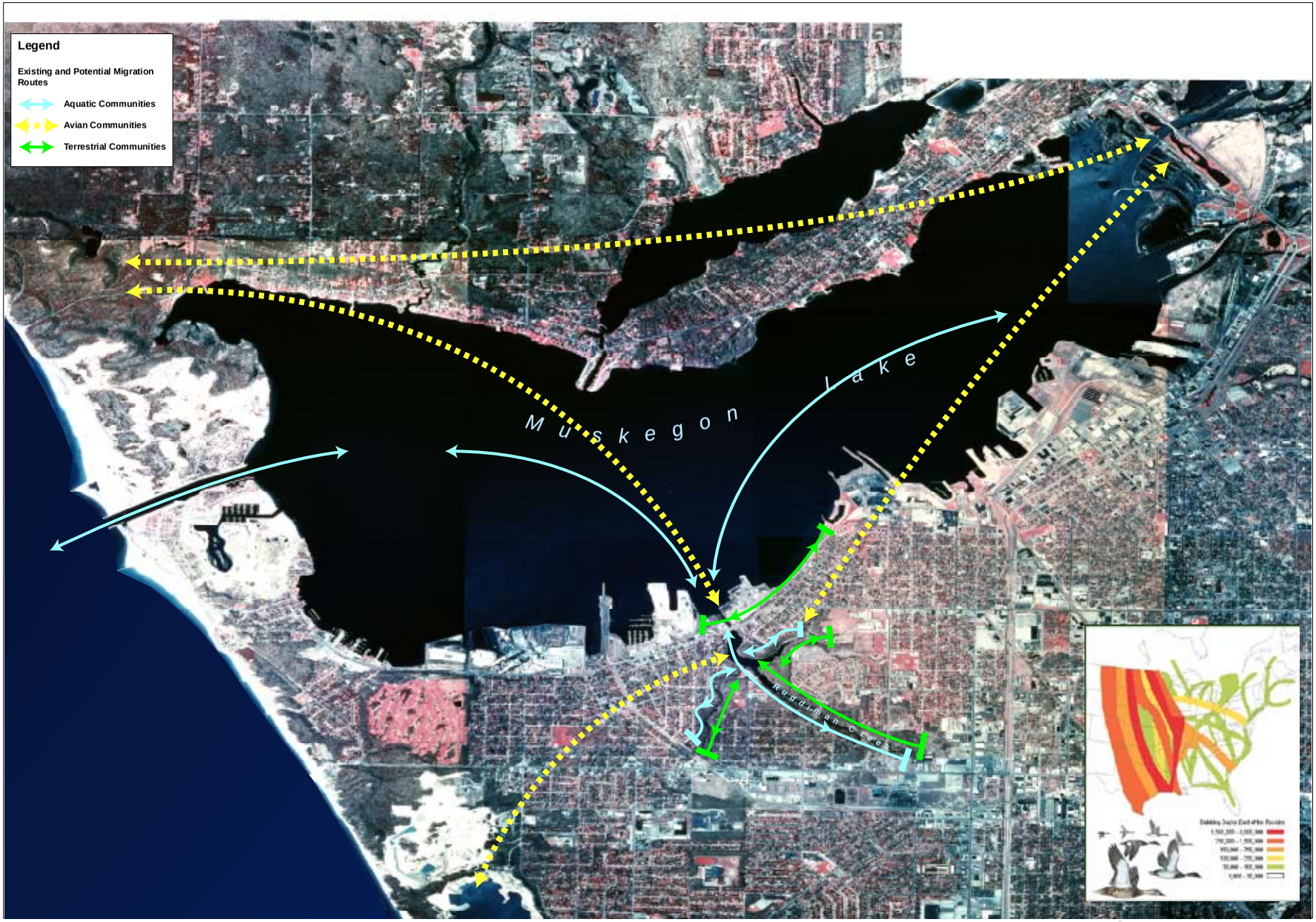
The project area includes one of the few marshes found around the perimeter of Muskegon Lake. The open water and remnant marsh habitat of Muskegon Lake provide a place for migratory fowl to rest and feed along the northwest route of the Atlantic Flyway. The northwest route is of great importance to migratory fowl such as flocks of canvasbacks (*Aythya valisineria*), redheads (*Aythya Americana*) and lesser scaups (*Aythya affinis*) that winter on the waters and marshes of south Delaware Bay.

5.3 Government and Community Relationships

At the federal level, the Environmental Protection Agency is interested in and supportive of any project that contributes to the delisting of the Muskegon AOC. The Great Lakes National Program Office provides and coordinates the funding for this ecological restoration plan. MDEQ is involved with monitoring the success of the soil remediation work that occurred recently in the lagoon and Ruddiman Creek and the Department of Natural Resources is interested in habitat restoration throughout the state. The Muskegon Conservation District and Natural Resources Conservation Service provide project staff as well as educational and technical support to implement the Muskegon RAP. The Conservation District also maintains the Muskegon Lake Information and Data Repository.

The local public interest group associated with the Muskegon Lake AOC is the Muskegon Lake Watershed Partnership (MLWP), formerly known as the Muskegon Lake Public Advisory Council. The Partnership is a coalition of community interests dedicated to working cooperatively for the improvement of the Muskegon Lake ecosystem through the RAP. The Ruddiman Creek Task Force is also a local group of residents specifically dedicated to supporting restoration and enhancement efforts associated with Ruddiman Creek. Institutional involvement includes the Muskegon Community College Life Science Department, and the Annis Water Resources Institute (AWRI) at GVSU.

The Cities of Muskegon, Norton Shores, Muskegon Heights and Roosevelt Park are permitted as municipal separate storm sewer systems (MS4s) under Phase II of the National



Muskegon Lake Ruddiman Creek Ecological Restoration Master Plan

MUSKEGON SOUTH LAKESIDE AND RUDDIMAN CREEK REGIONAL CONNECTIVITY

0 0.5 1 2 3 Miles

Biohabitats GREAT LAKES BIOREGION

Pollutant Discharge Elimination System (NPDES) program. The NPDES program requires MS4s to develop local programs to address pollution associated with stormwater runoff through public education and outreach; public participation/involvement; illicit discharge detection and elimination; construction site runoff control; post-construction runoff control; and pollution prevention / good housekeeping.

These permittees, along with the Muskegon County Administration and Drain Commissioner and the Muskegon County Road Commission, are working together through the Muskegon Area Municipal Storm Water Committee (MAMSWC). The MAMSWC completed a Watershed Management Plan (WMP) for the Muskegon Lake Watershed in November 2005. The Muskegon lake Watershed Partnership served as the advisory committee for the WMP. The main purpose of the WMP was to identify implementation actions needed to protect and restore designated uses and resolve water quality and quantity concerns. In April 2006 each permittee completed a Storm Water Pollution Prevention Initiative (SWPPI), based on the WMP. The purpose of the SWPPIs is to detail the specific actions the permittee will implement to meet the goals and objectives of the WMP and reduce

the discharge of pollutants to he maximum extent practicable. The permittees of the MAMSWC are currently in their second year of SWPPI implementation.

5.4 Recreation

Formal recreation amenities are focused along the shoreline of Muskegon Lake (greenway link trail) and the west side of the Ruddiman Lagoon (McGraft Park). Both recreation areas offer opportunities for walking, biking, running, fishing, viewing wildlife and enjoying views of wooded areas and water. The new greenway link trail is a combination of paved and boardwalk-type surfaces designed to accommodate pedestrian and non-motorized wheeled recreation. The trail includes benches and small picnic pavilions located in areas with views of Muskegon Lake. Informal fishing opportunities are also provided. A small memorial garden located on the link trail within the project area is maintained by the Muskegon High School class of 1967.

McGraft Park is a Muskegon City Park and it covers 92 acres including the lagoon and portions of Ruddiman Creek and the two tributaries. The park includes tennis and basketball courts, a baseball field, sledding hill, playground, band shelter, walking trails and a frisbee golf course. Approximately 45 acres have been developed for intense recreation while the remaining 47 acres has been reserved in a natural setting providing passive recreation enjoyment. Most of the park is separated from the Lagoon by Addison Street, the exception being a small, manicured area adjacent to the lagoon that provides easy access to the water's edge for fishing or taking in the view of water and trees. Informal trails parallel the stream beds.

5.5 Hydrology

The Ruddiman Creek watershed drains water collected by municipal stormwater systems from approximately 3,500 acres. The watershed collects water primarily from land associated with the City of Muskegon with some stormwater coming from the Cities of Norton Shores, Muskegon Heights, and Roosevelt Park. Land uses range from residential, recreational to commercial and heavy industrial operations. This project area includes a portion of the sewershed and some of the Muskegon Lake shoreline. The system includes 17 stormwater outfalls.

