Discovery Report

Great Lakes Coastal Flood Study

Lake Michigan

Basin-wide Report

Report Number 01

February 2013

FEMA

U.S. Department of Homeland Security
Federal Emergency Management Agency Region V
536 South Clark Street, 6th Floor
Chicago, Illinois 60605

Preface

The Department of Homeland Security (DHS), Federal Emergency Management Agency's (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) program provides states, tribes, and local communities with flood risk information and tools that they can use to increase their resilience to flooding and better protect their citizens. By pairing accurate floodplain maps with risk assessment tools and planning and outreach support, Risk MAP has transformed traditional flood mapping efforts into an integrated process of identifying, assessing, communicating, planning for, and mitigating flood-related risks.

This lake-wide Discovery Report provides users with a comprehensive and holistic understanding of the historical flood risk, existing coastal data, and current flood mitigation activities in the Lake Michigan area. The report includes a summary of the data collected, including information that could influence flood risk decision-making, historical information, existing flood hazard data and information, and mitigation activities. County-based Discovery Reports and data can be found within the appendices of this lake-wide report.

This Discovery Report summaries FEMA's intent to proceed with a Risk MAP coastal flood study project based on the data available, data collected, and analysis performed to date.

Cover photograph: Flooding at Green Bay, Wisconsin, April 1973. Photograph taken by Dick Koch.

SUBMITTED BY:

125 S. Wacker Drive, Suite 600
Chicago, IL 60606

Date Submitted: February 2013

Project Area Community List for Lake Michigan

This list includes all communities within the Lake Michigan Project Area covered by this report for the Great Lakes Coastal Study under consideration for new Federal Emergency Management Agency (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) products and datasets, which may include Flood Insurance Studies (FISs) and Flood Insurance Rate Maps (FIRMs). Not all communities will receive new/updated FEMA Risk MAP products and datasets or FISs and FIRMs.

State	County	Community
Illinois	Cook County	Chicago, City of
Illinois	Cook County	Evanston, City of
Illinois	Cook County	Glencoe, Village of
Illinois	Cook County	Kenilworth, Village of
Illinois	Cook County	Northfield, Village of
Illinois	Cook County	Wilmette, Village of
Illinois	Cook County	Winnetka, Village of
Illinois	Lake County	Beach Park, Village of
Illinois	Lake County	Highland Park, City of
Illinois	Lake County	Highwood, City of
Illinois	Lake County	Lake Bluff, Village of
Illinois	Lake County	Lake Forest, City of
Illinois	Lake County	North Chicago, City of
Illinois	Lake County	Waukegan, City of
Illinois	Lake County	Winthrop Harbor, Village of
Illinois	Lake County	Zion, City of
Indiana	Lake County	East Chicago, City of
Indiana	Lake County	Gary, City of
Indiana	Lake County	Hammond, City of
Indiana	Lake County	Lake Station, City of
Indiana	Lake County	Whiting, City of
Indiana	LaPorte County	Beverly Shores, Town of
Indiana	LaPorte County	Long Beach, Town of
Indiana	LaPorte County	Michigan City, City of
Indiana	Porter County	Chesterton, Town of
Indiana	Porter County	Dune Acres, Town of

State	County	Community
Indiana	Porter County	Ogden Dunes, Town of
Indiana	Porter County	Pines, Town of
Indiana	Porter County	Portage, City of
Indiana	Porter County	Porter, Town of
Michigan	Allegan County	Allegan, City of
Michigan	Allegan County	Casco, Township of
Michigan	Allegan County	Douglas City, City of
Michigan	Allegan County	Ganges, Township of
Michigan	Allegan County	Laketown, Township of
Michigan	Allegan County	Saugatuck, City of
Michigan	Allegan County	Saugatuck, Township of
Michigan	Allegan County	South Haven, City of
Michigan	Antrim County	Banks, Township of
Michigan	Antrim County	Central Lake, Township of
Michigan	Antrim County	Central Lake, Village of
Michigan	Antrim County	Elk Rapids, Township of
Michigan	Antrim County	Elk Rapids, Village of
Michigan	Antrim County	Forest Home, Township of
Michigan	Antrim County	Helena, Township of
Michigan	Antrim County	Milton, Township of
Michigan	Antrim County	Torch Lake, Township of
Michigan	Benzie County	Benzonia, Township of
Michigan	Benzie County	Benzonia, Village of
Michigan	Benzie County	Beulah, Village of
Michigan	Benzie County	Blaine, Township of
Michigan	Benzie County	Crystal Lake, Township of
Michigan	Benzie County	Elberta, Village of
Michigan	Benzie County	Frankfort, City of
Michigan	Benzie County	Gilmore, Township of
Michigan	Benzie County	Lake, Township of
Michigan	Benzie County	Platte, Township of
Michigan	Berrien County	Benton Harbor, City of
Michigan	Berrien County	Benton Harbor, Township of

State	County	Community
Michigan	Berrien County	Bridgman, City of
Michigan	Berrien County	Chikaming, Township of
Michigan	Berrien County	Coloma, City of
Michigan	Berrien County	Coloma, Township of
Michigan	Berrien County	Grand Beach, Village of
Michigan	Berrien County	Hagar, Township of
Michigan	Berrien County	Lake Charter, Township of
Michigan	Berrien County	Lincoln, Township of
Michigan	Berrien County	Michiana, Village of
Michigan	Berrien County	New Buffalo, City of
Michigan	Berrien County	New Buffalo, Township of
Michigan	Berrien County	Shoreham, Village of
Michigan	Berrien County	St. Joseph Charter, Township of
Michigan	Berrien County	Stevensville, Village of
Michigan	Berrien County	St. Joseph, City of
Michigan	Berrien County	Weesaw, Township of
Michigan	Berrien County	Three Oaks, Township of
Michigan	Berrien County	Three Oaks, Village of
Michigan	Charlevoix County	Bay, Township of
Michigan	Charlevoix County	Boyne City, City of
Michigan	Charlevoix County	Charlevoix, City of
Michigan	Charlevoix County	Charlevoix, Township of
Michigan	Charlevoix County	Evangeline, Township of
Michigan	Charlevoix County	Eveline, Township of
Michigan	Charlevoix County	Hayes, Township of
Michigan	Charlevoix County	Marion, Township of
Michigan	Charlevoix County	Norwood, Township of
Michigan	Charlevoix County	Peaine, Township of
Michigan	Charlevoix County	St. James, Township of
Michigan	Delta County	Bay De Noc, Township of
Michigan	Delta County	Brampton, Township of
Michigan	Delta County	Ensign, Township of
Michigan	Delta County	Escanaba, City of

State	County	Community
Michigan	Delta County	Escanaba, Township of
Michigan	Delta County	Fairbanks, Township of
Michigan	Delta County	Ford River, Township of
Michigan	Delta County	Garden, Township of
Michigan	Delta County	Garden, Village of
Michigan	Delta County	Gladstone, City of
Michigan	Delta County	Masonville, Township of
Michigan	Delta County	Nahma, Township of
Michigan	Delta County	Wells, Township of
Michigan	Emmet County	Bear Creek, Township of
Michigan	Emmet County	Bliss, Township of
Michigan	Emmet County	Carp Lake, Township of
Michigan	Emmet County	Center, Township of
Michigan	Emmet County	Cross Village, Township of
Michigan	Emmet County	Friendship, Township of
Michigan	Emmet County	Harbor Springs, City of
Michigan	Emmet County	Little Traverse, Township of
Michigan	Emmet County	Mackinaw City, Village of
Michigan	Emmet County	Petoskey, City of
Michigan	Emmet County	Pleasantview, Township of
Michigan	Emmet County	Readmont, Township of
Michigan	Emmet County	Resort, Township of
Michigan	Emmet County	Wawatam, Township of
Michigan	Emmet County	West Traverse, Township of
Michigan	Grand Traverse County	Acme, Township of
Michigan	Grand Traverse County	Blair, Township of
Michigan	Grand Traverse County	East Bay, Township of
Michigan	Grand Traverse County	Garfield, Township of
Michigan	Grand Traverse County	Peninsula, Township of
Michigan	Grand Traverse County	Traverse City, City of
Michigan	Grand Traverse County	White Water, Township of
Michigan	Leelanau County	Bingham, Township of
Michigan	Leelanau County	Centerville, Township of

State	County	Community
Michigan	Leelanau County	Cleveland, Township of
Michigan	Leelanau County	Elmwood, Township of
Michigan	Leelanau County	Empire, Township of
Michigan	Leelanau County	Empire, Village of
Michigan	Leelanau County	Glen Arbor, Township of
Michigan	Leelanau County	Leelanau, Township of
Michigan	Leelanau County	Leland, Township of
Michigan	Leelanau County	Northport, Village of
Michigan	Leelanau County	Solon, Township of
Michigan	Leelanau County	Suttons Bay, Township of
Michigan	Leelanau County	Suttons Bay, Village of
Michigan	Mackinac County	Bois Blanc, Township of
Michigan	Mackinac County	Clark, Township of [1]
Michigan	Mackinac County	Garfield, Township of
Michigan	Mackinac County	Hendricks, Township of
Michigan	Mackinac County	Hudson, Township of
Michigan	Mackinac County	Mackinac Island, City of
Michigan	Mackinac County	Marquette, Township of [1]
Michigan	Mackinac County	Moran, Township of
Michigan	Mackinac County	Newton, Township of
Michigan	Mackinac County	St. Ignace, City of
Michigan	Mackinac County	St. Ignace, Township of [1]
Michigan	Manistee County	Arcadia, Township of
Michigan	Manistee County	Bear Lake, Village of
Michigan	Manistee County	Brown, Township of
Michigan	Manistee County	Eastlake, Village of
Michigan	Manistee County	Filer, Township of
Michigan	Manistee County	Manistee, City of
Michigan	Manistee County	Manistee, Township of
Michigan	Manistee County	Onekama, Township of
Michigan	Manistee County	Onekama, Village of

[1] During this Discovery process, stakeholders suggested that Clark, Marquette, and St. Ignace Townships (Mackinac County, Michigan) be removed from the Lake Michigan Project Area as those communities are affected by Lake Huron.

State	County	Community
Michigan	Manistee County	Stronach, Township of
Michigan	Mason County	Grant, Township of
Michigan	Mason County	Hamlin, Township of
Michigan	Mason County	Ludington, City of
Michigan	Mason County	Pere Marquette, Township of
Michigan	Mason County	Summit, Township of
Michigan	Menominee County	Cedarville, Township of
Michigan	Menominee County	Ingallston, Township of
Michigan	Menominee County	Menominee, City of
Michigan	Menominee County	Menominee, Township of
Michigan	Muskegon County	Fruitland, Township of
Michigan	Muskegon County	Fruitport, Township of
Michigan	Muskegon County	Fruitport, Village of
Michigan	Muskegon County	Laketon, Township of
Michigan	Muskegon County	Montague, Township of
Michigan	Muskegon County	Muskegon, City of
Michigan	Muskegon County	North Muskegon, City of
Michigan	Muskegon County	Norton Shores, City of
Michigan	Muskegon County	Roosevelt Park, City of
Michigan	Muskegon County	White River, Township of
Michigan	Muskegon County	Whitehall, City of
Michigan	Oceana County	Benona, Township of
Michigan	Oceana County	Clay Banks, Township of
Michigan	Oceana County	Golden, Township of
Michigan	Oceana County	Newfield, Township of
Michigan	Oceana County	Pentwater, Township of
Michigan	Oceana County	Pentwater, Village of
Michigan	Oceana County	Weare, Township of
Michigan	Ottawa County	Ferrysburg, City of
Michigan	Ottawa County	Grand Haven , City of
Michigan	Ottawa County	Grand Haven Charter, Township of
Michigan	Ottawa County	Holland, City of
Michigan	Ottawa County	Park, Township of

State	County	Community
Michigan	Ottawa County	Port Sheldon, Township of
Michigan	Ottawa County	Spring Lake, Township of
Michigan	Schoolcraft County	Manistique, City of
Michigan	Schoolcraft County	Thompson, Township of
Michigan	Van Buren County	Covert, Township of
Michigan	Van Buren County	South Haven Charter, Township of
Wisconsin[2]	Brown County	Allouez, Village of
Wisconsin[2]	Brown County	Brown County
Wisconsin[2]	Brown County	Bellevue, Village of
Wisconsin[2]	Brown County	Green Bay, City of
Wisconsin[2]	Brown County	Howard, Village of
Wisconsin[2]	Brown County	Suamico, Village of
Wisconsin[2]	Door County	Door County
Wisconsin[2]	Door County	Egg Harbor, Village of
Wisconsin[2]	Door County	Ephraim, Village of
Wisconsin[2]	Door County	Sister Bay, Village of
Wisconsin[2]	Door County	Sturgeon Bay, City of
Wisconsin[2]	Kenosha County	Kenosha, City of
Wisconsin[2]	Kenosha County	Kenosha County
Wisconsin[2]	Kenosha County	Pleasant Prairie, Village of
Wisconsin[2]	Kewaunee County	Algoma, City of
Wisconsin[2]	Kewaunee County	Kewaunee, City of
Wisconsin[2]	Kewaunee County	Kewaunee County
Wisconsin[2]	Manitowoc County	Cleveland, Village of
Wisconsin[2]	Manitowoc County	Manitowoc, City of
Wisconsin[2]	Manitowoc County	Manitowoc County
Wisconsin[2]	Manitowoc County	Two Rivers, City of
Wisconsin[2]	Marinette County	Marinette, City of
Wisconsin[2]	Marinette County	Marinette County
Wisconsin[2]	Milwaukee County	Bayside, Village of

[2] In Wisconsin, only those jurisdictions known to be responsible for administering floodplain ordinances and potentially affected by the upcoming Lake Michigan coastal flood study were included in this Discovery process. However, all coastal communities are encouraged to participate in the future Lake Michigan coastal flood study process and may request to be included in future correspondence regarding the Lake Michigan coastal flood study.

State	County	Community
Wisconsin[2]	Milwaukee County	Cudahy, City of
Wisconsin[2]	Milwaukee County	Fox Point, Village of
Wisconsin[2]	Milwaukee County	Milwaukee, City of
Wisconsin[2]	Milwaukee County	Oak Creek, City of
Wisconsin[2]	Milwaukee County	Shorewood, Village of
Wisconsin[2]	Milwaukee County	South Milwaukee, City of
Wisconsin[2]	Milwaukee County	St. Francis, City of
Wisconsin[2]	Milwaukee County	Whitefish Bay, Village of
Wisconsin[2]	Oconto County	Oconto, City of
Wisconsin[2]	Oconto County	Oconto County
Wisconsin[2]	Ozaukee County	Bayside, Village of
Wisconsin[2]	Ozaukee County	Mequon, City of
Wisconsin[2]	Ozaukee County	Ozaukee County
Wisconsin[2]	Ozaukee County	Port Washington, City of
Wisconsin[2]	Racine County	Caledonia, Village of
Wisconsin[2]	Racine County	Mount Pleasant, Village of
Wisconsin[2]	Racine County	North Bay, Village of
Wisconsin[2]	Racine County	Racine, City of
Wisconsin[2]	Racine County	Racine County
Wisconsin[2]	Racine County	Wind Point, Village of
Wisconsin[2]	Sheboygan County	Cedar Grove, Village of
Wisconsin[2]	Sheboygan County	Oostburg, Village of
Wisconsin[2]	Sheboygan County	Sheboygan, City of
Wisconsin[2]	Sheboygan County	Sheboygan County

[2] In Wisconsin, only those jurisdictions known to be responsible for administering floodplain ordinances and potentially affected by the upcoming Lake Michigan coastal flood study were included in this Discovery process. However, all coastal communities are encouraged to participate in the future Lake Michigan coastal flood study process and may request to be included in future correspondence regarding the Lake Michigan coastal flood study.

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Acronyms and Abbreviations

AAL	Average Annualized Loss
AoMI	Area of Mitigation Interest
CAV	Community Assistance Visit
CBRS	Coastal Barrier Resources System
CID	Community Identification Number
CIS	Community Information System
CNMS	Coordinated Needs Management Strategy
CO-OPS	Center for Operational Oceanographic Products and Services
CRS	Community Rating System
FEMA	Federal Emergency Management Agency
FIPS	Federal Information Processing Standards
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
GLCFS	Great Lakes Coastal Flood Study
GLCRG	Great Lakes Coastal Restoration Grant
Hazus-MH	Multi-Hazard Risk Assessment and Loss Estimation Software Program
HWM	High Water Mark
HUC8	Hydrologic Unit Code 8
LiMWA	Limit of Moderate Wave Action
LOMA	Letter of Map Amendment
LOMC	Letter of Map Change
LOMR	Letter of Map Revision
LOMR-F	Letter of Map Revision based on Fill
MLI	Midterm Levee Inventory
NDBC	National Data Buoy Center
NFIP	National Flood Insurance Program
NID	National Inventory of Dams
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
Risk MAP	Risk Mapping, Assessment, and Planning
SFHA	Special Flood Hazard Area
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

Executive Summary

The Federal Emergency Management Agency's (FEMA's) Lake Michigan Discovery Report provides users with a comprehensive and holistic understanding of historical flood risk, existing coastal data, and current flood mitigation activities within the Lake Michigan basin. The report also provides users with a summary of FEMA's intent to proceed with a coastal flood hazard study under FEMA's Risk Mapping, Assessment, and Planning (Risk MAP) program and the Great Lakes Coastal Flood Study (GLCFS) project.

