COASTAL GRAND TRAVERSE BAY WATERSHED PLAN

May 2021

(Original-December 2003; Revised-December 2005)

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The Watershed Center
GRAND TRAVERSE BAY

ACKNOWLEDGEMENTS

Many organizations and agencies were committed to helping create the original Grand Traverse Bay Watershed Protection Plan and this subsequent update for the Coastal Grand Traverse Bay watershed area. We would like to thank the following participants for their involvement in making this project possible.

Members of the steering committee have played a crucial part in this update to the Coastal Grand Traverse Bay Watershed Protection Plan by providing technical and informational assistance as well as offering guidance on project components. Steering committee members include: Sarah U'Ren, Christine Crissman, and Heather Smith (The Watershed Center Grand Traverse Bay); Greg Goudy and Julia Kirkwood (Michigan Department of Environment, Great Lakes, and Energy); Jay Zollinger, Lindsey Wolf, and Shawn Winter (Acme Township); Wendy Warren and Heidi Shaffer (Antrim Conservation District); Eric Johnston (Benzie Leelanau District Health Department); Steve Hensler (Ceruelean Center); Kim Balke, Amy Beyer, Kira Davis, and DJ Shook (Conservation Resource Alliance); Liz Kirkwood and Rick Kane (For Love of Water-FLOW); Katie Grzesiak (Northwest Michigan Invasive Species Network); Matt Heiman (Leelanau Conservancy); Steve Christensen (Leelanau County Drain Commissioner); Carolan Sonderegger, Erik Olsen, and Dan Mays (Grand Traverse Band of Ottawa and Chippewa Indians); Steve Largent (Grand Traverse Conservation District and Drain Commissioner); Dan Thorell (Grand Traverse County Health Department); Brad Kluczynski, Wayne Schoonover, and Jim Cook (Grand Traverse County Road Commission); Steve Wade (Grand Traverse Regional Community Foundation); Dennis McCauley (Great Lakes Environmental Center); Scott Kendzierski (Health Department of Northwest Michigan); Jillian Votava and Jeanie Williams (Inland Seas Education Association); Mark Breederland (Michigan Sea Grant); Jo Lattimore (Michigan State University Extension) Jason Kimbrough (Natural Resources Conservation Service); Kathy Egan (Networks Northwest); Hans VanSumeren and Constanza Hazelwood (Northwestern Michigan College – Water Studies Institute) Monnie Peters (Peninsula Township Planning Commission); Keith Termaat (Township Neighbors Network): Angela Brennan (United States Geological Survey); and Patty O'Donnell (citizen).

Special thanks go to the following organizations/individuals for assistance:

- Grand Traverse Regional Land Conservancy and the Leelanau Conservancy identified ecologically significant parcels of land for water quality protection in their services areas within the Coastal Grand Traverse Bay watershed.
- The Conservation Resource Alliance completed an updated road stream crossing survey for the coastal watershed area.
- Kathyrn DePauw assisted in the design/development of many of the watershed maps.

The United States Environmental Protection Agency provided support and funding through Section 319 of the Clean Water Act and the Michigan Department of Environment, Great Lakes, and Energy (EGLE) administered the grant funding. Additionally, Greg Goudy from the EGLE Cadillac District Office has offered invaluable guidance and support throughout the entire approval process.

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Introduction

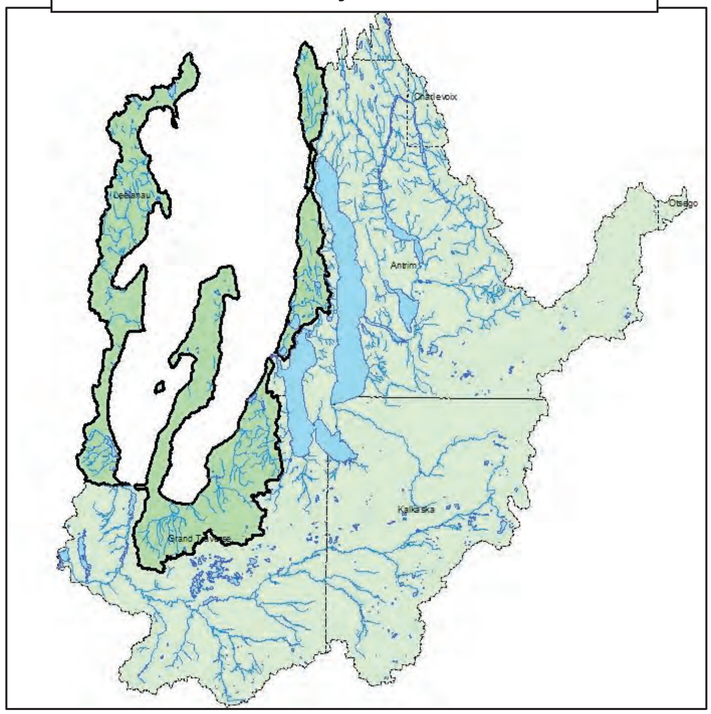
The Grand Traverse Bay region is one of the premier tourist and outdoor recreation regions in the State of Michigan. Its natural resource base and beauty contributes significantly to the quality of life enjoyed by year-round residents, which accounts for the area's continued growth and prosperity. However, increased growth and development, especially on and near the water, and the resulting pressure on natural resources are the largest threats to watershed health in the Grand Traverse Bay region.

In September 2001, TWC received a watershed management planning grant for the Grand Traverse Bay watershed from the U.S. Environmental Protection Agency (EPA) and the Michigan Department of Environmental Quality (now known as the Department of Environment, Great Lakes, and Energy – EGLE). The awarded funds were used to develop a watershed protection plan for the entire Grand Traverse Bay watershed. A subsequent Section 319 grant was awarded in 2004 to update the plan and include additional information according to newly implemented EPA requirements. The original watershed plan summarized existing water quality conditions in and around the bay while also outlining the major watershed pollutants and giving recommendations on how to reduce the impact and amount of pollution entering the system. The plan provided a description of the watershed, covering such topics as bodies of water, population, land use, municipalities, recreational activities, and current water quality conditions in the bay. Additionally, water quality threats were identified and prioritized, efforts to address water quality threats issues were researched and drafted, measurable milestones to guide implementation progress were put in place, and a set of criteria to evaluate the effectiveness of implementation efforts was drafted.

The initial Grand Traverse Bay Watershed Protection Plan (GTBWPP) has proven to be highly successful, with many organizations utilizing it to shape their restoration activities over the past 15 years. In fact, TWC has been steadily working to implement key recommendations from the plan since it was initially drafted in 2003 and has received almost $14 million in funding to implement key portions of the plan that annually prevent 1,726 tons of sediment, 1,482 pounds of phosphorus, and 4,604 pounds of nitrogen from entering Grand Traverse Bay and its watershed. In addition, the Grand Traverse Regional Land Conservancy and the Leelanau Conservancy have received millions of dollars in funding to purchase more than 50,000 acres of conservation easements throughout the watershed. Many portions of the original plan have now been implemented and it is time to evaluate those implementation successes, review what has been accomplished, and identify/update priorities for the next 10 years. The plan that follows does just that.

The Grand Traverse Bay watershed has 9 subwatersheds, most of which are major tributary drainages to Grand Traverse Bay and are highly unique and have specific assets, issues, and threats. As such, TWC and local partners decided to write management plans for the two largest subwatersheds in the Grand Traverse Bay Watershed: the Elk River Chain of Lakes (ERCOL) and the Boardman River. Together these plans account for nearly 81% (786 mi^2) of the land area in the Grand Traverse Bay watershed. The plans provide greater detail on issues specific to each watershed, as well as detailed recommendations for watershed protection efforts. The Boardman River Watershed Prosperity Plan was approved in 2019 and the ERCOL Watershed Plan was submitted in December 2020 and is awaiting approval.

Grand Traverse Bay Coastal Watershed



The watershed plan that follows here will focus on water quality recommendations for the other, smaller drainage areas of the Grand Traverse Bay watershed, with a specific focus on protecting water quality in Grand Traverse Bay. It includes the coastal subwatershed areas of Mitchell, Tobeco, Acme, and Yuba creeks, as well as areas along east and west Grand Traverse Bay and Old Mission Peninsula, totaling almost 190 mi^2. This area is referred to as the Grand Traverse Bay Coastal watershed (see insert at right). Additionally, major findings and recommendations from both the Boardman River Prosperity Plan and ERCOL Watershed Protection Plan are summarized here as well.

The intent of the overall Coastal Grand Traverse Bay Watershed Plan and the two subwatershed plans for the Elk River Chain of Lakes and Boardman River is to assist area watershed groups, lake associations, local governments, volunteer groups, and many others in making sound decisions to help improve and protect water quality in their area. It provides recommendations on how to reduce water quality degradation and protect our valuable resource, the Grand Traverse Bay watershed.

Watershed Characteristics

The Grand Traverse Bay watershed is located in beautiful northwest Michigan's lower peninsula and drains approximately 976 square miles of land. The watershed covers major portions of four counties: Antrim, Grand Traverse, Kalkaska, and Leelanau. The largest municipality in the watershed is the City of Traverse City. Other towns and villages in the watershed include Northport, Suttons Bay, Kingsley, Acme, Kalkaska, Mancelona, Bellaire, and Elk Rapids. Grand Traverse Bay comprises 132 miles of Lake Michigan shoreline from its northwest tip at the Leelanau lighthouse to its northeast tip at Norwood. The bay spans 10 miles at its widest point, stretches a lengthy 32 miles to its base in Traverse City. Grand Traverse Bay is one of the few remaining oligotrophic embayments in the Great Lakes and arguably has the highest water quality of the larger Lake Michigan bays.

The watershed may be broken up into nine distinctive major drainage basins, referred to as subwatersheds. These subwatersheds are the: Elk River Chain of Lakes, Boardman River, Mitchell Creek, Acme Creek, Tobeco Creek, Yuba Creek, East Bay shoreline and tributaries, West Bay shoreline and tributaries, and the Old Mission Peninsula. The coastal subwatersheds that this watershed plan will focus on total 189.6 square miles. Section 3.13 gives more detail on each of the coastal subwatersheds. In addition to the six major rivers and creeks entering the bay (Elk, Boardman, Mitchell, Acme, Tobeco, and Yuba), it has been estimated that there are more than 100 additional small streams that enter the bay draining portions of the watershed.

The Grand Traverse Bay watershed is home to more than 150,000 people sharing their living space with black bear, deer, great blue herons, lady slippers and trillium. Population densities in are the greatest in the Traverse City region, along the Bay's shoreline, and along the large lakes in the Elk River Chain of Lakes. By far, Traverse City and its surrounding townships are the most highly populated areas of the entire region. Between 1990 and 2000, populations in all the surrounding counties increased between 20-27%. The most recent time period (2000-2018) does not have as much population growth as previous years, however Grand Traverse County did increase by 19%. In fact, Grand Traverse County alone has seen a startling 352% increase in population, more than tripling its inhabitants since 1900.

Land use and land cover in the entire watershed is predominantly forest (41%) and agriculture (16%). Other land uses include open shrub/grassland (nonforested), water, wetlands, and urban. Patches of forests occur regularly throughout the watershed with the bulk occurring in the Pere Marquette State Forest (found in the upper Boardman River watershed) and the headwater areas in the Elk River Chain of Lakes watershed. Most of the urban area in the watershed is centered on Traverse City, with small villages dotted along both bays. Additionally, waterfront property along the bay and many inland lakes has also been a hotspot for the development of residential housing and businesses. Just over half of all of the agricultural land in the watershed is comprised of pasture and permanently seeded areas (58%), with orchards/vineyards comprising another 30%. Orchards (mostly cherries and apples) and vineyards dominate agricultural land uses surrounding the bay with other agricultural land types likes pasture and croplands mainly found in outlying watershed areas.

Wetlands are a vital part of the coastal ecosystem and perform important ecological functions like flood storage, pollutant filtration, and habitat for fish and wildlife. In the Coastal Grand Traverse Bay watershed, the most wetlands (by percentage) are found in the East Bay Shoreline subwatershed (~20% of its area). Other subwatersheds with significant amounts of wetlands are Yuba, Tobeco, and Mitchell. A wetland loss analysis for the coastal watershed areas along Grand Traverse Bay was conducted that shows wetland loss since pre-settlement times has been just over 7,000 acres (11 square miles), which is a 38% loss from the original 19,005 acres (30 square miles). However, some subwatersheds have experienced more substantial wetland losses compared to their watershed size – both Acme Creek and Old Mission Peninsula subwatersheds have lost over half of their pre-settlement wetlands, with East Bay Shoreline, Mitchell Creek, and Yuba Creek at just under a 50% loss.

The Grand Traverse Bay region receives an average annual rainfall of 42", of which approximately 16" is recharged to the water table, 20" is evapotranspirated, and the other 6" becomes overland flow to streams. The majority of water entering the bay comes from surrounding tributaries, approximately 604 million gallons of water a day. These tributaries carry replacement water, oxygen, and nutrient and provide habitat for waterfowl, insects, and fish spawning. They are also a source of shelter and food for the bay's inhabitants.

Grand Traverse Bay is on Lake Michigan, which is part of the Great Lakes ecosystem. Water levels in the Great Lakes fluctuate naturally daily, seasonally, and annually and are primarily affected by evaporation, surface runoff, and precipitation. Short term water level fluctuations in the Great Lakes (<24 hrs) are due to changes in barometric pressure and winds. Long-term annual variation of Great Lakes water levels occur over consecutive years and depend on climatic conditions. Because of changing water levels, the shorelands of the Great Lakes are considered a dynamic and quickly changing environment. Wave action, storms, wind, ground water seepage, surface water runoff, and frost are contributing factors to changing and reshaping the shoreline. High water levels dominated Lake Michigan in the 1980s and 1990s, however, this was followed by a period of below the long-term average annual levels in the 2000s. Since 2014, lake levels in Lake Michigan have been on the rise reaching record levels in 2019 and 2020. These high water levels have led to increased shoreline erosion, which can cause financial property loss as well as public losses to recreation facilities, roads and other public works.

Designated Uses and Their Pollutants, Sources, and Causes

Overall, the prevailing opinion among experts is that the water quality in Grand Traverse Bay is excellent. The bay is typical of other oligotrophic embayments in the Great Lakes; deep, clear, cold, with an overall low productivity. However, there are several potential threats to water quality, with localized areas of pollution, both in the bay and its watershed.

Michigan water quality standards and identified designated uses for Michigan surface waters were used to assess the condition of the watershed. Each of Michigan's surface waters is protected by Water Quality Standards for specific designated uses. These standards and designated uses are designed to 1) protect the public's health and welfare, 2) to enhance and maintain the quality of water, and 3) to protect the state's natural resources. Protected designated uses as defined by Michigan's Department of Environmental Quality include: agricultural, industrial water supply, public water supply (at point of intake), navigation, warm water and/or cold water fishery, other indigenous aquatic life and wildlife support, fish consumption, and partial and total body contact recreation.

None of the designated uses for the Grand Traverse Bay watershed are impaired on a watershed wide scale, however, there are local impairments of note due to bacteria contamination and poor macroinvertebrate communities. There are five waterbodies in the overall Grand Traverse Bay Watershed that are classified as 'impaired', three of which are in the Coastal Grand Traverse Bay watershed. Coincidentally, two are named Mitchell Creek – one in Grand Traverse County and the other in Antrim County. Additionally, Northport Creek in Leelanau County was recently listed as impaired at the end of 2020. All are impaired due to elevated *E.coli* levels and are not meeting their total body contact designated use. "At-risk" designated uses were also identified to protect in order to maintain water quality throughout the Grand Traverse Bay and its coastal watershed. These are the coldwater fishery; other indigenous aquatic life; total body contact; and public water supply at point of intake (for Traverse City municipal intake on East Bay only).

For each designated use to protect in the Grand Traverse Bay Coastal watershed there are several pollutants or stressors that are either currently affecting water quality or pose future threats if they are not addressed. The term environmental stressor is used to describe those factors that may have a negative effect on the ecosystem but aren't necessarily categorized as contaminants that change water chemistry. These environmental stressors include: sediment; nutrients; thermal pollution; toxic substances; changes to hydrologic flow; invasive species; pathogens; and loss of habitat.

A Comprehensive Watershed Management Table was developed listing sources and causes of watershed pollutants and environmental stressors. This table summarizes key information necessary to begin water quality protection, provides specific targets to act upon for watershed management, and forms the basis for all future implementation projects to protect the quality of the watershed. It may be used as a reference to distinguish what the major sources of pollutants are on a watershed-wide scale. However, it does not distinguish between pollutants and their sources and causes in individual subwatersheds. Not all of the pollutants listed in the table are a problem everywhere in the watershed and there are differences among the coastal subwatersheds. Each one is unique in the challenges it faces to maintain water quality protection. For example, the Tobeco Creek watershed is mainly a wetland type area and does not contain much development. In contrast, the Mitchell Creek watershed, just a few miles down the bay, faces extreme pressure from future development. Each must face water quality protection measures in its own way.

Prioritization of Pollutants

Watershed pollutants and environmental stressors were ranked and prioritized based on how they most affect (or have the potential to affect) the watershed's "at risk" designated uses. The ranking also took into account priorities from the 2005 Grand Traverse Bay Watershed Protection Plan, which ranked all pollutants/stressors and differentiated between the watershed and the bay. For the Grand Traverse Bay Coastal Watershed Plan, the Steering Committee chose to note the top four most important pollutants and environmental stressors rather than numerically rank anything. These top four pollutants and stressors are (in alphabetical order): changes to hydrologic flow; loss of habitat; nutrients; and sediment.

Grand Traverse Bay is part of the Great Lakes system and thus has differing priorities for pollutants and environmental stressors than the land-based area that makes up the coastal watershed. It is important to realize that the bay and its watershed are connected, but inherently different. While the watershed itself encompasses rivers, streams, lakes, and hundreds of square miles of land, the bay is a large open body of water that is connected to the Great Lakes. Certain pollutants have more of an impact on streams and lakes than on larger bodies of water like Grand Traverse Bay (i.e., thermal pollution and sediment), while other pollutants are more of a concern for the Grand Traverse Bay. The Steering Committee identified two priority environmental stressors to Grand Traverse Bay itself – invasive species and toxic substances (including emerging contaminants). Additionally, elevated nutrients in the nearshore area may cause localized problems in the bay.

Major sources for all of the priority pollutants include the following: road stream crossings; shoreline erosion; stormwater; reduction of wetlands; lack of riparian buffers/streamside canopy; and septic systems.

Priority Protection and Critical Areas

In addition to ranking priority pollutants and their sources, the Steering Committee identified several areas in the Grand Traverse Bay Coastal watershed as critical areas or those needing priority protections. Recommendations will be aimed at protecting land from future development or protecting water quality from future potential impairment. High priority locations for these actions are placed into either "Priority Areas" (for protective actions) or "Critical Areas" (for restoration actions). Priority areas are those that are particularly vulnerable to degradation or development pressure and should be protected from future harm. Critical areas are those in need of restoration that are contributing a significant amount of pollutants to the watershed (currently or in the future) and are considered targets for future water quality improvement efforts.

One of the best strategies for protecting priority areas is through the purchase/donation of land or the establishment of conservation easements. In cooperation with local land conservancies, areas of land in the coastal watershed areas of Grand Traverse, Antrim, and Leelanau County were reviewed and identified for their potential contribution to improve the water quality of Grand Traverse Bay and its watershed, among other factors. In addition to areas noted by each conservancy as priorities for their land protection efforts, there are a number of other priority areas in the Grand Traverse Bay Coastal watershed that should be protected. They are as follows:

- Critical Dunes
- Undeveloped Parcels Along Grand Traverse Bay Shoreline
- Headwaters of Acme Creek and Cedar Lake
- Wetlands
- Grand Traverse Bay Spawning Reefs.

Identified critical areas reflect the primary sources of nonpoint source pollution in the coastal watershed area and include urban stormwater, development, and shoreline management; shoreline/bank erosion; agriculture; road/stream (or other transportation) crossings; and malfunctioning septic systems. Critical areas are shown at two levels: general critical areas and specific critical areas. General critical areas represent broader areas where attention is generally needed, whereas specific critical areas encompass a more defined area.

General critical areas include the following:

- Grand Traverse Bay Shoreline
- Riparian corridors (Areas within 100 feet of bodies of water)
- City and village centers.

Specific critical areas include:

- Areas of Bacterial Impairment (Mitchell Creek – Grand Traverse County; Mitchell Creek – Antrim County; Northport Creek)
- Urban Sprawl
- Severe Road Stream Crossings
- High Risk Erosion Areas (identified by EGLE)
- Areas of Wetland Development Pressure
- Areas of Coastal Infrastructure Challenges (due to high-water)

- Grand Traverse Bay – Macrophyte Bed Clusters
- Compromised At-Risk Streams
- Small Dam Locations
- Agricultural Lands – Tobeco and Mitchell Creek headwater areas.

There are several areas in the coastal watershed where various specific critical areas are clustered and overlap. These include areas surrounding Mitchell Creek (GT County), Cedar Lake/Creek area just north of Traverse City, Suttons Bay area and south, and the Village of Northport. Special care should be taken for these areas and they should be prioritized for restoration activities.

Watershed Goals, Objectives, and Recommendations

The overall mission for the Grand Traverse Bay Coastal Watershed Plan is to provide guidance for the implementation of actions that will reduce the negative impact that pollutants and environmental stressors have on the designated watershed uses in the coastal watershed area. These goals work in conjunction with those identified in the companion subwatershed plans for the Boardman River and Elk River Chain of Lakes subwatersheds.

The envisioned endpoint is to have Grand Traverse Bay and all lakes and streams within its watershed support appropriate designated and desired uses while maintaining their distinctive environmental characteristics and aquatic biological communities.

Using suggestions obtained from stakeholder meetings conducted throughout the watershed and examples from other watershed management plans, the project steering committee developed seven broad goals for the Grand Traverse Bay Coastal watershed. Additionally, specific objectives were created for each of the watershed goals. Watershed goals are as follows:

1. Protect the integrity of aquatic and terrestrial ecosystems.
2. Protect and improve water quality.
3. Establish and promote land and water management practices that conserve or protect natural resources.
4. Encourage and support a sustainable local economy with diverse recreational and commercial opportunities that are compatible with a healthy watershed.
5. Develop and maintain effective education and outreach efforts to support watershed protection.
6. Preserve the distinctive character, cultural heritage, and aesthetic qualities of the watershed.
7. Integrate climate-resilient practices and efforts throughout the watershed.

In an effort to successfully accomplish the goals and objectives, specific and tangible recommendations for the Coastal Grand Traverse Bay watershed were developed based on the prioritization of watershed pollutants, sources, and causes while also looking at the priority and critical areas in the watershed. These implementation tasks include structural, vegetative, managerial, and educational elements and represent an integrative approach, combining watershed goals and covering more than one pollutant at times, to reduce existing sources of priority pollutants and prevent future contributions. Implementation tasks specific to the

Boardman River and Elk River Chain of Lakes subwatersheds can be found in their respective watershed plans.

Implementation tasks were summarized by the pollutant and/or source it relates to. In this way, organizations may work on a specific issue (i.e., urban stormwater or shoreline restoration) that may contribute more than one type of watershed pollutant and meet more than one watershed goal. The categories are as follows: Shoreline Protection and Restoration; Stormwater; Road Stream Crossings; Planning, Zoning, and Land Use; Land Protection and Management; Habitat, Fish and Wildlife; Recreation, Safety, and Human Health; Hydrology and Groundwater; Monitoring; Wetlands; Invasive Species; Agriculture; Wastewater and Septics; and Emerging Issues.

Additionally, an Information and Education Strategy was developed with specific recommendations which highlight the actions needed to successfully maintain and improve watershed education, awareness, and stewardship for the Grand Traverse Bay watershed. It lays the foundation for the collaborative development of natural resource programs and educational activities for target audiences, community members, and residents.

The project steering committee looked at the major sources of pollution in the watershed and carefully considered the impacts of each and measures that need to be taken to reduce their impacts. Feasibility of task implementation and its likelihood of pollutant reduction were considered as well. It was decided that focusing on reducing and/or eliminating the following pollutant sources will address the bulk of pollution entering the Coastal Grand Traverse Bay and its surrounding watershed (listed in no particular order):

- Development
- Lack of ordinances to protect water quality and natural resources
- Lack of riparian buffer
- Reduction of wetlands
- Road stream crossings
- Streambank and shoreline erosion
- Stormwater

Costs for implementing all the tasks noted in the plan reach into the tens of millions. Implementation tasks total more than $34 million, with the most expensive tasks in the categories containing stormwater management, road stream crossings, and septic systems. Outreach costs are much less at just over $2 million

Evaluation

An evaluation strategy will be utilized to measure progress during the Grand Traverse Bay Coastal Watershed Plan's implementation phase and to determine whether or not water quality is improving. The first aspect of the evaluation strategy measures how well the watershed plan is being implemented and whether or not project milestones are being met. The second aspect will evaluate water quality protection efforts.

Evaluating the effectiveness of improving and maintaining water quality throughout the watershed will be assessed through the results of monitoring efforts relative to established criteria and existing conditions. A set of criteria were developed using existing water quality standards/criteria as well as existing watershed conditions to determine if water quality is being maintained or improved in Grand Traverse Bay and its coastal tributaries. A comprehensive monitoring plan was drafted to help determine if the criteria are being met. The monitoring plan includes a variety of water quality parameters, as well as bacteria (*E. coli*), aquatic insects (benthic macroinvertebrates), and fish parameters such as population dynamics, abundance, mortality, recruitment and movement.

Conclusions and Next Steps

Over the next ten years The Watershed Center and other project partners will continue to strengthen existing partnerships with various groups throughout the watershed. Funding sources will be sought for future projects to implement recommendations made in this watershed plan. These may include government, foundation, and corporate grant sources, along with potential new mechanisms for funding by local communities. The project Steering Committee looked at the major sources of pollution in the watershed and decided that focusing on reducing and/or eliminating pollution stemming from stormwater runoff, streambank and shoreline erosion, road stream crossings, lack of riparian buffers, the reduction of wetlands, and a lack of ordinances to protect water quality will address the bulk of pollution entering the Grand Traverse Bay and its surrounding watershed. Priority should be given to implementation tasks (both BMPs and educational initiatives) that work to reduce the effects from these sources.

Priority work that should be conducted over the next several years is as follows, in no particular order:

- Streambank and shoreline erosion stabilization projects
- Establish riparian buffers in priority areas
- Install green infrastructure and other stormwater BMPs in urban areas to reduce stormwater runoff
- Road crossing improvements using BMPs
- Assist with developing or revising Master Plans and Zoning Ordinances to include more water quality protection, including stormwater ordinances
- Continue successful initiatives by local conservancies to preserve open space and wildlife corridors
- Implement measures to reduce bacteria contamination of local waters
- Wetland assessment, restoration, and protection
- Continue tracking the introduction and spread of invasive species and implement programs to reduce and eliminate their spread
- Continue developing Conservation Plans for farms
- Continue priority monitoring programs.
- Continue outreach and education efforts outlined in the IE strategy.

Additionally, outreach and education efforts should be continued as outlined in the IE Strategy in Chapter 9. Environmental awareness, education, and action from the public will continue to grow as the IE Strategy is implemented and resident awareness of the watershed about various issues increases. Implementing the IE Strategy is a critical and important long-term task to accomplish.

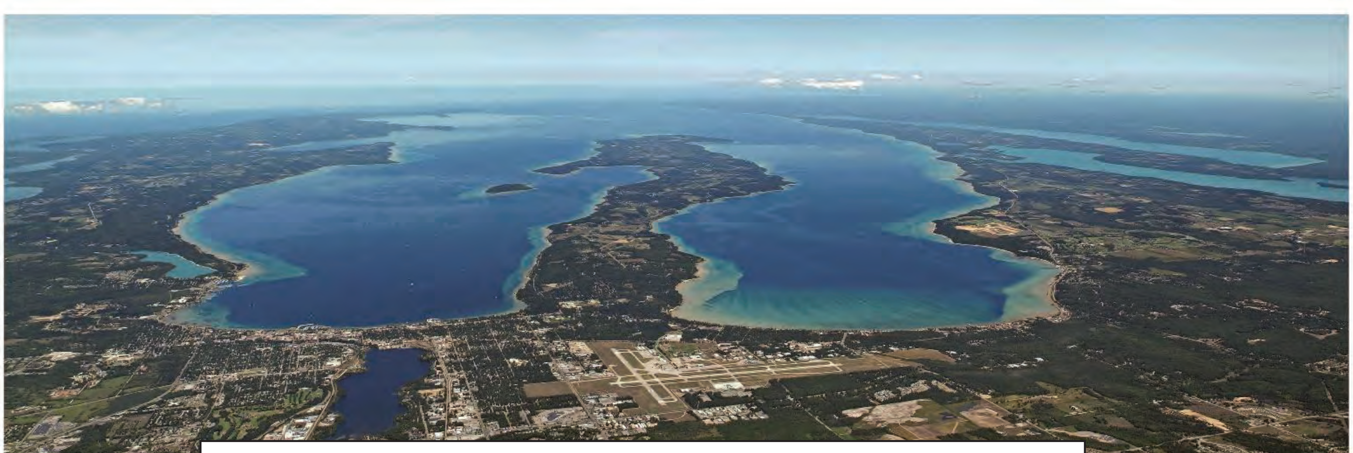
CHAPTER 2 INTRODUCTION

The Grand Traverse Bay region is one of the premier tourist and outdoor recreation regions in the State of Michigan. Its natural resource base and beauty contributes significantly to the quality of life enjoyed by year-round residents, which accounts for the area's continued growth and prosperity. However, increased growth and development, especially on and near the water, and the resulting pressure on natural resources are the largest threats to watershed health in the Grand Traverse Bay region.

The watershed contains major parts of four counties and more than 50 municipalities and townships. In order to maintain the quality of the resource, local governments, concerned citizens, and numerous agencies all need to work together towards a common goal – protecting the Grand Traverse Bay and its watershed from further environmental degradation.

How does the quality of water in this area affect us individually, and why should we care? These are questions that environmental agencies have been dealing with for years. How can we get people to care and learn about their water quality and consider how their individual actions may affect it? The answer is simple; our lives are tied to water by many different threads. The primary thread is that humans need clean, drinkable water to live. The drinking water that we rely upon may become contaminated by a number of chemicals and pollutants (like fertilizers, pesticides, and gasoline) that we and others use everyday and don't think about. Additionally, new and emerging issues involving pharmaceuticals and other wastes in water supplies are being researched.

What about the water and watershed that we recreate in? Healthy ecosystems are why people love to live here. Many people live in the Grand Traverse Bay region because of the numerous forms of recreation it provides. In fact, The Watershed Center Grand Traverse Bay (TWC) conducted a 'Core Values' study of the watershed in 2010 and key results showed that residents are deeply connected to Grand Traverse Bay and its watershed. Northern Michigan benefits from what TWC refers to as an "*Up North Quality of Life.*" Residents realize that the quality of



East and West Arms of Grand Traverse Bay, Photo credit: Jim Anderson life in the Grand Traverse region and the health of the local economy are inextricably linked to the health of its water resources. Tourists visit and people move and retire to northern Michigan because of its abundance of natural resources and beautiful, clean waters. Therefore, improved water quality in Grand Traverse Bay will not only result in improved water quality, but a healthier economy and improved quality of life. By improving the waters of Grand Traverse Bay, people will continue to visit and enjoy the area, and come back for many years.

But, if pollution is unchecked and degradation of this natural resource continues, many of the activities enjoyed by residents and visitors alike will be in jeopardy. Contamination of streams, lakes, and the bay from numerous sources may lead to unsafe swimming and blooms of aquatic plants, which are an annoyance to swimmers and boaters. Recreational fishing is also impacted by water pollution; many inland lakes already have fish consumption advisories due to heavy metal contamination. Other forms of recreation that many of us enjoy on a daily basis are at stake as well, including swimming, kayaking, canoeing, and even hiking. It is imperative that residents and visitors become educated about the watershed, know what is impacting the resource, and are educated on what can be done to help make the Grand Traverse Bay watershed a place where they want to live and come back to time and time again.

In September 2001, TWC received a watershed management planning grant for the Grand Traverse Bay watershed from the U.S. Environmental Protection Agency (EPA) and the Michigan Department of Environmental Quality (MDEQ). The grant and awarded funds were authorized by Section 319 of the federal Clean Water Act and were used to develop a watershed protection plan for the Grand Traverse Bay watershed. A subsequent Section 319 grant was awarded in 2004 to update the plan and include additional information according to newly implemented EPA requirements. The original protection plan summarized existing water quality conditions in and around the bay while also outlining the major watershed pollutants and giving recommendations on how to reduce the impact and amount of pollution entering the system. The plan provided a description of the watershed, covering such topics as bodies of water, population, land use, municipalities, recreational activities, and current water quality conditions in the bay. Additionally, water quality threats were identified and prioritized, efforts to address water quality threats issues were researched and drafted, measurable milestones to guide implementation progress were put in place, and a set of criteria to evaluate the effectiveness of implementation efforts was drafted.

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Mitt Watershed Council, the Grand Traverse Band of Ottawa and Chippewa Indians, numerous lake associations, and municipalities). In fact, TWC has been steadily working to implement key recommendations from the plan since it was initially drafted in 2003 and has received almost $14 million in funding to implement key portions of the plan that annually prevent 1,726 tons of sediment, 1,482 pounds of phosphorus, and 4,604 pounds of nitrogen from entering Grand Traverse Bay and its watershed. In addition, the Grand Traverse Regional Land Conservancy and the Leelanau Conservancy have received millions of dollars in funding to purchase more than 50,000 acres of conservation easements throughout the watershed. Many portions of the original plan have now been implemented and it is time to evaluate those implementation successes, review what has been accomplished, and identify/update priorities for the next 10 years. The plan that follows does just that.

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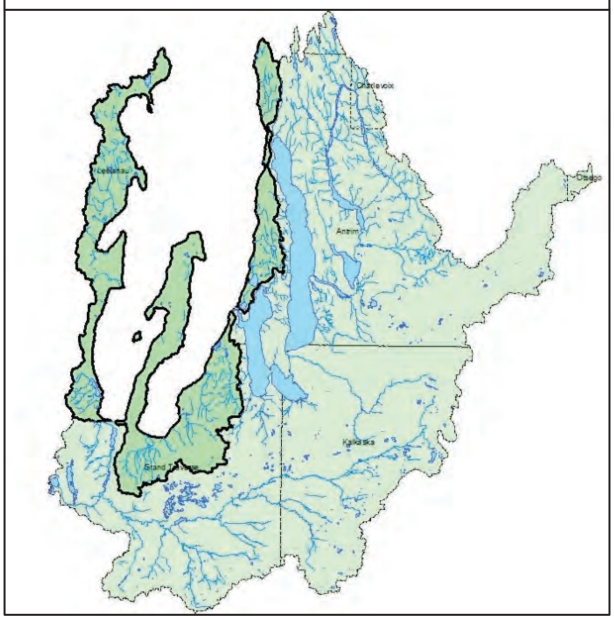
The watershed plan that follows here will focus on water quality recommendations for the other, smaller drainage areas of the Grand Traverse Bay watershed, with a specific focus on protecting water quality in Grand Traverse Bay. It includes the coastal subwatershed areas of Mitchell, Tobeco, Acme, and Yuba creeks, as well as areas along east and west Grand Traverse Bay and Old Mission Peninsula, totaling almost 190 mi^2. This area is referred to in the following plan as the Grand Traverse Bay Coastal watershed. Additionally, major findings and recommendations from both the Boardman River Prosperity Plan and ERCOL Watershed Protection Plan are summarized here as well. The Boardman River Watershed Prosperity Plan was approved in 2019 (TWC and PSC 2016) and the Elk River Chain of Lakes Plan was submitted in December 2020 and is awaiting approval (TOMWC and TWC 2020).

Grand Traverse Bay Coastal Watershed



The intent of the overall Coastal Grand Traverse Bay Watershed Plan and the two subwatershed plans for the Elk River Chain of Lakes and Boardman River is to assist area watershed groups, lake associations, local governments, volunteer groups, and many others in making sound decisions to help improve and protect water quality in their area. It provides recommendations on how to reduce water quality degradation and protect our valuable resource, the Grand Traverse Bay watershed.

CHAPTER 3 DESCRIPTION OF THE GRAND TRAVERSE BAY WATERSHED

3.1 Location and Size

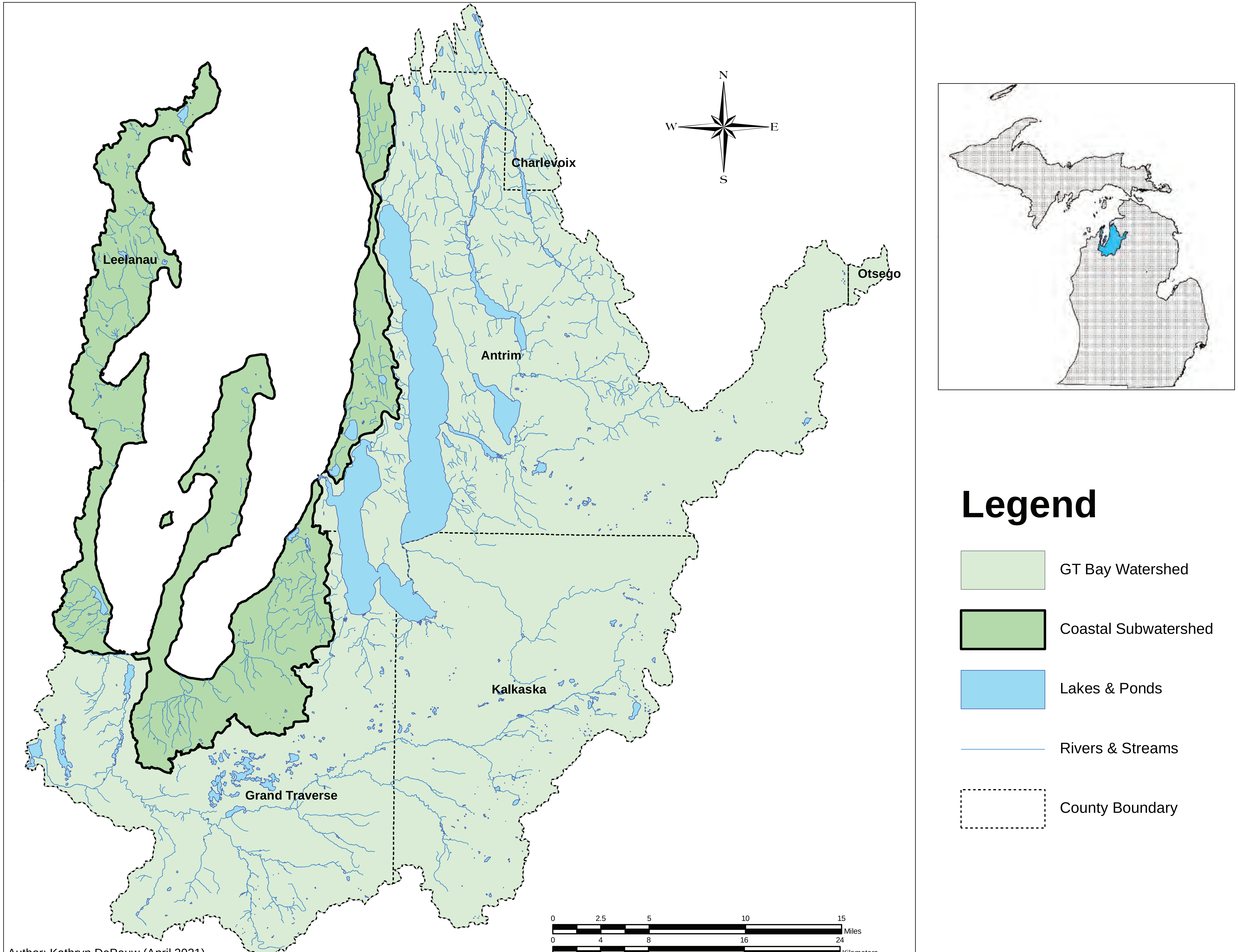
The Grand Traverse Bay watershed is located in beautiful northwest Michigan's lower peninsula and drains approximately 976 square miles of land. The watershed is one of the larger ones in the State of Michigan and covers major portions of four counties: Antrim, Grand Traverse, Kalkaska, and Leelanau (Table 1). The largest municipality in the watershed is the City of Traverse City. Other towns and villages in the watershed include Northport, Suttons Bay, Kingsley, Acme, Kalkaska, Mancelona, Bellaire, and Elk Rapids (Figure 1).

Table 1: Counties Located in the Grand Traverse Bay Watershed

County	Area (mi^2)	Area in Watershed (mi^2)	% County in Watershed	% Watershed per County
Leelanau	375.7	66.6	17.7%	6.8%
Grand Traverse	490.3	296.0	60.4%	30.3%
Kalkaska	571.0	212.6	37.2%	21.8%
Antrim	524.5	378.6	72.2%	38.8%
Charlevoix	453.9	19.0	4.2%	2.0%
Otsego	527.3	3.2	0.6%	0.3%
TOTAL	2942.7	976.0		

Grand Traverse Bay comprises 132-miles of Lake Michigan shoreline from its northwest tip at the Leelanau lighthouse to its northeast tip at Norwood. The bay spans 10 miles at its widest point and stretches a lengthy 32 miles to its base in Traverse City (Figure 1). The bay is divided into western and eastern arms by a peninsula, which extends northward approximately 18 miles. The maximum depth of west and east Grand Traverse Bay is 400 and 613 feet, respectively (GLEC 2006). Grand Traverse Bay is one of the few remaining oligotrophic embayments in the Great Lakes and arguably has the highest water quality of the larger Lake Michigan bays. Oligotrophic is a term applied to lakes that are typically low in accumulated nutrients and high in dissolved oxygen, both of which are characteristics of high quality waters. Lakes such as these are clear and blue and most often cold, much like the Grand Traverse Bay.

This watershed plan will be focusing on the Coastal Grand Traverse Bay watershed, which comprises about 190 square miles of the larger Grand Traverse Bay watershed.



GRAND TRAVERSE BAY WATERSHED

FIGURE 1: LOCATION AND SIZE

3.2 Water Bodies

The watershed may be broken up into nine distinctive major drainage basins, referred to as subwatersheds (Table 2, Figure 2). These subwatersheds are the Elk River Chain of Lakes, Boardman River, Mitchell Creek, Acme Creek, Tobeco Creek, Yuba Creek, East Bay shoreline and tributaries, West Bay shoreline and tributaries, and the Old Mission Peninsula. The coastal subwatersheds that this watershed plan will focus on are listed in Table 2 below and total 189.6 square miles.

In addition to the six major rivers and creeks entering the bay (Elk, Boardman, Mitchell, Acme, Tobeco, and Yuba), it has been estimated that there are more than 100 additional small streams that enter the bay draining portions of the watershed (Shoreline Inventory, Appendix A). By far, most of the streams and creeks in the watershed are designated trout streams. The largest creek that is not classified as a coldwater trout stream is Tobeco Creek.

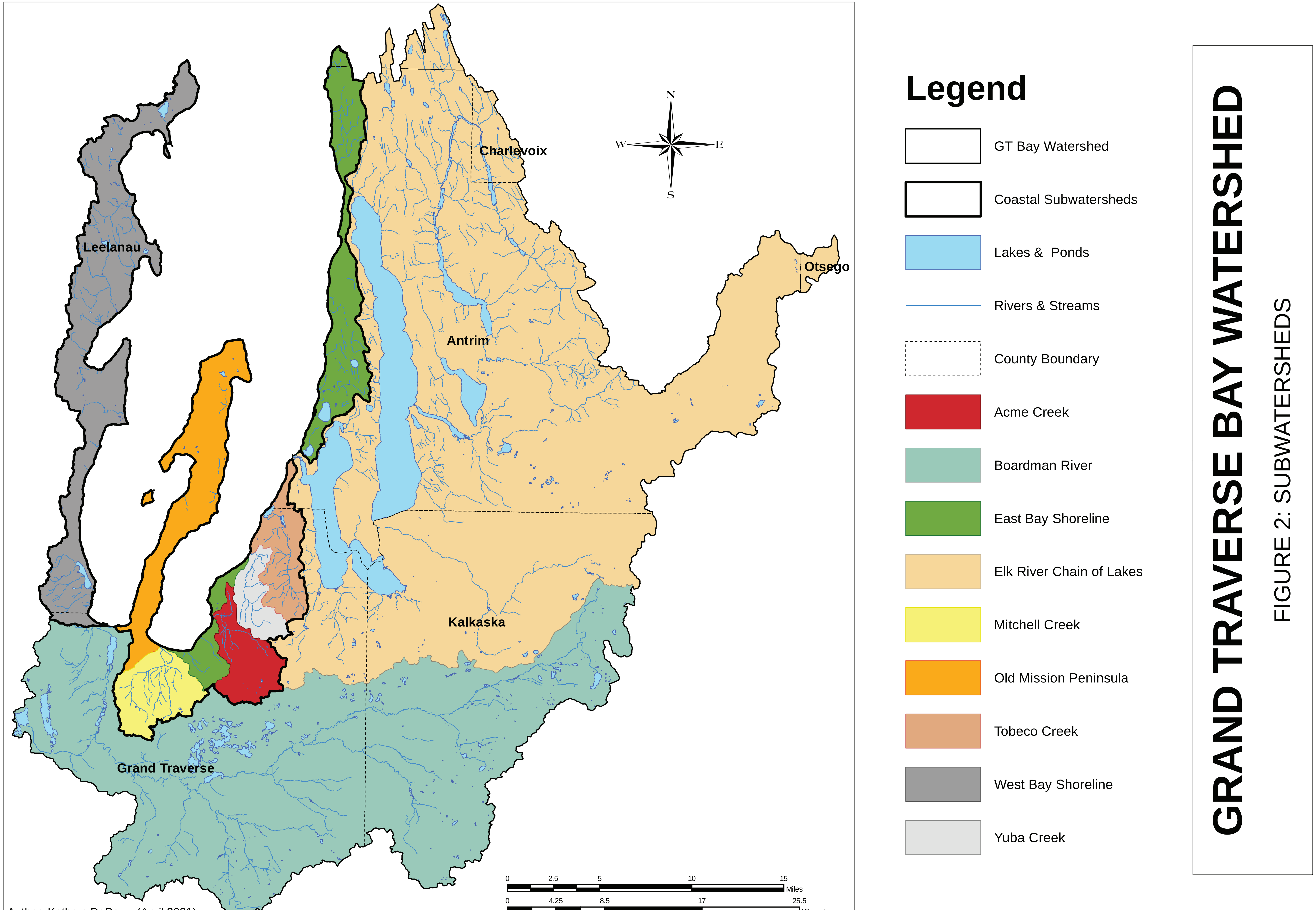
There are only a handful of lakes in the coastal watershed area – Birch and Bass lakes in Antrim County; Petobego Pond on Tobeco Creek; Prescott Lake on Old Mission Peninsula; and Cedar, Mougeys, and Mud lakes in Leelanau County. More information on these inland lakes can be found on the Michigan Glacial Lakes Partnership website using the Conservation Planner tool http://ifrshiny.seas.umich.edu/mglp/.