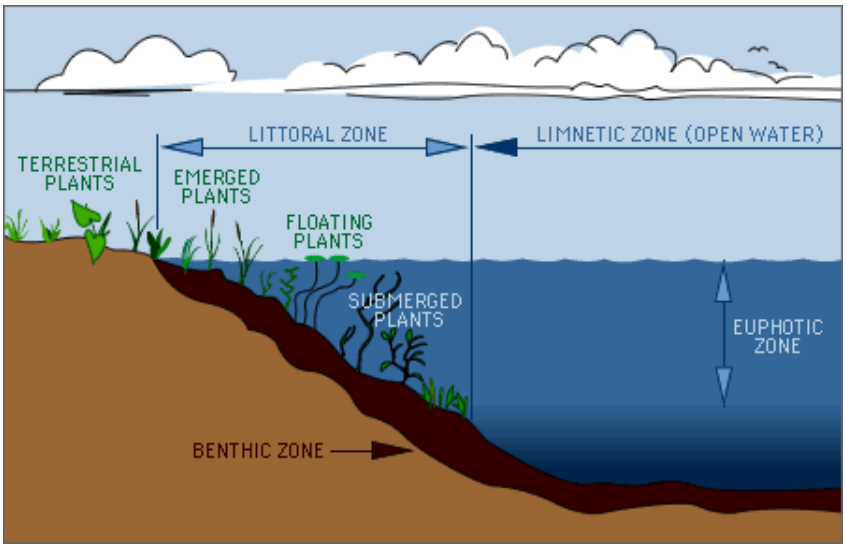
The width of the creek ranges between 10 to 60 feet, and low-flow water depths typical ranges between 1 to 7 feet. The mean flow for Ruddiman Creek is approximately 3.1 cubic feet per second. Creek width, depth and

Ruddiman Creek and Muskegon Lake Project Area Map

flow rates are naturally greater during heavy rain events and during spring thaw periods. Ruddiman lagoon is approximately 2,200 feet long, has an average width of 142 feet and average depth of 9 feet (Remediation of Ruddiman Creek Main Branch and Pond: Final Work Plan).

The west branch has two origins: a storm sewer outfall at Manor Street (drains a small industrial/commercial area within Norton Shores) and a storm sewer outfall at Wickam Street (drains a residential area within Roosevelt Park). The west branch then flows through primarily residential neighborhoods and McGraft Park until reaching the southern portion of Ruddiman Lagoon. The north branch also originates from two storm sewer outfalls; one south of Laketon Avenue and one northwest of a housing development near Glenside Boulevard. The north branch flows through a primarily residential area then discharges into the east end of Ruddiman Lagoon. The main branch of the creek begins at a 100-inch storm sewer outfall located east of Barclay Street and flows through residential areas until reaching Ruddiman Lagoon.

Water flows out of the lagoon under the Lakeshore Drive bridge, into a small pond, under a railroad bridge and a pedestrian/bike trail bridge and then out into Muskegon Lake. The area includes stream, emergent and scrub-shrub wetland habitats in a small, urban space. Although the area is small, it provides a connection between the Lake and the Ruddiman Lagoon and Creek. The connection, however, is marginal as a wildlife corridor due to the narrow passage under the three bridges and associated urban disturbances.



Modified from, http://lakeaccess.org/ecology/lakeecologyprim9.html

5.6 Habitats

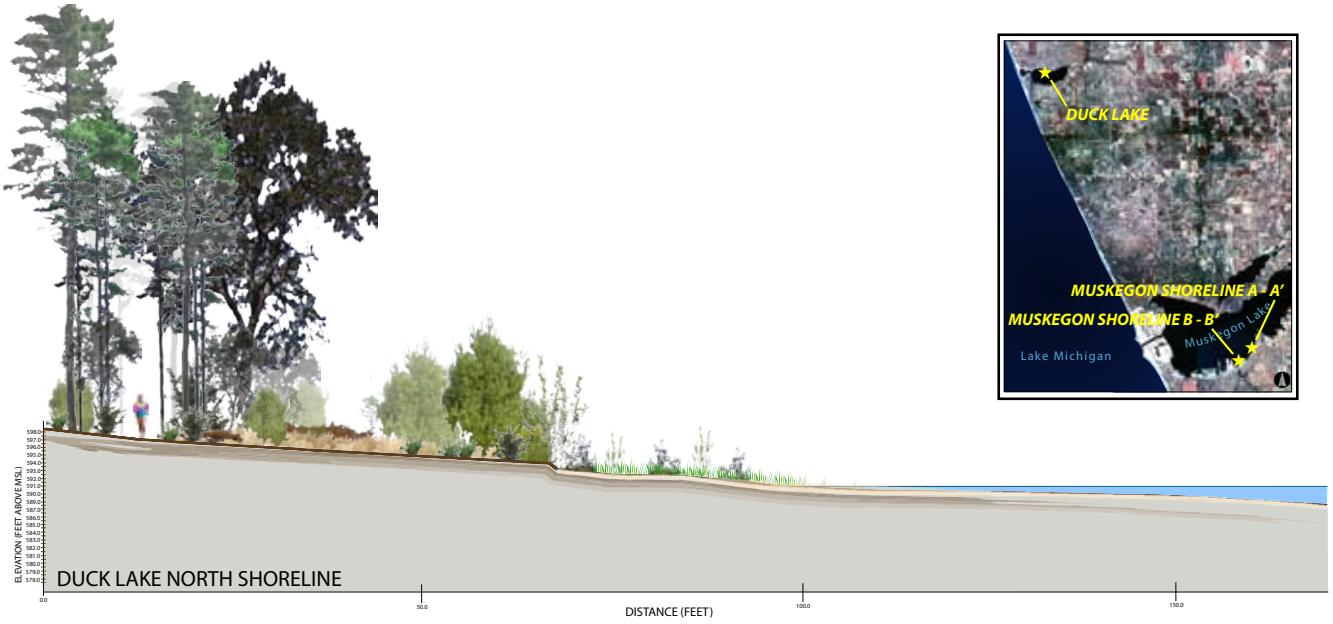
The habitats associated with the Ruddiman Creek and Nearby Muskegon Lake Shoreline project area have been organized into three categories; aquatic, wetland and terrestrial. The current conditions for each habitat are described below and focus on the characteristics that define each habitat type. Species lists are included in Appendices B, C and D).

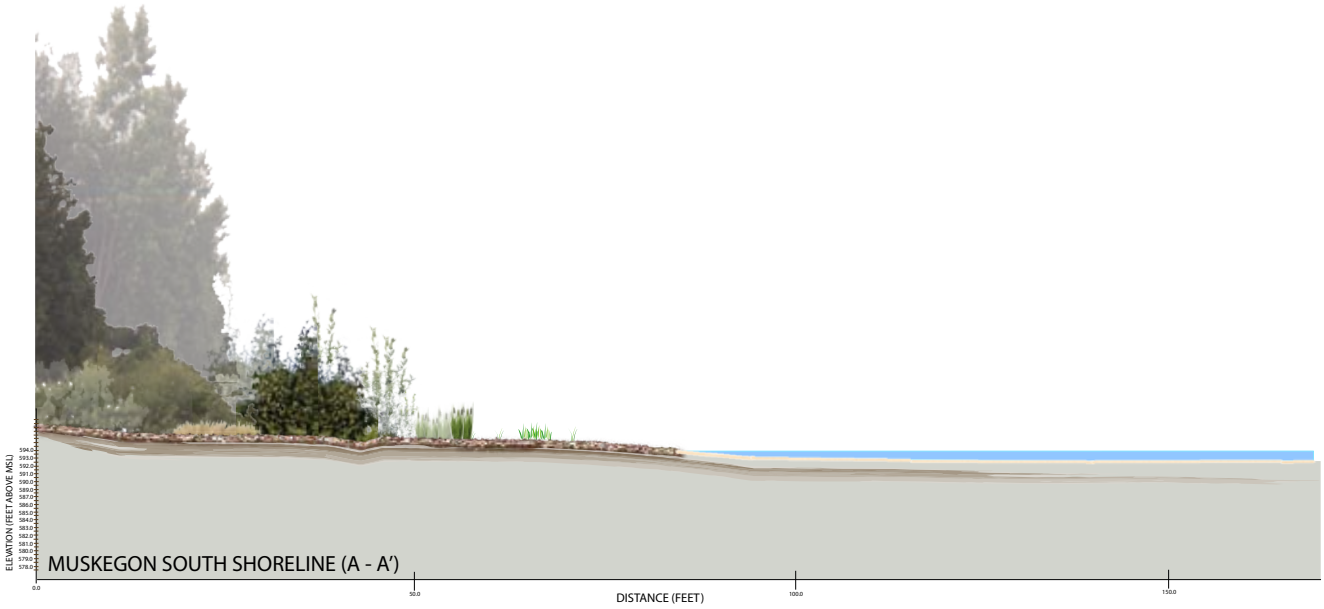
5.6.1 Aquatic

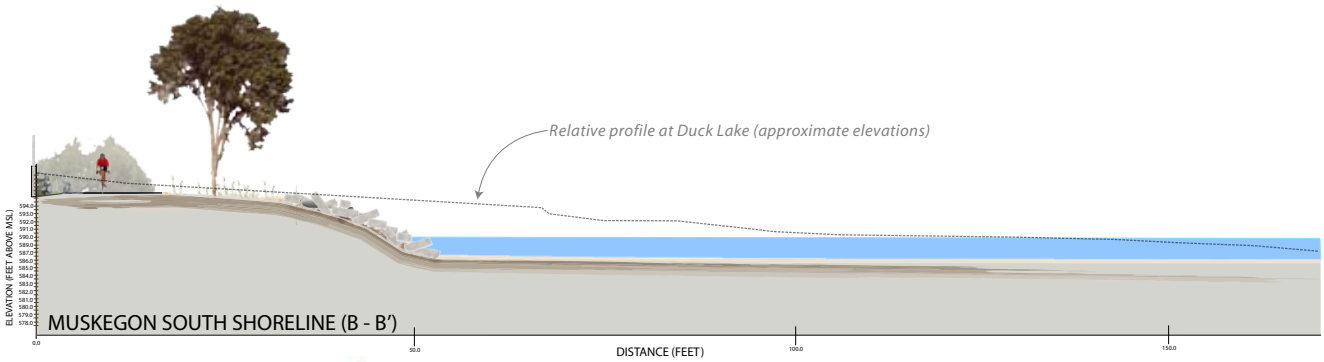
The aquatic habitat in the project area includes a range of characteristics that create three distinct systems including a lakeshore littoral zone, headwater streams and benthic zone. In general aquatic habitat quality is based on the form and function of water quality, water quantity, substrate, cover, vegetation and nutrients. Other characteristics, such as human presence and or exotic invasive species are also important factors that influence the effectiveness of habitat.