The GLCFS is a comprehensive study of coastal flood hazards for all United States shoreline along the Great Lakes Basin. The study is being performed by FEMA in cooperation with the U.S. Army Corps of Engineers (USACE), the Association of State Floodplain Mangers (ASFPM), and other partners. The GLCFS project will put a wide range of data in the hands of communities along the Great Lakes, including Lake Michigan, to promote long-term reduction in flood risk and enhance public safety.

Like all other Risk MAP projects, the GLCFS begins with a Discovery phase. The Discovery process for Lake Michigan involved basin-wide extensive data collection and outreach efforts with Lake Michigan stakeholders. The Lake Michigan stakeholder group includes representatives from FEMA, other federal agencies, state agencies, local government, and several other technical focus groups. Data collection efforts under Discovery phase include base map data, coastal data, historic flood data, risk assessment, flood mitigation information, community plans and projects along the shoreline, and other comments based on local knowledge of flood risk. Additionally, certain useful datasets are being developed for use in this study. These datasets include oblique imagery, topography and bathymetry data, shoreline feature dataset to classify shoreline characteristics, a draft transect layout, and a storm surge and wave study, all of which will feed into the coastal flood hazard analysis for Lake Michigan.

The GLCFS for Lake Michigan will include coastal flood hazard analysis for all communities located along the shoreline and will use the response-based computation approaches outlined in FEMA's *Draft Guidelines and Specifications for Coastal Studies along the Great Lakes, Appendix D.3 Update, May 2012*. The coastal flood hazard results will be transferred to workmaps and released to communities for review. Coastal flood risk assessment products may also be generated for identified Lake Michigan coastal communities. These products may include Flood Risk Maps, Flood Risk Reports, Changes Since Last FIRMs, Flood Depth and Analysis Grids, and Hazus 2010 1-percent exposure, as well as some additional Great Lakes products that are under consideration.

The study may result in delineation of new Special Flood Hazard Areas (SFHAs), designation of VE Zones, and identification of Limits of Moderate Wave Action (LiMWAs) on the FIRM for the first time. Communities participating in the National Flood Insurance Program (NFIP) that will have mapped VE Zones as a result of this study will be required to adopt floodplain management regulations that meet or exceed the

minimum NFIP requirements for building in VE Zone. FEMA does not impose any additional floodplain management requirements based on the LiMWA. The LiMWA is provided to help communicate the higher risk that exists in that area compared to rest of Zone AE areas.

In addition to the identification and assessment of flood risk along the Great Lakes, the GLCFS project may provide tools and information to communities that encourage identification and implementation of mitigation actions to reduce risk. Mitigation provides a critical foundation on which to reduce loss of life and property by avoiding or lessening the impact of hazard events and it is an essential part of this coastal flood study process.

As part of this Discovery process, local Hazard Mitigation Plans were reviewed to better understand existing flood risk within the Lake Michigan communities, as well as the strategies and actions that have already been developed as part of the local planning processes to mitigate that risk. By first obtaining a better understanding of existing local risk and mitigation actions during this Discovery phase, it is FEMA's intent to begin to work with communities to identify new mitigation actions and strengthen existing actions throughout the coastal flood study. In addition, FEMA will seek to identify communities that could benefit from mitigation assistance through partnership with FEMA.

To support the identification and attainment of mitigation actions, as well as local mitigation planning efforts during this coastal flood study, FEMA introduced the Mitigation Action Form and Mitigation Action Tracker to Lake Michigan stakeholders during Discovery. The form and tracker demonstrate FEMA's effort to help track and identify local potential Areas of Mitigation Interest (AoMI) and new or improved mitigation actions that seek to reduce risk.

FEMA will continue to coordinate and communicate as future developments in the Lake Michigan coastal flood study process occur. The GLCFS website http://www.greatlakescoast.org is an excellent resource where stakeholders can obtain up-to-date information about the status of this study, data collection, upcoming meetings, new technical reports, the latest methodologies, factsheets, and much more. FEMA encourages stakeholders to remain involved and will seek to identify partnership opportunities during the study.

I. Introduction

Lake Michigan is approximately 118 miles wide and 307 miles long and is the only Great Lake located entirely in the United States. Lake Michigan has over 1,600 miles of shoreline, a surface area of approximately 22,000 square miles, and a drainage basin more than twice its surface area. The Lake is hydrologically connected to Lake Huron by the Straits of Mackinac and averages 279 feet in depth and is 925 feet at its deepest (U.S. Environmental Protection Agency, 2012).

The Lake Michigan shoreline is subject to significant flooding and erosion that can be caused by several contributing factors, including water level and wind generated waves. Historic water levels show an oscillation on the scale of decades. Low water levels, such as those experienced recently, may result in the construction of buildings further lakeward in some areas due to the perception of a lower level of threat. Historic record suggests, however, that higher-than-average water levels will return again in the future. Flood events cause significant damage to beaches, bluffs, and structures costing millions of dollars and may result in loss of life.

Figure 1. Flooding at Green Bay, Wisconsin, April 1973
Photograph taken by: Dick Koch

The intent of this report is to provide users with a comprehensive and holistic understanding of historical coastal flood risk, existing coastal data, and current activities underway to mitigate coastal flood risk within the Lake Michigan basin. This report includes a summary of data collected from Lake Michigan stakeholders, as well as a compilation of Lake Michigan long-term issues and trends, as it relates to coastal flooding. This report also provides users with information about the intent to move forward with a new coastal flood risk study along the Lake Michigan shoreline as part of the Great Lakes Coastal Flood Study (GLCFS) initiative. An updated coastal flood study is needed to obtain a better estimate of coastal flood hazards along the Lake Michigan shoreline.

The subsection below outlines the Federal Emergency Management Agency (FEMA) program, Risk Mapping, Assessment, and Planning (Risk MAP), under which the new coastal flood study will be performed.

i. Risk MAP Introduction

Risk Mapping, Assessment, and Planning (Risk MAP) is a FEMA program that provides communities with flood information and tools they can use to enhance their mitigation plans and better protect their citizens against flood hazards. Through more accurate flood maps, risk assessment tools, and outreach support, Risk MAP strengthens local ability to make informed decisions about reducing flood risk.

Through collaboration with State, local, and Tribal entities, Risk MAP will deliver quality data that increases public awareness and leads to action that reduces risk to life and property. FEMA intends to collaborate with Federal, State, and local stakeholders to achieve the following goals:

- Address gaps in flood hazard data to form a solid foundation for risk assessment and floodplain management.
- Ensure that a measurable increase of the public's awareness and understanding of risk results in a measurable reduction of current and future vulnerability.
- Lead and support States, local, and tribal communities to effectively engage in risk-based mitigation planning resulting in sustainable actions that reduce or eliminate risks to life and property from natural hazards.
- Provide an enhanced digital platform that improves management of Risk MAP, stores information produced by Risk MAP, and improves communication and sharing of risk data and related products to all levels of government and the public.
- Align programs and develop synergies to enhance decision-making capabilities through effective risk communication and management.

ii. Great Lakes Coastal Flood Study

Through the Risk MAP program and in cooperation with the U.S. Army Corps of Engineers (USACE), the Association of State Floodplain Managers (ASFPM), and other partners, FEMA has initiated a comprehensive study of flood hazard for all the United States shoreline along the Great Lakes Basin, including Lake St. Clair. Figure 2 provides an overview of the Great Lakes Basin. Throughout a Risk MAP project lifecycle, FEMA provides information to enhance local mitigation plans, improve community outreach, and increase local resilience to floods.

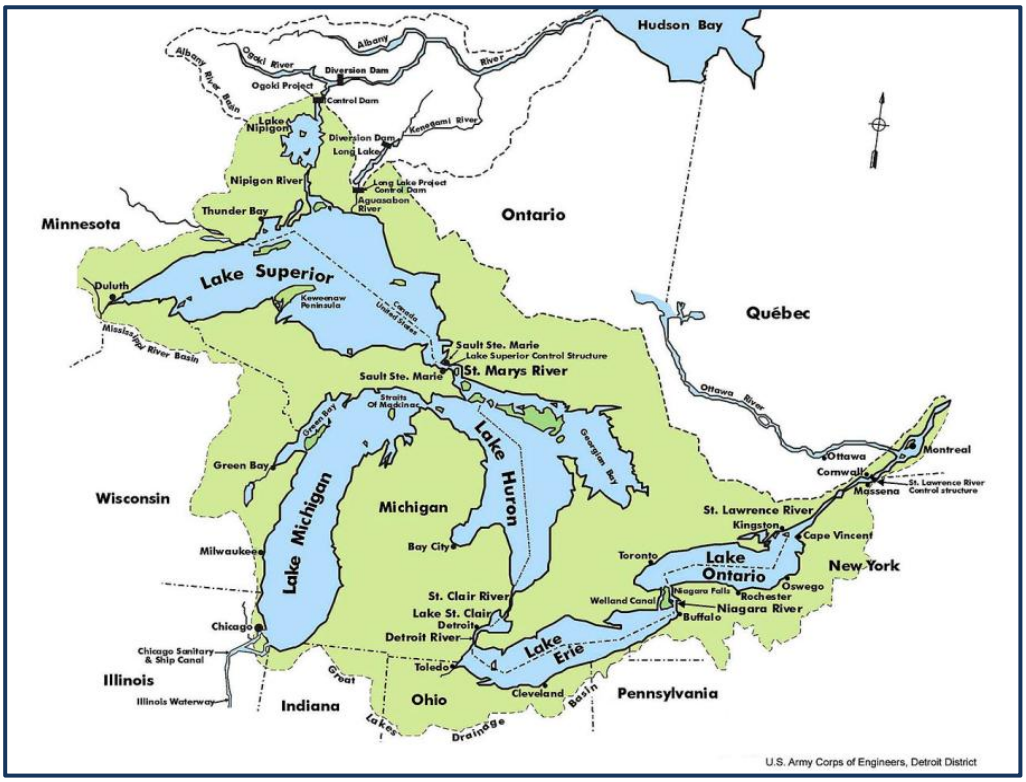


Figure 2. Great Lakes Basin Overview

The updated coastal flood study is intended to obtain a better estimate of coastal flood risk on the Great Lakes. Current, effective Flood Insurance Rate Maps (FIRMs) may be outdated primarily due to the age of data and the coastal methodologies used to produce them. Major changes in National Flood Insurance Program (NFIP) policies and methodologies have been implemented since the effective date of many Flood Insurance Studies (FISs) in the area, creating the need for an update that will reflect a more detailed and complete flood risk determination.

The GLCFS is a multi-year project that will accomplish the following:

- Provide storm-induced flood elevations based on surge and wave modeling and storm sampling from recorded data for water level, meteorological, and ice field conditions.
- Deliver updated flood maps and flood risk products in identified communities.
- Provide oblique photos, high-resolution bathymetry[2], geospatial inventory of coastal land features and structures, and other coastal data to advance local, State, and Federal capability in public safety, hazard mitigation, and asset management initiatives.
- Enhance local planning processes.

[2] Bathymetry is the measurement of the depth of bodies of water, including lakes or oceans

FEMA manages the NFIP, which is the cornerstone of the national strategy for preparing communities for flood-related disasters. Emulating the NFIP and the Risk MAP program, the GLCFS will include a system-wide solution that provides a comprehensive analysis of storm and high-water events within the Great Lakes Basin. FEMA, along with USACE, ASFPM, State partners, and FEMA contractors, will collaborate to update the coastal methodology and flood maps and to create new flood risk products defined by FEMA's Risk MAP program.

The GLCFS will incorporate modern analysis of historic storm and high-water events and provide for updated flood risk information serving United States communities having shoreline along the Great Lakes. The storm surge study is one of the most extensive coastal storm surge analyses to date, encompassing coastal floodplains in the eight States with coastlines on the Great Lakes. The new coastal flood hazard analyses will utilize updated 1-percent-annual-chance (100-year) flood elevations obtained from the comprehensive storm surge study being developed by the USACE

Each Risk MAP project, including the GLCFS, begins with a Discovery phase, which is the intent of this report. Section II of this report provides a Discovery overview.

II. Discovery Overview

Prior to moving forward with a Risk MAP project, FEMA conducts a process called Discovery. During the Discovery phase, FEMA:

- Gathers information about local flood risk and flood hazards.
- Reviews mitigation plans to understand local mitigation capabilities, hazard risk assessments, and current or future mitigation activities.
- Supports communities within the project area to develop a vision for the future.
- Collects information from communities about their flooding history, development plans, daily operations, and stormwater and floodplain management activities.
- Uses all information gathered to determine which areas require mapping, risk assessment, or mitigation planning assistance through a Risk MAP project.
- Develops a Discovery Map and Report that summarizes and displays the Discovery findings.

The Discovery process involves coordination with stakeholders at all levels, data collection and analysis, conducting community interviews, a Discovery Meeting with stakeholders or those expected to be affected by the study, and developing potential recommendations that may modify the scope of the Risk MAP project based on an analysis of data and information gathered throughout the Discovery process. Figure 3 provides an overview of the coastal Discovery Process.

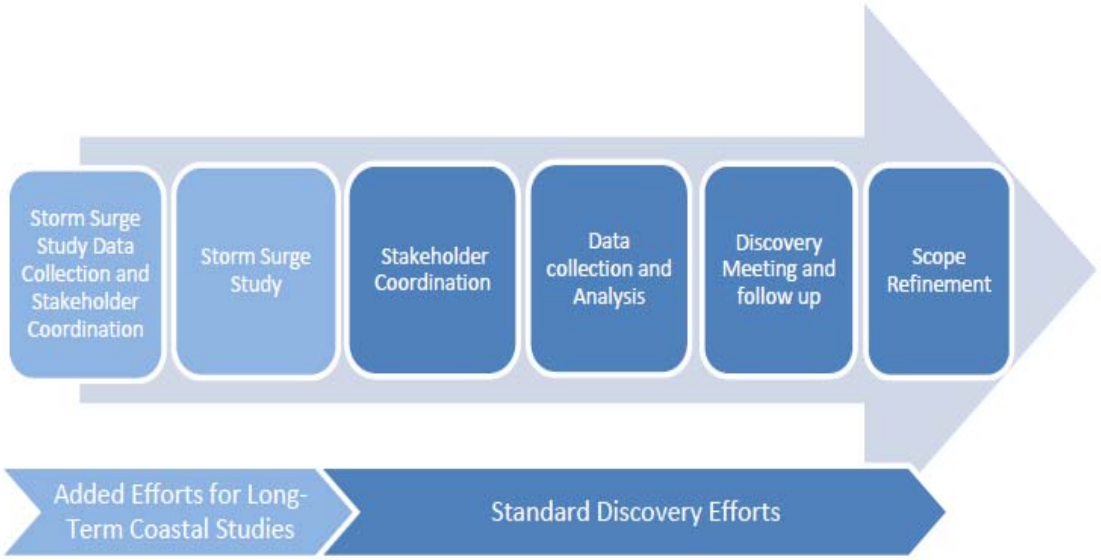


Figure 3. Discovery Process Overview

i. Purpose of Lake Michigan Discovery

The purpose of the Lake Michigan Discovery process and of this report is to perform basin-wide data collection and outreach efforts that lead to an informed assessment of lake-wide issues and long-term trends, which in turn will contribute towards the new coastal analysis, risk assessment, and mitigation strategy being developed for the current and potential future Lake Michigan Risk MAP projects.

This report focuses on the Discovery efforts for Lake Michigan coastal communities in Illinois, Indiana, Michigan, and Wisconsin as listed in "Project Area Community List for Lake Michigan" prior to the beginning of this report.

The Lake Michigan Discovery process will also help FEMA to better identify the types of datasets and products that will be useful at the local level, especially as it relates to identifying new mitigation strategies and actions, and for use in local planning efforts. Products that may be available to communities as a result of this Lake Michigan flood study include updated FIRMs and FIS, coastal flood risk products, calibrated models for storm surge and wave analysis, and accurate depictions of water level and wave response of the lake occurring during hundreds of actual events. The type of product a community will receive during a Risk MAP study depends not only on the coastal flood study analysis results, but also on the type of data (local or national) that is available and the funding available in future years.

The Lake Michigan Discovery process included tabular and spatial data collection, information exchange between all governmental levels of stakeholders, cooperative discussion with stakeholders to better understand the Lake Michigan area, and a

collaborative approach on the project planning. This process has allowed FEMA to continue to vet the Great Lakes coastal study methodologies with a large stakeholder group, to discuss local priorities and data, to discuss mitigation strategies and coastal issues, and to move towards a project that will successfully identify the risks associated with Lake Michigan flooding.

The results of this Discovery process and the next steps for the Lake Michigan coastal flood study project are discussed in the remaining sections of this report.

III. Stakeholder Communication and Coordination

Communication and coordination with Federal, State, and local stakeholders are key to the success of the GLCFS. Much emphasis has been placed on identifying stakeholders early and often and working with those stakeholders continually throughout the study process, from Discovery all the way through flood map and flood risk product development. The outreach goals are to increase understanding of the new coastal study methodologies and the tools and processes that will be available for risk-based community planning, and to increase flood hazard awareness within the Great Lakes Coastal Region.

Throughout this GLCFS process, FEMA will seek to identify partnerships with stakeholders. By coordinating with stakeholders to identify local flood risk, data, and mitigation needs, FEMA can better understand types of flood risk products that may be beneficial to communities as they seek to further protect and inform their citizens against flood risk. Additional information about the coastal flood risk products that may be available to communities as a result of this study can be found in the county-based individual Discovery Reports under the "Coastal Flood Risk Products" section in Appendices C-P of this report.

i. Lake Michigan Stakeholder Coordination for Discovery

Meetings, webinars, emails, telephone calls, and letters are essential to communicate effectively throughout the life of this Lake Michigan Coastal Flood Study project, which has begun with this Discovery process.

