CONSIDERATION OF THE IMPACT OF CLIMATE CHANGE ON LAKE LEVELS IN THE MANAGEMENT PLAN OF TRIBAL FISHERIES AND CULTURALLY IMPORANT SITES

GREAT LAKES WATER LEVELS INTEGRATED ASSESSMENT PHASE II REPORT

GRAHAM SUSTAINABILITY INSTITUTE
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EXECUTIVE SUMMARY

Coastal wetland ecosystems provide spawning grounds, food sources, and protective habitat for numerous fish species in the Great Lakes. While water level fluctuations within the Great Lakes are actually key to maintaining the biodiversity of coastal wetland ecosystems (Environment Canada & Wilcox 2002), long-term and sustained trends in water levels can result in a reduction of wetland biodiversity, placing considerable stress on the fish communities that depend up on these wetland ecosystems. Environmental drivers such as temperature, precipitation, run-off and evaporation play important roles in modulating Great Lakes water levels and are likely to experience changes in light of a warming climate. Considering that Great Lakes fisheries support a broad range of commercial, subsistence and recreational activities, communities which depend upon these fisheries must assess the implications of our changing climate on Great Lakes water level trends.

A number of unique challenges are faced by Indigenous Tribes within the Great Lakes Region with respect to the development of climate adaptation planning for their communities. The sovereignty and jurisdiction of Tribal governments, Tribal economic capacity, as well as cultural and spiritual considerations must be applied in any strategy that seeks to protect the Indigenous ways of life in the face of a changing climate. For this reason, Indigenous Tribes represent important collaborators in the Graham Sustainability Institute's Great Lakes Water Levels Integrated Assessment Plan (Graham Sustainability Institute 2014), a comprehensive effort to "develop information, tools and partnerships to help decision makers address the challenges and opportunities posed by the variability in Great Lakes water levels."

Through this project, we are working collaboratively with two federally-recognized Indigenous Tribes within the State of Michigan, the Little Traverse Bay Bands of Odawa Indians (LTBB) and the Grand Traverse Band of Ottawa and Chippewa Indians (GTB), to include the consideration of the impact of climate change on lake levels in the management plan of Tribal fisheries and in the protection of culturally important sites. An exciting element of this collaborative effort is that it provides a unique opportunity to address this topic with a blend of "western science" and "Indigenous science" approaches. Traditional Indigenous approaches to understanding natural science involve the observation of nature and the relations of elements of the natural system with other elements within the system, as opposed to the more linear measurement and theoretical approaches often applied as part of "western science".

The stated purpose of Phase II of the Graham Sustainability Institute's (GSI) Lake Levels Integrated Assessment (IA) is to identify and analyze viable policies and adaptive actions that respond to the GSI IA Question: What environmentally, socially, politically, and economically feasible policy options and management actions people, businesses, and governments can implement in order to adapt to current and future variability in Great Lakes water levels. We are still in the early phases of identifying potential options for each of the Tribes that are collaborating on our project. As a result, this report provides information on the identification of potential adaptive actions, though a full analysis of options and/or determination of preferred options by the Tribes has not been conducted at the time of this writing.

INTRODUCTION

The stated goal of Phase I of the Graham Sustainability Institute's Great Lakes Water Levels Integrated Assessment Plan was to provide an overview synthesis of the status, trends, causes and consequences of changing water levels as they relate to key issues for a particular locality/community. For our project, we have worked with the Tribal communities of the Little Traverse Bay Bands of Odawa Indians (Harbor Springs, MI) and the Grand Traverse Band of Ottawa and Chippewa Indians (Peshawbestown, MI).

Fishing is of great economic, recreational and cultural importance to the Indigenous Tribes within the State of Michigan. Tribal fishing activities are regulated through the 2000 Federal Consent Decree (United States 2000), which details how fishing in the 1836 Treaty waters will be allocated, managed and regulated by State of Michigan and the following federally-recognized tribes within the State of Michigan: the Bay Mills Indian Community, the Sault Ste. Marie Tribe of Chippewa Indians, the Grand Traverse Band of Ottawa and Chippewa Indians, the Little River Band of Ottawa Indians and the Little Traverse Bay Bands of Odawa Indians. The 2000 Federal Consent Decree will expire in 2020. The 2020 Federal Consent Decree likely will dictate how fishing in the 1836 Treaty waters will be regulated through the next 20 years, a period which is expected to experience potentially significant climatic changes within the 1836 Treaty area (GLISA 2014). Currently predicted changes in our regional climate will have the potential to impact coastal wetland ecosystems and thus the number, species diversity and distribution of fish species within Great Lakes fisheries, important considerations for Indigenous Tribes as they enter negotiations associated with the 2020 Federal Consent Decree.

While our average global climate is expected to continue to warm through the end of this century (IPCC, 2014), the anticipated regional patterns in temperature and precipitation are more complex. Efforts to understand the impact of these anticipated patterns on future Great Lakes water levels have required scientists to use the information provided by coarse-resolution global climate models in concert with fine-scale regional-scale models, the latter of which more explicitly describe the environmental drivers believed to control Great Lakes water levels (e.g., Angel and Kunkel, 2010; Hayhoe *et al*., 2010). Given the differences in the assumptions used to develop these regional models, in particular the description of potential evapotranspiration (PET) and its impact on surface lake water evaporation, the predicted impact of future climates on Great Lakes water levels derived from these regional models varies considerably in both magnitude and direction (Lofgren et al., 2011). At best, it would appear that these different lake level predictions can be looked upon as "plausible" futures, without regard to selecting any single result as "most likely".

Given that the uncertainties associated with the calculation of PET in regional global models, our efforts on Phase I of this project focused upon the analyses of <u>observed</u> relationships between Lake Michigan-Huron water levels and a number of large-scale atmospheric phenomenon (e.g., Arctic Oscillation, North Atlantic Oscillation), which might be more easily predicted by global climate models. In our analyses, we found statistically significant correlations between the Pacific Decadal Oscillation (PDO) (R^2=0.13, P<0.05, two-tailed) and Polar Eurasia (PE) (R^2=0.10P<0.05, two-tailed) indices for a given October through May "winter season" and the Lake Michigan-Huron water levels for the given October through May "winter season". The PDO is a shift in the temperature patterns of the North Pacific Ocean which occurs on a 20-30 year cycle. The PE is related to anomalies in upper level height patterns which impact the strength of the polar vortex. We also found statistically significant correlations between a given October through May "winter season" PDO (P<0.05, two-tailed) and PE (P<0.05, two-tailed) indices and the Calendar Year Lake

Michigan-Huron water levels. Statistically significant correlations were also found between the PE and Lake Michigan and Huron maximum "winter season" ice extent ($P < 0.01$ for each, two-tailed). Unfortunately, as noted by Mantua and Hare (2002), the mechanisms which cause variability in the PDO, as one example, are not well understood. As a result, we felt that even though significant correlations were found between Great Lakes water levels and the aforementioned large scale atmospheric patterns, it may be some time before the long-term prediction of such teleconnection patterns can be accomplished with sufficient confidence that such predictions can be used to infer potential lake level futures.

Later in our Phase I work, our analyses were directed by the work of Martin (2015) who investigated the shrinkage of the wintertime Northern Hemisphere polar cold pool over the past six decades. We then extended Martin's analysis to look at the potential linkage between the climate-related shrinking of the Northern Hemisphere, lower-tropospheric, wintertime cold pool and trends in the maximum extent of Lake Michigan-Huron ice coverage and Lake Michigan-Huron water levels. These analyses suggested that while there was inherent variability in the data, a statistically significant relationship existed which suggested that the long-term trend of declining area extent of the polar cold pool suggests the potential for future average Lake Michigan-Huron water levels approaching 186.0 meters.

The stated purpose of Phase II of the Graham Sustainability Institute's Lake Levels Integrated Assessment is to identify and analyze viable policies and adaptive actions that respond to the GSI IA Question: What environmentally, socially, politically, and economically feasible policy options and management actions people, businesses, and governments can implement in order to adapt to current and future variability in Great Lakes water levels. We are still in the early phases of identifying potential options for each of the Tribes that are collaborating on our project. As a result, this report provides information on the identification of potential adaptive actions, though a full analysis of options and/or determination of preferred options by the Tribes has not been conducted at the time of this writing. In order to provide an assessment of a range of plausible climate futures, we are using an approach that considers plausible futures which include extreme low water levels (as suggested by our Phase I analysis) and high water levels which are consistent with the highest persistent lake water levels which have been observed for the Lake Michigan-Huron system.

Finally, for completeness and as suggested by the Phase II reporting guidelines, we provide some repeat findings from our Phase I report to provide context for this report.

STATUS AND TRENDS

Monthly Lake Michigan-Huron Water Levels

Given that the ultimate goal of the Graham Sustainability Institute's Great Lakes Water Levels Integrated Assessment Plan is to help communities develop plans to address the impacts of changing Great Lakes water levels under plausible future climates, a necessary step is to assess the past trends in these levels. For our project, trends in both the mean and variability of Lake Michigan-Huron water levels are of importance. Derived from Master Gage data provided by the Great Lakes Environmental Research, Figure 1 presents the monthly average water levels for the Lake Michigan-Huron system. The dotted read line in the figure represents the linear trend over the period shown (R^2=0.21, P<0.01, two-tailed). As can be seen, while there is considerable variability, the overall trend is one of decreasing water levels, particularly after 1986, which was the start of a nearly two year period of El Nino conditions.

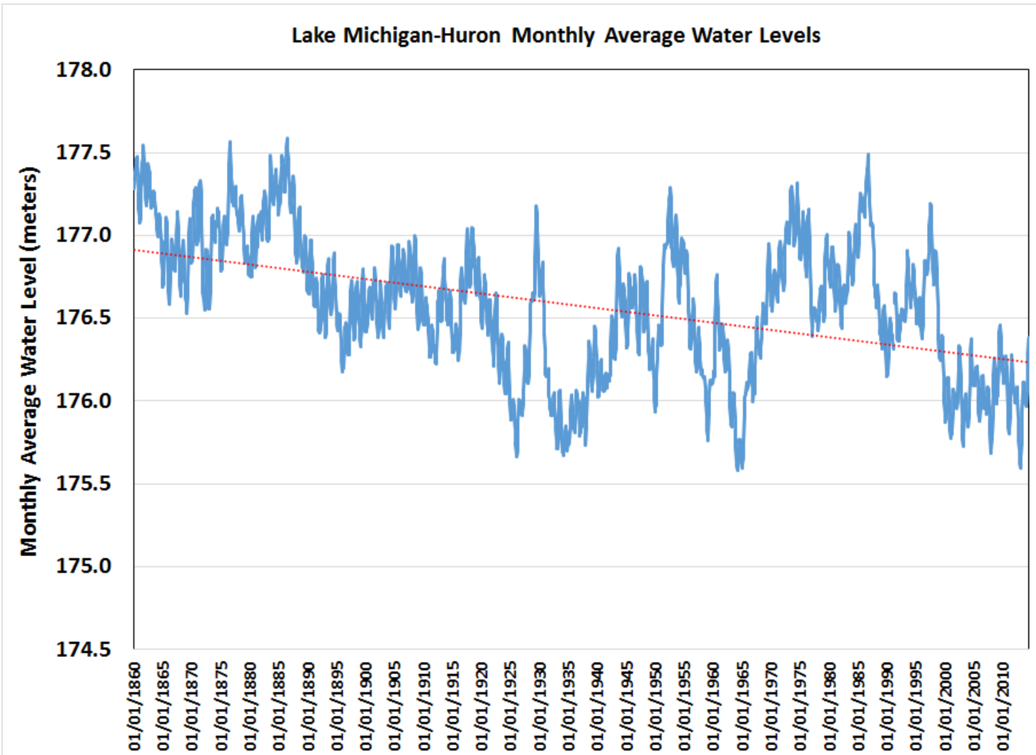

Figure 1. Lake Michigan-Huron Monthly Average Water Levels (Master Gage Data, Great Lakes Environmental Research Laboratory)

Using 30-year climatological periods, the average water levels for the system are as follows: 1861-1890 (177.05 meters), 1891-1920 (176.60 meters), 1921-1950 (176.25 meters), 1951-1980 (176.55 meters) and 1981-2010 (176.46 meters). In a similar manner, the variability (as expressed by standard deviation) over these same sequential 30-year climatological periods was calculated, and are as follows: 1861-1890 (0.23 meters), 1891-1920 (0.19 meters), 1921-1950 (0.32 meters), 1951-1980 (0.41 meters) and 1981-2010 (0.40 meters).

