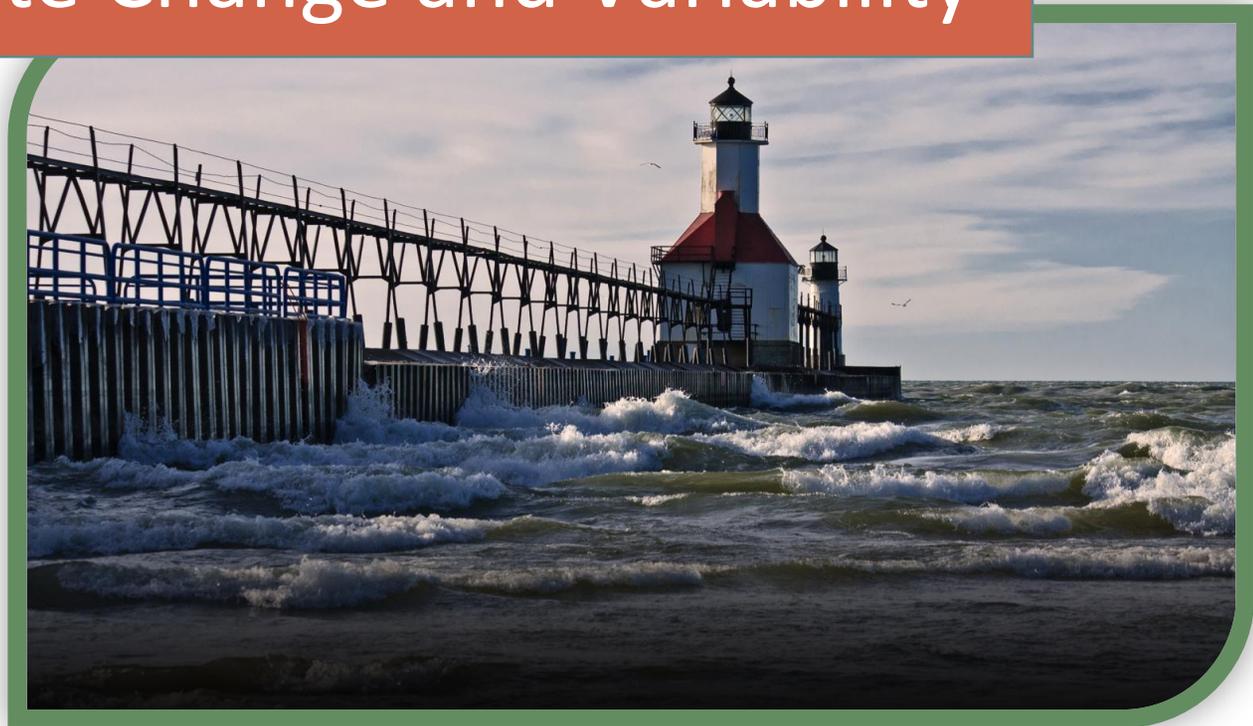


# Adapting to Climate Change and Variability

A Report for the  
Twin Cities Area  
Transportation Study

September 2013



## Acknowledgments

Funding for this project was provided by the Great Lakes Integrated Sciences and Assessments Center (GLISA) located at the University of Michigan. The Michigan State University Extension Project Team would like to acknowledge the assistance of the local partners from the Southwest Michigan Planning Commission (SWMPC): Kimberly Gallagher, Senior Planner; Gautam Mani, Associate Planner; Jill Plescher, GIS Specialist; and Kris Martin, Program Assistant, for arranging meeting facilities, providing mailings, technical assistance, and data throughout the project.

Climate change data and analysis was provided by Daniel Brown, GLISA Research Associate. In addition, the Michigan State University Department of Geography developed the GIS maps in the report. An audit tool designed by Minnesota Sea Grant specifically for communities in the Great Lakes Region was used in the report.

The Michigan State University Project Team was composed of Claire Layman, M.S. (Co-Principal Investigator, Public Policy Specialist, MSU Extension); Wayne Beyea, J.D., AICP (Co-Principal Investigator, Specialist, School of Planning Design and Construction); Julie Doll, Ph. D. (Education and Outreach Coordinator, Long-term Ecological Research Project, Kellogg Biological Station); Brad Neumann, AICP (Government and Public Policy Educator, MSU Extension, Negaunee, MI); Mark Skidmore, Ph. D. (Morris Chair in State and Local Government Finance and Policy, Department of Agricultural Economics); Dean Solomon, M.S. (Senior Extension Educator, Charlevoix

County); and MSU Research Assistants Ben Fraser, Jacob Maurer, Troy Anderson, and Cal Coplai (School of Planning, Design, and Construction). The Michigan State University Project Team would like to recognize the citizens of Southwest Michigan for their thorough participation and support during community input meetings which resulted in valuable information used in this report. Without citizen input this process would not be possible.



Lake Michigan Ice Coverage-March  
2013 Photo: NASA

Cover Photo courtesy of Daniel Brown



# Contents

<b>Introduction .....</b>	<b>1</b>	<b>Recommendations .....</b>	<b>6</b>
<i>Purpose .....</i>	<i>1</i>	Meeting Two Overview.....	6
<i>Process .....</i>	<i>1</i>	Identified Agriculture and Food Concerns.....	7
<i>Methodology.....</i>	<i>2</i>	Identified Land Use Concerns .....	8
<b>Issue Identification .....</b>	<b>3</b>	Identified Water and Public Health Concerns.....	10
Meeting One Overview.....	3	Identified Tourism and Economic Concerns .....	12
Climate Data Summary .....	4	<b>Implementation .....</b>	<b>14</b>
<i>Lake Levels.....</i>	<i>4</i>	Priority Actions .....	14
<i>Precipitation .....</i>	<i>4</i>	Relationship to Existing Plans .....	15
<i>Lake Temperature and Stratification.....</i>	<i>5</i>	<i>TwinCATS Long Range Transportation Plan .....</i>	<i>15</i>
<i>Ice Coverage .....</i>	<i>5</i>	<i>Related Documents .....</i>	<i>16</i>
<i>Snow Depth .....</i>	<i>5</i>	Audit Summary .....	18
<i>Temperature.....</i>	<i>5</i>	<i>Audit Tool .....</i>	<i>18</i>
		Stakeholder Interviews.....	19
		<b>Appendices .....</b>	<b>20</b>
		Appendix A: Maps – <i>Twin Cities Area Transportation Study (TwinCATS)</i> .....	20
		Appendix B: Citations.....	29

## List of Figures

Figure 1: Yale Center on Climate Communication, 2013: .....	2
Figure 2: Average Precipitation Rate, GLISA .....	4
Figure 3: Average Snow Depth, GLISA.....	5
Figure 4: Average Temperature, GLISA .....	5
Figure 5: Votes for Identified Areas of Concern .....	14
Figure 6: TwinCATS: Flood Risk Map .....	15
Figure 7: TwinCATS: Fire Susceptibility Map .....	17

## List of Tables

Table 1: Agriculture/Food Concerns, Best Practices, and Transportation Considerations .....	7
Table 2: Land Use Concerns, Best Practices, and Transportation Considerations .....	8
Table 3: Water and Public Health Concerns, Best Practices, and Transportation Considerations.....	10
Table 4: Tourism and Economy Concerns, Best Practices, and Transportation Considerations .....	12
Table 5: Implementation Strategy – Top 5 Best Practices .....	14
Table 6: Climate Change Readiness Audit, SWMPC .....	18



## Executive Summary

Berrien County comprises a key part of the Great Lakes Fruit Belt, which stretches roughly from LaPorte, Indiana, north to Traverse City, Michigan. The microclimate made possible by Lake Michigan is ideal for growing the grapes, apples, peaches, pears, asparagus, and berries that make Berrien County the second most agriculturally diverse county in the nation. The region's wineries, dunes, beaches, and marinas draw visitors from all over the Midwest. The County's transportation infrastructure, including portions of major highways and numerous marinas, allow for the transport of commuters and tourists, and for the export of produce and other goods.

But the climate of the Great Lakes region, along with the rest of the Earth, is changing. From 1968 to 2002, average temperatures in the Great Lakes region increased by 2.3°F. This trend is expected to continue: by 2050, average air temperature is expected to rise between 1.8 to 5.4 F. This temperature rise affects the timing of seasons and the level and intensity of precipitation.

The region's dependence on tourism, agriculture, and transportation infrastructure make it especially vulnerable to these climatic changes. Local officials and residents need tools and information to plan for and adapt to a future with more intense storms and less predictable weather patterns. For this reason, the Southwest Michigan Planning Commission (SWMPC), on behalf of the Twin Cities Area Transportation Study Metropolitan Planning Organization (TwinCATS MPO), applied for and received the technical assistance of Michigan State University (MSU) Extension community development specialists and the Great Lakes Integrated Science and Assessment (GLISA) climate scientists.

The MSU Extension Project Team worked with the SWMPC and GLISA to design a process that enlisted community members to identify and prioritize their climate change concerns. Key stakeholders in the agriculture, transportation, and natural resources areas then reviewed and added to these concerns and strategies. Overwhelmingly, residents and local leaders wanted to protect the agricultural heritage that made Berrien County unique. Residents also cared about protecting Lake Michigan, both for the public health value and for the tourism economy. Strategies to address the built environment (enforcing existing and creating new zoning ordinances, for example) were less widely embraced. This report details the process and results of this community-driven process. It also contains specific, detailed GIS maps of the region that reflect the climate vulnerabilities and concerns of the residents and leaders in Berrien County.



## Introduction

### Purpose

Certain towns and regions in Michigan are more vulnerable to the effects of a changing climate. Those bordering the Great Lakes, or with local economies heavily dependent on tourism or agriculture, have a more pressing need to plan for increased variability in lake levels, temperature, flash floods, droughts, or severe storms.

Yet local decision makers find it difficult to plan for climatic changes, given the nature of the issues: the political polarization and public controversy surrounding it, the fact that long-term weather patterns affect nearly every aspect of community life, and a scarcity of model policies and plans that are appropriate for that community.

Given this, the purpose of this project is to increase community resilience by studying and recommending community-driven, locally generated climate variability and change adaptation strategies into the TwinCATS long-range transportation plan.

The process included two community forums to identify and prioritize climate concerns, collaboration between MSU, GLISA, and the SWMPC to generate adaptation strategies, interviews with key stakeholders, the completion of a climate change readiness assessment, and the creation of multiple GIS maps.

Furthermore, this document could empower community agencies, citizens, and local elected and appointed officials with the information to take action as they see fit in their respective communities.

### Process

The Southwest Michigan Planning Commission, on behalf of TwinCATS, was one of two community partners selected to receive MSU Extension's technical assistance in creating a climate adaptation plan. (The City of Marquette was the second). Six communities applied for assistance, but the SWMPC was chosen based on its unique climate vulnerabilities in transportation, agriculture, and tourism, as well as its capacity to implement the final plan.

MSU Extension and GLISA held an initial organizational meeting with SWMPC staff in January, 2013. The first community forum was held in February, during which participants identified local climate concerns. At the second community-wide forum, held in May, participants took in a presentation by a GLISA researcher on the local climate, and then worked in small groups to prioritize adaptation strategies and identify trade-offs to these strategies. Following this, the MSU Project Team conducted interviews with key stakeholders in the areas of transportation, tourism, agriculture, land use, natural resources, and public health. The purpose of the interviews was to gather expert input on the adaptation strategies.

During this time, the SWMPC staff also completed a climate change readiness assessment, a detailed assessment of the region's overall capacity to handle floods, extreme temperatures, severe storms, and other climate hazards. The MSU Project Team also worked with SWMPC and MSU Remote Sensing and Geographical Information Systems to create a series of maps that will aid the region in its adaptation plans.



## Methodology

Climate change is a complex scientific process that affects how we eat, work, and live. So preparing for its impacts can be overwhelming. And any discussion about climate change can provoke conflict: despite widespread scientific agreement about climate change's occurrence and causes, it remains a divisive issue for the public (see Figure 1).

Education on climate science is one way to help inform decisions. But scientific education alone ignores the complexity of opinion-formation. Research in cognitive psychology reveals that emotions filter and interpret information based on prior experiences and deeply-held values and beliefs. People often make snap judgments and decisions about complex problems based on the trustworthiness of the messenger and the degree to which the data confirms or disconfirms their prior knowledge (Kahneman, 2011). Therefore, while science can increase our understanding of how the world works, it cannot tell us how to act.

A solid body of literature recommends using facilitated dialogue to solve complex, value-laden community problems. The National Research Council, in its publication *Public Participation in Environmental Decision-Making* (2008), recommends using "deliberation with analysis" as

the method that best supports decision-making around complex environmental and social issues such as climate change. Deliberation with analysis is a type of facilitated dialogue where diverse stakeholders share their expertise and their values to collectively decide "what should be done." The objective of the process is not necessarily consensus, which is the *minimum* amount of agreement needed for action, but rather a shared understanding of the community's values and the nature of the problem, in order to move forward.

For this reason, the MSU Project Team designed a process that incorporated climate science education with facilitated dialogue. During the community conversations, participants were given the chance to talk with one another at small groups, sharing their observations, interests, and beliefs. Later, the Project Team interviewed technical experts for their feedback on the priorities and issues identified by the community. In this way, local expertise on changes observed in their physical climate was gathered at the meetings, and technical expertise was gathered during the interviews.

Interest in the issue still seems to be at its peak, with many residents at the second forum indicating an interest in staying informed and engaged. Other public climate change workshops would likely be well-attended.