Littoral Zone

The littoral zone is the near shore area where sunlight penetrates all the way to the sediment and allows aquatic plants (macrophytes) to grow. Light levels of about 1% or less of surface values usually define this depth. Emergent wetlands typically fall within the







Muskegon Lake Ruddiman Creek Ecological Restoration Master Plan

MUSKEGON LAKE SOUTHSIDE AND DUCK LAKE BANK PROFILES

Biohabitats GREAT LAKES BIOREGION

littoral zone; however they are addressed separately in the Wetlands section. Wave action from wind does exist and water level is affected by changes in Lake Michigan as well as seasonal changes caused by local climate. The substrate in Muskegon Lake littoral zone is primarily sand mixed with woody debris which was deposited in the lake during the lumbering era. Prior to human impacts on the Muskegon Lake littoral zone was likely one of the many Great Lakes Marsh habitats, which are known as important resting stops for migratory birds and spawning/rearing areas for fish.

Littoral Zone Summary

Habitat value: The littoral zone provides a combination of shallow water, aquatic vegetation, shade, shelter and rearing beds for fish; and food for waterfowl, particularly diving ducks, marsh birds, and shore birds.

Issues: Hardened shoreline interferes with natural gentle slope that expands the diversity of habitat defined by water depth. Important aquatic vegetation exists and should be protected and enhanced. State of benthic community along shoreline is unknown.

Aquatic Topography

The shoreline topography within the project area varies including concrete rubble near the mouth of Ruddiman Creek and the Michigan Steel area, sheet-pile walls along the former AMOCO dock, and sandy beach west of the Lakeshore Yacht Club. Within the project area, 76.6% of the shoreline is hardened to contain filled areas. Based on 2007 field measurements, the natural shoreline area at profile "A-A" has an approximate slope of 2.6% and is comparable to the reference site at Duck Lake where the approximate slope at the north shoreline is 2%. In contrast, the approximate slope of the shoreline hardened with large rubble at profile "B-B" is 14%. Ideally, changes in elevation should not exceed a slope of 10%.

Aquatic Vegetation

Most lake littoral zones consist of a mix of submerged and emergent macrophytes (aquatic plants) which provide critical microhabitats for fish and many other aquatic organisms. Two aquatic vegetation studies (1995 and 2005, AWRI) indicate a possible reduction in macrophyte biomass and noted changes in macrophyte composition over the last ten years. Still the lake supports high biomass. While aquatic vegetation is needed to support aquatic species populations, dense stands can actually stunt fish populations. Local authorities suggest maintaining or increasing diversity while not attempting to increase abundance or biomass (M. Luttenton, personal communication). Data from the studies also indicate that aquatic biomass varies throughout the Lake. For example, a 2001 survey of the south shoreline by Wayne State University and Muskegon Conservation District revealed a diverse area of elodea (*Elodea canadensis*), wild celery (*Vallisneria americana*)and other beneficial aquatic plants (Appendix B) near West Michigan Steel, the mouth of Ruddiman Creek and the Grand Trunk (not within the Ruddiman Creek and Nearby Shoreline project area) areas. These areas provide good aquatic vegetation habitat and should be protected and enhanced (2002 RAP).

The Muskegon Lake Watershed Partnership, Muskegon Watershed Assembly, Muskegon Conservation District have partnered with U.S. Fish and Wildlife to re-establish wild rice in the lake littoral zone. Several areas have been planted with mixed success, mostly due to persistent herbivory from waterfowl.

AQUATIC HABITAT TYPES IN THE PROJECT AREA

Lakeshore and Littoral Zone

This habitat type is found along the South Muskegon lakeshore and consists of the shallow gently sloping littoral zone of the lake. Most lake littoral zones consist of a mix of submerged and emergent macrophytes, which provide microhabitats for many vertebrate and invertebrate species. The substrate in South Muskegon Lake littoral zone is primarily sand mixed with woody debris which was deposited when sawmills thrived along the shorelines. The shoreline topography varies from filled concrete rubble near the mouth of Ruddiman Creek and Michigan Steel, sheetpile walls along the former Amoco dock, and gently sloping beach, West of Lakeshore Yacht Club. Prior to human impacts the Muskegon Lake littoral zone was likely one of many Great Lakes Marsh habitats, which are known as important resting stops for migratory birds and spawning/rearing areas for fish.

Shallow Open Water Marsh

The area within Ruddiman Pond can be placed in this category. The amount of water in this area may have once fluctuated seasonally or from year to year depending on lake levels. The edges of this area are dominated by soft stemmed emergent plants such as cattails, grasses, sedges, rushes, arrowhead, pickerel weed, and smartweed. In deeper water are found lily pads and submerged plants such as elodea, milfoil, and pondweed. Marshes are critical for many fish species that live and/or breed there. Marshes offer primary breeding and feeding habitat for water birds (ducks, geese, herons, cranes, rails) and song birds like the marsh wren and yellow warbler, as well as numerous frog species, reptiles (turtles, water snakes), and mammals such as muskrats, beaver, and otter.

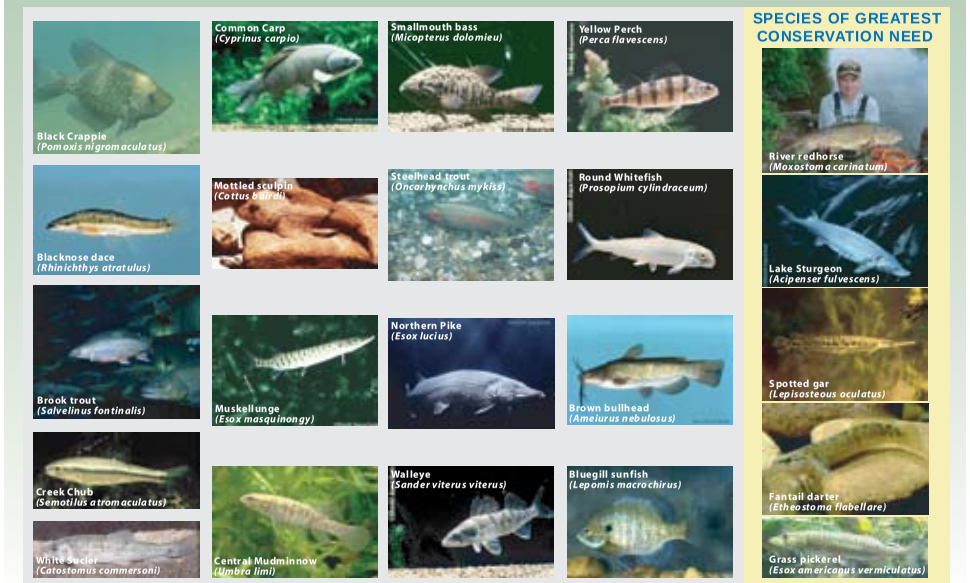
Headwater Stream

The Ruddiman Creek and the un-named south tributary are headwater tributaries to Muskegon Lake. Their watersheds cover approximately five square miles of mixed residential, industrial, commercial, and parkland uses. Approximately 2/3 of the watershed consists of storm sewers draining Muskegon, Muskegon Heights, Roosevelt Park, and Norton Shores. The natural stream bed consists of lacustrine sand and gravel. Unimpacted streams similar to Ruddiman Creek are often classified as "Cool Headwaters", because their hydrology is supported by cool groundwater inflows, have July mean temperatures ranging from 19-22°C, and support coolwater-adapted species. They are highly influenced by the riparian vegetation and woody debris. In Michigan 40% of the Cool Headwater streams are considered degraded, or very degraded.