This analysis therefore suggests that the Lake Michigan-Huron system has experienced a decrease in monthly average water levels of approximately 1.5 meters over the period of record, with a general increase in the 30-year period variability from approximately 0.20 meters at the beginning of the past century to approximately 0.40 meters over this same period. For this report, we did not perform an analysis in the periodicity of water level variability.

CAUSES AND CONSQUENCES

Lake Michigan-Huron Water Levels

Environmental Drivers

As described earlier, the primary environmental drives for the water levels in the Lake Michigan-Huron system are precipitation, run-off and evaporation. Using data from the Great Lake Environmental Research Laboratory (GLERL), we have analyzed each of these parameters to obtain a better understanding of the potential reasons for the long-term trend in mean water level decrease for the system. While the length of the data periods vary, we can still obtain a substantive view of trends in these parameters.

In Figure 2, the annual over-lake precipitation (in mm) for the Lake Michigan-Huron system, we can see that there has been statistically significant trend of increasing precipitation over the lakes. The dotted read line in the figure represents the linear trend over the period (R^2=0.17, P<0.01, two-tailed).

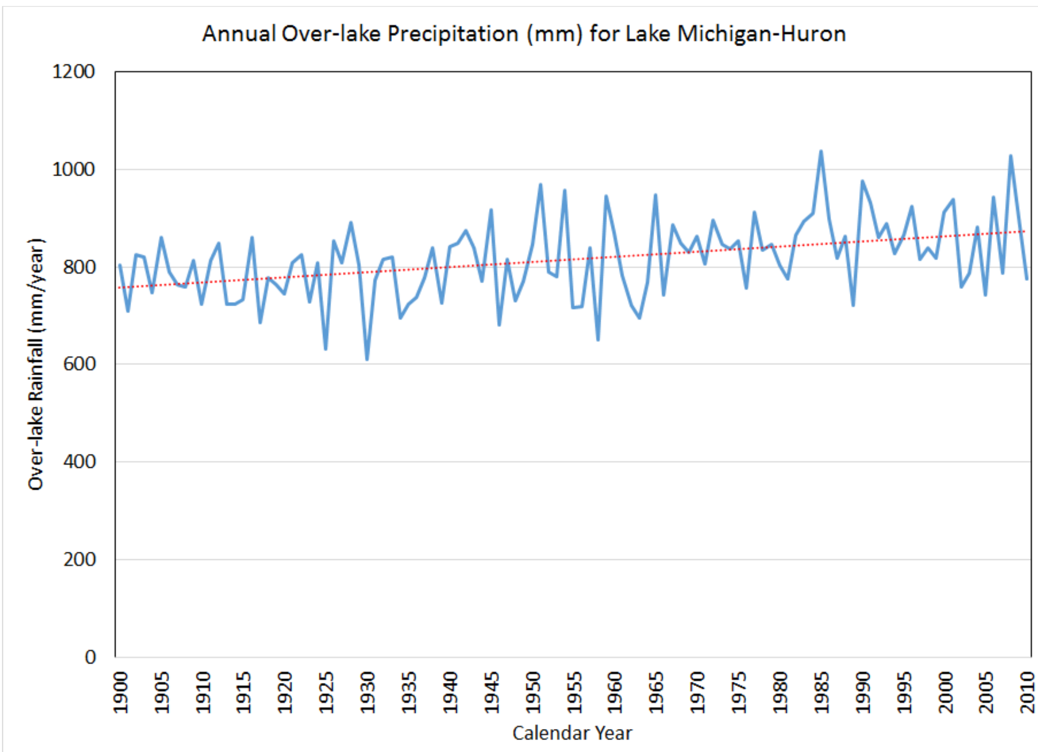

Figure 2. Annual Over-lake Precipitation (mm) for Lake Michigan-Huron.

As might be expected under a regime of increasing precipitation, the reported run-off for the two lake system has also been increasing (Figure 3). The dotted read line in the figure represents the linear trend over the period (R^2=0.05, P<0.10, two-tailed). Despite the long-term increase, it would appear that the rate of increase as slowed since around 1990.

The increases in precipitation and run-off into the lakes are counter to the observed general decrease in water levels for the system. Though not plotted, GLERL data for flow from Lake Huron to Lake St. Clair does show a slight increase over the period. The flow data from Lake Michigan-Huron to Chicago, again not plotted here, is significantly lower in volume.

The last major environmental driver to consider is over-lake evaporation, which is presented in Figure 4. The dotted read line in the figure represents the linear trend over the period (R^2=0.13, P<0.01, two-tailed). As can be seen, though the overall trend in the predicted over-lake evaporation has shown a statically significant increase, much of this increase appears to have occurred since around 1980. The timing of this increasing rate of over-lake evaporation is consistent with the observed significant decrease in average lake levels for the Lake Michigan-Huron system over this same thirty-year time period, underscoring the important role for evaporation in explaining the recent trend in decreasing lake levels.

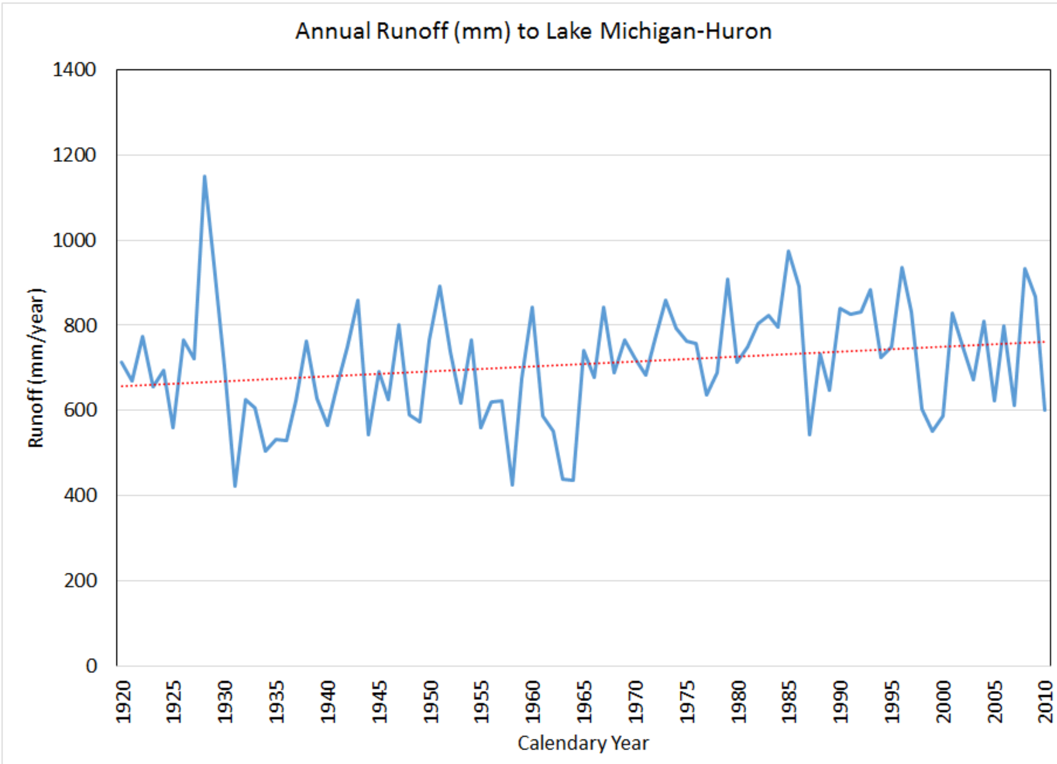

Figure 3. Annual Run-off (mm) for Lake Michigan-Huron.

As with the other drivers, there is considerable year-to-year variability in the observed times-series. Lenters et al. (2013) provide an extensive discussion on the complexities of such a lake level/evaporation relationship and how the timing of early season meteorological conditions can greatly impact overall seasonal evaporation. For example, conditions leading to strong evaporation during the early fall could help to cool the surface water temperatures sufficiently to limit evaporation in the late fall due to a reduced air-water temperature difference. Or in contrast, warmer temperatures during early fall in another year, might result in a delay in the cooling of surface waters and onset of seasonal lake ice, leading to significant evaporation occurring during the late fall when increasingly cold air moves through the region.

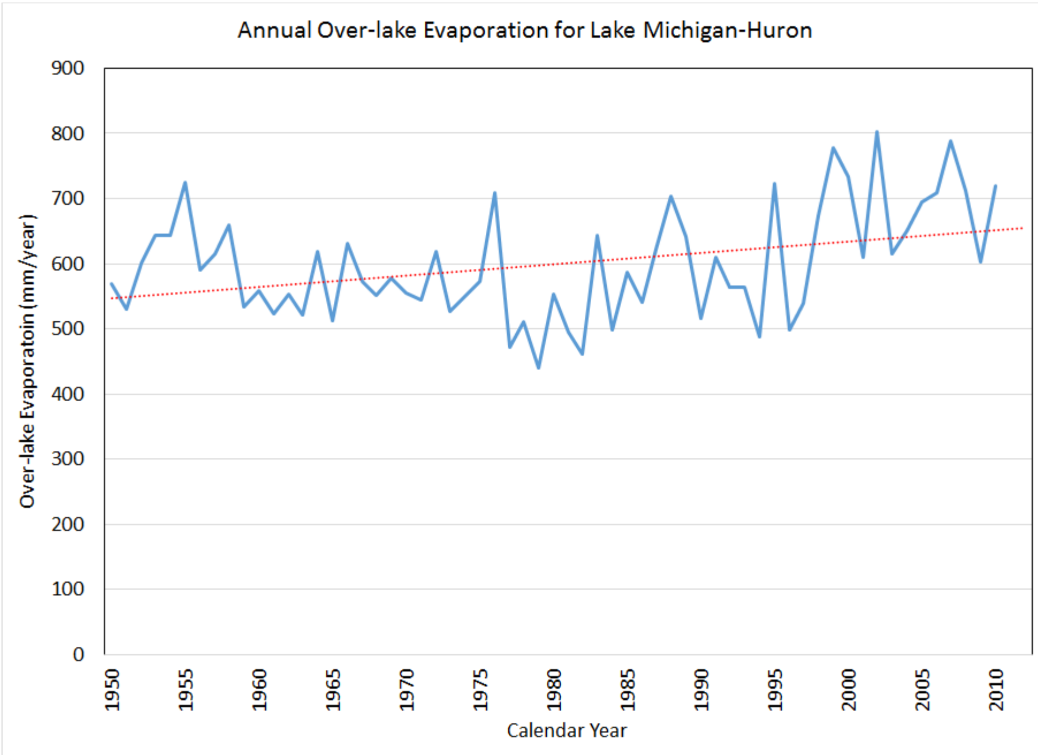

Figure 4. Annual Over-lake Evaporation (mm) for Lake Michigan-Huron.

