FINAL REPORT

Great Lakes Water Levels Integrated Assessment
Graham Sustainability Institute, University of Michigan

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Implementing Adaptation: Developing Land Use Regulations and Infrastructure Policies to Implement Great Lakes Shoreland Area Management Plans

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Executive Summary

Beyond a few general studies on shoreland area management in Great Lakes settings, little research has been conducted to evaluate the acceptance, adoption, and usefulness of various management options in context through actual attempts at implementation. Our initial research on Great Lakes shoreland area management offered a first-impression systematic, applied, interdisciplinary, and integrated assessment of shoreland area management efforts and outcomes in a Great Lakes setting, specifically in the context of preparing community master plans. Through the Integrated Assessment (IA), we hope to extend this work into plan implementation through the design, vetting, and adoption of regulation and policy, providing a vital assessment of the true applicability and viability of policies proposed through local shoreland-area master planning.

We have collaborated with the Lake Michigan communities of Grand Haven, St. Joseph, and Ludington to develop technical analysis and planning methods to incorporate these kinds of assessments into local planning efforts. In addition, we simultaneously evaluated the usefulness of those methods in application. This work addresses specifically the topics of Great Lakes shoreline dynamics (focusing on dynamics related to lake level variation), near-shore environmental analysis, near-shore land use and critical facilities analysis, fiscal impact analysis, and methods for visualizing shoreline dynamics. We have laid the foundation to undertake further collaboration through the IA with Grand Haven (City and Township), Traverse City, and St. Joseph to help implement our findings through the development of zoning ordinances and potentially other implementation policies.

The issues we address are typical throughout the Great Lakes. Most of the potential social and economic impacts include potential damage to and loss of built structures, including especially private residencies, private commercial establishments, public infrastructure (roads, water, and sewer), public buildings, and public parks and beaches. Most of these issues revolve around the identification and recommended adoption of potential policies in response to lake level variation, described in more detail below. All of these potential regulatory and policy measures raise difficult issues of political feasibility and the potential for litigation from shoreline property owners, environmental interest groups, or both.

We can report several key findings from the planning grant stage of the IA. Basic avoidance through setbacks from flood zones and natural features (primarily wetlands) appears to have the potential to substantially reduce risks to developed properties. We have determined, however, that FEMA-generated analysis and data will likely not provide adequate support to justify traditional zoning methods (e.g., fixed set-backs), necessitating the development of innovative methods and approaches to regulation—something we hope to do through IA. In addition, there appears to be substantial potential for significant additional buildout in critical dune areas, creating a potential conflict between local and state regulation of dunes, something we hope again to untangle through the IA. Finally, we need to address more thoroughly the management of wetlands through zoning and complementary approaches in high-value areas such as along bay shores, a topic we hope to explore more thoroughly through collaboration with Traverse City.

Introduction

The Great Lakes extend some 750 miles from east to west, touch some 4,500 linear miles of U.S. shoreline, and cover a combined surface area roughly the size of the United Kingdom (EPA 2014; GLERL 2014; MDEQ 2014). As with ocean coasts, the Great Lakes are large enough to generate substantial hazards to shorelands both from ongoing erosional processes and from periodic storm events.

Great Lakes coasts are different from ocean coasts, however, in several key respects physically and institutionally. Most prominently, they are geologically young features subject to background erosion rates of about 1 to 2 feet per year throughout much of the basin, while simultaneously subject to fluctuations in standing lake water levels on the order of 1 or 2 meters over the course of decades (Norton and Meadows 2014). Because of lake level fluctuations, Great Lakes shorelines can appear to be retreating lakeward (accreting) for extended periods while lake levels are low, only to move substantially inland as water levels again rise—sometimes from a single storm event. It is not clear how climate change will affect the Great Lakes overall, but it will likely increase the frequency and intensity of storms (Gronewold et al. 2013).