Section 3.13 gives more detail on each of the coastal subwatersheds including the streams and lakes located within each.

Table 2: Subwatersheds in the Grand Traverse Bay Watershed

Basin	**SQUARE MILES**	**% of Watershed**
1. Elk River Chain of Lakes*	502.6	51.5
2. Boardman River*	283.8	29.1
Coastal Subwatersheds		
3. West Bay Shoreline and Tributaries	68.0	7.0
4. East Bay Shoreline and Tributaries	38.8	4.0
5. Old Mission Peninsula	31.3	3.2
6. Mitchell Creek	15.7	1.6
7. Tobeco Creek	14.2	1.5
8. Acme Creek	13.2	1.4
9. Yuba Creek	8.4	0.9
Total	976.0	100.0

**These watersheds will not be addressed specifically in this watershed plan.*


Leelanau
Charlevoix
Antrim
Otsego
Kalkaska
Grand Traverse
N
S
E
W
Legend
GT Bay Watershed
Coastal Subwatersheds
Lakes & Ponds
Rivers & Streams
County Boundary
Acme Creek
Boardman River
East Bay Shoreline
Elk River Chain of Lakes
Mitchell Creek
Old Mission Peninsula
Tobeco Creek
West Bay Shoreline
Yuba Creek
0 2.5 5 10 15 Miles
0 4.25 8.5 17 25.5 Kilometers
Author: Kathryn DePauw (April 2021)
GRAND TRAVERSE BAY WATERSHED
FIGURE 2: SUBWATERSHEDS

3.3 Population

Rich in land and water resources, the Grand Traverse Bay region is home to more than 150,000 people sharing their living space with black bear, deer, great blue herons, lady slippers and trillium. Population densities in Grand Traverse Bay watershed are the greatest in the Traverse City region, along the bay's shoreline, and along the large lakes in the Elk River Chain of Lakes (Figure 3). By far, Traverse City and its surrounding townships are the most highly populated areas of the entire region.

Population in the Grand Traverse Bay region started increasing rapidly in the 1970s. Populations increased by more than 50% between 1970 and 1990 in some watershed counties, reaching as high as 156% for Kalkaska County (Tables 3 and 4). Between 1990 and 2000, populations in all the surrounding counties increased between 20-27% (Table 3). The most recent time period (2000-2018) does not have as much population growth as previous year; however Grand Traverse County did increase by 19%. In fact, Grand Traverse County alone has seen a startling 352% increase in population, more than tripling its inhabitants since 1900 (Table 4). It is also evident that the fastest population growth (from 2000 to 2010), and corresponding development, is currently occurring along the shoreline of Grand Traverse Bay as well as in areas located just outside city and village boundaries (i.e. Traverse City, Suttons Bay, Elk Rapids), indicating increasing sprawl in those areas (Figure 4).

Table 3: Percent Population Change for Selected Years

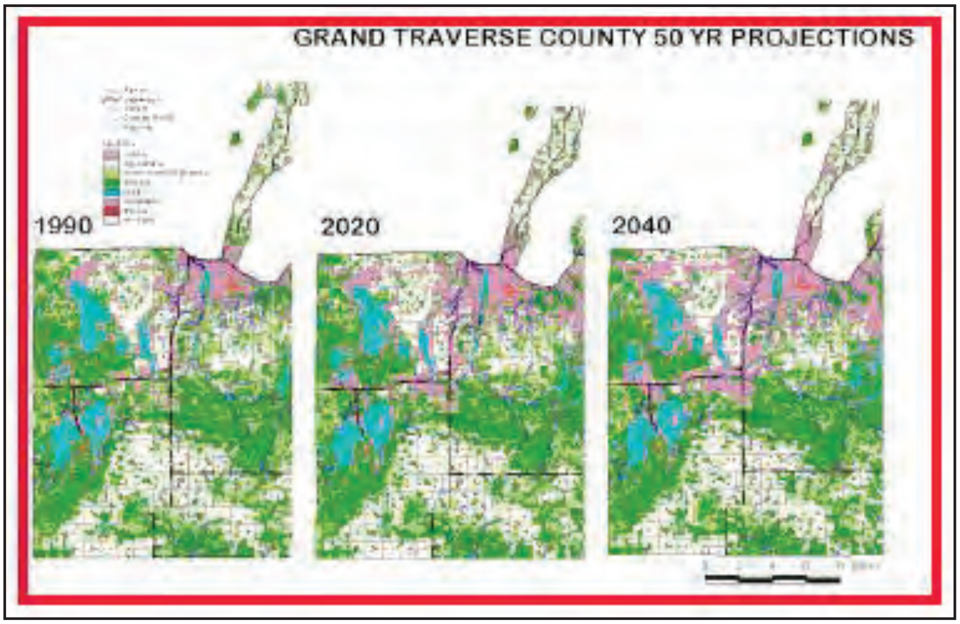
County	% Change 1900 - 1950	% Change 1950 - 1970	% Change 1970 - 1990	% Change 1990 - 2000	% Change 2000 - 2018
Antrim	35	18	44	27	1
Grand Traverse	40	37	64	21	19
Kalkaska	36	15	156	23	8
Leelanau	18	26	52	28	3
Total	4	29	66	23	12

Table 4: Current and Historic Population by County

County	1900	1950	1970	1990	2000	2010	2018 *Estimated*	% Change 1900 - 2018
Antrim	16,568	10,721	12,612	18,185	23,110	23,580	23,365	41%
Grand Traverse	20,479	28,598	39,175	64,273	77,654	86,986	92,573	352%
Kalkaska	7,133	4,597	5,272	13,497	16,571	17,153	17,824	150%
Leelanau	10,556	8,647	10,872	16,527	21,119	21,708	21,764	106%
Total	54,736	52,563	67,931	112,482	138,454	149,427	155,526	184%

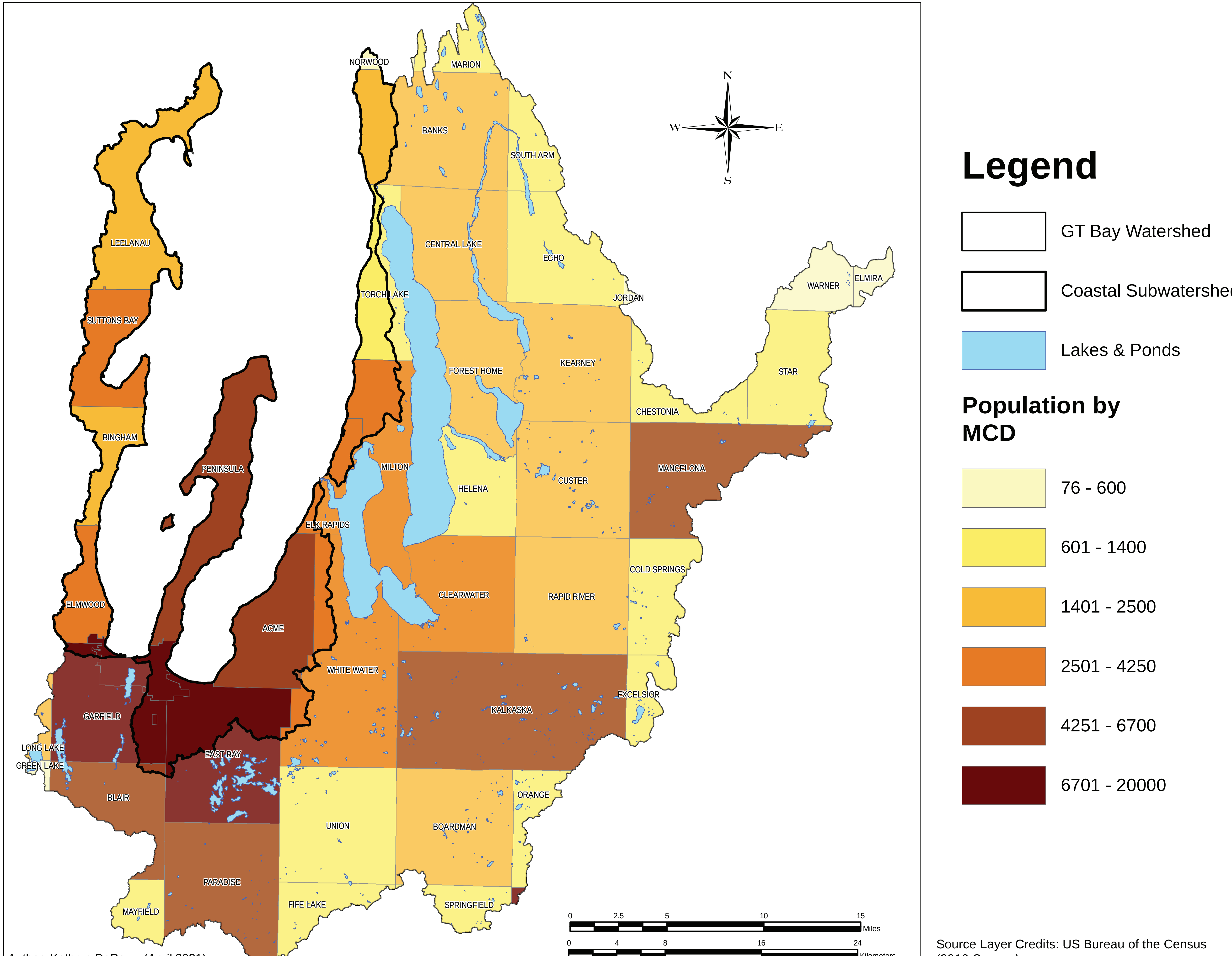
*Note: Since US Census Data does not follow watershed boundaries, populations from the four major counties making up the Grand Traverse Bay watershed were used to illustrate changes in population. Charlevoix County was not included due to the small amount of the watershed in its boundary.

A model developed by researchers in the late 1990s at Michigan State University projected future urban land uses and development in the Grand Traverse Bay watershed through 2020 and 2040. Termed the Land Transformation Model, it couples Artificial Neural Network (ANN) routines to GIS databases containing information on population growth, transportation factors, and locations of important landscape features such as rivers, lakes, recreational sites, and high-quality vantage points to forecast future land use patterns. The model then predicts where development will occur and how much area will be classified as urban in the future. For more information on the Land Transformation Model, see the following publications: Pijanowski et al., 1996; Pijanowski et al., 2000; and Boutt et al. 2001.



The model maps (shown at right) predict future urban development in Grand Traverse County is anticipated along the US 31 highway that runs east-west past the large lakes in the county. In addition, urban development up the Old Mission Peninsula is also possible. Urban development along the northwestern portions of the county, near 3- and 4-Mile Roads, is also anticipated.

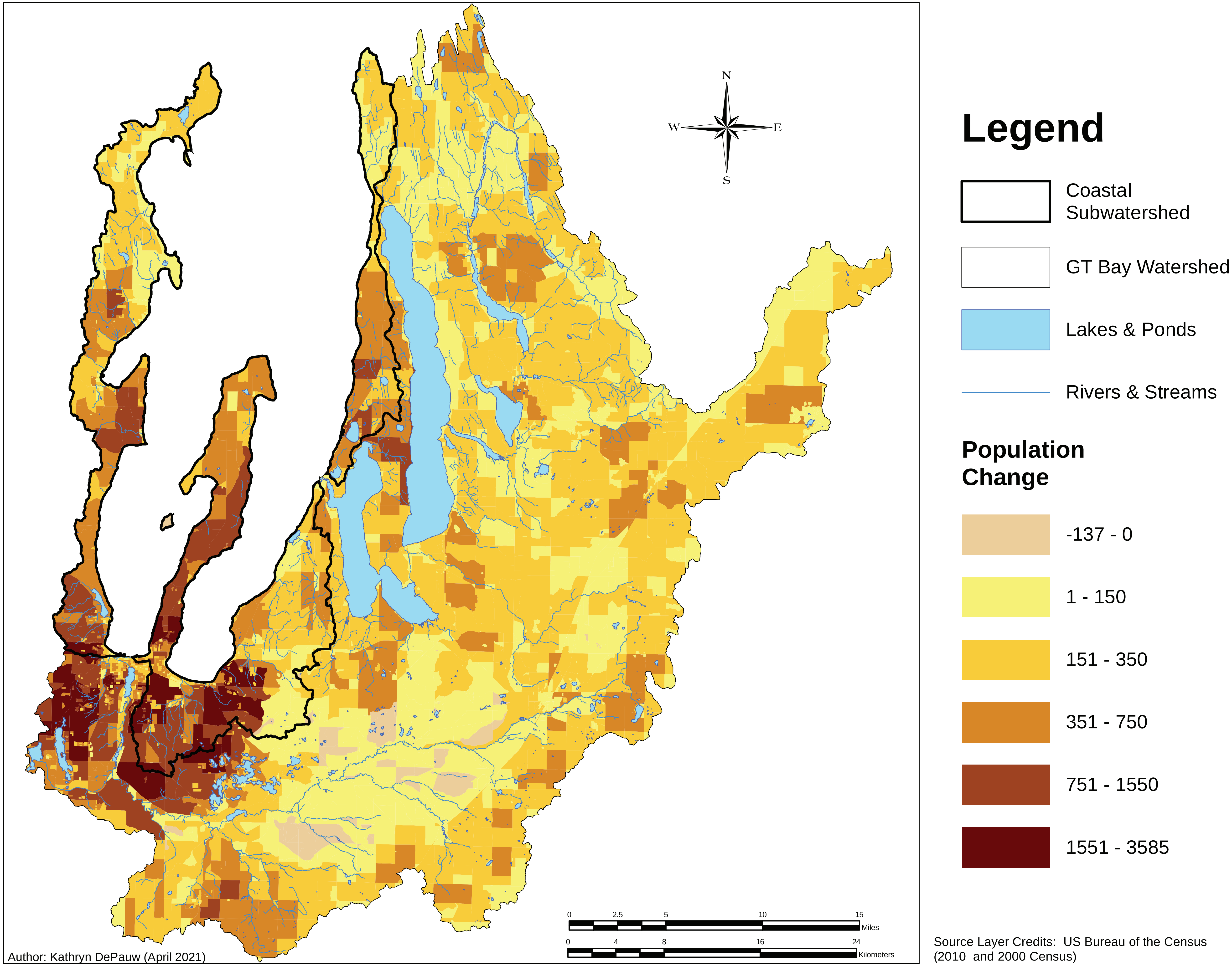
Urban growth puts tremendous pressure on the area's natural resources, particularly its water resources. Many of the threats to the watershed's environmental health are a direct result of this growth.



Source Layer Credits: US Bureau of the Census (2010 Census)

GRAND TRAVERSE BAY WATERSHED

FIGURE 3: POPULATION BY MINOR CIVIL DIVISON



GRAND TRAVERSE BAY WATERSHED

FIGURE 4: POPULATION CHANGE 2000-2010

3.4 *Jurisdictions*

There are 44 townships and 11 municipalities that have all or some of their boundaries located within the Grand Traverse Bay watershed (Table 5, Table 6, Figure 5). Some of these townships and municipalities have multiple subwatersheds within their boundaries that they must take into consideration (Table 6, Figure 5). Furthermore, there are 11 townships and 4 municipalities located along the shoreline of Grand Traverse Bay that must deal with Great Lakes shoreline issues as well as other watershed concerns (Table 5, Figure 5).

Since the watershed crosses so many political boundaries, with varying types of waterfronts to deal with, it is important for local governments to know and understand watershed boundaries and to plan on a watershed scale with neighboring townships and municipalities. This overlap of governance, with multiple systems of community and resource planning, zoning, and economic development, necessitates close coordination among jurisdictions for the management, protection, and leveraging of the watershed‘s abundant natural, cultural, and economic resources.

A general discussion and a more in-depth look at local governments' master plans and zoning ordinances is found in Section 3.12.

Table 5: Townships and Municipalities in the Grand Traverse Bay Watershed

Entire Grand Traverse Bay Watershed		
County	**Townships**	**Municipalities**
Leelanau	4	2
Grand Traverse	12	3
Kalkaska	9	1
Antrim	15	5
Charlevoix	3	0
Otsego	1	0
Total	44	11
Located on Grand Traverse Bay Shoreline		
County	**Townships**	**Municipalities**
Leelanau	4	2
Grand Traverse	3	1
Antrim	4	1
Total	11	4

Table 6: Watershed Areas of Townships and Municipalities
(Highlighted rows indicate township/municipality is in Coastal Grand Traverse Bay watershed.)

Township or Municipality	Subwatershed	Total Area (mi²)	Total Area in Watershed (mi²)	% of Municipality in Watershed
Leelanau County				
Bingham	West Bay Shoreline	26.09	10.22	39.2%
Elmwood	West Bay Shoreline	20.67	10.49	50.7%
Leelanau	West Bay Shoreline	41.17	26.76	65.0%
Suttons Bay	West Bay Shoreline	23.96	15.89	66.3%
Village of Northport	West Bay Shoreline	1.89	1.89	100.0%
Village of Suttons Bay	West Bay Shoreline	1.02	1.02	100.0%
Kalkaska County				
Boardman	Boardman River	36.22	35.35	97.6%
Clearwater	Chain of Lakes	33.79	33.79	100.0%
Coldsprings	Boardman River Chain of Lakes	36.31	16.82	46.3%
Excelsior	Boardman River	36.21	7.90	21.8%
Garfield	Boardman River	106.73	0.37	0.3%
Kalkaska	Boardman River Chain of Lakes	69.56	65.95	94.8%
Orange	Boardman River	34.79	8.08	23.2%
Rapid River	Boardman River Chain of Lakes	35.24	35.24	100.0%
Springfield	Boardman River	35.56	7.41	20.8%
Village of Kalkaska	Boardman River Chain of Lakes	1.66	1.66	100.0%
Grand Traverse County				
Acme	Acme Creek Chain of Lakes East Bay Shoreline Tobeco Creek Yuba Creek	24.17	24.17	100.0%
Blair	Boardman River Mitchell Creek	36.04	19.21	53.3%
East Bay	Acme Creek Boardman River East Bay Shoreline Mitchell Creek Old Mission Penin.	42.56	42.56	100.0%
Fife Lake	Boardman River	35.18	10.79	30.7%
Garfield	Boardman River Mitchell Creek Old Mission Penin. West Bay Shoreline	28.08	27.28	97.2%
Green Lake	Boardman River	36.41	0.91	2.5%
Long Lake	Boardman River	35.54	2.35	6.6%
Mayfield	Boardman River	36.05	7.05	19.5%
Paradise	Boardman River	52.11	34.24	65.7%
Peninsula	Old Mission Penin.	28.02	28.02	100.0%

Township or Municipality	Subwatershed	Total Area (mi^2)	Total Area in Watershed (mi^2)	% of Municipality in Watershed
Union	Boardman River	36.00	36.00	100.0%
Whitewater	Acme Creek Boardman River Chain of Lakes Tobeco Creek Yuba Creek	54.63	54.63	100.0%
Village of Fife Lake	Boardman River	0.76	0.01	0.9%
City of Traverse City (City is partially located in Leelanau County)	Boardman River Mitchell Creek Old Mission Penin. West Bay Shoreline	8.31	8.31	100.0%
Village of Kingsley	Boardman River	0.81	0.81	100.0%
Antrim County				
Banks	Chain of Lakes East Bay Shoreline	45.03	43.52	96.6%
Central Lake	Chain of Lakes	30.46	30.46	100.0%
Chestonia	Chain of Lakes	35.58	11.11	31.2%
Custer	Chain of Lakes	35.14	35.14	100.0%
Echo	Chain of Lakes	35.34	26.13	73.9%
Elk Rapids	Chain of Lakes East Bay Shoreline Tobeco Creek	8.96	8.96	100.0%
Forest Home	Chain of Lakes	32.85	32.85	100.0%
Helena	Chain of Lakes	22.71	22.71	100.0%
Jordan	Chain of Lakes	35.19	0.51	1.4%
Kearney	Chain of Lakes	34.63	34.38	99.3%
Mancelona	Chain of Lakes	70.40	33.32	47.3%
Milton	Chain of Lakes East Bay Shoreline	41.14	41.14	100.0%
Star	Chain of Lakes	34.33	21.67	63.1%
Torch Lake	Chain of Lakes East Bay Shoreline	20.65	20.65	100.0%
Warner	Chain of Lakes	35.59	9.52	26.8%
Village of Bellaire	Chain of Lakes	1.44	1.44	100.0%
Village of Central Lake	Chain of Lakes	1.25	1.25	100.0%
Village of Elk Rapids	Chain of Lakes East Bay Shoreline Tobeco Creek	1.99	1.99	100.0%
Village of Ellsworth	Chain of Lakes	0.82	0.82	100.0%
Village of Mancelona	Chain of Lakes	1.00	1.00	100.0%
Charlevoix County				
Marion	Chain of Lakes	26.49	7.40	27.9%
Norwood	East Bay Shoreline	18.28	0.88	4.8%
South Arm	Chain of Lakes	33.05	10.70	32.4%
Otsego County				
Elmira	Chain of Lakes	36.27	3.23	8.9%

Statewide Survey of Elected and Township Officials (by MSUE Victor Institute)
In spring 2002, Michigan State University Extension conducted a statewide survey of local officials to assess their perspectives on land use issues and decision-making as well as educational needs. One set of surveys was sent to county commissioners, county planning and zoning commissioners, township supervisors, trustees, and other township personnel (Suvedi et al. November 2002). Another set was sent to just township officials including supervisors, administrators, trustees, and other personnel (Suvedi et al. December 2002). Results of these surveys indicate that more than 75% of all respondents expect growth pressures to increase significantly in the next five years. When indicating the top ten future problems facing local governments, seven of the top ten problems were related to growth and water resource issues, indicating a strong concern for protection of natural resources by local officials.

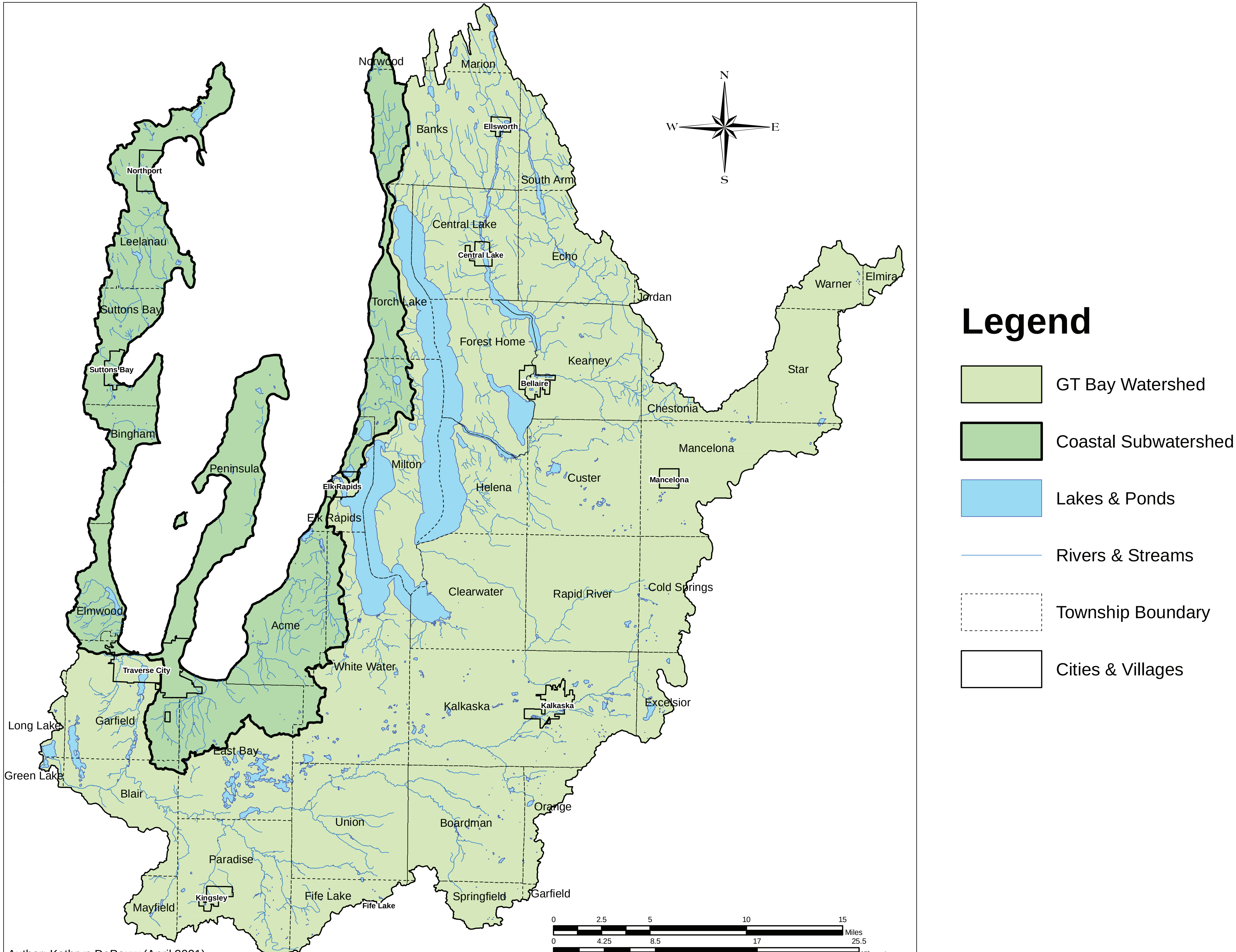
Growth issues:

- Loss of open spaces for other uses
- Loss of forestland
- Loss of farmland
- Beginning of suburban sprawl

Water Resource Issues:

- Ground water quality
- Surface water quality
- Over development of lakeshores

As far as barriers to meeting land use challenges in local governments, more than 60% of both survey respondents ranked "poor public understanding of land use issues" and "poor public support for difficult land use decisions" as the top two reasons. This clearly indicates a strong need for public education to increase awareness of land use issues throughout local governments in the state.



GRAND TRAVERSE BAY WATERSHED

FIGURE 5: TOWNSHIPS, CITIES, AND VILLAGES

3.5 Land Use/Land Cover

Land use can greatly influence the health of and water quality in a watershed, even affecting biological diversity, habitat complexity and flow regimes. Specifically, urban land uses can have negative impacts as it increases impervious surfaces and stormwater runoff and potentially reduces groundwater recharge areas. Agricultural land can also have significant impacts as it can also increase stormwater runoff, alter stream flows, and lead to increases in nonpoint source pollution into surrounding waterbodies from nutrients, sediments, and pesticides/herbicides. Studies have shown that forested river catchments support more species of aquatic organisms when compared to catchments with a large proportion of agricultural land (Allan 2004).

General land cover data was determined for the watershed using the U.S. Geological Survey's 2016 National Land Cover Database (NLCD), coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC). The MRLC is a group of federal agencies who coordinate and generate consistent and relevant land cover information at the national scale for a wide variety of environmental, land management, and modeling applications. https://www.mrlc.gov/.

Land use and land cover in the watershed is predominantly forest (41%) and agriculture (16%). Other land uses include open shrub/grassland (nonforested), water, wetlands, and urban (Figure 6A, Figure 6B, Table 7). Patches of forests occur regularly throughout the watershed with the bulk occurring in the Pere Marquette State Forest (found in the upper Boardman River watershed) and the headwater areas in the Elk River Chain of Lakes watershed. Most of the urban area in the watershed is centered on Traverse City, with small villages dotted along both bays. Additionally, waterfront property along the bay and many inland lakes has also been a hotspot for the development of residential housing and businesses (Figure 6A, 6B). It is worthy to note that, when looking at just the Coastal Grand Traverse Bay watershed area only, the land use percentages differ a bit from the entire watershed, with agricultural and urban uses increased along the coast (Figure 6B, Table 7).

Table 7: Land Use/Land Cover in the Grand Traverse Bay Watershed

Land Use/Cover Type	Percentage of Watershed	Percentage of Coastal Watershed
Forested	41	31
Agriculture	16	28
Nonforested (Open Shrub and Grassland)	15	11
Urban (Residential, Commercial, etc.)	11	17
Water (Lakes, Ponds, Rivers, etc.)	8	1
Wetlands	8	11
Barren (Beach, Sand Dune, Exposed Rock, etc.)	1	2

**USGS NLDC 2016*

Agricultural lands in the Grand Traverse Bay watershed were analyzed using the United States Department of Agriculture's (USDA) 2019 Crop Data Layer downloaded from their Geospatial Data Gateway (https://datagateway.nrcs.usda.gov/GDGHome.aspx). Local USDA Natural Resources Conservation Service (NRCS) staff helped consolidate all the 20+ types of agricultural land uses in the dataset to just the four types shown in Table 8. Since this data layer is specific to agricultural land uses and was compiled by a different agency and in a different way from the 2019 NLCD, the total acreage of agricultural land use differs slightly between the two. However, the USDA agricultural layer is useful to look at different types of agricultural lands within the watershed and where they are spatially located. For the total amount of agricultural lands in the Grand Traverse Bay watershed, there is about an even split between pasture and permanently seeded areas and orchards/vineyards at about 40% each (Table 8). Looking at the agricultural lands on the coastal watershed map (Figure 6C), one can clearly see that orchards (mostly cherries and apples) and vineyards dominate agricultural land uses surrounding the bay. Other agricultural land types of pasture and croplands are mainly found in outlying watershed areas of Antrim, Kalkaska, and Grand Traverse Counties.

Cherry Trees in Leelanau County

Photo credit: Danielle U'Ren

Numbers and types of agricultural animals for various subwatershed areas were obtained from model input data for the Spreadsheet Tool for Estimating Pollutant Loads (discussed in detail in Chapter 8.2) from the EPA website (https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl#oldas). Data for the STEPL model is pulled from various source, including the USDA's National Agricultural Census Data. Most farm animals in the watershed are beef cattle, pigs, or chicken (Table 9); this distribution is shown as pasture lands in Figure 6C. In the Coastal Grand Traverse Bay watershed, pigs comprise the largest number of agricultural animals, with most herds located in the Tobeco, Mitchell, Acme and Old Mission subwatersheds. The largest number of chickens are found in the West Bay Shoreline subwatershed area in Leelanau County, as well as in the Tobeco Creek subwatershed. Beef cattle and all other types of farm animals in the Coastal Grand Traverse Bay watershed seem to be evenly distributed.

Table 8: Agricultural Land Use in the Grand Traverse Bay Watershed

Type of Agriculture	Total Sq. Miles	Percentage of Total Ag Lands
Orchards and Vineyards	50.9	41%
Pasture/Permanent Seeding	49.8	40%
Cropland	21.2	17%
Other Agricultural Lands	2.2	2%

**USDA 2019 Crop Data Layer*

Table 9: Farm Animal Distribution in the Grand Traverse Bay Watershed

Subwatershed	Beef Cattle	Dairy Cattle	Swine	Sheep	Horse	Chicken	Turkey	Duck
Elk River Chain of Lakes	2,402	67	655	462	553	1,966	34	59
Boardman River	1,138	73	3,714	39	301	1,253	50	18
Coastal GT Bay	919	71	1,881	36	234	849	23	18
Total	**4,459**	**211**	**6,250**	**537**	**1,088**	**4,068**	**107**	**95**

**https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl#oldas*

Land cover percentages for each of the nine subwatersheds in the Grand Traverse Bay watershed were also calculated using both the 2019 NLCD land use dataset as well as the agricultural land use dataset from USDA (Tables 10 and 11). These tables show the unique differences each subwatershed may face when it comes to land use issues. For example, the Acme Creek watershed is over 60% forested, but the second top land use is urban (15%), which shows a potential trend of deforestation as more urban sprawl moves in from the dense urban area of Traverse City. This urban sprawl trend is further seen in that the top land use in the Mitchell Creek subwatershed, located partially within the Traverse City limits, is urban. Both of these subwatersheds are small, under 20-square miles (Table 2, previous section), and are vulnerable to the negative effects of water quality that follow with increasing urbanization. In fact, of all subwatersheds, Mitchell Creek has the highest amount of percentage of urban lands at 36%.

The lesser developed areas along Grand Traverse Bay comprise the West and East Bay Shoreline subwatersheds, as well as the Old Mission Peninsula watershed. These subwatersheds have more forested areas and agricultural lands dominated by orchards and vineyards (Table 10 and 11, Figure 6B and 6C). And, while the Tobeco Creek subwatershed is often thought of as a large wetland complex, over half of its land area is considered agricultural compared to its total area, most of that is orchards/vineyards with a mix of cropland and pasture lands in the headwater areas (Table 11, Figure 6C). As discussed above, pasture lands in the Tobeco Creek area are mainly pigs and chicken.

Land use issues in the Boardman and ERCOL subwatersheds are further discussed in their respective watershed management plans.

Table 10: Percent Land Use in the Grand Traverse Bay Watershed by Subwatershed

Land Use	West Bay	Old Miss.	East Bay	Mitchell	Acme	Yuba	Tobeco	Boardman	ERCOL
Forested	33.6	26.6	30.9	17.6	62.8	19.6	16.1	44.1	43.4
Agriculture	28.1	36.6	21.3	20.2	6.5	30.0	51.5	9.8	14.4
Nonforested	12.4	10.0	7.6	13.6	11.8	19.8	7.3	20.4	13.5
Urban	12.9	21.6	14.2	36.5	15.1	16.9	9.2	12.6	7.7
Water	1.4	0.4	2.6	0.1	0.1	0.1	1.5	2.2	13.7
Wetlands	9.6	1.8	20.2	12.0	3.7	12.8	12.5	10.8	7.3
Barren	2.0	3.0	3.2	0.0	0.1	0.9	2.1	0.2	0.2

**USGS NLDC 2019*

Table 11: Percent of Total Agricultural Land Types

LAND USE	West Bay	Old Miss.	East Bay	Mitchell	Acme	Yuba	Tobeco	Boardman	ERCOL
Pasture	9.1	6.4	31.1	31.1	38.1	33.7	33.1	61.9	53.3
Orchards and Vineyards	87.0	90.8	50.7	50.7	51.1	51.6	45.0	10.9	21.0
Cropland	3.6	2.5	14.2	14.2	8.8	14.2	21.7	21.4	24.6
Other Ag.	0.3	0.3	4.0	4.0	2.0	0.5	0.1	5.9	1.1

**USDA 2016 Crop Data Layer*

Protected and Public Lands

Of special note are all the publicly held and/or protected lands in the watershed, which are mostly natural and forested land uses. Land conservation groups in the watershed (Grand Traverse Regional Land Conservancy and Leelanau Conservancy, see Section 5.7 for more info) own tracts of protected lands as natural areas and have many private conservation easements protecting land indefinitely (Figure 7). In addition, there are several areas of state-owned land throughout the coastal watershed area. Other public lands include public parks such as those owned by municipalities (such as the City of Traverse City and individual townships), shown as point locations on Figure 7. This large amount of publicly owned land provides significant recreational opportunities within the watershed, attracting thousands of visitors every year, and adds significantly to the highly cherished quality of life that makes this area such a desirable place to live.

Maple Bay Natural Area, Grand Traverse County
Photo credit: Grand Traverse Regional Land Conservancy

Comparison to Land Use Data in 2005 Grand Traverse Bay Watershed Protection Plan (GTBWPP):

The land use dataset in the 2005 GTBWPP was patched from a variety of sources and defined at the county level. Depending on the source, the data layers were from as early as 1978 up to as recent as 2000. GIS and land use mapping capabilities have come a long way since the original plan was written and land use is now available on a watershed wide basis (as discussed above) from reliable sources. Because of this, caution must be used when comparing watershed and subwatershed land uses from the original plan to that of the 2016 NLCD data layer used for this plan. A cursory look at the changes in land use percentages reveals what would typically be expected within a developing watershed – decreases in forested and agricultural areas combined with an increase in urban areas (Table 12). Particularly concerning are decreases to wetland areas; this is discussed in-depth using detailed data in the next section. However, supporting the need for caution is the 'water' land use percentage calculation, which says that type of land use has increased over the past 11 years, which is unrealistic.

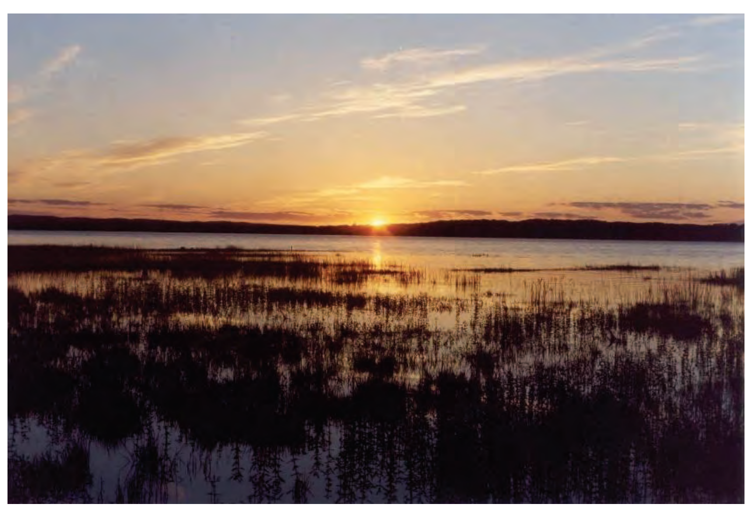
Table 12: Land Use Changes in the Grand Traverse Bay Watershed

Land Use/Cover Type	Percentage of Watershed 2016 NLCD	Percentage of Watershed 2005 GTBWPP	*Change*
Forested	41.1	49.8	*-8.7%*
Agriculture	15.7	19.4	*-3.7%*
Nonforested (Open Shrub and Grassland)	15.0	14.8	*-0.2%*
Urban (Residential, Commercial, etc.)	10.7	6.8	*3.9%*
Water (Lakes, Ponds, Rivers, etc.)	8.9	6.6	*2.3%**
Wetlands	8.0	12.9**	*-4.9%*
Barren (Beach, Sand Dune, Exposed Rock, etc.)	0.6	0.1	*0.5%*

**This is where caution should be taken when analyzing this data – it is unrealistic that the square miles of lakes/ponds/rivers increased by 2.3% over 11 years.*
***Adjusted wetland data from composite wetland analysis in 2005 GTBWPP)*

Grand Traverse Bay Coastal Watershed Wetland Loss Analysis

Wetlands are a vital part of the coastal ecosystem and perform important ecological functions. They act as a living filter by removing excessive nutrients, sediments, and other pollutants (like heavy metals) from the water. Wetlands also provide valuable habitat for fish and wildlife by providing spawning and breeding grounds, sources of food, migratory resting places, and safety zones for fish and wildlife. Most freshwater fish depend on wetlands during some part of their life cycle and nearly all of Michigan's amphibians are wetland dependent, especially for breeding. More than one-third of all threatened and endangered animal species



in the United States are either located in wetland areas or dependent on them. Examples of Michigan's threatened or endangered animals that rely on wetlands include the Bald Eagle, Osprey, Common Loon and King Rail. Wetlands also act like a sponge, temporarily holding large quantities of flood water and releasing them slowly, preventing flooding in downstream areas. Their roots systems also stabilize soil and reduce erosive wave action.

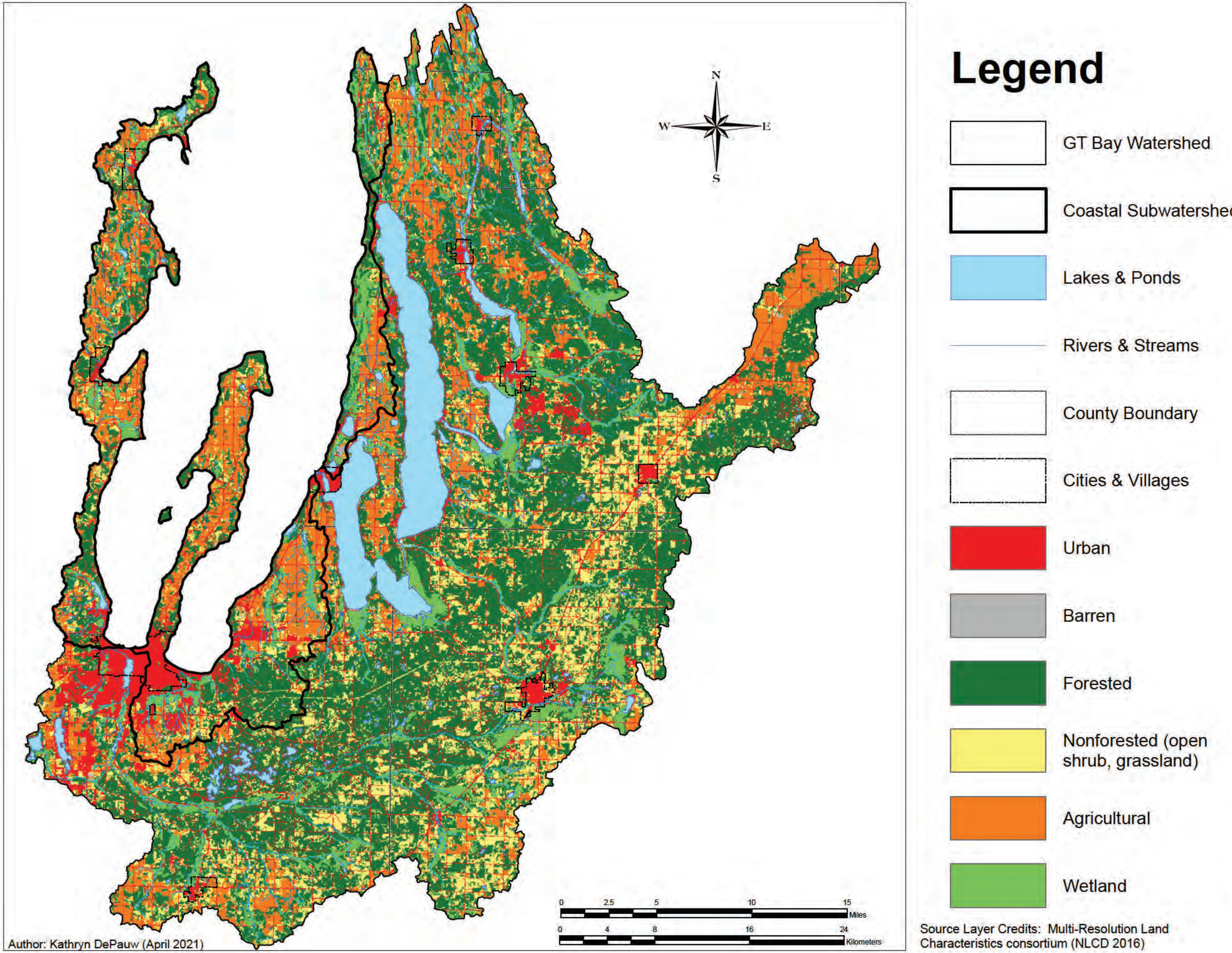
Data from the 2005 National Wetlands Inventory database show wetlands throughout the entire Grand Traverse Bay watershed, with the majority being classified as "forested" or "forested mix". In the Coastal Grand Traverse Bay watershed, the most wetlands (by percentage) are found in the East Bay Shoreline subwatershed (~20% of area). Other subwatersheds with significant amounts of wetlands are Yuba, Tobeco, and Mitchell (Figure 8A).

A wetland loss analysis for the coastal watershed areas along Grand Traverse Bay was conducted by EGLE using their pre-settlement wetlands spatial layer and comparing it to a 2005 National Wetland Inventory (NWI) data layer compiled by the U.S. Fish and Wildlife Service. Table 13 and Figure 8B show that the total wetland loss in the Grand Traverse Bay coastal watershed area since pre-settlement times has been just over 7,000 acres (11 square miles), about a 38% loss from the original 19,005 acres (30 square miles). However, some subwatersheds have experienced more substantial wetland losses compared to their watershed size – both Acme Creek and Old Mission Peninsula subwatersheds have lost over half of their pre-settlement wetlands, with East Bay Shoreline, Mitchell Creek, and Yuba Creek at just under a 50% loss (Table 13, Figure 8B).