Large-scale Influences on Environmental Drivers

<u>Teleconnections</u>

A major goal of this project will be to develop a set of "plausible climate scenarios" to use in the development of adaptation strategies for our Tribal collaborators. Given the important role of evaporation as a key driver in the determination of lake water levels, a logical next step in the process would be to use regional climate models to project potential trends in evaporation (and other important environmental drivers of lake water levels) under future plausible climates. However, as noted above, the approaches used to describe/quantify the evaporation process in regional climate models are currently debated and these different approaches lead to distinctly different projections for future water level scenarios.

Our group discussed that an alternate approach for determining plausible climate scenarios might be to link these historical variations in lake water levels with larger-scale atmospheric signals such as atmospheric teleconnections (El Nino/Southern Oscillation, Arctic Oscillation, North Atlantic Oscillation, etc.) that influence the important drivers of evaporation. First, we performed a set of simple correlations analyses using both Lake Michigan-Huron water level data, ice cover data and teleconnection indices data from GLERL data portal. Given that the period of October through May captures occurrences of ice on the Great Lakes, we used these months to define what was, admittedly, an extended "winter season" range in our comparison of lake water levels, maximum ice coverage and teleconnection indices. Additionally, when comparing the teleconnection indices against the Lake Michigan-Huron water levels, we used two measures of lake water levels: (a) the average Lake Michigan-Huron water levels during the same October through May period used to determine maximum ice coverage and average teleconnection values, and (b) the average Lake

Michigan-Huron water levels for the entire Calendar Year which included the end of a given "winter season". For example of this latter category, for the "winter season" covered by October 2000 to May 2001, the comparison was made with the average water levels during Calendar Year 2001. This Calendar Year water level variable was used to acknowledge that there is often a lag in the impact of winter season conditions and observed lake water levels.

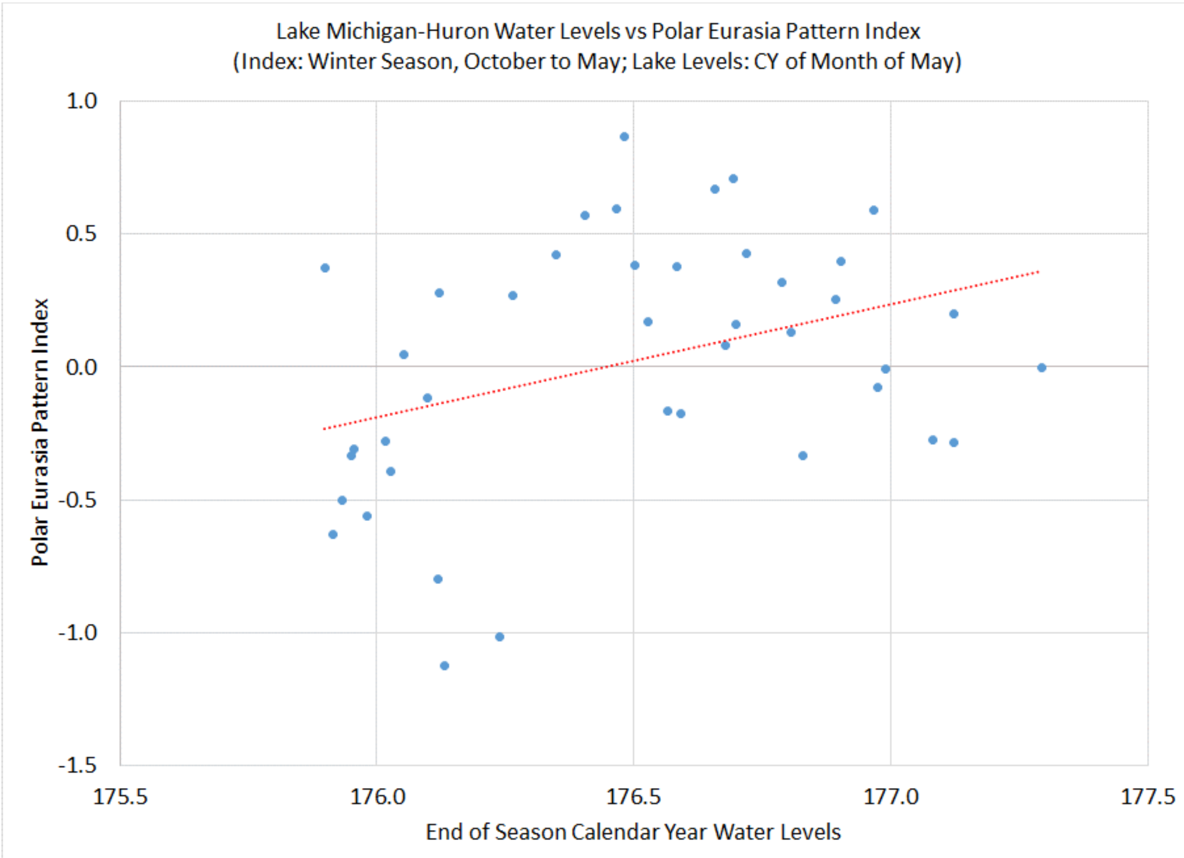

Figure 5. Annual Over-lake Evaporation (mm) for Lake Michigan-Huron.

In our analyses, we found statistically significant correlations between the Pacific Decadal Oscillation (PDO) (R^2=0.13, $P<0.05$, two-tailed) and Polar Eurasia (PE) (R^2=0.10$P<0.05$, two-tailed) indices for a given October through May "winter season" and the Lake Michigan-Huron water levels for the given October through May "winter season". The PDO is a shift in the temperature patterns of the North Pacific Ocean which occurs on a 20-30 year cycle. The PE is related to anomalies in upper level height patterns which impact the strength of the polar vortex. We also found statistically significant correlations between a given October through May "winter season" PDO ($P<0.05$, two-tailed) and PE ($P<0.05$, two-tailed) indices and the Calendar Year Lake Michigan-Huron water levels. Statistically significant correlations were also found between the PE and Lake Michigan and Huron maximum "winter season" ice extent ($P < 0.01$ for each, two-tailed). Unfortunately, Mantua and Hare (2002) note that the mechanisms which cause variability in the PDO, as one example, are not well understood. As a result, even if significant correlations can be found, it may be some time before the long-term prediction some teleconnection patterns can be accomplished with sufficient confidence that such predictions can be used to infer potential lake level futures.

A number of researchers have performed more detailed analysis on the relationships between Great Lakes water levels and atmospheric teleconnection patterns (e.g., Fyfe *et al*., 1999; Gillette *et al*., 2002; Ghanbari & Bravo, 2008; and Dogen, 2015). For example, Ghanbari and Bravo (2008) found significant correlations between frequencies of variations in Great Lakes water levels and the frequencies of variations in a number of traditional teleconnection indices. Dogan (2015) found statistically significant relationships between changes in *trends* of water levels and other environmental drivers and the timing of changes in the trends of the North Atlantic Oscillation (NAO). According to the Climate Prediction Center, the NAO is associated with basin-wide changes in the intensity and location of the North Atlantic jet stream and storm track relates the patterns. Despite the positive direction of such research, we felt that the complex nature of the published relations between Great Lakes water levels and teleconnection indices would not necessarily provide us with strong predictive capabilities upon which to develop a set of plausible climate futures.

Shrinking of Polar Ice Cover

We believe that a recent study reported by Martin (2015) could provide us with a very promising set of relationships which could be used to develop a set of plausible climate futures upon which to base our further work. This approach is attractive in that the relationships are rather straightforward and based upon temperature, a variable easily predicted by global climate models.

In his work, Martin (2015) sought to investigate trends in the areal extent of the Northern Hemisphere, lower-tropospheric, wintertime cold pool over the past 66 years. Using model reanalysis data, Martin determined the areal extent (in square kilometers) that would be enclosed by series of temperature contours (centered about the North Pole) at the 850-mb level (approximately 1000 to 1500 meters above the ground). An example of the areal extent encompassed by a -5˚C contour during a typical winter day is provided in Figure 6 below.

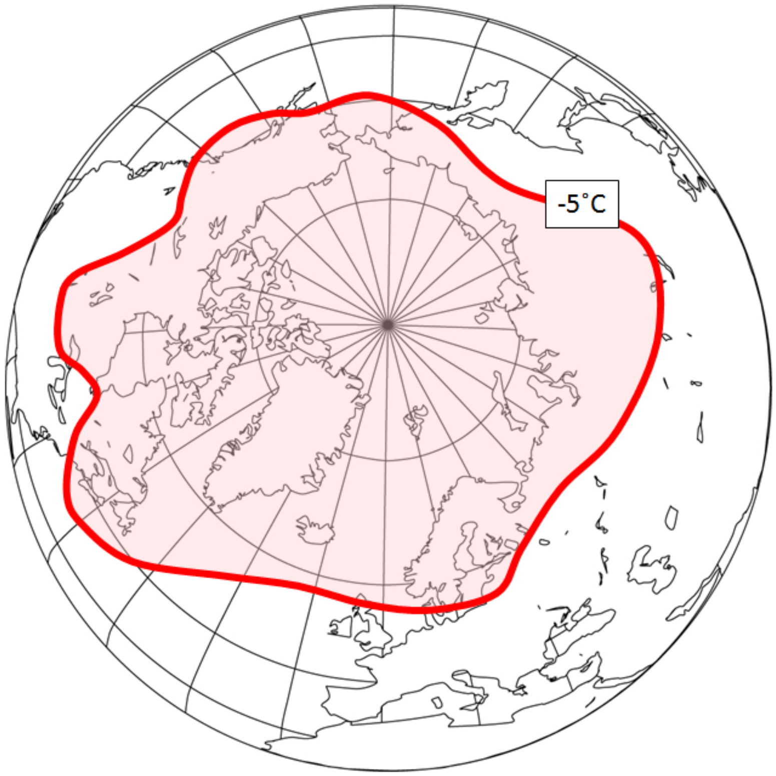

Figure 6. Example of the areal extent of region covered by a typical -5˚C contour at the 850-mb level during the Northern Hemisphere winter season.

The value of this analysis to our project is as follows. Air masses obtain the characteristics of the surfaces over which they form and reside for long periods of time. The Bergeron classification scheme, the most widely used form of air mass classification, typically characterizes and air mass based upon temperature and moisture content. The winter-time air masses which are most likely to drive strong evaporation from the Great Lakes waters are those that are cold (creating a strong temperature gradient with the relatively warm waters) and dry (creating an obviously strong moisture gradient). Air masses with these characteristics are generally termed continental polar (cP) and continental arctic (cA), forming north of approximately 66˚N latitude in the region where there is no/limited sunlight during the winter and where there is extensive snow and ice cover. In recent years, the extent of Arctic Sea ice has been decreasing, a likely result of our warming global climate (Figure 7). Thus, if the future trend is for a warming climate, then (a) the Arctic Sea ice extent will likely continue to decrease, (b) the reduction of Arctic Sea ice extent will likely lead to less cooling of the Northern Hemisphere, lower-tropospheric, wintertime cold pool, (c) the smaller areal extent will likely result in fewer cold outbreaks across the Great Lakes region during a given winter season, (d) the reduction in maximum lake ice extent will likely contribute to a subsequent increase in evaporation from the lakes and finally (e) reduction in Great Lakes water levels.