FISH POPULATION STATUS

* The targeted Beneficial Use Impairments for the Ruddiman Creek and South Muskegon Lake focus area are Loss of Fish and Wildlife Habitat and Degradation of Fish and Wildlife Populations.
* The major goal of the Remedial Action Plan for Muskegon Lake (Updated 2002) is to "Establish a native fishery that is naturally productive, safe from the impacts of non-native species and free of consumption advisories".
* The Michigan Natural Resources and Environmental Code states that "it is the goal of the state to encourage the lasting conservation of biological diversity." Suitable and diverse natural habitats including good water quality, submerged aquatic vegetation, woody debris, and naturally sloped, vegetated shorelines are key to supporting diverse aquatic wildlife (O'Neal and Soulliere, 2006).
* The Muskegon River watershed originally included 97 native fish species. As of 1997, 77 native species were verified in the watershed with five species assumed to have been extirpated (O'Neal, 1997).
* Muskegon Lake currently supports an extensive fishery including resident species and species that migrate between Lake Michigan and Muskegon Lake. Important resident sportfish include, black crappie, yellow perch, walleye, bluegill sunfish, smallmouth bass, Northern pike, and catfish. Spawning runs of potamodromous salmonids (primarily steelhead and chinook salmon) support important fisheries in the fall and early spring.
* One of the most significant problems impacting fish in Muskegon Lake is the degradation of lakeshore littoral habitat. Almost the entire length of the south shore has been impacted by dredging and/or filling (O'Neal, 1997). An intact littoral zone provides significant habitat for northern pike and yellow perch, and essential rearing habitat for most lake species.

FISH SPECIES IN THE REGION



Muskegon Lake Ruddiman Creek Ecological Restoration Master Plan

MUSKEGON SOUTH LAKESIDE AND RUDDIMAN CREEK FISH COMMUNITIES

Biohabitats GREAT LAKES BIOREGION

Fish

The Muskegon River watershed originally included 97 native fish species. As of 1997, 77 native species were verified in the watershed with five species assumed to be extirpated (O'Neal, 1997). Despite the decrease in species diversity, Muskegon Lake has good-to-excellent fishing for northern pike (*Esox lucius*), walleye (*Sander vitreus*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*M. salmoides*), yellow perch (*Perca flavescens*), bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*), black crappie (*Pomoxis nigromaculatus*), channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*), steelhead (*Oncorhynchus mykiss*), and Chinook salmon (*O. tshawytscha*) (O.Neal 1997). Stocked fish include walleye, brown trout (*Salmo trutta*) and Chinook salmon (Michigan DNR 2007). Fishery improvements were the direct result of treating industrial and municipal discharges thus reducing the loadings of pollutants into the Lake. Monitoring will continue for three more years.

Waterfowl

The most common waterfowl species found on the lake during times of migration is the common merganser (*Mergus merganser*). Bufflehead (*Bucephala clangula*) and golden-eye (*Bucephala clangula*) are regularly seen on the lake during the late winter and early spring. Nesting waterfowl are few because most of the shoreline is developed. Shorebird use of Muskegon Lake is limited due to hardened shoreline. Spotted sandpiper (*Actitus macularia*) has been observed along the rip-rap areas and blue heron (*Ardea herodias*) were seen in small marsh areas. Other avian species seen along the shore include: Kingfisher (*Ceryle alcyon*), killdeer (*Charadrius vociferous*), swallow (*Hirundininae* family), herring gull (*Larus argentatus*) and ring-billed gull (Larus delawarensis). Canada goose (*Branta Canadensis*), mute swan (*Cygnus olor* – non-native), and wood duck (*Aix sponsa*) are common and abundant nesters in the marshes and wooded swamps bordering Muskegon River (Wildlife Habitat Assessment, 1995).

Headwater Stream

Physical features that determine habitat and biological communities in creeks include stream discharge (volume), water quality (temperature, oxygen, nutrients and pollutants), channel width, depth and gradient, composition of bottom materials, in-stream cover, and water velocity. Streams where the dominant source of water is groundwater usually exhibit stable flow patterns, diverse bottom materials, stable in-stream cover, moderate velocity and moderate temperatures. For systems like Ruddiman Creek and the tributaries, the influx of water from stormwater systems creates unstable flow patterns which in turn affect the associated physical characteristics.

The Ruddiman mainstem begins at a culvert east of Barclay Street. As the stream flows toward the Muskegon Lake, it passes, via culverts under Barclay Street, Glenside Boulevard and lastly, after the lagoon, Lakeshore Drive. The north branch headwaters drain the Muskegon Catholic Central High School campus and flow uninterrupted into the lagoon. The west branch originates at a stormwater culvert south of West Sherman Boulevard and flows north under Estes Street, Lindberg Drive, West Sherman Boulevard and a foot bridge at Glen Avenue where it then flows along the edge of McGraft Park and finally flows under Addision Street into the lagoon. Organic matter, including large woody debris deposited by the vegetation growing in and along the channel, in the lower reach of the west branch is more prominent than in the other two streams.

Species of Greatest Conservation Need (MIDNR Wildlife Action Plan, Associated with Muskegon Lake Shore and Ruddiman Creek Riparian Corridor Habitats)

Threatened

Bald Eagle
Osprey
Least Bittern
Common Tern

Species of Concern

American Bittern
Black-crowned Night-heron
Black Tern
Common Moorehen
Cooper's Hawk
Marsh Wren
Northern Harrier
Yellow-headed Blackbird

Declining

Blue-winged Teal
Common Nighthawk
Eastern Meadowlark
Killdeer
Pied-billed Grebe
Sedge Wren
Spotted Sandpiper
Virginia Rail

Uncommon

Red-shouldered Hawk
Wilson's Snipe

Additional Wetland Species (Conservation Guidelines for Michigan Lakes)

American Black Duck
American Coot
Canada Goose
Canvasback Duck (C)
Great Blue Heron
Green Heron
Kingfisher
Mallard
Pintail (C)
Redhead (C)
Red-winged Blackbird
Ring-necked Duck
Snow Goose
Sora
Trumpeter Swan(C)
Tundra Swan (C)
Mute Swan (European)
Wood Duck

C = special concern in Michigan














*Despite conservation efforts, many species populations are still declining. Of the species noted to the left and marked as Species of Concern (C), most receive the special status because of habitat loss directly associated with wetland modifcations. The remaining wetlands in Michigan are extremly important to the survival of many species.

*The Ruddiman Creek site, though isolated, provides a diverse combination of bird habitats including open water, beaches and a variety of wetland and forest communities in close proximity to each other. Many bird species (resident and migratory) depend on this combination of habitat types to meet their full range of needs.

*Nesting sites include trees, shrubs, cattails, sedges, either suspended or on the ground and in some cases, a surface surrounded by water.

*Wetland and waterfowl feed on floating (duckweed, water lilies), emergent (sedges, wild rice) and submerged (wild celery) vegetation using all parts for nourishment such as leaves, stems, seeds, acorns, beech nuts, fruits (wild grapes), tubers, and roots. Prey include: aquatic and terrestrial invertebrates, macroinvertebrates (mayfly and dragon fly nymphs) insect larvae, insects, mollusks, crustaceans, worms, fish, frogs, and small rodents.

*State Bird Conservation Efforts

- As a result of hunting and habitat destruction Wood ducks were near extinction in the early nineteen hundreds. Today their population is thriving. Hunting laws have been put into place to protect them and man-made nest boxes are being created to counter their loss of habitat.
- For the past several years, the Nongame Wildlife Fund has supported the transfer of osprey chicks from the northern Lower Peninsula to southern Michigan. It is anticipated that these released birds will form the core of a successful population in southern Michigan.
- Sandhill crane numbers were much reduced by habitat loss and shooting in the early part of this century but have grown in recent decades. A two year survey funded by the Nongame Wildlife Fund confirmed 805 breeding pair statewide.
- During the 1980s, Michigan began a trumpeter swan reintroduction program. After nearly 15 years, the 2000 count of trumpeter swans in Michigan exceeded 400 individuals.

MUSKEGON SOUTH LAKESIDE AND RUDDIMAN CREEK AVIAN SPECIES

In general the physical characteristics of Ruddiman Creek and the tributaries include a low width to depth ratio (shallow and narrow channel) with low sinuosity ("S" curves) and sandy substrate. The hydrology is driven by a stormwater collection and conveyance system that delivers the stormwater to the stream channels. As a result, daily and seasonal fluctuations are dramatic causing increased velocities, increased sediment erosion, high summer temperatures and potential for pollutants to enter the system.

Natural streams similar to Ruddiman Creek are classified as "cool headwaters" because the hydrology is influenced by cool groundwater inflows. These streams typically have July mean temperatures within the range of 10-22° Celsius, and support species (such as brook trout *Salvelinus fontinalis*) which are adapted to cool water habitat. Furthermore, they are highly influenced by riparian vegetation and woody debris. In Michigan, 40% of the Cool Headwater streams are considered degraded, or very degraded. While cool groundwater may influence the Ruddiman Creek system, the channel lacks structural components such as large woody debris and channel variation in the form of pools and riffles. Furthermore, shade is not available to keep water temperatures low.

The recent remediation work on the Ruddiman mainstem included restoration activities such as; aggregate placement in the creek where sediment was removed, grading, seeding and replanting of native perennials and shrubs that were removed during construction process, installation of energy dissipation structures in the creek, creation of deeper pools in selected areas of the creek, armoring portions of the creek with rock, installation of riprap riffles at strategic locations along the creek, and leaving some of the diversion channels in place to create a braided stream effect (EQM, Inc., 2005). The creek and lagoon are in early stages of recovery from the past remediation activities. The shorelines are generally stable with some aquatic vegetation, however the recent dredging has left the stream channel, immediate floodplain, and open water portions of the lagoon void of habitat variability. In systems with typically sandy substrate such as Ruddiman Creek and the lagoon, woody debris can be an important contributor to fish habitat. Over 85 fish species depend on large wood during some portion of their life cycles (Dolloff and Warren, 2003) and O'Neal and Soulliere (2006) devote several pages citing the importance of deadwood in the littoral zones of lakes.