Table 13: Grand Traverse Bay Coastal Watershed Wetland Loss Analysis*

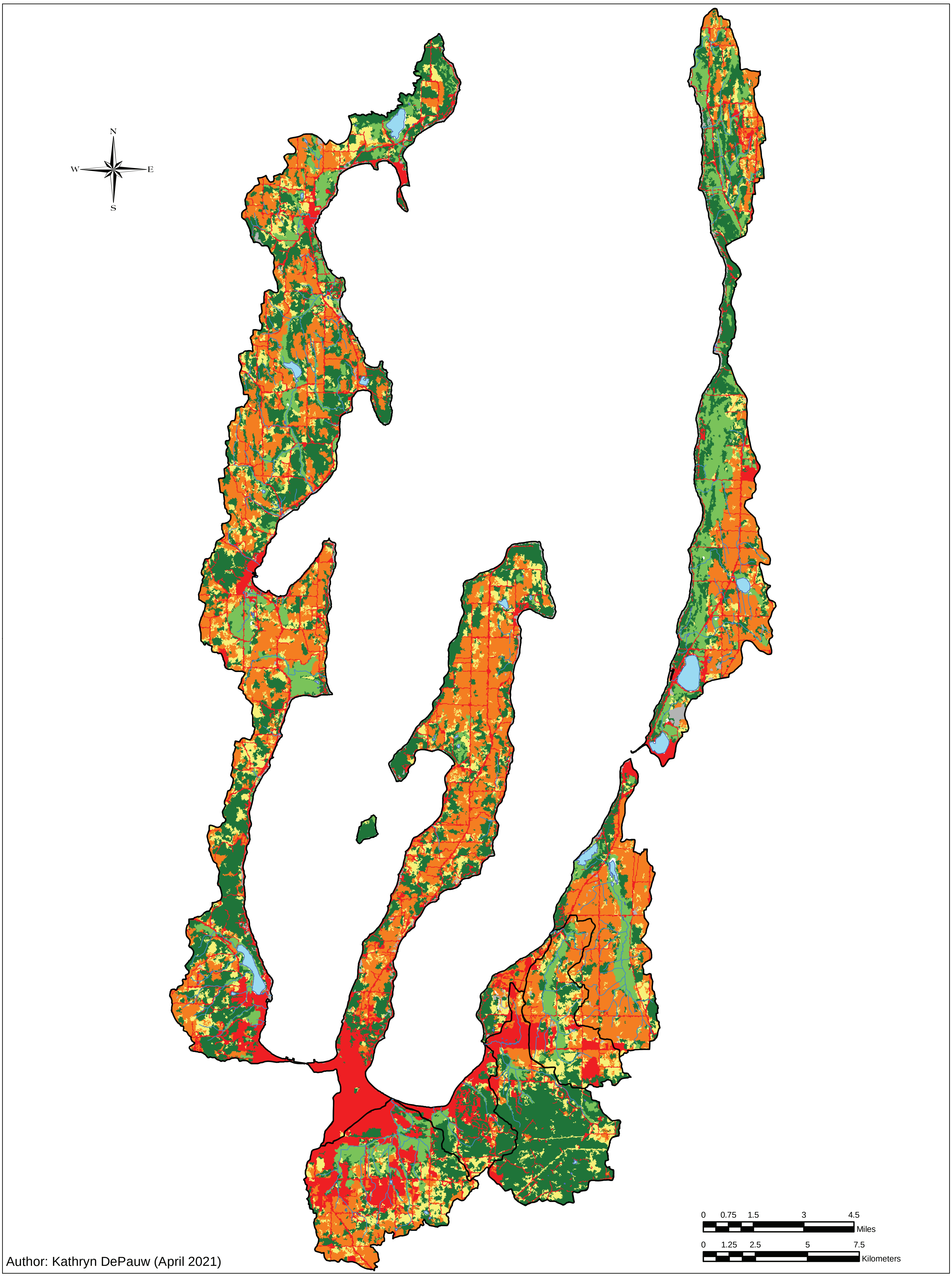
Subwatershed	Pre-settlement Wetland Acreage (ac)	2005 Wetland Acres	Lost Acres	Percent Loss
West Bay Shoreline	5,406	3,832	1,575	29%
East Bay Shoreline	7,371	4,300	3,071	42%
Mitchell Creek	2,298	1,255	1,043	45%
Yuba Creek	1,128	586	542	48%
Tobeco Creek	1,636	1,220	416	25%
Acme Creek	500	241	259	52%
Old Mission Peninsula	667	315	353	53%
TOTAL	**19,005**	**11,747**	**7,258**	**38%**

**Historical wetland data was produced from existing soils surveys and are approximations of wetland extent and condition. According to meta-data associated with the pre-settlement wetlands spatial layer, NWI Coding for Pre-European Settlement wetland polygons was derived from soil characteristics and checked against Pre-European Settlement vegetation maps produced by interpreting General Land Office (GLO) Surveys from the early 1800s. The National Wetland Inventory (NWI) in 2005 was conducted by the United States Fish and Wildlife Service through interpretation of aerial photos and topographic data. Land Cover as mapped by the Michigan Resource Inventory System (MIRIS), Michigan Department of Natural Resources, through interpretation of aerial photographs. Lake levels in 2005 were lower than the long term historical average generated by the Unties States Army Corps of Engineer. Because wetland networks are dynamic and can migrate over time, there are areas of land that were not predicted to be wetlands in the pre-settlement layers that are predicted to be wetlands according to the NWI 2005 layer.*



GRAND TRAVERSE BAY WATERSHED

FIGURE 6A: LAND USE AND LAND COVER



Layer Credits: Multi-Resolution Land Characteristics consortium (NLCD 2016)

Legend

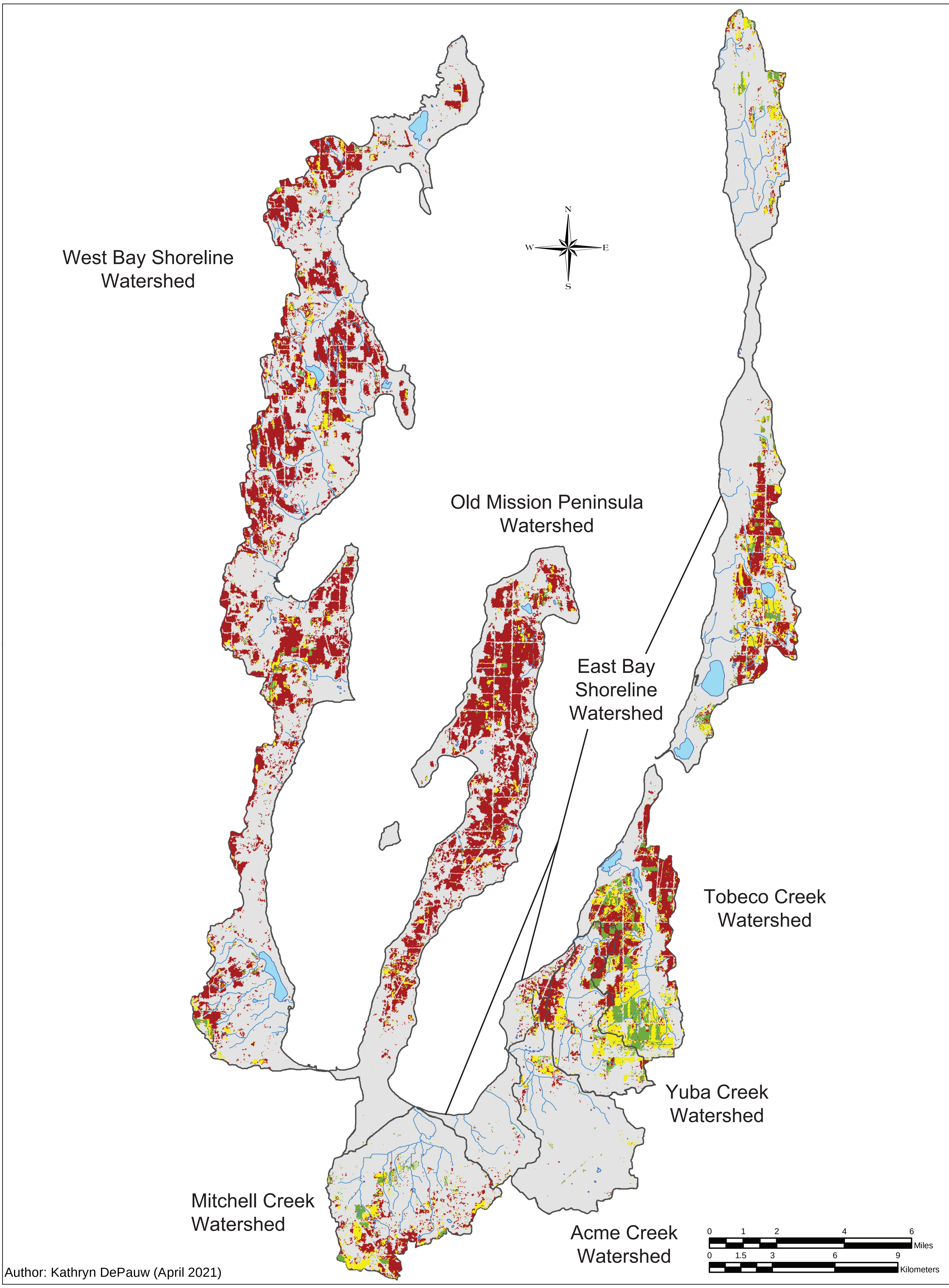
- Subwatershed Boundaries
- Lakes & Ponds
- Rivers & Streams

Land Cover/Use Type

- Urban
- Barren
- Forested
- Nonforested (open shrub, grassland)
- Agricultural
- Wetland

GRAND TRAVERSE BAY COASTAL WATERSHED

FIGURE 6B: LAND USE AND LAND COVER



Layer Credits: US Department of Agriculture (CDL 2019)

Legend

Subwatershed Boundaries

Lakes & Ponds

Rivers & Streams

Agricultural Land Use

Cropland

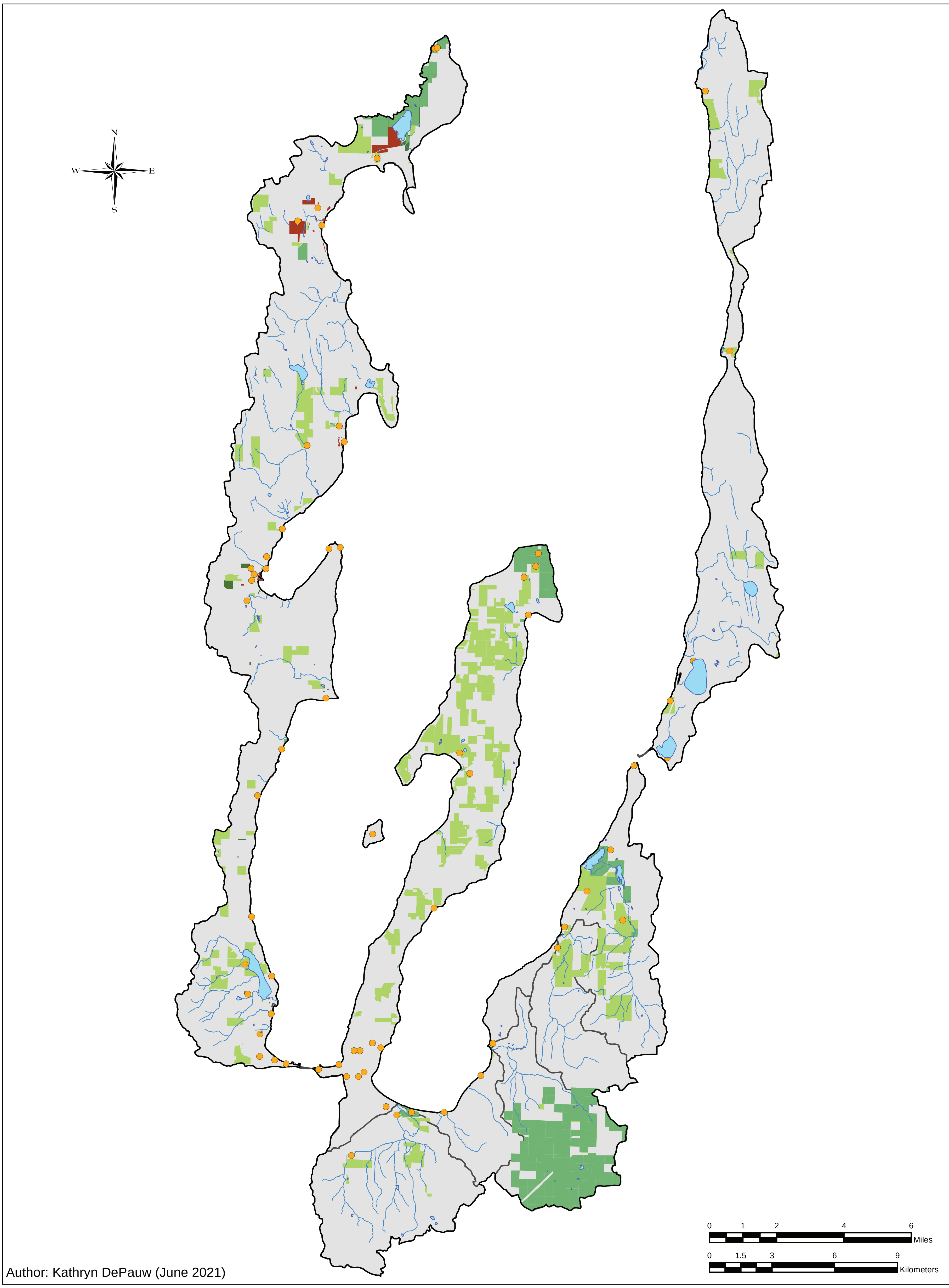
Permanent Pasture

Other

Orchard/Vineyard

GRAND TRAVERSE BAY COASTAL WATERSHED

FIGURE 6C: AGRICULTURAL LAND USE



Layer Credits: Michigan Department of Natural Resources (2020), GTRLC (2021), LC (2021)

Legend

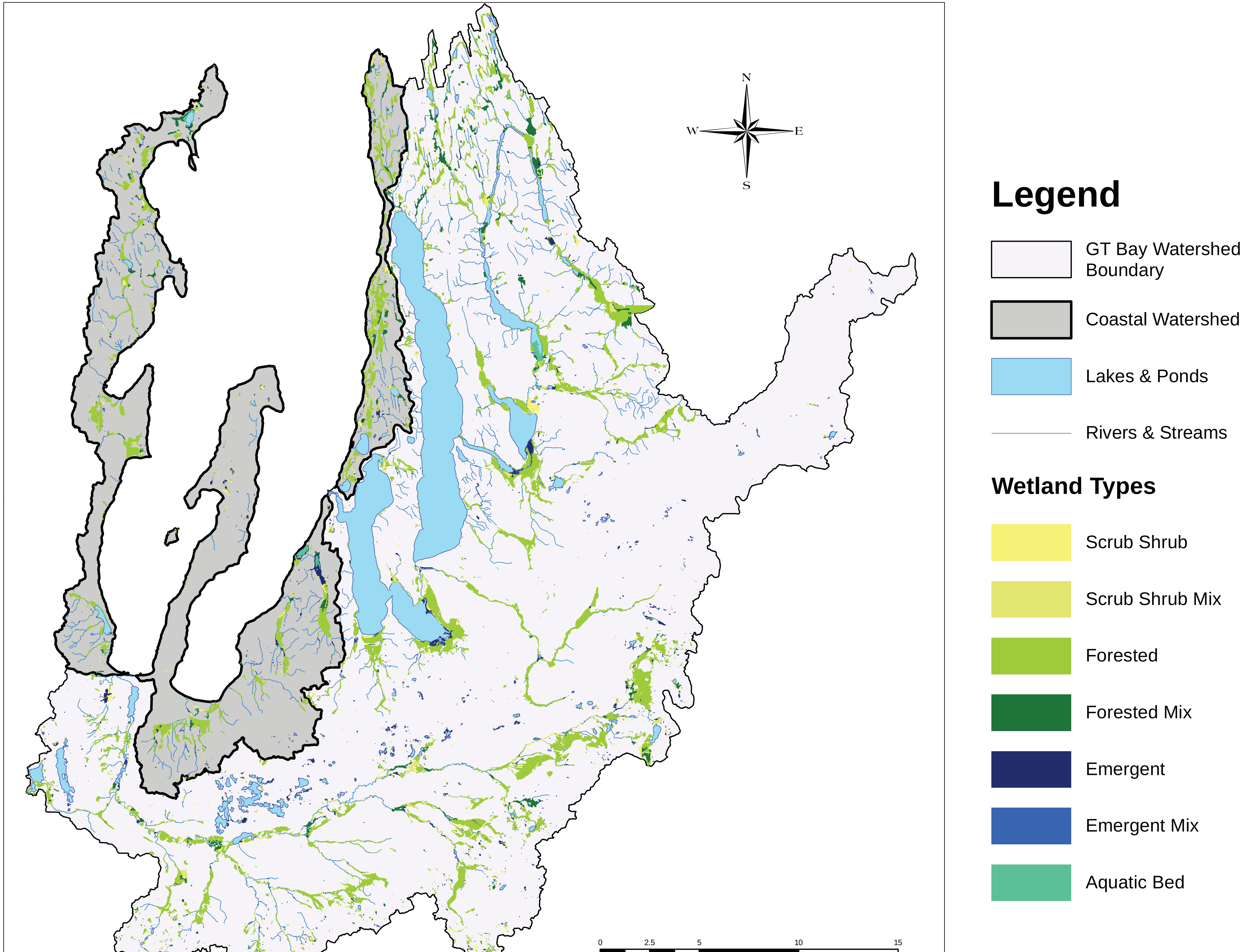
- Lakes & Ponds
- Rivers & Streams
- Subwatershed Boundaries
- State Owned Lands
- Other Public Lands
- Lands Protected By Conservancies
- Parklands in Leelanau County
- Parks

GRAND TRAVERSE BAY COASTAL WATERSHED

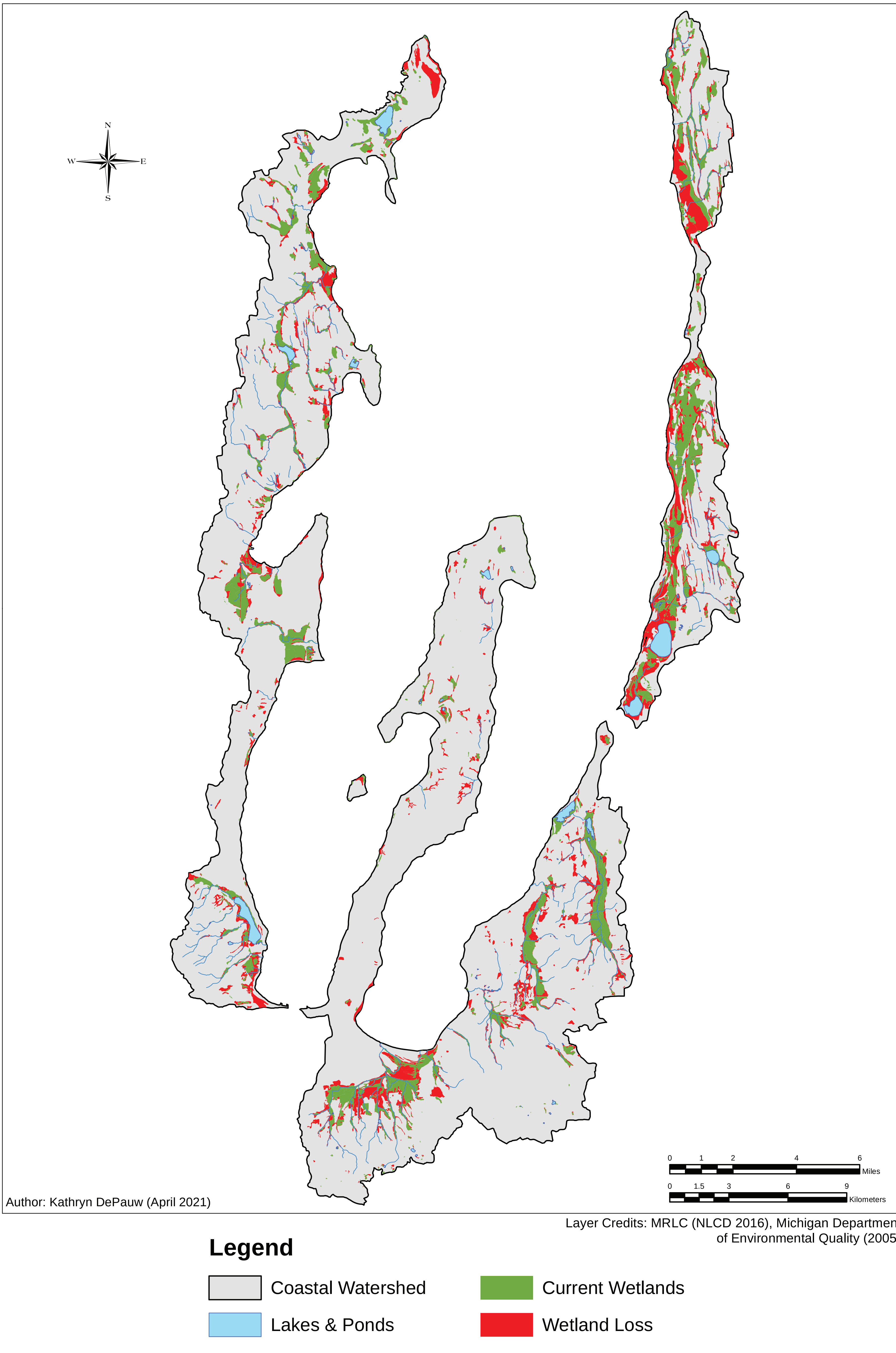
FIGURE 7: PUBLIC AND PROTECTED LANDS

GRAND TRAVERSE BAY WATERSHED

FIGURE 8A: WETLANDS



Layer Credits: National Wetlands Inventory 2005 (DEQ)



GRAND TRAVERSE BAY COASTAL WATERSHED

FIGURE 8B: WETLAND LOSS (PRE-SETTLEMENT - 2005)

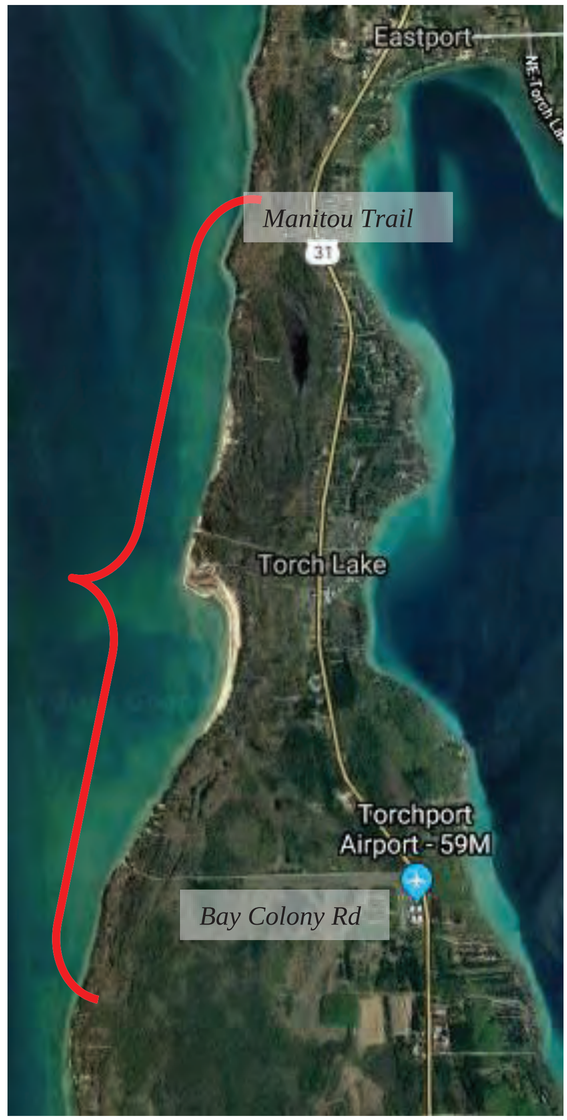
Critical Dunes and High Risk Erosion Areas

(Excerpted portions from EGLE [Critical Dunes Area Program website] and [High Risk Erosion Areas website])

Michigan's sand dunes are a unique natural resource of global significance. Collectively, they represent the largest assemblage of freshwater dunes in the world and support numerous threatened and endangered plant and animal species. The combination of topographic relief, vegetation and climatic conditions are a phenomenon unique to Michigan. The dunes support a wide diversity of habitats from temperate forests of maple and hemlock to the harsh environment of the open dunes, to quiet interdunal ponds teeming with life.

Michigan's sand dune program began in 1976 when concern for the impacts of sand mining on the dunes led to the passage of the Sand Dune Protection and Management Act (Part 353 of the Natural Resources and Environmental Protection Act (NREPA), 1994 PA 451 as amended). In Michigan there are approximately 225,000 acres of dunes, of which approximately 74,000 acres were designated as Critical Dune Areas (CDAs) in 1989. These areas represent the highest and most spectacular dunes in the state, extending along much of Lake Michigan's shoreline and the shores of Lake Superior. The legislature has found that Critical Dune areas of the state are a unique, irreplaceable, and fragile resource that provides significant recreational, economic, scientific, geological, scenic, botanical, educational, agricultural, and ecological benefits to the people of Michigan. Some CDAs are also in High Risk Erosion Areas where the shoreline is receding at a high rate (discussed below).

EGLE's "Atlas of Critical Dunes," published in February 1989, shows that there two areas along the shoreline of Grand Traverse Bay that are designated as a CDA. One is an approximate 3.8 mile (20,000-ft) section of shoreline in Torch Lake Township in Antrim County (see aerial photo from Google Maps to right).



Critical Dune Area –
East Grand Traverse Bay, Antrim County,
Torch Lake Township

The other is an approximate 1.1 mile (6,000 ft) stretch of shoreline in Leelanau Township north of the Village of Northport and east of Mud Lake

Critical Dune Area – West Grand Traverse Bay, Leelanau County, Leelanau Township

The shorelands of the Great Lakes are a dynamic and quickly changing environment. Lake levels may fluctuate dramatically in response to weather and climate. Wave action, storms, wind, ground water seepage, surface water runoff, and frost are contributing factors to changing and reshaping the shoreline. High water levels in the Great Lakes lead to increased shoreline erosion, which can cause financial property loss as well as public losses to recreation facilities, roads and other public works. (Note: Lake level fluctuations are discussed in greater detail in Chapter 3.7 below.)

EGLE formed their High Risk Erosion Area Program more than 20 years ago to prevent structural property loss in an area of the shoreland that is determined by the department, on the basis of studies and surveys, to be subject to erosion as required by Part 323, Shorelands Protection and Management, of NREPA. High risk erosion areas are those shorelands of the Great Lakes where recession of the landward edge of active erosion has been occurring at a long-term average rate of one foot or more per year, over a minimum period of 15 years. EGLE staff conducted initial recession rate research of coastal counties between 1980 and 1986; during that time they identified high risk erosion areas in 36 of 41 coastal counties.

EGLE calculates recession rates for shoreline areas and uses that information to calculate the appropriate setback distances for construction for 30-yrs and 60-yrs into the future. *(*Recession rates change over time as water levels fluctuate and coastal conditions change. The recession rate research is ongoing and often results in changes to the locations of high risk erosion areas along the shoreline.)* The 30-yr setback distance is for structures considered readily moveable, and the 60-yr setback is for structures determined non-readily movable (like a septic system). Construction projects in these areas will have additional review, under Part 323, of NREPA and will require an EGLE permit prior to construction on a parcel in a high risk erosion area regardless of where the structure is proposed on the parcel.

Currently approximately 250 miles of shoreline are designated as high risk erosion areas along the shorelines of Lakes Michigan, Superior and Huron. Table 14 shows specific townships along the shoreline of Grand Traverse Bay that have designated High Risk Erosion Areas.

Table 14: Townships with High Risk Erosion Areas

County	Townships
Antrim County	Banks Township City of Elk Rapids Elk Rapids Township Milton Township Torch Lake Township
Grand Traverse County	Acme Township Peninsula Township City of Traverse City
Leelanau County	Bingham Township Suttons Bay Township

History of Land Use in the Grand Traverse Region:

(Excerpted portions from The Watershed Center's "State of the Bay 2000 CD Resource Guide.")

The land known today as the Grand Traverse region began to be settled by Europeans in the mid-19th century. The new settlers joined the Ojibwa (also referred to as Chippewa, an English mispronunciation) and Ottawa (pronounced O-dah-wah) who made this land their home for generations prior, subsisting on hunting, fishing, gathering wild foods, and raising crops such as beans, corn, and squash.

Photos courtesy of the Leelanau Historical Museum and Grand Traverse Pioneer & Historical Society

The opening of the Erie Canal in 1825 between Albany and Buffalo created a new water highway, making the largely undeveloped lands of Michigan accessible to those traveling along the all-water route between Buffalo and Chicago.

The new settlers of the region found wealth in the land's virgin forests. Ancient forests of white pine, white cedar, maple, beech, and hemlock were cut, taken to sawmills, and then used for construction, tools, barrels, and fuel. Hardwoods were also used for processing steel. Fueling docks were established along the region's shoreline to supply passing steamships with wood for fuel. The forest products industry dominated the region's economy until the turn of the century, when it became apparent that the logging industry could not be sustained at its previous levels.

The abundance of fish in the waters of Lake Michigan and the inland lakes provided an important source of food both for the Native American and pioneer settlers. The Native peoples fished using fiber nets, spears and hooks. Offshore shoals were spawning grounds for lake trout and whitefish in the spring and sturgeon and northern pike in the fall. In the warmer waters of the inland lakes were yellow perch, largemouth and smallmouth bass, and northern pike. Later, residents harvested these fish for everyday use and later caught and exported lake trout and whitefish to cities in the east. Commercial fishing was one of the region's first industries, and sport fishing became a popular pastime of residents and visitors.

Photo Courtesy of the Grand Traverse Pioneer & Historical Society

Agriculture began as an industry in the Grand Traverse Region in the late 1800s. Over the years, the major crops have included potatoes and a wide variety of fruits including apples, cherries, peaches, raspberries, cranberries, and more recently, grapes for wine.

Photos Courtesy of the Leelanau Historical Museum

Food processing developed around the region's crops; Hannah Lay & Co. established a grist mill on the Boardman River, canning factories were needed for the cherry harvest, and apples were turned into cider, juice, jelly, and butter.

Photos Courtesy of the Grand Traverse Pioneer and Historical Society

3.6 Geology, Soils, and Topography

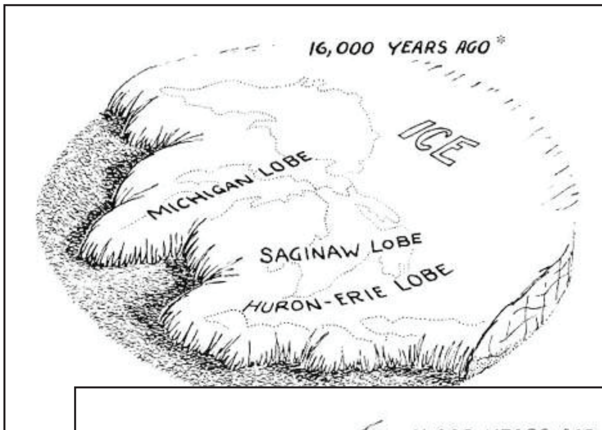
The watershed has a rich and complex geologic history. During the last glacial advance, glaciers carved deep valleys into the shale and limestone bedrock and deposited enormous sediment accumulations, some as thick as 1197 feet. Bedrock geology formations include Antrim Shale, Berea Sandstone, Coldwater Shale, Ellsworth Shale, Traverse Group, and others (Figure 9A). Glacial topology ranges from glacial till and lacustrine sand and gravel to moraines and glacial outwash sands (Figure 9B). Areas with more "coarse textured" labeled glacial topography typically have higher groundwater inputs.

Sediment characteristics vary widely throughout the watershed, in some areas changing from thick, lacustrine clay to a coarse-grained moraine within a hundred meters (Boutt et al. 2001). Predominant soils in the watershed are sandy. Figure 9C shows hydrologic soils groups for the watershed, where most soils are classified as A or B. These soils have a moderate to high infiltration rate and low runoff potential (see right for classification description). Specifically, the B type hydrologic soils are located in the northern headwaters of the ERCOL as well as throughout much of the coastal watershed area. It is also worth noting that soils with a high infiltration rate and low runoff potential are typically at less risk for erosion.

Hydrologic Soils Group Description	
A	High infiltration rate - Low runoff potential Consist mainly of deep, well drained to excessively drained sands or gravelly sands
B	Moderate infiltration rate Consist mainly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture.
C	Slow infiltration rate – Moderately high runoff potential Consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture.
D	Slow infiltration rate - High runoff potential Consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material.
From USDA Natural Resources Conservation Service: www.nrcs.usda.gov	

Elevation in the watershed ranges from a low of 177 meters (580 feet) above sea level to a high of 438 meters (1,437 feet) above sea level (Figure 10). Both the highest and steepest sections of the watershed are located in the headwater areas of the Elk River Chain of Lakes and Boardman River.

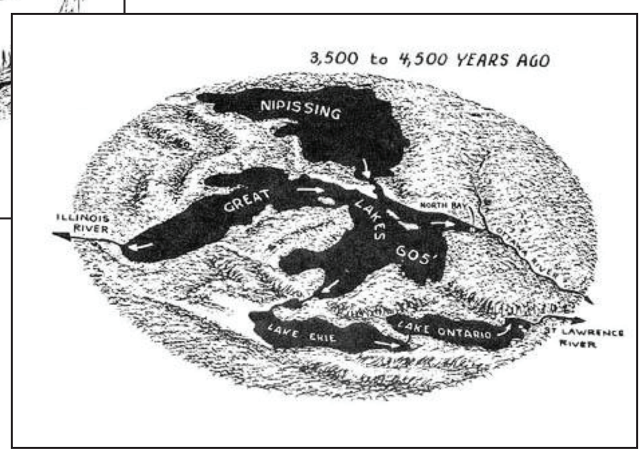
The following text and drawings illustrate the geological history of the Grand Traverse Bay Region and are excerpted from "The Glacial Lakes Around Michigan" by R.W. Kelley and W.R. Farrand (Kelley and Farrand 1967) and The Watershed Center's "State of the Bay 2000 CD Resource Guide."

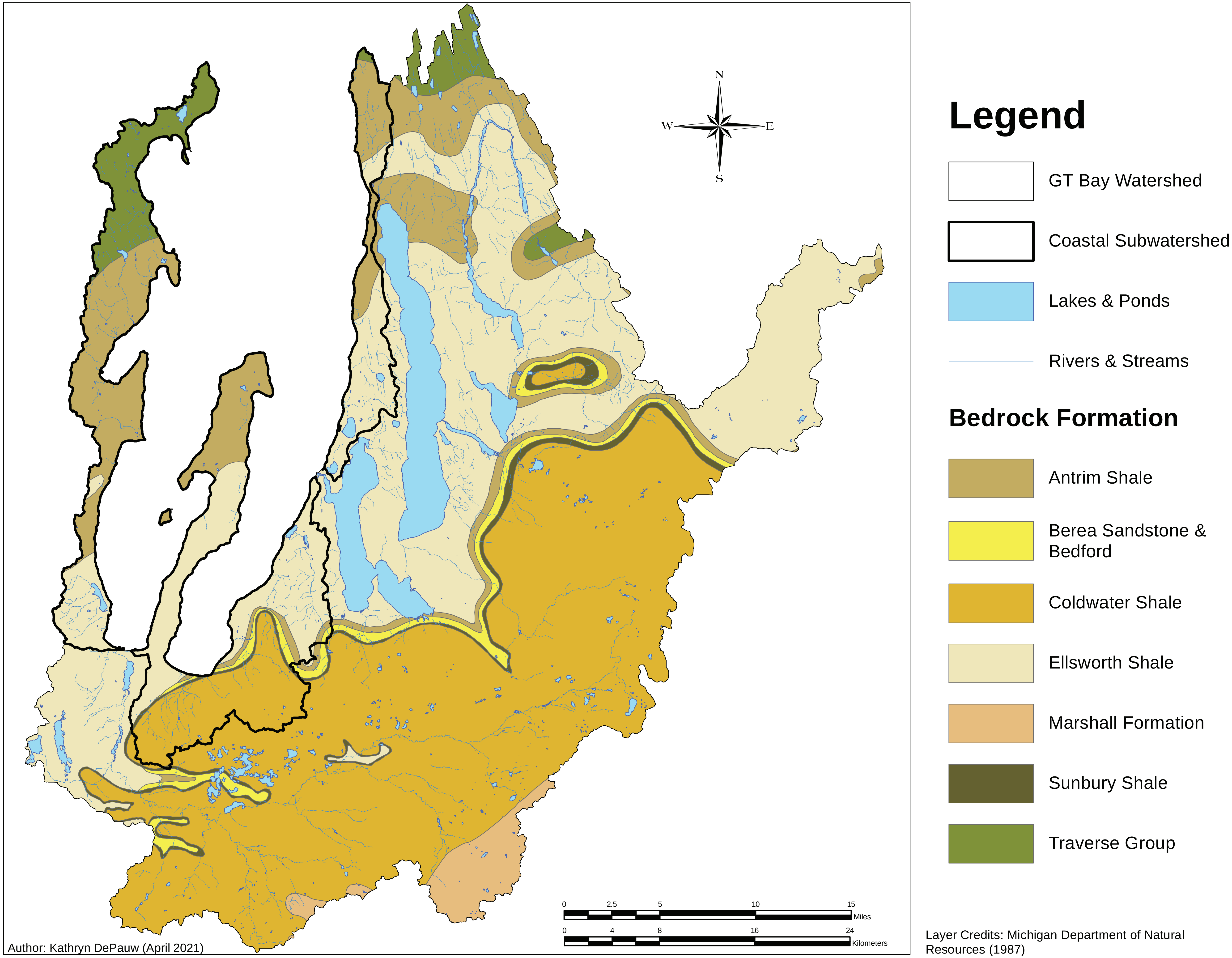


Grand Traverse Bay was formed by Pleistocene glaciers that moved across Michigan, covering the land one mile thick in places.

When the last of the glaciers retreated, water filled the valley left by the glaciers…

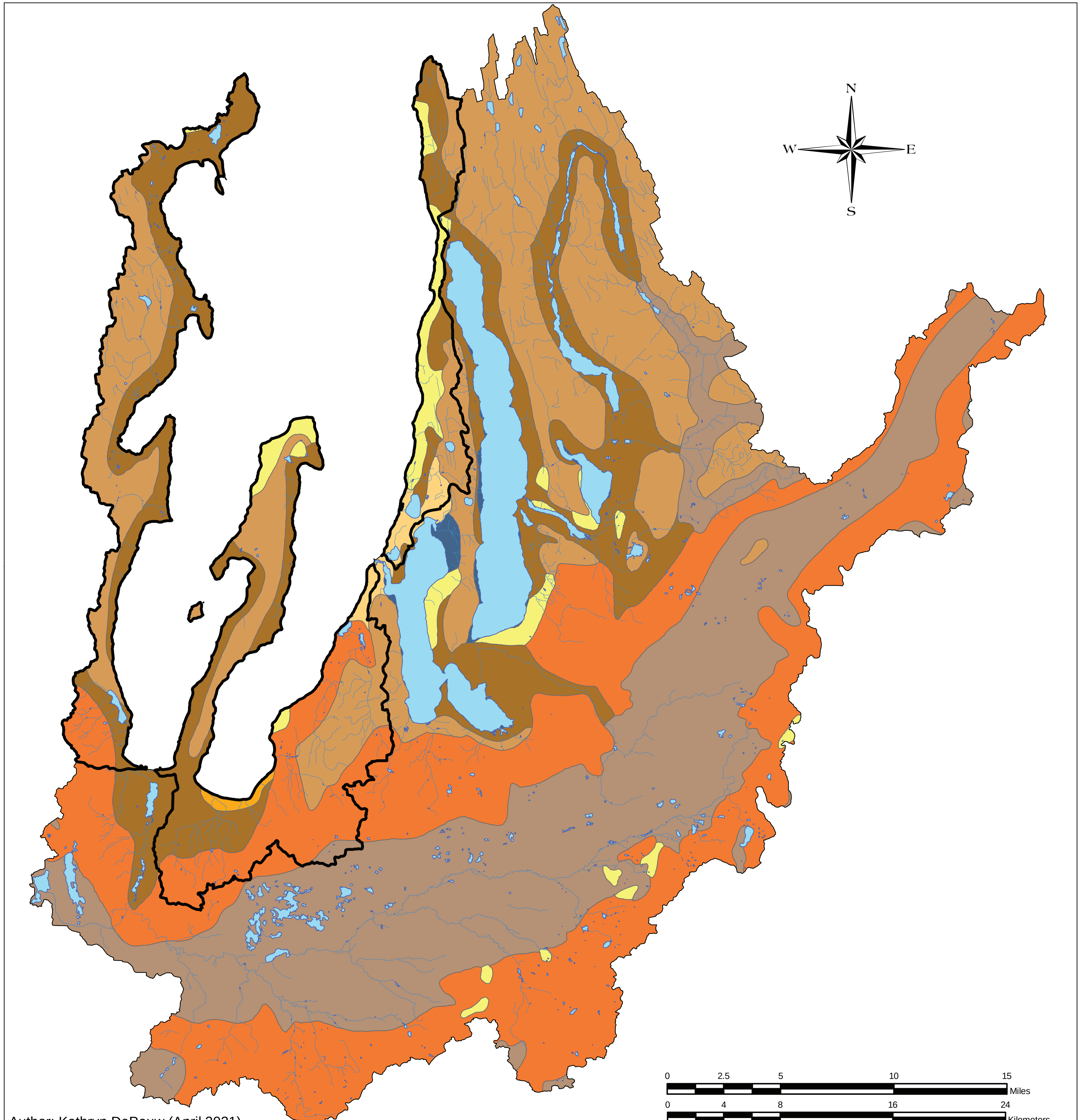
…forming the Great Lakes and the Grand Traverse Bay.





GRAND TRAVERSE BAY WATERSHED

FIGURE 9A: BEDROCK GEOLOGY



Legend

GT Bay Watershed

Coastal Subwatershed

Lakes & Ponds

Rivers & Streams

Glacial Landform Type

Coarse-textured glacial till

Dune sand

End moraines of coarse-textured till

End moraines of medium-textured till

Glacial outwash sand and gravel and postglacial alluvium

Lacustrine sand and gravel

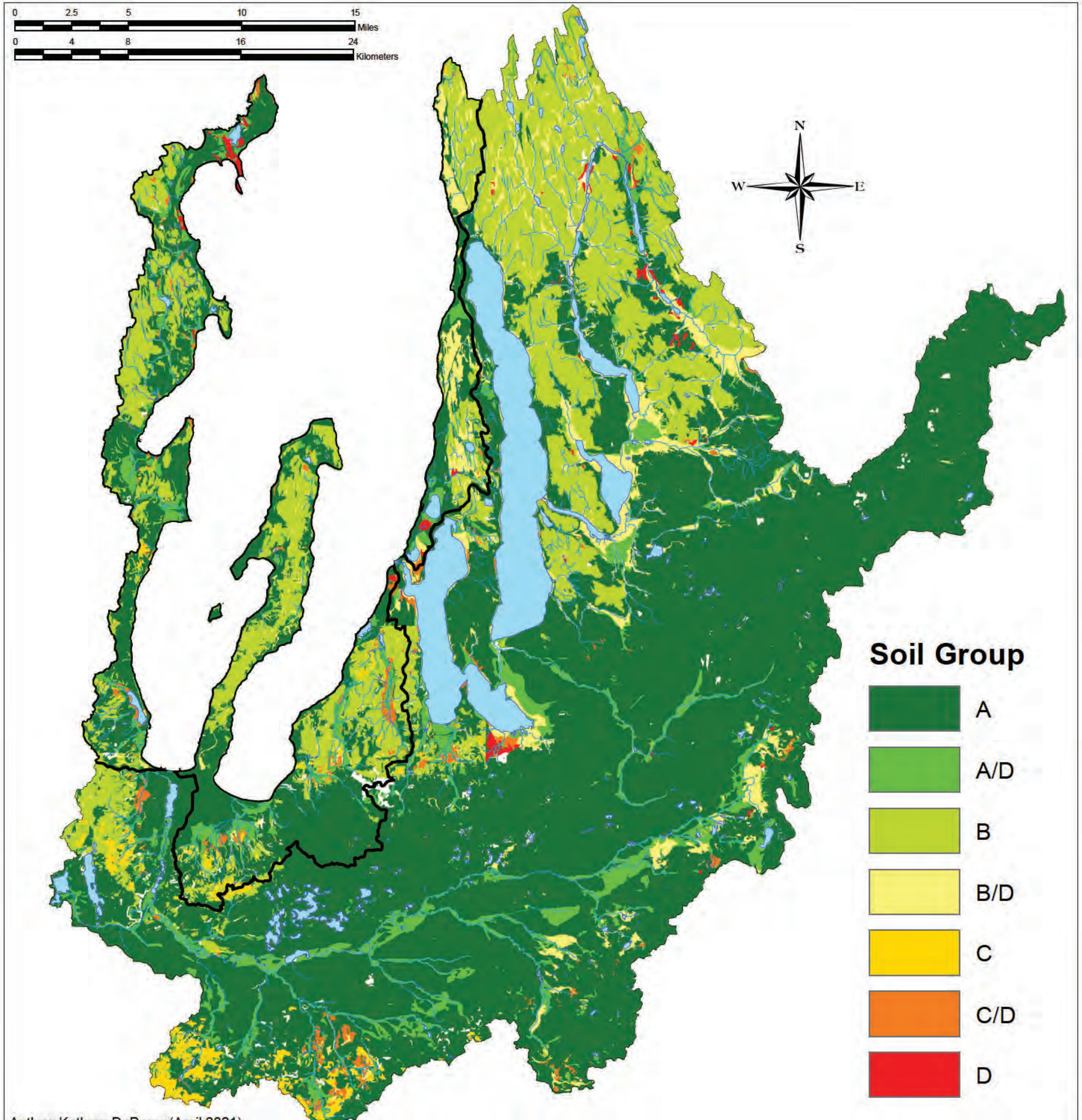
Peat and muck

Water

Layer Credits: Michigan Department of Environment, Great Lakes, and Energy (2020)

GRAND TRAVERSE BAY WATERSHED

FIGURE 9B: GLACIAL TOPOGRAPHY



Legend

GT Bay Watershed

Coastal Subwatershed

Lakes & Ponds

Rivers & Streams

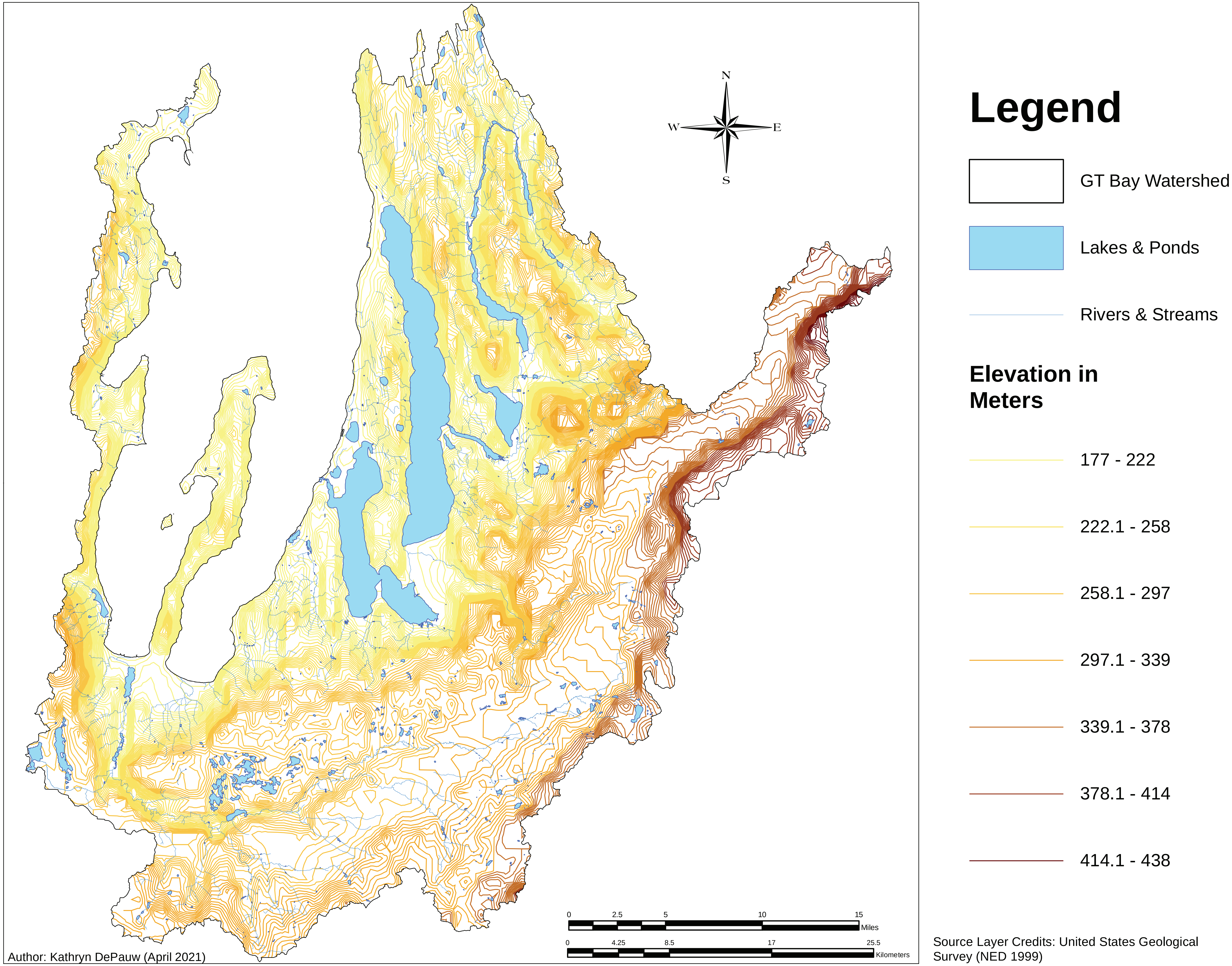
Hydrologic Group*	Description
A	· High infiltration rate - Low runoff potential · Consist mainly of deep, well drained to excessively drained sands or gravelly sands
B	· Moderate infiltration rate · Consist mainly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture.
C	· Slow infiltration rate – Moderately high runoff potential · Consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture.
D	· Slow infiltration rate - High runoff potential · Consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material.