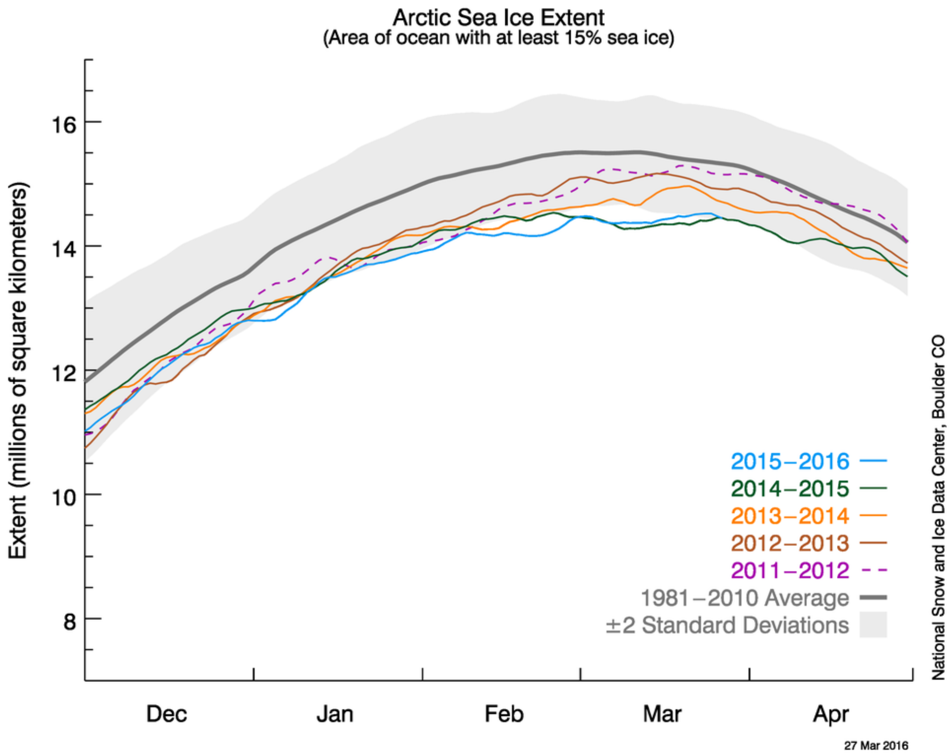

Figure 7. Areal extent of wintertime Arctic Sea Ice.

Estimating the areal extent values for the -5ºC isotherm (as shown in Figure 1 of Martin (2015)), we plotted the areal extent values versus the winter season maximum ice extent for Lake Michigan (Figure 8), and Lake Michigan-Huron water levels (Figure 11), for the respective winter seasons. As can be seen in Figure 8, the general trend is for decreasing maximum ice cover with decreasing areal extent of the -5˚C isotherm. The trend was found to be statistically significant ($P<0.05$, two-tailed). In Figure 9, the general trend is for decreasing Lake Michigan-Huron water levels with decreasing areal extent of the -5˚C isotherm. The trend was found to be statistically significant ($P<0.05$, two-tailed). Taken together, these results support the notion that when the Northern Hemisphere, lower-tropospheric, wintertime cold pool is smaller in areal extent, and thus less likely to impact the Great Lakes, the ice cover is typically lower, evaporation is likely greater and thus the water levels tend to be lower. In contrast, these results suggest that when the Northern Hemisphere, lower-tropospheric, wintertime cold pool is larger in areal extent, and thus more likely to impact the Great Lakes, the ice cover is greater, evaporation is likely less and thus the water levels tend to be higher.

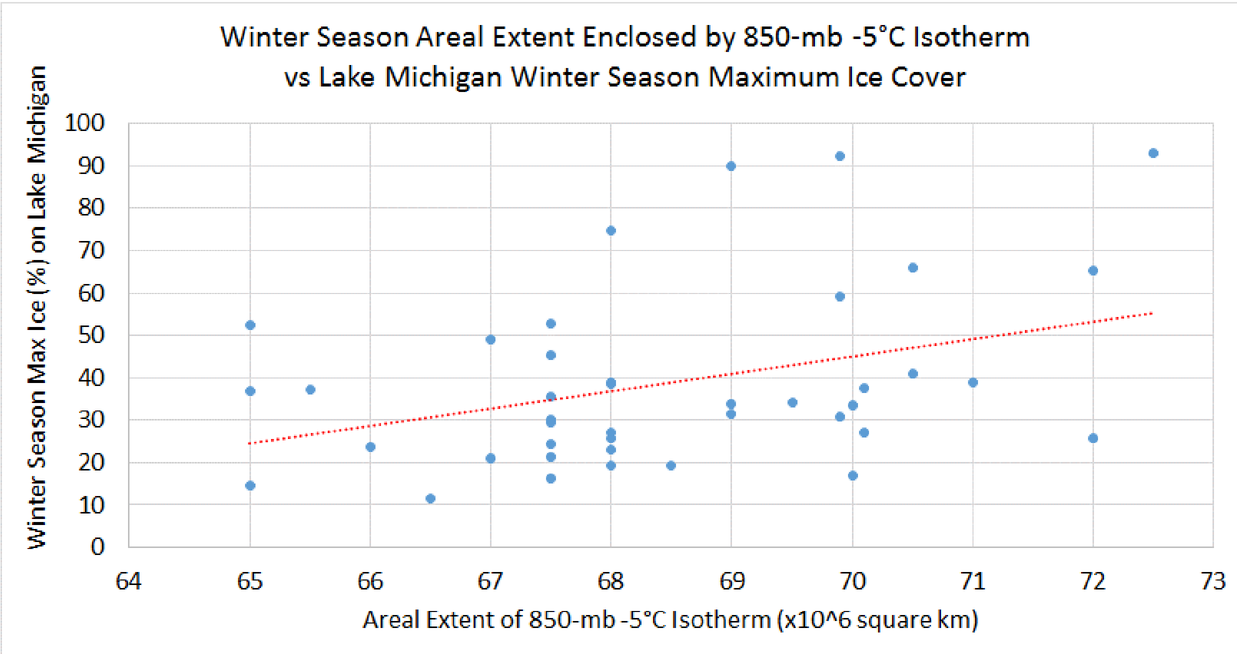

Figure 8. Winter season (DJF) areal extent enclosed by 850-mb -5°C Isotherm vs. Lake Michigan Winter Season Maximum Ice Cover.

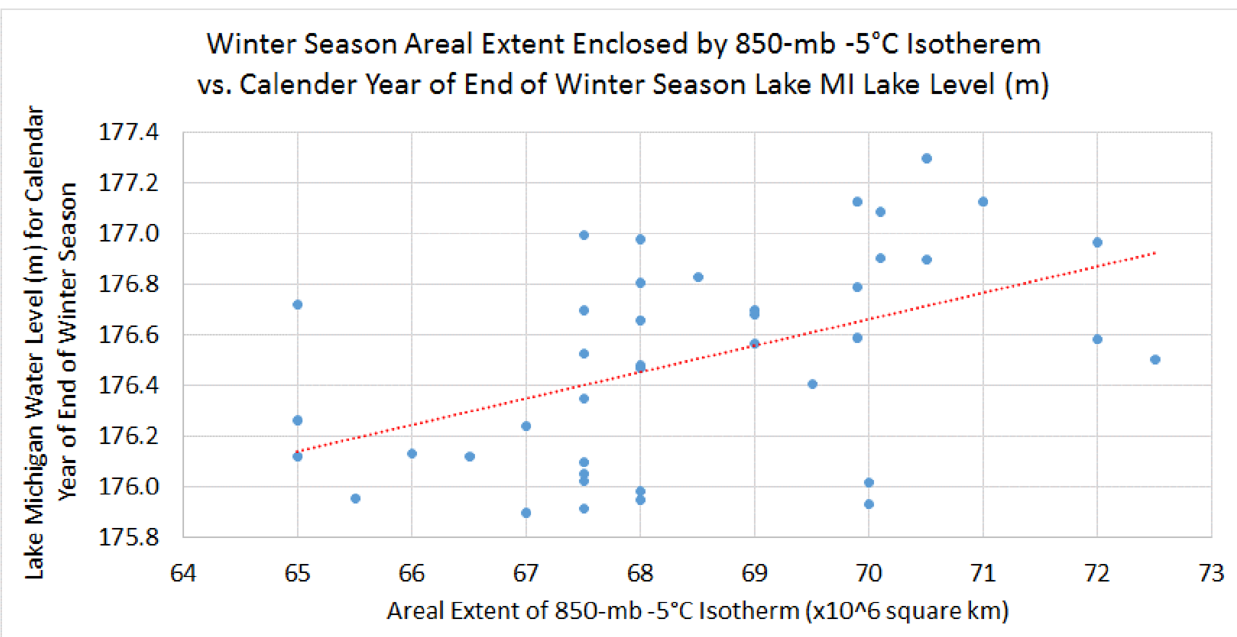

Figure 9. Winter season (DJF) areal extent enclosed by 850-mb -5°C Isotherm vs. Lake Michigan-Huron lake level for the following calendar year.

This interpretation is consistent with Assel *et al.* (2003) who noted that above annual maximum ice concentration on the Great Lakes is associated with wintertime flow patterns which enhance the transport of polar and Arctic air masses into the region. One would expect that a season characterized by a wintertime flow pattern with enhanced cold air advection would also be a winter season with a larger average area extent of the Northern Hemisphere, lower-tropospheric, wintertime cold pool.

Needless to say, there is still considerable variability in the data, with some values of the areal extent of the cold pool being associated with a wide range in lake level values. This variability underscores the complexity of the factors which contribute to ice extent and lake levels.

We acknowledge that trends are often not the best approach to project future conditions, namely because trends often mask the factors leading to the trend in question. In this particular case, however, the factors are fairly well-understood (warming temperature, reduced Arctic Sea ice, reduced cold pool) and thus we can make the assumption that in a climate that is projected to continue to warm through the end of this century, the trends of decreasing lake ice and lake water levels are reasonable projections based upon the observed data presented here. Based upon the relations shown, one might project that future water levels over the next few decades may be *tending toward* an average near 176.0 meters for the Lake Michigan-Huron system.

Finally, when considering the potential environmental impact of their actions, the traditional approach of Indigenous Tribes is to consider the impact of their actions on the next seven generations. It is not possible to predict exactly how our climate system will evolve over such an extended time period. As a result, in addition to considering adaptation options for our low water scenario, we are also working to consider adaptation options for extreme high water periods. Tools such as the *NOAA Lake Level Viewer* (https://coast.noaa.gov/llv) are available to project what the structure of the Great Lakes shoreline will look like under varying lake level conditions. We are working with our Tribal partners to determine what shoreline structure looked like during a number of historical high and historical low lake level periods, and our Tribal partners are reviewing historical information in an attempt to understand how their Tribal Communities were impacted during these periods.. Members of our project team are also comparing modeled reconstructions of shoreline structure during several historical high and historical low lake level periods (using the *NOAA Lake Level Viewer*) with photographic images provide by the Michigan State University Aerial Imagery Archive. These latter periods under consideration are low water periods (less than or approximately 176.0 meters) during 1938 and 1963, and high water level periods (greater than or approximately equal to 177.0 meters) during 1952 and 1973. These periods were chosen based upon the availability of aerial photographic imagery for the respective periods.