Institutionally, the Great Lakes are also unique because most of the states bordering them—including Michigan—are Northwest Territory states with civil townships (i.e., representing an added layer of local government in addition to counties and municipalities), yielding highly fragmented local governance of Great Lakes shorelands (Norton and Meadows 2014). All of the Great Lakes states have also applied the Public Trust Doctrine to their Great Lakes shorelands, yielding state-local legal and policy institutional arrangements that are highly diverse and complex (Norton et al., 2011, 2013).

The International Joint Commission (IJC) released several reports in the early 1990s, such as the Land Use and Management Report of the Great Lakes-St. Lawrence River Basin Levels Reference Study (IJC 1993), which collectively began to document the effects of Great Lakes lake-level variation on shoreline dynamics, the impacts those dynamics to natural and built resources, and the conflicts and challenges those impacts were yielding with regard to shoreland area management. Other agencies and authors since have issued similar reports, guidebooks, and "toolkits" designed to provide arrays of different kinds of shoreland area management options, along with generalized discussions of their applicability, strengths, and weaknesses (e.g., USACE and GLC 1999; Ardizone and Wyckoff 2010). Nonetheless, beyond these more generalized studies, little research has been conducted to systematically evaluate the acceptance, adoption, and usefulness of those various options in context through actual attempts at implementation.

Our ongoing research leverages work that is currently being conducted under the direction of the co-investigators with support from the UM Water Center, the MI Coastal Zone Management Program, and several foundations. The purpose of this work, conducted in collaboration with the non-profit planning firm LIAA, is to develop technical methods and planning techniques designed to improve efforts by Great Lakes coastal localities in

Michigan to analyze and incorporate information regarding Great Lakes shoreline dynamics into their local master plans and shoreland area management plans. This work is especially timely in light of a Great Lakes shoreline hazard study currently being conducted by the U.S. Federal Emergency Management Agency (FEMA), which will require technical insight and methodological guidance to fully leverage. In addition to LIAA, this larger project involves the participation of researchers from UM's Taubman College and School of Natural Resources and Environment, and Michigan Technological University.

The work we are currently conducting on Great Lakes shoreland area management, and that we look to extend through this Integrated Assessment (IA), offers a first-impression systematic, applied, interdisciplinary, and integrated assessment of shoreland area management efforts and outcomes in a Great Lakes setting. Extending that work beyond the master planning stage into the plan implementation stage through the design, vetting, and adoption of regulation and policy provides a vital assessment of the true applicability and viability of policies proposed through local shoreland-area master planning, highlighting in particular the political and legal issues inherent in shoreland area management—issues addressed only to a relatively limited extent through the master planning efforts we are engaging.

Nonetheless, such issues typically do not come to the fore until specific, legally significant regulations and policies are actually proposed. The benefit of this IA as a follow-on to our current work is that it will allow us to explore more thoroughly and systematically plan implementation efforts through the process of actually developing and presenting them in context, work that will be vital for promoting successful adaptation by Great Lakes coastal localities to lake water level variation given global climate change and ever-growing demand for shoreline development.

Collaborating actively with the Lake Michigan communities of Ludington, Grand Haven, and St. Joseph, we have been working to develop technical analysis and planning methods to incorporate these kinds of assessments into local planning efforts. We are simultaneously evaluating the usefulness of those methods in application through the plan development process. We are currently working with additional study localities in Macomb County, as well as Selfridge National Air Guard Station. Our work with these communities will fold newly developed methodologies directly into their planning efforts and thus further test those methods in application. For all of these analyses, we are developing scenario-based planning approaches to account for uncertainty in future climate conditions and to evaluate the advantages and disadvantages of potential arrays of local shoreland area management options. Key products from this work will include the methodologies developed through the project work, along with training materials that we are currently developing in collaboration with the Michigan Association of Planning for delivery to coastal localities around the state.