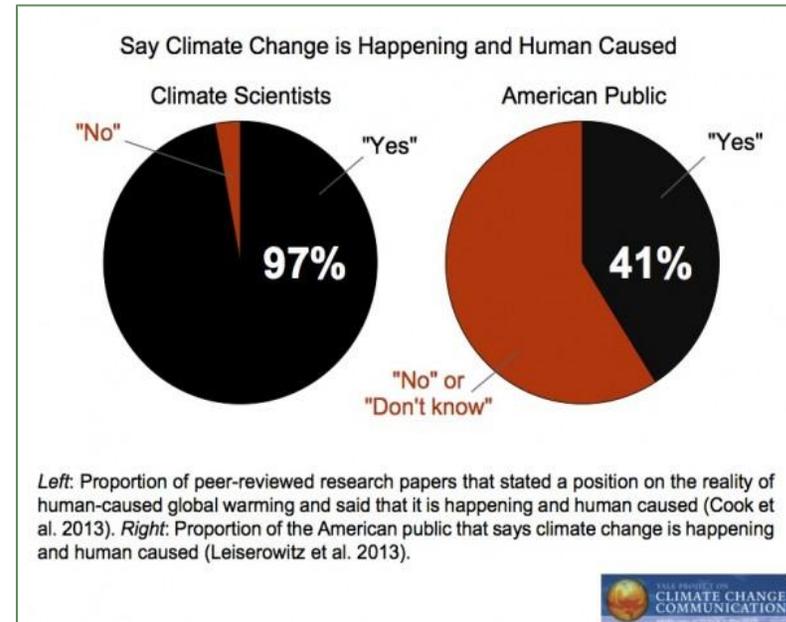


Figure 1: from the Yale Center on Climate Communication, 2013

## Issue Identification

### Meeting One Overview

The first community meeting was held on February 27, at the Michigan Works! facility in Benton Harbor. The event was advertised on local radio and on the SWMPC website, and personal invitations were sent to those with an expertise in planning and zoning, transportation, and natural resources. Approximately 80 participants were in attendance.

At the beginning of the event, five flip charts were placed around the room, each one posing a different question:

1. How has the change in climate affected the local economy?
2. How has the change in climate affected the area's natural resources?
3. How has the change in climate affected you and your family?
4. What is the difference between weather and climate?
5. What else would you like to know about climate change?

Following a brief presentation about the objective of the project and this particular meeting, participants sat in small groups at tables. Then they were asked to respond individually in writing to two questions:

1. What are some potential benefits from a changing climate?
2. What are some potential losses from a changing climate?

Participants first shared their responses within their group. Then, they summarized their discussions to the whole group. Each time, the summary transcripts were projected by computer to the whole room.



Small Group Input

After the meeting, the individual responses on flip chart paper/ and cards, and the small group responses on the computer were collected, summarized and analyzed for themes. The following issue areas emerged:

#### Land Use

(Ex. transportation, infrastructure, and zoning regulations)

#### Water

(Ex. Lake Michigan water level, river water level, extreme amounts of precipitation, and the shipping industry)

#### Public Health

(Ex. extreme temperature effects, increases in pests, and pathogens)

#### Agriculture and Food

(Ex. drought, exports, and road drains)

#### Tourism and the Economy

(Ex. marina access and recreational opportunities)

## Climate Data Summary

When considering climate change and variability implications for Southwest Michigan, local climate data about *Lake Levels, Precipitation, Snow and Ice Cover, Lake Temperature & Stratification, and Temperature* were collected. GLISA researchers analyzed then compared these data with historical climate data and determined the extent and variability of climate change that Southwest Michigan is currently experiencing. The following section summarizes these findings.

### Lake Levels

Water levels in the Great Lakes have decreased since 1980 (Pendleton, 2010). Lake levels are rising and falling a month earlier than during the 19<sup>th</sup> century (Lenters, 2001). Factors such as land use and lake regulations affect lake level, however, it is unclear how much of the recent trend in decreasing lake levels

may be attributed to climate change (Lamon, 2010; Lofgren, 2011)

### Precipitation

Figure 2 depicts the average precipitation rate for Southwest Michigan from 1951-1980 and illustrates the changes in total precipitation percentage per 9 year average.

- Similar to most of the Great Lakes region, annual total precipitation over Southwestern Michigan has increased since the 1951-1980 period (GLISA, 2012).
- Relative to the 1951-1980 averages of total seasonal precipitation, the greatest increases have occurred during the fall and winter months. Increases in the spring and summer have been more moderate (GLISA, 2012).
- Warmer temperatures may lead to less precipitation falling as snow and more falling as rain (Winkler, 2012).

- Lake-effect precipitation has increased in many areas of the Great Lakes region (Burnett, 2003; Wright, 2004)



Source: [www.greatlakesecho.org](http://www.greatlakesecho.org) November, 2012

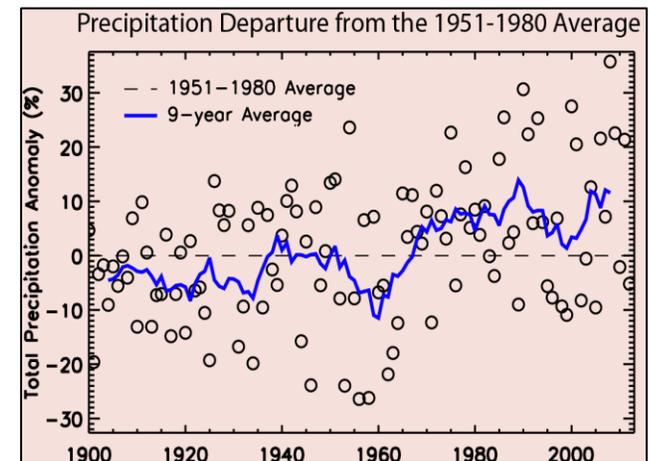


Figure 2: Average Precipitation Rate, GLISA

### Lake Temperature and Stratification

Lake temperatures have been increasing faster than surrounding air temperatures (Dobiesz, 2009).

The length of the summer stratification in the Great Lakes and inland lakes has increased over the last century (Brooks, 2002). Warmer water surface temperatures increase the stratification of the lakes, decrease vertical mixing in the spring-winter, and lead to more low-oxygen, “dead zones” and toxic algal blooms (Karl, 2009)

### Ice Coverage

From 1973 to 2010, annual average ice coverage on the Great Lakes declined by 71% (Wang, 2011)



Lake Michigan Ice Coverage-  
March 2013 Photo: NASA

### Snow Depth

The average snow depth for Southwest Michigan between the years 1940-2010, is shown in Figure 3. The results were averaged by 9-year periods to display the mean snow accumulation. Additionally, the winter average snow depths in Southwest Michigan have declined slightly since the 1980s but are near historic values (NCDC, 2012)

### Temperature

The average temperature for Southwest Michigan from 1951-1980 illustrates the changes in degrees Fahrenheit per 9 year average (see Figure 4).

- The 30-year average temperature over Southwestern Michigan has increased by about 0.9°F since the 1951-1980 period (GLISA, 2012).
- Winter temperatures have increased faster than those throughout the rest of the year (GLISA, 2012).
- The observed warming trends are projected to continue or accelerate in the coming decades (GLISA, 2012).

Figure 3: Average Snow Depth, GLISA

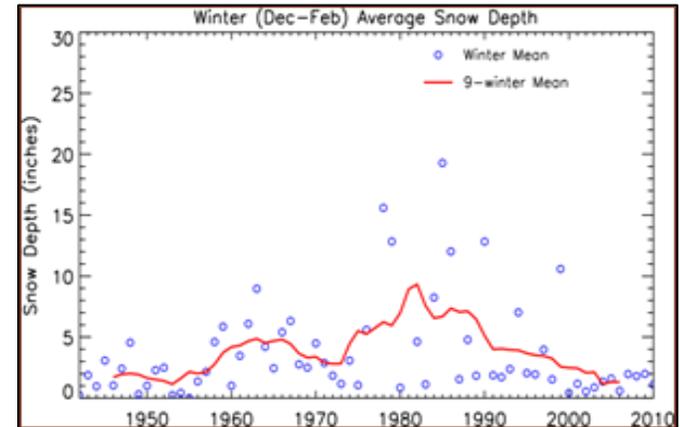
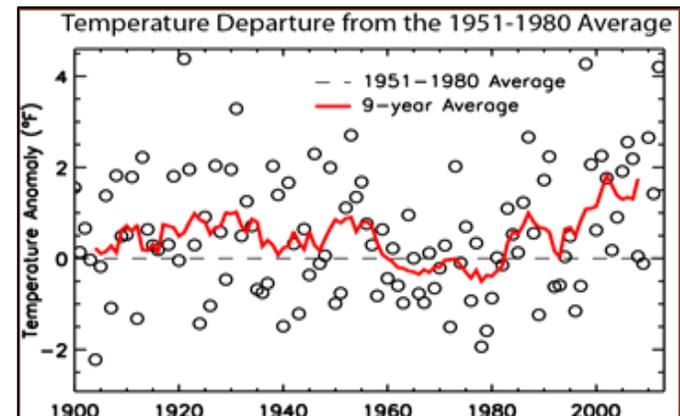


Figure 4: Average Temperature, GLISA



Change in mean temperature (°F) in Southwest Michigan from 1951-1980 to 1981-2010

Annual	0.9
Winter	1.9
Spring	1.1
Summer	0.6
Fall	0.2

## Recommendations

### Meeting Two Overview

The meeting objective was to elicit feedback on proposed adaptation strategies identified at the first meeting: water/public health; food and agriculture; land use; and tourism and economy. The meeting took place on May 8, at the Michigan Works! facility in Benton Harbor. This meeting drew less than half the number of participants as the first, but the 29 community members who attended were focused and committed.

To provide context necessary for the meeting's objective, the Southwest Michigan Planning Commission first presented information about the TwinCATS Metropolitan Planning Organization on climate adaptation measures. Photographs of recent local floods and sinkholes were shown, as well as a video of the effects of a road buckling under high heat.

Next, a climate scientist from GLISA, Dan Brown, presented historical climate data that focused on Southwest Michigan's climate in the past century. Mr. Brown then answered questions from participants about the data

he presented, as well as about climate change in general.

Participants then self-selected into small groups, based on their interest in one of the four adaptation themes. Each group assigned themselves roles (facilitator, timekeeper, recorder, and presenter) and then reviewed a list of adaptation strategies. These strategies described best practices that have been used by other local units of government to plan for and adapt to changes in weather patterns. Individually, group members ranked the best practices according to their own preferences. They then came together as a group and agreed on one high-priority strategy. They wrote this strategy on a flip-chart pad and listed some possible trade-offs that might accompany that strategy.

Each small group then presented their high priority and trade-offs to the whole group. At the completion of the presentations, all participants indicated their preferences for the strategies by using either a green or red sticker.

Although participants were limited by time-- about 30 minutes to complete the small group activity, and only 10 or so minutes to vote on all the strategies using stickers-- they were thoughtful and focused, and provided valuable feedback and ideas to the SWMPC.



Small Group Prioritization



Data Presentation



Report Out



The following recommendations (or, best practices) were presented and discussed at Meeting Two. Four categories including *Agriculture & Food*, *Tourism & Economy*, *Water & Public Health*, and *Land Use*, were identified during Meeting One as focal points. The recommendations address these areas of concern and relate them to long term transportation planning for the region. The recommendations were drawn from a number of local, regional, state, and national best practices (a complete list of citations is included in the appendix).

## Identified Agriculture and Food Concerns

As the “Fruit Belt” of Michigan, climate change in the Southwest metropolitan region could cause a number of serious problems relating to agriculture and food. Extended periods of drought and changes in the usual growing season are among the most pressing issues. Changes in the local ecosystem may bring in new pests and diseases that could destroy crops. The effect would be a lack of access and availability to food and could result in economic losses due to a decreased surplus for export.

Agriculture/Food Concerns	Best Practices: What Municipal Governments Can Do With Your Support	Transportation Considerations
<b>Drought</b>	Tree species that require an abundance of moisture could be replaced in urban forests with species that are drought-resistant. Replace monocultures with polycultures (multiple species instead of one) along streets and arterial corridors to counteract tree deaths from drought	Correct tree placement reduces street maintenance costs by reducing repair (surface destabilization from roots) and clean-up costs (leaves, fruits, and branches) associated with inappropriately-placed species
<b>Availability/Access to Food</b>	Identify areas within the region that could be used for additional Farmers Markets and seek out additional community, municipal, and regional collaborators, as well as local markets and growers. This way, food supply is less likely to be interrupted during extreme events	Temporary road closures, detours, and short-term conversion of parking areas to market areas; smaller local shipments to local markets rather than large semi-truck loads from major distribution centers
	Amend ordinances and plans, as well as economic development funding practices to allow food production within urban areas	May lead municipalities to install porous pavement that captures run-off before sediment, fertilizer, and pesticides end up in storm and/or sanitary sewers
<b>Water, Pests and Disease</b>	Form a working group among interested stakeholders to create a five-year collaborative plan to address issues of infestation	Encourage water management infrastructure on roads to be based on standards that take into account up-to-date flood plain
<b>Changes in the Growing Season</b>	Diversify crops to adjust to temperature variation	Anticipate earlier activity of agricultural vehicles on roadways. Road repairs may need to be done sooner into construction season to accommodate these vehicles
	Crops, gardens, and lawns should be watered at night to minimize evaporation while drinking water capacity should be adjusted to accommodate increased evening demand	
<b>Ability to Import/Export</b>	Strengthen the relationship between the SWMPC, the Michigan Food Policy Council and regional food security programs. Establish a SW Michigan food policy council to advocate for local food movement into international markets	Maintaining rail and road freight infrastructure to avoid impediments to imports and exports

Table 1: Agriculture/Food Concerns, Best Practices, and Transportation Considerations

## Identified Land Use Concerns

Land use strategies are necessary to address both the potential of a growing population and the human and development impacts from severe storms, flooding, and shoreline erosion. All of these can be devastating without proper preparation. By protecting crucial floodways and shorelines through effective land use management, the impacts of climate change may be lessened.