* If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Layer Credits: US Department of Agriculture, NRCS (gSSURGO 2019)

GRAND TRAVERSE BAY WATERSHED

FIGURE 9C: HYDROLOGIC SOIL GROUPS



GRAND TRAVERSE BAY WATERSHED

FIGURE 10: ELEVATION CONTOURS

3.7 Hydrology, Climate, and Water Levels

Hydrology and Climate

The Grand Traverse Bay region receives an average annual rainfall of 42”, of which approximately 16” is recharged to the water table, 20” is evapotranspirated, and the other 6” becomes overland flow to streams (Boutt et al. 2001, Holtschlag 1997).

The majority of water entering the bay comes from surrounding tributaries, approximately 604 million gallons of water a day. These tributaries carry replacement water, oxygen, and nutrient and provide habitat for waterfowl, insects, and fish spawning. They are also a source of shelter and food for the bay’s inhabitants. Tributaries also carry human-derived wastes such as trace metals, road salts and solvents, excessive nutrients, and wastewater from drains (State of the Bay 2000 CD Resource Guide).

The two principal river systems of the Grand Traverse Bay watershed are the Boardman River and the Elk River-Chain of Lakes. The Elk River delivers 60% of the surface flow to the bay, and the Boardman delivers 30%. The remaining 10% of surface water flow to Grand Traverse Bay comes from other small tributaries draining directly to the bay.

Findings from 2016 Climate Change Integrated Assessment

Summarized and quantified changes in temperature, precipitation, ice cover, and streamflow over the last 50 years (Hyndman et.al 2016)

- **Temperatures** have warmed across most of the region, with the highest increases in areas of higher elevations. A few areas near Lake Michigan have observed slight cooling or no increase in temperature.
- Observed **precipitation** has also increased across most of the region for the 23 stations in NW Michigan with more than 50 years of record.
- The **rise in precipitation** is much more significant in the past decade, with the Traverse City and Petoskey areas seeing more than an extra inch of rain per year on average in the past decade.
- There has also been an **increase in the number of heavy rain events** (described as days with > 20 mm of precipitation) in some portions of the region, which will has the potential to increase the risk of flooding and may require enhancement of stormwater infrastructure.
- Some, but not all, areas in the Grand Traverse Bay region have received **increased annual snowfall** since the early 1900’s.
- Streams surrounding the Grand Traverse Bay region with long-term (>60 years) records exhibit **increasing median flow trends** of +0.3% to 3.5% per decade.
- Forecasts suggest **temperatures will rise by 3.5 to 4 degrees C and precipitation will increase by approximately 10% by 2100** under the Representative Concentration Pathway (RCP) 6.0 emissions scenario.

Most of the rainfall and snowmelt falling on watershed lands seeps into the soil and recharges the groundwater. This groundwater flows into rivers, lakes and streams, which then flow to the bay. A smaller portion of the groundwater flows go directly into the bay in the form of seeps (about 7% of the total discharge of water to the bay) (State of the Bay 2000). Of all the water entering the bay annually, 35% is from rain or snowfall, 60% is from tributaries, and the other 5% is from direct groundwater flow (State of the Bay 2000 CD Resource Guide).

Inflow of Water to Grand Traverse Bay

A total of 373 billion gallons of water leaves Grand Traverse Bay annually. Outflow to Lake Michigan accounts for approximately 70% of the water leaving the bay, with evaporation taking the remaining 30%. On average, twenty-six inches of water evaporate from the bay's surface area each year (State of the Bay 2000 CD Resource Guide).

Outflow of Water from Grand Traverse Bay

The exchange of water between Grand Traverse Bay and Lake Michigan is significantly influenced by the presence of a sill along the bottom of the bay at its northern extent, which averages approximately 15 meters in depth. The presence of this sill generates a large gyre (ring-like system of currents), which rotates in the northeastern portion of the bay and impedes water exchange with Lake Michigan (Johnson 1975). The primary site of water exchange between the bay and Lake Michigan is at the western edge of the sill, where there is an approximately 43 meter deep trench in the sill. Circulation within the bay is reduced at the southern ends of each arm (GLEC 2005).

Great Lakes Water Levels and Shoreline Impacts

Grand Traverse Bay is on Lake Michigan, which is part of the Great Lakes ecosystem. Water levels in the Great Lakes fluctuate naturally daily, seasonally, and annually and are primarily affected by evaporation, surface runoff, and precipitation. Overall, changes to water levels in the Great Lakes are largely driven by weather patterns and climatic factors; however, anthropogenic factors, including dredging, diversions, withdraws and regulated outflows, may impact water levels as well.

These two photos show the dramatic fluctuations in Great Lakes water levels over the course of just 10 years. Both photos were taken at the same location in Traverse City, the top in 2009, the bottom in 2019.

Short term water level fluctuations in the Great Lakes (<24 hrs) are due to changes in barometric pressure and winds. Seasonally, lake levels decline in the fall and winter due to increased evaporation from cold, dry air moving over the warmer lake temperatures. Levels then typically rise in the spring and summer as snowmelt and precipitation enter the lake through streams and groundwater.

Long-term annual variation of Great Lakes water levels occur over consecutive years and depend on climatic conditions. Consecutive warm, dry years result in lower lake levels, while consecutive wet and cold years result in higher lake levels. The U.S. Army Corps of Engineers - Detroit District keeps track of water levels in the Great Lakes and has a wide variety of information available on their website: https://www.lre.usace.army.mil/Missions/Great-Lakes-Information/

Because of changing water levels, the shorelands of the Great Lakes are considered a dynamic and quickly changing environment. Wave action, storms, wind, ground water seepage, surface water runoff, and frost are contributing factors to changing and reshaping the shoreline. Army Corps water level data documented from 1918 – 2019 show just how cyclical water levels in the Great Lakes can be (Figure 11A). High water levels dominated Lake Michigan in the 1980s and 1990s, however, this was followed by a period of below the long-term average annual levels in the 2000s (shown as the red line in Figure 11A). Since 2014, lake levels in Lake Michigan have been on the rise reaching record levels in 2019 and 2020. These high water levels have led to increased shoreline erosion, which can cause financial property loss as well as public losses to recreation facilities, roads and other public works.

The Army Corps also offers monthly lake level graphs, and as shown in Figure 11B, water levels for Lake Michigan-Huron are at some of the highest levels seen in a long time. In fact, water levels were above the all time high water levels in 1986 for most of 2020. *(*Note: Lakes Michigan and Huron are hydrologically connected to each other and are therefore shown on the same lake level graphs.)*

Figure 11A: Great Lakes Water Levels (1918 – 2019)

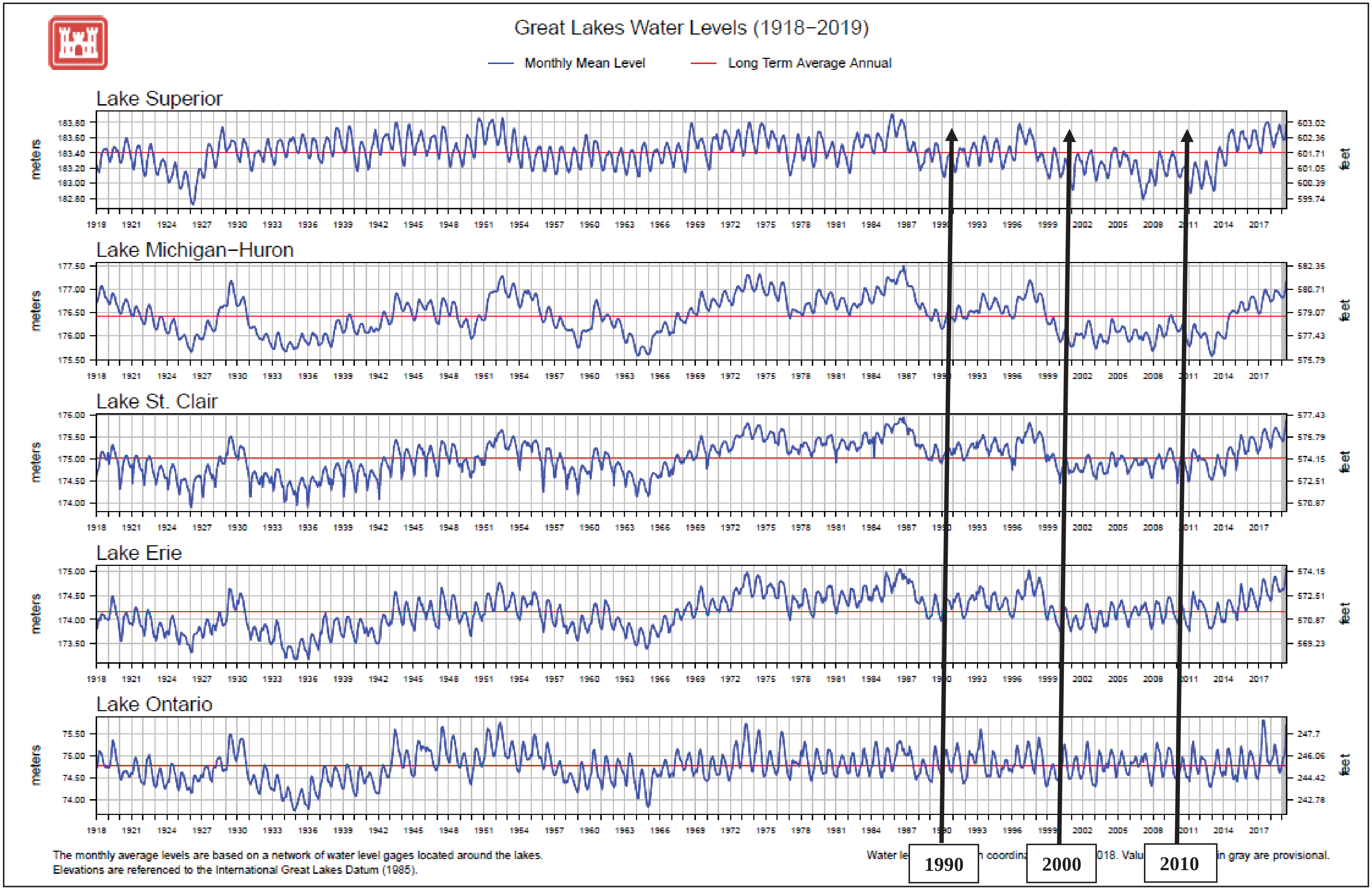
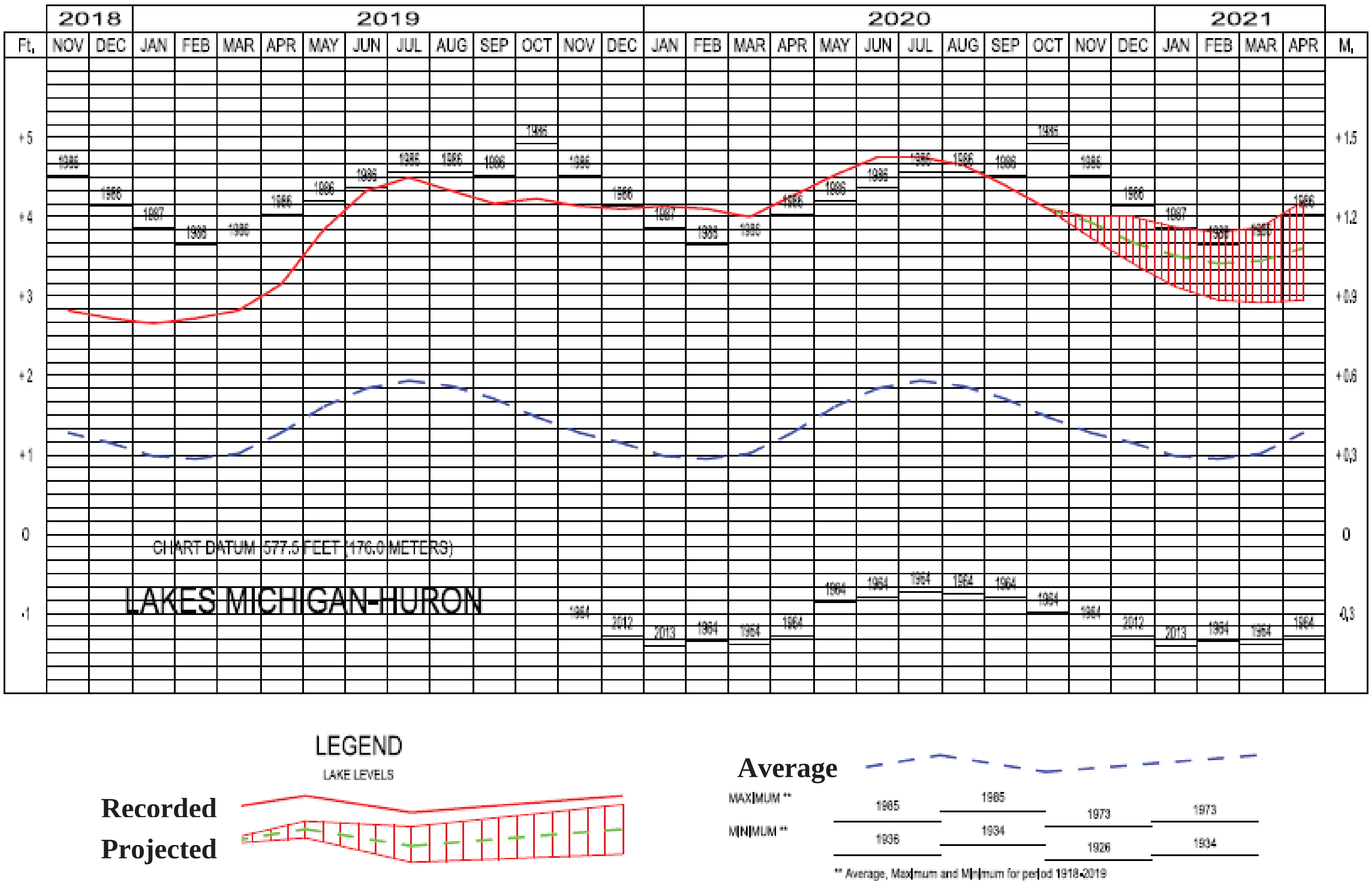


Figure 11B: Lakes Michigan-Huron Water Levels – November 2020



Water levels for the previous year and the current year to date are shown as a solid line on the hydrographs. A projection for the next six months is given as a dashed line. This projection is based on the present condition of the lake basin and anticipated future weather. The shaded area shows a range of possible levels over the next six months dependent upon weather variations. Current and projected levels (solid and dashed lines) can be compared with the 1918-2017 average levels (dotted line) and extreme levels (shown as bars with their year of occurrence). The legend below further identifies the information on the hydrographs. The levels on the hydrographs are shown in both feet and meters above (+) or below (-) Chart Datum. Chart Datum, also known as Low Water Datum, is a reference plane on each lake to which water depth and Federal navigation improvement depths on navigation charts are referred. All elevations and plots shown in this bulletin are referenced to International Great Lakes Datum 1985 (IGLD 1985). IGLD 1985 has its zero base at Rimouski, Quebec near the mouth of the St. Lawrence River (approximate sea level).

Integrated Assessment Report – Challenges and Opportunities

In February 2018 the University of Michigan's Graham Sustainability Institute released their Great Lakes Water Levels Integrated Assessment Report (Allan et.al 2018). This report was developed to help decision makers address the challenges and opportunities posed by Great Lakes water level variability. Further discussion on climate change is found in Section 5.6. Information on climate change and its impacts will be taken into consideration in the determination of critical areas (Section 5.7) and implementation tasks (Section 8.5).

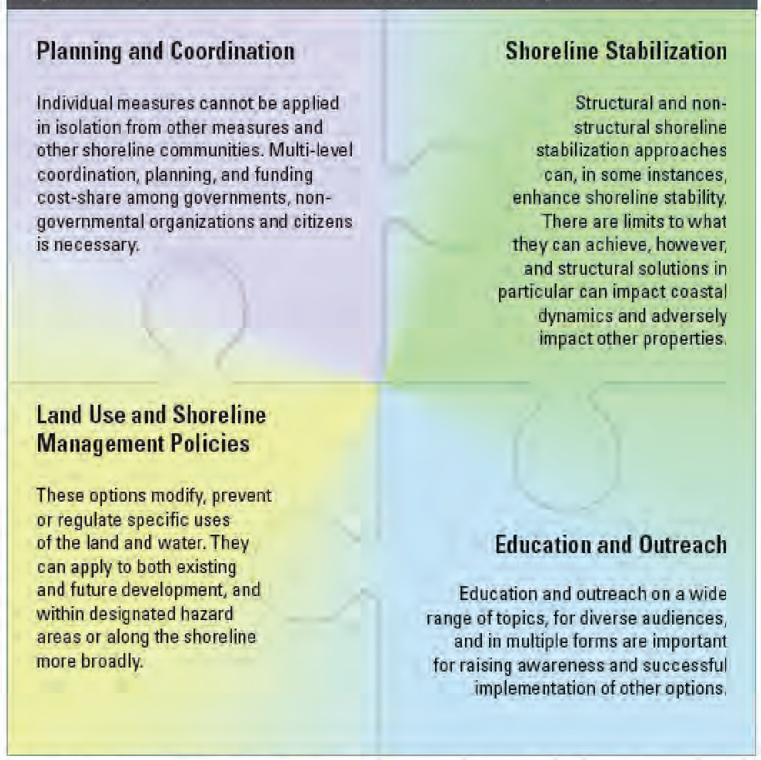
Excerpts from the Executive Summary of the Integrated Report (IA) (Allan et.al 2018):

> "The purpose of the IA has been to develop information, tools, and partnerships to help decision makers address the challenges and opportunities posed by variability in Great Lakes water levels. The IA aimed to transform extensive existing research about water levels, flows, and impacts into practical, adaptive strategies to address issues facing shoreline property owners and managers.
>
> The IA was informed by a binational advisory committee, who provided input and advice reflecting the views of key stakeholder groups. To focus the work, the following guiding question was developed in consultation with the advisory committee:
>
> > *What environmentally, socially, politically, and economically feasible policy options and management actions can people, businesses, and governments implement in order to adapt to current and future variability in Great Lakes water levels?*
>
> To respond to the question, the IA focused on Lakes Michigan and Huron and took both a place-based and regional approach. Place-based teams collaborated with specific communities to assess specific, integrated, and feasible options related to water level variability. This report integrates and builds upon the local projects to demonstrate variation and similarities among the communities' needs and identify insights for the basin more broadly. "
>
> …
>
> "The IA was divided into three phases. The first two phases were focused on specific localities. During Phase I, teams used existing data and information to develop an overview synthesis report on the status, trends, causes, and consequences of changing water levels as they relate to the key issues in the community they were working with. Each report then outlined the future research and planning each group intended to complete, whether that involved further community outreach, ordinance drafting, or geological mapping. Results from this work were shared at a public meeting (in person and live streamed) in May of 2016 and posted to the project website.
>
> In Phase II the research teams worked in collaboration with their partners to identify and analyze viable policies and adaptive actions that meet local objectives. Phase II reports outlined the full findings of each group. These included the options proposed by communities and researchers, the feedback to those options, and the challenges and opportunities of each option. Each group also presented webinars on their findings, which generated widespread public participation and feedback.
>
> This Phase III report seeks to integrate the findings of each group regarding the unique challenges and opportunities faced by each community to identify opportunities for the region. While relying primarily on material from the previous IA phases, the report also includes additional material to support findings and clarify topics of relevance. The hope is that this report can inform communities facing similar situations as to how to approach water level variability, given the environmental, social, political, and economic characteristics of their community."

…

“There exists a wide array of options that communities and shoreline property owners can implement in order to adapt to current and future variability in Great Lakes water levels. Many of these options are not new. Going back decades, the IJC and others have completed extensive studies identifying and assessing options around Great Lakes water level fluctuations. One key challenge, as those studies noted, is identifying and tailoring the suite of options according to unique local conditions and interests.

Figure 8: Categories of water level variability response options explored through the IA



Responding to variable water levels will require a suite of measures that consider the characteristics of the shoreline, natural systems, built environment, interest groups, and political and legal factors. The categories of response options here are often interrelated, and they do not represent a comprehensive list of options. Rather, they represent the most common options identified by the place-based teams during Phase II of the IA.

As described briefly, during Phase II of the IA, the four place-based research teams proposed and assessed a variety of options and strategies for their partner communities to consider. To support other communities and interest groups in thinking through ways to approach variable water levels, this chapter organizes and explores the options the teams considered during their Phase II work.

The options are grouped into four broad categories that include the most common options among the teams: Planning and Coordination, Shoreline Stabilization, Land Use and Shoreline Management Policies, and Education and Outreach.”
…

“While the primary focus of the IA was to identify place-based adaptive strategies and options for water level variability in the Great Lakes, several common themes can be identified when examining the work of the research teams. These themes are reminders of conditions that may be critical for the success of any suite of strategies, or overall approach to identifying strategies, that a community takes.

Capacity: At the local level, capacity is variable, and efforts should be cognizant of capacity needs and develop strategies to meet them. As noted previously, while a significant amount of data and information are available on a range of water level issues it can require a substantial amount of work and expertise to convert those resources into actionable items at the local level. A good understanding of capacity can also provide insights on where partnerships can be particularly useful.

Context: When implementing policy options, context matters. Significant effort is needed to move general policy recommendations to locally-specific adaptive management strategies.

Jurisdiction: It is critical to understand the relevant authorities for decision making, particularly when multiple authorities (local, state, provincial, etc.) are involved, as is often the case with the Great Lakes resource issues.

Key Institutions: Efforts should be made to identify and engage critical partners and key institutions. Depending on the context, a key institution may be a property owners association, a local community organization, or a planning commission. Determining how to best apply limited resources and time can hinge on engaging key institutions.

Public Input: To find acceptable solutions, it is critical to solicit input from stakeholders, and competing perspectives should be sought out in a thoughtful manner. How stakeholder input is conducted can be as influential to an outcome as the methods of data collection and analysis. The work of all four of the research teams provides important insights on the value of and approaches to this engagement.

Uncertainty: Although uncertainty may be unavoidable to a certain extent, it need not preclude action. Tools such as scenario planning or approaches like adaptive management can help to develop and refine adaptive approaches in light of incomplete information."

Discharge/Flow

Stream/river discharge measurements are not readily available on a watershed wide scale. Baseflow discharge values were obtained by extrapolating and making some simple assumptions using actual measured historical data taken at various locations throughout the watershed. The major assumption is that flow (discharge) throughout the Grand Traverse Bay watershed is proportional on a per unit area basis. This means that the ratio of flow to watershed area at any point along the stream is a constant. Therefore (where Q = discharge and A = drainage area):

$$Q_x/A_x = \text{constant } (k) \text{ and } Q_x = A_x k$$

It is important to note that these are extrapolated baseflow measurements that do not take into account storm flow events or spring runoff. Further in-depth hydrologic studies are needed to determine specific stream flows and discharges throughout the watershed.

Table 15 lists known measured flow values for various streams throughout the watershed taken over the past 30 years. The average k value for all data was 1.13. Table 16 uses this value and lists estimated discharges for each subwatershed in the Grand Traverse Bay watershed. It is noted that the Old Mission Peninsula and East Bay Shoreline and Tributaries subwatersheds have no significant tributaries, and therefore, even though they comprise about 70 mi^2 of watershed area, discharge values were not calculated for them. Additionally, it has long been noted that the Elk River Chain of Lakes accounts for approximately 60% of the discharge to the bay and the Boardman River accounts for 30%. The values in Table 16 support this.

TABLE 15: CONSTANT (K) VALUES FOR DISCHARGE MEASURED DRAINAGE AREAS

Basin	Area (mi^2)	Measured Flows (cfs)	Constant (k)
Elk River Chain of Lakes *(State of the Bay)*	502.6	582	1.16
Elk River Chain of Lakes *(ERCOL Plan)*	502.6	669	1.33
Elk River Chain of Lakes *(Sea Grant)*	490.35	567.98	1.16
Boardman River *(State of the Bay)*	283.8	295	1.04
Boardman River *(Sea Grant)*	278.77	294.88	1.06
Boardman River *(USGS Gauge above Brown Bridge)*	141	138.4	0.98
Mitchell Creek *(NPS Pollution Study)*	15.7	18.6	1.18
Mitchell Creek *(Sea Grant)*	14	16.76	1.20
Acme Creek *(Planning Project)*	13.2	13.9	1.05
Acme Creek *(Sea Grant)*	13.01	14.54	1.12
Yuba Creek *(Sea Grant)*	8.19	9.12	1.11
GT Bay Watershed *(State of the Bay)*	976	935.3	0.96
		Average k	**1.13**

Flow Data Sources

- *Acme Creek Watershed Planning Project – April/May 1995 (GTCDC June 1995)*
- *Elk River Chain of Lakes Clean Lakes Phase I Diagnostic Feasibility Study – April 1990 - March 1991 (Bednarz 1993)*
- *Final Report: Mitchell Creek Watershed Non-point Source Pollution Study – 1990/91 (GCA & GLEC 1991)*
- *The Limnology of Grand Traverse Bay - MI Sea Grant 1976 (Auer et. al 1975)*
- *State of the Bay 1998*
- *USGS Gauging Station February 2004 - February 2005 Data for Boardman River above Brown Bridge (USGS 2005)*

TABLE 16: DISCHARGE MEASUREMENTS BY SUBWATERSHED

Subwatershed	Area (mi^2)	Estimated Flow (cfs) *using k=1.13	% of Total Discharge to Bay
Elk River Chain of Lakes	502.6	567.9	55.5
Boardman River	283.8	320.7	31.3
West Bay Shoreline and Tributaries	68	76.8	7.5
East Bay Shoreline and Tributaries*	38.8	--	--
Old Mission Peninsula*	31.3	--	--
Mitchell Creek	15.7	17.7	1.7
Tobeco Creek	14.2	16.0	1.6
Acme Creek	13.2	14.9	1.5
Yuba Creek	8.4	9.5	0.9
Total	**976**	**1023.7**	**100**

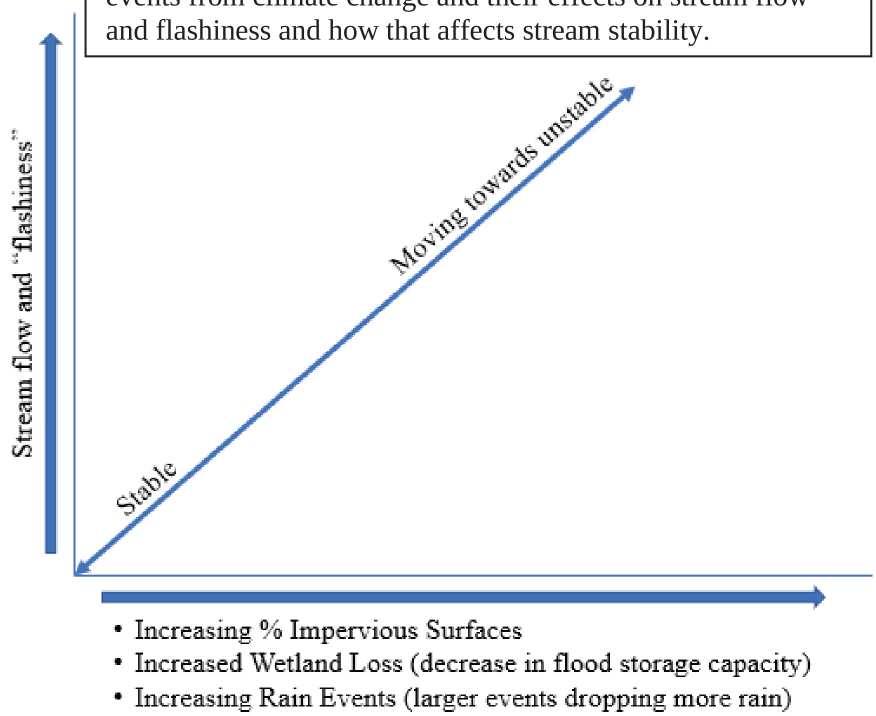
*There are no significant tributaries in these two subwatersheds and surface water discharge to the Bay is negligible. Most of the precipitation getting to the Bay from these subwatersheds is from groundwater.

Effects on Aquatic Life

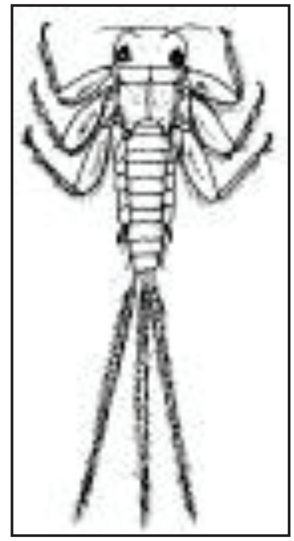
The hydrology of a river system, which is mainly determined by soils, geology, and land use, is a critical physical factor to aquatic life (O'Neal 1997). In streams where groundwater is the principal water source, stable flow patterns occur, characterized by low seasonal and daily fluctuations in discharge. Wetlands also promote stable flows in streams by acting as storage areas, temporarily holding large quantities of flood water and releasing them slowly, preventing flooding in downstream areas (see section 3.5 for more information on benefits of wetlands).

Unstable water flow patterns occur in streams with high contributions of surface water runoff and are characterized by high seasonal and daily fluctuations in discharge. The term "flashy" is used to describe unstable streams, where the flashiness of the stream reflects how quickly flow in a river or stream increases and decreases during a storm. Flashy streams are common in urbanized areas because, with the increased amounts of impervious surfaces,

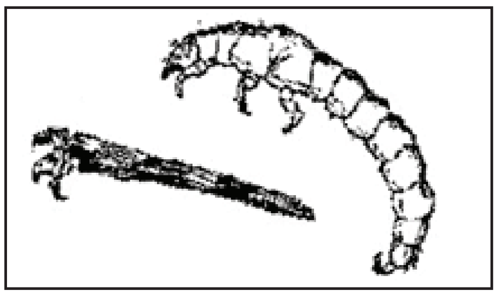
The graphic below shows the relationship between the increase of impervious surfaces, wetland loss, and intensity of rain events from climate change and their effects on stream flow and flashiness and how that affects stream stability.



stormwater runoff reaches the waterways much more quickly than it would under natural conditions. Some factors contributing to stream instability and increased stream flow are climate change (i.e. increasing frequency and intensity of rain events), loss of wetlands, urban and agricultural land development, logging, hydroelectric dams, and lake-level control structures.



The stability of a stream can have dramatic effects on aquatic life. Stable flows promote stable habitat for aquatic life in the form of diverse bottom substrates, secure in-stream cover, and moderate water velocities and temperatures. Unstable streams have increased water velocities, which leads to streambank erosion, scouring, and the removal of in-stream cover. The excess scouring and erosion also increases sedimentation in the stream, which covers necessary habitat for aquatic life.



Aquatic insects such as mayflies and caddisflies depend on stable flows, high water quality, and sufficient in-stream habitat for survival.

3.8 *Grand Traverse Bay Fishery*

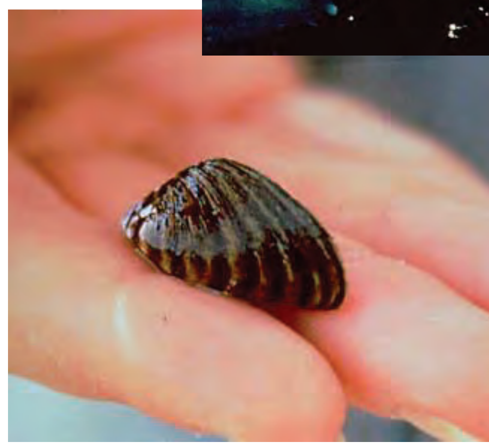
Grand Traverse Bay hosts not only a diverse and popular recreational fishery, but also a tribal commercial fishery for the Grand Traverse Band of Ottawa and Chippewa Indians. Table 17 lists the common fish found in bay as of 2019. This tribal commercial fishery is more than a means of paying the bills for the fishers; it is a tie to the past and is viewed as a traditional way of life. The favored commercial species, Lake Whitefish, have declined in the Bay due to changes in the food web induced by invasive species (see invasive species discussion in Section 5.5). This has led tribal commercial fishers to rely more upon Lake Trout to make a living. That pressure, coupled with the popularity of Lake Trout with recreational fishers, has caused high levels of harvest and mortality on this native species; however, populations remain stable due to consistent stocking by the United States Fish and Wildlife Service. Even though Lake Trout are important to the recreational fishery, they are far from the only opportunity pursued by State anglers. The salmon fishery in West Grand Traverse Bay has declined in recent years, but still attracts anglers each summer and fall. A resurgent cisco population has also developed a following among recreational fishers who catch them using a variety of angling methods.

Table 17: Common Fish Found in Grand Traverse Bay

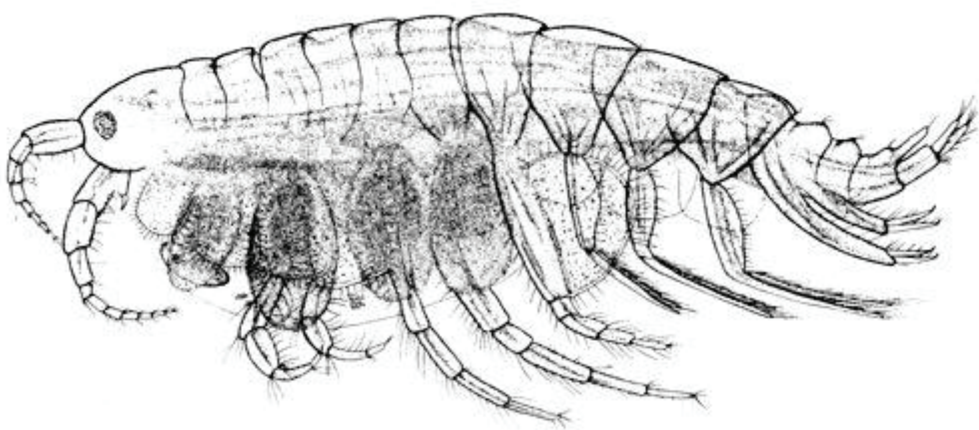
Alewife	Common Carp	Longnose Dace	Sand Shiner
Atlantic Salmon	Common White Sucker	Longnose Sucker	Slimy Sculpin
Black Crappie	Deepwater Sculpin	Mottled Sculpin	Smallmouth Bass
Blacknose Shiner	Eastern Banded Killifish	Muskellunge	Spottail Shiner
Bluegill	Freshwater Drum	Ninespine Stickleback	Steelhead
Bluntnose Minnow	Green sunfish	Northern Pike	Threespine Stickleback
Brook Stickleback	Iowa Darter	Pink Salmon	Trout Perch
Brown Bullhead	Johnny Darter	Pumpkinseed sunfish	Walleye
Brown Trout	Lake Chub	Rainbow Smelt	Western Banded Killifish
Burbot	Lake Sturgeon	Rainbow Trout	Yellow Perch
Chinook Salmon	Lake Trout	Rock Bass	
Cisco	Lake Whitefish	Round Goby	
Coho Salmon	Largemouth Bass	Round Whitefish	

It's not all about the cold-water fish in Grand Traverse Bay, this area hosts some of the finest smallmouth bass fishing anywhere in the region, and anglers of all skill levels have taken notice. It's not uncommon to find camera crews aboard bass boats filming fishing shows each June. The perch population fluctuates in the Bay like many other areas, but in recent years, both open water and ice anglers have found good numbers of large fish. Similarly, walleye have been a small but steady portion of the creel data over the years, supported by stocking conducted by the Grand Traverse Band of Ottawa and Chippewa Indians. The Great Lakes are unpredictable and always changing, but fishing opportunities within the protected waters of Grand Traverse Bay remain abundant.

There is a general decline in the overall fish prey-base in Lake Michigan due to the arrival of invasive species such as *Dreissena* mussels (zebra and quagga, see photo below), spiny water fleas, and round gobies. *Dreissena* mussels specifically are reducing phytoplankton populations, which serve as the primary food source for *Diporeia*, a native shrimp-like crustacean and important base in the Great Lakes food web. *Diporeia* are approximately a quarter-inch long and live in the sediment at the bottom of most of the Great Lakes (see diagram below). They are considered one of the basic building blocks of the Great Lakes food chain. Researchers used to find 10,000 *Diporeia* in a square yard of sediment. Today researchers are finding only hundreds in a square yard and sometimes finding none at all. Severe declines in *Diporeia* populations will have an effect on Lake Michigan food webs and fish populations (like whitefish or lake trout), either starving some of them or resulting in lower fish weights and size. This is resulting in a shortage of food for many foraging fish. In addition, the improved water clarity is adding more stress by hindering small prey fish's ability to hide from predators.



Dreissena mussels (zebra)



Diporeia
Image from: Zooplankton of the Great Lakes by Mary Balcer,

3.9 *Water Quality Summary*

Overall, the prevailing opinion among experts is that the water quality in Grand Traverse Bay is excellent. The bay is typical of other oligotrophic embayments in the Great Lakes; deep, clear, cold, with an overall low productivity. However, there are several potential threats to water quality, with localized areas of pollution, both in the bay and its watershed. Excessive nutrients and pollutants from stormwater runoff are just two examples of those potential threats. Water quality impairments are being realized in the tributaries that feed Grand Traverse Bay, including both Kids and Mitchell creeks, illustrating the importance of watershed protection and restoration efforts.

A number of water quality standards and reference conditions were used to assess both current and historic water quality data for the Grand Traverse Bay Coastal watershed. The following provides a summary of existing water quality information for Cedar Lake, coastal tributaries to Grand Traverse Bay, and Grand Traverse Bay itself. Cedar Lake is one of the only inland lakes within the coastal watershed area. As has been noted before, this watershed plan covers the Grand Traverse Bay Coastal watershed; detailed water quality summaries for the Boardman River and Elk River Chain of Lakes subwatersheds are found in their respective watershed plans.

Water Quality Standards, Reference Conditions, and Parameters

Several thresholds or standards exist that can be used to reference water quality data collected in the Grand Traverse Bay Coastal watershed. The State of Michigan has developed water quality standards (WQS) under Part 4 of the Administrative Rules issued pursuant to Part 31 of the Natural Resources and Environmental Protection Act (1994 PA451, as amended), which are discussed in detail in Chapter 4.1.

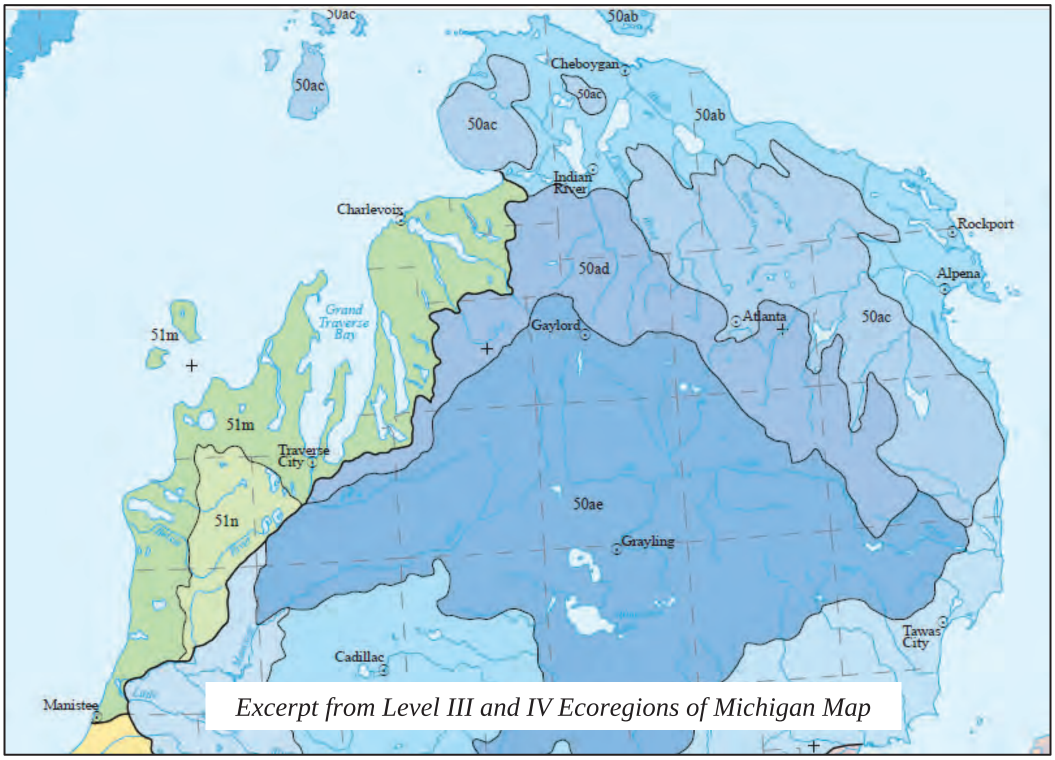
The EPA National Aquatic Resource Survey's (NARS) National Coastal Condition Assessment (NCCA) 2010 Technical Memorandum includes a set of water quality thresholds that can be used to assess the condition of the nearshore waters of the Great Lakes (USEPA 2016). These thresholds are shown in Table 18.

Table 18: EPA Lake Michigan Water Quality Thresholds

Parameter	Good	Fair	Poor
Surface Concentrations of Total Phosphorus	< 0.007 ug/L	0.007 – 0.01 ug/L	> 0.01 ug/L
Surface Concentrations of Chlorophyll *a*	< 1.8 μg/L	1.8 – 2.6 μg/L	> 2.6 μg/L
Water Clarity (Secchi Depth)	> 6.7 m	5.3 – 6.7 m	< 5.3 m

EPA, in collaboration with other federal and state agencies, researchers, and other neighboring North American countries designed "ecoregions" where ecosystem type, quality, and quality are similar. Ecoregions, which have been broken into different hierarchical levels, serve as a spatial framework for monitoring, research, and assessment of ecosystems and their components. North America has been divided into 15 broad Level I ecoregions, 50 Level II ecoregions, and 182 Level III ecoregions.

The map to the right is an excerpt from a larger map of the Level III and IV Ecoregions for Michigan (USEPA June 2010). The Coastal Grand Traverse Bay Waterhsed falls primarily in Sub-ecoregion 51: Nothern Central Hoardwood Forests, while a small portion of some of the headwaters area for Yuba, Acme, and Tobeco Creeks falls within Sub-ecoregion 50: Northern Lakes and Forests. Each sub-ecoregion posesses reference condtions that are useful in assessing water quatlity data.



Excerpt from Level III and IV Ecoregions of Michigan Map

Table 19 lists reference conditions for a variety of water quality parameters for both sub-ecoregions represented in the Grand Traverse Bay Coastal watershed (USEPA 2000- 1-4).

Table 19: EPA Ecoregion Reference Conditions for Sub-ecoregions 50 and 51

Parameter	Lake Value		Stream Value	
	Sub. 51*	Sub. 50	Sub. 51*	Sub. 50
Chlorophyll a (µg/L) - F	2.02	1.38	1.03	0.6
Chlorophyll a (µg/L) - S	5	2.46	8.76	2
Chlorophyll a (µg/L) - T	5.51	–	–	4.3
NO2 + NO3 (mg/L)	0.008	0.003	0.13	0.03
Secchi (meters)	3.2	4.2	–	–
TKN (mg/L)	0.65	0.32	0.33	0.33
TN (mg/L)	0.81	0.40	0.71	0.44
TP (ug/L)	20	9.69	15.35	12
Turbidity (NTU)	–	–	0.84	0.63

**Comprises most of coastal watershed area*

Twelve target water quality parameters were identified to be of greatest significance to this management plan for analyzing water quality in coastal tributaries and inland lakes based on data availability and principles of aquatic system health. This set of variables represents the most concise and effective picture of water quality within the Grand Traverse Bay Coastal watershed tributaries about past, current, and near-future monitoring efforts. Most of the following parameters will also be used to summarize water quality in Grand Traverse Bay waters in addition to the following: macrophyte bed distribution, climate data (freeze/thaw), endangered and invasive species, plankton/fish, minerals, silica, and heavy metals.

Benthic Macroinvertebrates

Sampling the benthic macroinvertebrate community within a stream or river can provide valuable information about long-term water quality characteristics. Chemistry observations are useful for environmental conditions in streams but can fluctuate widely over short time periods due to precipitation events and often do not reflect the status of the aquatic biota. Benthic macroinvertebrates are measured due to their more constant community composition, yet relatively short life cycles (typically 1-3 years) that allow them to respond relatively quickly to changes in water quality. Some aquatic invertebrates can tolerate a wider range of habitat types and fluctuations of pH, dissolved oxygen, and temperature than others. There are many measures of benthic macroinvertebrate community structure and function that relate to the quality of the ecosystem. For example, measures of total taxa, pollution sensitive taxa, and species evenness, with some metrics—such as EGLE's Procedure 51 and the Michigan Clean Water Corps (MiCorps) Biotic Index—integrating multiple measures of community composition and species abundance. Most assessments classify community health into discrete categories: *excellent, good, fair* and *poor.*

Chlorophyll a

Chlorophyll a is a pigment found in plants that is necessary for photosynthesis. Chlorophyll *a* is the most dominant form of chlorophyll found in green plants and algae and concentrations of this parameter are used to quantify the amount of algae growing within a particular body of water. Some naturally occurring algae is to be expected in all but the most oligotrophic and nutrient-poor lakes, but particularly high values of chlorophyll a can indicate an overabundance of algae that leads to reductions in dissolved oxygen and water clarity. Elevated concentrations of chlorophyll often occur with increases in nutrient runoff and distinct peaks may indicate the presence of harmful algal blooms within a body of water.