The focus of our work has been on developing shoreland area plan-making methodologies and plans for use by coastal localities around the Great Lakes. However, we did not propose through earlier grants to develop methods for actually implementing local master plans or shoreland area management plans once those plans are adopted. These kinds of plans are typically implemented through the adoption of local land use regulations, such as zoning codes, and infrastructure policies, such urban service boundaries for the provision of water and sewer infrastructure. Both of those implementation mechanisms typically involve substantial additional analysis and investment beyond the adoption of the master plan. The work through this IA continues our collaboration with LIAA and existing study localities to assess the issues and outcomes related to the development and adoption of regulations and policies that will be needed to actually implement local master and shoreland area management plans.

Because of the focus of our ongoing work and the settings encompassed by our study sites to date, the impact areas and topics we have been addressing—and that we will continue to address through this IA—revolve around natural system dynamics of both the lake shoreline and near-shore coastal riverine system, given combinations of longer-term lake-level fluctuations and near-term storm events. That effort translates to identifying potential zones of impact with regard to high-velocity wave action, storm-induced sheet flow, and inundation under varying lake levels and uncertain future climate conditions, and then overlaying those zones on natural and built features to determine the potential for significant impacts.

Outcomes of the Planning Grant

Focus Area

We have secured commitments from the City of Grand Haven and Grand Haven Township to continue the work we are currently completing with them on master plan updates, undertaking zoning code updates that would implement their plans. We have tentatively secured a commitment from the City of St. Joseph to similarly assist them with updates to their zoning code as well.

We have also secured a commitment from Traverse City to work with them on a zoning code amendment and/or infrastructure policy development that would address wetland resources within their jurisdiction given fluctuating lake water levels.

Contributors

We expect to continue with our current team, with LIAA and UM researchers conducting most of the project work and Guy Meadows, MTU, providing advisory counsel and support. Local partners will include public officials and citizen groups in our final study communities.

Activities/Process

There are a number of regulatory and non-regulatory options that are commonly put forward for managing ocean and Great Lakes coastal shorelands. These include, for example: avoidance measures (e.g., regulatory setbacks for new development, regulatory "retreat" requirements for structures, hazard area service boundaries); adaption measures (e.g., heightened building standards for new construction, "hard" and "soft" shoreline stabilization structures); and "retrofit" measures (e.g., restoration of structures following damage to elevation and other enhanced building standards, acquisition of hazard-prone properties, no-rebuild rules and policies).

All of these and similar policies may be put forward by a locality in its master plan as a first step in improving shoreland area management. The difficulty in implementing the plan subsequently is twofold. The first challenge is in applying an abstract policy prescribed in a general plan to a particular place, ensuring that it can in fact be applied and that it will likely yield the desired outcome. The second challenge is confronting the political and legal controversy that often arises when a community moves to apply a more abstract plan policy to a concrete, on-the-ground regulation or policy action. A focus of our work for this IA will be to study systematically and contextually in what ways and how well this translation works in practice, again working collaboratively with our partners and community stakeholders. Two particular questions we hope to address are, first, how well the master plan serves both to inform and to justify the regulatory and non-regulatory policies actually adopted, and second how effective those policies will likely be in actually promoting effective shoreland area management.

We have recruited local partners through communications with them (primarily Grand Haven and St. Joseph) as part of our ongoing work and by contacting local officials with Traverse City with whom we have established relationships.

The work we are currently conducting, which is similar to the IA, is premised on using available "tools" and data for local planning purposes rather than having to undertake original data collection efforts. Given that approach, we have been exploring extensively the availability, applicability, and usability of a number of data sources, including especially current "effective" flood insurance rate maps (FIRMs) produced by the U.S. Federal Emergency Management Agency (FEMA); updated data and maps currently being produced by FEMA as part of a multi-year Great Lakes wave run-up study; and hazard mitigation data and costing tools developed by FEMA for evaluating potential hazard recovery costs and hazard mitigation policies (the HAZUS program and corresponding data).

In addition, we have been exploring the availability of, and collecting data and information currently available from, the U.S. Census Bureau, the U.S. Army Corp of Engineers (e.g., shoreline aerial images), the MDEQ, and local coastal localities. Local data and information include, for example, current master plans, zoning codes, and infrastructure policies; parcel maps; county hazard mitigation plans; and various other local plans, studies, and data. We anticipate employing these same data for use in the IA, as well as identifying and collecting additional data that might be required to fully assess, for example, the actual adoption of hazard area setbacks through zoning codes.