Land Use Concerns	Best Practices: What Municipal Governments Can Do With Your Support	Transportation Considerations
<b>Increased Frequency of Intense Storms</b>	Adopt a riparian buffer system and/or establish overlay zones to address setbacks, lot sizes, and impervious surfaces	Better timing of storm water infrastructure upgrades to coincide with road maintenance projects; this will potentially help keep costs low
	Develop incentives for home and business owners to implement green roofs, rain barrels, rain gardens, and permeable paving	May lead municipalities to consider installing porous pavement that captures run-off before sediment, fertilizer, and pesticides end up in storm and/or sanitary sewers
<b>Increased Sediment Delivered to Waterways</b>	Form a working group among interested stakeholders to create a five-year collaborative plan to address invasive species issues.	Continue to monitor culverts and dams in conjunction with Friends of St. Joseph River watershed study. Open avenues for exchange of information on sedimentation between MPO staff partners and the public during project selection
<b>Shoreline Change</b>	Update and use shoreline erosion data in implementing appropriate setbacks	Roads and driveways close to the shorelines, which provide major routes for tourists and the local economy, need better monitoring
	Explore the establishment and maintenance of a predetermined setback line with beach nourishment (adding sand) to priority areas	Storm surge could relocate sand and, if so, thereby disrupt adjacent roadways and beach nourishment schedules
	Limit development close to shorelines with incentive programs	

Table 2: Land Use Concerns, Best Practices, and Transportation Considerations



Land Use Concerns (continued)	Best Practices: What Municipal Governments Can Do With Your Support	Transportation Considerations
<b>Increased Localized Flooding</b>	Update flood zone maps to account for climate change and water level changes	Roads in low-lying areas are at risk; transit unable to deliver services to rural areas. MPO staff can update flood zone maps to take into account recent lake and river levels and community identified at-risk areas
	Culverts, medians, and drains along roads augmented for water absorption	Storm water improvements may lead to temporary road closures as construction occurs
	Strict enforcement of zoning ordinances and re-evaluation of floodplain data to control floodplain development	Right-of-ways may be at risk because floodplain maps may be out of date
	Elevate flood prone structures, install sewage backflow devices	Take potentially higher flood levels into account when placing and designing new bridges or replacements; better coordination between truck, rail, and shipping freight when floods cause problems in one mode. Intelligent transportation systems need to make it easier for these different mode operators to talk to one another during weather events
	Develop incentive programs for property owners to maintain a certain percentage of permeable surface on their property	
<b>Population Growth</b>	Revise conservation subdivision regulations to create incentives for greater density and services in certain areas, while conserving open space and rural character in others	Population is continuing to move towards townships; Berrien County continuing to lose population; dispersed services would require greater maintenance of infrastructure where roads are already deteriorating
	Protect valuable natural landscapes from development through incentives to build and supply transportation in existing areas	Refocus transportation connections around key destinations; both service centers and natural amenities
<b>Increased Number of Lake Effect Events</b>		Better communication with transit passengers when there will be delays through real-time information on road closures
		Since Lake effect events are highly local and unpredictable, ITS boards can help drivers in other areas avoid getting stuck in Lake Effect areas

Table 2: Land Use Concerns, Best Practices, and Transportation Considerations (continued)



## Identified Water and Public Health Concerns

A decrease in Great Lakes ice cover may lead to increased water evaporation and lower lake levels. An increase in lake temperatures may result in increased algae, invasive species, and health impacts from water-borne pathogens. At the same time, changes in lake levels could cause businesses to relocate while increasing ambient air temperatures during the day and night may lead to human health concerns such as: new pests and diseases, increased risk of wildfire, heat stress, and heat stroke.

Water and Public Health Concerns	Best Practices: What Municipal Governments Can Do With Your Support	Transportation Considerations
<b>Changes in Lake levels</b>	Devise grey water storage and reuse systems to recycle and utilize water resources more efficiently	Incorporate impacts on water management into prioritization of different projects
	Development of emergency management plans for all dams	Better communication between MPO members and groups that have studied dams in the area, to take into account problems with dams in transportation projects
<b>Rising Lake Temperatures, Increased Algae, Invasive Species, Pests, and Pathogens</b>	Enhance programs that control invasive species and remove them from lakes and rivers	Road signage indicating problematic areas and real-time updates on beach hazards
	Increase current beach monitoring activities to detect presence of pathogens that could affect human health	

Table 3: Water and Public Health Concerns, Best Practices, and Transportation Considerations



Water and Public Health Concerns (continued)	Best Practices: What Municipal Governments Can Do With Your Support	Transportation Considerations
<p><b>Heat Stress</b></p>	<p>Public education and awareness programs to alert citizens about necessary precautions and solutions to heat hazards</p>	<p>Roadways and rails may literally buckle due to heat, creating a greater need to monitor and constantly maintain completed transportation projects</p>
		<p>Road worker safety in extreme heat: if number of “Code Red” days in summer increases over time, number of construction days in summer may decrease, meaning transportation projects get done less frequently</p>
		<p>Transit operating costs may increase due to increased air conditioning costs. Greater need for investment in shading infrastructure at transit stops and more service to reduce wait times in the heat</p>
<p><b>Decreased Ice Cover</b></p>	<p>Identify, acquire, and protect critical habitat, including beaches and dunes</p>	
<p><b>Increased Risk of Forest Fires</b></p>	<p>Prepare and implement emergency response plans for fire-related hazards</p>	<p>Need for an intelligent transportation system (ITS) to report on road closures due to fallen trees or fires where drought conditions exist. The ITS would safely and efficiently move transportation system users onto alternative routes</p>

Table 3: Water and Public Health Concerns, Best Practices, and Transportation Considerations (continued)



## Identified Tourism and Economic Concerns

Lower lake levels impact deep water shipping lanes and cold water fishing opportunities. Shoreline erosion limits marina access and, potentially, opportunities for young people. Tourism may decrease as a result, thereby affecting the economy. Finally, negative impacts on the economy could force lifestyle changes upon the community.

Tourism and Economy Concerns	Best Practices: What Municipal Governments Can Do With Your Support	Transportation Considerations
<b>Lower Lake Levels</b>	Maintain and increase permeable surface area (open spaces, porous pavement, etc.) to enhance groundwater entering the Lake and reduce the amount of contamination and sedimentation from ground and surface waters	Water transportation safety and efficiency will be improved and reduce heavy truck traffic from the road network
<b>Shoreline Erosion</b>	Use Geographic Information Systems (GIS) maps to show critical transportation vulnerabilities to expected climate change impacts	Choices between rebuilding, relocating, and decommissioning transportation infrastructure will occur with more frequency
<b>Decrease in Tourism</b>	Adjust parks and recreation expenditures to support and capitalize on changes in the use of outdoor recreation areas	Transportation patterns may fluctuate based on use demand between parks and recreation areas and urban cores
	Enhance the pedestrian environment with attractive elements (shade, furniture, art), wayfinding (signage, community identification), security, and universal accessibility	Demand may increase for Complete Street amenities to enhance the pedestrian environment

Table 4: Tourism and Economy Concerns, Best Practices, and Transportation Considerations



Tourism and Economy Concerns (continued)	Best Practices: What Municipal Governments Can Do With Your Support	Transportation Considerations
<b>Lifestyle Changes</b>	<p>Promote public transit and park-and-ride connections between regional and local trail systems</p> <p>Strengthen motorized and non-motorized connectivity between coastal and non-coastal areas to improve the resiliency within the tourism sectors of local and regional economies</p>	<p>Assess the feasibility of existing and new transit routes for future expansion. Not enough funding currently to get people to life sustaining destinations like medical, employment etc.</p>
<b>Decreased Marina access due to water level issues and decreased transport cargo barge</b>	<p>Invest in dredging of critical harbors to maintain minimum acceptable access to transportation by water, whether for recreation or commercial</p> <p>Utilize low impact design principles to reduce sediment loading in riparian zones before it occurs</p>	<p>Dredged materials must be transported off site and available locations are constrained by regulations regarding containment/treatment of contaminated soils. Variable water levels and funding for dredging could increase costs of road materials for regional roads. Uncertain local funding for dredging of recreational waters could decrease access to recreational vessels</p>
<b>Access to Major Roadways</b>	<p>Develop scenario planning for emergency preparedness</p>	<p>The role of transportation systems and emergency preparedness will need to be re-evaluated</p>
<b>Loss of Cold Water Fisheries</b>	<p>Use buffer zones to prevent streams, rivers, and lakes from becoming too warm</p>	<p>New bridge construction and bridge repair projects may cost more and take longer to complete to minimize impact</p>
<b>Decrease in Opportunities for Young People</b>		<p>Currently, many students in the TwinCATS region have achievement scholarships to attend local community colleges and obtain the skills they need, but may not own cars and are unable to get to class. A transportation network that takes into account all modes will help these students take advantage of opportunities that exist</p>

Table 4: Tourism and Economy Concerns, Best Practices, and Transportation Considerations (continued)



## Implementation

### Priority Actions

Identified areas of concern about climate change and variability impacts were discussed in the second community meeting held May 8<sup>th</sup>, 2013. Community members were asked whether they were in support or opposition of best practices within each of the four categories. Figure 5 indicates the total support and opposition votes for each respective category. “Support” indicates higher priority should be given by the local government. Land Use and Development is the only category with best practices that showed more opposition than support.

The top five best practices as identified during the meeting based on votes of support is shown in Table 5. Native diversity of crops and trees was the top best practice, followed by enhanced pedestrian trails & access. Habitat protection, public transit, and utilizing water efficiently round out the top five best practices.

The following section of this report highlights how climate change is addressed in two existing plans: TwinCATS 2009-2035 and proposed 2013-2040 Long Range Transportation Plan, and the Berrien County Hazard Mitigation Plan.

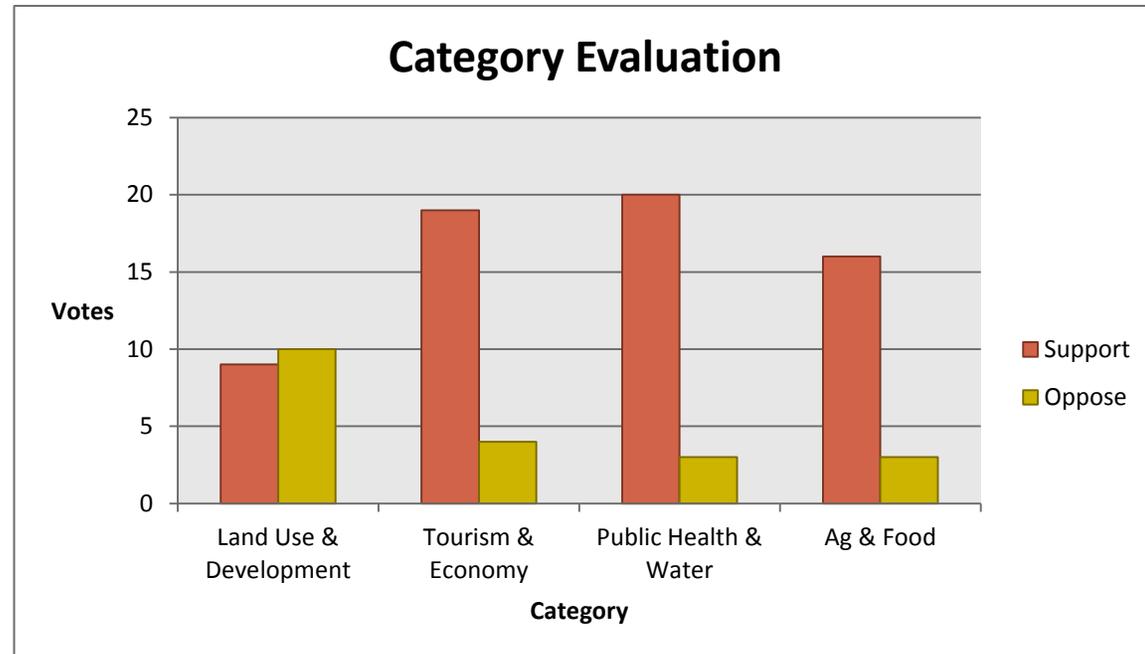


Figure 5: Votes for Identified Areas of Concern

Top 5 Best Practices			
#	Best Practice	Support	Category
1	Maintain diversity of native of crops/trees	15	Agriculture/Food
2	Enhance: pedestrian environment; non-motorized paths; access to marinas	10	Tourism/Economy
3	Critical habitat: identify, acquire, protect	10	Public Health/Water
4	Promote public transit	8	Tourism/Economy
5	Utilize water resources more efficiently	7	Public Health/Water

Table 5: Top Five Best Practices Identified by Participants



## Relationship to Existing Plans

### TwinCATS Long Range Transportation Plan

This plan does not recommend actions or projects that specifically address climate change alone. However, the plan identifies climate change as a major and emerging concern in the region. Furthermore, many actions in the plan (pages 64-78) are designed to address air quality and congestion issues. These actions may have a secondary benefit of some form of climate change mitigation, although they less clearly address adaptation strategies.

Among the programs that SWMPC manages is Rideshare, which serves as an official means of organizing carpooling within the TwinCATS region (and throughout Berrien County). The goal of this program is to promote less automobile use to ease air quality problems. In addressing air quality issues, however, the program has an ancillary benefit of reducing greenhouse gas emissions, which could potentially help mitigate global warming to some degree. Rideshare continues to be a part of SWMPC’s annual funding request during the project selection process.