Recently Observed/Anticipated Impacts on Tribal Collaborators

We are only now beginning to explore potential plausible climate futures with our Tribal collaborators. We are hoping to work with our collaborators to engage Tribal Elders to obtain more extensive information on the relationships between past high/low lake level periods and the observed vulnerabilities of the Tribes during these periods. For the purposes of this report, we provide the following list of impacts recently observed by the Tribal communities.

1. Impacts on Tribal Fisheries:
    a. During recent low lake water level periods, Tribal community members indicated that the low levels provided challenges to their ability to launch fishing operations from traditional launch points. If one plausible future lake level scenario is one in which the long-term (30-year) lake levels are lower than at present, challenges to

the ability of Tribal fishing captains/recreational fishermen to launch fishing operations may persist. Such conditions will likely require a long-term solution to insure the capability of commercial/subsistence/recreational fishing. Similar challenges could arise during extreme high lake water levels.

b. Tribal fisheries staff at the Little Traverse Bay Bands of Odawa Indians have noted a strong relationship between shoreline ice extent and spring larval fish population of Lake Whitefish. This relationship is likely linked to the role of shoreline ice in the protection on whitefish eggs which are deposited on rocky shoals near the shoreline (Lynch et al., 2010). During winters with significant lake ice, the ice helps to dampen the effect of storm winds/waves, thus protecting the eggs that were laid during the fall spawning season. In contrast, during winters without significant lake ice, rougher waters can lead to the eggs being dislodged from where they were laid, thus reducing their survivability. While lake water temperature is thought to be a primary driver of seasonal lake ice extent, changes in lake water levels in regions conducive to being spawning grounds and nursery areas may also impact the extent of lake ice formation due to the impact of changing water depth on nearshore lake water temperatures.

c. Tribal natural resources staff indicated that lower lake water levels may make currently viable spawning/nursery areas unviable and it may take fish time to find/adapt to new spawning/nursery areas.

d. Tribal natural resources staff are concerned that during low lake water level periods, community members may seek to groom newly exposed beaches, making native aquatic vegetation vulnerable. If future lake water levels return to the current levels, native vegetation may not be present to allow traditional spawning grounds and nurseries to be of use as spawning/nursery grounds.

2. During recent low lake water levels, ancient Tribal burial grounds and other historical sites were exposed due to receding water/lake shoreline interface.

3. Our conversations with members of the LTBB indicated that the women of the Tribe are considered to be the caretakers of the water. The occurrence of, or trend toward, persistent and extreme water levels would impact the role of women in the Tribe, impacting their ceremonial and educational activities related to water.

IDENTIFICATION AND ANALYSIS OF ADAPTIVE ACTIONS AND POLICY OPTIONS

As noted earlier in this report, our analysis of recent trends in the areal extent of the polar cold pool and its impact on Lake Michigan-Huron lake ice extent, and subsequently lake water levels, suggests that if current climate trends continue, a plausible future scenario for the Lake Michigan-Huron system will be one of lower average water levels. However, one must always consider the inherent variability in the natural Earth system, as both extreme low and high lake water levels have been observed I the past. As a result, in our analysis, we also include consideration of the need for adaptive actions during prolonged high water periods.

Interaction between Michigan's Federally-recognized Tribes and the U.S. Federal, State of Michigan and Local Governments and Organizations

Any consideration of climate change adaptation actions and policies by indigenous Tribal Nations must also consider the relationship between the individual Tribal Governments and the U.S. Federal, State of Michigan and Local Governments and other Regional/Community Organizations. The U.S. Army Corps of Engineers (USACE) website (http://www.usace.army.mil) lists the USACE Tribal Policy Principles, which are followed in their interactions with Tribal Nations. Summarized below, these principles are founded on the U.S. Constitution, Federal laws and court decisions, regulations and Executive Orders.

1. The U.S. Army Corps of Engineers recognizes that Tribal Governments are sovereign entities.
2. The U.S. Army Corps of Engineers will work to meet trust obligations, protect trust resources and obtain Tribal views of trust and treaty responsibilities.
3. The U.S. Army Corps of Engineers will ensure that Corps leaders and Tribal leaders meet as governments and recognize that Tribes have the right to be treated in accordance with principles of self-determination.
4. The U.S. Army Corps of Engineers will involve the Tribes collaboratively, before and throughout decision-making, to ensure the timely exchange of information, the consideration of disparate viewpoints, and the utilization of fair and impartial dispute resolution processes.
5. The U.S. Army Corps of Engineers will search for ways to involve the Tribes in programs, projects, and other activities that build economic capacity and manage Tribal resources while preserving cultural identities.
6. The U.S. Army Corps of Engineers will act to fulfill its obligations to preserve and protect trust resources and to consider the potential effects of Corps programs on natural and cultural resources. The Corps is determined to comply with the Native American Graves Protection and Repatriation Act and to ensure reasonable access to sacred sites.

These principles are further discussed at the following website:

http://www.usace.army.mil/Missions/Civil-Works/Tribal-Nations/

Similarly, the State of Michigan Government has developed a set of principles which are set forth in the "Intergovernmental Accord between the Federally Recognized Tribes in Michigan and the Governor of the State of Michigan Concerning Protection of Shared Water Resources". The accord was signed on May 12, 2004 by then Governor Jennifer Granholm and representatives of the twelve Federally Recognized Tribes of Michigan. Through the Office of the Great Lakes, the State of Michigan also works with the Tribes through the Michigan Tribal Environmental Group, the United Tribes of Michigan and other such forums. Despite these principles, the collaboration between Tribal governments and the State of Michigan can be complex. For example, at the time of this writing, the Little Traverse Bay Bands of Odawa Indians has urged a Michigan Federal Court to force the State of Michigan to recognize its reservation boundaries set during the 1855 Federal Treaty. The Tribe feels that the State's recognition of these boundaries is key to the protection of the Tribe's sovereignty.

As Sovereign "Domestic Dependent" Nations, the Tribal Governments are most similar to the Federal Government. That said, the Tribal Governments also work with Local Governments within their Tribal reservation boundaries with respect to the coordination of a number of services, including law enforcement, as an example (Emily Proctor, personal communication). Such collaborations will be essential to any climate adaptation plan that is developed by the Federally recognized Tribes within the State of Michigan, including our collaborating Tribes: the LTBB and the GTB.

Within the State of Michigan, one organization that has been particularly effective in bringing together Tribal representatives, as well as other Local Governments in northern Lower Michigan is the *Tip of the Mitt Watershed Council* (https://www.watershedcouncil.org/), which we feel will likely be a key partner in Tribal efforts to carry out any climate adaptation plans which are developed and formalized in the future. This council has been effective in bringing together a number of Tribal and local governments, as well as other interested partners, in the development of regional watershed management plans. One example, and one which is directly applicable to the LTBB, is the Little Travers Bay Watershed Protection Plan, which was approved by the MDEQ/USEPA in 2007.

Over the course of this project, we have worked with both the LTBB and the GTB Tribal Nations. The LTBB is in the midst of a formal, more expansive review of the impacts of our changing climate on the Tribe and thus our work has been considered to be one element of a larger effort that the Tribe is currently undertaking. Our project team has not been involved in that larger effort. The GTB is at the very early stages of exploring how they would like to move forward addressing the impacts of our changing climate on their Tribal Nation. At the time of this writing, through our conversations with the GTB, it has been decided that they would prefer their first steps in this process to focus upon community education and thus we are continuing in our efforts to assist them in that plan. We are also continuing to share the overall results of our project with the GTB. However, much of the material presented has been developed through conversations with the LTBB Tribal Nation.

In the discussion that follows, we present a series of potential impact that have been/may be experienced by the LTBB and GTB. While formal adaptation plans have yet to be developed, here we present elements of our conversations and potential approaches that our partner Tribes could consider in addressing these conditions that may be observed as a result of the plausible lake water level futures for the Lake Michigan-Huron system.

Extended Periods of Low Lake Michigan-Huron Water Levels

- **Impacted Resource: Great Lakes fisheries spawning and nursery sites**
    - **Impact: Loss or relocation of viable spawning and nursery sites**

The spawning and nursery sites along the Lake Michigan-Huron shorelines vary considerably in character. Many of the fish species of importance to Tribal and other commercial/recreational fisherman prefer to use relatively sediment free, rocky or gravely shoals for spawning grounds. These species include, but are not limited to: Lake Whitefish, Lake Trout and Lake Whitefish (www.michigan.gov/dnr). One plausible consequence of extended periods of low Lake Michigan-Huron water levels would be the potential for some of existing areas to cease to be productive due to loss of water due to the retreating water's edge. While other areas of rocky shoals could become better suited to serve as spawning grounds than was previously the case, it might take time for natural removal of sediments from these areas and subsequent response of the fish populations with respect to finding and using these new locations.

Potential Adaptive Action: Utilization of Fish Hatcheries

In the past, fish hatcheries have been proven to provide an effective means of supporting the viability of fish species within the Great Lakes. The LTBB opened a state-of-the-art fish hatchery in 2013 as one means of restoring the community structure and function of the populations of native fish species within the Great Lakes fishery. The LTBB Tribal fish hatchery provides one option for the Tribe to maintain the populations of culturally important fish species should such species face declining populations as the results of plausible climate futures.

An example of the success of the LTBB Tribal fish hatchery can be seen in the Tribe's efforts to restore the native Cisco population in Lake Michigan. According to the Tribe, in the 1950's, the Cisco population experienced a significant decline due to overharvest, invasive species and poor water quality. Following the completion of the Tribal fish hatchery, the LTBB began a program of collecting Cisco eggs and raising them in the Tribal fish hatchery and then reintroducing them into Lake Michigan. While it is difficult to determine the long-term effects of the program on the Cisco population, preliminary results from this effort have been encouraging.

The utilization of the Tribal fish hatchery in this way requires coordination through the Technical Fishery Committee (TFC). The TFC was established as part of the 2000 Consent Decree and is comprised of Tribal, State and Federal biologists (www.1836cora.org). The TFC operates on a consensus basis. According to Kevin Donner, an LTBB Great Lakes Fisheries Biologist, "Per the 2000 decree, any new stocking action in ceded waters (including by the State) must be reviewed by the TFC which allows for a party to object. Without an objection, new stocking can move forward."

The utilization of the Tribal fish hatchery for such efforts offers another positive aspect, in that the approach can be considered consistent with Tribal cultural practices. For example another potential approach to supporting the Cisco population could be the relocation of Cisco from other Great Lakes waters. However, such an option would not be favored by the Tribe. In additional to removing the fish from an aquatic environment that the species had genetically adapted to, such an action would also require the removal of the fish from their native places of birth and rearing (Personal Communication with Kevin Donner).

- **Impacted Resource: Lake Michigan-Huron coastal wetland vegetation**
    - **Impact: Loss or viability of vegetated wetland as spawning and nursery areas of fisheries**

Lake Michigan-Huron coastal wetlands which consist of a variety of wetland vegetation species are also important spawning grounds and nursery areas for fish species of importance to Tribal and other commercial/recreational fishermen. These species which typically use such wetlands at some point in their life cycle include, but are not limited to, Lake Sturgeon, Yellow Perch and Northern Pike (www.michigan.gov/dnr).

As described in our Phase I report, varying lake levels are vital to health wetland vegetation ecosystems. The diversity of vegetation provides the necessary environment for foraging and protection of fingerlings from species that seek to prey upon them.