To kick-off this Discovery process, the Lake Michigan Discovery Risk MAP Project Team [FEMA and Strategic Alliance for Risk Reduction (STARR)] identified a group of core stakeholders, including representatives from FEMA Region V, as well as ASFPM, USACE, National Oceanic and Atmospheric Administration (NOAA), State NFIP Coordinators, State Hazard Mitigation Officers (SHMOs), and State Engineers. The core stakeholders reviewed the Discovery plan, objectives, and key outcomes for Lake Michigan Discovery with FEMA, provided suggestions for outreach and communication, and raised any concerns as it related to Lake Michigan and the coastal flood study process.

Following this kick-off process, outreach, communication, and coordination efforts with local stakeholder were initiated. A list of stakeholders within the project area covered by this Discovery Report (Lake Michigan) has been established as part of Discovery and is included in Appendix A. This list includes the community elected officials (CEOs), floodplain administrators, planners, engineers, emergency managers, community leaders, regional planning agencies, coastal organizations, Great Lakes organizations, other federal agencies, and other key stakeholders. FEMA and STARR will continuously update this list throughout the life of this project.

Representatives from the local governments-including cities, townships, and villages- are considered fundamental stakeholders in this process because they have been elected or appointed to represent the interests of the residents of the project area.

Fourteen (14) Discovery Meetings were held for the Lake Michigan project area. Discovery Meeting invitations were sent to local stakeholders within the Lake Michigan Coastal Flood Study project area. In addition, an email invitation was sent to a larger list of stakeholders including, but not limited to, other federal agencies, state agencies, universities, watershed groups, Great Lakes associations, technical stakeholders, and emergency management agencies.

The Discovery Meeting letter invitations included a Coastal Data Request Form, which can be found in Appendix B following this report. The form requested communities provide information on data that they had available at the local level that may be of use during the flood study update and during the development of the coastal flood risk products. The Coastal Data Request Form listed requests for information and data, including:

- Base map data
- Coastal data
- Historic coastal flood data
- Risk assessment
- Flood mitigation information
- Community plans and projects
- Other comments/concerns based on local knowledge

The county-based individual Discovery Reports (one for each Discovery Meeting) are included in Appendices C – P of this basin-wide report. A compilation of the data and information collected via the completed Coastal Data Request Forms can be found in Appendix Q of this report, and also in the individual Discovery Reports.

In addition to the hard copy letter invitations, and in order to improve the communication and data sharing leading up to the Discovery Meetings, FEMA offered local communities an opportunity to attend pre-Discovery Meeting conference calls, also termed “Information Exchange Sessions”. The Information Exchange conference call information was included in the Discovery invitation letters mailed to local community officials, and an email reminder was sent out as well. The sessions were held to initiate the process of learning about local data availability and critical issues for the communities, and to review the

Coastal Data Request Form. A copy of the presentations and other related information from the Information Exchange Session conference calls can be found within the individual Discovery Reports in Appendices C – P.

The Discovery Meetings are discussed in greater detail in the next section of this report.

IV. Lake Michigan Discovery Meetings

Communities and stakeholders affected by coastal flooding in the Lake Michigan study area were invited to the Discovery Meetings. A total of 14 Discovery Meetings were held along Lake Michigan in Illinois, Indiana, Michigan, and Wisconsin in the months of August and September 2012. Figure 4 depicts the date and location of the Discovery Meetings in the Lake Michigan basin.

Below is a summary of the stakeholders in attendance, excluding FEMA, STARR, and State meeting facilitators:

- Attendees included, but were not limited to, planners, engineers, Geographic Information Systems (GIS) Specialists, natural hazard program specialists, educators, building inspectors, and conservation agents.
- Out of the 226 coastal communities included in this study area, 32 communities and 13 townships were represented in at least one (1) of the 14 Discovery Meetings.
- In total, the meetings were represented by 38 percent county officials, 32 percent community officials, 17 percent State officials, 6 percent planning organizations, 3 percent local engineering firms, 2 percent academic community, 2 percent other professional firms, and 1 percent from the Natural Resources Conservation Service.

Sign-in sheets for each meeting can be found within the individual Discovery Reports found in Appendices C – P of this report. All stakeholders listed in Appendix A, Lake Michigan Stakeholder List, were invited to attend these Discovery Meetings either via email or hard copy letter. Copies of the hard copy invitations, along with local community official contact lists, can be found in within the individual Discovery Reports.

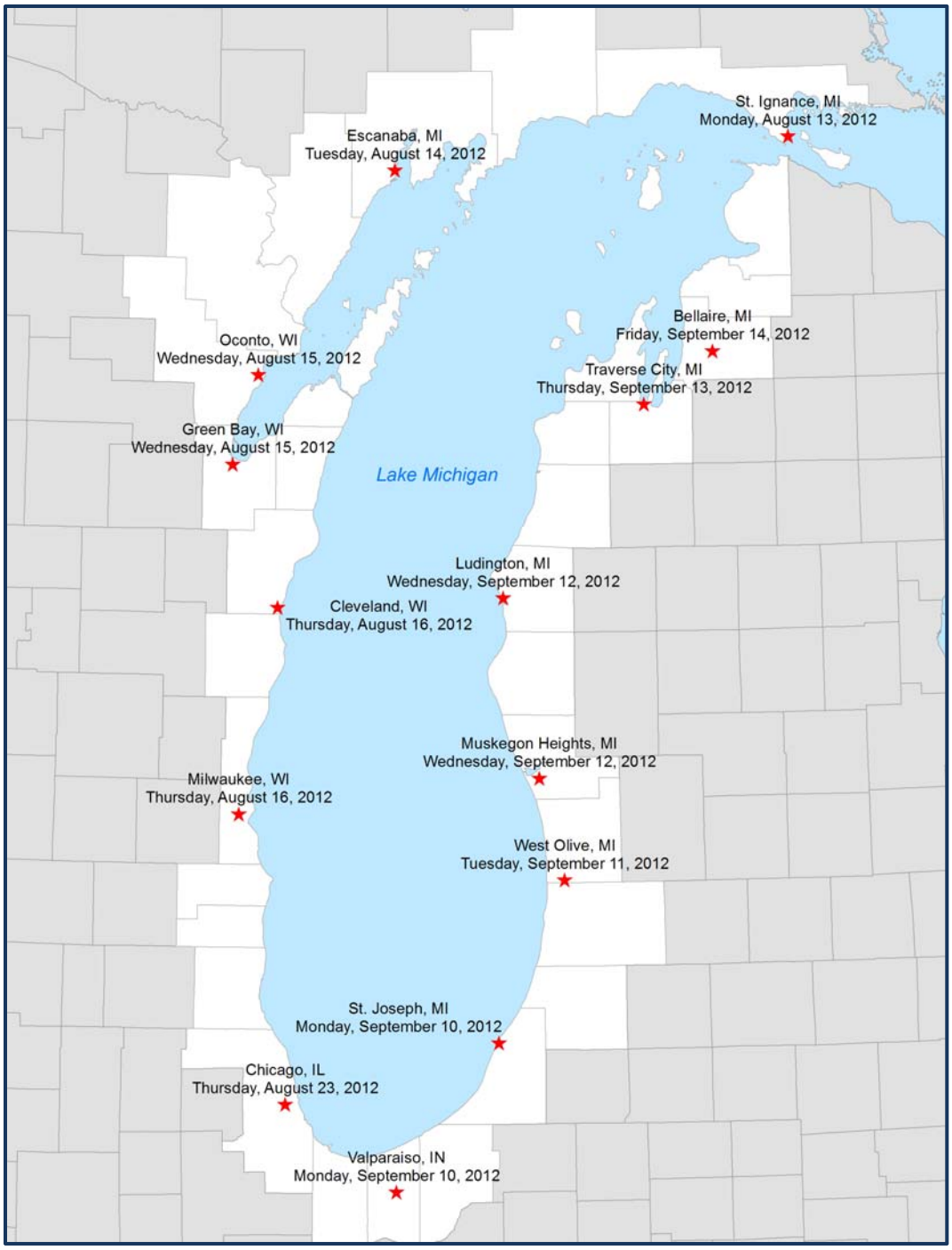


Figure 4. Discovery Meeting Location Overview

The objectives of the Discovery Meetings included:

- Continuation and expansion upon stakeholder engagement
- Discussion of data inputs from Federal, state, and local stakeholders
- Identification of local coastal flood hazard needs and areas of concern
- Identification of flood risk products and datasets that best advance coastal mitigation action
- NFIP regulatory updates
- Discovery schedule and deliverables

The Discovery Meeting presentations included the following information:

- An overview of the Great Lakes Coastal Flood Study and schedule
- Review of the Discovery process and outcomes
- Discussion of coastal mapping and flood risk topics to be aware of
- Discussion of how the study may affect the communities, including compliance requirements
- Review of hazard mitigation opportunities and grant funding
- Encouragement and facilitation discussion regarding coastal study needs, mitigation project needs, desired compliance support, and local flood risk awareness efforts

Draft Discovery Maps (found in Attachments within individual Discovery Reports in Appendices C – P) were displayed and utilized during the meetings to encourage discussion regarding areas of coastal flood risk concern and Areas of Mitigation Interest (AoMI). The draft Discovery Maps shown at the meetings included geospatial and tabular data that had been collected prior to the meetings, such as:

Geospatial Data:

- Average Annualized Loss (AAL) data
- Coastal Barrier Resources System (CBRS)[3]
- Coastal structures
- Coordinated Needs Management Strategy (CNMS)[4] Data (riverine only)
- Dams

[3] CBRS consists of the undeveloped coastal barriers and other areas located on the coasts of the United States that are identified and generally depicted on a series of maps. CBRS areas are ineligible for most new Federal expenditures and financial assistance.

[4] CNMS is FEMA's strategy for coordinating the management of mapping needs using modern geospatial technologies and current policies, requirements, and procedures. CNMS makes information related to mapping needs readily accessible and more usable. CNMS is only for riverine studies at this time. It is expected coastal needs will be captured in this system in the future.

- Effective Special Flood Hazard Areas (SFHAs)
- Jurisdictional Boundaries
- Letters of Map Change (LOMCs)
- Levees
- Proposed transects locations
- Shoreline
- Streams
- USGS gages
- Watershed boundaries

Tabular Data:

- Declared disasters
- Flood insurance data
- Potential mitigation actions (from local Hazard Mitigation Plans)
- Summary of shoreline data (type and material)

Participants at each of the Discovery Meetings were asked to cooperatively identify areas of concern related to hazards and Areas of Mitigation Interest (AoMIs) within the Lake Michigan study area using the Draft Discovery Map (attachments found within Appendices C – P) and through general discussion during the meetings.

In addition to the draft Discovery Maps, figures showing the location of initially proposed transects around Lake Michigan were presented during the Discovery Meetings. Transects are profiles along which coastal flooding analysis is performed. They are used to transform offshore conditions to the shoreline and to define coastal flood risks inland of the shoreline. Transects are placed to define representative profiles for a shoreline reach. Stakeholders were encouraged to review the proposed transects and provide comments related to the location of transects. The proposed draft transect maps that were available at the Discovery Meetings can be found as attachments in the individual Discovery Reports located in Appendices C – P. A sample map is shown as Figure 5. Users should note that transects have since been revised and should refer to the updated proposed transect locations found on the Final Discovery Maps (Appendix R).

Figure 5. Sample Proposed Draft Transect Figure

Stakeholder comments are valuable to the Discovery process, as they offer local knowledge of the topography, development, and shoreline features of the coastal study area. Comments received included 11 comments related to erosion, six (6) comments indicating flooding due to ice, 12 comments related to past or current flooding issues, two (2) comments regarding mitigation projects, and over 100 comments related to the transects. The majority of transect comments received were related to capturing effective transects, critical facilities, infrastructure, and populated areas or the realignment, relocation, or removal of specific transects.

All comments that were provided during these meetings and captured on the draft Discovery Maps and transect figures have been compiled into geospatial layers and associated tables. The layers, titled "Stakeholder General Comments" and "Stakeholder Transect Comments", can be found on the Final Discovery Maps in Appendix R. A list of each comment collected for all Lake Michigan coastal communities can be found in Appendix S, along with a map identification number (if one exists), which correlates to its location on the Final Discovery Maps (Appendix R). In the table in Appendix S and on the Final Discovery Maps in Appendix R, the identification of a comment (ID) categorized as a "Stakeholder General Comment" is represented by using the first three letters of the county name followed by a unique number (i.e. for Brown County, ID's would include BRO – 1, BRO – 2). The identification of a comment (ID) categorized as a "Stakeholder Transect Comment" is represented by using the first three letters of the county name, followed by "TR", followed by a unique number (i.e. for Brown County, ID's would include BRO-TR-1, BRO-TR-2). A summary and analysis of the comments collected for

each Discovery Meeting can be found in the individual Discovery Reports located in Appendix C – P of this report.

Discovery Meeting documents, including meeting minutes, sign in sheets, presentations, coastal data request forms, and correspondence documentation, have been included in the attachments for each individual Discovery Report found in Appendices C – P.

Following the Discovery Meetings and prior to the issuance of this Final Discovery Report, Great Lakes stakeholders were provided with an opportunity to review a draft Lake Michigan Discovery Report. The 45-day review period ended on January 11, 2013. Several comments related to the draft Discovery Report were received during that review period and have been incorporated into this final report. Questions received from stakeholders that related to the upcoming GLCFS projects and upcoming coastal analyses were resolved on an individual basis or could not yet be resolved due to the nature of the question and the current status of the coastal flood study projects. Those questions will be revisited as the new coastal flood studies progress.

The next section summarizes the data and information collected for Lake Michigan during this Discovery process.

V. Summary of Data

This section summarizes the data and information collected for Lake Michigan during this Discovery process. A massive effort of collecting tabular and spatial data was conducted for all the coastal communities from Federal, State, and local sources. In addition, information was collected through phone conversations, information exchange session conference calls, the Discovery Meetings, and the Discovery Coastal Data Request forms sent to each coastal community. Table 1 is a comprehensive list of all the types of data that were collected for this Lake Michigan study area.

Table 1. Data Collected for Lake Michigan

Data Types	Deliverable/Product	Source	Date of Data Collection	Level
Average Annualized Loss Data (AAL)	Discovery Map/Tabular Data	Federal Emergency Management Agency (FEMA)	June 2012	Nationwide
Bathymetry and Topography	Discovery Report	USACE	2012	Lakewide
Census Blocks	Discovery Map/Tabular Data	U.S. Census Bureau	June 2012	Countywide
Coastal Data Request Form	Discovery Report/Tabular Data	Community and County Stakeholders	July 2012	Countywide
Contacts	Discovery Report/Tabular Data	Local Community Websites, State/FEMA updates	June 2012	Countywide
Community Assistance Visits (CAVs)	Discovery Report/Tabular Data	FEMA Community Information System (CIS)	July 2012	Countywide
Community Rating System (CRS)	Discovery Report/Tabular Data	FEMA's "Community Rating System Communities and Their Classes"	July 2012	Nationwide
Comprehensive Plans	Discovery Report	Local Community Websites	July 2012	Countywide
Coastal Barrier Resources System (CBRS)	Discovery Map	U.S. Fish and Wildlife Service	July 2012	Nationwide
Coastal Structures	Discovery Map/Tabular Data	U.S. Army Corps of Engineers (USACE)	August 2012	Nationwide
Coordinated Needs Management Strategy (CNMS)	Discovery Map	FEMA	July 2012	Countywide
Critical Beach Erosion Areas	Discovery Report	Local Stakeholders	July/August 2012	Countywide
Critical Facilities	Discovery Report/Discovery Map	Local Mitigation Plans, Discovery Meetings	July 2012	Countywide
Dams	Discovery Map/Tabular Data	USACE, National Inventory of Dams, Flood Insurance Rate Map (FIRM) Database	July 2012	Countywide
Declared Disasters	Discovery Report/Tabular Data	FEMA's "Disaster Declarations Summary"	June 2012	Nationwide
Demographics, Industry	Discovery Report/Tabular Data	U.S. Census Bureau, Local Mitigation Plans	June 2012	Countywide
Effective Floodplains	Discovery Map	FEMA Map Service Center and Mapping Information Platform	June 2012	Countywide
Flood Insurance Policies	Discovery Report/Tabular Data	FEMA CIS	July 2012	Nationwide
Hazard Mitigation Plans and Status	Discovery Report/Tabular Data	Local Mitigation Plans	July 2012	Countywide

Table 1. Data Collected for Lake Michigan

Data Types	Deliverable/Product	Source	Date of Data Collection	Level
Hazard Mitigation Assistance (HMA) Program Grants Received	Discovery Report/Tabular Data	FEMA's "Hazard Mitigation Program Summary" Community Input	June 2012	Nationwide
Hazard Mitigation Projects	Discovery Report/Tabular Data	Local Mitigation Plans/Local Stakeholders	July 2012	Countywide
High Water Marks	Discovery Report, Tabular Data	Effective Flood Insurance Study (FIS)	August 2012	Countywide
Historical Flooding & Storm Events	Discovery Report	Effective Flood Insurance Study (FIS), Local Mitigation Plans	July 2012	Countywide
Individual/Public Assistance	Discovery Report/Tabular Data	FEMA's "Public Assistance Subgrantee Summary"	June 2012	Nationwide
Letters of Map Change (LOMCs)	Discovery Map/Tabular Data	FEMA's Mapping Information Platform	July 2012	Countywide
Meteorological Gages	Discovery Map/Tabular Data	National Oceanic and Atmospheric Administration (NOAA) Great Lakes Environmental Research Laboratory	July 2012	Regionwide
Oblique Imagery	Discovery Report	USACE	2012	Lakewide
Ordinance Status	Discovery Report/Tabular Data	FEMA CIS	July 2012	Countywide
Proposed Draft Transects	Discovery Map	FEMA	February 2013	Lakewide
Repetitive Loss	Discovery Report/Tabular Data	FEMA CIS	July 2012	Countywide
Shoreline Classification Dataset	Discovery Map/Tabular Data	USACE	July 2012	Regionwide
Stream Gages	Discovery Map/Tabular Data	USGS	July 2012	Countywide
Water Level Gages	Discovery Map/Tabular Data	NOAA Department of Fisheries and Oceans (DFO)	July 2012	Regionwide
Wave Gages	Discovery Map/Tabular Data	NOAA	July 2012	Regionwide

Information and data collected for each county along Lake Michigan was compiled into individual Discovery Reports and can be found in Appendices C-P of this report. The data in the individual reports is divided into two sections: one section contains the data that can be used for Risk MAP products and the other section contains the information that helped the study team form a better understanding of the Lake Michigan project area prior to moving forward with the GLCFS projects.