Finally, in addition to collecting these kinds of site-specific data, we anticipate conducting as part of this planning grant additional literature review research on regulatory and policy approaches to implementing plans specifically in coastal settings, as well as research on model ordinances or other materials that have already been developed and that may be applicable for our efforts.

Key Findings
We can report several key findings from our ongoing work to date, including work conducted as part of the planning grant stage of the IA, which will help inform how best to proceed with an IA in collaboration with our partner communities to help them implement planning policies that enhance their coastal resiliency.

First, through various buildout assessments, it appears that implementing basic Best Management Practices (BMPs) does indeed offer the potential to substantially reduce development in high risk flooding areas, which in turn will reduce future potential damage (see Figure 1 below). The BMPs we tested were spatial avoidance measures, including specifically buffers of 50 feet around inland water and wetland features, as well as the exclusion of potential future development in wetlands down to 5 acres in size. Comparing the results of buildout assessments—setting full build-out allowable under current communities zoning ordinances against regulations that would incorporate avoidance BMPs—we found that in each of the communities evaluated the use of the avoidance BMPs reduced both potential future development in high risk flooding areas substantially.

This analysis was conducted at a relatively low level of resolution, however, suitable for plan policy development but likely not for regulatory development. That observation is compounded by our second key finding, which is that the data and analyses currently available from FEMA for identifying near-shore high-risk areas do not appear to be sufficiently rigorous or reliable for use in developing and applying conventional zoning code regulations (i.e., fixed setback or overlay zones), particularly in near-shore areas. One of the key efforts we hope to continue developing with support of the IA, collaborating with our community partners, is to continue fine-tuning the methods we have been developing to identify high-risk zones in the absence of other good data from FEMA (see Figure 2), in conjunction with the development of innovative approaches to zoning regulation (e.g., performance or contingency base standards) for addressing development or redevelopment in near-shore, high-risk areas.

Third, while the use of basic avoidance BMPs offers some potential to reduce risk to built properties, the avoidance BMPs we have modeled in our research to date do not appear to be sufficient to protect all sensitive environmental areas. In particular, the BMPs we tested did not fully address resource protection within Critical Dunes Areas (CDAs) because, under current state law, local zoning regulations within CDAs cannot be more stringent than requirements imposed statutorily by the State of Michigan. Given that limitation, our build-out assessments suggest the potential for significant additional development within CDAs, especially within the Grand Haven area (see Figures 3A and 3B). Nonetheless, we have not yet been able to untangle the relationships between the local Grand Haven codes and the state statutory regulations—something no one else appears to have done, and that we hope to do through the IA.

Finally, because of the physical settings of the localities with which we have been working, we have not had the opportunity to explore fully the potential to reduce impacts to significant near-shore wetlands, such as might be found within more sheltered bays. We hope to explore the potential for implementing plan-level policies that call for the adoption of such protections by collaborating with Traverse City to explore the potential for developing and adopting zoning-code amendments speaking to wetland protection along the shores of Grand Traverse Bay.

Potential for Transferability

All of the issues we are addressing are typical throughout the Great Lakes. Given the settings under study, most of the environmental issues relate to beach erosion, ranging from shifts in sloping beaches to the undercutting of steep bluffs; potential impacts to state-designated critical dunes; and some potential for impacts to coastal wetlands and other natural habitats, although most of the wetlands in our study jurisdictions are located along inland riverine systems rather than immediately adjacent to lake shorelines, as noted. The addition of communities along Lake St. Clair will likely expand the environmental features we are able to address, including especially wetlands and other shoreline habitat.