There are a variety of types of wetlands within the Great Lakes. Figure 10 represents a typical open-shoreline wetland community ecosystem gradient, which consists of diverse vegetation communities ranging from forest and shrubs in the drier portions of the ecosystem and meadows, emergent and floating vegetation as one moves toward the water. Mortsch (1988) notes that stable water levels are not beneficial to coastal wetland ecosystems. Rather, occasional flooding and then drying maintain wetlands at productive, intermediate stages of development. During low water level periods, the vegetation communities shift downward toward the land-water interface, while during high water level periods, the vegetation communities shift in the upland direction. During prolonged low water periods, perennial forest and shrub communities can take foothold in locations formerly occupied by meadow and emergent communities. Invasive species, such as phragmites, can also take hold in a wetland ecosystem during such dry conditions. When water levels rise, these regions may no longer viable ecosystems for diverse fish species, taking several years to return to their original states which are more favorable for supporting diverse vegetation and thus fish communities. If phragmites has taken hold, the more highly dense vegetation may not allow young fish to hide within the stands, thus depriving these species of important protective cover from prey species.

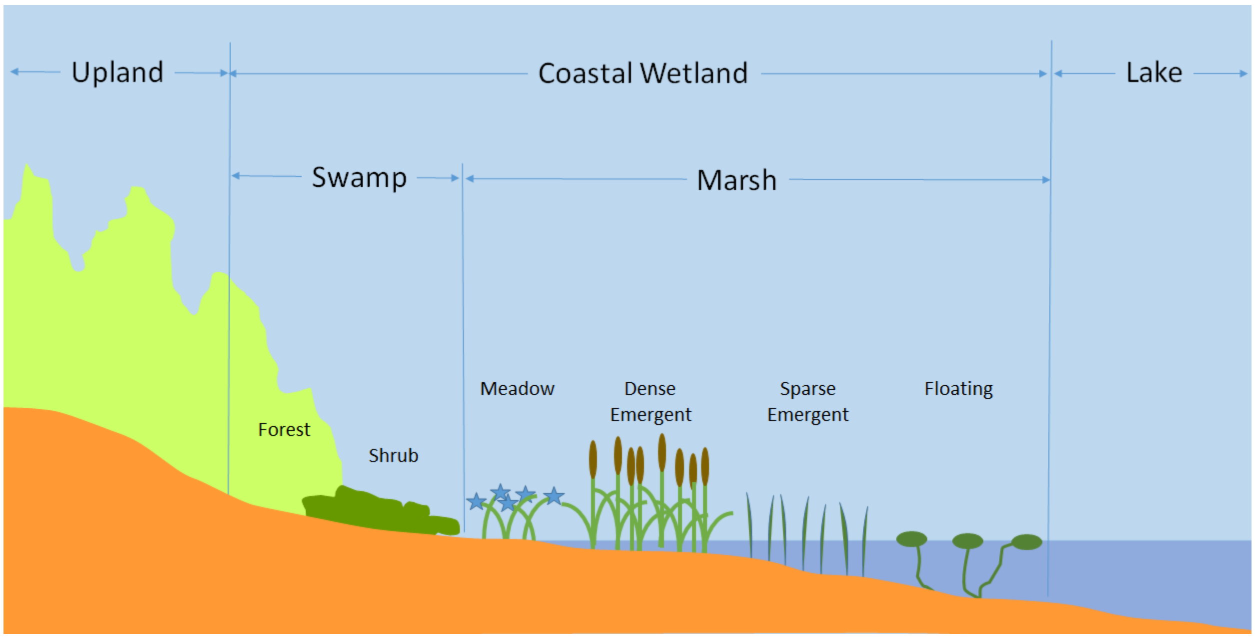

Figure 10. Typical lacustrine coastal wetland ecosystem gradient, after Wilcox (2002, *Where Land Meets Water: Understanding Wetlands of the Great Lakes*)

Our Tribal collaborators have indicated that to date, the extensive expansion of phragmites in wetlands associated with their Tribal fisheries has not been a significant problem (Jon Mauchmar, personal communication), in contrast to its observed expansion across the southern part of Lake Michigan. However, one issue of concern noted by our collaborators was the occurrence of beach grooming activities during the recent low lake water period, particularly the removal of native vegetation by community members seeking to clean up the newly exposed beaches. In the same way that the expansion of phragmites can reduce the viability of a vegetated coastal wetland, the removal of native vegetation can have the same impact given that when water levels rise to, or near, their previous levels, the native vegetation may no longer be in place to serve as protective cover for young fish.

Potential Adaptive Action: Participation in select permit application review processes

As a Sovereign Nation, the Little Traverse Bay Bands of Odawa Indians have developed their own environmental protection statutes, which are formalized within the Waganaksing Odawak Tibal Code of Law and further by the Waganaksing Odawak Statute - Nibiish Naagdowen "The Care of Water": Clean Water Act. The Tribal Code of Law contains the requirement of the acquisition of a permit to conduct wetland modifications. As such, **the Tribal Government can use this authority to ensure that any such modifications are consistent with the natural resource planning goals of the Tribe and any climate adaptation options developed by the Tribe**. The statutes outlined in the Tribal Code of Law apply to: (a) Non-contiguous and contiguous wetlands at least 1/3 acre in size, and (b) high quality wetlands, regardless of size, located on lands held in fee by, or trust for, LTBB, or otherwise under the jurisdiction of LTBB. A map outlining the LTBB reservation boundaries, as well as LTBB lands held in trust by the U.S. Federal Government, is included at the end of this document.

Beyond its own statutes, the LTBB has the opportunity to participate in the review of permits for wetland modification activities for areas which fall under the jurisdictions of the Local governments, the State of Michigan (through the Department of Environmental Quality – Water Resources Division) and the U.S. Federal Government (though the U.S. Army Corps of Engineers). Local, State and Federal Wetland Regulations and Permitting processes are summarized in a series of web-based resource pages provided by the Tip of the Mitt Watershed Council at the following sites:

- Wetland Regulations
  - https://www.watershedcouncil.org/wetland-regulations.html
  - This resource includes information outlining the Federal, State and Local jurisdictions, a summary of activities requiring permits and a list of general permit review standards.
- Wetland Permitting
  - https://www.watershedcouncil.org/wetland-permitting.html
  - This resource focuses on a general description of the permitting process for the State of Michigan and the Federal Governments.

For proposed activities within Michigan coastal wetlands that require a permit, a joint permit application is required (State of Michigan and U.S. Army Corps of Engineers). The State of Michigan reviews the proposed activities that are regulated by the State's Natural Resources and Environmental Protection Act, while the U.S. Army Corps of Engineers reviews proposed activities which are regulated by Federal statutes.

State of Michigan

The State of Michigan has three categories of permits:

- <u>General and Minor</u>: These categories include proposed activities which are deemed to likely have minimal adverse effects on the environment or aquatic resources, including high value aquatic habitats. Neither of these categories requires a formal public notice and comment period. A description of activities which fall under these categories can be found at the following websites;

- General Permit:

  http://www.michigan.gov/documents/deq/General_Permit_Categories_360925_7.pdf

- Minor Permit:

  http://www.michigan.gov/documents/deq/Minor_Project_Categories_360884_7.pdf

- Individual: This category includes proposed activities which are deemed to likely have more than minimal adverse effects on the environment or aquatic resources, including high value aquatic habitats. This category requires a formal public notice and comment period, during which the Tribal Governments would have the opportunity to address concerns that the proposed activities may compromise their climate adaptation goals.

At the time of this writing, we were still attempting to obtain clarification on the mechanisms for Tribal participation in the State of Michigan permitting process beyond the public notice comment period associated with the Individual Permit Category.

Federal

The following information is a synthesis of the Federal Government permitting process carried out by the U.S. Army Corps of Engineers. This information was synthesized with the help of the U.S. Army Corps of Engineers, Detroit District Office (Charles Simon, personal communication).

USACE has federal jurisdiction between the water's edge and the Ordinary High Water Mark (Figure 11). Authority for these activities come from Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act.
USACE has two broad permit categories, which are further subdivided:

- General (minimal impacts on environment) Permits:
  - Nationwide Permit:
    - **NOTE:** A public notice is required only for the initial and subsequent authorization of the Nationwide (NWP) categories which is valid for five years. A public notice is not required for review of each application for the NWP.
  - Regional (MI, IN) Permit:
    - **NOTE:** A public notice is required only for the initial and subsequent authorization of the Regional permit which is valid for five years. A public notice is not required for review of each application for the regional permit.
  - State Programmatic (IN) Permit:
    - **NOTE:** A public notice is required only for the initial and subsequent authorization of the programmatic general permit which is valid for 5 years. A public notice is not required for review of each application for the programmatic general permit.

- Individual Permit (activities not covered by a General permit):
    - Standard Permit - Requires a public notice and full public interest review.
    - Letter of Permission – Requires coordination with State/Federal agencies and select others.

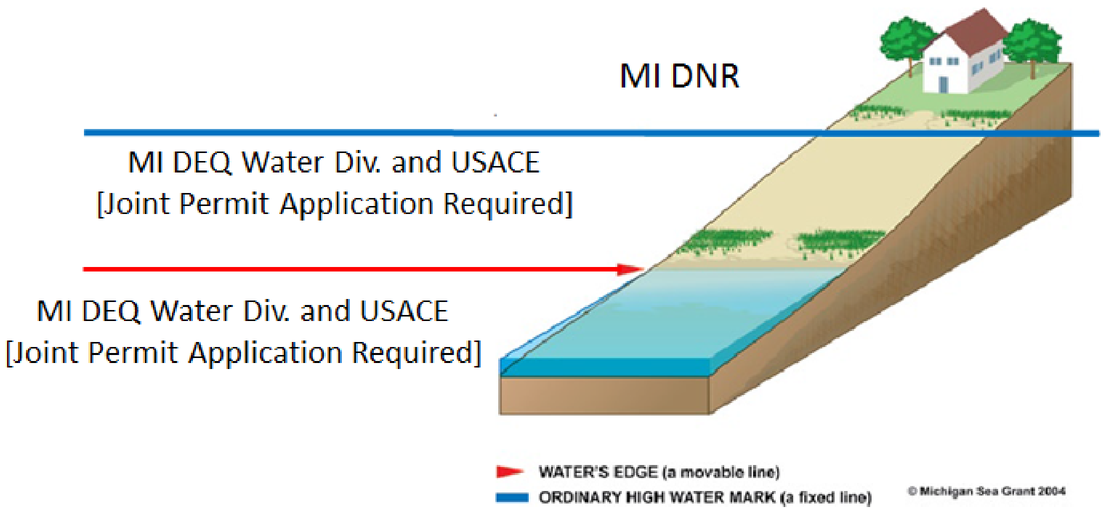

Figure 11: Definition of jurisdictional boundaries for Great Lakes Coastal Wetlands (after Michigan Sea Grant)

For all permit application processing, the USACE review includes coordination with a number of external organizations and/or review of sources which provide the USACE with support for the consideration of the impact of the activity on Tribal and Cultural resources, including categories covered by the National Historic Preservation Act and the Native American Graves Protection and Repatriation Act.

Tribes are contacted/involved when a public notice is issued, and/or when potential Tribal resources are identified that may be affected by proposed work, even if the review does not include a public notice. When a public notice is issued, anyone can submit comments whether or not they own property adjacent to the area in which the permit-requested activity will occur.