Headwater Stream Summary

Habitat value: Headwater streams offer places where fish lay their eggs, young hatch and can hide from predators in shallow water while they feed and grow. Close proximity to terrestrial habitat provides accessible water for terrestrial animals.

Issues: Aligning stormwater discharge (quantity and quality) with natural hydrologic characteristics. Fish passage blockages at the mouth and at culverts make it difficult for fish to reach stream habitat.

Benthic Zone Summary

Habitat value: A healthy benthic community is not only a sign of good water quality; it also provides an important food source for fish and waterfowl.

Issues: The status of benthos within the project area is unknown.

Benthic Zone

All of the aquatic habitats above have bottom sediment, known as the benthic zone, which has a surface layer abundant with organisms, benthos. This upper layer of sediments may be mixed by the activity of the benthic organisms that live there, often to a depth of 2-5 cm (several inches) in rich organic sediments. Most of the organisms in the benthic zone are invertebrates, such as Dipteran insect larvae (midges, mosquitoes, black flies, etc.) or small crustaceans. The productivity of this zone largely depends upon the organic content of the sediment, the amount of physical structure, and in some cases upon the rate of fish predation (lakeaccess.org). At historic contamination sites associated with Muskegon Lake and Ruddiman Creek, benthic communities were reduced to only a few species that could tolerate pollutants. A decrease in benthos leads to a decrease in food for aquatic wildlife. Benthic animals include aquatic insects, mollusks, clams, snails, worms and crayfish.

5.6.2 Wetlands

Wetlands are defined by hydrology, soils and vegetation and they are transitional lands between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is covered by shallow water. Wetlands are valued for their contribution to flood abatement, filtering pollutants, trapping excess nutrients and, natural nutrient and water cycles. Wetlands in the project are organized into three groups; Open Water Marsh (a combination of open water and emergent wetland), Emergent Wetland and Scrub-shrub Wetland.

Open Water Marsh Summary

Habitat Value: Open water marshes are critical for many fish species that live and /or breed there. Marshes offer primary breeding and feeding habitat for water birds (ducks, geese, herons, cranes, rails) and song birds like the marsh wren, and yellow warbler, as well as numerous frog species, reptiles (turtles, water snakes) and mammals such as muskrats, beaver and otter.

Issues: Fill material, the lack of aquatic vegetation, and low habitat complexity select for "generalist" species that are highly adaptable.

Emergent Wetland Summary

Habitat value: Emergent wetlands are one of the most productive habitat types. They provide food, cover and water for many species of birds, mammals, reptiles and amphibians, many of which depend on emergent wetlands for their entire life cycle.

Issues: Current species diversity is low with cattail being the dominant species. Creating more of this habitat type will benefit a wide range of species.

Open Water Marsh

This habitat type is associated with the Ruddiman Lagoon where water levels may fluctuate in response to cyclical and seasonal fluctuations in Lake Michigan and Muskegon Lake. The lagoon also has a littoral zone that supports a range of aquatic habitat. The edges of the lagoon are dominated by soft stemmed emergent plants such as cattails (*Typha* spp.), grasses (*Phragmites australis*), sedges (*Carex* spp.), rushes (*Scirpus* spp.), arrowhead (*Sagittaria* spp.), pickerel weed (*Pontederia cordata*), and smartweed (*Polygonum* spp.). Lily pads and submerged plants such as elodea, milfoil and pond weed grow in the deeper water.

Emergent Wetland

Wetlands dominated by erect, rooted herbaceous vegetation are considered emergent wetlands. This type of wetland is associated with the natural areas along the Muskegon Lake shoreline and floodplain areas adjacent to the mainstem and north branch of Ruddiman Creek. The emergent wetland along the Lake shoreline is dominated by cattail *(Typha sp.)* and common reed (*Phragmites australis*) with a very small representation of purple loosestrife (*Lythrum salicaria*) and reed canary grass (*Phalaris arundinacea*). This area of emergent wetland is long and narrow bounded by the lake on one side and a railway at the toe of a very steep slope on the other side. The width of vegetation varies from 10-60 feet and includes some shallow open water areas. The main stem of Ruddiman Creek and the north branch are both flanked by emergent wetlands also dominated by cattail with sparse populations of purple loosestrife and common reed.

Riparian Scrub-shrub Wetlands

Wetlands dominated by shrubs and tree saplings less than twenty feet in height are classified as scrub-shrub wetlands. Horizontal and vertical complexity created by various shrub species creates dynamic habitat. This type of wetland exists at the mouth of Ruddiman Creek, around the edge of the lagoon and throughout the main stem and north branch riparian corridors. Shoreline scrub-shrub wetland species consists mainly of willow (*Salix* spp.) and shrub dogwood (*Cornus* spp.) with some areas having a strong presence of eastern cottonwood (*Populus deltoids*) saplings. Native riparian scrub-shrub wetland species consist of, willow, shrub dogwood, and swamp rose (*Rosa palustris*). Non-native species are prevalent and include glossy buckthorn (*Rhamnus frangula*), tartarian honeysuckle (*Lonicera tartarica*) (widespread)

Scrub Shrub Wetland Summary

Habitat value: Scrub-shrub wetland habitat is especially important for birds but other species also rely on the dense cover and food resources that some shrub species offer. Vegetation also provides shade and woody debris for stream ecosystem.

Issues: Invasive species are dominant thus changing food, shelter, shading and woody debris characteristics typically associated with this habitat type. A specific example is that the tartarian honeysuckle produces shiny red fruit that is more attractive to birds, yet it does not provide the necessary nourishment needed for the winter months. Furthermore the branches are weak and low to the ground exposing nests with young to predators.

and a few small patches of Japanese knotweed (*Polygonum cuspidatum*).

The scrub shrub wetlands along the riparian corridor of the Ruddiman Creek mainstem consist of patchy stands, including shrub willow, glossy buckthorn, tartarian honeysuckle, red osier dogwood, speckled alder, cattail, purple loosestrife and swamp rose. These stands are separated by road crossings and areas obviously cleared during the sediment remediation process. Restoration plantings in the remediated areas are in an early successional state and appear to be recovering. Restoration records indicate that plants and shrubs were installed 3 feet on center at approximately 16 plants per 100 square feet (EQM, Inc. 2005). The restoration species included, but were not limited to, red osier dogwood (*Cornus sericea*), witch hazel (*Hamamelis virginiana*), winterberry (*Ilex verticillata*), swamp oak (*Quercus* sp.), cardinal flower (*Lobelia cardinalis*), black eyed susan (*Rudbeckia hirta*). These plantings should be monitored to ensure that they develop toward the desired riparian community, as their shading, nutrient sequestering, and discharge attenuating properties will have an important influence on Ruddiman Creek.

5.6.3 Terrestrial/Upland

The land use surrounding the project area is primarily suburban, dominated by homes with yards, community parks, church and schools with spacious grounds and industrial and business parks containing associated open space. Human activity and development fragment natural habitats into smaller and more isolated units. The number and type of vertebrate species inhabiting an area is dependent upon the size of the habitat area, the distance between habitat areas, and the percent of vegetative cover found in these areas.

Lakeshore Upland

The upland areas along the Lakeshore include a former AMOCO docking pier , narrow strips along the pedestrian/bike trail, a cluster of trees and shrubs near the Lakeshore Yacht Club, a steep embankment and twin spits at the northeast end of the project area near Michigan Steel. In general the sites are old industrial sites now covered with vegetation, much of which is non-native. The soil is sandy and the areas are confined by the lake on one side and paved trail, railway, residential use and/or commercial use on the other.

Lakeshore Upland Summary

Habitat value: Trees and shrubs along the lakeshore provide cover and refuge for animals moving between terrestrial and aquatic habitats.

Issues: Lakeshore terrestrial habitat is highly fragmented, narrow and isolated from inland terrestrial habitat in addition to harboring non-native species.

The twin spits area consists of fill (large rubble and slag) covered with vegetation mostly consisting of willow, shrub dogwood, viburnum and sumac with a few white birch trees and substantial stands of cottonwood, black locust and oak trees. The flat upland area includes mowed grasses and forbs. The vegetated buffer is confined mostly to the shoreline slope and lacks a diverse shrub layer. The twin spits area shows limited use by wildlife yet seems best suited for rabbit, small rodent and reptiles.

Michigan's pre-settlement Vegetation, as Interpreted from the General Land Office Surveys 1816-1856 shows historic vegetation cover as white pine-white oak forest along the south shoreline of Muskegon Lake. Native species include cottonwood, boxelder shrub dogwood, willow, viburnum and sumac. Non-native species include, but are not limited to black locust, tree-of-heaven, sweet clover, chicory, wild grape, St. Johnswort and bouncing bet (Appendix: D).

Riparian Upland

Terrestrial riparian habitat in the project area generally includes slopes greater than 10%. The tree canopy is dominated by deciduous trees (Red and white oak, cotton wood, sassafras wild cherry), a shrub layer (mapleleaf viburnum, witchhazel) and herbaceous ground layer (ferns and forbs). In general, the vegetation is composed of native species with only a few places where invasive species have become established. Slopes are vegetated and show isolated erosion at stormwater sewer outfalls. Vegetation changes dramatically at the top of the slopes and becomes dominated by urban landscapes (Appendix: D).