Another suggested action in the plan that may help with climate change mitigation is encouragement of non-motorized paths, on-road bicycle lanes, and greater transit use. All three of these program areas are designed to offer more safe choices to people than the use of the automobile. The desired outcomes from such programs, as discussed in the plan, are not necessarily decreased vulnerability from climate change. Rather, these programs provide health benefits, air quality improvements, as well as mobility options for populations young and old who may be unable or unwilling to operate a vehicle. In addition, these programs can offer greater access for tourists and residents to the area’s natural resources. Still, a secondary benefit may be reduced greenhouse gas emissions within the region, as people use other modes of transportation to access destinations locally.

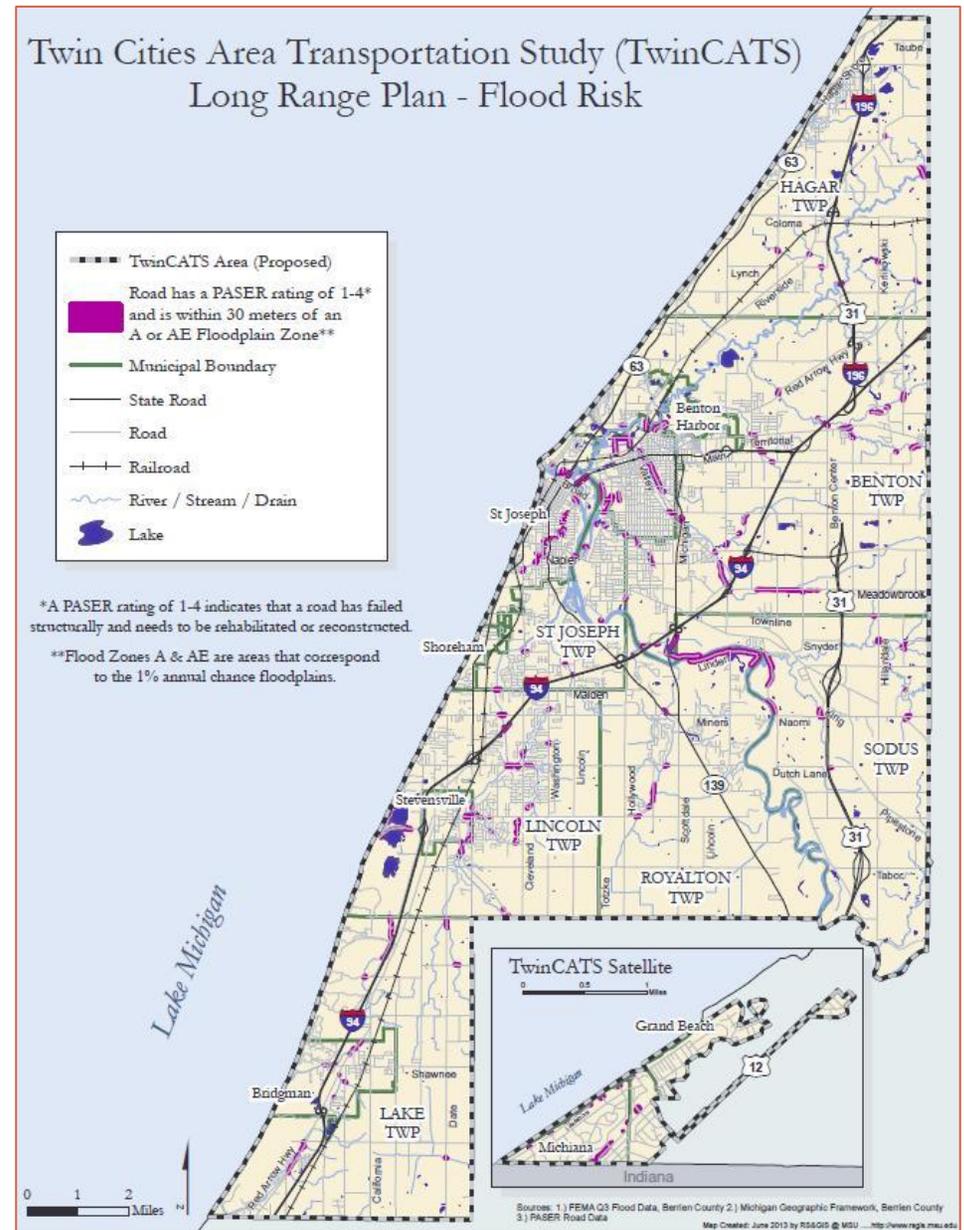


Figure 6: TwinCATS: Flood Risk

Expectations that climate change will cause flood events to become more frequent and more extreme means that some mitigation strategies may evolve into adaptation strategies over time. For instance, Figure 6 depicts transportation infrastructure that needs rehabilitation or reconstruction and is located within a 100-year floodplain. The relationship between failing infrastructure and potential flood hazards is an issue that needs further attention in the updated TwinCATS Long Range Plan. The infrastructure most in need of repair under current conditions could potentially be the most vulnerable section of the transportation network during flooding events.

## Related Documents

### *Berrien County Hazard Mitigation Plan*

The Berrien County Hazard Mitigation Plan, published in 2005, does not address climate change explicitly, but alludes to its possible effects on several occasions. The plan already uses data from the National Weather Service (NWS), and Federal Emergency Management Agency (FEMA), both of which may serve as resources for further explorations of climate change.

The plan acknowledges that Berrien County's location in a lake effect zone does leave it particularly susceptible to extreme and unexpected precipitation events, especially during winter months (pages 32-36). Based on a hazard ranking process, severe winter weather was the largest hazard identified by municipalities. The plan details a history of these extreme events from 1962-2004, which can be used to assess frequency levels. The plan also discusses the potential costs of these events, in terms of road maintenance, losses to the tourism-based economy, and lost productivity due to increased travel time and injuries or health issues on the roads. Of particular relevance to climate change was the identification of the effect of the timing of these winter weather events on success or failure of agricultural crops.

Berrien County's susceptibility to extreme temperatures is also discussed in the plan (Pages 41-44). The plan outlines health issues and the frequency of extreme heat and extreme cold events. The plan details health and safety issues related to these temperatures. The plan identifies two groups that warrant particular attention. One population group that is particularly vulnerable to extreme heat and cold is comprised of low-income individuals, who may not be able to afford heating and cooling devices necessary to maintaining healthy temperature in their homes. A second vulnerable population is comprised of elderly and mobility-challenged individuals who may be unable to escape situations of extreme heat and cold, either in their homes or in the outdoors. Both of these vulnerable populations are of significant size within the TwinCATS MPO.



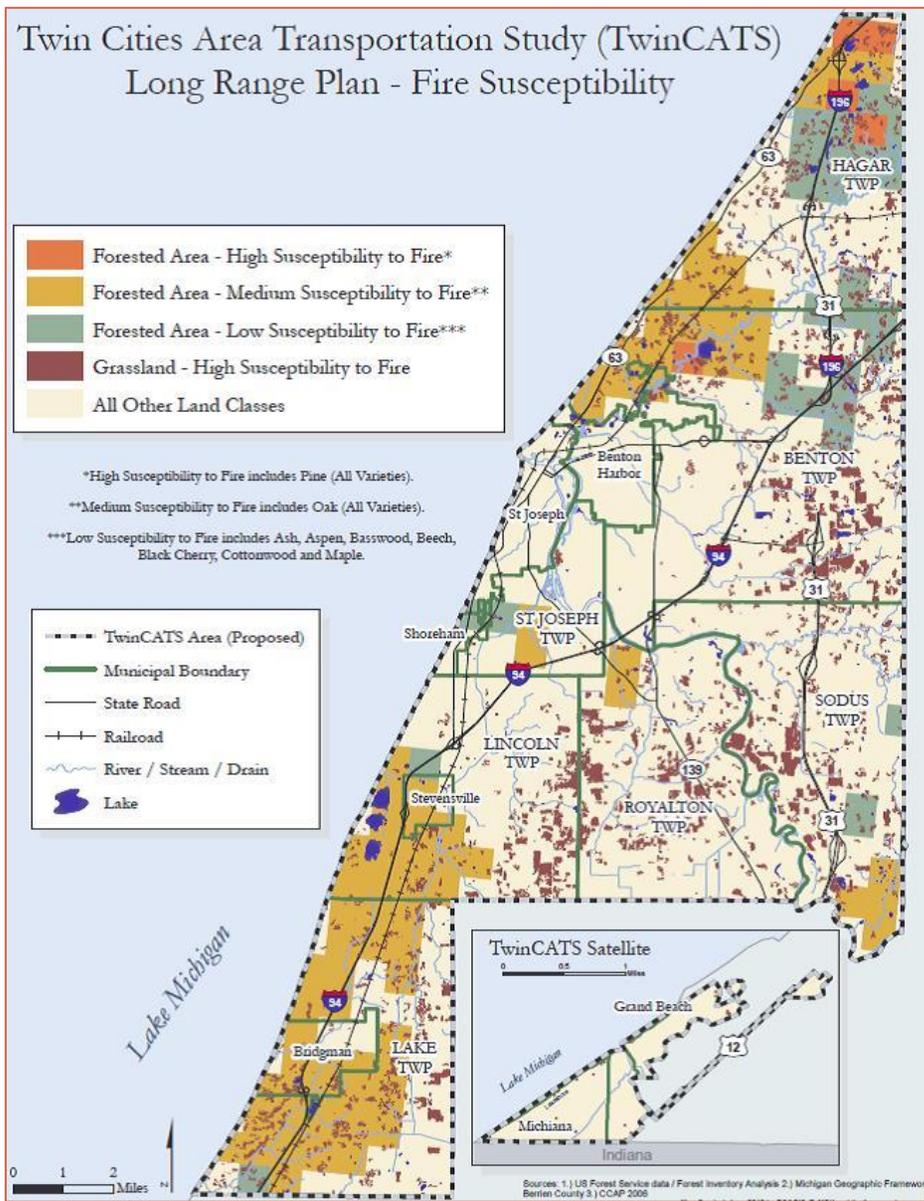


Figure 7: TwinCATS: Fire Susceptibility

The plan makes allusions to storm drainage failure due to capacity overloads resulting from flooding as well. The plan stresses the need for the establishment of a regular maintenance schedule and proper inventory of storm drains in each municipality. The plan also examines health impacts during flooding and drought events and the need for emergency preparedness.

The plan provides an extensive list of recommended actions for the SWMPC, County officials, and local governments to take to address these hazards. Many of the actions relate to better communication between various forms of government and maintenance of warning and response systems throughout Berrien County. The recommended actions also relate to better design guidelines for flooding barriers and suggest local land use planning that takes into account areas that the community has identified as vulnerable to flooding.

Furthermore, the Hazard Mitigation Plan addresses fire susceptibility (*wildfires*). Fire hazard concerns were identified during the community input session including extreme heat and drought. Figure 7 addresses areas of high, medium, and low susceptibility to fire. There is an opportunity to incorporate this issue into the TwinCATS Long Range Plan in concert with the Hazard Mitigation Plan to address impacts on roads and other infrastructure. Additional maps and information showcasing other climate-related hazards were compiled and can be found in the appendix section of this report.

## Audit Summary

### Audit Tool

The Southwest Michigan Planning Commission (SWMPC) was provided with the Climate Change Readiness Audit (CCRA), designed by Minnesota Sea Grant specifically for communities in the Great Lakes Region. It provides community leaders a means to review their community's vulnerability climate change by asking a series of yes and no questions.

The CCRA first explains that high- or medium-readiness does not necessarily equate to low impact potentials. Also, a low-readiness is not the only determinant in deciding on future assessment needs. Other determinants may include cost, public support, and political will.

The results of the SWMPC's CCRA were telling in two ways. First, the CCRA was effective in discovering several regional strengths and vulnerabilities (identified internally by the SWMPC and externally by the MSU Project Team via interviews with key stakeholders).

Second, because the CCRA was designed by Minnesota Sea Grant for communities and not regions, some aspects of the CCRA were not as probative as other aspects. Therefore, the SWMPC might consider encouraging local governments operating within the TwinCATS MPO boundary to use the CCRA internally and then share the results externally with the SWMPC to address regional priorities.

The SWMPC staff identified *Critical Infrastructure, Built Environment & Infrastructure, Operations & Maintenance, and Community Plans* as high priority issues for the MPO during their Climate Change Readiness Audit (see Table 6). Furthermore, the high priority issues were addressed during the stakeholder interviews. The SWMPC staff identified agencies and key officials for phone interviews conducted by the MSU Project Team. The following strengths and vulnerabilities surfaced during these discussions. The full assessment and additional tools can be found at

[www.glisla.umich.edu](http://www.glisla.umich.edu).

### Strengths

- Capability of shoreline structures (levees, piers, and breakwaters) to handle extreme storm events/changes in lake levels
- Urban tree maintenance and replacement programs
- Addressing the aftermath of extreme lake effect (snow) events

### Vulnerabilities

- Road infrastructure
- Water quality
- Erosion and land subsidence
- Tourism

SWMPC's Climate Change Readiness Audit	
Category	Relevance
Critical Infrastructure Flooding	High
Critical Facilities Flooding	N/A
Built Environment & Infrastructure	High
Operations & Maintenance	High
Water Resources	Medium
Ecosystems & Habitats	Medium
Tourism & Recreation	Medium
Business Plans & Equipment	N/A
Community Plans	High

Table 6: Climate Change Readiness Audit, SWMPC

## Stakeholder Interviews

Local experts in the fields of transportation, public health, agriculture, and tourism were contacted by the MSU Project Team and asked to take part in a 30-minute telephone interview. During the interview, the experts were asked to review and comment on the priorities and actions identified at the two public meetings, as well as add their own additional issues and actions. They also were asked to identify opportunities or barriers in implementing these actions.

Overall, the interviewees were impressed by and agreed with the community concerns and the preferred best practices to adapt to these concerns.