Most of the potential social and economic impacts include potential damage to and loss of built structures, including especially private residencies, private commercial establishments, public infrastructure (roads, water, and sewer), public buildings, and public parks and beaches. Our initial analyses suggest that while the total numbers of such properties located within near-shore coastal zones—however defined—are relatively small compared to the entire jurisdiction, the cultural and economic values of those properties are disproportionately large. Similarly, it is not unusual for critical facilities (e.g., public facilities like hospitals) to be located in harm's way, sometimes unavoidably when those facilities are water dependent (e.g., water intake and wastewater treatment plants).

Given the nature of these potential physical impacts, we are and will continue to grapple with a number of compelling political and legal issues. Most of these issues will revolve around the identification and recommended adoption of potential policies in response to lake level variation, described in more detail below. All of these potential regulatory and policy measures raise difficult issues of political feasibility and the potential for litigation from shoreline property owners, environmental interest groups, or both.

Feasibility

The feasibility of extending this work through an additional IA is quite high because of our established relationships and background work, including especially our understanding of data availability and data limitations for future analysis, our knowledge of local institutional and physical conditions, and the work we have conducted to date in rigorously identifying different near-shore high-risk zones under various climate future/management options scenarios (see, e.g., Figure 4).

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Figures

FIGURE 1: Acreas and buildings potentially affected by flooding in the City of Grand Haven and Grand Have Township under various "climate futures" ("lucky," "expected," and "perfect storm") and various development management options ("current," "build-out" under current zoning, and buildout incorporating best management practices or "BMPs")

Acres Impacted:

	Lucky	Expected	Perfect Storm
City of Grand Haven	682 total – 346 water = 336 Land	911 total – 346 water = 565 Land	953 total – 347 water = 606 Land
Grand Haven Township	1,722 total – 527 water = 1,195 Land	1,908 total – 527 water = 1,381 Land	1,946 total – 528 water = 1,418 Land

Structures Impacted:

City of Grand Haven	Current	Build-Out	BMPs
Lucky	78	+150	+2
Expected	239	+202	+48
Perfect Storm	256	+241	+49

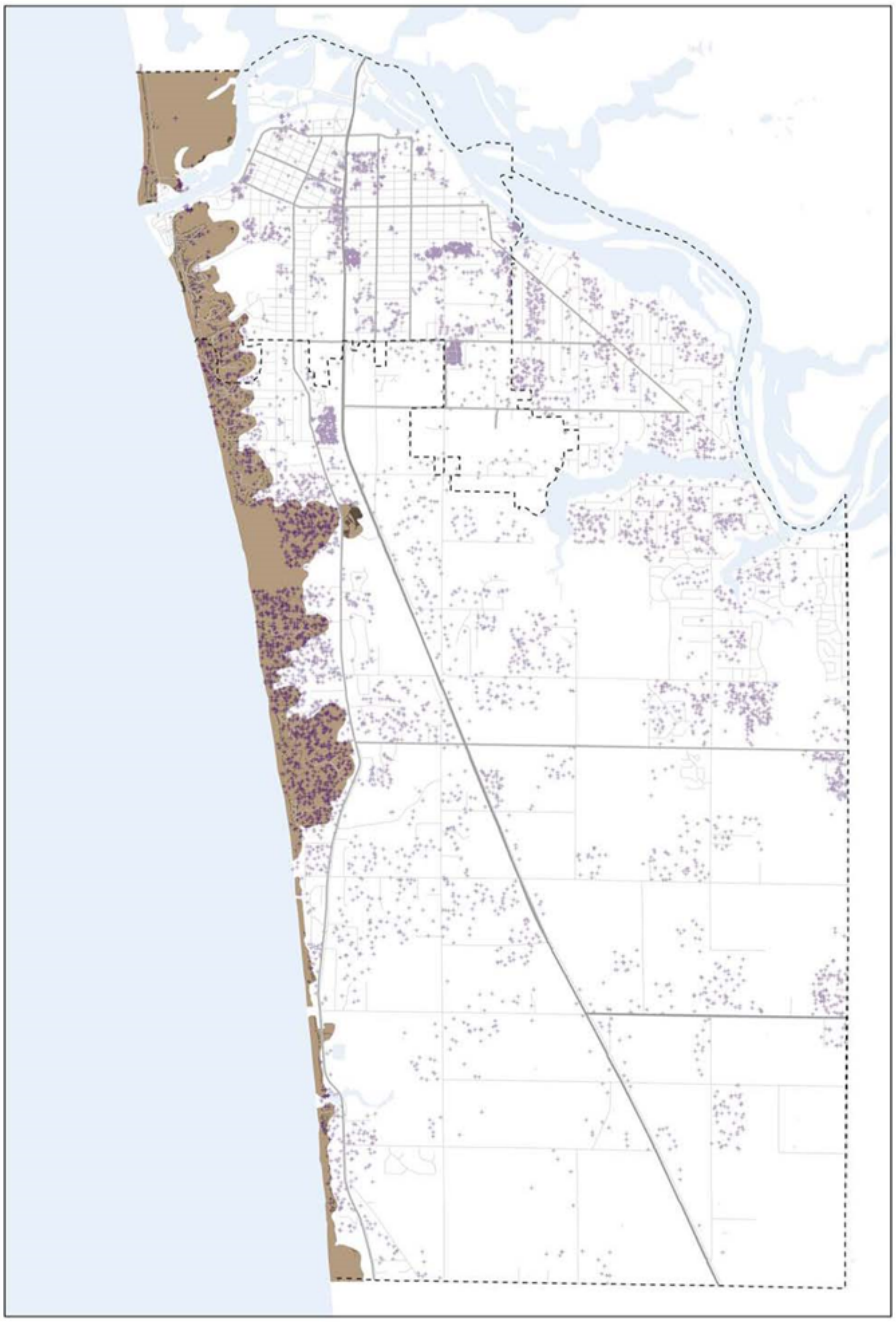
Grand Haven Township	Current	Build-Out	BMPs
Lucky	46	+163	+6
Expected	96	+251	+49
Perfect Storm	119	+266	+52