The area around McGraft park has been manicured, and harbors many exotics and invasive species. Visual appeal for the general public is important here. The ground layer is mostly turf and in most areas it extends to the edge of the water. Where vegetation has been allowed to grow along the water, shrubs are the dominant type of vegetation and include gray dogwood, swamp rose, viburnum, honeysuckle and glossy buckthorn. Wooded slopes include stands of exotic species including, Norway maple, tree-of-heaven, silver maple.

Mammals and Herpetofauna:

Small suburban habitat areas like the Ruddiman Creek Corridor generally serve as refuges for deer, small rodents and larger nocturnal scavengers and omnivores such as raccoons, opossums, skunks, and Norway rats. These mammals along with muskrats, squirrels, cottontail rabbits, chipmunks,

Riparian Upland Summary

Habitat Value: Wooded areas provide a buffer between urban areas and waterways and the variety of vertical vegetation structure provides and nesting and refuge for birds and small mammals.

Issues: Encroachment of ornamental plants such as vinca, lily-of-the-valley and ivy pose a potential threat to the diversity of the groundlayer.

brown bats, moles, and shrews are the most prevalent mammals to be found in the project area and immediate surroundings. To retain amphibian and reptile populations, habitat areas of at least 1.30 acres near a permanent source of water are important. Species most likely to be present include:

- Snapping turtles
- Painted turtles
- American toads
- Bull frogs
- Northern leopard frog
- Green frog
- Northern water snakes
- Eastern garter snake

Overall, due to habitat fragmentation and modification reduces the number of wildlife species able to use these areas and most wildlife species will be habitat generalists who have adapted to living close to human activity.

5.7 Ecological Reference Sites

As defined by the project guiding principles articulated by the stakeholders during the workshops, the restoration of the Ruddiman Creek and Nearby Shoreline area will be guided by suitable reference systems. Reference systems are often local model sites that can be used to guide the restoration. Reference attributes are generally derived from a similar system that lacks major impacts and displays the desired restored condition (e.g. diverse native communities and good water quality). The reference systems will provide an initial framework for restoration actions, and specific criteria for evaluation. Species lists are located in Appendix E.

Often, ecological restoration scientists use data that provide accounts of the restoration site in pre-disturbance conditions, prior to degradation. This can include the following sources of information: ecological descriptions, species lists and maps of the project site prior to damage; historical and recent aerial and ground-level photographs; remnants of the site to be restored, indicating previous physical conditions and biota; historical accounts and oral histories by persons familiar with the project site prior to damage; and paleoecological evidence, e.g. fossil pollen, charcoal, tree ring history, rodent middens (SER, 2004). These accounts can also be used as reference attributes as they provide an account of the past ecological condition.

The selection of appropriate reference conditions for habitat types along the lake shoreline and

Ruddiman Creek corridor presents unique challenges. These systems are man-made (in the case of extensive fill along the shoreline), or so severely altered from their original condition (sewershed as opposed to watershed hydrology) that a return to a pre-disturbance state would be both difficult and very expensive. In addition, many of these areas currently support functional ecological communities. Additional hydrologic studies and soil testing may be necessary to determine if hydrologic alteration, or soil amendments are necessary to attain the desired ecological condition. This was recognized by the stakeholders during the public workshop, and a guiding principle of the project leads restoration actions away from pristine references and toward functional reference sites that have remained resilient under some form of disturbance.

The approach adopted by this Master Plan is three-fold; 1) to use regional ecosystems that are appropriate references for the specific ecosystem components slated for restoration; 2) to use existing literature and "tools" for helping to determine desired attributes for restored habitat complexes, such as target species assemblages or hydrologic function; 3) to use MDEQ Guidance for addressing the habitat related BUIs.

Duck Lake

5.7.1 Duck Lake

Duck Lake is a drowned river mouth located to the north of Muskegon Lake. While smaller in size its shoreline is relatively undisturbed and provides a good reference for shoreline habitat restoration in the project area. The littoral zone included a gradual slope of 2% with a sandy substrate. Sedges populated the water's edge and the sandy shoreline consisted of willow, alder, eastern cottonwood and oak saplings. Terrestrial vegetation consists of an overstory including white pine, white oak, red oak, red maple, eastern cottonwood and beech trees. Understory and shrub vegetation includes sassafras, witchhazel, shrub dogwood, lowbush blueberry, bearberry and creeping juniper.

5.7.2 Pentwater Lake

Pentwater Lake is a drowned located to the north of Muskegon Lake and Duck Lake. Similar to Muskegon Lake, the connection to Lake Michigan has been dredged to form a permanent shipping channel. It is smaller in size compared to Muskegon Lake and has areas of developed and undisturbed shoreline, while supporting communities that may be desirable for the restoration of the Muskegon Lake shoreline. Shoreline morphology and vegetation investigations were not conducted on this lake.

Reyerson Creek

5.7.3 Ryerson Creek

The reach of Ryerson Creek between Home Street and Getty Street is a somewhat stable, intact stream system with comparable hydrology to that of Ruddiman Creek. The riparian area includes both open areas with emergent wetlands dominated by cattails and wooded areas where trees and shrubs provide shade and woody debris. Native species composition was similar to Ruddiman Creek with the main difference being the absence of prolific invasive vegetation. In addition, in some areas the floodplain was very narrow with steep valley side slopes dropping to the edge of the channel allowing trees to grow very close to the water.

5.8 Potential Threats to Muskegon Lake and Ruddiman Creek Habitats

The habitats and biota described previously exist in an extremely altered ecological condition compared to what occurred in pre-industrial times. Despite these changes and influences, robust, diverse natural communities exist, while still others can be established in the current landscape matrix. They are influenced by the regional geology and climate, as well as from anthropogenic sources including the people of the City of Muskegon, and all of the industrial, commercial, residential, and transportation infrastructure operations that occur in the project area. The function of the ecological components is greatly affected by the presence of this infrastructure, and the influence of humans on the landscape. These are viewed as potential threats to ecological integrity, which must be managed to maintain the stability and viability of natural communities in the project area.

Potential ecological threats in the project area include:

- Impacts from urban hydrology
- Poorly planned development
- Invasive vegetation and wildlife
- Impacts from recreational use
- Global climate change
- Fluctuating lake levels and wave action

The ultimate success of the restoration master plan will depend on thorough plan execution, including alleviating these threats.

5.8.1 Impacts from Urban Hydrology

Roughly two thirds of the Ruddiman Creek watershed has been culverted and/or placed in storm sewers. When rain water hits the parking lots streets and driveways in the watershed, it is rapidly transported to the storm sewers,

which quickly deliver it to the stream channel. Rain water has little opportunity to infiltrate into the ground, and instead, enters the stream channel with erosive velocities and flooding volumes. In addition to flashy flows, runoff from parking lots and roadways carries chemical byproducts of petroleum combustion, nutrients, road grit, bacteria from sewer mammals and pet feces, and other pollutants into the stream channel, reducing water quality. It is documented that the stream does not meet water quality standards for human contact due to bacteria (MDEQ, 2006). A Total Maximum Daily Load (TMDL) is required for this stream and is slated to go into effect in 2010. Conversely, during dry weather there is little groundwater discharge to the channel. This results in extremely low flows in the channel that concentrate the deposited pollutants, often cause anoxic conditions, and stress aquatic fauna.