Transportation stakeholders expressed support for continued dredging of the harbors. They believed it vital to the region's economy to remove sediment so that larger ships could load and unload cargo at the ports.

Agriculture stakeholders stressed the importance of keeping more locally-grown

produce in the region. If Berrien County residents could buy and eat more locally-grown fruits and vegetables, the whole area could benefit, both economically and health-wise. One stakeholder pointed out that food grown locally cuts down on greenhouse gas emissions used to transport the produce, as well as makes the region more food-secure in the event of a power outage or flu pandemic.

Public health officials brought up the presence of two nuclear power plants in Berrien County, and the comprehensive emergency management plan that is required by Federal law. They pointed out that Zebra Mussels, an invasive species, routinely clog the water intake mechanisms.

The public health officials also noted that the increased severity of the storms they have witnessed can bring increased power outages, which can result in lack of refrigeration and food-borne illnesses. These storms could produce stronger rip-currents and more drowning. The concern about increased pests and disease, which were identified by community members as a

possible result of warmer temperatures, was echoed by the public health stakeholders.

Many stakeholders identified lack of resources as a barrier to implementing adaptation plans, particularly those that are long-range and need to be supported by taxpayers. Michigan's prolonged recession has meant that many public institutions, non-profits, and small businesses have had to tread water and address only the most immediate or pressing needs.

Some stakeholders identified the lack of political will in implementing the strategies. Limited taxpayer resources, term limits, and lack of a Federal energy policy were all cited as barriers to long-term climate adaptation plans.

Several stakeholders expressed confidence that Berrien county residents and leaders would successfully adapt to climate change, and do what needed to be done when necessary.

## Appendices

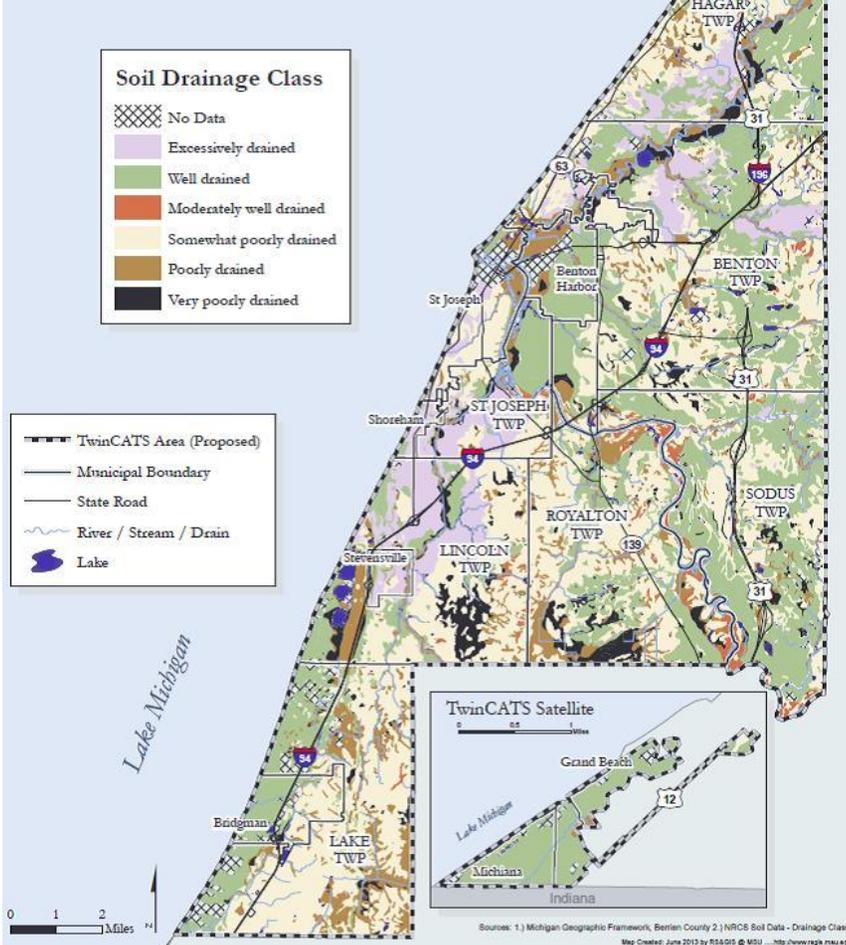
### Appendix A: Maps – Twin Cities Area Transportation Study (TwinCATS) Long Range Plan

- i. Flood Risk – Road Vulnerability
- ii. Flood Risk – Floodplain Zones
- iii. Drought / Flash Flood Risk
- iv. Flood Risk – Developed Land Residing Within a Floodplain Zone
- v. Flood Risk – Developed Land Residing Within Flood Prone Areas
- vi. Flood Risk - Elevation
- vii. Flood Risk – Bridges and Dams
- viii. Drought Risk – Soil Type
- ix. Fire Susceptibility – Forests
- x. Lake Levels – Lincoln Twp.
- xi. Lake Levels – Berrien County
- xii. Flood Risk – Developed Land At or Below 650ft.
- xiii. Lake Levels – Lake Twp.
- xiv. Lake Levels – Hagar Twp.
- xv. Lake Levels – St. Joseph
- xvi. Lake Levels – Grand Beach

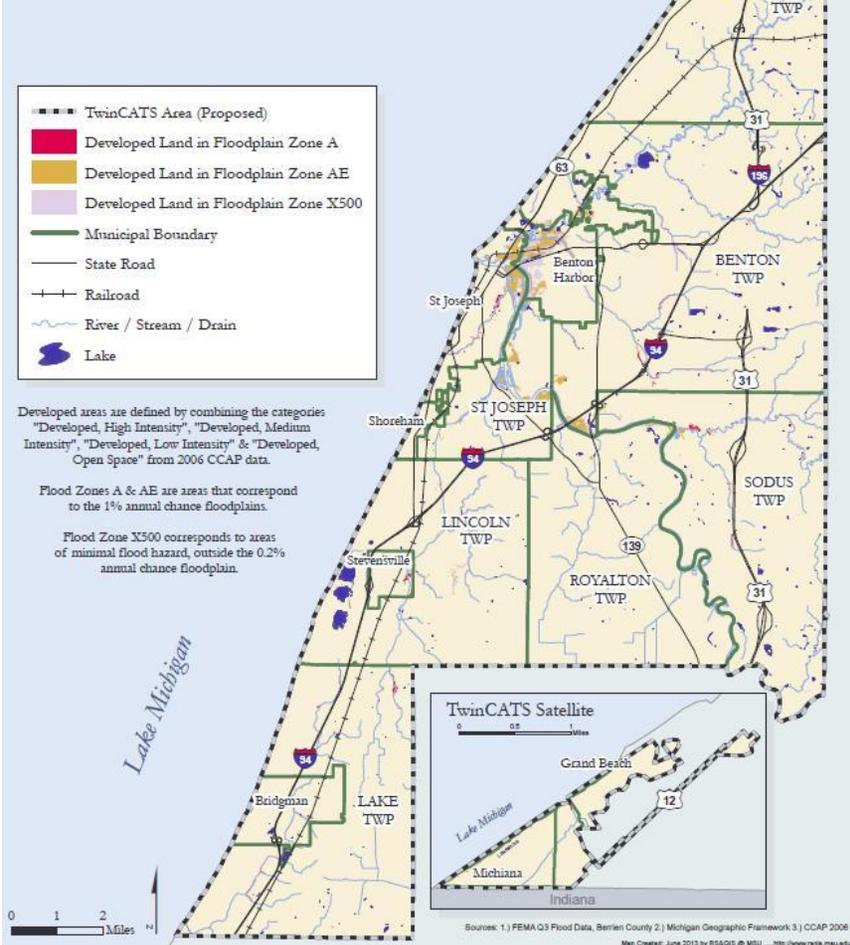




### Twin Cities Area Transportation Study (TwinCATS) Long Range Plan - Drought/Flash Flood Risk

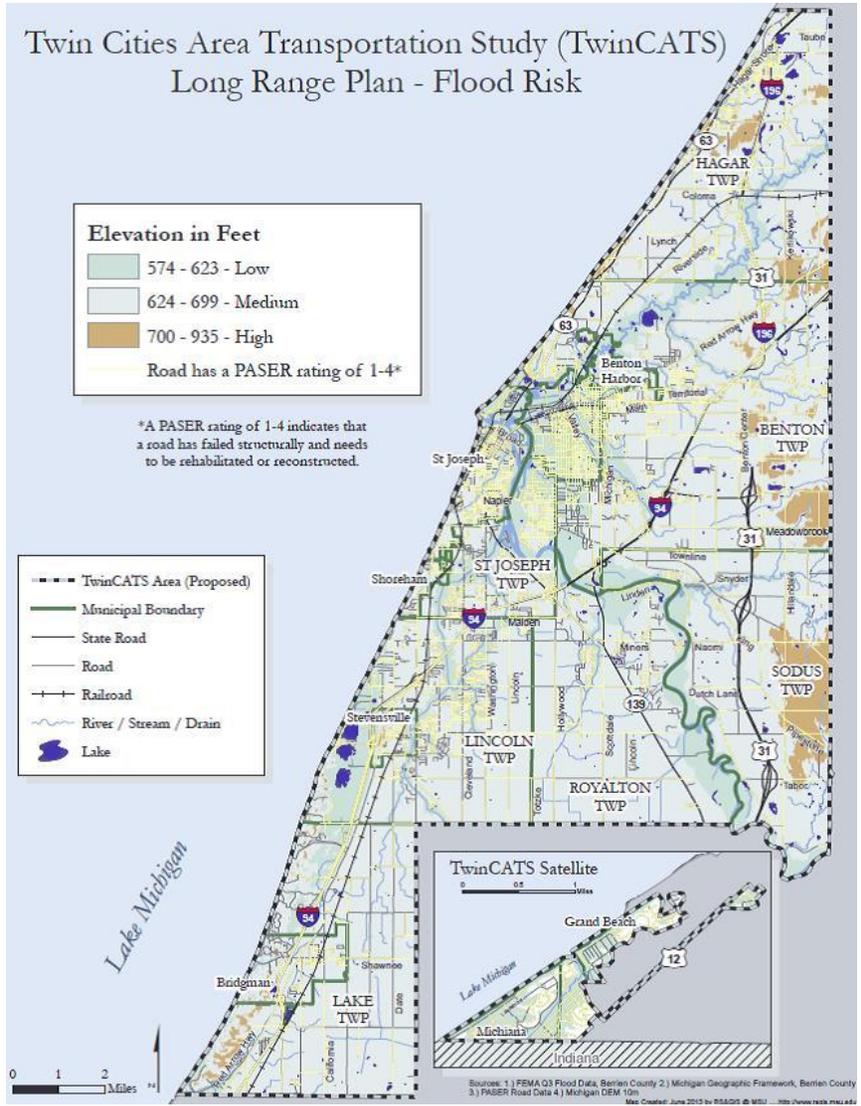
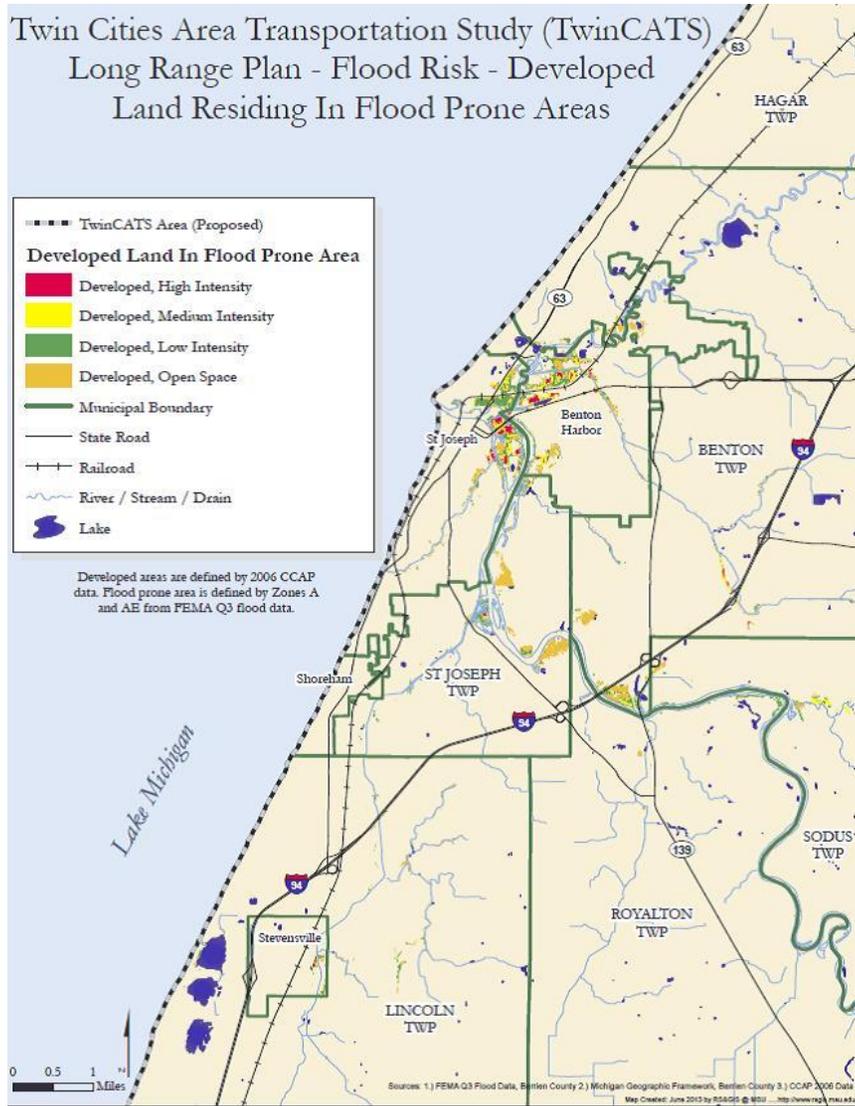


### Twin Cities Area Transportation Study (TwinCATS) Long Range Plan - Flood Risk - Developed Land Residing Within a Floodplain Zone



iii.