Dissolved oxygen

Dissolved oxygen concentration is a measure of the amount of oxygen dissolved in a body of water and is one of the primary limiting factors for aquatic life. Dissolved oxygen can vary drastically diurnally and seasonally due to photosynthesis and lake stratification. Dissolved oxygen is affected by bacteria in the water that can consume oxygen as organic matter decays. Temperature also plays a role as colder water has the capacity to hold more oxygen.

***Esherichia coli* (*E. coli*)**

E. coli is a type of bacteria commonly found in the intestines of mammals, so its presence in water indicates that fecal pollution has occurred and there is a potential for the presence of other disease-causing pathogens. *E. coli* provides a reliable indicator of potentially hazardous conditions in recreational waters. EPA studies indicate that when the numbers of *E. coli* in fresh water exceed water quality standards, swimmers are at increased risk of developing gastroenteritis (stomach upsets) from pathogens carried in fecal pollutions. Michigan has adopted the EPA's *E. coli* water quality standards. If more than 130 *E. coli* are present in 100mL of water in 5 samples over 30 days, or if more than 300 *E. coli* per 100mL of water are present in a single sample, the water is considered unsafe for total body contact. Surface waters for partial body contact recreation are not to exceed 1,000 cfu/100ml.

Human-related enteric bacteria enter waterways primarily through wastewater discharge and septic system failure and can be a serious health concern. Animal farming operations, stormwater runoff, waterfowl, and pet waste can lead to increased *E. coli* concentrations in nearby waterways and can be problematic when highly concentrated or improperly managed. A more detailed discussion of *E. coli* and other pathogens is found in the discussion of watershed pollutants in Chapter 5.5.

Habitat Assessments

Habitat assessments are a type of visual evaluation of stream conditions and watershed characteristics. The Grand Traverse Band of Ottawa and Chippewa Indians completed a habitat assessment in the watershed following EGLE's Procedure 51 survey which is based on substrate, available cover, pool substrate and variability, sediment deposition, channel flow volume, flow flashiness, channel alteration, channel sinuosity, bank stability, vegetative protection, and riparian vegetative width. Numeric scores range from 0-154. For a habitat characterization to rate as excellent, the score must be greater than or equal to 154. To rate as good, the score must fall between 105 and 154. To rate as marginal, the score must fall between 56 and 104. Any score that is equal to or less than 55 is considered poor. Stream channel alterations, riparian vegetation removal, stormwater and agricultural runoff, can affect in-stream habitat.

Nitrogen

Nitrogen is a key nutrient in the growth of aquatic plants and algae. Total nitrogen consists of the sum of all its common forms; ammonia, nitrate, nitrite, and organic nitrogen. Nitrate and Nitrite, commonly referred to as NOx, are inorganic forms of nitrogen biologically available, though nitrite is readily converted to nitrate in water by bacteria. Total Kjeldahl Nitrogen (TKN) is the sum of organic nitrogen and total ammonia. Nitrogen is typically present in much greater abundance than phosphorus in water bodies and is usually not considered a limiting nutrient for harmful algal growth or overstimulation of rooted aquatic plants in freshwater systems. However, when high quantities of nitrogen exist in conjunction with high levels of phosphorus, there is a risk of promoting algal activity that can lead to dangerous reductions in dissolved oxygen. Further, high concentrations of nitrogen in drinking water sources can cause health issues. Nitrogen enters bodies of water primarily through nutrient runoff from agriculture, lawn fertilizer, and wastewater, including human waste carried through septic systems. Further discussion of nitrogen is found in the watershed pollutants section in Chapter 5.5.

Phosphorus

Phosphorus is the other key nutrient controlling growth of aquatic plants and algae. Phosphorus exists in far lower concentrations than nitrogen in most freshwater systems, operating as the primary limiting nutrient. Total phosphorus consists of all organic and inorganic forms of phosphorus, including phosphates. Elevated concentrations of phosphorus can lead to increased algal and aquatic plant growth which can result in significant reductions in dissolved oxygen. Phosphorus enters bodies of water primarily through nutrient runoff from agriculture, lawn fertilizer, and wastewater, including human waste carried through septic systems. Further discussion of phosphorus is found in the watershed pollutants section in Chapter 5.5.

Secchi Depth

Secchi depth is a measure of the amount of water clarity and is recorded as a distance beneath the water surface to which visibility extends. This is not a true measure of turbidity as it can be affected by several environmental factors, and it is important to take note of recent runoff events when collecting data. Given that sediment levels are typically very low in the center of lakes where measurements are usually taken and the high variability of such levels, this measure is most useful as an indicator of phytoplankton density and eutrophication.

Specific Conductance

Specific conductance measures the ability of water to pass an electrical current and is affected by the presence of anions and cations from dissolved solids. Temperature also affects conductivity as an increase in temperature results in greater dissociation of molecules. Specific conductance can vary greatly based on storm events and periods of increased runoff, and it is important to take note of previous runoff events when recording data. Specific conductance can also be a surrogate for chloride as a well-defined relationship between the two parameters exists. According to the EPA, conductivity of rivers in the United States generally range from 50 to 1500 µmhos/cm (USEPA 2012). Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µmhos/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates.

Temperature

Temperature is a key water quality parameter as it dictates the types of organisms found in lakes and streams and has a profound effect on dissolved oxygen and the rate of chemical and biological reactions. Temperature in a stream or lake can be influenced by season, vegetation cover, water origin (groundwater, surface water, or precipitation-fed systems), velocity, point-source discharges, and neighboring land uses. Each aquatic organism has a preferred temperature regime or threshold. For instance, optimal growth for brook trout occurs at water temperatures below 61^{o} F (Raleigh 1982, Meehan and Bjornn 1991).

Turbidity

Turbidity is a measure of the degree to which the water transparency decreases due to suspended particulates. Turbidity can increase in streams and lakes due to increased algal or plant biomass, sedimentation, and erosion. It can be an early indicator of surface water nutrient enrichment. Turbidity is measured in Nephelometric Turbidity Units (NTUs).

Summary of Monitoring Efforts (Long-term, Historical, Special)

Grand Traverse Bay and its surrounding watershed have been studied extensively over the past 50 years. Many organizations conduct regular monitoring programs, while others have completed special monitoring projects. TWC reached out to a wide array of organizations that have conducted monitoring efforts in the bay and watershed in an effort to summarize existing water quality data. Not all organizations responded to this request, and some could not provide reliable data for this report (i.e. no quality control, not sure on metrics, parameters, or units), so the summary on the following pages is not inclusive of ALL existing data for the watershed; however, it does provide a good summary of water quality monitoring projects in the last 15 years. Table 20 summarizes ongoing monitoring programs and other special projects that have been completed in the Coastal Grand Traverse Bay watershed over the past 15 years.

Table 20: Monitoring Programs and Special Projects

Organization	Program	Parameters	Location	Frequency	Time Period
Grand Traverse Band of Ottawa and Chippewa Indians (GTB)	Water Quality Assessment Monitoring	SC, DO, pH, temp, turbidity, habitat assessment, velocity, water clarity, chlorophyll a, SRP, TN, TP, macroinvertebrates, mercury	Grand Traverse Bay & tributaries	spring, summer, fall	unknown
	Tribes are required to assess, and report annually on water quality monitoring data that were gathered using U.S. Environmental Protection Agency (USEPA) Clean Water Act (CWA) Section 106 funding (USEPA, 2006).				
Michigan Department of Environment, Great Lakes, and Energy (EGLE)	Grand Traverse Bay Trend Monitoring	TP, ortho-P, TKN, NH3, NOx, chlorophyll a, pH, turbidity, DO, alkalinity, hardness, SC, TSS, TDS, TOC, calcium, magnesium, potassium, sodium, chloride, sulfate, lead, chromium, copper and mercury	4 total stations: -2 in West Arm -2 stations in East Arm	spring, summer, fall	1998-present
	Grand Traverse Bay watershed: 5 Year Cycle Monitoring	water quality, habitat, and macroinvertebrates	variable	variable	Every 5 years
	EGLE is required to monitor each water body every five years, biannually assess and report on the status of its waterbodies, and publish a list of waterbodies that are not attaining water quality standards or meeting their designated uses. The most recent published listing of the bodies of water and stream reaches in the State of Michigan that are in nonattainment can be found in EGLE's 2018 Integrated Report (EGLE 2018). Biosurvey reports also published in varying years for macroinvertebrate and habitat surveys following P51 procedures				
	Polyaromatic Hydrocarbon (PAH) Monitoring	Surface lot scrapings for coal tar sealants; stream sediment samples for Total PAH17	20 locations in Traverse City: -10 surface lots -10 stream bottom locations on Kids Creek and Boardman River	once	2018 *(Results in Appendix B)*

Organization	Program	Parameters	Location	Frequency	Time Period
The Watershed Center (TWC)	Adopt-A-Stream	Volunteer Stream Monitoring using MiCorps protocols – macroinvertebrate biotic index, water temperature	Various wadable streams within the Grand Traverse Bay watershed	June, October	2003- present
	Purpose is to flag issues, inform advocacy efforts, help EGLE collect data to determine attainment of designated uses, evaluate restoration projects, collect baseline data.				
	Healthy Beaches	*E. coli*	Public beaches in Grand Traverse, Leelanau, and Benzie counties (Great Lakes and inland lakes)	weekly during swimmable season (June-early Sept)	2001 - present
	Monitoring done in conjunction with local health departments. Beachgoers are cautioned about swimming/contact if *E. coli* levels are elevated				
	Macrophyte Bed Mapping	Aquatic plant survey along bay shoreline; water and sediment testing for nutrients	Grand Traverse Bay	n/a	1991, 1998, 2009
	Mitchell Creek *E.Coli* Study	*E. coli*	Mitchell Creek and tributaries	n/a	2005
	This study was completed using EGLE standard methods in order to provide sufficient data to have creek added to the State's Impaired Watershed; funding through EGLE grant #2015-0530. TWC had previously worked with Michigan State University (MSU), United States Geological Survey, Environmental Canine Services, and others to complete bacteria monitoring and source tracking efforts that found high *E.coli* levels in the creek. Those studies also indicated that some of the pathogen inputs found in Mitchell Creek may be from human sources.				
Leelanau Conservancy	Volunteer Stream Monitoring	NH3, NOx, TKN, TP, water temperature, stream flow	Tributaries in Leelanau County	year-round	1992- present
	Lake Monitoring (conducted by DEQ, GLEC, or other consultants)	NOx, TP, chlorophyll a, secchi, water temperature, DO, ORP, SC, pH	Lakes in Leelanau County	spring, summer, fall	1992- present
Acme Township (via Barr Engineering)	Acme Creek Post VGT Monitoring	water temperature, TSS, turbidity, E. coli, DO, SC, pH, VOC, TOC, TDS, velocity	Two locations on Acme Creek	year-round	2014 - present
	Post construction surface water quality monitoring in response to the development known as the Village at Grand Traverse, LLC at the Grand Traverse Town Center (site in Acme Township)				

The Watershed Center also hosts an online interactive water quality database at www.gtbay.org/wqquery.asp. This database is comprised of mostly historical data and was designed to provide a comprehensive storehouse of available water quality data, collected by The Watershed Center, volunteer monitoring projects, researchers, and other organizations, for the entire Grand Traverse Bay watershed. More than 37 reports have been entered into the database so far, with plans to enter new reports and data as they become available. Users can search for specific results by parameter (nitrogen, phosphorus, etc.), report, or location (river, lake, open bay, etc.). Additionally, the database has a mapping feature where users can search for water quality data using an interactive map. Historical reports utilized for water quality summary of Grand Traverse Bay (and select tributaries).

Water Quality Summary – Grand Traverse Bay Coastal Watershed Area

The following provides a summary of water quality parameters (described above) for coastal tributaries to Grand Traverse Bay and one costal inland lake, Cedar Lake. Detailed water quality summaries for the two largest subwatersheds in the Grand Traverse Bay watershed, the Boardman River and Elk River Chain of Lakes, are available in their respective watershed management plans (TWC and PSC 2016, TOMWC and TWC 2020). However, since both the Boardman River and Elk River are large river systems that may affect water quality in Grand Traverse Bay, especially in the nearshore area, water quality data taken at the mouths of both are included in some of the summaries below.

Benthic Macroinvertebrates

Benthic macroinvertebrates have been analyzed at numerous stream sites throughout the watershed. Most recently, EGLE completed macroinvertebrate analyses in coastal tributaries in 2003, 2008 and 2013 using their "Procedure 51" method (DEQ 2008, DEQ 2009, DEQ 2015). The P51 method has a scale of 9 to -9 for macroinvertebrates. Stations with a score greater than or equal to +5 are considered excellent. Stations with a score less than or equal to -5 are classified as poor. Stations with a score of -4 through +4 are classified as acceptable (moderately impaired). Most streams sampled fell into the acceptable range, however they were at the lowest end of acceptable which indicates a moderate amount of impairment (Table 21).

In addition, TWC conducts a volunteer monitoring program in the watershed following the Michigan MiCorps Program procedures. This program utilizes volunteer generated index scores for aquatic insects in streams and ranks them on a scale from Poor, Fair, Good, to Excellent. This biotic index is based off benthic macroinvertebrate abundance, diversity, and tolerance to physical and chemical conditions of a stream. Organisms are identified to order or sub-order. Data summarized for coastal Grand Traverse Bay tributaries from 2017-2019 is shown in Table 22 with red squares indicated a "Poor" ranking, yellow indicating "Fair", and green indicating a "Good" ranking. It should be noted that no stream scored as "Excellent" based on the MiCorp's index. These data indicate that multiple streams, including Brewery Creek, Acme Creek, Mitchell Creek and Yuba Creek, may have compromised benthic macroinvertebrate communities caused by poor water quality and/or physical in-stream degradation affecting habitat. A full data set for all TWC generated data through the MiCorps program can be found in TWC's online water quality database at http://data/gtbay.org/wqdb.asp.

Table 21: P51 Macroinvertebrate Scores for Grand Traverse Bay Coastal Tributaries

	2003 Score	*Rank*	2008 Score	*Rank*	2013 Score	*Rank*
Northport Creek						
@Melkild Rd (3rd St) u/s of mouth	-4	*acceptable*			-4	*acceptable*
Bay Street					-2	*acceptable*
Leo Creek						
@E Pine View Rd	-4	*acceptable*				
d/s Richter Rd					-5	*poor*
Unnamed Creek (Leelanau County)						
@Grandview Rd	-1	*acceptable*				
Mitchell Creek						
3 Mile Rd	-4	*acceptable*				
E of Parsons Rd, u/s of RR Tracks	-4	*acceptable*				
@Vanderlip Rd	1	*acceptable*				
Bakers Creek						
u/s RR Tracks, u/s M72	-5	*poor*				
Acme Creek						
Bunker Hill Rd	-1	*acceptable*				
@US 31	-1	*acceptable*				
@M72					-1	*acceptable*
Creeks Crossing					-4	*acceptable*
Yuba Creek						
@Yuba Rd	-6	*poor*			-6	*poor*
@US 31			1	*acceptable*	0	*acceptable*
Guyer Creek						
@ Old Dixie Hwy	0	*acceptable*				
Antrim Creek						
@ Old Dixie Hwy			2	*acceptable*		

P51 Rank Scale: < -5 Poor, -4 to 4 Acceptable, >5 Excellent

Table 22: MiCorps Volunteer-Generated Macroinvertebrate Scores Coastal Grand Traverse Bay Tributaries (2017-2019)

Stream Name *(as appears in TWC database)*	Spring 2017	Fall 2017	Spring 2018	Fall 2018	Spring 2019	Fall 2019
Acme Creek - Site 2	23	28	25	10	32	31
West Arm Acme Creek - Site 1	-	-	-	-	31	28
Baker Creek - Site 3	32	30	27	26	34	31
Brewery Creek - Site 1	10	-	-	-	-	-
Brewery Creek- Site 2	-	-	-	-	30	21
Cedar Creek- Site 2	28	20	30	29	20	26
Leo Creek - Site 1	-	34	29	22	34	21
Mitchell Creek - Site 2	-	-	-	-	31	42
Mitchell Creek - Site 3	-	-	28	18	-	-
Northport Creek - Site 4	-	23	37	-	-	-
Water Wheel Park Creek - Site 1	28	33	26	35	38	39
Weaver Creek - Site 1	-	-	-	-	-	38
Yuba Creek - Site 1	-	-	-	-	24	15
Yuba Creek - Site 2	-	-	-	-	34	29

MiCorps Rank Scale

Excellent	*>48 Excellent*
Good	*34-48 Good*
Fair	*19-33 Fair*
Poor	*< 19 Poor*

Chlorophyll a

Chlorophyll *a* data has been gathered at very few sites in the coastal watershed area over the last 20 years. Those sites that were measured suggest relatively low amounts of algal biomass (Table 23). The river mouth sites investigated by the Grand Traverse Band of Ottawa and Chippewa Indians (GTB) shown in Table 23 have both lake and stream influences because samples were collected where they outlet to Grand Traverse Bay. While the mouths of Elk River and Mitchell Creek have slightly elevated levels of Chlorophyll *a* when compared to EPA's Sub-ecoregion 51 reference conditions for streams (Table 19 above), they both fall below the lake threshold as well as the EPA's NCCA guidelines for Lake Michigan (Table 18 above).

Table 23: Chlorophyll a Data for Cedar Lake and Select River Mouths

Site Name	Mean (ug/L)	Time Period	# of Samples	Organization
Cedar Lake	1.59	1993-2017	108	Leelanau Conservancy
Mouth of Elk River	1.36*	2012-2017	17	GTB
Mouth of Boardman River	0.62*	2012-2017	21	GTB
Mouth of Mitchell Creek	1.71*	2012-2017	18	GTB

**Data represents a weighted mean (yearly averages were combined for an overall mean with number of samples taken considered).*

Dissolved oxygen
Dissolved oxygen (DO) samples were taken by the GTB from 2012 – 2017 at the mouth of the Elk River, Boardman River, and Mitchell Creek. Additional DO information was found for two sites on Acme Creek. All DO levels noted suggest that stream and river mouth sites support healthy warmwater and coldwater fisheries (Table 24).

Table 24: Dissolved Oxygen Measurements Grand Traverse Bay Coastal Tributaries

Site Name	Latitude	Longitude	Mean mg/L	Time Period	# of Samples	Org.
Mouth of Elk River	44.90277	-85.4182	11.07*	2012-2017	16	GTB
Mouth of Boardman River	44.7656	-85.6122	10.87*	2012-2017	14	GTB
Mouth of Mitchell Creek	44.75003	-85.5581	10.68*	2012-2017	15	GTB
Acme Creek -1	44.76988	-85.4904	12.13	2011-2018	22	Acme Twp.
Acme Creek -2	44.76759	-85.4882	11.93	2011-2018	22	Acme Twp.

**Data represents a weighted mean (yearly averages were combined for an overall mean with number of samples taken considered).*

Esherichia coli (E. coli)
E. coli monitoring data for coastal tributaries throughout the watershed is sporadic over the past 20 years. In general, peak *E. coli* concentrations in coastal streams often occur during high flow periods when floodwater is washing away possible contaminants along the streambank such as waste from ducks, geese, or domestic pets. However, *E. coli* levels in streams can be highly variable from day to day, and dependent upon a variety of factors, especially weather.

TWC received a grant from the DEQ (now EGLE) in 2002 to perform a variety of monitoring activities, including *E. coli*, in the watershed from 2002-2004 (TWC 2004). Those results show that Cedar, Tobeco, and Mitchell creeks exhibited relatively low *E. coli* concentrations during the time periods sampled (Table 25). However, Waterwheel Creek, located in downtown Suttons Bay, had levels over EGLE's partial and total body contact water quality standards.

Table 25: *E. coli* Results (col/ 100mL) for Select Coastal Tributaries (2002-2004)

Date	Cedar Creek	Tobeco Creek	Waterwheel Creek	Mitchell Creek (GT County) *Added in 2004*
9/17/2002	22	47	613	
9/24/2002	59	244	435	
10/1/2002	24	58	770	
10/8/2002	10	81	461	
3/25/2003	0	5	17	
4/2/2003	2	2	28	
4/8/2003	1	1	4	
4/16/2003	6	3	187	
4/22/2003	5	6	36	
4/29/2003	0	9	22	
5/7/2003	23	17	145	
5/14/2003	3	12	27	
7/1/2003	47	39	129	
7/8/2003	25	291	133	

Date	Cedar Creek	Tobeco Creek	Waterwheel Creek	Mitchell Creek (GT County) *Added in 2004*
8/12/2003	17	50	866	
8/19/2003	45	120	62	
8/26/2003	69	411	727	
9/2/2003	35	36	276	
9/8/2003	43	30	74	
9/15/2003	56	67	195	
9/23/2003	17	110	517	
9/30/2003	19	29	326	
10/7/2003	6	14	70	
10/15/2003	6	47	205	
10/21/2003	3	15	31	
10/27/2003	1	12	20	
3/3/2004	1	9	12	
3/11/2004	0	1	4	
3/17/2004	0	0	1	42
3/24/2004	1	0	12	58
4/1/2004	1	0	0	20
4/7/2004	0	9	0	19
4/14/2004	1	1	0	6
4/21/2004	13	129	194	210
4/28/2004	2	2	23	48
5/5/2004	2	35	0.1	29
5/12/2004	3	17	1	33
5/19/2004	6	3	11	210
5/26/2004	50	31	16	199
6/2/2004	20	131	23	135

Pink highlighted cells = Total Body Contact WQS exceeded (>300 col/100mL)
Yellow highlighted cells = Partial Body Contact WQS exceeded (>1,000 col/100mL)

Two creeks in the Grand Traverse Bay Coastal Watershed are listed as impaired due to *E.coli* (EGLE June 2019). Both creeks are named Mitchell Creek, but they are in two different counties. Mitchell Creek in Antrim County is a very small ephemeral stream and is most likely impacted due to wildlife and potentially land application of septage waste.

The other Mitchell Creek is a larger costal tributary to Grand Traverse Bay in Grand Traverse County that drains 16 square miles of land, with a significant portion of its downstream area in urbanized areas of the City of Traverse City and East Bay Township. Significant monitoring efforts undertaken by TWC in 2015 led to its inclusion on the most recent update to the State's Impaired Waters List. Samples were taken at 11 locations along Mitchell Creek for a period of 12 weeks during Summer 2015 with results listed as a geometric mean of triplicate samples taken (Figure 12).

Results varied each week for sampling locations (Table 26). Six locations exhibited *E. coli* levels above the 1,000 *E. coli*/100mL daily maximum threshold for Water Quality Standard (WQS) attainment for partial body contact (11 samples total). Virtually all sites had instances where the *E. coli* levels were above the 300 *E. coli*/100mL daily maximum threshold for Water Quality Standard (WQS) attainment for total body contact recreation (56 samples total). A rain event occurred on August 19 when all but two of the sample locations were above 300 *E.*

coli/100mL, with the majority of those above 1,000 *E. coli*/100mL (TWC 2016). Almost all the 30-day geometric means calculated at each site during the project were above WQS for total body contact (Table 27). Site MC-11, located in the headwaters of Four Mile Creek (a tributary of Mitchell Creek on the east side) had no occurrences where results were above WQS for single-day or 30-day geometric means for *E. coli*. Results for this stream section could be used as reference levels for *E. coli* in other sections of Mitchell Creek (TWC 2016).

Table 26: Mitchell Creek 2015 *E. coli* Monitoring Results: Geometric Mean Results for Triplicate Samples at Each Location (col/100mL)

	6/10	6/17	6/24	7/1	7/8	7/15	7/22	7/29	8/5	8/12	8/19	8/26
MC_1	281	411	105	649	558	557	358	568	319	303	1,967	403
MC_2	93	61	90	160	328	637	83	537	171	868	546	185
MC_3	271	243	93	636	464	478	451	649	351	220	924	346
MC_4	236	395	86	601	436	383	443	986	244	286	1,534	281
MC_5	366	461	112	1,056	620	434	387	1,010	402	162	2,121	366
MC_6	102	104	55	160	142	126	164	365	134	246	302	326
MC_7	242	939	100	1,418	899	1,211	N/A	N/A	1,647	N/A	N/A	1,733
MC_8	335	396	116	918	541	455	314	527	478	194	1,505	267
MC_9	165	218	90	479	329	434	402	308	319	172	1,187	217
MC_10	63	97	83	131	76	26	14	326	96	30	351	50
MC_11	44	45	41	126	96	118	70	174	122	115	285	79

Table 2 from Mitchell Creek E.coli Monitoring Final Project Report (TWC 2016)
Pink highlighted cells = Total Body Contact WQS exceeded (>300 col/100mL); Yellow highlighted cells = Partial Body Contact WQS exceeded (>1,000 col/100mL); N/A = Stream was dry and no samples were taken that day

Table 27: Mitchell Creek 2015 *E. coli* Monitoring Results: 30-day Geometric Mean Results for Triplicate Samples at Each Location (col/100mL)

	7/8	7/15	7/22	7/29	8/5	8/12	8/19	8/26
MC_1	338	387	377	528	466	412	530	543
MC_2	122	179	191	272	276	335	325	381
MC_3	283	317	358	529	470	404	461	437
MC_4	292	321	329	535	447	411	542	495
MC_5	416	430	415	644	531	406	558	552
MC_6	106	110	121	176	170	190	227	260
MC_7	492	679	N/A	N/A	N/A	N/A	N/A	N/A
MC_8	378	401	383	518	455	370	471	456
MC_9	220	267	301	385	355	312	381	337
MC_10	87	73	49	65	61	51	86	111
MC_11	63	77	84	112	111	115	137	141

Table 3 from Mitchell Creek E.coli Monitoring Final Project Report (TWC 2016)
Pink highlighted cells = Total Body Contact WQS exceeded (>300 col/100mL)
N/A = Geometric Mean not calculated that day

Figure 12: Mitchell Creek 2015 *E. coli* Monitoring Sampling Locations

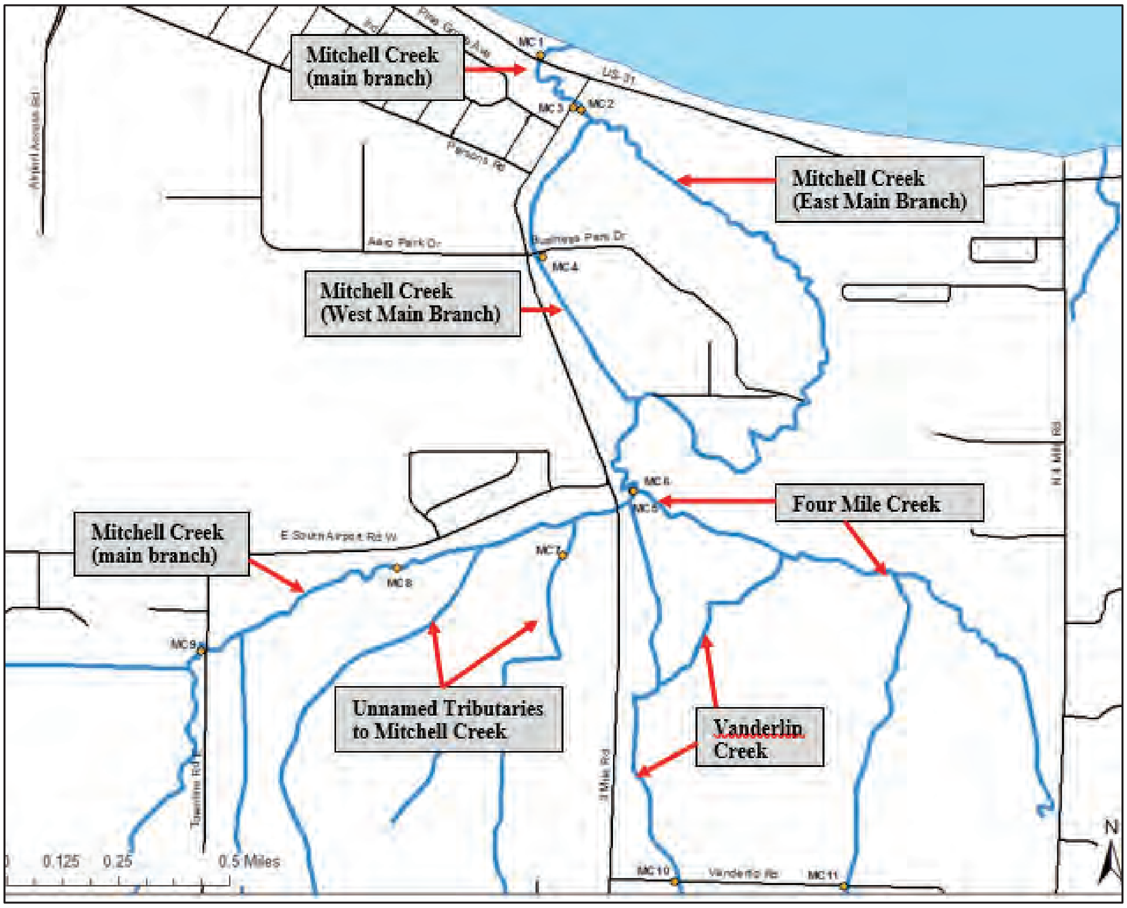


*Figure 2 from Mitchell Creek *E.coli* Monitoring Final Project Report (TWC 2016).

****June 2024 Update: In 2021, TWC secured an EGLE grant (#2020-0006) to conduct a bacteria monitoring and source tracking study at select locations on Mitchell Creek to identify the potential sources of contamination to address the bacterial impairment. The main objective was to determine if septic systems are impacting Mitchell Creek and are the cause of impairment. Secondarily, TWC wanted to determine if other sources of bacteria from canines, cows, pigs, or gulls add to the impairment. The bacteria source tracking project consisted of surface water sampling at select locations on the creek and groundwater flow determination and sampling at five locations. A summary of this study that highlights major findings, results, and conclusions is included as Appendix E. While there were several locations where human source tracking markers were found, the study did not find evidence that septic systems are a main source of bacterial pollution. The western tributaries had higher occurrences of pig markers while the central main branch had more human marker influence. The canine marker that includes wild animals such as fox and coyote is widespread. ****

Both TWC and the City of Traverse City have documented extremely high levels of *E.coli* bacteria in its stormdrains during rain events. The highest results were noted at 8th Street, Bryant Park, East Bay Park, Sunset Park where results for *E.coli* during rain events were routinely documented in the tens of thousands of colonies per 100mL. Some results have even reached over 100,000 col/100mL. This can be a major problem as many of the City's stormdrains outlet adjacent to public lands and designated beaches which pose a risk to beachgoers. Bacteria sampling in stormdrains is discussed in further detail in the next section, which is a summary of water quality for just Grand Traverse Bay areas, as well as in the Pathogens discussion in Chapter 5.5.

TWC has also been working with the Grand Traverse and Benzie-Leelanau District County Health Departments and Traverse City officials since 2001 to monitor various Great Lakes and inland beaches in the Grand Traverse Region for bacterial/pathogen pollution during the summer swimming season. Results are posted to EGLE's BeachGuard database (https://www.egle.state.mi.us/beach/) and are discussed in further detail under the Grand Traverse Bay monitoring section below.

Habitat Assessments

Both the GTB and EGLE have completed stream habitat assessments at various locations in the watershed using Procedure 51 protocols (Table 28). Habitat evaluations are based on 10 metrics, with a possible maximum total score of 200. Stations are classified as excellent with a habitat score >154, good with a score between 105 and154, marginal with a score between 56 and 104, and poor with a score <56. Good and Marginal classifications indicate that a stream is "slightly" to "moderately" impaired, respectively. Table 28 shows that most of the streams assessed scored in the Good to Marginal range, indicating some habitat impairments.

Table 28: Habitat Assessment Rankings for Grand Traverse Bay Coastal Tributaries

Site ID	Habitat Score	Ranking	Year	Sampling Done By
Elk River (mouth)	104 - 125	Marginal - Good	2012 - 2017	GTB
Boardman River (mouth)	85 - 108	Marginal - Good	2012 - 2017	GTB
Mitchell Creek (mouth)	164 -196	Excellent	2012 - 2017	GTB
Northport Creek				
@Melkild Rd (3rd St) u/s of mouth	103 122	Marginal Good	2003 2013	EGLE
Bay Street	99	Marginal	2013	EGLE
Leo Creek				
@E Pine View Rd	118	Good	2003	EGLE
d/s Richter Rd	103	Marginal	2013	EGLE
Unnamed Creek (Leelanau County)				
@Grandview Rd	128	Good	2003	EGLE
Mitchell Creek				
3 Mile Rd	119	Good	2003	EGLE
E of Parsons Rd, u/s of RR Tracks	75	Marginal	2003	EGLE
@Vanderlip Rd	160	Excellent	2003	EGLE
Bakers Creek				
u/s RR Tracks, u/s M72	124	Good	2003	EGLE
Acme Creek				
Bunker Hill Rd	139	Good	2003	EGLE
@US 31	113	Good	2003	EGLE
@M72	137	Good	2013	EGLE
Creeks Crossing	120	Good	2013	EGLE
Yuba Creek				
@Yuba Rd	120 133	Good Good	2003 2013	EGLE
@US 31	135 144	Good Good	2008 2013	EGLE
Guyer Creek				
@ Old Dixie Hwy	167	Excellent	2003	EGLE
Antrim Creek				
@ Old Dixie Hwy	152	Good	2008	EGLE

Nitrogen

There is not a lot of widespread, existing data for nitrogen parameters in the Grand Traverse Bay Coastal watershed. The Leelanau Conservancy took regular samples at 5 creeks and 1 lake in Leelanau County between 1992-2001, and the Grand Traverse Band of Ottawa and Chippewa Indians took samples at three major river mouths between 2012-2017 (Table 29). The data show that most of the creeks have total Kjeldahl nitrogen levels either above or very close to the EPA's Sub-ecoregion threshold of 0.33 mg/L. Only Hines Creek, also called Cedar Creek, is low. Additionally, water samples collected where the Boardman River and Mitchell Creek empty into Grand Traverse Bay show total nitrogen levels above both the lake and stream EPA Sub-ecoregion threshold levels (TN lake: 0.81 mg/L; TN stream: 0.71 mg/L) (Table 19).

Table 29: Mean Nitrogen Values for Grand Traverse Bay Coastal Tributaries

Site Name	Parameter	Mean (mg/L)	Time Period	# of Samples	Sampling Done By
Belanger Creek	TKN	0.30	1992-2001	38	LC
Ennis Creek	TKN	0.33	1992-2001	36	LC
Hines (Cedar) Creek	TKN	0.13	1992-2001	38	LC
Leo Creek	TKN	0.37	1992-2001	36	LC
Northport Creek	TKN	0.39	1992-2001	39	LC
Cedar Lake	$NO_2 + NO_3$	0.39	1992-2017	368	LC
Elk River (mouth)	TN	0.32*	2012-2017	18	GTB
Boardman River (mouth)	TN	1.05*	2012-2017	15	GTB
Mitchell Creek (mouth)	TN	0.9*	2012-2017	15	GTB

Total Kjeldahl Nitrogen (TKN), Nitrate and Nitrate ($NO_2 + NO_3$), and Total Nitrogen (TN)
**Data represents a weighted mean (yearly averages were combined for an overall mean with number of samples taken considered).*
Highlighted cells above water quality standard threshold.

The nitrate and nitrite data from Cedar Lake in Table 29 above indicates mean values were well above EPA's Sub-ecoregion 51 threshold of 0.008 mg/L, suggesting potential issues with nutrient enrichment. Even though nutrient concentrations can vary greatly among lakes, these values appear to be very high compared to other inland lakes in Michigan, suggesting a point source, onsite wastewater, agricultural, or lakefront residential fertilizer issue. While a portion of Cedar Lake is served by municipal sewer, the remaining portion is on private onsite wastewater (septic) systems. This data may suggest improperly functioning or designed onsite septic systems, which often add more nitrogen than phosphorus to waterbodies through groundwater contributions (Dr. S. Francoeur, personal communications, March 2, 2020). It's important to note that Cedar Lake's phosphorus concentrations are relatively low, which is preventing an algal bloom regardless of how much nitrogen is available as phosphorus is the limiting nutrient in this freshwater system.

EGLE staff sampled four creeks in the coastal watershed area in 2003 for nitrogen and phosphorus as part of their 5-year cycle sampling for Grand Traverse Bay watershed. Their sampling also included rain events at two creeks (Table 30). Their data shows only three sites at two creeks (Mitchell and Baker) with total Kjeldahl nitrogen values above the EPA Sub-ecoregion 51 threshold of 0.33 mg/L, and two of those samples were taken after rain events when nutrient values are expected to be elevated. However, it appears that all nitrate/nitrate values obtained for all streams sampled were well above the EPA threshold of 0.13 mg/L. (Ammonia does not have an EPA Sub-ecoregion threshold parameter.)

Table 30: Nitrogen and Phosphorus Values from 2003 EGLE Study

Northport Creek	**TKN (mg/L)**	**Ammonia (mg/L)**	**Nitrate/Nitrite (mg/L)**	**TP (mg/L)**
@Melkild Rd (3rd St)	0.21	0.03	1.25	0.018
Immediately u/s of mouth	0.22	0.03	1.01	0.036
Mitchell Creek				
3 Mile Rd	0.1	0.008	1.12	0.012
3 Mile Rd **(after rain event)**	0.38	0.018	0.95	0.037
@Vanderlip Rd **(after rain event)**	0.61	0.006	0.152	0.058
Baker Creek				
u/s RR Tracks, u/s M72	0.37	0.006	0.36	0.026
Yuba Creek				
@Yuba Rd **(after rain event)**	0.32	0.017	1.55	0.022

Highlighted cells above water quality standard threshold.

Phosphorus

EGLE data from Table 30 above show Total Phosphorus (TP) levels in Northport, Mitchell, Baker, and Yuba creeks all above the 15.35 ug/L (0.015 mg/L) EPA Sub-ecoregion 51 threshold for TP in streams. Additionally, data from the Leelanau Conservancy in Table 31 below show that TP values at Belanger and Hines/Cedar creek fall below the TP threshold for streams, while Ennis Creek is close to exceeding and Northport Creek exceeds it. Cedar Lake TP values fall well below the 20 ug/L (0.02 mg/L) EPA Sub-ecoregion 51 TP threshold for inland lakes. Additionally, water samples collected where the Boardman River and Mitchell Creek empty into Grand Traverse Bay show TP levels well above both the lake and stream EPA Sub-ecoregion 51 threshold levels (TP lake – 20ug/L (0.02 mg/L) TP stream - 15.35 ug/L (0.015mg/L) (Table 31).

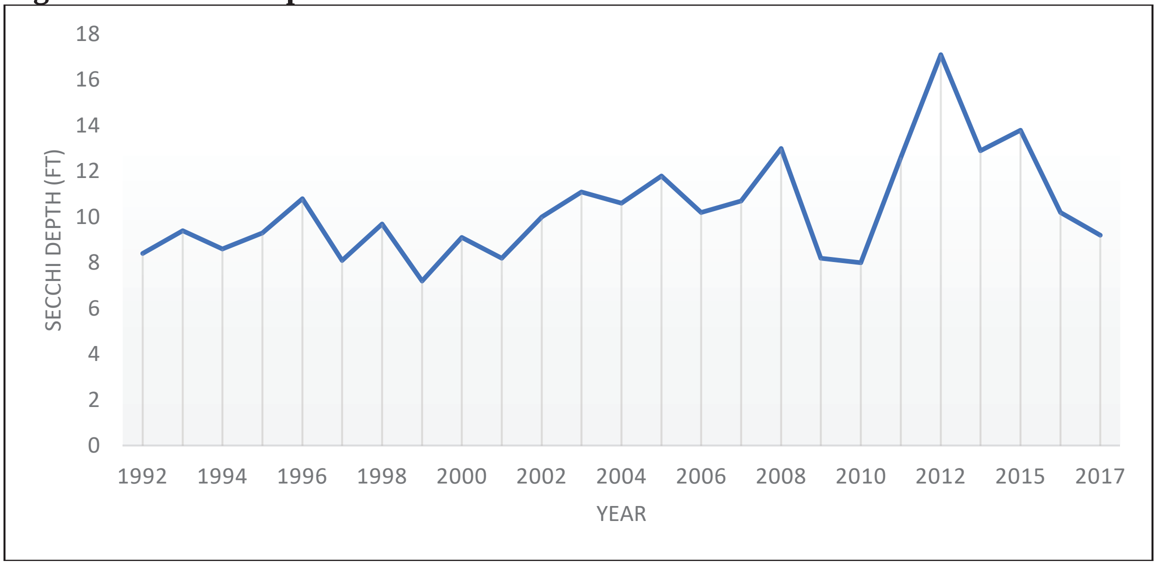
Table 31: Total Phosphorus Values for Grand Traverse Bay Coastal Tributaries

Site Name	Mean (ug/L)	Time Period	# of Samples	Sampling Done By
Belanger Creek	10.36	2007-2017	24	LC
Ennis Creek	12.66	2007-2017	21	LC
Hines (Cedar) Creek	7.37	2006-2017	39	LC
Leo Creek	10.15	2008-2017	21	LC
Northport Creek	23.93	2007-2017	29	LC
Cedar Lake	5.74	1992-2017	373	LC
Elk River (mouth)	3.89*	2012-2017	18	GTB
Boardman River (mouth)	35.03*	2012-2017	12	GTB
Mitchell Creek (mouth)	26.97*	2012-2017	12	GTB

**Data represents a weighted mean (yearly averages were combined for an overall mean with number of samples taken considered).*

Secchi Depth
Secchi data collected by the Leelanau Conservancy at Cedar Lake shows variation over the past three decades (Figure 12). Data suggests that water clarity may be increasing, potentially from invasive zebra mussel invasion.

Figure 13: Secchi Depths in Cedar Lake*



**Annual means were calculated from data collected from April – November*

Specific Conductance
Conductivity data is available for few sites in the watershed. The Leelanau Conservancy sampled Cedar Creek from 2006-2017, Acme Township measured two locations in Acme Creek from 2014-2018, and the Grand Traverse Band of Ottawa and Chippewa Indians has data from the mouths of Elk River, Boardman River, and Mitchell Creek from 2014-2017. Specific conductance data from all locations indicate that all stream lake, and river mouths sites are within normal specific conductance ranges for freshwater systems and should support a good mixed fishery (Table 32). As stated previously, studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µmhos/cm, or 0.15 mS/cm – 0.5 mS/cm, and the values in Table 32 all fall within that range.

Table 32: Specific Conductance Values for Grand Traverse Bay Coastal Tributaries

Site Name	Mean (mS/cm)	# of Samples	Time Period	Sampling Done By
Cedar Lake	0.36*	430	2006-2017	LC
Acme Creek - 1	0.36	22	2011-2018	Acme Twp.
Acme Creek -2	0.35	22	2011-2018	Acme Twp.
Elk River (mouth)	0.48**	12	2014-2017	GTB
Boardman River (mouth)	0.37**	11	2014-2017	GTB
Mitchell Creek (mouth)	0.29**	12	2014-2017	GTB

**Cedar Lake data represents averages from various water depths. **Data represents a weighted mean (yearly averages were combined for an overall mean with number of samples taken considered).*

Temperature
Stream temperature data suggest that all streams in the Grand Traverse Bay Coastal watershed support a healthy cold-water fishery (Table 33).

Table 33: Mean Monthly Water Temperature for Streams and Rivers

Site Name	Mean Water Temp (˚F)						Time Period	Sampling Done By
	May	June	July	Aug	Sept	Oct		
Acme Creek	50	57	57	55	49	n/a	2011-2018	Acme Twp.
Acme Creek	50	56	58	55	49	n/a	2011-2018	Acme Twp.
Belanger Creek	52	56	59	62	58	n/a	2007-2017	LC
Ennis Creek	50	58	63	68	59	n/a	2007-2017	LC
Hines (Cedar) Creek	51	52	51	52	50	n/a	2006-2017	LC
Leo Creek	50	55	58	n/a	59	n/a	2008-2017	LC
Northport Creek	53	56	60	62	57	n/a	2007-2017	LC
Elk River (mouth)	52	n/a	n/a	55	n/a	48	2012-2017	GTB
Boardman River (mouth)	51	n/a	n/a	53	n/a	51	2012-2017	GTB
Mitchell Creek (mouth)	51	n/a	n/a	56	n/a	49	2012-2017	GTB

Turbidity
Little turbidity data is available for the watershed. Data available for the few sites with information indicate that all except for the Elk River mouth exceed the EPA's Sub-ecoregion 51 threshold of 0.84 NTU (Table 34). The data is reported as a mean with samples taken from several months. Spring heavy rain and snowmelt events could be contributing to these exceedances.

Table 34: Mean Turbidity Values for Grand Traverse Bay Coastal Tributaries

Site Name	Mean (NTU)	Time Period	# of Samples	Sampling Done By
Mouth of Elk River	0.42*	2012-2017	15	GTB
Mouth of Boardman River	3.62*	2012-2017	15	GTB
Mouth of Mitchell Creek	1.31*	2012-2017	12	GTB
Acme Creek - 1	2.86	2015-2018	21	Acme Twp.
Acme Creek - 2	2.50	2015-2018	21	Acme Twp.

**Data represents a weighted mean (yearly averages were combined for an overall mean with number of samples taken considered).*

Water Quality Summary – Grand Traverse Bay

As stated previously, Grand Traverse Bay has excellent water quality, typical of other oligotrophic embayments in the Great Lakes; deep, clear, cold, with an overall low productivity. A unique characteristic of Grand Traverse Bay is that the exchange of water between the bay and Lake Michigan is significantly influenced by the presence of a sill (deep trench) along the bottom northern part of the bay. This sill affects water circulation and currents in the bay. As a result, the flushing rates at the southern base of West Grand Traverse Bay, where the Boardman River empties, can be dramatically lower than other bay regions (GLEC 2005). This may affect nutrient concentrations in the bay since they vary from one location to another.

In addition to the reports and studies used in the previous section to summarize water quality parameters in the coastal watershed area, several historical reports were used to asses water quality in Grand Traverse Bay for the 2005 watershed plan and those results are also included in this Grand Traverse Bay water quality summary section that follows. The first is the *State of the Bay* document which is a collection and summary of publications and ongoing research studies and information about the Grand Traverse Bay and its watershed from before 2000 (State of the Bay 2000). The second document used was the *2000 Integrated Habitat and Water Quality Inventory for the Grand Traverse Bay*, which was compiled for TWC by the Great Lakes Environmental Center (GLEC 2000, GLEC 2005) and utilized a number of historical reports from 1957, 1975, and 1992 (Lauff 1957, Auer et.al 1975, Shuey et.al 1992). The final historical document was a stormwater monitoring report from 2001 compiled by GLEC for TWC (GLEC 2001).