A list of local data and information collected from local stakeholders as part of this Discovery process through the Coastal Data Request Form (Appendix B) has been

compiled for Lake Michigan and can be found in Appendix Q. In summary, out of the 226 coastal communities included in this study area, 31 community officials provided information via the Coastal Data Request Form. In addition, ten (10) counties and a regional planning agency completed the form. Information was provided regarding what digital data is currently available, including basemap data, topography, coastal structure information, critical facilities, and property information, as well as risk assessment data availability, hazard mitigation practices, and other community plans and projects that may tie into risk-reduction activities at the local level.

As the Risk MAP project for Lake Michigan advances, FEMA will continue to work with local officials to determine partnerships that may be achieved based on local community or county-based data that has been identified through this Discovery process as already available. Available datasets may be used to create certain flood risk products or may be used to help initiate mitigation projects on a community to community basis. It will be important for study teams to refer to this list of available local data as the study moves forward.

i. New data for Lake Michigan

In addition to data identified from local, state, and federal sources, several new datasets were developed specifically as part of the GLCFS effort, and include the Lake Michigan project area. These datasets have been summarized in the subsections below.

I.V.i.1 Oblique Imagery

As part of the GLCFS, USACE collected oblique imagery for the entire Great Lakes coastline in 2012. Oblique imagery is captured at an angle, as compared to an overhead view provided by orthophotos, and allows users a 3-dimensional view of landscape, buildings, and other features. This dataset may be useful to communities during emergency response, planning, and identification of shoreline types and obstructions; and management of assets, critical facilities, and public properties along the Lake Michigan shoreline. The oblique photo viewer is available from USACE at http://greatlakes.usace.army.mil/ .

I.V.i.2 Topography and Bathymetry

As part of the GLCFS, Light Detection and Ranging (LiDAR) was collected to develop topographic and bathymetric data along the Lake Michigan shoreline. Topography is the configuration of natural and man-made features of a surface area and their relative position and elevations. Bathymetry is the underwater equivalent to topography.

LiDAR is an optical remote sensing technology that can measure the distance to, or other properties of, a target by illuminating the target with light, often using pulses from a laser. A narrow laser beam can be used to map physical features with very high resolution. Downward-looking LIDAR instruments fitted to aircraft and satellites are used for surveying and mapping. LiDAR can be used to create DTM (Digital Terrain Models) and DEM (Digital Elevation Models), which is a digital model or 3-dimensional representation of the terrain's surface.

The LIDAR data for this study was collected within a 1500 meter buffer (500 meters inland and 1000 meters seaward of the land/water interface). Where water clarity permitted, data was collected to cover all federal navigation projects. Flight lines were flown along the channel alignment to ensure the best possible coverage of inlets and structures. The processing of the bathymetric data will be performed based on the strongest return of each LiDAR pulse, assuming this depth represents the bottom. Data will be processed to produce bottom reflectance data from the LiDAR data.

For quality control purposes, one cross line was used every 25 miles along shore or more frequently to ensure 90 percent of all planned lines within the area were crossed by a cross line. In areas of the coast where natural or artificial barriers prevent aircraft operations, the cross line(s) were collected at the nearest possible location to the required interval, but no closer than five (5) miles to an adjacent planned cross line. Overlapping lines and datasets were compared to each other and to cross lines and the differences calculated.

At the time this report was generated, the quality control process was not yet completed on the LiDAR dataset. However, as part of that process, the vertical difference between the LiDAR and ground truth data will be calculated. Ground truth refers to a process in which a pixel on a satellite image is compared to what is there in reality. This is especially important in order to relate LiDAR data to real features and materials on the ground. The collection of ground truth data enables calibration of the LiDAR data, and aids in the interpretation and analysis of what is being sensed. Using this process, all systematic errors will be identified and eliminated and remaining errors should have a normal distribution. Differences between a DEM created from the LiDAR data representing bare ground and the ground truth data will be unbiased and within +/-15 centimeters (RMSE[5]) in flat terrain and within +/-30 centimeters (RMSE3) in hilly terrain. Horizontal positions will be accurate to +/- 1.5m (RMSE). Data will be processed to 2-ft contours.

As of the date of this report, the LiDAR data is expected to become available in the spring of 2013 for this study area. There is a delay in the schedule to collect new bathymetric data; therefore, existing bathymetric data may be used for the transect-based coastal flood hazard analysis. Existing high-resolution bathymetric and topographic data is currently available at http://csc.noaa.gov .

I.V.i.3 Shoreline Feature Dataset

The shoreline feature dataset was generated by USACE Detroit District (U.S. Army Corps of Engineers, 2012) using the 2012 oblique photographs mentioned earlier in this section. The dataset captures shoreline types, land uses, coverage, and vegetation types along the entire Great Lakes shoreline, including Lake Michigan. The dataset includes identification of "artificial" shoreline, which may be indicative of local coastal flood protection structures. This dataset does not identify the level of protection of any coastal structures and it does not validate whether or not a coastal structure exists. The current dataset

[5] Root-mean-square-error is a measure of the differences between values predicted by a model or an estimator and the values actually observed.

contains data at one-mile spacing. The dataset does not include field-based reconnaissance or sediment/subsurface soil collection.

This dataset is shown on the Final Discovery Maps (Appendix R). The dataset (Great Lakes Shoreline Geodatabase) can also be downloaded from http://www.greatlakescoast.org/ under the "Technical Resources" section. Shoreline information specific to each county can be found in the individual Discovery Report in Appendices C-P of this report.

I.V.i.4 Proposed Draft Transects

As discussed in earlier sections of this report, transects are cross-shore profiles along which coastal flooding analysis is performed. Transects are used to transform offshore conditions to the shoreline and are used to define coastal flood risks inland of the shoreline. They are placed to define representative profiles for a shoreline reach.

For Lake Michigan, proposed draft transects were placed in advance of the Discovery Meetings and were provided to local stakeholders for review and comment. Based on the comments captured throughout the Discovery process, some transects have been revised and there has been an overall reduction in the number of draft transects placed along Lake Michigan. The revised proposed transects and associated stakeholder comments can be seen on the Final Discovery Maps, located in Appendix R, and in the Lake Michigan Stakeholder Comments (General and Transect) table found in Appendix S.

Not all stakeholder comments related to the request to reduce the overall number of transects along certain shorelines (i.e. those with high bluffs) were able to be resolved as of the date of this report. Discussion related to a possible reduction in the number of transects and re-evaluation of specific locations will be pursued with those stakeholders prior to the start of the coastal analysis phase. Specific concerns provided by local stakeholders related to the total amount of transects has been captured in the individual Discovery Reports located in Appendices C-P. The draft transects presented in this report are therefore subject to change based on the future coastal analysis and local stakeholder discussions and should not be considered final at this time.

The final transect layout for a coastal hazards analysis and subsequent floodplain delineation is determined by physical factors such as changes in topography, bathymetry, shoreline orientation, and land cover data, in addition to societal factors such as variations in development and density.

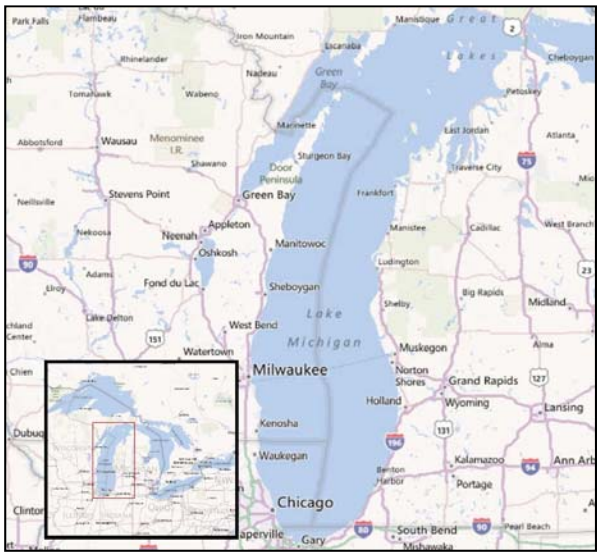
I.V.i.5 Storm Surge and Wave Study

Lake level and wave climate are necessary to identify the coastal flood risks along Lake Michigan. While there are observations of lake levels and waves within Lake Michigan, they are limited due to wave buoys being removed in the winter due to ice concerns. In addition, lake levels are spatially limited around the lake. Therefore, USACE undertook a storm surge and wave study effort that allows for the identification of the surge value away from the gage locations. USACE modeled historical events (a process known as

hindcasting). The hindcasted lake level and wave models are driven by wind and pressure fields on a grid defined by available bathymetric data. The resultant model outputs are available on a gridded basis within Lake Michigan. Additional information can be found at http://www.greatlakescoast.org/ under the "Technical Resources" section.

VI. Lake-wide Issues and Long-term Trends

According to the U.S. Environmental Protection Agency's (EPA's) Lake Michigan Lakewide Management Plan, Lake Michigan has internationally significant habitat and natural features; supports food production and processing; supplies fish for food, sport, and culture; has valuable commercial and recreational uses; and is the home of the nation's third-largest population center (U.S. Environmental Protection Agency, 2012a).



Major tributaries into Lake Michigan include the Fox-Wolf, Grand, and the Kalamazoo Rivers. Lake Michigan's cul-de-sac formation means the time it takes for water to exit the Lake at the Straits of Mackinac is 99 years (Great Lakes Information Network, 2012).

The western shoreline of Lake Michigan is rocky, while the eastern shoreline beaches are sandy due to the prevailing wind from the west. As a result, the largest freshwater dune system is located along the shore of Lake Michigan (Great Lakes Information Network, 2012).

The subsections below detail trends and issues specific to Lake Michigan, including water levels, historical flooding and high water marks, coastal flood protection measures, and coastal recession.

i. Water Levels

Coastal flooding along the Great Lakes is primarily the result of storm-induced surge and waves and is directly related to the long-term lake water levels. Variations in lake water levels due to decadal scale variations in precipitation and human activities affect the risk of flooding and will be taken into account during the upcoming GLCFS projects.

NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) maintains several water level stations along the Great Lakes that produce high quality and accurate measurements of lake level. The Great Lakes water levels constitute one of the

longest high quality hydrometeorological data sets in North America, with reference gage records beginning about 1860, and with sporadic records back to the early 1800's.

Measurements for Lake Michigan water levels exist from 13 stations around the lake. Long term data is available from nine of these stations. Measurements at these stations are collected at 6-minute or hourly intervals. Table 2 lists the nine water level stations with long-term data for Lake Michigan.

Table 2. Lake Michigan Water Level Stations

Station Number	Station	Latitude	Longitude	6-minute Records	Hourly Records
9075080	Mackinaw City, MI	45° 46.6' N	84° 43.5' W	None	1/1970-1/2010
9087023	Ludington, MI	43° 56.8' N	86° 26.5' W	1/1998-1/2010	1/1970-1/2010
9087031	Holland, MI	42° 46.0' N	86° 12.0' W	9/2000-1/2010	1/1970-1/2010
9087044	Calumet Harbor, IL	41° 43.7' N	87° 32.3' W	1/1996-1/2010	1/1970-1/2010
9087057	Milwaukee, WI	43° 0.1' N	87° 53.2' W	1/1996-1/2010	1/1970-1/2010
9087068	Kewaunee, WI	44° 27.8' N	87° 30.0' W	10/2000-1/2010	1/1970-1/2010
9087072	Sturgeon Bay, WI	44° 47.7' N	87° 18.8' W	8/1999-1/2010	1/1973-1/2010
9087079	Green Bay, WI	44° 32.4' N	88° 0.4' W	1/1998-1/2010	1/1970-1/2010
9087096	Port Inland, MI	45° 58.1' N	85° 52.2' W	9/1994-1/2010	1/1970-1/2010

The station information and water level data are available at NOAA CO-OPS Website: http://tidesandcurrents.noaa.gov/station_retrieve.shtml?type=Great Lakes Water Level Data&state=LakeMichigan .

The monthly high and low water level data from the year 1918 to 2011 for Lake Michigan are available at the USACE website: http://www.lre.usace.army.mil/greatlakes/hh/greatlakeswaterlevels/

Figure 6 is a graphic that shows Historic Great Lakes Water Levels from 1918 to 2011 based on available water level data (U.S. Army Corps of Engineers, 2012). Monthly mean level and long term annual water level elevations are shown in feet and are referenced to the International Great Lakes Datum (IGLD 1985).

Along the Great Lakes shoreline, flooding is dependent on the local lake levels which vary as a result of precipitation and evaporation and other natural processes, as well as human activities. Ice cover impacts the flood hazard significantly. These phenomena make the analysis of flood risk for the Great Lakes unique from ocean coastal areas (U.S. Army Corps of Engineers, October 2012).

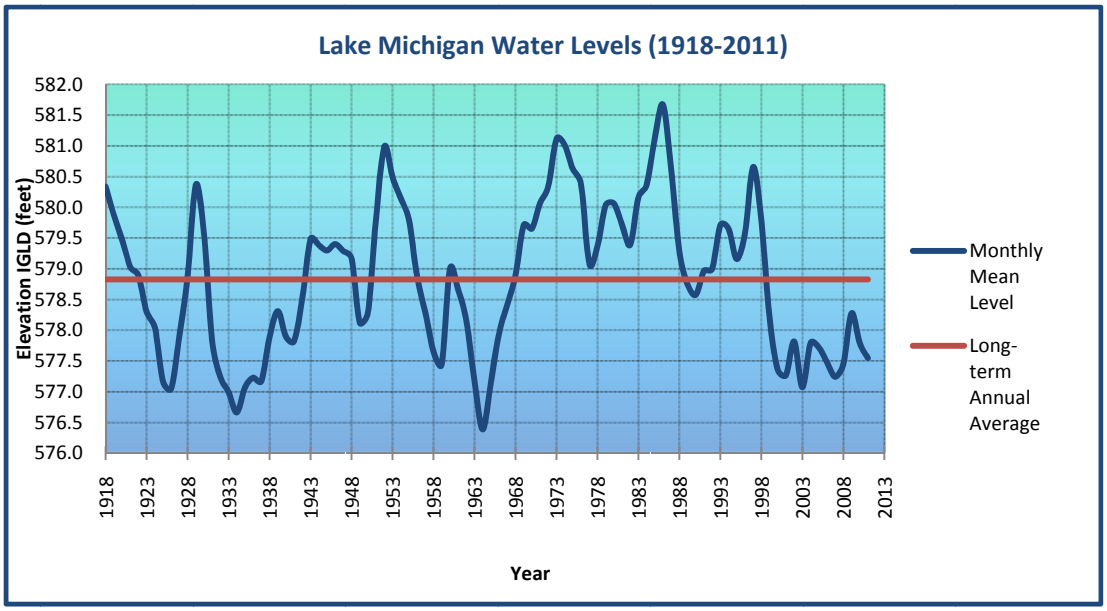


Figure 6. Historic Great Lakes Water Levels from 1918 to 2011

In recent history, a period of nearly three decades of above average water levels on the Great Lakes was followed by a decade of low levels. Lake Michigan-Huron rose from record lows in the 1960s to extreme high levels in less than a decade. Seasonally, lake levels along Lake Michigan are lowest in the winter and highest in the summer. In the short-term, strong storm events often produce high winds and atmospheric pressure variations that can generate substantial surge or elevated water levels along the lake boundaries.

The International Joint Commission (IJC) regulates lake levels using control structures in connecting waterways. In addition, the Michigan-Huron system water levels are influenced by human activities related to water diversion at Chicago and by channel management activities of the St. Clair River channel. The IJC reviews studies related to these activities and makes recommendations to maintain optimal lake levels (U.S. Army Corps of Engineers, October 2012).

Recent developments in mathematical and computer modeling of storm winds, waves, and storm surge, combined with more extensive measurements, provide an opportunity to significantly improve the accuracy of flood risk maps along the Great Lakes. In USACE's October 2012 technical report, *Wave Height and Water Level Variability on Lake Michigan and Lake St. Clair*, the evaluation and assessment of lake levels were used as the basis for a proposed strategy for revising the flood risk maps for the Great Lakes. By evaluating long term lake levels, seasonal trends, and storm-induced changes in lake levels on Lake Michigan, the statistical characteristics of the data was able to be analyzed in the context of computing flood risk (U.S. Army Corps of Engineers, October 2012).