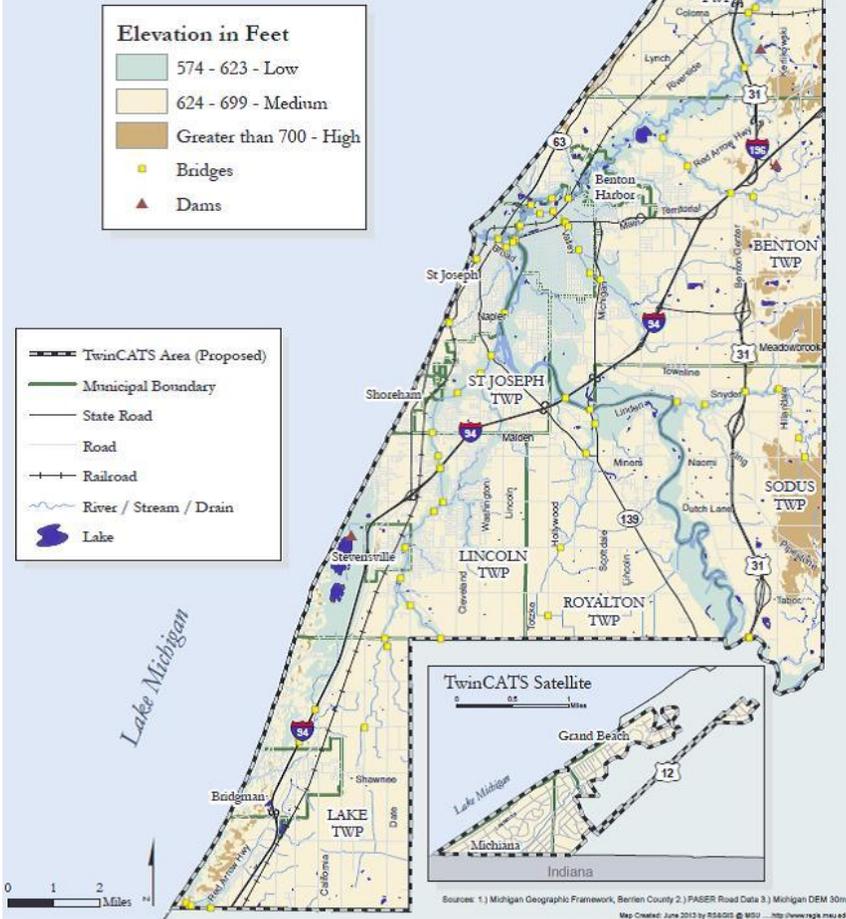
iv.



v.

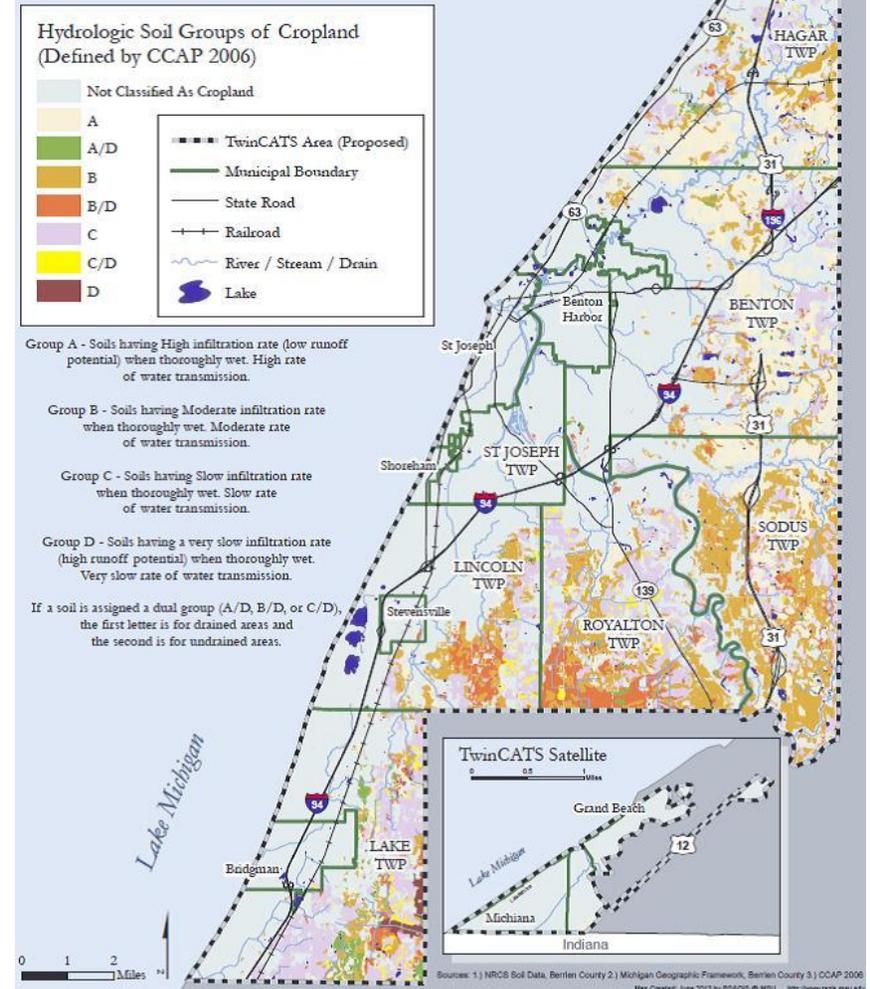
vi.

### Twin Cities Area Transportation Study (TwinCATS) Long Range Plan - Flood Risk

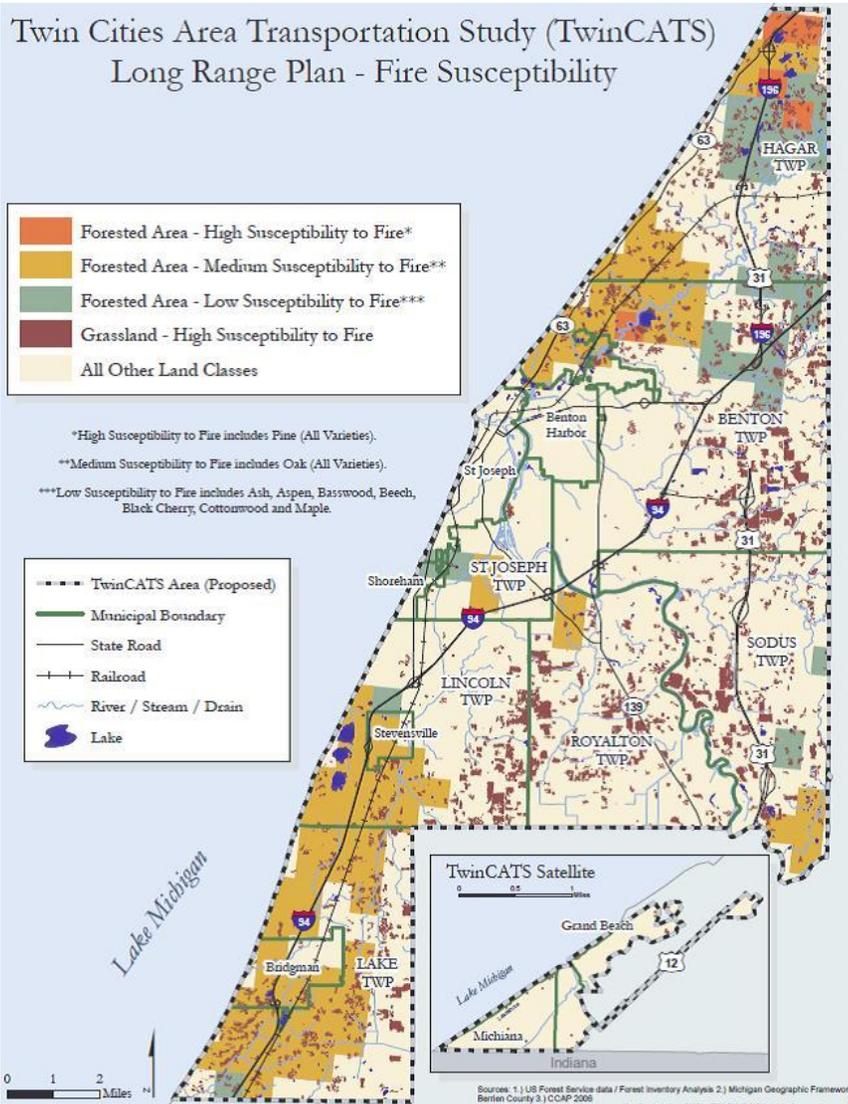


vii.

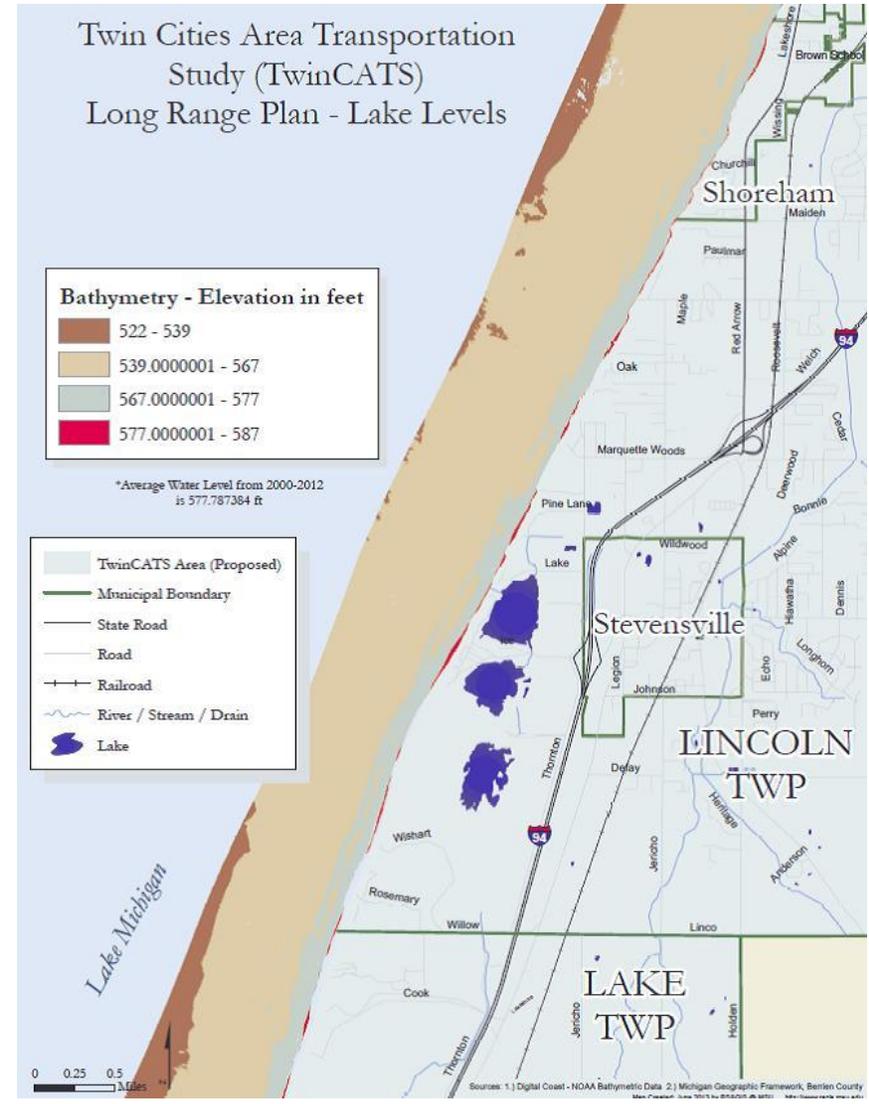
### Twin Cities Area Transportation Study (TwinCATS) Long Range Plan - Drought Risk



viii.

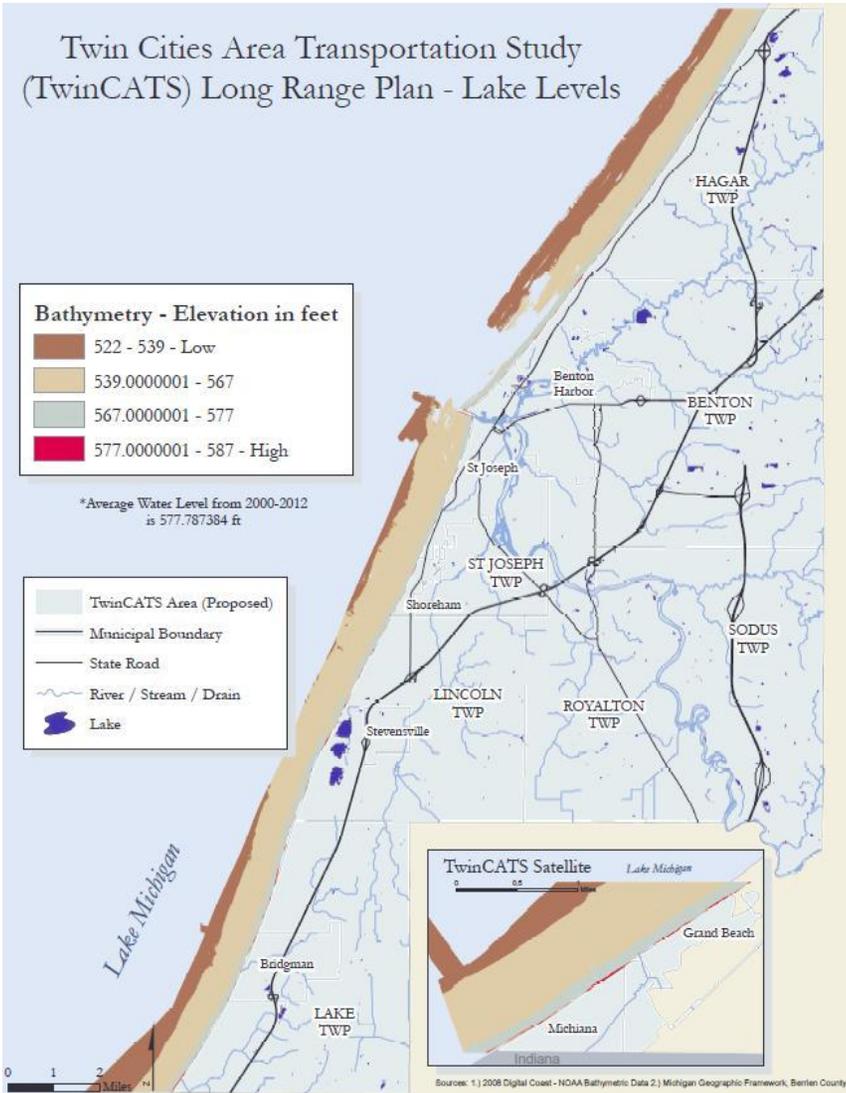


ix.