In addition, a significant amount of data was available from EGLE through their Water Chemistry Monitoring Program at four fixed stations in Grand Traverse Bay. They recently released a report the status and trends of their fixed monitoring stations from 1998 – 2014 (EGLE November 2019). While detailed information is below, in summary, these trend monitoring data show that the bay's trophic status has remained oligotrophic and excellent in quality, with total phosphorus decreasing since EGLE's water chemistry trend monitoring program began in 1998. Additionally, the data suggest that the Boardman River does not appear to influence nutrient or metal distributions within Grand Traverse Bay and that total phosphorus has been decreasing at the only station meeting data requirements for trend analysis at a rate of -6.15%. Chlorophyll a has also been decreasing at all 4 stations at a rate of -6.76% to -10.66% annually. Decreases in total phosphorus and chlorophyll in Grand Traverse Bay may be the result of improved wastewater treatment practices and the introduction of zebra mussels in 1992. EGLE also identified increasing trends in magnesium, sodium, chloride and sulfate at stations within Grand Traverse Bay. While these are required nutrients for plant growth, elevated levels can be indicative of disturbance, such as the increasing development of Grand Traverse Bay. Regardless, all values are meeting relevant screening values and EGLE will continue to monitor quality and the environmental and ecological significance of these patterns trends as resources allow. Trace metals were not analyzed for trend analysis due to limited sample size and high frequency of censored data; however, all samples met Rule 57 criteria.

Chlorophyll a

Grand Traverse Bay has relatively low chlorophyll *a* levels that vary with seasons, averaging 1ug/L, which classifies it as oligotrophic. Concentrations were highest in the fall and lowest in spring. EGLE trend analysis shows a decreasing trend at all 4 stations at a rate of -6.76% to -10.66% annually (EGLE November 2019).

Dissolved Oxygen
Dissolved oxygen (DO) and temperature indicate little stratification is occurring in the bay. The overall median concentration of DO was 10.64 mg/L and levels ranged from 8.01-17.23 mg/L. Concentrations vary and are highest in spring and fall and lowest in summer (EGLE November 2019).

Escherichia coli
There is significant potential for *E.coli* contamination in nearshore areas of Grand Traverse Bay coming from stormdrains and tributaries following rain events. Extremely high concentrations of *E. coli* were noted in several stormdrains in Traverse City following rain events in studies conducted between 2000 – 2015 (Appendix C). For example:

- 11/9/00 – 8th Street – 51,330 col/100mL
- 8/16/12 – 8th Street – 198,630 col/100mL
- 9/21/11 – Bryant Park #1 – 10,460 col/100mL
- 8/2/11 – Bryant Park #2 – 19,863 col/100mL
- 9/7/12 – East Bay Park – 241,920 col/100mL
- 11/9/00 – East Bay Park – 80,000 col/100mL
- 7/3/12 – Sunset Park – 130,000 col/100mL
- 8/16/12 – Sunset Park – 111,990 col/100mL

These high *E.coli* levels can be a major problem as many of the City's stormdrains outlet adjacent to public lands and designated beaches, which pose a risk to beachgoers. Stormwater inputs at other locations along the coast of Grand Traverse Bay can also contribute significant amounts of bacteria during rain events, specifically from stormdrain systems in coastal areas like the Villages of Northport, Suttons Bay, and Elk Rapids. These stormdrain systems, too, pose a risk to beachgoers when they outlet adjacent to beaches.

There are currently no beaches along Grand Traverse Bay that are listed as impaired for *E.coli* bacteria. However summer storm events have the potential to cause significant public health risks from *E.coli* bacteria at local beaches because of stormwater outfalls and urban tributaries. TWC has been working with the Grand Traverse and Benzie-Leelanau District County Health Departments and Traverse City officials since 2001 to monitor various Great Lakes and inland beaches in the Grand Traverse Region for bacterial/pathogen pollution during the summer swimming season. Additionally, the Health Department of Northwest Michigan tests beaches on Grand Traverse Bay in Antrim County. Results are posted to EGLE's BeachGuard database (http://www.deq.state.mi.us/beach/).

TWC has also successfully completed beach restoration projects using EPA Great Lakes Restoration Initiative funding to reduce bacterial contamination at local Great Lakes beaches including at the Village of Northport, Village of Suttons Bay, and Bryant and East Bay Parks in Traverse City.

Currently, the most at-risk beaches in terms of *E coli* issues along Grand Traverse Bay include Northport Beach, Suttons Bay Marina Beach and South Shore Park, West End Beach, Bryant Park Beach, Sunset Park, Senior Beach, and Veterans Memorial Park in Elk Rapids.

See Section 5.5 – Pathogens for a more in-depth discussion of *E.coli*.

Nitrogen
Nitrogen levels are relatively low in Grand Traverse Bay. Average nitrate nitrogen levels are 0.23 mg/L (EGLE November 2019). Other average nitrogen levels as reported by EGLE trends analysis are: Kjeldahl nitrogen – 0.16 mg/L; nitrite nitrogen – all below quantification limit; ammonia nitrogen – 83% below quantification limit, of measured median was 0.01 mg/L (EGLE November 2019).

Other studies have shown offshore nitrogen levels to be higher near the bottom than surface samples, except in Omena Bay (GLEC 2000). Additionally, urban tributaries and stormwater drains are a significant source of nitrogen to the bay.

The nitrogen requirements of microorganisms are about 10 times that of phosphorus. Because nitrogen/phosphorus ratios exceed 10:1 in most freshwater systems, including Grand Traverse Bay watershed, nitrogen is not usually the limiting nutrient for growth.

Phosphorus
EGLE trend analysis results show the overall median concentration of total phosphorus was 0.005 mg/L (5 ug/L) for all 4 stations in the bay, which categorizes Grand Traverse Bay as oligotrophic. Total phosphorus values ranged from nondetectable to 0.011 mg/L (11 ug/L). These have historically been some of the lowest concentrations in the Great Lakes. The EPA's NARS-NCCA study (previously mentioned) classifies Lake Michigan waters as "good" if total phosphorus levels are below 7 mg/L (Table 18). Total phosphorus results from various studies show a general decline since early 1970's (GLEC 2000):

- 1975 - 7.8ug/L
- 1992 – 5.4ug/L
- 1994 – 4.9ug/L
- 1998 – 3.8ug/L
- 1999 – 3.0ug/L
- 2000 – 8.3ug/L
- 2001 – 4.8ug/L
- 2002 – 3.5ug/L
- 2003 – 6.3ug/L

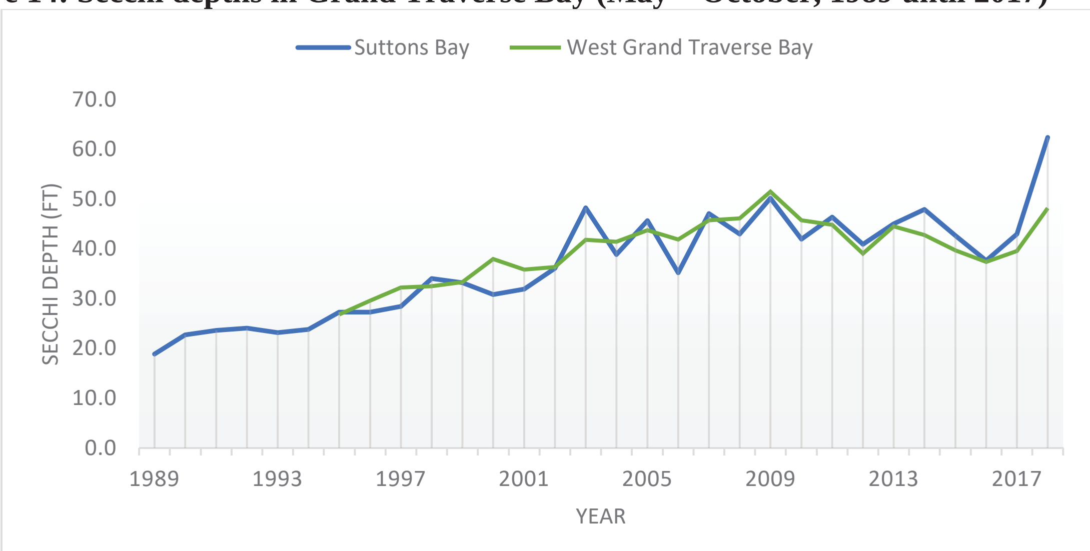
Total phosphorus concentrations are higher at nearshore areas than offshore. The nearshore average from a 1998 study shows 4.6ug/L, while the offshore average was 2.8ug/L. Additionally, there are significant differences between offshore surface and bottom samples in Omena Bay (due to sediment quality and incomplete mixing of Omena Bay with Grand Traverse Bay): Spring 1999- 2ug/L at surface; 64ug/L at 80ft (GLEC 2000). As with nitrogen, the highest concentrations of total phosphorus are found at stormwater outfalls, see Chapter 5.4 - A Note About Stormwater for more information.

Secchi Disk

Transparency and secchi disk readings vary throughout year, with typically greater readings in Spring. Generally, secchi disk readings have increased over the past 40 years in Grand Traverse Bay (GLEC 2000). The EPA's NARS-NCCA study classifies Lake Michigan waters as "good" if secchi depth levels are more than 6.7 meters (23 ft) (Table 18). That threshold level is continually exceeded in Grand Traverse Bay and has only increased in the past 40 years since the introduction of zebra mussels in the late 1980s and a corresponding decrease in plankton community. More information on the introduction of zebra mussels to the Great Lakes is found in Chapter 5.5 Invasive Species. Historic secchi disk readings are: 1957-10.5m (34ft), 1975-7.0m (23ft), 1992-5.7m (19ft), 1999-8.5m (28ft).

Secchi data collected from Inland Seas Education Association's School Ship Program at various locations in the West Arm of Grand Traverse Bay and Suttons Bay clearly illustrates the increasing water clarity after the introduction of zebra mussels in the 1980s (Figure 14).

Figure 14: Secchi depths in Grand Traverse Bay (May – October, 1989 until 2017)*



Sediment

Sediment data is available from various historical reports complied for Grand Traverse Bay. In general, sediment quality is good - typically coarse sand with numerous areas of cobble and gravel. At depths greater than 100 feet the bottom of Grand Traverse Bay is silt and clay. There are increases in silt and organic detritus along nearshore bottom, with isolated areas that are relatively rich in inorganic matter (i.e., Omena Bay) (GLEC 2000).

Seiche events, which are large scale periodic movements of water, can re-suspend sediments in deeper portions of the bay. If carried into the water column, they can release contaminants deposited decades ago. However, sediment does not contribute significant concentrations of nutrients to the water column as most of the phosphorus in the sediment is organically bound. Sediment testing was also conducted at various locations in Grand Traverse Bay in 2009 for nitrogen and phosphorus in conjunction with a macrophyte bed survey (TWC 2010), those results are discussed in the next section.

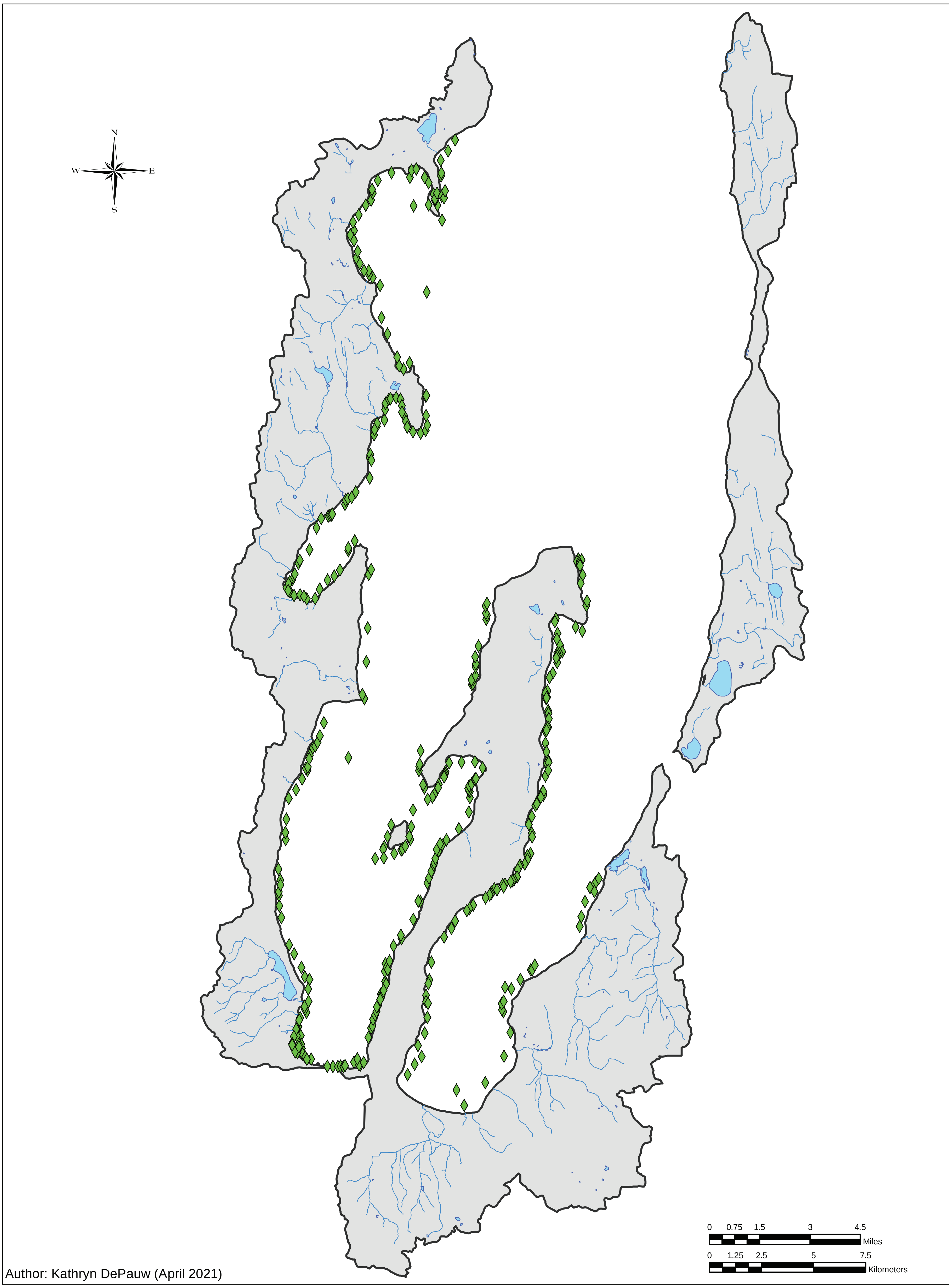
Macrophyte Beds

TWC conducted aquatic plant surveys in Grand Traverse Bay in 1991, 1998, and 2009, and completed a variety of water and sediment testing for nitrogen and phosphorus at locations with and without macrophyte beds and the mouths of several tributaries to the bay (TWC 2010). These surveys showed a six-fold increase in the number of plant beds identified between 1991 and 2009 (1991: 64 beds; 1998: 124 beds; 2009: 402 beds). The vast majority of plants found in the study were chara and milfoil, with some other various forms of pondweed. Virtually no cladophora was found in the entire survey.

Most of the macrophyte beds from the 2009 study were concentrated in embayments, such as Northport and Omena bays, as well as the southern end of west Grand Traverse Bay, where the Boardman River drains (Figure 15). This growth is attributed to increased developed areas and nutrient flushing from stormwater inputs, particularly the amount of phosphorus entering the bay. Nutrient inputs and the amount of water flushing an area were most important determinants for locations of beds.

Sediment and water chemistry analyses were also completed at macrophyte and non-macrophyte bed locations in the bay to determine if there were any differences that could be attributed to excessive bed growth. Results of surface and bottom water sampling at macrophyte beds and non-macrophyte bed areas did not indicate any significant variation in concentrations of nitrogen or phosphorus (TWC 2010). Sediment analyses were done for ammonia, total Kjeldahl nitrogen (TKN), and TP. Average ammonia concentrations at macrophyte sites was 17.77 mg/kg, whereas non-macrophyte bed sites averaged just 1.09 mg/kg. Additionally, average TKN concentrations at macrophyte sites was 336 mg/kg, whereas non-macrophyte bed sites averaged just 95.7 mg/kg. This suggests that both sediment ammonia and TKN concentrations are associated with some macrophyte bed areas within East and West Grand Traverse Bay (TWC 2010). Average concentrations of TP within sediments at macrophyte bed locations was 0.65 mg/kg, and 0.10 mg/kg at locations lacking rooted aquatic or "macrophyte" vegetation. Comparing average TP concentrations at macrophyte and non-macrophyte bed areas suggests that macrophyte bed locations are indeed associated with locations with higher concentrations of TP in sediment (TWC 2010).

Some scientists categorize inland freshwater lakes production or "trophic" levels according to total phosphorus (TP) concentrations in sediments (Mueller and Helsel 1999). Lakes with TP concentrations below 0.2 mg/kg are classified as oligotrophic; between 0.2 and 0.4 mg/kg as mesotrophic; and over 0.4 mg/kg as indicative of eutrophic lakes (low quality, and high biologic productivity). Results of Grand Traverse Bay sediment sampling for TP at macrophyte bed survey areas indicated concentrations above this eutrophic threshold at 21 sites (52.5%, all in West Bay), mesotrophic conditions at four sites (10%), and oligotrophic conditions at15 sites (37.5%). Results of sediment sampling at non-macrophyte bed areas indicated no TP concentrations above the eutrophic threshold, two within the mesotrophic threshold, and the remaining eight samples in the oligotrophic range (TWC 2010).



Layer Credits: The Watershed Center Grand Traverse Bay (2009)

Legend

- Coastal Subwatershed
- Lakes & Ponds
- Rivers & Streams
- Macrophyte Bed Site

GRAND TRAVERSE BAY COASTAL WATERSHED

FIGURE 15: MACROPHYTE BED LOCATION - 2009 STUDY

Freeze/Thaw Data for Grand Traverse Bay

Freeze/thaw data is available for Grand Traverse Bay since 1851. From this dataset, the bay is considered frozen when its West Arm freezes to Power Island for at least 24 hours. Back in the early to mid-1900s Grand Traverse Bay froze 80-90% of the time. Around 1990, freeze years dropped to 20-30%. In the last 20 years the bay has only frozen over 6 times, staying frozen an average of 43 days.

Endangered Species

The bay's watershed hosts five federally listed endangered or threatened species (+1 candidate): Bald Eagle, Kirtland's Warbler, Piping Plover, Pitcher's Thistle, Michigan Monkey Flower, Eastern Massasauga Rattlesnake (State of Bay 2000).

Minerals

As stated previously, EGLE identified increasing trends in magnesium, sodium, chloride and sulfate at stations within Grand Traverse Bay with their trend monitoring (EGLE November 2019). While these chemicals are required nutrients for plant growth, elevated levels can be indicative of disturbance, such as the increasing development of Grand Traverse Bay. Regardless, all values are typical of high-quality freshwater lakes. Average values for various minerals are as follows:

- Sodium – 6.4 mg/L
- Chloride – 11 mg/L (Range 9 – 48 mg/L)
- Hardness – 130 mg/L (Range 121 – 146 mg/L)
- Calcium – 33.8 mg/L (Range 30.2 – 38.7 mg/L)
- Magnesium – 11.2 mg/L (Range 10.4 – 13 mg/L)
- Conductivity – 279 uS/cm (Range 70 – 773 uS/cm)
- Alkalinity – 98.5 mg/L $CaCO_3$ (Range 86 – 123 mg/L)

Heavy Metals

Trace metals were collected from all four trend monitoring stations in Grand Traverse Bay in the months of October and November only. There were no water quality standard exceedances for metals in the 2012-2013 Integrated Report cycle (EGLE November 2019). Other historical reports for Grand Traverse Bay confirm Cadmium, Chromium, Lead, Zinc, and Nickel are all relatively low and consistent with other lakes. Copper decreased by 60% from 1975 (1ug/L) to 1998 (0.4ug/L). Mercury levels were low as well (0.26ng/L), but slightly higher at the south end of West Arm and the north end of East Arm, likely because of loadings from Boardman and Elk rivers (State of Bay 2000).

Silica

Silica occurs naturally in the water; it is an essential element used by diatoms (planktonic organisms) for cell structure. Historical silica studies found it in colloidal and suspended matter or in biomass (diatoms), with a dramatic decline in past 40yrs (GLEC 2000):

- 1957 - 3.6mg/L
- 1976 - 0.423mg/L
- 1992 - 0.410mg/L
- 1998/9 - 1.06mg/L.

Phytoplankton and Zooplankton

Historical studies of phytoplankton in Grand Traverse Bay indicate that the greatest abundance is observed in the spring. A total of 21 total species were observed in a 1957 study with dominant species typical of oligotrophic systems (summarized in GLEC 2000). Studies from the 1990s found that the West Arm of Grand Traverse Bay has more organisms/liter than East Arm in late summer, which *suggests* more nutrients available in West Arm and a higher level of eutrophication. However, overall samples taken have been typical of oligotrophic systems and there is no suggestion of eutrophication (GLEC 2000).

Zooplankton assemblages are similar to those typically found in Lake Michigan and Great Lakes (GLEC 2000).

Phosphorus Dynamics in Grand Traverse Bay

Nutrient dynamics and the aquatic food web in the Great Lakes have changed dramatically since the invasion and establishment of dreissenid mussels. The nearshore phosphorous shunt, a conceptual model first described by Hecky et al. (2004) suggests that phosphorous remains high in nearshore areas of the Great Lakes due to the mussels' ability to trap and recycle phosphorous. Further, Bootsma et al. (2008) concluded that dreissenid mussels have altered Lake Michigan nutrient dynamics as mussel-mediated recycling of phosphorous acts as a significant source of dissolved phosphorous in the nearshore area. Recent modelling simulations also revealed that mussels reduced particulate phosphorous in the offshore region, which could affect offshore fish abundance.

The nearshore phosphorous shunt is a complex issue that highlights how invasive mussels in Lake Michigan can concentrate phosphorous in the nearshore zones and cause lake-wide ecosystem changes. Elevated concentrations of phosphorous in the nearshore are of Grand Traverse Bay suggests that phosphorous from tributaries may accumulate in nearshore waters due to a low flushing rate as well as mussel metabolism (Dr. Harvey Bootsma, personal communication, July 1, 2019). More research is needed to better understand phosphorous dynamics in Grand Traverse Bay.

Nutrient and Sediment Loading

Nitrogen, phosphorus, and sediment loads were calculated for all nine subwatersheds in the Grand Traverse Bay watershed using the EPA's Spreadsheet Tool for Estimating Pollutant Load (STEPL). The STEPL is a model supported by EPA to calculate reductions in nonpoint source pollution that will be achieved as a result of installing Best Management Practices (BMPs) in a watershed. In order to calculate pollutant reductions, the model must first calculate existing pollutant loads before adding in BMPs. The program can be accessed and the latest version downloaded from the EPA's website at: https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl. The model employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various BMPs, taking into consideration annual precipitation, land use, agricultural practices, household septic use, and soil conditions. Common sources of nutrient loading include riparian septic systems, fertilizer use, livestock waste, and stormwater runoff. STEPL's use in calculating pollutant load reductions after BMP installation is discussed in detail in Chapter 8.2 – Best Management Practices.

The model estimates total annual loading to the entire Grand Traverse Bay watershed of 83,219 lbs/year of phosphorus, 547,682 lbs/year of nitrogen, and 12,276 tons/year of sediment (Table 35). Those totals include the two large subwatersheds of the Boardman River and Elk River Chain of Lakes. Totals annual loading rates for only those areas in the Grand Traverse Bay Coastal watershed areas are significantly lower at 25,259 lbs/year of phosphorus, 155,642 lbs/year of nitrogen, and 4,459 tons/year of sediment (Table 35).

As Table 35 reflects, the greater the subwatershed area, the greater the pollutant load it contributes. A different way to look at these results to see which subwatersheds might be impacted more than others is to divide the pollutant load results by the subwatershed area to get a load rate by acres/year. Using that analysis, one can see that smaller subwatersheds of Mitchell, Tobeco, and Yuba Creeks as well as the Old Mission Peninsula have higher loading rates of pollutants per acre and may be more at risk to water quality degradation. Mitchell Creek is experiencing the highest loading rates/acre with 1.98 lb/ac/year of nitrogen, 0.3 lb/ac/year of phosphorus, and 0.05 tons/ac/year of sediment.

Table 35: Pollutant Loading for Phosphorus and Nitrogen by Subwatershed*

Subwatershed	Area (ac.)	N (lb/yr)	P (lb/yr)	Sediment (ton/yr)	N (lb/ac/yr)	P (lb/ac/yr)	Sediment (ton/yr)
Elk River Chain of Lakes	321,664	234,307	35,084	4,835	0.73	0.11	0.02
Boardman River	181,632	157,733	22,877	2,982	0.87	0.13	0.02
West Bay Shoreline	43,520	50,001	8,266	1,489	1.15	0.19	0.03
East Bay Shoreline	24,832	25,473	4,194	727	1.03	0.17	0.03
Old Mission Peninsula	20,032	32,233	5,298	971	1.61	0.26	0.05
Mitchell Creek	10,048	19,885	3,001	476	1.98	0.30	0.05
Tobeco Creek	9,088	13,295	2,147	430	1.46	0.24	0.05
Acme Creek	8,448	6,553	1,130	153	0.78	0.13	0.02
Yuba Creek	5,376	8,202	1,222	213	1.53	0.23	0.04
Total	624,640	547,682	83,219	12,276	0.88	0.13	0.02

**SOURCE: Calculations generated using the STEPL model. Available:* *http://it.tetratech-ffx.com/steplweb*

3.10 Other Considerations: Groundwater

The groundwater system of the Great Lakes Watershed is composed of aquifers and relatively impermeable rocks and sediments called confining units. Groundwater discharge into lakes, streams, and wetlands can greatly impacts flows, water temperatures, and water quality. Groundwater recharge is the process of adding water to the groundwater system. This typically takes place where soils are permeable such as in the land area between streams. Water that makes its way into the groundwater system is stored for a period of time until it reaches discharge areas. A variety of environmental factors, such as soil type, precipitation, and the amount of impervious surface, impact the quantity and rate of groundwater recharge. Urban development often reduces groundwater recharge because impervious surfaces such as paved roads, buildings, and compacted soils reduce the amount of water that infiltrates the ground, which consequently increases surface runoff (USGS 2013).

The largest areas of groundwater recharge in the Grand Traverse Bay watershed occur in the easternmost portion of the ERCOL subwatershed and the mid-section of the Boardman River subwatershed. Recharge rate in these areas can reach up to 15-20 inches per year. In just the Coastal Grand Traverse Bay watershed, the areas with the highest groundwater recharge are the headwaters of Acme Creek and a small area near in Leelanau County near the headwaters of Cedar Lake, where recharge rates are also between 15-20 inches per year (Figure 16).

Groundwater is an important source of hydrologic input throughout the Grand Traverse Bay watershed. It should be valued and managed efficiently not only for its quality but for its quantity as well. It is important to note that most groundwater will eventually become surface water; it only depends on how long it will take. By protecting groundwater quality, surface water quality will also be protected. Additionally, protecting groundwater resources is important due to the vast majority of watershed residents (most everybody except for City of Traverse City residents) using groundwater for their drinking water source. There are some significant groundwater contamination issues within the Grand Traverse Bay watershed related primarily to underground storage tanks that have leaked or poor historical waste disposal practices.

There are a number of other pollutants to groundwater in the Grand Traverse Bay watershed as well. For example, commercial agricultural fertilizers, if applied excessively, also have the potential to leach into the ground and eventually contaminate drinking water wells, as is the case in parts of Old Mission Peninsula in Grand Traverse County. Past fertilization practices on orchards on the peninsula have led to high nitrate levels in groundwater wells, leading some residents to consider pumping water from Traverse City to use for drinking water. Additionally, pesticides and other types of toxic compounds used at agricultural facilities have the potential to be spilled and leach into the ground. Agricultural areas that irrigate their waste and wastewater onto land can introduce excessive nutrients to the ground, mostly in the form of nitrogen. Examples of this type of pollutant include irrigation from milkhouse wastewater and manure lagoons.

Abandoned wells and oil wells are other examples of potential ways pollutants can reach groundwater. When a well is drilled and abandoned, however many years later, and either capped improperly or not at all, it leaves an open conduit to groundwater. Pollutants can either reach groundwater sources down through the drilled well shaft itself or down along the outside of the well shaft. In this same way, existing wells may be potential sources for groundwater pollution. Wellhead protection programs are important where a threat to groundwater exists if there is a pollutant spill, such as oil or gasoline, which can seep down along the sides of a well shaft into the aquifers below.

Other sources of pollutants to groundwater are from leaking septic systems. Places in the Grand Traverse Bay watershed that have a high density of residents utilizing septic systems pose an increased threat to groundwater contamination.

Overall, groundwater is a precious resource, and it must be protected. Sound management decisions must be made to protect groundwater contamination wherever and whenever possible. In Conservation Districts and MSU-Extension offices throughout the State of Michigan, there is a groundwater stewardship resource person to educate the public on these specific issues.

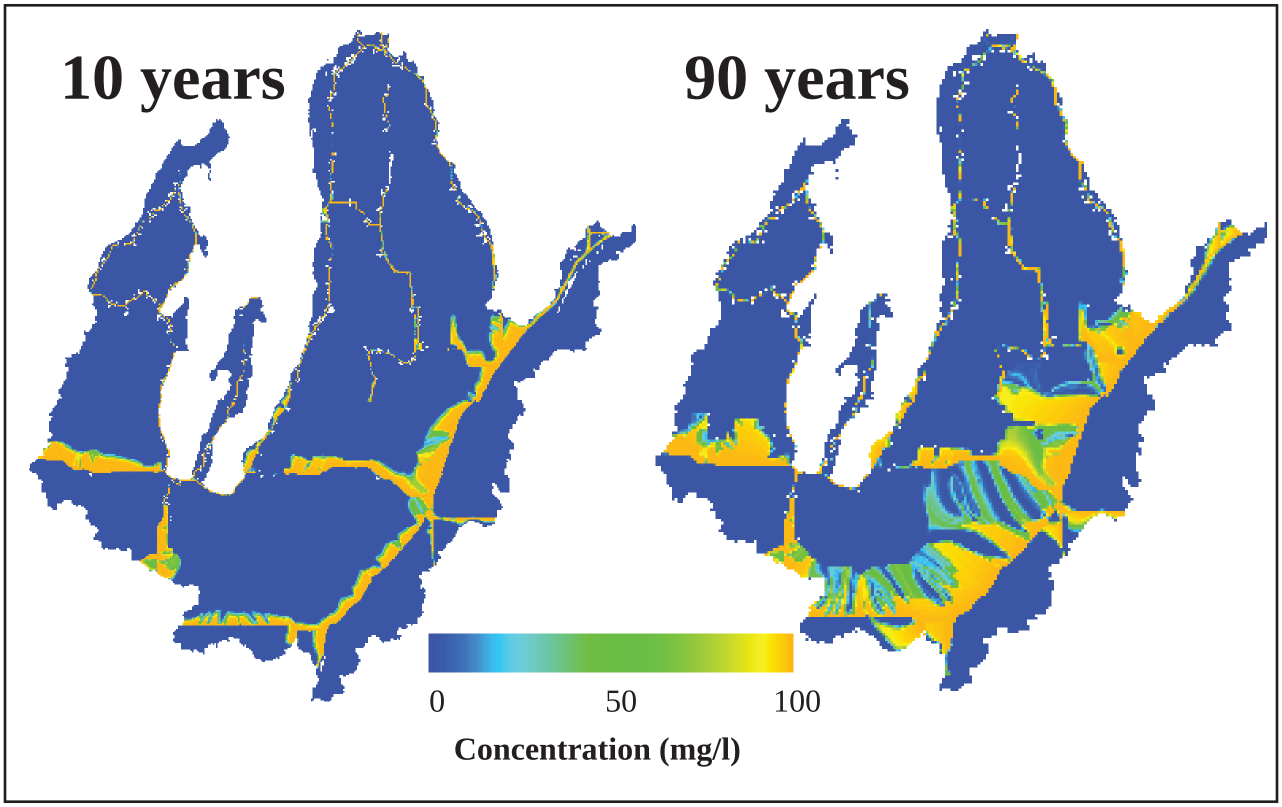
In addition, it is important to manage the quantity of groundwater supplying the Grand Traverse Bay watershed. Many businesses, agricultural operations, and local residents draw water from lakes, rivers, and groundwater for a variety of purposes. The issue of drawing groundwater from underground aquifers is contentious in parts of the state. Groundwater quantity and its withdrawal from the watershed is an issue that goes beyond the scope of the Grand Traverse Bay Watershed Protection Plan. However, it is an issue that should and will be debated in the near future by watershed residents, local governments, local and national businesses, watershed groups, and state and federal agencies. Combined, these groups must come to a general consensus and determine guidelines for proper groundwater management.

Recommended actions to reduce the risks to groundwater contamination are found in Sections 7.3 and 7.4.

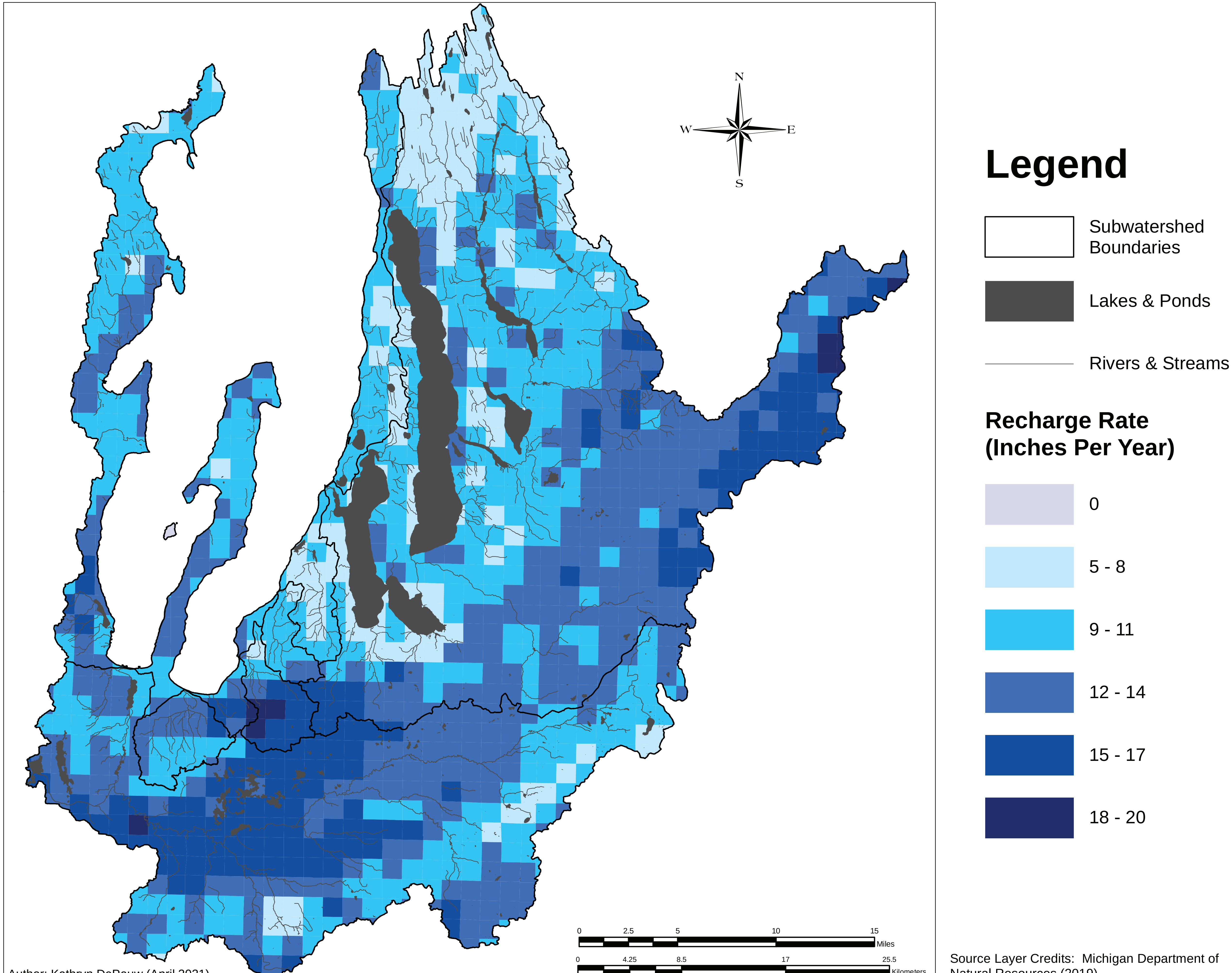
Groundwater Study by MSU/USGS

Data from a study by MSU and USGS to model the impacts of land use changes on the region's water quality indicate that modeled hydraulic heads, which denote where the groundwater table is, in the watershed vary from 177 meters above sea level along the Grand Traverse Bay to more than 350 meters above sea level in the eastern high topography area (Pijanowski et al. 2001, Boutt et al. 2001). The Boardman River southeast of Traverse City is noted as a dominant groundwater discharge area due to the significant slopes of the water table in the region (Boutt et al. 2001).

The study also demonstrates that groundwater processes have a major role in the hydrology within the watershed and that there is a considerable legacy of land use on surface water quality. For example, the model demonstrates that "solutes that are applied to portions of the watershed will likely take over 50 years to move through the shallow groundwater, thus current human activities will have an impact on water quality for several decades to come," (State of the Bay 2000). Additionally, research from MSU show that modeled data from road salt application (using chlorides as tracers) can have a considerable temporal impact across the Grand Traverse Bay watershed; even after a fifty-year simulation, chloride only travels 40-50 miles. In some cases, the temporal legacy of land use can exceed 100 years (Pijanowski et al. 2001, Boutt et al. 2001).



Chloride concentrations across the watershed based on halite application to roads and dispersed through the groundwater system. These maps represent a computer model simulation of groundwater chloride concentration for a scenario where 100 mg/L of chloride (through road salt) is applied to the major highways across the Grand Traverse Bay region at a constant rate over the 90 year simulation period.
Figure courtesy of David Hyndman, Michigan State University



GRAND TRAVERSE BAY WATERSHED

FIGURE 16: GROUNDWATER RECHARGE RATES

3.11 Economy, Tourism, and Recreation

Traditional uses of watershed resources have included agriculture, tourism and recreation. Cherries, apples, and grapes dominate agricultural fruit production in the Traverse Bay region and are harvested for the global market. Northwestern Michigan, also known as the Cherry Capital of the World, produces half the state's tart cherry crop and more than 80% of its sweet cherries.

National Cherry Festival

The National Cherry Festival in Traverse City attracts more than 500,000 participants each year who celebrate the harvest and revel with festivities over an eight-day period each summer. Other tourism and recreational activities include: boating, biking, swimming, golfing, fishing, camping, and skiing. Attracted to the natural beauty of Grand Traverse Bay and its surroundings, tourists from around the world come to enjoy the pleasures of the region, away from the busy rush of more urban areas. These recreational opportunities can be quite profitable for businesses like marinas, rental shops (for activities such as water recreation, biking, and skiing), ski resorts, golf resorts, hotels, restaurants, and bed and breakfasts.

The area also supports a thriving regional business community representing many economic sectors including banking, healthcare, retail, light industry and others.

While many tourists come to the Grand Traverse Bay watershed to recreate, there are also year-round residents who benefit from the many recreational opportunities the bay and watershed offer. A public telephone survey conducted for TWC by Northwestern Michigan College's Research Services in 2007 revealed that more than 3/4 of residents in the region use water for recreational activities (77%), with Grand Traverse Bay as their most frequently used water body (TWC 2007). The most abundant activities reported were swimming, boating, fishing, and canoeing/kayaking.

The survey found that while more people thought the water quality at that time in the Grand Traverse Bay had worsened rather than improved, the bulk of respondents indicated they felt that way due to low water levels the region was experiencing at that time, as well as due to *E.coli* contamination at beaches.

3.12 Local Ordinances Impacting Water Quality

In addition to state and federal laws and regulations that impact water quality, local governmental entities may adopt ordinances and policies that directly or indirectly impact water quality. Along the Coastal Grand Traverse Bay watershed, there are three counties, 12 townships, one city, and three villages. Each of these governmental entities has the authority to regulate a variety of activities that may improve or degrade water quality within their respective jurisdictions. In particular, local governments regulate land use, construction activities, runoff, and wastewater discharges through a combination of planning, zoning, soil erosion, stormwater, and septic ordinances and policies.

This section first provides a description of the types of local ordinances that contribute to water quality protection within the Coastal Grand Traverse Bay watershed, then considers the contents of those ordinances for the municipalities within the watershed. This information has also been previously been provided in-depth for the Boardman River and Elk River Chain of Lakes watersheds in their respective management plans.

Municipal Planning and Zoning

Land use activities and decisions have great potential to affect local water quality. Local land use is regulated through master plans and zoning ordinances. Overall, master plans and zoning ordinances are enacted to protect the use of a property and ensure the public's safety, health, and welfare.

A master plan is a comprehensive set of a community's long-term goals and policies that are intended to guide development decisions. The master plan guides zoning decisions (including special land use and site plan reviews); capital improvement programs; special programs such as economic development, parks, trails, and gateway improvements; and leveraging financial support for community efforts. Zoning is a tool for making master plans a reality. Zoning is regulatory and provides specific enforceable standards. Overall, zoning ordinances are enacted to protect the use of a property and ensure the public's safety, health, and welfare. Zoning ordinances regulate the permitted uses of the land, including, for example, maximum impervious surface coverage, lot size, and setbacks from neighbors, roads, and water bodies. How communities make and implement these land use provisions has a direct impact on the community's water resources.

Since protecting water quality requires consideration of what happens on land, master plans and zoning ordinances are important watershed management tools. Watershed planning is best conducted at the subwatershed scale, especially in a watershed the size of the Grand Traverse Bay watershed. Planners must recognize that stream quality is directly related to land use, and that the amount of impervious surfaces is particularly important.

> Findings reveal that stream degradation consistently occurs when impervious surface levels in a watershed reach between 10-20% (CWP 1994) due to increased outputs of stormwater (discussed later in Section 5.4).
>
> Land use planning techniques should be applied that preserve sensitive areas, redirect development to those areas that can support it, maintain or reduce impervious surface cover, and reduce or eliminate nonpoint sources of pollution.

Master Plans

Michigan law requires local planning commissions to adopt a master plan to guide development and public capital improvements within the jurisdiction. In addition, the planning commission is obligated to update the master plan every five years. The master plan may be developed at a county level and adopted by individual townships in the county or may be developed on a township-by-township basis.

A master plan is intended to help ensure that development is coordinated, harmonious, efficient, and economical, considering the character of the community and the suitability of particular uses. In addition, the master plan is intended to ensure that future development will be in accordance with the community's present and future needs and will promote public health, safety, morals, order, convenience, prosperity, and general welfare. It is through the master plan that a community's goals and vision are established.

The master plan, in turn, guides zoning decisions as well as community capital improvement projects. Municipalities with a master plan must adopt an annual capital improvement plan for all agencies and departments within the municipality, which guides public structures and improvements. The capital improvement plan identifies the structures and improvements needed or desired, along with their relative priority, in the ensuing six-year period. In addition, public entities may not undertake a new street, park, playground, open space, public building, or other structure in a community with a master plan without first obtaining planning commission approval.

Through the master plan and capital improvement plan process, a community may identify and prioritize water quality improvement and protection goals. For example, a master plan may identify protecting water quality as a community goal, and then identify specific ordinances and infrastructure projects to achieve that goal. A master plan is adopted and amended through a public process that includes coordination with other municipalities, open meetings, and public input. The capital improvement plan is also adopted in a public forum. As a result, the process of adopting and amending a community's master plan and capital improvement plan offer an opportunity for stakeholders to identify, prioritize, and plan for water quality protection measures in the community in a way that is consistent with watershed management goals.

All of the townships, villages, and municipalities in the Grand Traverse Bay Coastal watershed have adopted their own master plan. Table 36 identifies these townships and shows when each of their master plans was last updated.

Table 36: Coastal Bay Watershed Jurisdictions with Master Plans

Unit of government	Master Plan	Last Updated
Antrim County		
Banks Twp	Yes	2013 (in process of update)
Milton Twp	Yes	2015
Torch Lake Twp	Yes	2012 (Land Use Plan)
Village of Elk Rapids and Elk Rapids Township	Yes	2018 (Collaborative Master Plan)
Grand Traverse County		
Acme Twp	Yes	2019
East Bay Twp	Yes	2015
Garfield Twp	Yes	2018
Peninsula Twp	Yes	2011
City of Traverse City	Yes	2017
Leelanau County		
Bingham Twp	Yes	2015
Elmwood Twp	Yes	2018
Leelanau Twp	Yes	2010
Suttons Bay Twp and Village of Suttons Bay	Yes	2011 (Suttons Bay Community Plan)
Village of Northport	Yes	2018

Source: Online research via local governments' websites, August 2019

Zoning Ordinances

A zoning ordinance is adopted to establish the permissible uses of property within the municipality. As it relates to water quality, a zoning ordinance may impose vegetative buffer zones along bodies of water, require greenbelt areas, protect the integrity of soil by having filtered views along stream corridors (protect banks from erosion), protect wetlands, limit impervious areas, and even address stormwater management. In other words, zoning can be used effectively for managing land uses in a way that is compatible with watershed management goals.

Zoning's effectiveness depends on many factors, particularly the restrictions in the language, enforcement, and public support. Zoning is a sensitive issue for some units of government within the region and there are many challenges to implementing and enforcing a strong ordinance (community support, fiscal, legal, etc.). Many people believe local or state laws protect sensitive areas, only to find otherwise when development is proposed. Some benefits of zoning include: increased local control/autonomy over land use decision-making; communicating clear expectations with developers based on community needs; and an opportunity for the residents of the area to design the type of community they want to live in and be one that respects their unique cultural, historic, and natural resource values.

A wide variety of zoning and planning techniques can be used to manage land use and impervious cover in subwatersheds. Some of these techniques include: watershed-based zoning, overlay zoning, impervious overlay zoning, floating zones, incentive zoning, performance zoning, urban growth boundaries, large lot zoning, infill/community redevelopment, transfer of development rights (TDRs), and limiting infrastructure extensions. Local officials face hard choices when deciding which land use planning techniques are the most appropriate to modify current zoning. Table 37, from the Center for Watershed Protection's Rapid Watershed Planning Handbook, provides further details on land use planning techniques and their utility for watershed protection (CWP 1998).