The results of USACE's water level analysis detailed in the October 2012 technical report show that long term water levels are stationary. Extreme values of water levels are mostly due to strong non-convective storms that occur from November to April (U.S. Army Corps of Engineers, October 2012).

To view USACE's analysis of the historical storm climatology and resulting measured waves and water levels, detailed history of water levels and wave time series, and flood map methodology proposed to seek improved accuracy to base flood elevation prediction along the Great Lakes, the October 2012 final technical report *Wave Height and Water Variability on Lakes Michigan and St. Clair* can be accessed from http://www.greatlakescoast.org/ under the "Technical Resources" section.

ii. Historical Flooding & High Water Marks

Floods are the result of a multitude of both naturally occurring and human induced factors, but can simply be defined as the accumulation of too much water in too little time in a specific area.

Along Lake Michigan, fast melting snow combined with severe storms and heavy rainfall has the potential to cause extensive flooding, particularly during periods of high lake levels. During each episode of high lake levels, there is an increase in property loss and rate of coastal erosion, and structures and beaches may become submerged. During periods of low lake levels, beaches may appear high and wide and structures are emergent. Also during times of low lake levels, navigation channels often require extensive dredging to maintain proper depths.

Late winter and spring floods are the most common in the vicinity of Lake Michigan. Frontal systems tend to produce light to moderate, but steady and widespread rainfall on saturated snowpack. When the upper soil layer is frozen, the ground is impervious and rain cannot penetrate the ground. This runoff effect is compounded by melting snowpack and frozen soil layers.

Floods during summer and fall are caused by intense, localized thunderstorms and can result in devastating flooding. When accompanied by low pressure systems, flooding can be intensified by storm surge. Wind friction 'drags' across the water surface resulting in a 'piling up' of water at the coast that can be more than 20 feet above the normal water surface elevation. Wave action combined with storm surge can result in extensive flooding, particularly in low lying coastal areas.

According to the USGS National Water Summary, major flooding along the shoreline of Lake Michigan occurred in 1960 and again in 1986. Reports also indicate significant flooding in 1973 (Federal Emergency Management Agency, 2009). In October 1986, a record stage of 583.55 feet from the National Geodetic Datum of 1929 (NGVD29) was established on Lake Michigan (Federal Emergency Management Agency, 2007). These

high water level events following periods of low water have caused significant damage to beaches, bluffs, and structures costing millions of dollars.

In the analysis of a flood event, often the high water mark is identified to determine the maximum elevation of floodwaters. If a high water mark on a tree, building, or other fixed object can be identified and measured following a flood event, the floodwater elevation and therefore the extent of flooding can be determined. Such high water mark information combined with storm data, lake water level, and river stage data can be useful when modeling the extent of flooding associated with the 1-percent-annual-chance event during the upcoming coastal flood hazard studies.

The high water mark should not be confused with the term 'Ordinary High Watermark' (OHW). The OHW is the line along the Lake Michigan shoreline that defines the boundary between uplands and submerged lands and designates a line of regulatory jurisdiction. The line is often used to define the boundary between public and private lands.

High water mark data identified during Discovery came from the available existing Flood Insurance Studies (FISs). It should be noted that FISs were not available for all counties along Lake Michigan. High water mark data, while infrequently reported, captured high lake level data from the nearest lake gage associated with a weather event. The high water mark data identified during this Discovery process is presented in Table 3. Please note the vertical datum referenced for each high water mark elevation. Additional lake level gage data is available from the sources discussed and presented in earlier sections of this report. No additional information on high water mark data was identified or provided during Discovery.

Table 3. High Water Mark (HWM) Data

State	County	Location	Reference Buoy	Date	HWM (feet)	Vertical Datum
IL	Lake	N of Kellogg Ravine	Unknown	Apr-1960	578.9	NGVD29[6]
IL	Lake	N of Lake Michigan Tributary	Unknown	Apr-1960	578.8	NGVD29
IL	Lake	N of Kellogg Ravine	Unknown	Feb-1966	577.9	NGVD29
IL	Lake	N of Lake Michigan Tributary	Unknown	Feb-1966	578.1	NGVD29
MI	Berrien	Calumet Harbor Gage	9087044	19-Jul-1970	582.1	NGVD29
MI	Berrien	Calumet Harbor Gage	9087044	23-Jul-1971	584.6	NGVD29
MI	Berrien	Calumet Harbor Gage	9087044	14-Nov-1972	583.4	NGVD29
MI	Berrien	Calumet Harbor Gage	9087044	25-Apr-1973	583.3	NGVD29
MI	Berrien	Calumet Harbor Gage	9087044	17-Jun-1973	583.2	NGVD29
MI	Berrien	Calumet Harbor Gage	9087044	16-May-1973	583.2	NGVD29
MI	Berrien	Calumet Harbor Gage	9087044	22-Feb-1974	583.5	NGVD29
MI	Berrien	Calumet Harbor Gage	9087044	22-Jun-1974	583.1	NGVD29

[6] National Geodetic Vertical Datum of 1929

Table 3. High Water Mark (HWM) Data

State	County	Location	Reference Buoy	Date	HWM (feet)	Vertical Datum
MI	Berrien	Calumet Harbor Gage	9087044	13-Jun-1976	581.9	NGVD29
MI	Van Buren	Holland, Calumet Harbor Gage	7031	17-Jun-1973	582.5	NAVD88[7]
MI	Van Buren	Holland, Calumet Harbor Gage	7031	22-Jun-1974	582.4	NAVD88
MI	Van Buren	Holland, Calumet Harbor Gage	7031	29-Aug-1975	581.8	NAVD88
MI	Van Buren	Holland, Calumet Harbor Gage	7031	13-Jun-1976	581.9	NAVD88
MI	Ottawa	City of Holland, Calumet Harbor Gage	7031	17-Jun-1973	582.7	NAVD88
MI	Ottawa	City of Holland, Calumet Harbor Gage	7031	22-Jun-1974	582.6	NAVD88
MI	Ottawa	City of Holland, Calumet Harbor Gage	7031	2-Dec-1985	583.7	NAVD88
MI	Ottawa	City of Holland, Calumet Harbor Gage	7031	3-Oct-1986	583.1	NAVD88

Local stakeholders who may have historical flooding photographs and high water mark information are encouraged to submit them to the FEMA Region V Mitigation Division.

iii. Coastal Flood Protection Measures

Coastal structures and shoreline material along Lake Michigan will be reviewed in more detail during the engineering analysis portion of the Lake Michigan study. A summary of information collected to date regarding existing coastal structures, shoreline material, and flood protection measures along Lake Michigan is described below.

The USACE has constructed dams, levees, and other water control structures to reduce flood damages in the Great Lakes basin (U.S. Army Corps of Engineers, 2005). Many dikes were constructed along Lake Michigan to protect low-lying shore from wave runup as part of the USACE Operation Foresight, following flooding in 1973 (Federal Emergency Management Agency, 2009). It's important to note that the design for Operation Foresight was generally for temporary measures, and the dikes and other structures have since been partially removed in some cases. The protection measures were constructed to meet immediate flood threats and were never considered to be permanent.

The USACE Coastal & Hydraulics Laboratory (CHL), a member of the Engineer Research & Development Center (ERDC), has compiled an inventory of coastal structures called the Enterprise Coastal Inventory Database (ECID). The ECID application and database houses information on more than 900 coastal structures in the U.S. and utilizes a Google Earth interface for users to access information on the structures including project reports, aerial

[7] North American Vertical Datum of 1988

photographs, wave and water level and bathymetric data. Appendix T lists the major coastal structures along Lake Michigan that were extracted. Additional information on this database can be found by visiting the website http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=Projects;246.

According to USACE Detroit District, there are more than 104 miles of navigation structures on the Great Lakes, constructed mostly between 1860 and 1940. The function of the structures include containment and reduction of shoaling in the navigation channel, protection of the channel and shoreline infrastructure, controlling wave climate in the channel and harbor, or any combination of these purposes. Typical structure construction types include wood crib with concrete cap, steel sheet pile, and rubble mound structures.

Low lake levels since the 1990's have accelerated deterioration of these navigation structures and USACE Detroit District launched an investigation to assess the effects of changes in Lake Michigan water levels on the performance and stability of these structures. An inventory of critical infrastructure protected by federally maintained navigation structures was conducted along with a condition assessment of the structures including an estimation of the risk associated with structure failure. Structures were rated on the following scale:

A – Failure Unlikely
B – Low Risk of Failure
C – Medium Risk of Failure
D – High Risk of Failure
F – Failed

The inventory for Lake Michigan structures along with their rating is illustrated in Figure 7 taken from USACE.

Figure 7. U.S. Army Corps of Engineers Coastal Structures Inventory Assessment Rating

For each location of harbor infrastructure identified in Figure 7, USACE has prepared, or is in the process of preparing, a Harbor Infrastructure Inventory Report. Included in the report is a high level display of potential impact areas associated with structures at risk. The display in the report indicates three potential impact areas defined at 500 foot intervals and estimates potential value of land and infrastructure within each potential impact area. An example of the potential impact area graphic for Grand Haven Harbor, Michigan is presented in Figure 8.

Figure 8. Example of the Potential Impact Area for Grand Haven Harbor, MI

In 2011, USACE embarked on a series of Regional Risk Communication Meetings with local stakeholders to share the results of the condition assessments. These meetings are ongoing and information on the Structure Risk Communication process along with the completed Harbor Infrastructure Inventory Reports can be found on the USACE Detroit District website at: http://www.lre.usace.army.mil/_kd/go.cfm?destination=Page&Pge_ID=2438.

In addition to USACE structures, many local property owners use seawalls, revetments, riprap, and other shore protection structures to prevent storm damage and beach erosion along Lake Michigan. During Discovery, stakeholders reported the presence of additional shore protection structures buried by sand and currently not visible. It is important to note that these coastal structures do not necessarily protect areas from the 1-percent-annual-chance flood event.

Figure 9 depicts the 2012 USACE shoreline feature dataset, including identification of artificial shoreline material (which may include seawalls, revetments, and other shore protections structures mentioned above), as well as the USACE Coastal Structure Inventory within the Lake Michigan basin.

Lake Michigan
Lake Huron
Schoolcraft County Michigan
Mackinac County Michigan
Delta County Michigan
Menominee County Michigan
Marinette County Wisconsin
Oconto County Wisconsin
Door County Wisconsin
Door County Wisconsin
Kewaunee County Wisconsin
Brown County Wisconsin
Manitowoc County Wisconsin
Sheboygan County Wisconsin
Ozaukee County Wisconsin
Milwaukee County Wisconsin
Racine County Wisconsin
Kenosha County Wisconsin
Lake County Illinois
Cook County Illinois
Lake County Indiana
Porter County Indiana
La Porte County Indiana
Berrien County Michigan
Van Buren County Michigan
Allegan County Michigan
Ottawa County Michigan
Muskegon County Michigan
Oceana County Michigan
Mason County Michigan
Manistee County Michigan
Benzie County Michigan
Leelanau County Michigan
Grand Traverse County Michigan
Antrim County Michigan
Charlevoix County Michigan
Emmet County Michigan
N
0 5 10 20 30 40 Miles
Legend
Buoy
USACE Structure
Water Level Gauge
Shoreline Material
Artificial
Boulders, Bedrock
Cohesive Clays and Silts
Sand
Shingles, Pebbles, Cobbles

iv. Coastal Recession

Coastal erosion is the recession of land and the removal of beach or dune sediments. It affects all of the beaches and coasts in the world, including those of Lake Michigan. Over the years, breakwaters, riprap, groins, and beach nourishment projects have been used to alleviate erosion problems along the shoreline of Lake Michigan. The erosion can be caused from one or several factors, including high water levels, storms, wind, ground water seepage, surface water runoff, and frost. High waves erode vulnerable shorelines if not protected by these structures. In the section below, coastal erosion and recession along the Lake Michigan shoreline is discussed on a State to State basis.

In Michigan, areas prone to erosion along the shoreline, including Lake Michigan, are subject to special setback requirements established by the Michigan Department of Environmental Quality (MDEQ). Much of the eastern Lake Michigan shoreline has been designated as High Risk Erosion Areas (HREA). Available Lake Michigan HREA data are compiled in Appendix U. Studies have shown these areas are receding at a long-term average rate of one foot or more per year. The erosion can be caused from one or several factors, including high water levels, storms, wind, ground water seepage, surface water runoff, and frost. The HREA regulations require setback distances to protect new structures from erosion for a period of 30 to 60 years, depending on the size, number of living units, and type of construction.

For the Lake Michigan study area along the State of Michigan coastline, HREA maps by MDEQ are available for the communities listed in Table 4. The maps depict the high risk erosion areas and show the number, in feet, of the 30-year projected recession distance and 60-year projected recession distance. The maps are included in Appendix U.

Table 4. Michigan DEQ High Risk Erosion Area Maps

County	Community	County	Community
Allegan	Casco Township	Mackinac	Garfield Township
	Ganges Township		Moran Township
	Laketown Township		Newton Township
	Saugatuck Township	Manistee	Arcadia Township
Antrim	Banks Township		Manistee Township
	Elk Rapids Township		Onekama Township
	Milton Township		Filer Township
	Torch Lake Township	Mason	Grant Township
Benzie	Blaine Township		Hamlin Township
	Crystal Lake Township		Pere Marquette Township
	Gilmore Township		Summit Township
	Lake Township	Menominee	Cedarville Township
Berrien	Chikaming Township		Ingallston Township
	Hagar Township		Menominee Township
	Lake Township	Muskegon	Fruitland Township
	Lincoln Township		Laketon Township
	New Buffalo Township		

Table 4. Michigan DEQ High Risk Erosion Area Maps

County	Community	County	Community
Berrien	St. Joseph Township	Muskegon	Muskegon Township
	Benton Township		Norton Shores Township
Delta	Ensign Township		White River Township
	Escanaba Township	Oceana	Benona Township
	Ford River Township		Claybanks Township
	Masonville Township		Golden Township
	Wells Township		Pentwater Township
Emmet	Bear Creek Township	Ottawa	Grand Haven Township
	Bliss Township		Park Township
	Cross Village Township		Port Sheldon Township
	Resort Township		Spring Lake Township
	West Traverse Township	Schoolcraft	Thompson Township
Grand Traverse	Acme Township		
	Garfield Township	Van Buren	Covert Township
	Peninsula Township		South Haven Township
Leelanau	Bingham Township		
	Empire Township		
	Glen Arbor Township		
	Leelanau Township		
	Leland Township		
	Suttons Bay Township		

Additional information can be found at the MDEQs High Risk Erosion Areas website at http://www.michigan.gov/deq/0,1607,7-135-3313_3677_3700-10860--,00.html .

According to the Michigan DEQ, Michigan's sand dunes are a unique natural resource of global significance and collectively represent the largest assemblage of fresh water dunes in the world. As such, the state passed the Sand Dune Protection and Management Act in 1976 to regulate mining and later in 1989 amended the act to regulate development and other activities. Critical Dune Areas are protected by the state as a unique, irreplaceable and fragile resource. Maps of Michigan's Critical Dune Areas can also be found in Appendix U.

In Wisconsin, coastal erosion along the Great Lakes shoreline is a significant issue in the coastal communities. According to the Wisconsin *Coastal Management Program 2011-2016 Needs Assessment and Strategy*, all fifteen of Wisconsin's coastal counties experience erosion. Wisconsin's Lake Michigan shoreline is generally vulnerable to shore erosion from the Illinois State line to the Sturgeon Bay Canal, a distance of 185 miles. From the Sturgeon Bay Canal around the northern tip of Door County to Green Bay, shore erosion is largely limited to bays and clay banks. Erosion rates are particularly high along sand plains and high bluffs composed of till. Short-term erosion rates of 3 to 15 feet per year have been recorded along sand plains and 2 to 6 feet per year along high bluff lines (Wisconsin Department of Administration, 2010).

Erosion impacts along Wisconsin's Great Lakes coasts are varied in severity and geology. The sandy bluffs of mid Lake Michigan are more susceptible to continual slope failures than the gradual shoreline of southern Lake Michigan or the rocky shoreline of Door County (Wisconsin Department of Administration, 2010). There are 11 Lake Michigan counties in Wisconsin that have maps depicting erosion rates. These counties include Marinette, Oconto, Brown, Door, Kewaunee, Manitowoc, Sheboygan, Ozaukee, Milwaukee, Racine, and Kenosha. Studies and reports relevant to Wisconsin's coastal hazards, and in particular erosion, were pulled from the Wisconsin *Coastal Management Needs Assessment and Strategy* as well as Southeastern Wisconsin Regional Planning Commission's (SEWRPC's) online publication library and are listed in the individual Discovery Reports for Wisconsin found in Appendices E-H.

In Illinois, according to their *Coastal Management Program* document, updated November 3, 2011, the Lake Michigan coast is a dynamic setting influenced by waves, ice, and changing lake levels and the potential for coastal erosion exists along nearly the entire Illinois coast (Illinois Department of Natural Resources, 2011). Areas of greatest concern for Illinois coastal erosion change with time and thus mitigation efforts are adjusted accordingly. In the 1970s, most of the bluff coast was a critical erosion area, and during the record high lake levels of 1986-1987, erosion of beaches and parklands and deteriorated shore protection were major concerns along the Chicago lakefront (Illinois Department of Natural Resources, 2011).