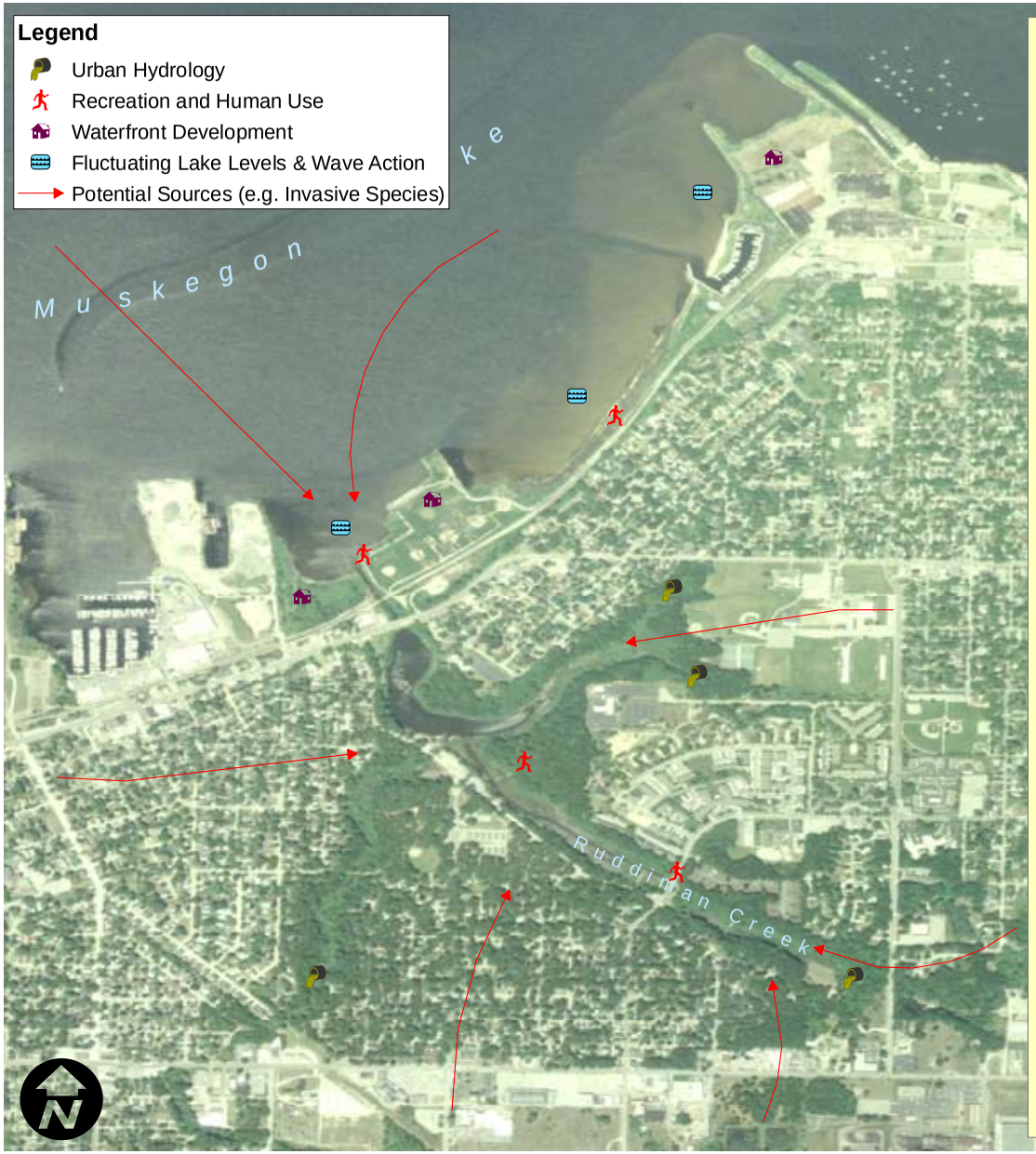
Potential threats

5.8.2 Poorly Planned Development

The expansion or additional construction of residential, commercial, or industrial development and associated infrastructure has the potential to disturb ecosystems through habitat loss, direct displacement of plant and animal communities, alteration of watershed hydrology, noise and light pollution, and trash.

Aside from existing development and infrastructure in the project area, many shoreline and riparian properties have the potential for expanded industrial, residential, or marina development. Valuable riparian areas must be cleared to create roads that access properties through wetlands and/or currently undeveloped areas. Once in place, these roads can prevent the migration of aquatic and terrestrial organisms laterally along the corridor, disconnecting the ecological link between the wetland and upland areas. Culverts and roadside ditches also concentrate stormwater flows which affect channel morphology and in-stream habitat. Lighted parking areas around homes and businesses reduce the nighttime number of refugia for terrestrial wildlife.

Although valuable for lake access; the construction of shoreline marinas, can reduce wetland and littoral habitat. Shorelines must be cleared and some littoral zones filled to construct protective headwalls. Areas with shallow emergent vegetation and/or submerged aquatic vegetation are frequently dredged for boat access. In addition, many cleaning solutions and antifouling agents used on boats are harmful to aquatic life.



POTENTIAL SOURCES OF DISTURBANCE

Poorly Planned Development

The construction of houses, roads, sidewalks, marinas and associated infrastructure has the potential to disturb ecological function, by reducing habitat, directly displacing plant and animal species, altering hydrology, and increasing light pollution and trash.

Urban Hydrology

Roughly two thirds of the Ruddiman Creek watershed has been culverted and/or placed in storm sewers. Rain water is rapidly transported to the storm sewers, which quickly deliver it to the stream channel. The rain water has little opportunity to infiltrate into the ground, and instead, enters the stream channel with erosive velocities and flooding volumes. In addition, runoff from parking lots and roadways carries pollutants into the stream channel, reducing water quality.

Fluctuating Lake Levels & Wave Action

Water levels in Lake Michigan are directly related to water levels in Muskegon Lake and the Ruddiman lagoon. Currently the Lake Michigan is approximately 1-foot above the lowest recorded level from 1964, and appears to be on a downward trend. Further reductions in lake levels will result in a change in shoreline vegetation around the lake perimeter. It is anticipated that upland vegetation will encroach on the shoreline, while wetland vegetation adapted for quick colonization will be able to exploit new wetland marsh habitats.

Wave action, either from strong winds over a long fetch, and or excessive boat wake can uproot aquatic vegetation and exacerbate erosion. Marsh areas should have protection such as baffles and breakwaters to help maintain the shoreline vegetation.

Recreation and Human Use

Many recreational human activities like fishing, hiking, and canoeing/kayaking have the potential to negatively impact ecosystems. Eroding trails, litter, pet waste, increased predation, and noise pollution can impact plant and animal communities and cause ecological stress.

Invasive Species

Invasive species can alter the local species composition and potentially reduce ecological function. Invasive species introductions can result from the intentional release of once "harmless" and/or "beneficial" species, as well as from discarded pets. Other introductions have come from ballast waters and private gardens, and are exacerbated by ecological disturbance.

Muskegon Lake Ruddiman Creek Ecological Restoration Master Plan

MUSKEGON SOUTH SHORELINE AND RUDDIMAN CREEK POTENTIAL THREATS TO ECOLOGICAL SUSTAINABILITY

0 500 1,000 2,000 3,000 4,000 5,000 Feet

Biohabitats GREAT LAKES BIOREGION

5.8.3 Fluctuating Water Levels and Wave Action

Water levels in Lake Michigan have fluctuated both seasonally and cyclically. Extremely low levels occurred in the 1920s, mid-1930s, 1960s, and late-1990s (http://www.great-lakes.net/teach/envt/levels/lev_3.html). The lowest water levels occurred in 1964 (576.6 feet IGLD). The highest levels were recorded in the early 1950s, early 1970s, mid-1980s and mid-1990s. The highest recorded level of 581.9 feet IGLD was recorded in 1986 (http://www.lre.usace.army.mil/_kd/Items/actions.cfm?action=Show&item_id=3887&destination=ShowItem). Currently the lake is at about 577.3 feet IGLD and appears to be on a downward trend. The lake generally fluctuates 12 to 18 inches every year based on annual rainfall and snow melt. Global climate change may cause the lake water levels to continue decreasing, which will result in considerably lower water levels in Muskegon Lake.

Wave action, either from strong winds over a long fetch, and or excessive boat wake can uproot aquatic vegetation and exacerbate erosion. The marsh areas should have protection to help establish restored vegetation and maintain a buffer from direct wave action.

5.8.4 Invasive Vegetation and Wildlife

Invasive species can alter the local species composition and potentially reduce ecological function. Invasive species introductions can result from the intentional release of once "harmless" and/or "beneficial" species, as well as from discarded pets. Other introductions have come from ballast water, private gardens, and altered distribution due to climate change, hybridization, and/or local habitat loss.

Many non-native and invasive plant species have the ability to colonize quickly and out-compete native woody and herbaceous species. Prior to vegetative restoration, it is imperative to undertake a comprehensive invasive species inventory and create an invasive species management plan for the project area. Areas should be treated for undesirable invasive vegetation prior to any site restoration. Restored areas should be monitored for the presence and/or expansion of invasive plants after the restoration to make sure that they do not overtake more desirable native species. Areas where invasive species were treated and/or removed prior to, and after construction should be evaluated annually for new growth, and re-growth of targeted invasive species.

Invasive wildlife can severely impact native plantings through overgrazing and disturbance. Adequate protection of restoration plantings will be necessary during development stages and periodically after establishment to make sure that invasive/nuisance wildlife are not destroying restoration plots.

5.8.5 Impacts from Recreational Use

Many recreational human activities like fishing, hiking, and canoeing/kayaking have the potential to negatively impact ecosystems. Eroding trails, litter, pet waste, increased predation, and noise pollution can impact plant and animal communities and cause ecological stress.

Hiking trails, fishing, and hunting are recreational elements that occur in the area; all of these human activities have the potential to negatively impact ecosystems. Erosion, litter, pet waste and predation, noise and light pollution, and graffiti can influence plants and animals, and be sources of ecological stress.

Invasive / Exotic Species

A number of introduced species in the Lake Michigan basin have caused problems for existing native flora and fauna. Since the early 1800s, over 160 non-native species have been introduced into the Great Lakes. Over 60% of these have arrived since 1960 following the opening of the St. Lawrence Seaway, most likely through the ballast water discharge of large ships. Other sources include past conservation practices and the horticulture industry.

Upland and Wetland Invasive Plant Species

WOODLAND INVASIVES

Oriental bittersweet engulfs trees often girdling them. Furthermore, trees break or come down under the weight of the vines.

Black locust forms dense stands and can shade out native species.

Garlic mustard is a major threat to the survival of woodland flowers and tree seedlings. It can dominate a forest floor within 5-7 years of introduction.

oriental bittersweet

black locust

garlic mustard

OPEN, DISTURBED AREAS

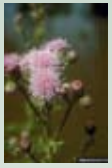
In general these species are aggressive, rob natives of water nutrients and sunlight.