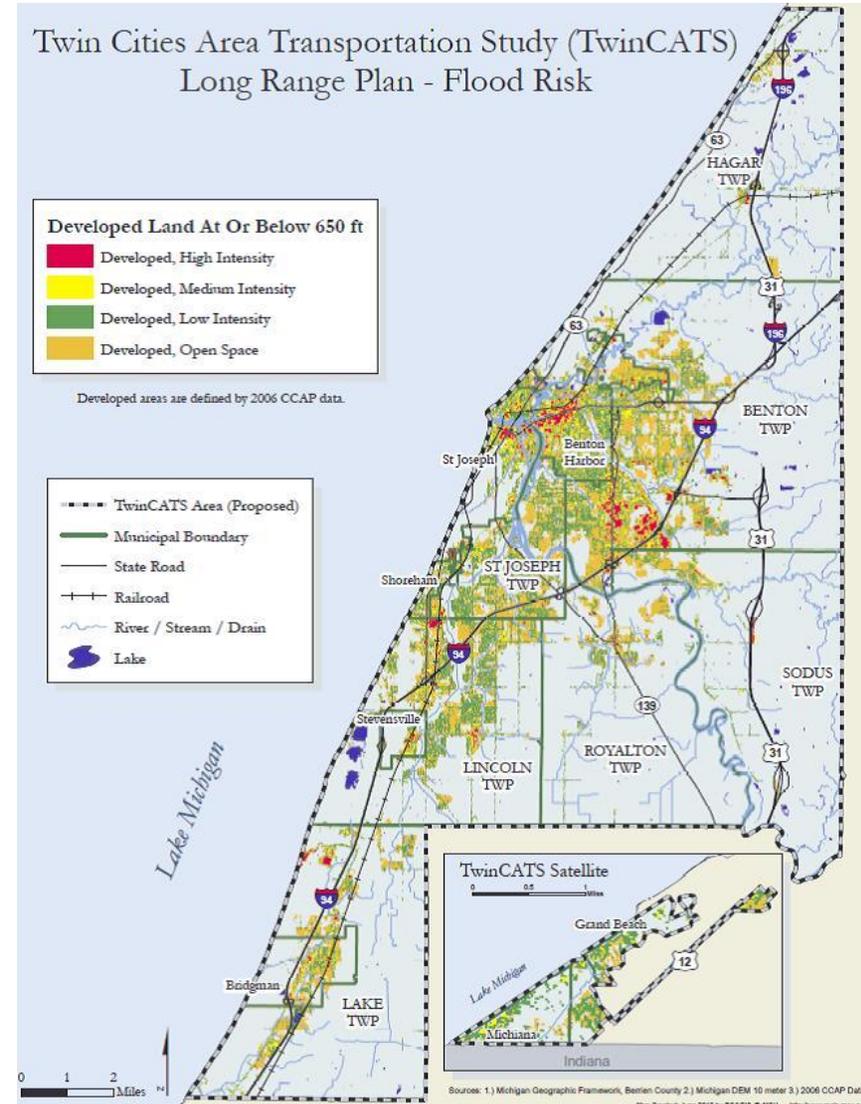
x.

### Twin Cities Area Transportation Study (TwinCATS) Long Range Plan - Lake Levels

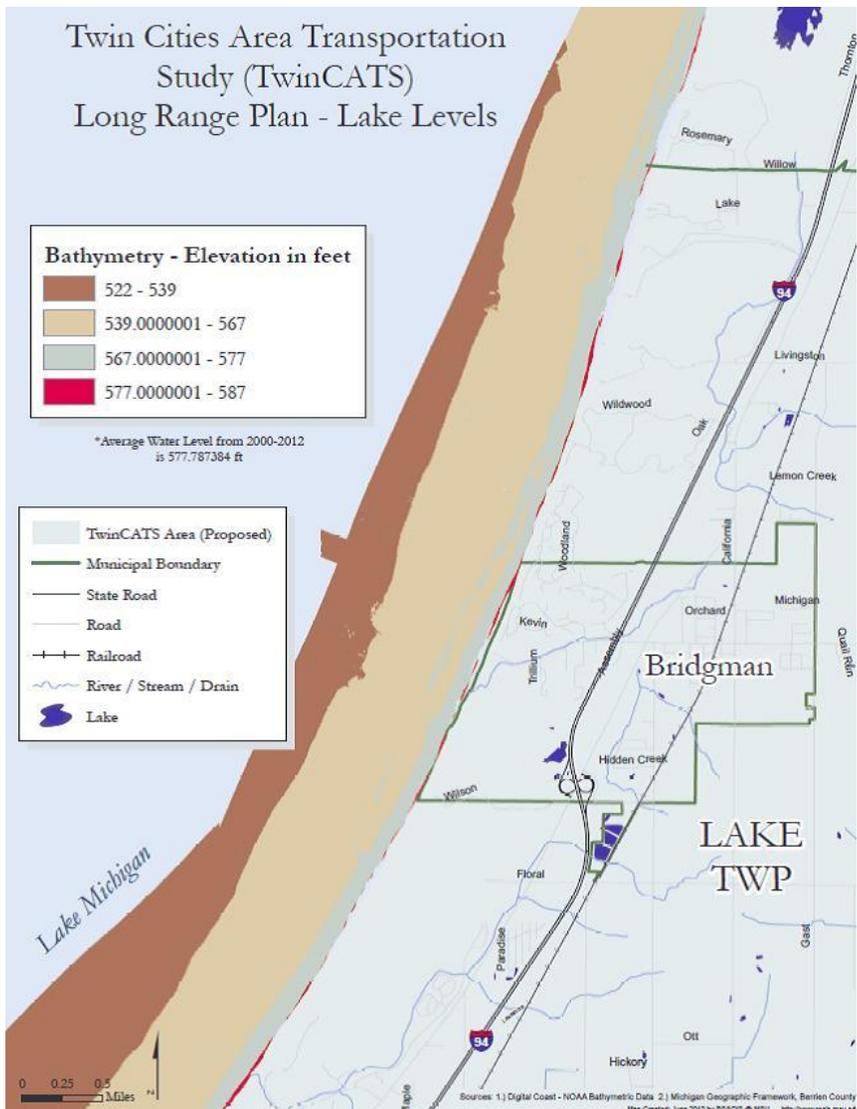


xi.

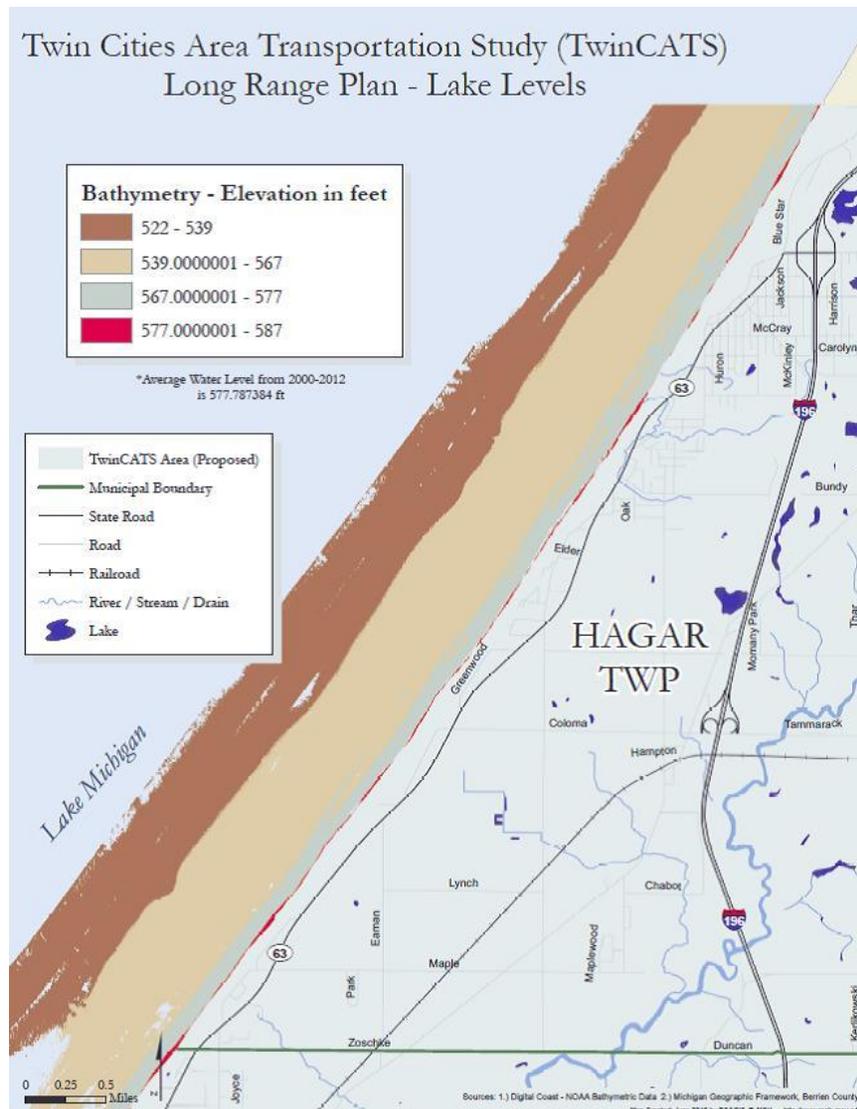
### Twin Cities Area Transportation Study (TwinCATS) Long Range Plan - Flood Risk



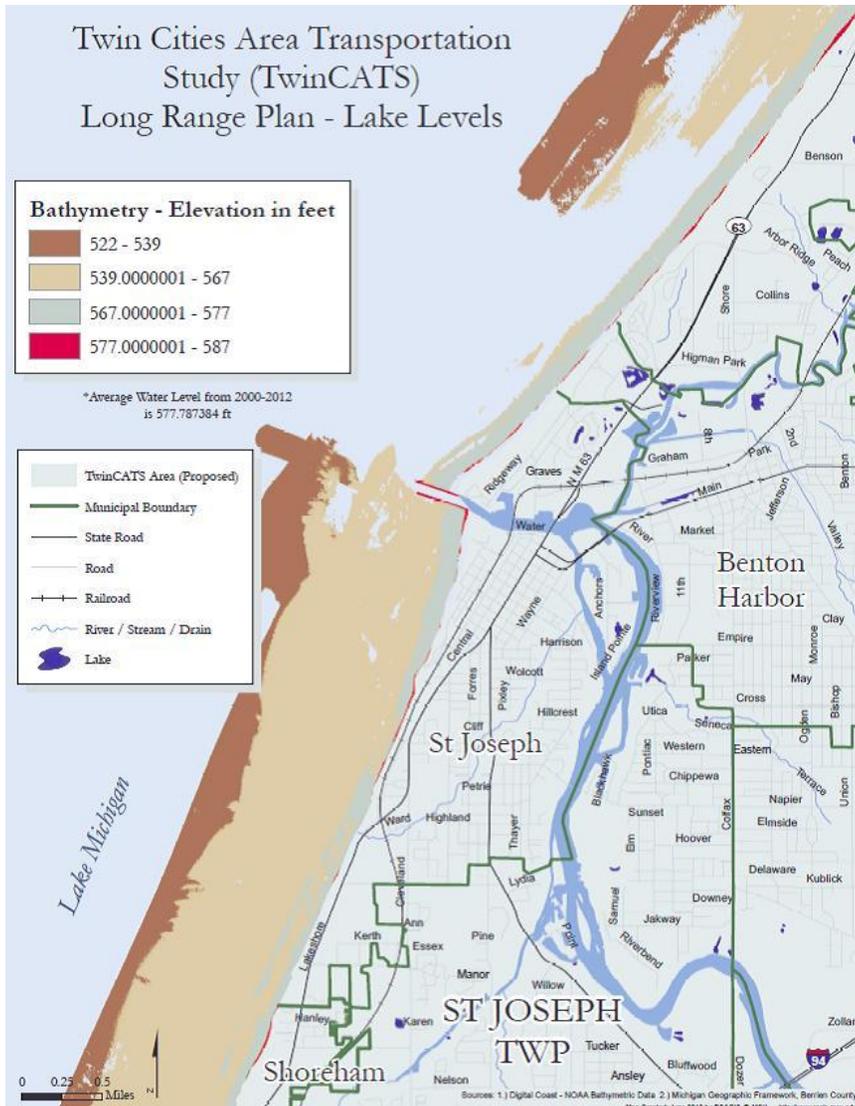
xii.