Erosion along the Illinois coast tends to get public and media attention during times of high lake levels as high water causes partial to total submergence of some beaches; storm waves can damage and overtop shore structures, and localized coastal flooding may occur. It is, however, a common misconception that coastal erosion only occurs during high lake levels. Erosion can be an ongoing process regardless of lake level. Changing lake levels merely shift the erosion zone either landward or lakeward.

Four categories of coastal erosion have been, and continue to be, an issue along the Illinois Lake Michigan coast and inland waterways. This includes shore, bluff, lakebed, and waterway bank erosion. These categories of erosion correspond to different locations on the topographic/bathymetric profile (Illinois Department of Natural Resources, 2011). More information on this can be found in the Illinois *Coastal Management Program* document, Section 4, "Coastal Erosion and Assessment", found at http://www.dnr.illinois.gov/cmp/Documents/4_Erosion.pdf.

The majority of the Lake Michigan coastline in Illinois is protected from erosion by structures. The Illinois Department of Natural Resources (IDNR) estimates that close to 85 percent is protected. The Illinois Coastal Management Program (ICMP) reviews recent aerial photography combined with visual inspections of areas not currently protected by hardened structures in order to assess coastal erosion issues. Illinois Beach State Park represents approximately 95 percent of the area that is not currently protected by hardened structures (Illinois Department of Natural Resources, 2011).

In Indiana, the shoreline of Lake Michigan includes several High Erosion Hazard Areas (HEHAs), which are portions of the shoreline with a long term erosion rate greater than one foot per year. Many of the areas are currently protected from erosion by man-made structures or are included in the national or state park where the natural shoreline is preserved (Indiana Natural Resources Commission (NRC), 2012). During this Discovery process, the National Park Service noted they are responsible for the Indiana Dunes National Lakeshore. The shoreline is not owned exclusively by the National Park Service, but is held by a combination of public and private entities. The National Park Service noted that they maintain extensive data on erosion management, with data spanning 75 years of record.

The next section discusses Hazard Mitigation resources that are available to stakeholders, the importance of hazard mitigation planning, and existing and potential strategies and actions around Lake Michigan that seek to reduce flood risk.

VII. Hazard Mitigation Resources, Strategies and Actions

A review of hazard mitigation resources, strategies, and actions was performed as part of this Discovery process and were discussed with Lake Michigan stakeholders during the Information Exchange Sessions and the Discovery Meetings. This section provides general information about hazard mitigation, as well as mitigation topics specific to Lake Michigan.

i. Hazard Mitigation Overview

Hazard mitigation is any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards. This creates safer communities and facilitates resilience by enabling communities to return to normal function as quickly as possible after a hazard event. Once local officials understand risk from flooding and other hazards, the community is in a better position to identify potential mitigation actions that can reduce that risk to its people and property. Mitigation activities may be implemented prior to, during, or after an incident. However, it has been demonstrated that hazard mitigation is most effective when based on an inclusive, comprehensive, long-term plan that is developed before a disaster occurs. Hazard mitigation planning helps communities develop strategies to reduce their risk to natural hazard events.

Hazard mitigation plans form the foundation for a community's long-term strategy to reduce disaster losses and break the cycle of disaster damage, reconstruction, and repeated damage. The planning process is as important as the plan itself. It creates a framework for risk-based decision making to reduce damages to lives, property, and the economy from future disasters.

Hazard mitigation plans are required by the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288), as amended by the Disaster Mitigation Act of 2000, as well as the National Flood Insurance Act of 1968, as amended by the Flood Insurance Reform Act of 2004 (Public Law 108-264). Under the Disaster Mitigation Act of 2000; governments have certain responsibilities including reviewing and updating effective mitigation plans every five (5) years.

The status of hazard mitigation plans for communities along the Lake Michigan shoreline are listed in Appendix V and indicate expiration dates.

During the Discovery Meetings, several stakeholders noted the intent to update recently expired plans. This included:

- Schoolcraft, Delta, and Menominee County: Hazard mitigation plans are currently being updated by Menominee County Emergency Management.
- Mackinac County: Eastern Upper Peninsula Regional Planning and Development noted that Mackinac County is starting to update their hazard mitigation plan.
- County of Sheboygan: In the process of updating their plan.
- Ozaukee County: In the process of updating their plan.

Other plan updates may be underway; however, they were not noted during this Discovery process. The Final Discovery Maps in Appendix R display the status of local hazard mitigation plans (i.e. adopted, expired), along with hazard mitigation projects that have been completed via FEMA's Hazard Mitigation Grant Program (HMGP).

In addition to the review of plan status, existing hazard mitigation plans in the study area were reviewed for content to better understand flood risks within the Lake Michigan communities, and the strategies and actions that had already been developed as part of their planning process. By obtaining a better understanding of efforts made at the local level to reduce risk, FEMA can then work with the communities to identify areas of additional need or areas where partnerships may be formed throughout this coastal flood study process.

As a part of the review of the local hazard mitigation plans included in this Discovery process, potential mitigation actions were compiled from existing plans and have been provided as tables within the individual Discovery Reports found in Appendices C-P. Table 5 contains a summary of common hazard mitigation actions and strategies identified in local plans that relate to flooding in Lake Michigan coastal communities. Note that mitigation actions compiled in Table 5 may apply to all types of flooding, not just coastal.

Table 5. Summary of Mitigation Actions and Strategies from Local Hazard Mitigation Plans

Action/Strategy Number	Local Hazard Mitigation Action or Strategy
1	Undertake structural projects to lessen flood damage
2	Encourage municipalities to join the National Flood Insurance Program (NFIP) so that residents can obtain flood insurance
3	Construct flood walls to protect vulnerable areas
4	Identify ways in which to prevent coastal erosion damage
5	Encourage additional local governmental agencies to participate in the natural hazards mitigation process
6	Update of zoning ordinances to reflect new building codes, shoreline protection rules, etc
7	Develop community education and warning systems
8	Encourage public and business involvement in natural hazards mitigation projects and activities
9	Development setbacks, lot sizes, driveways, relocation of structures, and Lake Michigan coastal zoning ordinances
10	Enforce and/or incorporate natural hazard mitigation provisions in building code standards, ordinances, and procedures
11	Encourage local governments to include hazard mitigation concepts in the development of their comprehensive plans
12	Enforce Michigan's Sand Dune and Shorelands Protection and Management Programs that control development in high-risk erosion areas and protect dunes
13	Add floodwater storage; provide structural protection to developed areas where possible, without increasing flooding elsewhere
14	Promote low impact development techniques that reduce stormwater run-off and lessen flooding
15	Identify measures to take to protect local roadways from coastal erosion
16	Maintain current land use regulations that permit building of structures within vulnerable coastal locations
17	Construction of riprap to manage bluff erosion shifts due to the eroding force of the water where coastal areas lack bluff reinforcement
18	Implement floodproofing techniques such as elevation, relocation, barrier construction, and wet floodproofing for residents, businesses, and critical facilities.
19	Purchase houses in floodplain: relocating of buildings, flood-proofing structures, elevation of structures
20	Acquire repetitive loss structures

Source: Local Hazard Mitigation Plans for Lake Michigan communities

The next subsection discusses new Risk MAP tools introduced to communities during this Discovery process to support the identification and attainment of mitigation actions.

ii. The Mitigation Action Form and Action Tracker

As part of this Discovery process, FEMA introduced the Mitigation Action Form and Mitigation Action Tracker to Lake Michigan stakeholders. The Mitigation Action Form and Action Tracker are new Risk MAP tools designed to supplement existing mitigation planning processes by tracking and identifying local potential Areas of Mitigation Interest (AoMI) and new or improved mitigation actions that seek to reduce risk. The Action Form, which aligns with questions on the Action Tracker website, can be completed by anyone that has identified a potential AoMI.

Once in the Action Tracker, an AoMI can be tracked by a variety of entities, such as the community, county, state, and FEMA, for different uses such as:

- To identify all AoMIs in a community, State, or Region
- To document AoMIs in between mitigation plan updates
- To track progress on mitigation activities
- To assess the ability of the Risk MAP program to encourage communities to take action to reduce risk

FEMA uses the Action Form and Action Tracker website to document and track local mitigation needs and actions.

It is important to note that entering a potential Mitigation Action does not obligate a jurisdiction to fund or complete an identified action. When updating local hazard mitigation plans, local planning teams may find it useful to review the actions stored in the Mitigation Action Tracker, assess them, and consider adding them as new or modified actions during the planning process.

Through collaboration between Risk MAP project teams and communities, new actions can be identified and existing actions may be improved upon. In addition, funding and collaboration opportunities to implement mitigation actions may be identified.

Stakeholders who attended the Discovery Meetings were provided with the Mitigation Action Form and were encouraged to complete and return the form to FEMA Region V. Table 6 summarizes potential mitigation actions, as well as potential Areas of Mitigation Interest (AoMIs), collected via the Mitigation Action Form or captured from discussions with stakeholders during the Discovery Meetings. Users should note that these potential mitigation actions may or may not proceed and will depend on further discussion at the local level. A copy of the Mitigation Action Form can be found in Appendix W.

Table 6. Potential Mitigation Actions and Areas of Mitigation Interest

State	County	Stakeholder	Potential Mitigation Action or Area of Mitigation Interest	Hazard Type	Source of Action or AoMI
IL	Cook	Evanston, City of	City of Evanston Water Utility has identified an area east of the water plant that needs to be returned to natural dune habitat. Funding fell through for this project, which is designed to mitigate erosion issues.	Erosion	Mitigation Action Form
IL	Cook	Evanston, City of	City of Evanston noted two areas of concern on Northwestern University's campus and along Sheridan Road at the very south end of the county that have experienced significant erosion due to wave action. Erosion protection structures or strategies need to be identified.	Erosion	Discovery Meeting
IL	Cook	Evanston, City of	City of Evanston identified a need for protection along Lake Shore Drive where wave action (up to 15 feet) caused road closures last year.	Erosion/ Flood	Discovery Meeting/ Mitigation Action Form
IL	Lake	Highland Park	In the City of Highland Park, an area of eroding bluffs is a potential area of concern.	Erosion	Discovery Meeting
IL	Lake	North Chicago	Abbot Labs in North Chicago may need additional wave protection, and the nearby water treatment plant is investigating a potential expansion.	Flood	Discovery Meeting
MI	Mackinac	Hudson Township	Bridge at Black River. May be a sand buildup here.	Flood	Mitigation Action Form
MI	Mackinac	Mackinac County	Properties repetitively flood at Black River mouth. Black River/Pine River mouth is an area for potential mitigation projects.	Flood	Discovery Meeting
MI	Mackinac	Mackinac County	Ice build-up at the mouth of Black and Pine Rivers during winter snow melts; it causes a jam at the mouth of the river where it meets Lake Michigan. The river then backs up and can cause serious flooding and well contamination issues. Mitigation action that was identified is to elevate well heads.	Flood	Discovery Meting/Mitigation Action Form
MI	Mackinac	Mackinac County	Update of County Hazard Mitigation Plan is underway.	All Hazards	Discovery Meeting
MI	Mackinac	St. Ignace, City of	Depending on lake levels, there are some potential flooding issues near St. Ignace.	Flood	Discovery Meeting
MI	Delta, Schoolcraft, Menominee	MDEQ	MDEQ identified ice issues at mouths of the Sturgeon, Rapid, Ford, and Walton Rivers.	Flood	Discovery Meeting

Table 6. Potential Mitigation Actions and Areas of Mitigation Interest

State	County	Stakeholder	Potential Mitigation Action or Area of Mitigation Interest	Hazard Type	Source of Action or AoMI
MI	Delta, Schoolcraft, Menominee	MDEQ	MDEQ identified flooding issues in Garden.	Flood	Discovery Meeting
MI	Muskegon	North Muskegon, City of	Determine flood risk along Muskegon Lake	Flood	Mitigation Action Form
WI	Door	Door County	Door County indicated there may be a need to develop a Hazard Mitigation Plan.	All Hazards	Discovery Meeting
WI	Manitowoc	Manitowoc, City of	Silver Creek Road & Sloth Street/CTH LS. Erosion along bluff, stabilize bank; protect infrastructure	Erosion	Mitigation Action Form
WI	Manitowoc	Manitowoc, City of	Identified a bluff erosion issue along or across Silver Creek Road and South 10th Street/County Highway LS	Erosion	Discovery Meeting
WI	Milwaukee	Milwaukee County	Northern area in Milwaukee County has had erosion issues.	Erosion	Discovery Meeting
WI	Milwaukee	Milwaukee County	Milwaukee Emergency Planning Department noted that northern part of the county, Village of Bayside, Fox Point, Whitefish Bay, and Shorewood, has had storm sewer back-up issues and flooding. This is an existing identified area of concern. They are redoing the culverts in this area.	Flood	Discovery Meeting

The Mitigation Action Tracker can be accessed at: http://fema.starr-team.com . Stakeholders are encouraged to visit the site and add in new potential actions or revise and update existing actions. The Mitigation Action Form template can be downloaded and printed at http://fema.starr-team.com/MAF-Form.pdf.

FEMA is undertaking an effort in 2013, with support from state partners and a core stakeholder group, to identify a strategy that defines hazard mitigation actions to reduce loss of life and property and build resilience throughout the coastal communities of the Great Lakes regions.

FEMA's Mitigation Planning Technical Assistance (MPTA) may also be available to help communities plan for and reduce risks by providing communities with specialized assistance. MPTA is a part of Risk MAP program and includes risk assessment, mitigation planning, and traditional hazard identification (flood mapping) activities. Additional information on MPTA and how it applies to the Lake Michigan Coastal Flood Study is included in Section VIII of this report under "Potential for Mitigation Assistance".

The next subsection provides a description of various types of mitigation actions.

I.VII.ii.1 Types of Mitigation Actions

Hazard mitigation actions include adoption of local plans and regulations, creation of community identified programs that may help to reduce flood risk or other risks within a community, and structure and infrastructure projects. The FEMA Mitigation Action Form and Tracker request the identification of potential mitigation actions in one of these three categories. The outline presented below lists the potential types of actions that fall within each category.

Local Plans and Regulations:

- *Building codes.* The use and enforcement of building codes and development standards can ensure structures are safe from flooding.
- *Planning and land use regulations.* These regulations can mitigate flooding by influencing development. Consider updating and aligning Comprehensive and Master Plans, as well as other local plans to ensure that risk is considered at all levels of community planning.
- *Stormwater management plan.* Rainwater and snowmelt can cause flooding and erosion in developed areas and the plan can seek to mitigate that risk.
- *Floodplain management*. Through enforcement and adoption of NFIP floodplain management requirements, communities can reduce risk for new developed areas, and property owners in participating communities may purchase insurance protection against flood losses.

Community Identified Programs:

- *Funding mechanisms.* Mechanisms can be developed for local risk reduction.
- *Incentives for local risk reduction.* Studies have shown that many people are willing to take actions to reduce their risk if they believe they are actually at risk.
- *Mitigation Program.* Regular maintenance will help drainage systems and flood control structures to continue functioning properly.

Structure and Infrastructure Projects:

- *Structure Protection.* There are many ways to protect residential and non-residential structures from flood damage, such as flood proofing and elevation.
- *Infrastructure and Critical Facility Protection.* Techniques can be used to protect infrastructure and critical facilities from flood events.
- *Flood Control Structures.* These structures can be built to prevent flood damage.
- *Natural Systems.* Natural systems can provide floodplain protection, riparian buffers, and other ecosystem services that mitigate flooding.
- *Soil Stabilization or Erosion Control.* These processes can stabilize slopes that may be susceptible to erosion.

To learn more about mitigation planning, mitigation actions, and mitigation best practices, we recommend you visit http://www.fema.gov/hazard-mitigation-planning-resources .

The next section discusses funding opportunities that may be available to assist local officials in implementing hazard mitigation planning and projects.

iii. Hazard Mitigation Programs and Assistance

Not all mitigation activities require funding, and those that do are not limited to outside funding sources. For those mitigation actions that require assistance through funding or technical expertise, several state and federal agencies have flood hazard mitigation grant programs and offer technical assistance. These programs may be funded at different levels over time or may be activated under special circumstances such as after a presidential disaster declaration.

Communities can link hazard mitigation plans and actions to the right FEMA grant programs to fund flood risk reduction. More information about FEMA HMA programs can be found at http://www.fema.gov/hazard-mitigation-assistance

FEMA, as well as other federal agencies, award many mitigation grants each year to states and communities to undertake mitigation projects to prevent future loss of life and property resulting from hazard impacts, including flooding.

The FEMA Hazard Mitigation Assistance (HMA) programs provide grants for mitigation through the programs listed in Table 7. State and local mitigation plans are a requirement for most FEMA HMA project grant funding.