Table 37: Land Use Planning Techniques

Land Use Planning Technique	Description	Utility as a Watershed Protection Tool
Watershed-Based Zoning	Watershed and subwatershed boundaries are in the foundation for land use planning.	Can be used to protect receiving water quality on the subwatershed scale by relocating development out of particular subwatersheds.
Overlay Zoning	Superimposes additional regulations for specific development criteria within specific mapped districts.	Can require development restrictions or allow alternative site design techniques in specific areas.
Impervious Overlay Zoning	Specific overlay zoning that limits total impervious cover within mapped districts.	Can be used to protect receiving water quality at both the subwatershed and site level.
Floating Zones	Applies a special zoning district without identifying the exact location until land owner specifically requests the zone.	May be used to obtain proffers or other watershed protective measures that accompany specific land uses within the district.
Incentive Zoning	Applies bonuses or incentives to encourage creation of amenities or environmental protection.	Can be used to encourage development within a particular subwatershed or to obtain open space in exchange for a density bonus at the site level.
Performance Zoning	Specifies a performance requirement that accompanies a zoning district.	Can be used to require additional levels of performance within a subwatershed or at the site level.
Urban Growth Boundaries	Establishes a dividing line that defines where a growth limit is to occur and where agricultural or rural land is to be preserved.	Can be used in conjunction with natural watershed or subwatershed boundaries to protect specific water bodies.
Large Lot Zoning	Zones land at very low densities.	May be used to decrease impervious cover at the site or subwatershed level, but may have an adverse impact on regional or watershed imperviousness.
Infill/ Community Redevelopment	Encourage new development and redevelopment within existing developed areas.	May be used in conjunction with watershed based zoning or other zoning tools to restrict development in sensitive areas and foster development in areas with existing infrastructure.
Transfer of Development Rights (TDRs)	Transfers potential development from a designated "sending area" to a designated "receiving area".	May be used in conjunction with watershed based zoning to restrict development in sensitive areas and encourage development in areas capable of accommodating increase densities.
Limiting Infrastructure Extensions	A conscious decision is made to limit or deny extending infrastructure (such as public sewer, water, or roads) to designated areas to avoid increased development in these areas.	May be used as a temporary method to control growth in a targeted watershed or subwatershed. Usually delays development until the economic or political climate changes.

Table from Center for Watershed Protection's Rapid Watershed Planning Handbook – page 2.4-5

Zoning may be implemented at the township, city, or village level of local government, or it may be done at the county level. In the Grand Traverse Bay Coastal watershed all municipalities have their own zoning ordinances and most have their own master plans. However, a few communities have chosen to collaboratively develop and adopt maters plans with their neighboring communities.

No two zoning ordinances are the same; each is inherently unique because each community determines the exact combination of land uses (*e.g*., commercial, residential, open space), density, setbacks, and other tools to implement their desired development goals. In addition, zoning ordinances are amended regularly. In 2018-2019, TWC staff reviewed current zoning ordinances for all the local governments in the Grand Traverse Bay Coastal watershed (16 total) looking for water quality and natural resource protection provisions (Table 38). Information was gathered pertaining to the following protections:

- Special districts for environmentally sensitive areas (lake district, overlays, Natural River district, etc.)
- Special permitting requirements for environmentally sensitive sites
- Riparian buffer/vegetated strip requirements
- Water's edge setback
- Stormwater management/control ordinance
- Special wetland provisions
- Other water quality protection provisions
- Septic ordinance (Mandatory Pumping, Time of Transfer, Point of Sale)

On an encouraging note, all the communities in the Coastal Grand Traverse Bay watershed have established water's edge setbacks which mandate that buildings and/or structures be set back certain linear distances from the water's edge. However, some communities only have these provisions for certain types of waterbodies such as Grand Traverse Bay, whereas they would be ideal for all waterbodies in the jurisdiction including streams and rivers. Table 38 shows which municipalities have setbacks for Grand Traverse Bay and those that have setbacks for other types of water bodies.

Also encouraging is that a majority of the communities (10 out of 16) have provisions for riparian buffer or vegetated strip requirements (Table 38). Additionally, most of the more urban townships have stormwater requirements of some sort (Acme, East Bay, Garfield Townships and the City of Traverse City). Notably lacking in all communities are provisions for wetland protection (such as wetland setbacks or wetland regulations) and septic system requirements (mandatory pumping, required inspections, etc.). Furthermore, not many townships are exercising their right to utilize special districts and overlay zoning to protect sensitive areas and water features. These are important tools for protecting water quality which could be strengthened in most jurisdictions in the Grand Traverse Bay watershed.

Table 38: Special Environmental Regulations in Coastal Grand Traverse Bay Watershed Jurisdictions

Township or Municipality	Special district for environmentally sensitive area	Special permitting requirement for environmentally sensitive sites	Riparian buffer or vegetated strip requirements	Water's edge setback *B=Bay O=Other*	Stormwater management/ control ordinance	Special wetland provisions	Other water quality protection provisions	Septic Ordinance (mandatory pumping, time of transfer, point of sale)	Coal tar sealcoat ban ordinance
Bingham Township	NO	NO	YES	B & O	NO	NO	NO	NO	NO
Elmwood Township	NO	NO	Minimal *(only in clustered development)*	B & O	NO	NO	NO	NO	NO
Leelanau Township	NO	YES	NO	B & O	NO	NO	NO	NO	NO
Suttons Bay Township	NO	NO	Minimal *(only in open space residential development or cluster housing)*	B & O	NO	NO	NO	NO	NO
Village of Suttons Bay	NO	NO	YES	B	NO	YES	*Steep slope vegetation and replanting requirements (ZO Sec. 2-6)*	NO	NO
Village of Northport	YES	NO	NO	B & O	NO	NO	NO	NO	NO
Acme Township	NO	YES	YES	B & O	YES	YES *(on parcels subject to stormwater ordinance)*	*Limitations on types of developments within a floodplain*	NO	NO
East Bay Township	YES	YES	YES	B & O	YES	NO	NO	NO	NO

Township or Municipality	Special district for environmentally sensitive area	Special permitting requirement for environmentally sensitive sites	Riparian buffer or vegetated strip requirements	Water's edge setback	Stormwater management/ control ordinance	Special wetland provisions	Other water quality protection provisions	Septic Ordinance (mandatory pumping, time of transfer, point of sale)	Coal tar sealcoat ban ordinance
Garfield Township	NO	NO	YES	O (not on GTBay shore)	YES	YES *(wetland setbacks)*	NO	NO	NO
Peninsula Township	NO	NO	YES	B & O	YES	YES *(wetland setbacks)*	*Floodplain restrictions and setbacks (incl. Great Lake floodplains)*	NO	NO
City of Traverse City	NO	NO	NO	B & O	YES	NO	*Prohibition on open geothermal systems; minimum tree canopy requirements*	NO	YES
Banks Township	NO	NO	YES	B & O	NO	NO	NO	NO	NO
Elk Rapids Township	YES	YES	YES	B & O	NO	*Wetland setback and buffer requirements*	NO	NO	NO
Milton Township	YES	YES	YES	B & O	NO	NO	NO	YES	NO
Torch Township	NO	NO	NO	B & O	NO	NO	NO	NO	NO
Village of Elk Rapids	YES	YES	YES	B & O	NO	NO	NO	YES	YES

Source: Online research via local governments' websites, February 2018 – March 2020

Soil Erosion Programs

Earth change activities such as digging, land clearing, and construction-related activities have a significant potential to cause soil erosion that may pollute water bodies. EGLE administers Part 91 of the Natural Resources and Environmental Protection Act, known as the Soil Erosion and Sedimentation Control (SESC) Act (MCL 324.9101 *et seq*). The primary intent of Part 91 is to protect waters and adjacent properties by minimizing soil erosion and controlling off-site sedimentation during construction or earth change activities. Counties are mandated by statute to administer and enforce Part 91, while some townships, cities, and villages elect to enforce Part 91 themselves. EGLE maintains an oversight role of the SESC programs in Grand Traverse, Leelanau, and Antrim counties as well as the City of Traverse City (who administers their own SESC program) to ensure compliance with Part 91 requirements. Each county or local governmental unit must require that proper measures are taken to protect soil and water when earth changes are within 500 feet of a lake or stream or disturb one or more acres of land, which are the state's minimum criteria. Local units of government have the ability to add additional requirements for needing to obtain a SESC permit beyond the state minimum criteria.

In Grand Traverse County, soil erosion regulations are administered by the Soil Erosion and Sedimentation Control Department. Grand Traverse County adopted a Soil Erosion and Sedimentation Control Ordinance (Grand Traverse County 2018). Under this ordinance, a permit is required for earth changes that disturb one or more acres; are within 500 feet of a lake, stream, wetland, and/or County Drain; on steep slopes (>20%); or on clay soils. The Soil Erosion Control Program at Antrim County Conservation District is responsible for administering and enforcing Part 91 through the Antrim County Soil Erosion Sedimentation and Stormwater Runoff Controls Ordinance (2008). Under Antrim Conservation District's program, a permit is required for earth changes within 500 feet of a lake or stream or which disturbs one or more acres of land. Leelanau County Conservation District administers the Leelanau County Stormwater Ordinance (2014), which incorporates Part 91 standards. Under this ordinance, a permit is required for earth changes within 500 feet of a lake or stream; on one or more acres of land; within 100 feet of a regulated wetland; involving construction of a driveway with a slope of 10% of greater; and on all commercial projects.

The City of Traverse City is a Municipal Enforcing Agency that has elected to enforce Part 91. The City of Traverse City Engineering Department's Ground-Water Protection and Storm-Water Runoff Control Ordinance (2019) requires a permit for earth changes within 500 feet of a lake, stream or regulated wetland; on one or more acres of land; and on slopes of 10% or more.

Stormwater Ordinances

Stormwater runoff from developed sites is a significant source of pollutants to the Coastal Grand Traverse Bay watershed. Stormwater runoff may be regulated by both state and local governments within the United States, depending on the type of runoff and locality. From a regulatory perspective, stormwater regulations or ordinances may be distinguishable from soil erosion programs addressed in the section above. Soil erosion regulatory programs generally address soil erosion only during earth changes (activities that involve changing the topography of land which are typically construction-related activities). Stormwater regulatory programs generally address runoff from a site after construction and earth change activities are completed.

From a practical perspective, there is obviously overlap between these regimes, which results in some complexity and confusion.

Unless a community is designated as a Phase II MS4 community under the Clean Water Act or a property falls under the regulation of the Industrial Stormwater Program, EGLE has a limited role overseeing stormwater regulations. Point-source discharges to a stream, river, lake or wetland are regulated under the federal Clean Water Act and Part 31 of the Natural Resources and Environmental Protection Act (MCL 324.3101 *et seq*). Point-source discharges are generally required to obtain a National Pollutant Discharge Elimination System (NPDES) permit from EGLE. In Phase II MS4 communities, certain operators are required to obtain NPDES permits and develop stormwater management programs. However, municipal stormwater systems within the Coastal Grand Traverse Bay watershed are not currently classified as Phase II MS4 communities and, therefore, are not required to obtain NPDES permits for stormwater discharges. In many communities within the Coastal Grand Traverse Bay watershed, stormwater has little or no treatment before it discharges into lakes, rivers, streams and wetlands.

Several municipalities within the Coastal Grand Traverse Bay watershed have adopted ordinances to address stormwater runoff from property within their jurisdiction. These ordinances generally restrict the quantity of stormwater that may leave a site during a particularly sized storm event. These ordinances typically apply to new developments and to existing developments that undertake site changes.

As with zoning ordinances, stormwater ordinances are generally unique. In Grand Traverse County, however, there was previously an effort in 2007 to consolidate the regulation of both stormwater and soil erosion through a single ordinance administered by the County. However, since 2012, Grand Traverse County no longer regulates stormwater as part of the soil erosion ordinance. Some townships in Grand Traverse County adopted the 2007 stormwater ordinance, which was originally administered by the County.

Well and Septic System Regulations

Many residents within the Coastal Grand Traverse Bay watershed rely on private wells to supply their water and private onsite wastewater systems (septic systems) to manage their wastewater. Statewide, about 30 percent of homes and businesses manage their wastewater through private septic systems, and more than half of new single-family homes are built with septic systems. When wells are improperly sited or inadequately constructed or maintained, they create risk for groundwater contamination (*e.g.*, broken well caps, abandoned wells, nearby contamination sources). Further, improper sites or inadequate construction or maintenance of septic systems may result in untreated wastewater discharges that may adversely affect local water quality. See Section 5.5 for further discussion about water quality impacts of septic systems. The placement and construction of wells and septic systems are regulated primarily by county or district health departments, with oversight and guidance from EGLE. State law does not require post-construction inspections of private wells or septic systems. For over a decade there has been dialogue calling for a state-wide inspection standard for private well and septic systems, but that has not yet come to fruition.

Some communities in Michigan have adopted and implemented onsite wastewater system ordinances in the absence of a uniform statewide standard that addresses onsite wastewater system management. The most common types of regulatory tools in the state to address such gaps in protection are Point-of-Sale (POS) and Time-of-Transfer (TOT) provisions that mandate inspection and pumping before property sales or transfers. Although these particular tools do not identify all failing systems, they can serve as an effective regulatory and educational tool to protect homebuyers, public health, and surface and ground water resources. Several communities within the Coastal Grand Traverse Bay watershed have adopted TOT ordinances, including Long Lake Township (2008), Milton Township (2012), and the Village of Elk Rapids (2018).

A large portion of the Grand Traverse County population is served by municipal water and wastewater treatment rather than on-site disposal. Blair, East Bay, and Garfield townships are part of a master sewer agreement with the City of Traverse City. The Villages of Northport, Suttons Bay, and Elk Rapids are served by municipal water and wastewater treatment rather than onsite disposal. In Grand Traverse County, the Environmental Health division of the Health Department regulates wells and septic systems through the Environmental Health Regulations (Grand Traverse County Health Department 1990). In Leelanau County, the Benzie-Leelanau Health Department regulates wells and septic systems through the Environmental Health Regulations for Leelanau County Health Department (1989). The Health Department of Northwest Michigan provides well and septic system regulations in Antrim, Charlevoix, Emmet and Otsego counties through the District Sanitary Code.

Regional Planning Efforts

In an effort to coordinate development and address regional inconsistencies, there have been several regional planning efforts in the Coastal Grand Traverse Bay watershed that bear mention because of their potential to further watershed management goals.

New Designs for Growth

In 1992, the Northwest Michigan Council of Governments, now known as Networks Northwest, with support from the Traverse City Area Chamber of Commerce, developed an initiative called New Designs for Growth (NDFG). This was a collaboration among community volunteers, planning and design professionals, developers, and governmental representatives. NDFG promotes planning and development best practices that accommodate growth while maintaining quality of life and protecting the high-quality resources in northwest lower Michigan. As part of this program, NDFG created a Guidebook that includes examples of smart growth development practices that protect valuable natural resources while promoting economic growth and prosperity (NDFG 2008). The guidebooks are used by citizens, developers, and community leaders to better understand local land use and regulations and to more effectively incorporate smart growth principles into local policies and development projects.

The Grand Vision

In 2008, a diverse group of stakeholders came together to complete a regional land use and transportation study for the six-county region of Antrim, Benzie, Grand Traverse, Kalkaska, Leelanau, and Wexford counties. The scope expanded and became the broader Grand Vision, a citizen-led vision for the future of land use, transportation, economic development, and environmental stewardship. Based on three years of community engagement, in which over 15,000 citizens participated, the Grand Vision is built upon and sets out a framework for regional collaboration centered on six guiding principles (Grand Vision Coordinating Committee 2009):

- **Transportation**. A regional multimodal transportation system that supports energy conservation
- **Energy**. Sustainable energy uses in construction, transportation, and economic development
- **Natural Resources**. Protected and preserved water, forests, natural and scenic areas
- **Growth and Investment**. Unique and vibrant communities that strengthen the local economy
- **Food and Farming**. Local farms and regional food systems as a viable part of local communities
- **Housing**. A diverse mix of regional housing choices with affordable option

Participating communities have formed issue networks and have been leveraging resources to implement programs and projects identified through the Grand Vision process. The Boardman River Watershed Prosperity Plan embraces the principles of the Grand Vision, and is one of the regional cooperative efforts to advance the goals of that collaboration.

Tough Choices

Communities face tough choices when deciding what, if any, zoning regulations they want to put in place. It is easy to see from master plans that most communities have good intentions when it comes to protecting natural resources. The natural resources of this area are why most people choose to live in the Grand Traverse Region. However, townships and municipalities often lack the knowledge on how to draft and enact effective, yet enforceable, zoning requirements. The validity or necessity of zoning provisions, particularly those that are more restrictive to how and where development happens, are often challenged by developers and property owners. Communities often face the argument of property rights vs. the public good, with local governments trying to show and/or prove that a certain ordinance is critical to protect water quality. Further, it is possible to regulate private property so intensely that local units of government are believed to be taking land without compensation. However, clear and unambiguous ordinance language continues to stand up in court as a legal way to protect community character.

It is important for communities that have high growth rates and/or high populations (see Figures 3 and 4) to enact and enforce zoning regulations that protect water quality and natural resources before they become degraded. Zoning is a great opportunity for these communities to decide what kind of development and growth they want in their area, as well as what kind of protection they want for natural resources.

Important Role for Local Governments

Assisting local governments in updating and enacting strong zoning provisions to protect water quality and secure natural areas is extremely important in the Grand Traverse Bay watershed and is a high priority for implementation efforts (Chapter 8.5). While the state and federal government have laws and regulations to protect water, local governments play a vital role in protecting water as they have the ability fill in gaps in state and federal protection. If local governments don't address these gaps through ordinances and zoning provisions, the gaps are often not addressed. For example, many local governments in the Coastal Grand Traverse Bay watershed have chosen to adopt riparian buffer provisions to protect trees and other vegetation at the land-water interface. The state and federal governments only regulate certain types of wetlands and lakes, rivers and streams below the water's edge. Neither the state or federal governments provide protection of vegetation landward of the ordinary high water mark of a waterbody or on upland (non-wetland) areas. Local governments can fill in these gaps using a variety of zoning tools.

EGLE has published a book titled: *Filling the Gaps: Environmental Protection Options for Local Governments* that equips local officials with important information to consider when making local land use plans, adopting new environmentally focused regulations, or reviewing proposed development (Ardizone, Wyckoff, and MCMP, 2003). A copy of this guidebook is available via the EGLE website: https://www.michigan.gov/documents/deq/lwm-czm-ftg-cover_266076_7.pdf. EGLE's webpage titled Land Use Planning to Protect Water Quality also provides a plethora of resources for local governments (https://www.michigan.gov/egle/0,9429,7-135-3313_71618_3682_3714-479775--,00.html).

3.13 Subwatershed Summaries

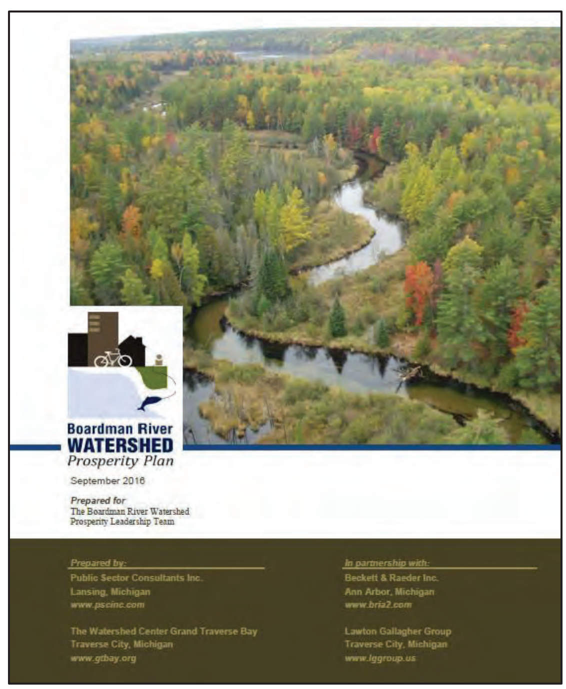
Elk River Chain of Lakes

The Elk River Chain of Lakes (ERCOL) is the largest subwatershed in the Grand Traverse Bay watershed, spanning an impressive 500 mi^2. Villages in the ERCOL include Elk Rapids, Kalkaska, Bellaire, Mancelona, Central Lake, and Ellsworth. The ERCOL is a unique series of 14 interconnected lakes and rivers in Antrim and Kalkaska counties (Figure 17). This 'Chain of Lakes' empties into East Grand Traverse Bay through the Elk River in Elk Rapids, providing approximately 60% (Table 16) of the bay's input of surface water. The ERCOL watershed area has more than 200 streams, with 138 miles as designated trout streams. Of the 500 mi^2 of watershed, more than 10% is covered by water. From the uppermost lake in the chain, the waters flow 55 miles and drop 40 feet in elevation on their way to the bay (Fuller 2001). With the exception of two dams, you can travel from Elk Lake all the way up to Beals Lake, which is the headwater area for the Chain of Lakes.

A subwatershed plan was developed and completed for the ERCOL subwatershed in December 2020 and is summarized in Chapter 6.2.

Boardman River

The Boardman River is the largest tributary to the west arm of Grand Traverse Bay and contributes approximately 30% (Table 16) of the water to the surface water input for the entire bay. Its watershed comprises 284 mi^2 and covers portions of Grand Traverse County on the west and Kalkaska County to the east (Figure 18). Urban areas in the Boardman River watershed include Traverse City, Kingsley, and Kalkaska. The Boardman River is a state-designated "Blue Ribbon" trout stream and a state designated Natural River. The Boardman River and its watershed provide immense recreational opportunities in the area; residents and visitors alike inject hundreds of thousands of dollars into the local economy (Largent 1991). More than 60% of the watershed is forested (most of which is located in the Pere Marquette State Forest), with the majority of the remainder being dedicated to agriculture and open space; urban land uses occur in 7% of the watershed (Table 10, Figure 18).



The Boardman River Watershed Prosperity Plan was approved by EGLE and EPA in February 2019. The Prosperity Plan is a vision and a roadmap for the future management of the Boardman River and meets the community's desire to have a management plan that goes well beyond traditional watershed studies to provide a blueprint for multijurisdictional cooperation to improve the environmental, economic, and social prosperity of the watershed region. It is one of the first intentional planning initiatives in Michigan to bridge the gap that often exists between natural resource protection and economic prosperity. A detailed summary of this plan is included in Chapter 6.1.

Mitchell Creek

Mitchell Creek, located at the southern end of East Bay, is the third largest single tributary watershed to the Grand Traverse Bay (Figure 19). Draining approximately 16 mi^2 of land, the watershed is principally located in East Bay and Garfield Townships and contains 16 miles of high-quality coldwater trout stream.

From its outlet next to the Traverse City State Park, the Mitchell Creek watershed has a significant portion of its downstream area in an urban setting in Traverse City and East Bay Township. Headwater areas in Blair, Garfield and East Bay Townships are mostly agriculture (pasture and orchards/vineyards) or forested and contain steep slopes. The middle and lower portions of the watershed are flatter and contain a greater amount of wetland areas. Mitchell Creek is classified as a gaining stream because of significant groundwater contributions to its flow. The watershed is experiencing increased pressure from development and land use in the area and is beginning to shift from agriculture and forest to urban and residential. In addition, the Mitchell Creek subwatershed has lost 45% of its pre-settlement wetland cover (Table 13) and wetlands now comprise approximately 12% of its land cover.

In 1991, Gosling Czubak Associates and the Great Lakes Environmental Center completed a Nonpoint Source Pollution Study for Mitchell Creek watershed (GCA and GLEC 1991). This study found water quality and aquatic diversity to be 'good' in spite of obvious signs of degradation. However, in a 2003 DEQ biological survey, two sites on Mitchell Creek scored in the low range of acceptable for aquatic insects (DEQ 2003).

Past research by the Grand Traverse County Drain Commissioner showed that 8.9% of the Mitchell Creek watershed was covered by impervious surfaces in 1995, and it is assumed this number has increased significantly in the past 20 years (Harrison and Dunlap 1998). (This study was also conducted on the Acme and Yuba Creek watersheds.) Impervious surfaces are those areas on land that cannot effectively absorb or infiltrate rainfall. Areas such as these may include: roads, streets, sidewalks, parking lots, and rooftops. Research suggests that there is a threshold to the amount of impervious cover that can occur within a watershed at which aquatic systems degradation occurs. Findings reveal that stream degradation consistently occurs when impervious surface levels in a watershed reach between 10-20% (CWP 1994).

Mitchell Creek is currently experiencing problems with *E.coli* bacteria, and as shown in Chapter 3.10, has levels above EGLE Water Quality Standards. It was recently added to the State's Impaired Watershed list as a result of an extensive monitoring program conducted by TWC in 2015 (EGLE grant #2015-0530). TWC had previously worked with Michigan State University (MSU), United States Geological Survey, Environmental Canine Services, and others to complete bacteria monitoring and source tracking efforts that found high *E.coli* levels. Those studies also indicated that some of the pathogen inputs found in Mitchell Creek may be from human sources. See Section 4.2 for more details on the impairment.

E. coli sampling in Mitchell Creek

Acme Creek

Acme Creek covers 13 mi^2 and is located at the southern end of East Grand Traverse Bay. It covers portions of three townships in Grand Traverse County: Acme, East Bay, and Whitewater (Figure 19). Along with Mitchell Creek, the Acme Creek subwatershed is under increasing pressure from urbanization. Acme Creek and its tributaries originate from groundwater seeps in a near-pristine area at the southern end of the watershed in East Bay and Whitewater Townships (GTCDC June 1995). Land use in this watershed consists mainly of 63% forest, 15% urban, and 12% nonforested (Table 10, Figure 19). Only 6.5% is agricultural lands, which are mainly pasture or orchards/vineyards. The Acme Creek system, which is replenished mostly from groundwater, is designated as a cold water trout stream (GTCDC June 1995). A GTCDC study shows that the percent impervious coverage in the Acme Creek watershed in 1995 was 4.2% (Harrison and Dunlap 1998). *(Please see the section on Mitchell Creek for a discussion regarding impervious surfaces.)*

A Watershed Planning Project for Acme Creek was completed in 1995 by the GTCDC. The project listed the following as the most significant current and future water quality and quantity impacts on Acme Creek: sedimentation; nutrient loading from golf courses, residential and agricultural lands; and stormwater runoff resulting from increased impervious surfaces.

In addition to noting threats to water quality, the project also completed a number of other tasks. A watershed database was developed that included information on wetlands, parcel lines, slopes, land cover, township zoning, and potentially sensitive areas. Local township ordinances were reviewed and found to be weak and not targeted to the protection of the creek and its fisheries habitat. Specific streambank erosion sites and inadequate culverts were identified for future restoration and remediation. Also, public input sessions were held where concerns were raised regarding golf course practices, road construction, and the current level of protection for public and private lands near the creek's headwaters (GTCDC June 1995).

Yuba Creek

Yuba Creek watershed is the smallest subwatershed to the Grand Traverse Bay, covering just 8 mi^2. It is also a designated coldwater trout stream and is adjacent to the Acme Creek subwatershed and located almost entirely in Acme Township, east of Traverse City (Figure 19). Much like Acme Creek, the Yuba Creek watershed is in the rapidly developing sprawl area outside of Traverse City. Most of the land use in the Yuba Creek watershed is agriculture (30%), with a mix of pastures and orchards/vineyards. Remaining watershed land uses are forested and nonforested (each 20%) and urban (17%) (Table 10, Figure 19). As of 1995, the percent impervious coverage in the Yuba Creek watershed was only 2.4% (Harrison and Dunlap 1998). *(Please see the section on Mitchell Creek for a discussion regarding impervious surfaces.)* Yuba Creek currently has a significant amount of wetland land cover (13%) compared to other subwatersheds, but has also lost about 48% of its original pre-settlement wetland land cover.

Protection and monitoring work was completed in Yuba Creek as part of a GTCDC Implementation Project in conjunction with Acme Creek from April 1997 – March 2000. The project promoted use of stream buffers as primary water resource management tool, corrected severe runoff erosion sites, worked with the GTRLC to protect priority land parcels, and conducted a successful education campaign (GTCDC 2000).

Tobeco Creek


Aerial View of Lower Petobego Pond entering Grand Traverse Bay

The Tobeco Creek watershed is widely considered by some to be the most beautiful wetland area in the entire Grand Traverse Bay watershed. The majority of the 14 mi^2 watershed area is located in Grand Traverse County's Whitewater and Acme Townships, with a smaller portion in Antrim County's Elk Rapids Township (Figure 19). Also spelled *Tobego*, or *Petobego*, the Tobeco Creek watershed includes a vast complex of wetlands near its outlet to Grand Traverse Bay and is home to a thriving wildlife population.

However, while the Tobeco Creek subwatershed is often thought of as a large wetland complex, over half of its land area is considered agricultural, most of that is orchards/vineyards near downstream areas along US-31, with a mix of cropland and pasture in headwater areas (Table 10, Figure 19).

The watershed is made up of a single creek that flows lazily into the Upper Petobego Pond and then meanders through a wetland complex into the Lower Petobego Pond, which then outlets into the bay. The Petobego Creek Wildlife Preserve and State Game Area, an approximate 400-acre parcel of land, is centered on these two ponds in Grand Traverse County. Additionally, the Grand Traverse Regional Land Conservancy established the Maple Bay Farms Natural Area in the watershed, a 400+ acre parcel of land adjacent to the wildlife preserve.

West Bay Shoreline and Tributaries

This 68 mi^2 watershed area stretches along a small sliver of Leelanau County on the west side of Grand Traverse Bay and encompasses the land draining all tributaries and groundwater seeps entering the bay (Figure 20). Tributaries along the West Bay shoreline include: Cedar, Leo, Lee, Belanger, Weaver, Ennis, and Northport creeks, all of which are designated coldwater trout streams. Lakes in this subwatershed include Cedar, Mougeys, and Mud lakes. Villages along this portion of the watershed include Suttons Bay, Omena, Northport, and Peshawbestown, which is the governmental seat of the Grand Traverse Band of Ottawa and Chippewa Indians (GTBOCI). The Leelanau State Park is located at the tip of this watershed.

Most of the land use along this area is either forested or agriculture, with developed areas along the shoreline (Table 10, Figure 20). Leelanau County itself is a peninsula and is surrounded by Lake Michigan to the west and Grand Traverse Bay to the east. As such, it enjoys the same kind of 'micro-climate' that Old Mission Peninsula does and 70% of the agricultural land in the West Bay Shoreline subwatershed is vineyards and orchards comprised of cherries and apples. Also, like Old Mission Peninsula, Leelanau County is widely known for its award-winning wines and has an American Viticultural Area designation.

Northport Creek

Of all the small creeks in this subwatershed, Northport Creek has been studied the most extensively. Data collected by EGLE staff in summer 2018 indicate Northport Creek has high *E.coli* levels at one location, and it is now subsequently listed as impaired for its Total Body Contact designated use as of EGLE's 2020 Integrated Report (EGLE 2020). The source of *E. coli* is unknown at this point, see Section 4.2 for more details.

Additionally, a report was completed for Northport Creek in 2017 that summarized existing features in the creekshed, as well as water quality, biotic (macroinvertebrates and fish), and habitat conditions in the creek (Comfort and Kelly 2017). It also contains a brief evaluation of the environmental stressors to the creek: loss of stream bank habitat, runoff from village streets and the larger watershed, perched culverts, wastewater treatment facility, and an historical impoundment. Recommendations for future riparian and in-stream improvements are included in the report as well. The most impacted segment of Northport Creek indicates that the Mill Pond Dam and impoundment causes a fragmentation of the stream that blocks fish passage, fish migration, and stream flow. The impoundment also contributes sediments and nutrients to Northport Creek, which negatively impacts fish habitat and reproduction. In-stream habitat and the riparian zone along the creek also lacks the diversity of vegetation needed for fish and other aquatic organisms (Comfort and Kelly 2017).

East Bay Shoreline and Tributaries

The East Bay Shoreline watershed encompasses 39 mi^2 land along the east side of East Grand Traverse Bay in Antrim and Grand Traverse Counties (Figure 21). For simplifying subwatershed areas, this subwatershed combines two separate areas – one surrounding Baker Creek a large wetland complex in Grand Traverse County and the other encompassing a 22-mile long stretch of shoreline north of the Village of Elk Rapids in Antrim County. There are two lakes, Birch and Bass lakes, in the subwatershed just north of the Village of Elk Rapids. Tributaries in stretch north of Elk Rapids include Paradine-McGuire, Mitchell, Guyer, and Antrim Creeks, all designated coldwater trout streams. A 2003 shoreline inventory along the Antrim County portion of East Bay (Appendix A) reveals a total of twenty-four small streams and many groundwater seeps entering the bay from the Village of Elk Rapids up to Norwood. The most interesting and beautiful seeps were observed north of Eastport seeping from the blue Antrim Shale Bluffs. The Grand Traverse Regional Land Conservancy has three nature preserves along this stretch: the 41-acre Wilcox-Palmer-Shah Nature Preserve by Kewadin, the 38-acre Torch Bay Beach Nature Preserve south of Eastport, and the 156-acre Antrim Creek Natural Area located south of Norwood.

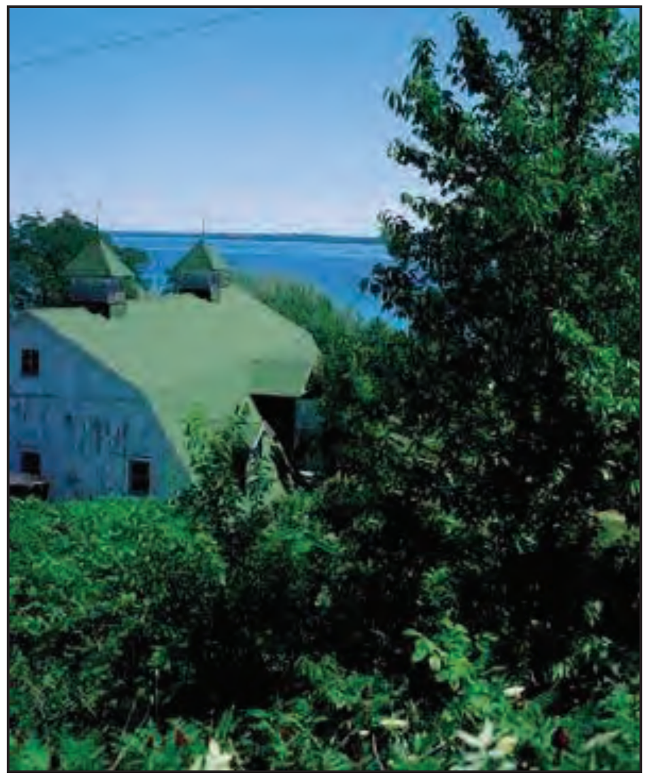
Antrim Creek Natural Area
Photo credit: Grand Traverse Regional Land Conservancy

Land uses along this stretch are mostly forested, agricultural (orchards/vineyards, row crops, hay, pasture), and wetlands. In fact, the East Bay Shoreline subwatershed has the highest percentage of wetlands (20%) than any of the other subwatersheds in the Grand Traverse Bay. These wetlands are mainly located in the northern section of the watershed in Antrim County. Since pre-settlement times this subwatershed has lost approximately 42% of its wetland area. Urban land cover is low, around 14%, and is mainly focused in the southern section of this watershed near Baker Creek and the Village of Elk Rapids.

The 12 mi^2 Mitchell Creek subwatershed is experiencing bacteria issues and was added to the State's Impaired Waters List more than 10 years ago as a result of testing completed in Summer 2006 that showed highly elevated levels of *E.coli*. The creek enters Grand Traverse Bay north of Elk Rapids in Milton Township. Suspected sources of contamination were due to land application of sewage/septage waste. Since then, all septage disposal in the area has ceased, however, testing has not been repeated since 2006 so it is unknown if bacterial contamination in this creek is still an issue.

Old Mission Peninsula

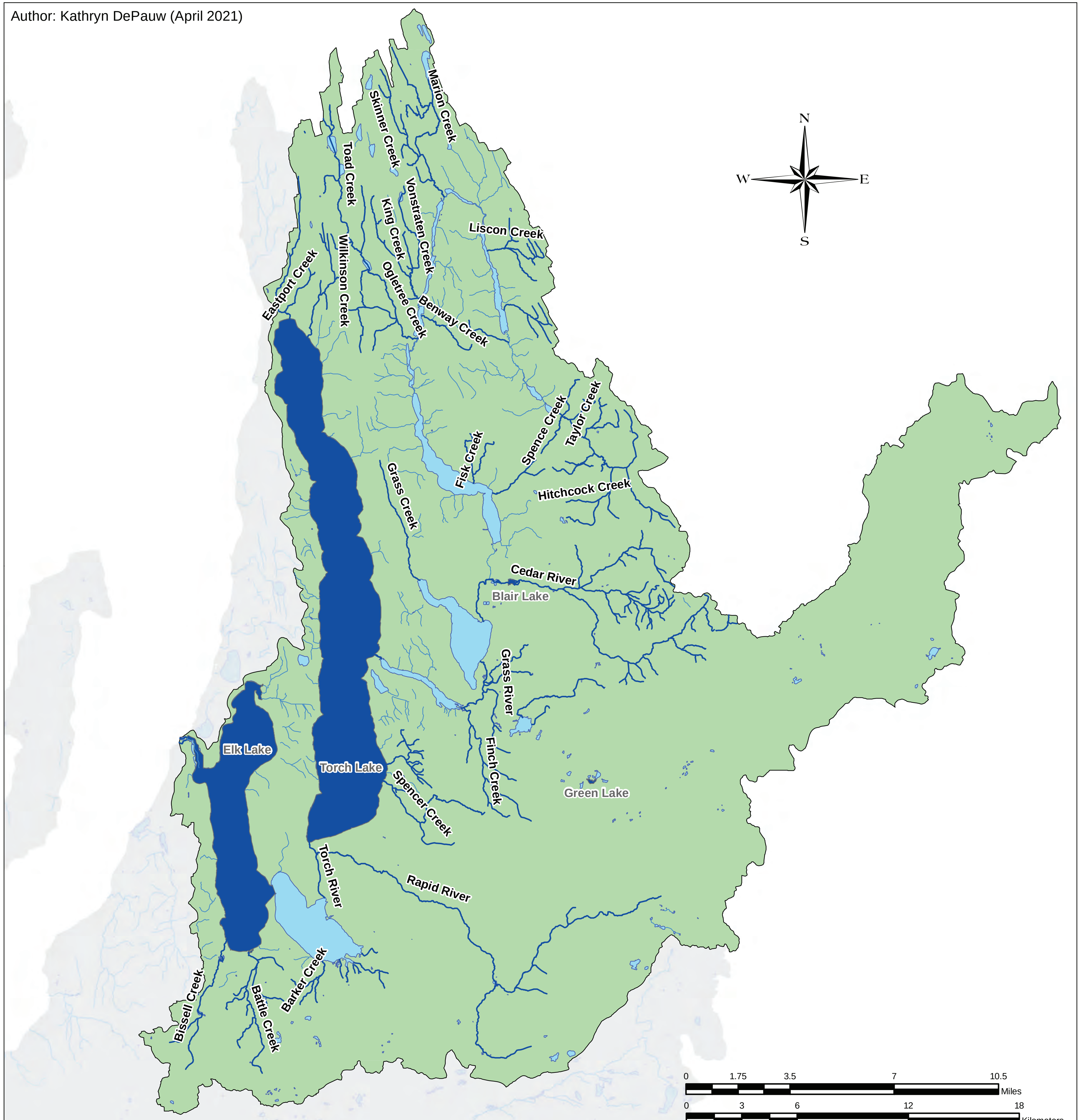
The 31 mi^2 watershed of the Old Mission Peninsula is perhaps one of the most unique of the smaller subwatersheds to the bay. The peninsula is 19 miles long and 3 miles at its widest point and is located in the middle of Grand Traverse Bay, forming the East Arm and West Arm of Grand Traverse Bay (Figure 22). It has no major named creeks (only small, unnamed ones) and only one lake, Prescott Lake. The peninsula offers breathtaking panoramic views of both arms from its highest ridges.



View of Grand Traverse Bay from Old Mission Peninsula

The subwatershed has the highest percent of agricultural land cover (37%) compared to others in the Grand Traverse Bay Watershed, which is almost extensively orchards and vineyards and some crops. Since the peninsula is surrounded on both sides by the bay, it enjoys a 'micro-climate' that is ideal for growing both wine-grapes and orchard crops like cherries and apples. The lingering warmth of the water in the Bay in fall helps to stave off early frosts, while its cold spring temperatures prevent premature budding during a warm spring. In fact, Old Mission Peninsula is well known for its award-winning wines and has an American Viticultural Area designation as an official wine grape-growing region in the United States.

The tip of the peninsula, Old Mission Point, is largely a public accessible area with township and state parks. The watershed has no major streams or lakes, and its water flows or seeps into either West or East Grand Traverse Bay.