FIGURE 2: Alternative methods for identifying high-risk zones given variations in the availability of key data by source (e.g., FEMA flood maps, wave run-up study maps, digital elevation models, and depth grids).

	Minimum Input (Existing FEMA FIRMs + USGS DEM)	Wave Run-up Study (VE, AO, & Additional AE Zones)	HAZUS Level 2 (DEM + Depth Grids used to supplement analysis)	Full Input (all components available)
Lucky	Wave = None Flood =FIRM (BFE – A & AE Zones)	Wave = None Flood = FIRM (BFE)	Wave = None Flood = 2% Storm + Low still water elevation	Wave = None Flood = 2% Storm + Low still water elevation
Expected	Wave= OHWM & DEM for Pseudo VE Flood = FIRM (BFE – A & AE Zones)	Wave = Mapped VE Flood = FIRM (BFE – A, AO, & AE Zones)	Wave = None (OHWM inundation on coast) Flood = 1% Storm + Avg. still water elevation	Wave = Mapped VE Flood = 1% Storm + Avg. still water elevation
Perfect Storm	Wave = HHWM & DEM for Pseudo VE Flood = FIRM (BFE – A & AE Zones + 0.2% (shaded X) Zones)	Wave = Mapped VE Flood = FIRM (BFE – A, AE, & AO Zones + 0.2% (shaded X) Zones)	Wave = None (HHWM inundation on coast) Flood = 0.2% Storm + High still water elevation	Wave = Mapped VE Flood = 0.2% Storm + High still water elevation

FIGURES 3A and 3B (labeled Figs 16 and 17): Buildout assessments in Grand Haven City and Township showing potential development within critical dune areas without and with the use of BMPs.