Table 7. FEMA Hazard Mitigation Assistance Program

Mitigation Grant Program	Authorization	Purpose
Hazard Mitigation Grant Program (HMGP)	Robert T. Stafford Disaster Relief and Emergency Assistance Act	Activated after a presidential disaster declaration; provides funds on a sliding scale formula based on a percentage of the total federal assistance for a disaster for long-term mitigation measures to reduce vulnerability to natural hazards
Flood Mitigation Assistance (FMA)	National Flood Insurance Reform Act	To reduce or eliminate claims against the NFIP
Pre-Disaster Mitigation (PDM)	Disaster Mitigation Act	A national competitive program focused on mitigation project and planning activities that address multiple natural hazards
Repetitive Flood Claims (RFC)	Bunning-Bereuter-Blumenauer Flood Insurance Reform Act	Seeks to reduce flood claims against the NFIP through flood mitigation; properties must be currently NFIP insured and have had at least one NFIP claim
Severe Repetitive Loss (SRL)	Bunning-Bereuter-Blumenauer Flood Insurance Reform Act	Seeks to reduce or eliminate the long-term risk of flood damage to SRL residential structures currently insured under the NFIP

The HMGP and PDM programs, described in the table above, offer funding for mitigation planning and project activities that address multiple natural hazard events. The FMA, RFC, and SRL programs focus funding efforts on reducing claims against the NFIP. Funding under the HMA programs is subject to availability of annual appropriations, and HMGP funding is also subject to the amount of FEMA disaster recovery assistance provided under a presidential major disaster declaration.

FEMA's HMA grants are awarded to eligible states, tribes, and territories (applicant) that, in turn, provide sub-grants to local governments and communities (sub-applicant). The applicant selects and prioritizes sub-applications developed and submitted to them by sub-applicants and submits them to FEMA for funding consideration. Prospective sub-applicants should consult the office designated as their applicant for further information regarding specific program and application requirements. Contact information for the FEMA Regional Offices and State Hazard Mitigation Officers (SHMO) is available on the FEMA website at www.fema.gov.

Some examples of other Federal programs that include funding available for hazard mitigation are displayed in Table 8. Several of these agencies, including USACE and National Oceanic & Atmospheric Administration (NOAA), have specialists on staff and can offer further information on flood hazard mitigation programs. The State NFIP Coordinator and SHMO are State-level sources of information and assistance.

Table 8. Other Agency Mitigation Program and Assistance

Mitigation Program or Assistance	Agency	Purpose
Coastal Services Center Cooperative Agreements	National Oceanic & Atmospheric Administration (NOAA)	Funds for coastal wetlands management and protection, natural hazards management, public access improvement, reduction of marine debris, special area management planning, and ocean resource planning. http://www.csc.noaa.gov/funding /
Coastal Services Center Grant Opportunities	National Oceanic & Atmospheric Administration (NOAA)	Formula and program enhancement grants for implementing and enhancing Coastal Zone Management programs that have been approved by the Secretary of Commerce. http://www.csc.noaa.gov/funding//
Coastal Zone Management Program	National Oceanic & Atmospheric Administration (NOAA)	The Office of Ocean and Coastal Resource Management (OCRM) provides federal funding and technical assistance to better manage our coastal resources. http://coastalmanagement.noaa.gov/funding/welcome.htmll
Marine and Coastal Habitat Restoration	National Oceanic & Atmospheric Administration (NOAA)	Funding for habitat restoration, including wetland restoration and dam removal. http://www.nmfs.noaa.gov/habitat/recovery//

Table 8. Other Agency Mitigation Program and Assistance

Mitigation Program or Assistance	Agency	Purpose
Planning Assistance to States (PAS)	U.S. Army Corps of Engineers (USACE)	Fund plans for the development and conservation of water resources, dam safety, flood damage reduction and floodplain management. http://www.lre.usace.army.mil/planning/assist.htmll
Emergency Streambank and Shoreline Protection	U.S. Army Corps of Engineers (USACE)	To prevent erosion damages to public facilities by the emergency construction or repair of streambank and shoreline protection works. www.usace.army.mill
Environmental Laboratory	U.S. Army Corps of Engineers (USACE)	Guidance for implementing environmental programs such as ecosystem restoration and reuse of dredged materials. http://el.erdc.usace.army.mil/index.cfmm
Small Flood Control Projects	U.S. Army Corps of Engineers (USACE)	To reduce flood damages through small flood control projects not specifically authorized by congress. www.usace.army.mill
Coastal Wetlands Conservation Grant Program	U.S. Fish & Wildlife Service	Matching grants to states for acquisition, restoration, management or enhancement of coastal wetlands. http://ecos.fws.gov/coastal_grants/viewContent.do?viewPage=homee
Disaster Recovery Assistance	U.S. Department of Housing and Urban Development (HUD)	Disaster relief and recovery assistance in the form of special mortgage financing for rehabilitation of impacted homes. http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs/dri
Neighborhood Stabilization Program	U.S. Department of Housing and Urban Development (HUD)	Funding for the purchase and rehabilitation of foreclosed and vacant property in order to renew neighborhoods devastated by the economic crisis. http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs/neighborhoodspg
USDA Smith-Lever Special Needs Funding	U.S. Department of Agriculture (USDA)	Grants to State Extension Services at 1862 Land-Grant Institutions to support education-based approaches to addressing emergency preparedness and disasters. http://www.csrees.usda.gov/funding/rfas/smith_lever.html
Community Facilities Direct Loans	U.S. Department of Agriculture (USDA)	Loans for essential community facilities. http://www.rurdev.usda.gov/HCF_CF.html
Community Facilities Direct Grants	U.S. Department of Agriculture (USDA)	Grants to develop essential community facilities. http://www.rurdev.usda.gov/HCF_CF.html
Farm Service Agency Disaster Assistance Programs	U.S. Department of Agriculture (USDA)	Emergency funding and technical assistance for farmers and ranchers to rehabilitate farmland and livestock damaged by natural disasters. http://www.fsa.usda.gov//

Table 8. Other Agency Mitigation Program and Assistance

Mitigation Program or Assistance	Agency	Purpose
Small Business Administration Loan Program	U.S. Small Business Administration (SBA)	Low-interest, fixed rate loans to small businesses for the purpose of implementing mitigation measures to protect business property from damage that may be caused by future disasters. Also available for disaster damaged property. http://www.sba.gov/about-sba-services/208

The programs described above may require a local match or have requirements that must be met in order for one to be eligible. To learn more about these programs and assistance, please contact your SHMO as they are the state-level source of information and assistance. A listing of SHMOs can be found by visiting http://www.fema.gov/state-hazard-mitigation-officers .

VIII. Risk MAP Projects and Needs

This section provides information about the planned next steps for the Lake Michigan coastal flood study, including information about the upcoming coastal analysis, potential for mitigation technical assistance within the project area, possible changes in compliance as a result of the coastal flood study, future communications, and how unmet needs will be addressed.

i. Future Coastal Study

Information and data collected as part of the Lake Michigan Discovery effort and provided in this report will be utilized in the upcoming GLCFS for Lake Michigan.

A summary of the GLCFS project, as well as project updates, can be found at http://www.greatlakescoast.org/ under the "Great Lakes Coastal Analysis & Mapping" section.

The following work is expected to be performed for Lake Michigan as part of the GLCFS, pending congressional funding. The scope of work described in this section is therefore subject to change and may not be performed within all Lake Michigan communities.

All engineering and mapping analysis performed as part of this study will follow guidance provided within FEMA's Draft *Guidelines and Specifications for Coastal Studies Along the Great Lakes*, issued on May 8, 2012 (Federal Emergency Management Agency, 2012). The upcoming study is expected to include the following tasks: creation of bathymetric and topographic data, base map acquisition, coastal flood hazard analysis, and risk assessment product development.

I.VIII.i.1 Engineering and Mapping

Coastal flood hazard analyses and mapping for all communities located along the Lake Michigan shoreline will be performed. Below is a summary of data that will be collected and analysis that will be performed:

1) Creation of Bathymetric and Topographic Map Data Inventory.
New bathymetric LiDAR, RGB Imagery, and Hyperspectral Imagery will be used for the coastal study areas. Topographic data for the coastal areas to be studied will be used for coastal analysis, floodplain boundary delineation and/or testing of floodplain boundary standard compliance. The topographic data used will be based on the data collected as part of this Discovery process, and will depend on the ability to gather currency and accuracy information for existing topographic data. Only topographic data that is of better quality than that of the original study or effective studies will be used. New topographic and bathymetric LiDAR, RGB Imagery, and Hyperspectral Imagery will be used for the coastal study areas and will replace the existing datasets.

2) Base Map Acquisition.
Base map data for all counties, including data collected during this Discovery process as an initial inventory, will be collected and organized. The necessary permission from the map sources will be obtained to allow FEMA to use and distribute hardcopy and digital map products using the digital base map. Base map data must comply with FEMA G&S (Federal Emergency Managment Agency, 2003).

3) Coastal Flood Hazard Analysis.
Response-based computational approaches outlined in FEMA G&S Appendix D.3 draft dated May 2012 will be used to perform coastal flood hazard analysis for the Lake Michigan shoreline and areas subject to coastal flooding. The coastal flood hazard analyses include the following components:
   - Wave setup
   - Erosion
   - Wave runup
   - Wave overtopping
   - Overland wave propagation
   - Primary frontal dune identification (where applicable).

A transect-based approach for assessing coastal flood risks along Lake Michigan will be used. The 1.5 foot breaking wave height will be selected from the Wave Height Analysis for Flood Insurance Studies (WHAFIS) results and used to define the Limit of Moderate Wave Action (LiMWA) as described in FEMA Procedural Memorandum No. 50 updated in 2012.

The coastal flood hazard results will be transferred to topographic work maps. Topographic data provided by the USACE in 2012 and early 2013 will be utilized. Coastal flood hazards will be mapped as outlined in FEMA's G&S Appendix D.3 draft dated May 2012 (Federal Emergency Management Agency, 2012). Flood hazard mapping will extend to the landward limit of coastal flooding as a result of waves and storm surge.

Draft coastal flood maps (or workmaps) will be produced for the study area. The workmaps will include the 1-percent- and 0.2-percent-annual chance Special Flood Hazard Area (SFHA), Coastal High Hazard (VE Zone) and Coastal A Zone (AE Zone), Base Flood Elevations (BFEs), and LiMWA. Communities will be provided with an opportunity to review the workmaps after the coastal analysis is complete and prior to FIRM production.

I.VIII.i.2 National Flood Insurance Program Data Integration:

Regulatory FIRM files may be updated through FEMA's Physical Map Revision (PMR) process using the floodplain delineations created from the work performed in the Engineering and Mapping tasks. For areas adjacent to updated coastal analysis, tie-ins will be resolved between coastal and riverine floodplains using the topographic data acquired.

Data collected as part of the coastal analysis will be put into FIRM database format and reviewed per FEMA's G&S Procedural Memorandum No. 42 for Quality Control Requirements in the FIRM Production Process.

The final production and distribution of updated FIRMs will be dependent on the results of the coastal analysis and discussions with the communities, as well as congressional funding. Therefore, it cannot yet be identified at this time the exact communities that will received updated FIRMs for adoption. The risk assessment products and their distribution, discussed below, are also dependent on the results of the coastal analysis and further community discussions and are subject to change.

I.VIII.i.3 Risk Assessment Product Development

Depending on available data, results of coastal analysis, local needs identified, local partnerships, and fiscal year funding, coastal flood risk products, such as Flood Risk Map, Flood Risk Report, Changes Since Last FIRM (CSLF),
Flood Depth and Analysis Grids, and Hazus-MH analyses, may be generated for identified coastal communities in Illinois, Indiana, Michigan and Wisconsin along the Lake Michigan shoreline. Optional Flood Risk Assessment products such as coastal wave height grids, erosion risk determination, and wave hazard severity area datasets have not yet been funded. Table 9 summarizes the products projected for coastal communities by county.

Table 9. Potential Flood Risk Products for Lake Michigan Communities

County	State	Risk Map and Flood Risk Report	Changes Since Last FIRM	Flood Depth and Analysis Grids	Optional Risk Assessment Products
Cook	IL	✓	✓	✓	TBD
Lake	IL	✓	N/A	✓	TBD
Lake	IN	✓	✓	✓	TBD
LaPorte	IN	✓	✓	✓	TBD
Porter	IN	✓	✓	✓	TBD
Allegan	MI	✓	N/A	✓	TBD
Antrim	MI	✓	N/A	✓	TBD
Benzie	MI	✓	N/A	✓	TBD
Berrien	MI	✓	✓	✓	TBD
Charlevoix	MI	✓	✓	✓	TBD
Delta	MI	✓	N/A	✓	TBD
Emmet	MI	✓	N/A	✓	TBD
Grand Traverse	MI	✓	✓	✓	TBD
Leelanau	MI	✓	✓	✓	TBD
Mackinac	MI	✓	N/A	✓	TBD
Manistee	MI	✓	N/A	✓	TBD
Mason	MI	✓	✓	✓	TBD
Menominee	MI	✓	✓	✓	TBD
Monroe	MI	N/A	✓	N/A	TBD
Muskegon	MI	✓	✓	✓	TBD
Oceana	MI	✓	✓	✓	TBD
Ottawa	MI	✓	✓	✓	TBD
Schoolcraft	MI	✓	N/A	✓	TBD
Van Buren	MI	✓	✓	✓	TBD
Brown	WI	✓	✓	✓	TBD
Door	WI	✓	✓	✓	TBD
Kenosha	WI	✓	✓	✓	TBD
Kewaunee	WI	✓	N/A	✓	TBD
Manitowoc	WI	✓	✓	✓	TBD
Marinette	WI	✓	N/A	✓	TBD
Milwaukee	WI	✓	✓	✓	TBD
Oconto	WI	✓	✓	✓	TBD
Ozaukee	WI	✓	✓	✓	TBD
Racine	WI	✓	✓	✓	TBD
Sheboygan	WI	✓	✓	✓	TBD

TBD = to be determined

Below is a brief description of each flood risk product and their uses:

Changes Since Last FIRM (CSLF)

The CSLFs serve the following purposes:

- Identify Areas and Types of Flood Zone Change:
  - Compares current effective (previous) with proposed (new) flood hazard mapping; and
  - Flood zone changes are categorized and quantified.
- Provide Study/Reach Level Rationale for Changes Including:
  - Methodology and assumptions; and
  - Changes of model inputs or parameters (also known as Contributing Engineering Factors).

Flood Depth and Analysis Grids

- Flood Depth and Analysis Grids will be created for the 1-percent frequency event of the engineering studies performed and as appropriate for the data. Wave runup areas may not be applicable. Flood-depth and analysis grids (DAGs) will include the 1-percent-annual-chance flood for coastal areas.

HAZUS 2010 1-percent Exposure

- The 2010 HAZUS national dataset for 1-percent exposure data will be used to tabulate the results by identified community.

For additional information regarding coastal flood risk products, users may review the individual Discover Reports found in Appendices C-P of this report, or visit http://www.fema.gov.

ii. Potential for Mitigation Assistance

As part of a Risk MAP project, Mitigation Planning Technical Assistance (MPTA) may be available to help communities plan for and reduce risks by providing communities with specialized assistance. MPTA includes risk assessment, mitigation planning, and traditional hazard identification (flood mapping) activities. Technical assistance through MTPA can be performed at any time during the hazard mitigation planning process.

Determining which communities receive MPTA is dependent on identification of a need, the willingness of a community to partner with FEMA, local resources and data availability, and federal funding availability. Unfortunately, not every community will be able to receive MPTA as part of a Risk MAP project. Forming a partnership between FEMA and a local community is an essential part of initiating a MPTA project. Assistance will be prioritized after all data and information is collected and assessed by FEMA in coordination with the local communities to determine where MPTA resources would be beneficial. Communities should alert FEMA of any resources that are available at the local

level, and of actions they are interested in implementing in partnership with FEMA. Technical assistance activities should be based on the needs of the community and assist with already established capabilities.

Some technical assistance activities could include (but are not limited to):

- Advising in the creation of initial hazard mitigation plans
- Advising in the update of existing hazard mitigation plans
- Training to improve a community's capabilities for reducing risk
- Assistance in incorporating flood risk datasets and products into potential and effective community legislation, guidance, regulations, procedures, etc.
- Assistance with the creation, acquisition, and incorporation of GIS data into potential and effective maps, planning mechanisms, emergency management procedures, etc.
- Facilitating the identification of data gaps and interpret technical data to identify risk reduction definiencies that should be corrected.

At the time this report was created, local stakeholders had provided information to FEMA related to potential mitigation actions via the Mitigation Action Form and through discussions held throughout this Discovery process. Table 6 listed earlier in this report, located in Section VII, "Hazard Mitigation Resources, Strategies, and Actions", summarized several potential mitigation actions and AoMIs that were identified through this Discovery process. This included hazard mitigation plan updates and structural projects to protect against flooding and erosion.

It is recommended additional discussion occur between FEMA and these stakeholders as this coastal flood study moves forward to see if MPTA would be an appropriate and beneficial option.

Continued discussion regarding FEMA partnership with local communities to assist in developing new mitigation actions and moving those actions forward will be essential as this coastal project moves forwards.

iii. Compliance Status

FEMA uses a number of tools to determine a community's compliance with the minimum regulations of the NFIP. Among them are Community Assisted Contacts (CACs), Community Assistance Visits (CAVs), the Letter of Map Change (LOMC) process, and Submit-for-Rates. These tools help assess a community's implementation of their flood damage reduction regulations and identify any floodplain management deficiencies and violations.

The CAC is a telephone call or brief visit by a FEMA staff member (or staff of a State agency on behalf of FEMA) verifying the community's floodplain management contact. The CAC can be used as a way to screen for potential floodplain management issues in communities that would require a CAV.

The CAV is a visit to a community by a FEMA staff member or staff of a state agency on behalf of FEMA that serves the dual purpose of providing technical assistance to the community and assuring that the community is adequately enforcing its floodplain management regulations. Potential violations may be identified during the CAV visit as a result of touring the floodplain, inspecting community permit files, and meeting with local appointed and elected officials.