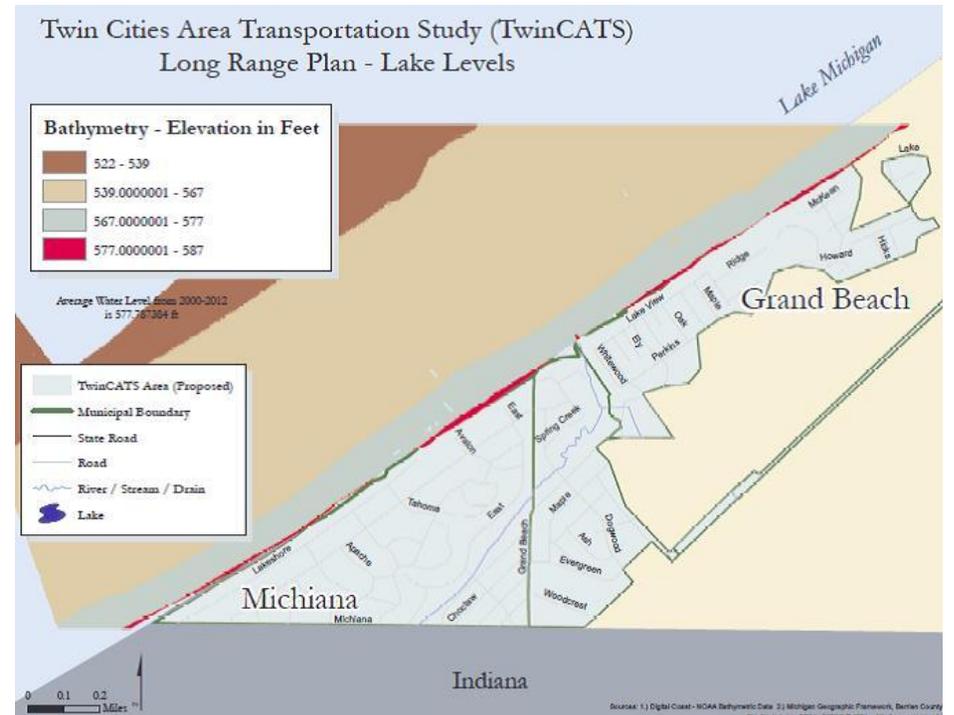
xiii.



xiv.



xv.



xvi.



## Appendix B: Citations

- Berrien County Office of Emergency Management; Southwestern Michigan Commission, Jan. 2005: "Berrien County Hazard Mitigation Plan." [www.swmpc.org](http://www.swmpc.org). Web. June-July 2013. <[http://www.swmpc.org/downloads/berrien\\_haz\\_mit.pdf](http://www.swmpc.org/downloads/berrien_haz_mit.pdf)>.
- Brooks, A.S. and J.C. Zastrow, 2002: "The Potential Influence of Climate Change on Offshore Primary Production in Lake Michigan". *Journal of Great Lakes Research*, 28(4): p. 597-607.
- Burnett, A.W., M. Kirby, H.T. Mullins, and W. Patterson, 2003: "Increasing Great Lake-Effect Snowfall during the Twentieth Century: A Regional Response to Global Warming?" *Journal of Climate*, 16(21): p. 3535-3542.
- D. Brown, J. Andresen, A. Pollyea, Editors. (2012). "Historical Climatology: Michigan Climatic Division 8: Southwest Lower Michigan". Great Lakes Integrated Sciences and Assessments (GLISA) Center, Great Lakes Climatic Divisions. [http://glisa.msu.edu/docs/climaticdivs/Michigan\\_Climatic\\_Division\\_8.pdf](http://glisa.msu.edu/docs/climaticdivs/Michigan_Climatic_Division_8.pdf)
- Dinse, Keely, Jen Read, and Don Scavia: "Preparing for Climate Change in the Great Lakes Region." [www.miseagrant.umich.edu](http://www.miseagrant.umich.edu). Michigan Sea Grant; University of Michigan, 27 Feb. 2009. Web. May-June 2013. [http://www.miseagrant.umich.edu/downloads/climate/Climate\\_Workshop\\_Report.pdf](http://www.miseagrant.umich.edu/downloads/climate/Climate_Workshop_Report.pdf)
- Dobiesz, N.E. and N.P. Lester, 2009: "Changes in Mid-Summer Water Temperature and Clarity Across the Great Lakes Between 1968 and 2002" *Journal of Great Lakes Research*, 35(3): p. 371-384.
- Drs. Sarah Nicholls and Dan McCole: "Michigan Tourism Year-in-Review and Outlook". Presented at "Pure Michigan Governor's Conference on Tourism" in Grand Rapids on March 27 2012.
- Federal Highway Administration: "Integrating Climate Change into the Transportation Planning Process." [Http://www.fhwa.dot.gov](http://www.fhwa.dot.gov), July 2008. Web. June-July 2013. [http://www.fhwa.dot.gov/environment/climate\\_change/adaptation/resources\\_and\\_publications/integrating\\_climate\\_change/climatechange.pdf](http://www.fhwa.dot.gov/environment/climate_change/adaptation/resources_and_publications/integrating_climate_change/climatechange.pdf)
- GLISA: "Climate Changes in the Great Lakes Region", [http://www.glisa.msu.edu/docs/fact\\_sheets/GLISA\\_climate\\_change\\_summary.pdf](http://www.glisa.msu.edu/docs/fact_sheets/GLISA_climate_change_summary.pdf)

- Great Lakes Integrated Sciences & Assessments Center (GLISA). 2013: "Climate Change in Southwest Michigan". [http://glisa.msu.edu/great\\_lakes\\_climate/background.php](http://glisa.msu.edu/great_lakes_climate/background.php).
- Hanrahan, J.L., S.V. Kravtsov, and P.J. Roebber, 2010: "Connecting Past and Present Climate Variability to the Water levels of Lakes Michigan and Huron". *Geophysical Research Letters*, 37(1): p. L01701.
- Hodgson, Campbell, and Baikley: "Urban Agriculture: Growing Healthy, Sustainable Places". Chicago IL: American Planning Association, 2011. Print.
- IPCC (Intergovernmental Panel on Climate Change). 2007: Summary for policymakers. In: "Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, UK, and New York. <http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf>
- Kahneman, Daniel: "Thinking, Fast and Slow. New York". Farrar, Straus and Giroux, 2011. Print.
- Karetnikov, D., M. Ruth, K. Ross, and D. Irani: "Economic Impacts of Climate Change on Michigan". The Center for Integrative Environmental Research, University of Maryland. 2009.
- Karl, T.R., J.M. Melillo, T.C. Peterson, and S.J. Hassol, 2009: "Global Climate Change Impacts in the United States". Cambridge University Press.
- Lamon, E.C. and C.A. Stow, 2010: "Lake Superior Water Level Fluctuation and Climatic Factors: A Dynamic Linear Model Analysis". *Journal of Great Lakes Research* 36(1): p.172-178.
- Lenters, J.D., 2001: "Long-term Trends in the Seasonal Cycle of Great Lakes Water Levels". *J. Great Lakes Res.*, 27(3): p. 342-353.
- Lofgren, B.M., T.S. Hunter, and J. Wilbarger, 2011: "Effects of Using Air Temperature as a Proxy for Potential Evapotranspiration in Climate Change Scenarios of Great lakes Basin Hydrology". *Journal of Great Lakes Research*, 37(4): p. 744-752.
- Marlon, J.R., Leiserowitz, A., and Feinberg, G., 2013: "Scientific and Public Perspectives on Climate Change". Yale University. New Haven, CT: Yale Project on Climate Change Communication.



- Michigan Department of Community Health Division of Environmental Health, 18 Jan. 2011: "Michigan Climate and Health Adaptation Plan 2010-2015 Strategic Plan." [www.michigan.gov](http://www.michigan.gov). Web. May-June 2013.  
[http://www.michigan.gov/documents/mdch/MDCH\\_climate\\_change\\_strategicPlan\\_final\\_1-24-2011\\_\\_343856\\_7.pdf](http://www.michigan.gov/documents/mdch/MDCH_climate_change_strategicPlan_final_1-24-2011__343856_7.pdf)
- Michigan Department of Transportation, July 2013: "Michigan Freight Plan Draft." P. 45-48, 65. [www.michigan.gov](http://www.michigan.gov). Web. July 2013.  
<[http://www.michigan.gov/documents/mdot/MDOT\\_I-19\\_Intro\\_Narative\\_426678\\_7.pdf](http://www.michigan.gov/documents/mdot/MDOT_I-19_Intro_Narative_426678_7.pdf)>.
- Michigan Department of Transportation, Sept. 2011: "Michigan State Rail Plan." P. 4, 11. [www.michigan.gov](http://www.michigan.gov). Web. May-June 2013.  
<[http://www.michigan.gov/documents/mdot/MDOT\\_MI\\_SRP\\_public\\_review\\_draft\\_2011-05-23\\_600dpi\\_353776\\_7.pdf](http://www.michigan.gov/documents/mdot/MDOT_MI_SRP_public_review_draft_2011-05-23_600dpi_353776_7.pdf)>.
- National Climatic Data Center, N.C.D.C, 2012: "GHCN (Global Historical Climatology Network) – Daily".
- National Research Council (NRC), 2010: "America's Climate Choices: Adapting to the Impacts of Climate Change".  
[http://www.nap.edu/catalog.php?record\\_id=12783](http://www.nap.edu/catalog.php?record_id=12783)
- Natural Resource Program Center, National Park Service, U.S. Department of the Interior. 2010: "Understanding the Science of Climate Change. Talking Points – Impacts to the Great Lakes". Natural Resource Report NPS/NRPC/NRR – 2010/XXX.  
<http://www.nps.gov/climatechange/docs/GreatLakesTP.pdf>
- Pendleton, E.A., E.R. Thieler, and S.J. Williams, 2010: "Importance of Coastal Change Variables in Determining Vulnerability to Sea- and Lake-Level Change". *Journal of Coastal Research*: p. 176-183.
- Raja, Samina; Branden M. Born, and Jessica Kozlowski. Russell: "A Planners Guide to Community and Regional Food Planning: Transforming Food Environments, Facilitating Healthy Eating" p. 97-8. Chicago, IL: American Planning Association, 2008. N. p. Print
- Schwab, James: "Hazard Mitigation: Integrating Best Practices into Planning". Chicago, IL: American Planning Association, 2010. Print.
- Southwest Michigan Planning Commission, Apr. 2009: "Twin Cities Area Transportation Study Long Range Transportation Plan 2009-2035." [www.swmpc.org](http://www.swmpc.org). Web. June-July 2013. [http://www.swmpc.org/twincats\\_docs.asp](http://www.swmpc.org/twincats_docs.asp)



- Southwest Michigan Planning Commission, July 2013: "What Moves You, TwinCATS? - 2013-2040 Long Range Transportation Plan for the Twin Cities Area Transportation Study." [www.swmpc.org](http://www.swmpc.org/downloads/final_twincats_plan.pdf). Web. July 2013. <[http://www.swmpc.org/downloads/final\\_twincats\\_plan.pdf](http://www.swmpc.org/downloads/final_twincats_plan.pdf)>.
- Superior Watershed Partnership, 2012: "Lake Superior Climate Adaptation Mitigation and Implementation Plan." [Http://www.superiorwatersheds.org](http://www.superiorwatersheds.org). Web. May-June 2013.
- The Great Lakes Integrated Sciences and Assessments (GLISA): "Great Lakes Climate", [http://glisa.msu.edu/great\\_lakes\\_climate/background.php](http://glisa.msu.edu/great_lakes_climate/background.php)
- Transportation Research Board; National Research Council of the Academies : "Transportation Research Board Special Report 290: Potential Impacts of Climate Change on U.S. Transportation." p. 147-151, 161, 168, 189-207. [Onlinepubs.trb.org](http://onlinepubs.trb.org), 2008. Web. May-June 2013. <<http://onlinepubs.trb.org/onlinepubs/sr/sr290.pdf>>
- U.S. Department of Transportation, 2013: "U.S. Department of Transportation Climate Adaption Plan: Ensuring Transportation Infrastructure and System Resilience", p. 7, Web. May-June 2013. < <http://www.dot.gov/sites/dot.dev/files/docs/DOT%20Adaptation%20Plan.pdf>>
- Wang, J., X. Bai, H. Hu, A. Clites, M. Colton, and B. Lofgren, 2011: "Temporal and Spatial Variability of Great lakes Ice Cover, 1973-2010\*". *Journal of Climate*, 25(4): p.1318-1329.
- Winkler, J.A., R.W. Arritt, and S.C. Pryor, 2012: "Climate Projections for the Midwest: Availability, Interpretation and Synthesis". In: U.S. National Climate Assessment Midwest Technical Input Report. J. Winkler, J. Andresen, J. Hatfield, D. Bidwell, and D. Brown, coordinators. Great Lakes Integrated Sciences and Assessments (GLISA) Center. [http://glisa.msu.edu/docs/NCA/MTIT\\_Future.pdf](http://glisa.msu.edu/docs/NCA/MTIT_Future.pdf)
- Wright, D.M., D.J. Posselt, and A.L. Steiner, 2012: "Sensitivity of Lake-Effect Snowfall to Lake Ice Cover and Temperature in the Great Lakes Region". *Monthly Weather Review*, 141(2): p. 670-689.
- Wuebbles, D.L. and K. Hayhoe. 2003: "Climate Change Projections for the United States Midwest. Mitigation and Adaptation Strategies for Global Change" 9: 335-363. <http://www.springerlink.com/content/k066717671581161/>