Federal policy requires that Tribes are treated as Governments. The USACE has a responsibility to protect the interests of Tribes and protect treaty rights.

Potential Adaptive Action: Education of Tribal and surrounding communities regarding the need to protect native vegetation during low lake water periods

As noted above, not all activities which occur within Michigan's coastal wetlands require a formal permit application and review by the State of Michigan and the U.S. Federal Government. However, an informed public can assist in caring for these sensitive ecosystems which are of vast economic, recreational and cultural importance to Tribal and other communities. For example, Tribal and other communities may choose not to participate in certain activities if they are informed of "potential" harm that could occur as a result of these activities, particularly if these activities may cause harm to vegetation or other resources that are of cultural importance to the

Tribes. The development of an educational program to inform the both the Tribal and other communities of these issues would be a relatively easy, but important, action. The *ESRI Story Map Tool* (http://storymaps.arcgis.com/en/) is an innovative resource which allows for the creation of educational text with GIS mapping capabilities that would allow lessons to be tailored to specific wetlands. There may be some instances when is not desired to include geographical information pertaining areas of cultural importance to the Tribal communities in order to protect these locations from vandalism. However, appropriate information could be presented which would heighten the public's awareness of the potential importance of various resource types which may become more vulnerable under a changing climate and subsequent plausible lake water level futures.

Potential Adaptive Action: Education of Tribal Youth regarding the need to protect native vegetation during low lake water periods

The LTBB have been providing education about the impact of our changing climate on the environment through the LTBB Education Department's Summer Youth Camp. Thought this project, Education Directory Jannan Cotto has been able to present materials which provide an overview of this relationship through consideration of both Traditional Ecological Knowledge (TEK) and Wester Science approaches. The program has been able not only to provide the Tribal youth with important lessons regarding climate change and adaptation, but the information has been presented in a way that is consistent with their traditional/cultural relationship with the natural environment. A similar program is desired by the GTB and we have had conversations with the Tribe regarding how to move forward in this direction.

- **Impacted Resource: Lake Michigan-Huron coastal cultural sites (burial grounds and historical sites)**
    - **Impact: Important cultural and historical sites may become exposed during low water level periods, making these site vulnerable to vandalism**

Potential Adaptive Action: Participation in permit application review process

As noted above, when joint permit applications propose work that could have more than a minimal impact on wetland ecosystems, a public notice is required and a public comment period is established. During such public comment periods, the Tribal Governments (like private citizens) have the opportunity to express any concerns they may have related to the activity. Also as noted above, for all permit application reviews, the U.S. Army Corp of Engineers include consideration of the impact of any activity Tribal culture and/or historical artifacts. Should the U.S. Army Corp of Engineers deem consultation with the Tribes is warranted, such a consultation is initiated even if a public comment period is not.

Potential Adaptive Action: Education of Tribal and Surrounding Communities regarding the need to protect cultural sites

The same educational tools that would be available to the Tribes for use in providing information on the need for protection of vulnerable native plants in plausible lake water level futures would also be of value for educating the public regarding potential vulnerability of cultural sites (burial grounds and other historical artifacts) which may become exposed during periods of low water levels. However, the Tribes could also enlist the surrounding communities in such educational efforts or reach out to these communities for additional ideas or avenues for reaching the citizens of these communities. As noted earlier, the *Tip of the Mitt Watershed Council* facilitates meetings and dialogue between communities across northern Lower Michigan (see Figure 12) and their area of focus includes the reservation lands of the LTBB. Dr. Grenetta Thomassey (personal communication), Program Director at the *Tip of the Mitt Watershed Council*, indicated that her organization hosts regularly scheduled regional meetings that would provide an appropriate and effective venue for the LTBB to present their concerns to other communities and to seek their assistance in facilitating/disseminating educational and other information about vulnerable Tribal resources and cultural sites to these respective communities.

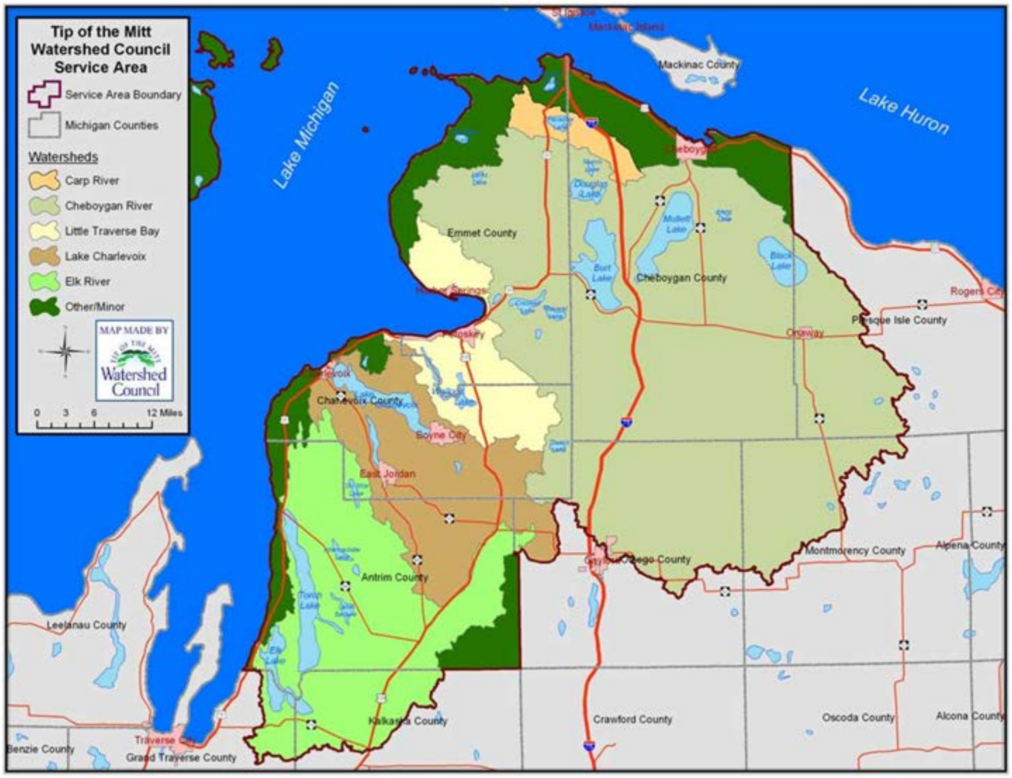

Figure 12. Tip of the Mitt Watershed Council Service Area

- **Impacted Resource: Viability of specific fishing boat launch sites or recreational marinas**
  - **Impact: Loss of access to Tribal fisheries for economic, recreational and cultural purposes (including cultural use of fish as a primary food source)**

Given the critical importance of Tribal fisheries to the economic well-being, recreational and cultural needs of the LTBB and GTB Tribal communities, access to the lakes by Tribal fishing captains and other recreational fisherman is of great importance. Under extreme low lake water levels, the viability of existing fishing boat launch sites may be compromised. The same concerns would apply to existing or future recreational marinas for the Tribal and other communities.

Potential Adaptive Action: Review of potential changes in lakeshore structure during extreme low water levels.

Using the *NOAA Lake Level Viewer* tool described above, the LTBB and GTB Tribal communities could determine the extent of potential changes in lakeshore structure during potential extreme low lake water conditions, providing an understanding as to whether existing boat launching sites will be viable under plausible future lake water level conditions. Such information will be of value for the planning of future boat launch sites, including multi-use marinas. A better understanding of the range of plausible lake water level futures could allow for the design of facilities which could be less susceptible to extremes in varying lake levels.

<u>High Lake Michigan-Huron Water Levels</u>

As described earlier, traditional Tribal planning considers the impact of any activity, including that involving the natural environment, on the next seven generations. Should our current trend of a warming global climate continue, lower lake water levels is one plausible climate outcome. That said, historical variability in lake levels has suggested that despite trends in mean lake water levels, occasional high lake water periods (lasting several years) are still possible and thus any climate adaptation planning necessarily should also include adaptive actions which account for this possibility. These plans could involve short-term adaptive actions, or could include the planning of actions which would make our partner Tribal communities most resilient regardless of the observe lake water level conditions. While the direct impacts may be different, the adaptive processes/actions needed under high lake water conditions are likely to be very similar to those described for low lake water level conditions. During high lake water level conditions, impacted resources are likely to be:

1. Viability of existing Tribal fisheries spawning and nursery coastal zones/wetlands, as extended periods of high lake water levels could damage the diversity of wetland plants which support the use of a given wetland for spawning/nursery activities
2. Viability of existing/future Tribal fisheries, recreational boat launches and marinas
3. Beach/lakefront property erosion

Given that beach and lakefront property erosion was not a consideration during the discussion of likely impacts during low lake water levels, we address this impact here. It is important to note that at this time, we have also not had discussions with our Tribal collaborators regarding potential areas within reservation boundaries that may have susceptible to erosion in the past. For completeness, we briefly address this topic at this time.

- **Impacted Resource: Lake shoreline structure**
    - **Impact: Erosion of physical lakeshore and associated structures near/above Ordinary High Water Mark**

During periods of high lake water levels, erosion of the physical lakeshore and associated structures may be possible. Utilization of tools such as the *NOAA Lake Level Viewer* by the Tribal planning departments could be a vital tool in the determination of particular areas of Tribal lands which are vulnerable to such conditions. Naturally, given the range of processes involved in erosion, the tool will not be able to predict the extent of potential erosion under plausible future lake water level conditions. Adaptive actions will likely need coordination with Local officials, which as discussed earlier could be facilitated in part through the Tip of the Mitt Watershed Council. Additionally, a Guide to Permitting and Zoning was created in 2012 for communities within Emmet County (http://www.networksnorthwest.org/userfiles/filemanager/1314/) and could provide a framework for the Tribal Planning Departments to work with Local communities.

Additionally, as noted in this guide, the Tribal Planning Departments would have sole local jurisdiction over Tribal Lands which are held in Trust for the Tribes by the Federal Government.

ADDITIONAL CONSIDERATIONS

There are two additional considerations that we would like to touch upon in this section of our Phase II report:

(a) The use of cultural/conservation easements by the Tribes
(b) The impact of a current legal action by the Little Traverse Bay Bands of Odawa Indians to have the State of Michigan recognize and respect its 1855 Treaty Reservation Boundaries

Conservation and Cultural Conservation Easements

One potential approach that could be used by the LTBB and other Tribal Nations to preserve coastal wetlands, particular those which are important to fisheries and cultural practices, is the use of conservation easements. Such easements could be used protect the resources vulnerable to development activities, activities which may occur in response to our changing climate; for example, beach grooming or removal of critical wetland vegetation during extended periods of low lake levels. According to the Cornell University Law School's (https://www.law.cornell.edu/) Legal Information Institute:

"An easement is the grant of a nonpossessory property interest that grants the easement holder permission to use another person's land……There are two types of easements: affirmative and negative. An affirmative easement gives the easement holder the right to do something on the grantor of the easement's land, such as travel on a road through the grantor's land. A negative easement, on the other hand, allows the easement holder to prevent the grantor of the easement from doing something on his land that is lawful for him to do, such as building a structure that obscures light or a scenic view." Under such agreements, an easement could continue even if the property is sold to a new party.

Under the Waganakising Odawa Tribal Code of Law (Version 2016-4.5), "Conservation and Cultural Preservation Easement Act", the LTBB have provided guidelines for "holding, negotiating, and enforcing conservation easements, cultural easements, and traditional use easements." A cultural conservation easement might allow for an agreement with a non-tribal land owner, such as a private citizen or a conservancy group, which would allow tribal members the right to access the land-owners property for the purpose of conducting traditional ceremonies and/or for traditional medicinal gathering activities.