Violations can also be discovered when Letter of Map Revision based on Fill (LOMR-F) applications depict a non-compliant structure based on elevation data; or can be found through Submit-for-Rate requests, which occur when a structure applies for flood insurance but has been identified as being two or more feet below BFE. Elevation comparisons identified through LOMR-F applications and Submit-for-Rates imply structures were not built compliantly.

If administrative problems or potential violations are identified, the community will be notified and given the opportunity to correct those administrative procedures and remedy the violations to the maximum extent possible within established deadlines. FEMA or the state will work with the community to help them bring their program into compliance with NFIP requirements. In extreme cases where the community does not take action to bring itself into compliance, FEMA may initiate an enforcement action against the community.

After coastal analysis is completed for this study, communities may be faced with adopting new regulations related to coastal high hazard areas. An understanding of regulations associated with coastal areas will be important so that communities remain compliant. During this Discovery process, stakeholders were provided with information regarding NFIP requirements that are associated with coastal hazard zones, as well as information about new FEMA guidance related to moderate wave action. These topics, including coastal Special Flood Hazard Areas (SFHAs), building requirements in VE Zones, and Limit of Moderate Wave Action (LiMWA), are compiled below and discussed in greater detail.

I.VIII.iii.1 Coastal Special Flood Hazard Areas (SFHAs)

The Lake Michigan Coastal Flood Hazard study analysis may result in new Special Flood Hazard Areas (SFHAs), which is defined as the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood. SFHAs labeled as Zone AE have been studied by detailed methods and show Base Flood Elevations (BFEs). SFHAs labeled as Zone VE are along coasts and are subject to additional hazards due to storm-induced velocity wave action. BFEs derived from detailed hydraulic analyses are shown within these zones.

The NFIP shows coastal flood hazards in two different zones on its FIRMs:

- Zone VE, where the delineated flood hazard includes wave heights equal to or greater than three feet; and

- Zone AE, where the delineated flood hazard includes wave heights less than three feet.

During the Discovery Meetings these zones were discussed in greater detail as the updated coastal analysis results may show that these flood risks exist along the Lake Michigan shoreline.

Additional information on coastal SFHAs can be found at http://www.greatlakescoast.org under the "Great Lakes Flood Zones Overview" section.

I.VIII.iii.2 Building Requirements in VE Zones

The zone designation and the BFE are critical factors in determining what requirements apply to a building and, as a result, how it is built. The NFIP minimum requirements for buildings built in Zone VE (coastal high hazard areas) are:

1) The building must be elevated on pile, post, pier, or column foundations,
2) The building must be adequately anchored to the foundation,
3) The building must have the bottom of the lowest horizontal structural member at or above the BFE,
4) The building design and method of construction must be certified by a design professional,
5) The area below the BFE must be free of obstructions,
6) If enclosed, the enclosure must be made of lightweight wood lattice, insect screening, or breakaway walls.

Communities participating in the NFIP, and that have mapped VE Zones, must adopt floodplain management regulations that meet or exceed these minimum NFIP requirements, as described above.

I.VIII.iii.3 Limit of Moderate Wave Action (LiMWA)

Post-storm field visits and laboratory tests have confirmed that wave heights as small as 1.5 feet can cause significant damage to structures when constructed without consideration to the coastal hazards. Additional flood hazards associated with coastal waves include floating debris, high velocity flow, erosion, and scour, which can cause damage to Zone AE-type construction in these coastal areas.

To help community officials and property owners recognize this increased potential for damage due to wave action in the AE zone, FEMA issued Procedure Memorandum No. 50 in December of 2008, which provides guidance on identifying and mapping the 1.5-foot wave height line, referred to as the Limit of Moderate Wave Action, or LiMWA. The LiMWA alerts property owners that although their property is in a Zone AE area, it may also be affected by waves 1.5 feet or higher. Consequently, it is important to be aware of the area between this inland limit and the Zone VE boundary as it still poses a high risk, though not as high of a risk as Zone VE. Figure 10 helps to explain the LiMWA zone location.

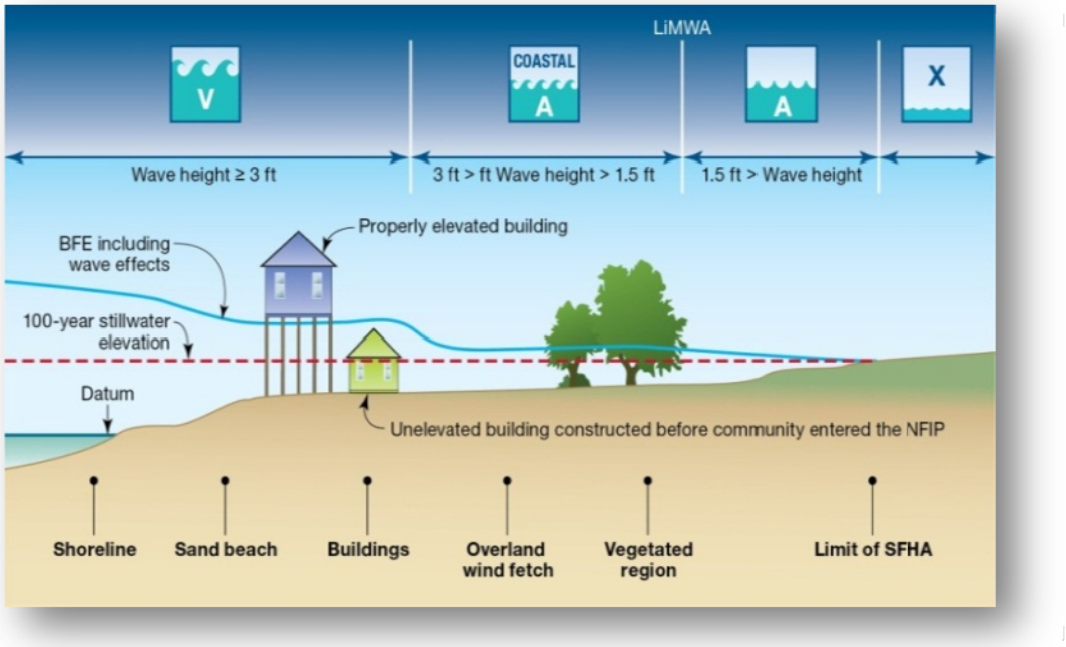


Figure 10. Limit of Moderate Wave Action

If areas that are subject to waves between 3-ft and 1.5-ft are identified, then FEMA will delineate the inland extent of the 1.5-ft wave as the LiMWA when producing new FIRMs. A new line layer will be added to the FIRM Database to accommodate the LiMWA features and will be depicted on updated FIRMs as two black dots and three white dash lines in a sequential pattern. The LiMWA will be identified in the FIRM legend as "Limit of Moderate Wave Action" and a note will be included in the "Notes to Users" section on the map panel to explain the LiMWA boundary.

Although not labeled as such on FIRMs, the areas between the LiMWA and the Zone V boundary (or shoreline) are also referred to as "Coastal A Zones". Current effective FIRMs may not show a LiMWA, however future maps may include the LiMWA boundary if the data supports it.

Figure 11 is an example FIRM showing the delineated LiMWA. The area in Map A shows the delineation of the LiMWA in an area where the predominant coastal flood hazard is overland wave propagation. Map B shows delineation of the LiMWA in a region where the major coastal flood hazard is wave breaking and run-up.

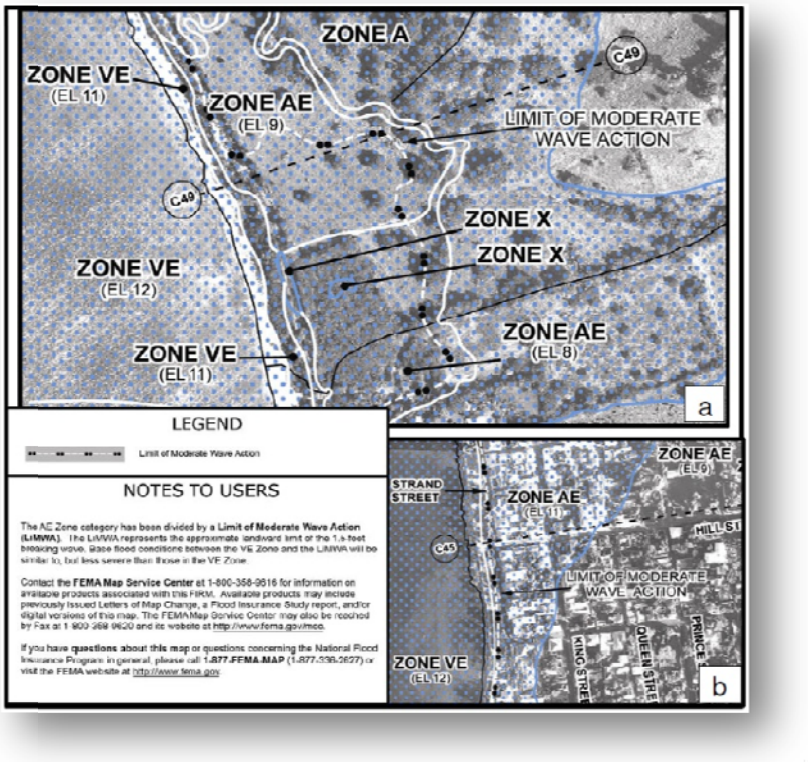


Figure 11. Example FIRM showing LiMWA

While FEMA does not impose floodplain management requirements based on the LiMWA, the LiMWA is provided to help communicate the higher risk that exists in that area. Because the 1.5-foot breaking wave in the LiMWA zone can potentially cause foundation failure, communities are encouraged to adopt building construction standards similar to Zone VE in those areas. For communities that do adopt Zone VE building standards in the area defined by the LiMWA, additional Community Rating System (CRS) credits are available. CRS credits can lower insurance premiums for residents and business owners. For additional information on CRS, please visit http://www.fema.gov/national-flood-insurance-program/community-rating-system.

Starting in 2009, flood-resistant provision and floodplain management requirements began to be incorporated into model building codes, such as the International Building Code (IBC), the International Residential Code (IRC), and the National Fire Protection Association (NFPA). If a local community has adopted a recent version of these codes, specifically the IBC, without amending the code to remove the flood provision then the community must enforce flood-resistant design and construction requirements based on the IBC, as well as the floodplain management ordinance that must be adopted to meet minimum requirements per the NFIP. It is important for local communities to note that some Coastal A Zone practices, specifically practices that go above the minimum NFIP requirements, may be required by the IBC through its reference to American Society of Civil Engineers (ASCE) Flood Resistant Design and Construction (24-98). In ASCE 24-

98 (issued in 2000), there are basic building requirements related to high risk flood areas and flood hazard areas subject to high velocity wave action. In addition, ASCE has issued an update in 2006, Flood Resistant Design and Construction (24-05), which includes basic requirements for flood hazard areas including high-risk flood hazard areas, coastal high-risk hazard areas, and Coastal A Zones.

Mapping the LiMWA, or Coastal A Zone, will provide community officials and other stakeholders with additional important flood risk details to consider when buying/developing, mitigating, or enforcing floodplain management regulations in the coastal flood hazard areas.

Residents and business owners living or working in the LiMWA, or Coastal Zone A, should be aware of the potential wave action along with floating debris, erosion, and scour that could cause significant damage on their property. They are encouraged to build safer and higher than minimum local requirements to reduce the risk to life and property. Additional guidance for design and construction in Coastal A Zones can be found in FEMA 499, Home Builder's Guide to Coastal Construction (http://www.fema.gov/fima/mat/fema499.shtm).

While the risk of damage is higher between the LiMWA line and the Zone VE line than other parts of the coastal AE zone, the NFIP flood insurance rates currently do not differ from other AE zone rates. The Federal mandatory purchase requirement does apply in these zones and property owners are encouraged to carry coverage equivalent to the replacement cost of their building and to include contents coverage.

For additional background information on LiMWA, please refer to FEMA Procedure Memorandum No. 50 at www.fema.gov/library/viewRecord.do?id=3481.

iv. Communication

Throughout this Discovery process, community representatives and local stakeholders indicated the need to be kept informed about the results of Discovery, the upcoming coastal flood study, and opportunities for public input throughout the study process. As a result of communication to date, several new stakeholders have been identified and added to the master contact database for this study.

Throughout this study process, Federal, State, and local stakeholders will be kept informed via email, phone calls, letters, newsletters, and meetings as appropriate. A dedicated email account was created (GreatLakesFloodStudy@STARR-Team.com) to distribute project information, meeting reminders, and summaries.

Stakeholder involvement will continue to be important through the remainder of the project. The GLCFS website http://www.greatlakescoast.org is an excellent resource where stakeholders can obtain the most update-to-date information about the status of the

Great Lakes flood study projects, data collection, upcoming meetings, new technical reports, the latest methodologies, factsheets, and additional information.

Social media sites such as Twitter (http://www.twitter.com/GreatLakesCoast) and Facebook (http://www.facebook.com/pages/Great-Lakes-Coastal-Flood-Mapping-Program/225293657496579) will also be important communication tools to keep stakeholders informed and engaged throughout this process.

FEMA encourages stakeholders to remain involved throughout the study process and will seek to identify partnership opportunities during the study process.

v. Unmet Needs

During this Discovery process, stakeholders provided FEMA with a wide variety of information. Some of the information, while valuable, may not be able to be utilized in the upcoming coastal study. In addition, some questions may be unresolved as of the end of this Discovery process. This section seeks to summarize those unmet needs and to provide the steps that may be taken to address them in the future.

During the Discovery Meetings and throughout the Discovery process, Lake Michigan stakeholders were concerned about what to expect in terms of extent of new SFHA boundaries, the possible introduction of VE Zones, the number of property owners who would be affected, and the additional NFIP requirements and flood insurance costs that may go along with a flood map revision. FEMA acknowledged this concern, adding that upcoming engineering and mapping tasks include the distribution of workmaps and other flood risk products designed to give local stakeholders an opportunity to review and comment on flood risk data before the data is carried into NFIP FIRM maps.

Comments and questions related to the proposed transects were provided throughout this Discovery process by State and local representatives. Over 100 comments were reviewed and incorporated where possible and appropriate. Despite a reduction in total number of draft transects located along the Lake Michigan shoreline that was part of this Discovery process, stakeholders requested further reduction, specifically along shorelines with high bluff. FEMA intends to review these areas and initiate additional discussions with stakeholders as the coastal analysis proceeds. Therefore, the transects proposed in this report remain subject to change. Stakeholders will be made aware of revised transect locations via the future workmaps that will be provided to local communities for review as the study moves forward.

For specific local unmet needs, users should refer to the unmet needs section within the individual Discovery Reports found in Appendices C-P of this report.

IX. Close

Federal, State, and local stakeholders that were involved in this Discovery process contributed valuable information about Lake Michigan, including information and data that may be utilized in the upcoming Lake Michigan coastal flood study. The data and opportunities presented in this report will be considered as the study process moves forward and will assist the project team as the Lake Michigan coastal flood study proceeds. FEMA encourages continued participation and engagement from stakeholders throughout this coastal flood study.

The ultimate goal of this Discovery process and the future coastal flood study is to provide updated flood risk information to local stakeholders and to increase awareness of those flood risks, which in turn leads to actions that reduce risk.

X. References

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XI. Appendices

Discovery data and information, as well as this report and appendices, have been stored digitally on FEMA's Mapping Information Platform (MIP) Discovery Data Repository at J:\FEMA\DISCOVERY_DATA_REPOSITORY\R05_DATA\ and can be accessed by FEMA authorized users. The MIP can be accessed from https://hazards.fema.gov/. A username and password is required to access certain data within the MIP.

The final Discovery Report and appendices are also available for download from http://www.greatlakescoast.org/.

Appendices in this report include:

Appendix A: Lake Michigan Stakeholder List
Appendix B: Coastal Data Request Form
Appendix C: Mackinac County, Michigan Discovery Report
Appendix D: Delta, Schoolcraft, and Menominee County, Michigan Discovery Report
Appendix E: Marinette and Oconto County, Wisconsin Discovery Report
Appendix F: Kewaunee, Door, and Brown County, Wisconsin Discovery Report
Appendix G: Sheboygan, Manitowoc, and Ozaukee County, Wisconsin Discovery Report
Appendix H: Milwaukee, Racine, and Kenosha County, Wisconsin Discovery Report
Appendix I: Cook and Lake County, Illinois Discovery Report
Appendix J: LaPorte, Lake, and Porter County, Indiana Discovery Report
Appendix K: Berrien and Vanburen County, Michigan Discovery Report
Appendix L: Allegan and Ottawa County, Michigan Discovery Report
Appendix M: Muskegon and Oceana County, Michigan Discovery Report
Appendix N: Manistee and Mason County, Michigan Discovery Report
Appendix O: Benzie, Grand Traverse, and Leelanau County, Michigan Discovery Report
Appendix P: Antrim, Charlevoix, and Emmet County, Michigan Discovery Report
Appendix Q: Coastal Data Request Form Compilation: Local Data from Stakeholders
Appendix R: Final Discovery Maps
Appendix S: Lake Michigan Stakeholder Comments (General and Transect)
Appendix T: USACE Enterprise Coastal Inventory Database, Lake Michigan Basin
Appendix U: Critical Dune Areas and High-Risk Erosion Figures (MDEQ)
Appendix V: Status of Hazard Mitigation Plans
Appendix W: Mitigation Action Form