Spotted knapweed releases a toxin into the soil that inhibits the growth of neighboring species.

crown vetch

knapweed

canada thistle



white sweet clover

WETLANDS AND RIPARIAN AREAS

glossy buckthorn

Glossy buckthorn is particularly aggressive in wet areas producing a dense shade that eliminates native tree seedlings, saplings and ground layer species. In the absence of diverse plant species, birds sufffer from the lack of variation in horizontal canopy cover and complexity of veritcal structure.

reed canarygrass

Tartarian (and amur) honeysuckle inhibits the growth of native shrubs and ground layer species. Bird nests built in the fine branches bring young within reach of terrestrial predators. In addition, the berries do not provide nutrients for overwintering birds.

common reed

japanese knotweed

tartarian and amur honeysuckle

narrow-leaved cattail

native species: common cattail

purple loosestrife

Aquatic Invasive Species

spiney water flea

zebra mussel

mute swan

bighead & silver carp

threespine stickleback

eurasian water-milfoil

round goby

sea lamprey on lake trout

Muskegon Lake Ruddiman Creek Ecological Restoration Master Plan

MUSKEGON SOUTH LAKESIDE AND RUDDIMAN CREEK INVASIVE SPECIES

Biohabitats GREAT LAKES BIOREGION

Currently, recreational activities in the ecologically-sensitive portions of the project area are limited, and likely the associated risk of ecological disturbance is minor in comparison to other potential threats. However, any increase in recreation within or adjacent to natural communities may be incompatible with ecosystem restoration goals, and be considered a more active source of disturbance.

5.8.6 Global Climate Change

In the Great Lakes region, the impacts of climate change will be profound. Recent studies conclude that the climate of the region is already changing; winters are growing shorter, average annual temperatures are getting warmer, extreme heat events are occurring more regularly, the duration of lake ice cover is decreasing as air and water temperatures rise, and heavy precipitation events are becoming more common (MEC 2007, Kling et al. 2003). Some climate models predict that by the end of the century, regional temperatures will be 5° to 12° Fahrenheit warmer in the winter months, and 5° to 20° Fahrenheit warmer in the summer months. Annual precipitation levels are unlikely to change, but their distribution will lead to an overall warmer, dryer climate (Kling et al., 2003). Other climatologists predict a 2° to 4° C rise in temperatures in the Great Lakes region, accompanied by a 25% increase in precipitation by the end of the 21st century (Sousounis and Glick, 2000). Despite the increase in precipitation, lake levels are projected to decrease by an estimated 1.5 to 8 feet, due to the increase in evaporation associated with higher temperatures (Sousounis and Glick, 2000).

The ecological consequences of these climatic trends are complex, many, and varied. A recent report issued by the Union of Concerned Scientist and Ecological Society of America entitled *Confronting Climate Change in the Great Lakes Region* (Kling et al. 2003) offers the following predictions of ecosystem response for the Great Lakes physiographic province:

Lake Ecology

- Future declines in both inland lakes and the Great Lakes are expected.
- Declines in the duration of winter ice are expected to continue.
- Loss of winter ice may reduce winterkill in shallow lakes but it may also jeopardize whitefish in the Great Lakes, where ice cover protects the eggs from winter storms.
- The distributions of many fish and other organisms in lakes and streams will change. Coldwater species such as lake trout, brook trout, and whitefish and cool-water species such as northern pike and walleye are likely to decline in the southern parts of the region, while warmwater species such as smallmouth bass and bluegill are likely to expand northward.
- Invasions by native species currently found just to the south of the region and invasions of warm-water nonnative species such as common carp will be more likely.
- In all lakes, the duration of summer stratification will increase, adding to the risk of oxygen depletion and formation of deep-water "dead zones".
- Many fish species should grow faster in warmer waters. It remains uncertain whether prey species and the food web resources on which they depend will increase to meet these feeding demands.

Streams and Wetlands

- Earlier ice breakup and earlier peaks in spring runoff will change the timing of stream flows,

and increases in heavy rainstorms may cause more frequent flooding.
- Warmer water temperatures will reduce the habitat available for native brook trout.
- Changes in the timing and severity of flood pulses are likely to reduce safe breeding sites, especially for amphibians, migratory shorebirds, and waterfowl, and may cause many northern migratory species such as Canada geese to winter further north.
- Reduced summer water levels are likely to cause small streams and wetlands to dry up, resulting in poorer water quality and less habitat for wildlife.
- Drought and lower water levels may ultimately increase ultraviolet radiation damage to frogs and other aquatic organisms, especially in clear, shallow water bodies.
- Shrinking of streams and wetlands will also decrease the number and type of refugia available to aquatic organisms, especially those with limited dispersal capabilities such as amphibians and mollusks.

Woodlands

- The distribution of forests is likely to change as warmer temperatures cause the extent of boreal forests to shrink and many forest species to move northward.
- A hotter and drier climate will create ideal conditions for the start and spread of wildfires.
- An increased number of forest fires can exacerbate drought episodes by reducing rainfall. Smoke particles absorb solar heat, robbing convective currents of the energy they need to transport water vapor upward, and thus interfering with the cycle that generates rainfall in the region.
- Long-distance migratory birds such as scarlet tanagers, warblers, thrushes, and flycatchers depend on trees and caterpillars for food. Especially for those migratory birds that time their migration by day length rather than by weather, food sources may be severely reduced when they arrive in the Great Lakes region.
- Resident birds such as northern cardinals, chickadees, and titmice might be able to begin breeding earlier and raise more broods each season. However, increasing populations of resident species could further reduce the food available for migratory songbirds that breed in the Great Lakes, ultimately reducing forest bird diversity in the region.
- The geographic range of forest pest species such as the gypsy moth is likely to expand as temperatures warm and the distribution of food plants changes.
- Changes in leaf chemistry due to CO^2 fertilization are possible, reducing food quality for some organisms. This could cause some leaf-eating pests to eat more and could ultimately alter aquatic and terrestrial food webs.

Currently, tools to address the impacts of climate change are limited. Ongoing international research may identify common impacts and solutions during the implementation of the Plan. The solutions may be useful in guiding future implementation, monitoring, and maintenance strategies in the project area.

6.0 References

Comer, P.J. and D.A. Albert et al. 1997. *Vegetation circa 1800 of Muskegon County, Michigan: An Interpretation of the General Land Office Surveys*. Michigan Natural Features Inventory, Lansing, MI. Digital Map.

Day and Associates. 1995. *Muskegon Lake Wildlife Habitat Assessment.* Grand Haven, MI.

Dollof, C.A. and M.L. Warren. 2003. *Fish Relationships with Large Wood in Small Streams*. American Fisheries Society Symposium 37:179-193.

Kling, G.W., D. J. Wuebbels *et al.* 2003. *Confronting Climate Change in the Great Lakes Region*. Union of Concerned Scientists and Ecological Society of America. http://www.ucsusa.org/greatlakes/glchallengereport.html

Lake Access. http://lakeaccess.org/aboutus.html - understanding lakes (11/1/07)

Lake Michigan Lakewide Management Plan (LaMP) fact sheet (glossy brochure) Prepared by the Office of Great Lakes, MDEQ (no date on the publication, but the assumption is 2000 because that is when the MI LaMP was published)

Muskegon Lake Community Action Plan: 2002 RAP Update. Prepared for the Muskegon Lake Public Advisroy Council and the Muskegon Lake Watershed Community by the Muskegon Conservation District.

Luttenton, M. 1995. *Muskegon Lake Aquatic Plant Assessment*. Grand Valley State University Michigan.

Day & Associates Environmental Planners. 1995. *Muskegon Lake Wildlife Habitat Assessment.* Grand Haven, MI

Environmental Quality Management, Inc. 2005. *Remediation of Ruddiman Creek Main Branch and Pond, Muskegon Michigan.* EQM, Inc. Cincinnati, OH.

Muskegon Weather Station Office. 1951-2000. Michigan State University, Geography Department, Climatological Resources Program, East Lansing, Michigan.

USDA Natural Resources Conservation Service, Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/app/).

Muskegon Chronicle. May 15, 2007. *History of Muskegon informed by the historical review of the City*.

Michigan Environmental Council. Spring 2007. *Climate change in Michigan: Lower lakes, higher temps.* (http://www.mecprotects.org/MER/07spring/climatechange.html)

NOAA/National Climatic Data Center. 2002. *Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971 - 2000: 20 Michigan.* Asheville, NC.

O'Neal, R.P. 1997. *Muskegon River Watershed Assessment.* Michigan Department of natural Resources. Fisheries Special Report 19. Ann Arbor.

O'Neal, R.P. and G.J. Soulliere. 2006. *Conservation Guidelines for Michigan Lakes and Associated natural Resources.* Michigan Department of natural Resources. Fisheries Special Report 38. Ann Arbor.

Schueler, T. 2003. *Impacts of Impervious Cover on Aquatic Systems.* Center for Watershed Protection. Ellicott City, MD

Sousounis, P. and P. Glick. 2000. *The Potential Impacts of Global Warming on the Great Lakes Region; Critical Findings for the Great Lakes Region.* in the First National Assessment of the Potential Consequences of Climate Variability and Change. (http://www.climatehotmap.org/impacts/greatlakes.html)