An example of this approach can be found in a collaborative effort between the LTBB, the *Little Traverse Conservancy (LTC)* and the *Tip of the Mitt Watershed Council (TOM)*, which is highlighted in "First Peoples: New Directions in Indigenous Studies: Trust in the Land: New Directions in Tribal Conservation" (Middleton, 2001) and summarized here. Each of these entities had an interest in preserving a 55-acre parcel of land that: (a) was located within the traditional LTBB reservation boundaries, (b) contained a stream and wetland, (c) included traditional tribal gathering areas, (d) was located within an existing 200-acre conservancy preserve of the LTC (Susan's Creek Nature Preserve). Through an agreement with the LTBB, the LTC purchased the property with the understanding that the LTBB would eventually buy the property from the LTC. Through a $250,000 grant that the LTBB obtained from the National Oceanic and Atmospheric Administration's (NOAA) Michigan Coastal Management Program, and through additional funding provided by the LTC, this land was purchased by the LTBB. The land has since been dedicated as the Taimi Lynne Hoag Natural Area and the Federal Government (through the Bureau of Indian Affairs) holds the land in trust for the LTBB, while the LTC holds a "Conservation Easement Supplemental Agreement" (CESA) on the Property. The CESA allows the general public to have access to the site, namely through a connected, interpretive trail that runs through the Taimi Lynne Hoag Natural Area and the TLC's adjacent Susan's Creek Nature Preserve. The agreement, which insures protection of the land from development, and restricts some uses on the site, is binding in perpetuity. In the future, the LTBB or other Tribal Nations could use a similar process to protect lakeshore areas which serve either as culturally important sites, or sites which serve as important fisheries spawning and/or nursery areas.

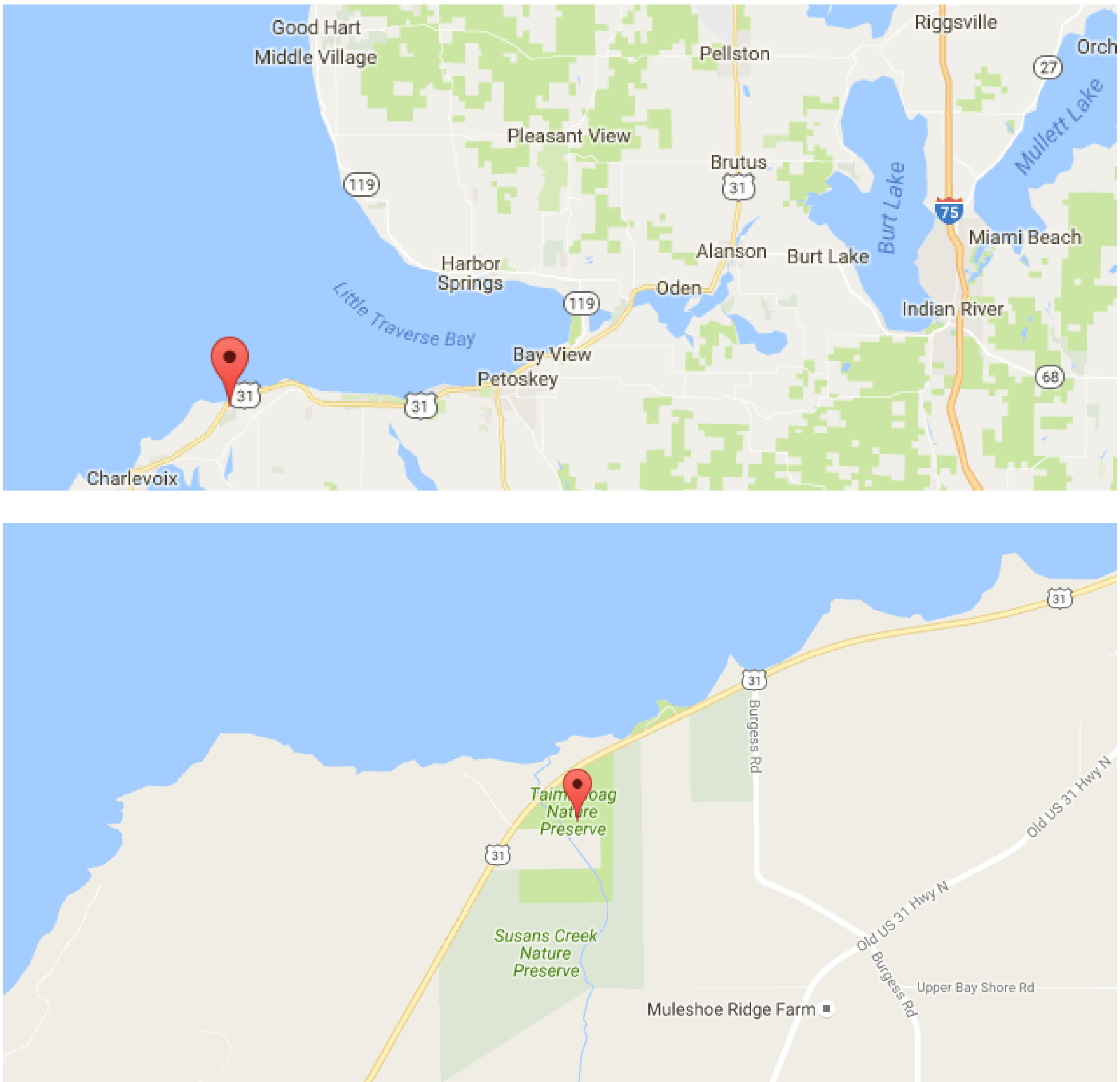

Figure 13. Location of the Taimi Hoag Natural Area (Source: Google Maps)

Formal Recognition of the Little Traverse Bay Bands of Odawa Indians by the State of Michigan recognize

On August 20, 2015, the Little Traverse Bay Bands of Odawa Indians filed a Federal Complaint against Michigan Governor Rick Snyder. The introduction of the related media release from the LTBB is as follows:

"The Little Traverse Bay Bands of Odawa Indians is a federally recognized Indian tribe whose people have occupied the Little Traverse Bay area for centuries. In an 1855 treaty, the United States promised the Tribe a reservation—a permanent home—along Little Traverse Bay. Today the Tribe filed a federal-court complaint against Rick Snyder, the Governor of Michigan, to confirm the Tribe's treaty-protected reservation boundaries in order to best serve its citizens and to offer certainty to the local and state governmental departments with which it works."

The media release further notes that "*In pursuing boundary recognition the Tribe does not seek title to private lands, to remove private owners from their properties, or otherwise affect land and property values. The Tribe only seeks to clarify jurisdictional lines that are largely invisible to the general population. This clarity will allow the Tribe to best protect its children, its vulnerable adults, and its ancestors. It will bring tangible benefits to the local tribal and non-tribal population."*

Highlighted in the release is the fact that the Tribe believes that, among other benefits, the affirmation of its 1855 Treaty boundaries will offer a framework for future government to government agreements with both the State and Local Governments. Our project team believes that such a framework could be critical to the Tribe's ability to develop and enforce climate adaptation procedures and policies within its boundaries, consistent with the goals of self-governance highlighted in the USACE Tribal Policy Principles.

The full press release can be obtained via the LTBB websites: http://www.ltbbodawa-nsn.gov .

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APPENDIX I:
LIST OF EVENTS AND PARTICIPANTS DURING PHASE II

1. 13 June 2016
    a. General project meeting with Little Traverse Bay Bands of Odawa Indians in Harbor Springs, MI
        i. Participants: Frank Marsik (University of Michigan), Jon Mauchmar (Little Traverse Bay Bands of Odawa Indians), Kevin Donner (Little Traverse Bay Bands of Odawa Indians) and Jannan Cotto (Little Traverse Bay Bands of Odawa Indians)

2. 13 June 2016:

    a. General project meeting with Grand Traverse Band of Ottawa and Chippewa Indians in Peshawbestown, MI
        i. Participants: Frank Marsik (University of Michigan), Carolan Sonderegger (Grand Traverse Band of Ottawa and Chippewa Indians)

3. 14 June 2016:

    a. Education outreach planning meeting
        i. Participants: Frank Marsik (University of Michigan), Jannan Cotto (Little Traverse Bay Bands of Odawa Indians) and Dorothy Perry (Little Traverse Bay Bands of Odawa Indians)

APPENDIX II:

ONLINE MAPPING RESOURCES

Great Lakes Aquatic Habitat Framework
http://glahf.org

Great Lakes Coastal Wetland Mapping Tool
http://www.mtri.org/coastal_wetland_mapping.html

Great Lakes Environmental Research Laboratory Dashboard Project
http://www.glerl.noaa.gov/data/dashboard/portal.html

NOAA Digital Coast Lake Level Viewer
https://coast.noaa.gov/digitalcoast/tools/llv

U.S. Fish & Wildlife Service National Wetlands Mapper
http://www.fws.gov/wetlands/Data/Mapper.html

EDUCATIONAL DEVELOPMENT RESOURCES

ESRI STORY MAPS
http://storymaps.arcgis.com/en/

RESOURCES RELATED TO TRIBAL CLIMATE ADAPTATION PLANNING

Center for Indigenous Environmental Resources
http://www.yourcier.org/

Tribes & Climate Change website
http://www7.nau.edu/itep/main/tcc/

A Tribal Planning Framework – Climate Change Adaptation Strategies by Sector
http://tribalclimate.uoregon.edu/files/2010/11/Tribal_CC_framework_April_2013-25wov2q.pdf

Tribal Climate Change Adaptation Planning Toolkit
https://toolkit.climate.gov/tool/tribal-climate-change-adaptation-planning-toolkit

Climate Change Adaptation Plan for Coastal and Inland Wetlands in the State of Michigan
http://www.aswm.org/pdf_lib/michigan_wetlands_and_climate_change_report_final_403251_7.pdf

Climate Change Adaptation & Local Planning for Michigan's Coastal Wetlands
http://www.greatlakeswetlandadaptation.org/uploads/2/6/5/3/26539851/final_wetlands_report_sept_2014.pdf

OTHER RESOURCES

Tip of the Mitt Watershed Council
https://www.watershedcouncil.org/

LTBB Tribal Code of Law
http://www.ltbbodawa-nsn.gov/TribalCode.pdf

Video Presentation on Tribal Law
https://www.youtube.com/watch?v=NAvBPretiMQ&feature=youtu.be

APPENDIX III:
LIST OF PUBLICATIONS AND PRESENTATIONS

Graham Sustainability Institute Lake Levels Integrated Assessment Webinar Series
Planned for Conclusion of Phase II: December 1, 2016

APPENDIX IV:
REMAINING TIMELINE OF PROJECT ACTIVITIES

NOTE: The following timeline is based upon the assumption that the funding for this specific project will extend only to January 31, 2017 (which was the case as of this writing).

- Over the period of December 31, 2016 through January 31, 2017, the project team will work with the Graham Sustainability Institute and other project teams to synthesize all team reports into the final, overall Integrated Assessment Report.

APPENDIX V:
LIST OF STUDENTS INVOLVED

During Planning Grant Phase:

Ellie Masters, Oberlin College

During Phase I:

Barbara Doyle, University of Michigan

During Phase II:

Isaac Abram-Craig, Little Traverse Bay Bands of Odawa Indians Tribal Citizen and Student