Figure 16 Critical Dunes and the Final Build-outs:



Critical Dunes
Final Build-outs
Final Build-outs in Critical Dunes
1:42,000
0 0.55 1.1 1.65 2.2 Miles

Figure 17 Critical Dunes and the BMP Build-outs:

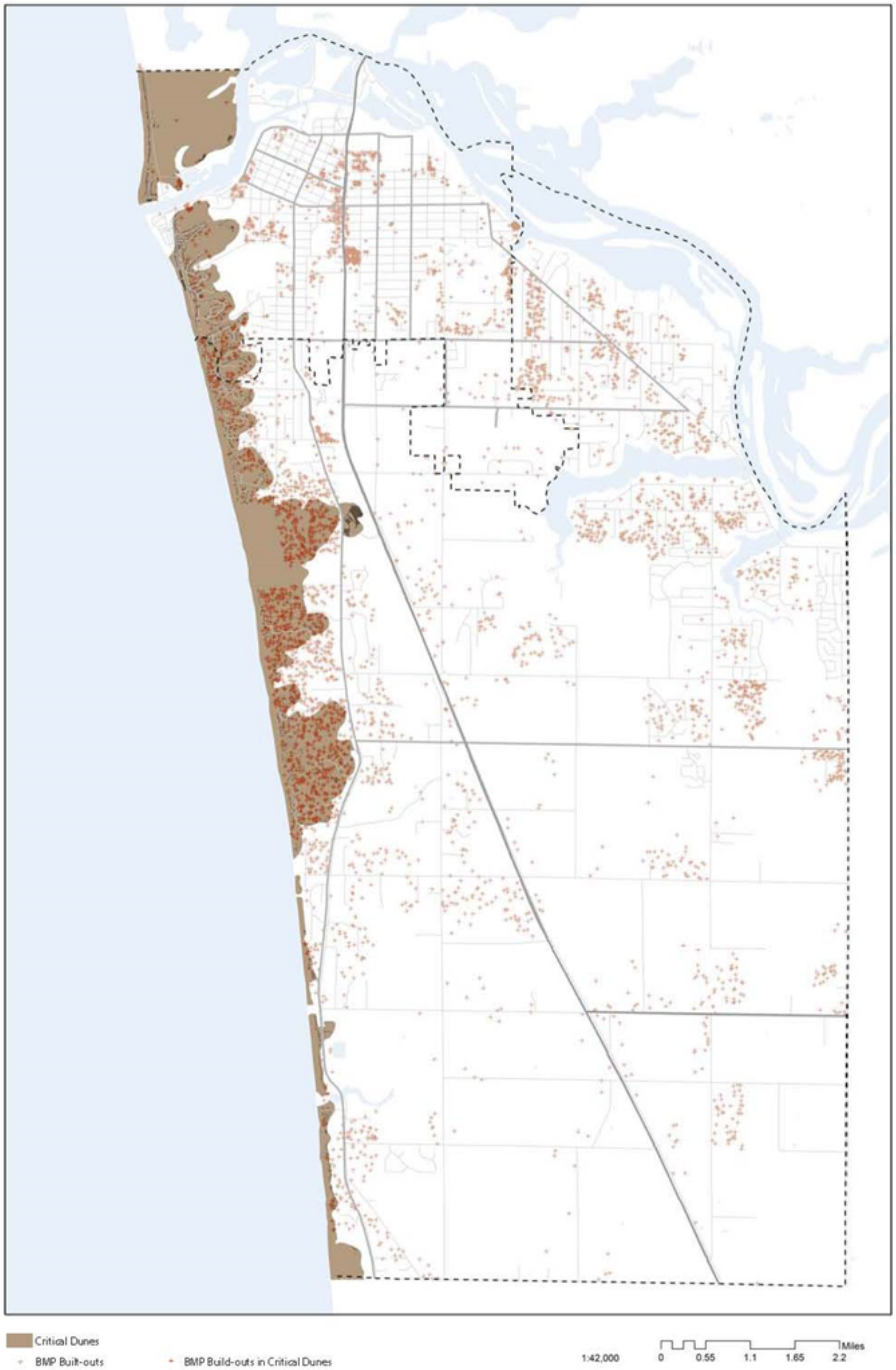


FIGURE 4: High risk flood zones in Grand Haven City and Township