Legend

Watershed Boundary

Lakes & Ponds

Coldwater Trout/Salmon Lake

Rivers & Streams

Coldwater Trout/Salmon Stream

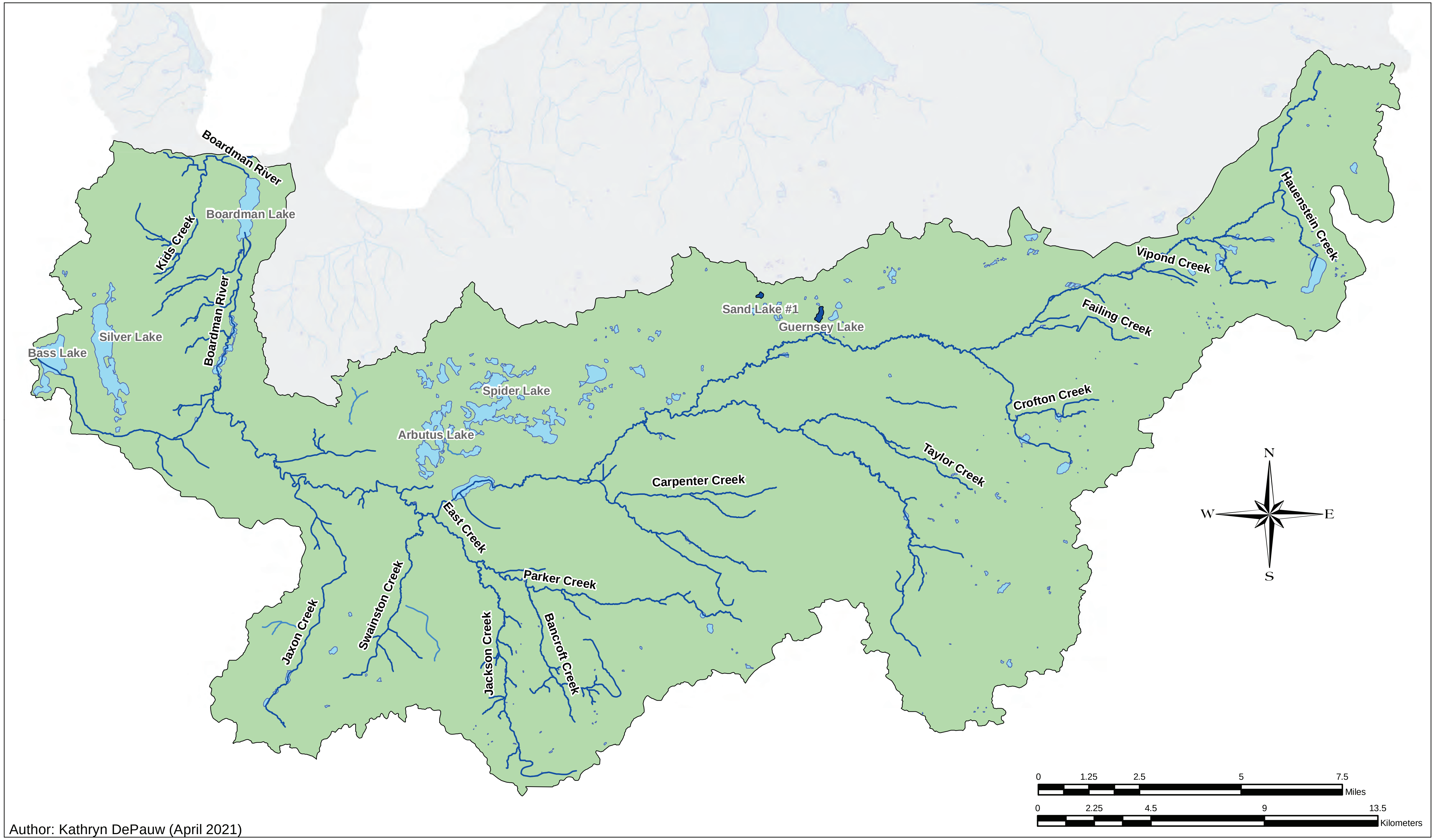
Layer Credits: Michigan Department of Natural Resources (NHD 2020)

ELK RIVER CHAIN OF LAKES WATERSHED

FIGURE 17: COLDWATER RIVERS AND LAKES

BOARDMAN RIVER WATERSHED

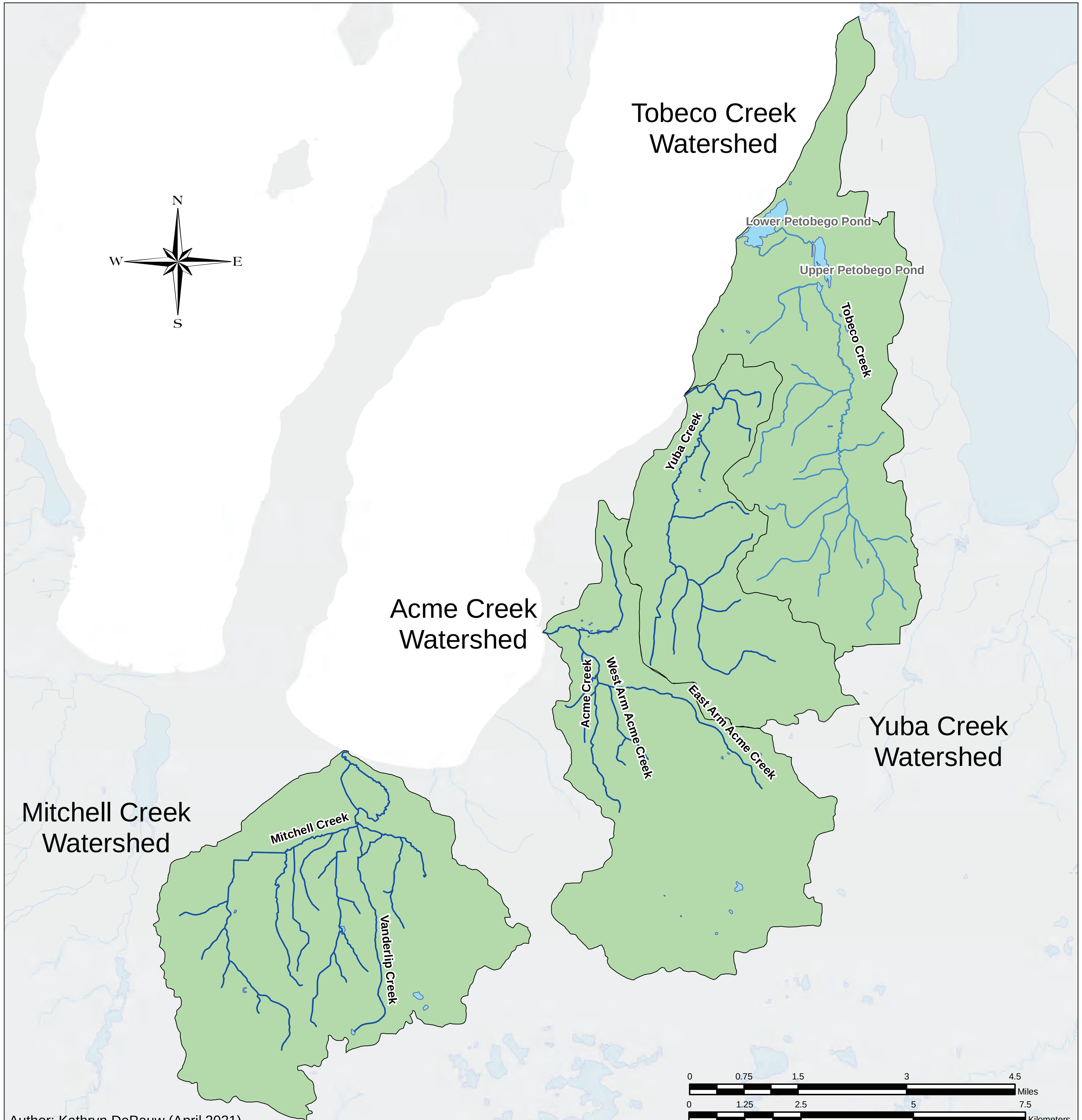
FIGURE 18: COLDWATER RIVERS AND LAKES



Layer Credits: Michigan Department of Natural Resources (NHD 2020)

Legend

- Watershed Boundary
- Lakes & Ponds
- Coldwater Trout/Salmon Lake
- Rivers & Streams
- Coldwater Trout/Salmon Stream



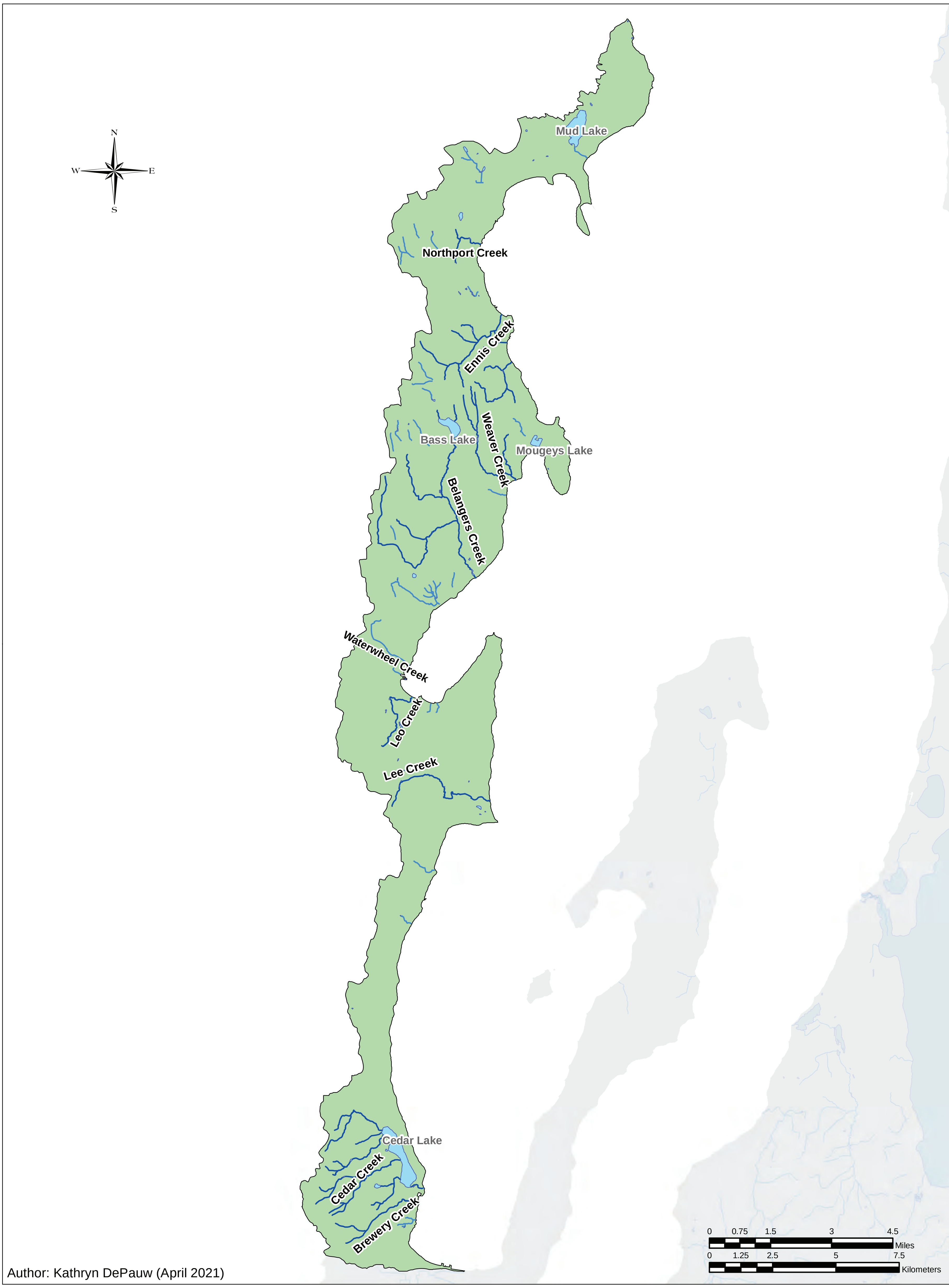
Legend

- Watershed Boundaries
- Lakes & Ponds
- Rivers & Streams
- Coldwater Trout/Salmon Stream

Layer Credits: Michigan Department of Natural Resources (NHD 2020)

MITCHELL, ACME, YUBA, AND TOBECO WATERSHEDS

FIGURE 19: COLDWATER RIVERS AND LAKES



Layer Credits: Michigan Department of Natural Resources (NHD 2020)

Legend

- Watershed Boundary
- Lakes & Ponds
- Rivers & Streams
- Coldwater Trout/Salmon Stream

WEST BAY SHORELINE WATERSHED

FIGURE 20: COLDWATER RIVERS AND LAKES

Layer Credits: Michigan Department of Natural Resources (NHD 2020)

Legend

Watershed Boundary

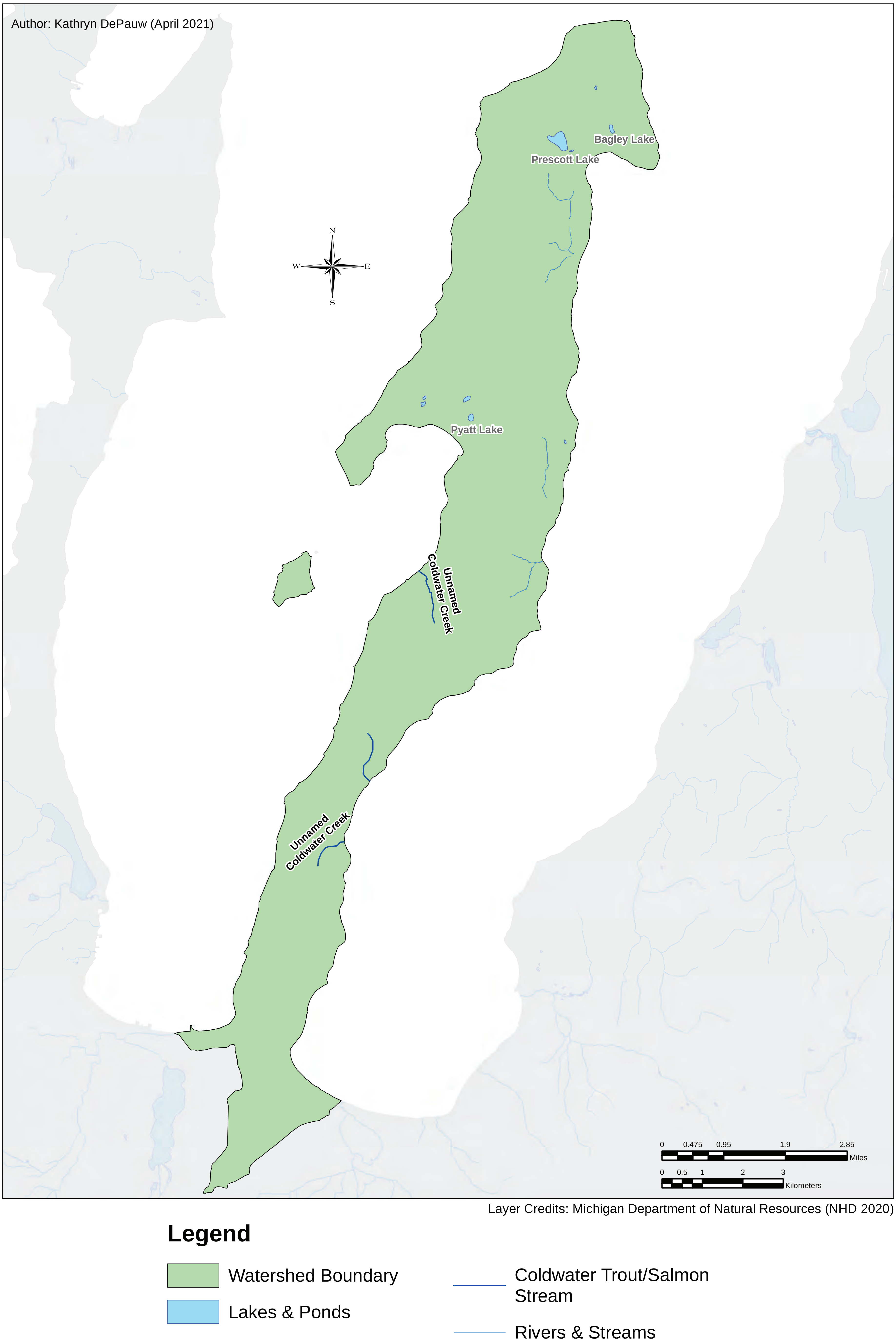
Lakes & Ponds

Rivers & Streams

Coldwater Trout/Salmon Stream

EAST BAY SHORELINE WATERSHED

FIGURE 21: COLDWATER RIVERS AND LAKES



OLD MISSION PENINSULA WATERSHED

FIGURE 22: COLDWATER RIVERS AND LAKES

CHAPTER 4 DESIGNATED AND DESIRED USES

4.1 Designated Uses and Water Quality Standards in the State of Michigan

Watershed plans approved under Section 319 of the federal Clean Water Act must determine whether or not surface waterbodies within the watershed meet the designated, protected uses specifically identified in the state water pollution control statutes and promulgated rules established consistent with the authority delegated under federal law. That determination includes an assessment of compliance with Michigan Water Quality Standards established to protect those uses. Under Michigan's water pollution control statute (324.3109 Natural Resources and Environmental Protection Act, Act 451 of 1994), discharges to surface waters are unlawful that are or may become injurious to:

- Public health, safety, or welfare
- Domestic, commercial, industrial, agricultural, recreational, or other uses that are being made or may be made of such waters
- Value or utility of riparian lands
- Livestock, wild animals, birds, fish, aquatic life, or plants or to their growth or propagation or the value of fish and game

Michigan water quality rules based on state law and the federal Clean Water Act establish as a minimum that all waters of the state are designated and protected for the following uses:

- Agriculture
- Navigation*
- Industrial water supply
- Warmwater or coldwater fishery
- Other indigenous aquatic life and wildlife
- Partial body contact
- Fish consumption*
- Total body contact from May 1 to October 31

In addition, protected uses include the following if identified by the state of Michigan:

- Migratory routes for anadromous salmonids*
- Public water supply intakes

**not addressed/analyzed in this watershed plan*

The State of Michigan has developed water quality standards (WQS) under Part 4 of the Administrative Rules issued pursuant to Part 31 of the Natural Resources and Environmental Protection Act (1994 PA451, as amended). These WQS set the goals, pollution limits, and protection requirements for waterbodies and are found in Table 39. Standards also drive water quality restoration activities because they help to determine which waterbodies must be addressed, what level of restoration is required, and which activities need to be modified to ensure that the waterbody meets its minimum standards. In all cases where waters are designated for more than one of these protected uses, the most restrictive water quality standards apply.

Also, if existing water quality is superior to the designated use requirements, it must be maintained at that level until it has been adequately demonstrated to the state that the change in quality does not or will not become injurious to the public health, safety, or welfare, or become injurious to any other uses being made of such waters.

Table 39: State of Michigan Water Quality Standards

Pollutant	State-required level	Designated Uses Affected
Dissolved solids	500 mg/L monthly average or 750 mg/L at any time as a result of controllable point sources	All
Chlorides	125 mg/L monthly average	Public water supply
pH	6.5 to 9.0	All but navigation
Taste or odor producing substances	Any concentration	Public water supply, industrial water supply, agricultural water supply, fish consumption
Toxic substances (selected shown here; see rule for complete listing)	DDT and metabolites: 0.00011 ug/L mercury, including methylmercury: 0.0013 ug/L PCBs (class): 0.00012 ug/L 2,3,7,8 - TCDD: 0.0000000031 ug/L	All but navigation
Radioactive substances	Pursuant to U.S nuclear regulatory commission and EPA standards	All but navigation
Plant nutrients	Phosphorus: 1 mg/L monthly average for permitted point-source discharges	All
Microorganisms (*E.coli* and fecal coliform)	1. 300 *E.coli* per 100 mL 2. 30-day mean of 5 or more sampling events: 130 *E.coli* per 100 mL 3. 1,000 *E.coli* per 100 mL 4. Human sewage discharges (treated or untreated) 200 fecal coliform per 100 mL 30-day mean or 400 fecal coliform per 100 mL in 7 days or less	1. Partial body contact 2. Total body contact 3. Total body contact 4. Total body contact
Dissolved oxygen	1. Minimum 7 mg/L for coldwater designated streams, inland lakes, and Great Lakes/connecting waters; Minimum 5 mg/L for all other waters 2. Minimum 5 mg/L daily average	1. Coldwater fishery 2. Warmwater fishery
Temperature	Natural daily and seasonal temperature fluctuations shall be preserved: 1. Monthly averages for inland lakes: J F M A M J J A S O N D 45-45-50-60-70-75-80-85-80-70-60-50 2. Monthly averages for warmwater inland streams in this watershed: J F M A M J J A S O N D 38-38-41-56-70-80-83-81-74-64-49-39 3. Monthly averages for coldwater inland streams in this watershed: J F M A M J J A S O N D 38-38-43-54-65-68-68-68-63-56-48-40	1. Coldwater fishery 2. Other indigenous aquatic life and wildlife 3. Warmwater fishery

Summary of Michigan WQS as required by section 3103 and 30106 of 1994 PA 451, MCL 324.3203 and 324.3106

4.2 *Impacted Designated Uses in the Grand Traverse Bay Watershed*

EGLE is required to monitor each water body every five years, biannually assess and report on the status of its waterbodies and publish a list of waterbodies that are not attaining water quality standards or meeting their designated uses. If a body of water or stream reach is not meeting the water quality standards set for a specific designated use, then it is said to be in “nonattainment” and listed on the State Impaired Waters List, also known as the Section 303(d) list. Section 303(d) of the Clean Water Act and the USEPA’s Water Quality Planning and Management Regulations (40 CFR, Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting water quality standards and are in “nonattainment.” The TMDL process establishes the allowable loadings of pollutants for a water body based on the relationship between pollution sources and in-stream water quality conditions. TMDLs provide states a basis for determining the pollutant reductions necessary from both point sources and NPS to restore and maintain the quality of their water resources. The most recent published listing of the bodies of water and stream reaches in the state of Michigan that are in nonattainment can be found in EGLE’s 2020 Integrated Report (EGLE 2020).

Non-Attainment of Designated Uses (Impaired Waters)

The Grand Traverse Bay watershed was last monitored in the summer of 2018 and EGLE’s 2020 Integrated Report indicates that there are no widespread impairments to the designated uses in the Grand Traverse Bay watershed (EGLE 2020). However, there are local impairments of note due to bacteria contamination and poor macroinvertebrate communities (Table 40, Figure 23).

The most significant impairment in the Grand Traverse Bay watershed is a 4-mile portion of Kids Creek located in an urban area on the west side of Traverse City. Kids Creek is listed due to the 'Other Indigenous Aquatic Life' Designated Use not being met because of a poor macroinvertebrate community. This is mainly due to sedimentation, flow regime alteration, and other human-caused sources. Kids Creek experiences severe changes in flow due to stormwater inputs during storm events and exhibits signs of flashiness, often flooding portions of the urban area within Traverse City. This flashiness has led to scoured stream bottoms and increased sedimentation from eroding stream banks within the creek, causing a lack of habitat for aquatic insects. Additionally, as of the 2020 Integrated Report, Kids Creek is now also listed as impaired for “Total Body Contact” due to bacterial contamination from *E. coli*. Kids Creek is a major tributary to the Boardman River and its impairment as well as restoration efforts to have it removed from the Impaired Waters List are discussed in-depth in the Boardman River Watershed Prosperity Plan.

Five other bodies of water in the Grand Traverse Bay watershed are listed as not meeting “Total Body Contact” designated uses due to bacterial contamination from *E.coli*. Two of them are for tributaries Torch Lake and are discussed further in the Elk River Chain of Lakes subwatershed management plan. The three others are in the Grand Traverse Bay Coastal watershed area, two of which are coincidentally named Mitchell Creek (one in Antrim County and the other in Grand Traverse County) as well as Northport Creek in Leelanau County (Table 40, Figure 23).

Mitchell Creek in Grand Traverse County is significantly larger and contains more tributaries than Antrim County’s Mitchell Creek and enters Grand Traverse Bay on the east side of Traverse City near Three Mile Road. It was recently added to the State’s Impaired Watershed list because of an extensive monitoring program conducted by TWC in 2015 (EGLE grant #2015-0530). TWC had previously worked with Michigan State University (MSU), United States Geological Survey, Environmental Canine Services, and others to complete bacteria monitoring and source tracking efforts that found high *E.coli* levels. Those studies also indicated that some of the pathogen inputs found in Mitchell Creek may be from human sources. ****June 2024 update: From 2021-2023, TWC conducted a bacteria monitoring and source tracking study at select locations on Mitchell Creek to identify the potential sources of contamination to address the bacterial impairment. The main objective was to determine if septic systems are impacting Mitchell Creek and are the cause of impairment. Secondarily, TWC wanted to determine if other sources of bacteria from canines, cows, pigs, or gulls add to the impairment. While there were several locations where human source tracking markers were found, the study did not find evidence that septic systems are a main source of bacterial pollution. The western tributaries had higher occurrences of pig markers while the central main branch had more human marker influence. The canine marker that includes wild animals such as fox and coyote is widespread. A summary of this study that highlights major findings, results, and conclusions is included as Appendix E.****

Mitchell Creek in Antrim County enters Grand Traverse Bay north of Elk Rapids in Milton Township. It was added to the State's Impaired Waters List more than 10 years ago as a result of testing completed in Summer 2006 that showed highly elevated levels of *E.coli*. Suspected sources of contamination were due to land application of sewage/septage waste. Since then, all septage disposal in the area has ceased, however, testing has not been repeated since 2006 so it is unknown if bacterial contamination in this creek is still an issue.

Northport Creek runs through the Village of Northport in northern Leelanau County and was recently designated as impaired in EGLE's 2020 Integrated Report as the result of samples collected at two sites in Summer 2018 (EGLE 2020). Sources and causes are unknown.

Statewide TMDL for *E. coli*

Routine testing by EGLE has shown *E. coli* levels in many areas of the state are above the WQS. Given the extent of the problem and the multitude of potential sources, EGLE decided that a statewide approach would be more effective and efficient at addressing the *E. coli* issue, rather than writing and approving numerous *E. coli* TMDLs for waterbodies throughout the state. As such, a Statewide *E. coli* TMDL was approved by the U.S. Environmental Protection Agency (EPA) in 2019 that provides a general legal framework for reducing pollutant loads in areas identified throughout the state where the *E. coli* WQS have been exceeded. The goal of the Statewide *E. coli* TMDL is to meet the *E. coli* WQS as well as the total and partial body contact designated uses in each water body. Therefore, the numeric targets for all potential sources are equal to the total body and partial body contact WQS.

Long term solutions to bacterial problems can only be accomplished through a collaborative approach. The TMDL describes the regulatory and voluntary ways that nonpoint sources of pollution can be corrected. In addition to its work on effective National Pollutant Discharge Elimination System (NPDES) permit requirements and corrective actions on illegal sources to reduce bacterial problems in waterways, EGLE is looking for assistance from landowners, local health departments, conservation districts, other state and local agencies, and environmental groups to focus voluntary improvements in areas where nonpoint sources are a problem. EGLE lacks direct regulatory authority for most nonpoint sources, so EGLE and stakeholders must work together with other agencies and groups to solve these problems. For nonpoint sources, much of the solution is voluntarily achieved by federal, state, and local agencies working together with the public to find sources, pass local ordinances, promote and implement best management practices, and educate residents. More information on the statewide E. coli TMDL can be found at www.mi.gov/ecolitmdl. Additionally, a statewide interactive mapping tool available is available for organizations to assist in identifying impacted areas as well as provide resources for getting involved in efforts to reduce the *E. coli* levels. The purpose is to encourage and empower local communities to protect our waters.

Because EGLE does not currently know the full extent of *E. coli* impairments in Michigan, the TMDL will be updated to include new impaired waters as they are identified based on future monitoring. The statewide TMDL will be updated every two years, consistent with the Integrated Report schedule, by adding waters listed in an addendum.

This plan will address nonpoint source contributions to bacterial impairments listed for the three creeks in the Grand Traverse Bay Coastal Watershed (Table 40) and follow recommendations in the statewide TMDL.

Table 40: Designated Use Impairments in the Grand Traverse Bay Watershed*

Waterbody	**Designated Use Not Met**	**Reason for Nonattainment Status**	**Assessment Unit ID**
GT Bay Coastal Watershed			
Mitchell Creek (GT Co.)	Total Body Contact	*Escherichia coli*	040601050705-01
Mitchell Creek (Antrim Co.)	Total Body Contact	*Escherichia coli*	040601050702-04
Northport Creek	Total Body Contact	*Escherichia coli*	040601050708-02
Boardman River Watershed*			
Kid's Creek *(From confluence with Boardman River u/s to M-37/US-31)*	Other aquatic life Fish Consumption Total Body Contact	Macroinvertebrate community rated poor PCB's in water column *Escherichia coli*	040601050507-01
Elk River Chain of Lakes Watershed*			
Eastport Creek (Torch Lake)	Total Body Contact	*Escherichia coli*	040601050305-02
Wilkinson Creek (Torch Lake)	Total Body Contact	*Escherichia coli*	040601050305-03

**Data from EGLE 2018 and EGLE 2020*
***Impairments in the Boardman River and Elk River Chain of Lakes watersheds will not be addressed in this management plan; they are addressed in their own separate watershed plans*

Widespread Impact from Mercury and Polychlorinated Biphenyls – Statewide TMDLs

Overall, many of Michigan's surface waters are impacted by polychlorinated biphenyls (PCBs) and mercury and consequently do not support the other indigenous aquatic life and wildlife designated use and/or the fish consumption designated use. A statewide mercury-based fish consumption advisory applies to all of Michigan's inland lakes, reservoirs, and impoundments as well. Noted waterbodies in the 2018 Integrated Report that were assessed and confirmed to have mercury and PCB contamination issues are Torch, Elk, and Silver Lakes as well as tributaries and the main branch of the Boardman River (EGLE 2018). In addition, sampling completed in 2015 from Grand Traverse Bay showed fish tissue samples from top predators all had elevated mean mercury concentrations indicating the fish consumption designated use was not supported. In addition, PCBs and dioxins cause restricted consumption advisories for certain species of gamefish in the bay (EGLE 2018). Atmospheric deposition is considered to be the major source of these persistent bioaccumulative chemicals.

Mercury is a metal that occurs naturally in the environment. Major uses of mercury in the United States include lighting, switches, instruments, the dental industry, laboratory uses, and other industrial applications. Local and global anthropogenic activities such as mining, coal combustion, and industrial uses have release mercury in excess of pre-industrial period concentrations.

PCBs are a class of synthetic, chlorinated organic chemicals that were produced mainly for their excellent insulating capabilities and chemical stability. The EPA banned production of PCBs in 1979 due to their toxic properties, and this class of chemicals was ultimately phased out of new uses in 1983. PCBs have been shown to cause a variety of adverse health effects, notably cancer in animals. Non-cancer effects include impacts to the nervous, immune, reproductive, and endocrine systems, among other adverse effects. PCBs concentrate in the fatty tissues of organisms and bioaccumulate in living tissues. Thus, despite the United States ban of PCB production, PCBs remain in the environment in soil, water, air, animal tissue, and vegetation. PCB concentrations in water and fish tissue have been declining since the early 1990s; however, numerous water bodies in the state remain impaired due to PCBs that continue to be found in fish tissue and water.

EGLE-drafted statewide PCB and mercury TMDLs were approved by the USEPA in September 2017 and 2018, respectively. These TMDLs address most inland waterbodies not supporting designated uses for fish consumption due to exceedances of the numeric mercury/PCB water column Water Quality Standard (WQS) and/or elevated mercury/PCB concentrations in fish tissue. The problem of mercury contamination and other related widespread toxic contamination problems in the Grand Traverse Bay watershed will not be discussed in this Management Plan. EGLE has taken the lead to develop pollution prevention and abatement strategies throughout the State of Michigan in their mercury and PCB TMDLs.

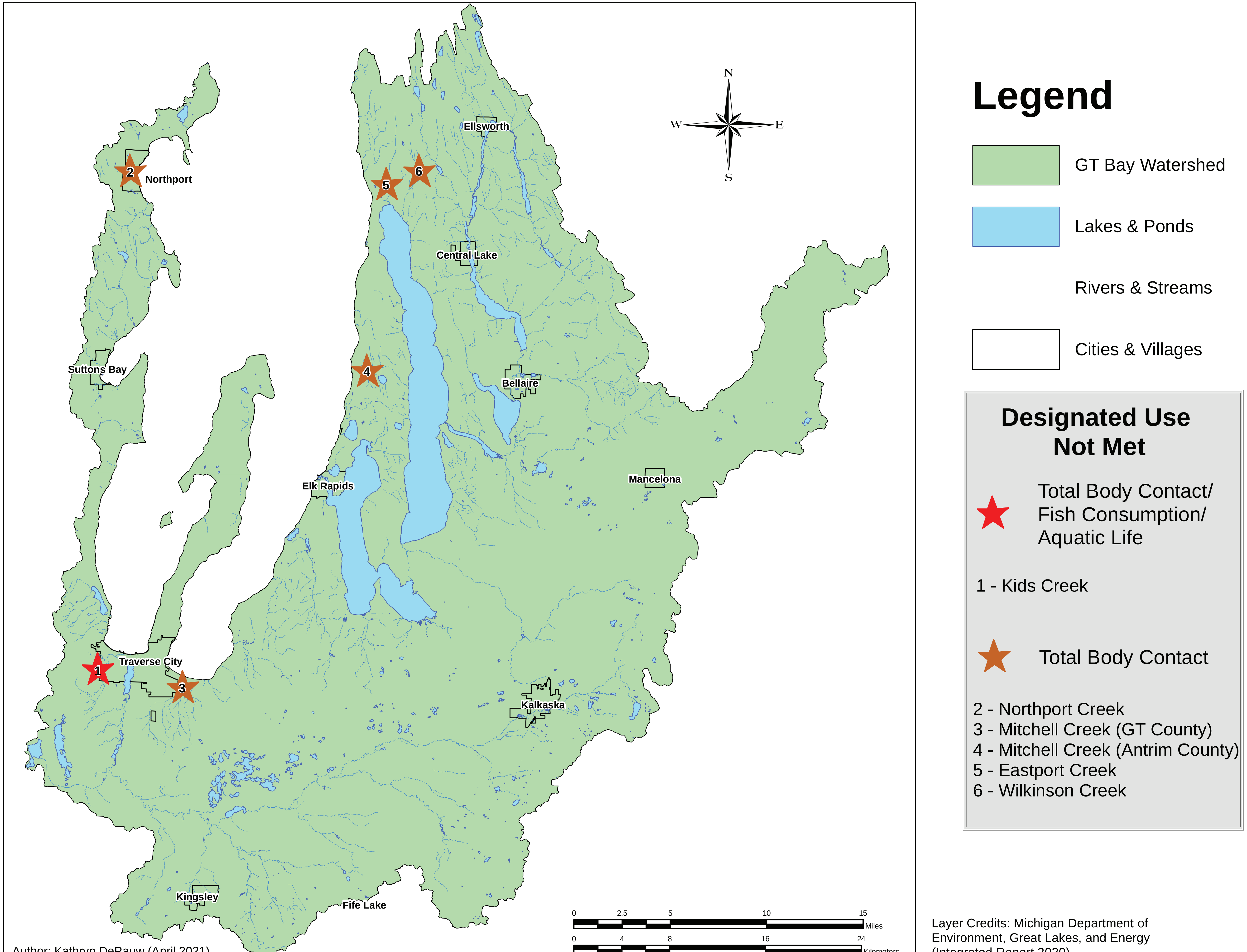
At Risk Designated Uses

As stated above, none of the designated uses for the Grand Traverse Bay watershed are impaired on a watershed-wide scale. As such, this plan will focus on protecting the watershed from future degradation rather than reducing pollutant loads to meet water quality standards. In some cases, activities and resulting pollutants in the watershed may prove to be a threat to water quality and designated uses. 'At risk' waterbodies are defined as those that currently meet water quality standards, but may not in the future and are at risk of becoming degraded. This watershed plan, which as discussed previously, focuses solely on the coastal watershed areas, will consider four at risk designated uses to protect in order to maintain water quality throughout the Grand

Traverse Bay and its coastal watershed: Coldwater Fishery; Other Indigenous Aquatic Life; Total/Partial Body Contact; and Public Water Supply at point of intake (for Traverse City municipal intake on East Bay only).

At risk designated uses were ascertained through scientific research reports, existing subwatershed management plans, state water quality reports, field observations by TWC staff and Steering Committee members, and personal contact with watershed residents and scientific experts on the Grand Traverse Bay watershed. The vast majority of streams in the watershed are designated trout streams with the only major exception being Tobeco Creek (shown in subwatershed maps in Figures 17-22). Therefore, the more restrictive designated use for Coldwater Fishery is noted rather than Warmwater Fishery.

Not Applicable or Addressed in this plan	• Navigation • Fish consumption • Migratory routes for anadromous salmonids
Impaired (not watershed-wide, specific locations listed in Table 40)	• Other indigenous aquatic life and wildlife • Total/Partial body contact
Meeting Standards	• Agriculture • Industrial water supply • Warmwater fishery (Tobeco Creek) • Coldwater fishery (all others) • Public water supply intake (Traverse City only)
At-Risk **Watershed-wide**	• Other indigenous aquatic life and wildlife • Coldwater fishery • Total/Partial body contact • Public water supply intake (Traverse City only)



GRAND TRAVERSE BAY WATERSHED

FIGURE 23: DESIGNATED USE IMPAIRMENTS

4.3 *Desired Uses*

In addition to researching regulated designated uses, the project's steering committee has also identified a number of locally determined desired uses for the watershed. Desired uses can be defined as the ways in which people use the watershed and think should be protected and/or preserved for future generations. They may be very general or very specific, or somewhere in between. Desired uses for the Grand Traverse Bay watershed include uses for recreational, aesthetic, and ecosystem preservation purposes (Table 41).

Table 41: General Desired Uses for the Grand Traverse Bay Watershed

Desired Use Category	Goal
Recreation	• Maintain high quality areas in the watershed for recreation such as fishing, paddling, boating, hiking, camping, and birding. • Develop additional Designated Natural Areas throughout the watershed for recreation and education. • Increase the number of boardwalks, gardens, and public parks along rivers and lakes in urban settings.
Aesthetic Character	• Preserve the distinctive aesthetic character and inherent beauty of the bay and its watershed. • Design and promote, without compromising water quality, development that 1) respects privacy, 2) personal enjoyment and security of public and private land and public water courses, and 3) visual quality throughout the watershed.
Ecosystem Preservation	• Maintain, preserve, and enhance wildlife habitat corridors, wetlands, and ecologically critical lands throughout the watershed. • Identify and enhance opportunities for green infrastructure and wetlands to play a role in protecting coastal communities from extreme storm events.

CHAPTER 5 WATER QUALITY PROBLEMS

5.1 Watershed Pollutants

For each designated use to protect in the Grand Traverse Bay Coastal watershed there are several pollutants or stressors that are either currently affecting water quality or pose future threats if they are not addressed (Table 42). The term environmental stressor is used to describe those factors that may have a negative effect on the ecosystem but are not necessarily categorized as contaminants that change water chemistry. Examples of environmental stressors include changes to hydrologic flow, thermal pollution, and loss of habitat. Each of the pollutants and environmental stressors noted below is discussed in more detail in Section 5.5.

Table 42: Pollutants Affecting Designated Uses in the GT Bay Coastal Watershed

Pollutant or Environmental Stressor	Designated Uses Affected
Sediment	Coldwater Fishery Other Indigenous Aquatic Life
Nutrients	Coldwater Fishery Other Indigenous Aquatic Life Total/Partial Body Contact Public Water Supply
Thermal Pollution	Coldwater Fishery Other Indigenous Aquatic Life
Toxic Substances ***(Pesticides, Herbicides, Oils, Gas, Grease, Salt/Chlorides, Algal Toxins, Etc.)***	Coldwater Fishery Other Indigenous Aquatic Life Total/Partial Body Contact Public Water Supply
Changes to Hydrologic Flow	Coldwater Fishery Other Indigenous Aquatic Life
Invasive Species*	Coldwater Fishery Other Indigenous Aquatic Life Total/Partial Body Contact Public Water Supply
Pathogens **(*E. Coli* and Fecal Coliform indicators)**	Total/Partial Body Contact Public Water Supply
Loss of Habitat	Coldwater Fishery Other Indigenous Aquatic Life

Note: This is a general list that encompasses pollutants for the entire Grand Traverse Bay Coastal watershed.
**The National Invasive Species Information Center (https://www.invasivespeciesinfo.gov) defines an invasive species as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health."*

Emerging Contaminants of Concern

For the purposes of this watershed plan, we are including "Emerging Contaminants of Concern" with the Toxics environmental stressor category throughout the plan. Emerging contaminants are potentially harmful substances that have not yet been rigorously studied or have standards developed for water quality protection. They are often unregulated and are concerning because we do not yet know their fate in the watershed and the full extent of the risks they may pose to both humans and aquatic life and other wildlife. This nonpoint source watershed plan is not designed to address these contaminants.

Specific emerging contaminants of concern in the Grand Traverse Bay Coastal Watershed include:

1) **Per- and Polyfluoroalkyl Substances (PFAS)**
2) **Microplastics, Microfibers, and Microbeads**
3) **Pharmaceuticals and other Personal Care Products**

Per- and Polyfluoroalkyl Substances (PFAS)

Per- and polyfluoroalkyl substances, commonly known as PFAS, are a group of over 3,000 manufactured chemicals used in various industries around the world since the 1950s. Researchers, scientists, and public health officials have grown increasingly concerned with the threat that PFAS poses to our water, soil, wildlife, and humans. These chemicals are very persistent in the environment and in the human body and wildlife and can bioaccumulate over time, as well as move through the soils and seep into groundwater. There is evidence that exposure to PFAS can lead to adverse human health effects.

PFAS can be found in a wide variety of food packaging materials including fast-food wrappers, popcorn bags, and pizza boxes, as well as commercial products like nonstick cooking products, polishes, waxes, stain-resistant fabrics, water-resistant fabrics, cleaning products, fire-fighting foam, upholstery, carpets, rugs and fabric treated with flame-retardants.

The State of Michigan launched a multi-agency PFAS Action Response Team (MPART) in 2017 "to investigate sources and locations of PFAS contamination in the state, take action to protect people's drinking water, and keep the public informed as we learn more about this nationally emerging contaminant," (https://www.michigan.gov/pfasresponse). A statewide initiative was launched to test public water supplies and schools that use well water for PFAS. PFAS are not currently regulated under the Safe Drinking Water Act, however EPA has issued a health advisory level of 70 parts per trillion (ppt) for two classes of PFAS: perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). The State of Michigan has also adopted PFOS and PFOA cleanup criteria of 70 ppt for groundwater used as drinking water.

Microplastics, Microfibers, and Microbeads

Microplastics, microfibers, and microbeads are broadly defined as plastic particles less than five millimeters in size in any one dimension. They originate from hundreds of sources which include personal care products, synthetic clothing fibers, pre-production pellets and powders, and fragments degraded from larger plastic products. Microplastics can be found nearly everywhere in watershed ecosystems, including in living organisms such as freshwater fish and enter our waters through urban runoff, wastewater treatment effluent.

Most plastics do not biodegrade, but rather break down into smaller and smaller pieces until it is considered a microplastic. These pieces can accumulate in animals, humans, river and lake sediment, soils, and plants where they remain for a very long time. In addition to not being biodegradable, microplastics/microbeads can absorb pollutants that can pose a danger to aquatic life. Further, microbeads are about the same size as fish eggs which look like food to aquatic life. Adverse physical health effects to ingesting microplastics include digestive obstruction, impaired reproduction, and death. Chemical hazards such as the additives in plastic, can possibly lead to cancer or endocrine disruption in humans.

Microplastic pollution is extremely difficult to regulate since it comes from waste such as plastic bottles, bags, clothes fibers, balloons, toys, etc. that are not properly recycled or disposed of. The Microbead-Free Waters Act of 2015 banned the manufacturing of personal care products containing microbeads and banned the sale of personal care products containing microbeads by 2018.

Pharmaceuticals and other Personal Care Products

Another set of contaminants to watch include pharmaceuticals and personal care products. While these have been around a long time, their negative impacts to the environment are still unclear. They include things like antibiotics, pain killers, blood pressure medications, contraceptives, vitamins, toothpaste, shampoo, perfume, and makeup. For humans, once these items are ingested or applied to the body they can be excreted in waste or washed off the body, where they enter the wastewater stream via septic systems or municipal wastewater treatment plants. Most wastewater plants and septic systems do not remove pharmaceuticals or various chemicals from personal care products in their cleaning processes so these substances may end up in wastewater effluent into our lakes, streams, and groundwater. Additionally, pharmaceuticals can be found in animal waste from pets, livestock, or aquaculture farms. Runoff from these sources may find their way to groundwater and surface water as well.

When these products enter local waters, they may be taken up by fish and other aquatic organisms and enter drinking water sources. While the current risk to humans is unknown, we know that these products can impact the physiology of aquatic organisms, negatively impacting fish, birds, and other wildlife. There are many pharmaceuticals and personal care products that act as so-called endocrine disruptors (EDCs), which are compounds that alter the normal functions of hormones resulting in a variety of health effects. EDCs can alter hormone levels leading to reproductive effects in aquatic organisms. And, while these contaminants may demonstrate low acute toxicity, then can cause significant reproductive effects at very low levels of exposure. In addition, the effects of exposure to aquatic organisms during the early stages of life may not be observed until adulthood. Evaluating these effects may require testing methodologies not typically available or widely used. Increases in antibiotics in water may lead to antibiotic resistance; antimicrobial resistance has been found in some parts of the Great Lakes, leading to concerns that harmful bacteria will develop resistance to antibiotics.

Currently, there are no federal or state regulations regarding pharmaceuticals and personal care products. And no long-term health or environmental effect studies have been done on pharmaceuticals and chemical laced waters.

5.2 Sources and Causes of Water Quality Degradation

Through review of literature, existing water quality information, and input from the Steering Committee, numerous sources and causes of water quality degradation in the Grand Traverse Bay Coastal watershed have been identified. A Comprehensive Watershed Management Table was developed listing sources and causes of watershed pollutants and environmental stressors (Table 43). This table summarizes key information necessary to begin water quality protection, provides specific targets to act upon for watershed management, and forms the basis for all future implementation projects to protect the quality of the watershed. Sources and causes were identified using a wide variety of methods including: streambank erosion and road stream crossing inventories; physical inventories that note specific sources along stream reaches (such as locations of soil erosion, stormwater drains, presence of waterfowl, lawns mowed to edge of stream, etc.); review of existing subwatershed management plans; meetings with Steering Committee members; and personal contact with watershed residents and scientific experts on the Grand Traverse Bay watershed.

Grand Traverse Bay shoreline communities are also increasingly evaluating and planning for the potential impacts on water quality associated with climate change, including warming water temperatures, more frequent and severe storm events, increased stormwater runoff, drought conditions, and flooding. In this way, climate change could be considered a cause for the sources of pollutants/stressors in the watershed (Table 43). For example, increased storm events would increase stormwater volumes and outputs, resulting in more pollutants entering the watershed. Communities in the Great Lakes must prepare for these impacts and develop adaptation measures. The Watershed Center (TWC) was a partner in a Michigan Sea Grant Climate Change Integrated Assessment grant completed by Michigan State University. That project conducted an integrated assessment to help communities in the Grand Traverse region understand how climate knowledge can inform planning in a realistic way by evaluating the vulnerabilities and assessing strategies to increase resilience against anticipated climate change impacts. The assessment was able to quantify changes in temperature, precipitation, ice cover, lake levels, streamflow, and water quality, as well as project future conditions and assess the impacts of those changes. It also developed and assessed adaptive management strategies, such as the mitigation benefits of stormwater projects such as the ones TWC is currently conducting. The results of this study will help Grand Traverse Bay shoreline communities understand management options for adapting to climate change over time (Michigan Sea Grant N.d).

The Comprehensive Watershed Management Table (Table 43) may be used as a reference to distinguish what the major sources of pollutants are on a watershed-wide scale. However, they do not distinguish between pollutants and their sources and causes in individual subwatersheds. Not all of the pollutants listed are a problem everywhere in the watershed and there are differences among the coastal subwatersheds. Each one is unique in the challenges it faces to maintain water quality protection. For example, the Tobeco Creek watershed is mainly a wetland type area and does not contain much development. In contrast, the Mitchell Creek watershed, just a few miles down the bay, faces extreme pressure from future development. Each must face water quality protection measures in its own way. See Section 3.13 for a discussion of each subwatershed.

Table 43: Pollutants, Sources, and Causes to Water Quality Degradation in the Grand Traverse Bay Coastal Watershed

Environmental Stressor or Pollutant	Impaired or At Risk Use	Sources K = known, S = suspected, P = potential	Causes K = known, S = suspected, P = potential
Sediment	*Coldwater Fishery *Other Indigenous Aquatic Life	Road Stream Crossings (k)	Poor design/construction/maintenance (k) Lack of erosion/surface runoff controls (k) Steep approaches (k) Culverts not aligned to streambed (k) Undersized culverts (k) Failing/eroding culverts/bridges (k) Road sanding (k)
		Bank/Shoreline/ Channel Erosion (k)	Removal of riparian/aquatic vegetation (k) Boat traffic/wakes (k) High flow velocities (k) Recreational activities (k) Sandy soils (k) Higher water levels related to climate change and other human-related activities (k) Hardened shorelines (k) Stream channelization (k) Deforestation/urbanization (k) Undersized culverts (k) Wetland loss (k)
		Urban/Agricultural/ Rural Storm Water (k)	Inadequate storm water management practices (k) Climate change-related storm frequency and precipitation amounts (k) Snow storage piles (k)
		Soil exposed to stormwater runoff (k)	Improper landscaping or land use practices, lack of riparian vegetation (k) Poor soil erosion practices during construction (k)
		Livestock (p)	Unlimited access to streams (p) Proximity to streams and wetlands (p)
		Oil and gas well development (k)	Stream crossings for new access roads (k) Clearing for wellhead sites (k)
		Wetland Filling (k)	Inadequate storm water management practices (k) Non-compliance with permits (k) Development (k)
		Dams, Lake-level Control Structures (p)	Physical failures (p) Improper dredge spoil disposal (p)
**Special note: Nutrients often attach to soil particles, thereby linking sediment and nutrient pollution. Therefore, any sources of sediment from above may also be sources of nutrients as well.*			

Environmental Stressor or Pollutant	Impaired or At Risk Use	Sources K = known, S = suspected, P = potential	Causes K = known, S = suspected, P = potential
Changes to Hydrologic Flow	*Coldwater Fishery *Other Indigenous Aquatic Life	Fluctuating Water Levels (k)	Dams and lake-level control structures (k) Urban storm water runoff, (k) Loss of terrestrial vegetation (k) Climate change-related changes to precipitation amounts (p) Increased flashiness/extreme flow events (k) Deforestation/urbanization (k) Hardened stream channel (k) Invasive species clogging stream channels (s)
		Sedimentation (k)	Erosion and deposition (k) *(*See Sediment section above)*
		Road Stream Crossings (k)	Road crossing flow obstructions or restrictions (k)
		Loss of Flood Water Storage Capacity (k)	Loss of wetlands due to development and filling (k) Stream degradation causing floodplain reduction (k)
		Dams, Lake-level Control Structures (k)	Creation/removal of man-made dams (p) Changes in operation (p) Creation/destruction of beaver dams (k)
		Reduction of Groundwater Recharge (k)	Increasing develop. on recharge areas (k) Loss of terrestrial vegetation (k) Global warming (p) Climate change-related changes to precipitation amounts (p) Deforestation/urbanization (k)
Loss of Habitat	*Coldwater Fishery *Other Indigenous Aquatic Life	Development (including 're-development') (k)	Poor development and design practices (k) Lack of knowledge on impact (k) Inadequate laws or regulations (p) Lack of adequate enforcement (p) Habitat fragmentation (k) Wetland loss (k)
		Shoreline Erosion & Hardening (k)	Wave/ice action (k) High lake/river levels (k) Improperly designed/sited sea walls (k) Removal or lack of riparian vegetation (k)
		Conversion of forested areas to developed land uses (s)	Increasing local population without sufficient land use regulations in local zoning ordinances to protect high priority land protection areas (s)
		Sedimentation (k)	Erosion and deposition (k) *(*See Sediment section above)*
		Removal of in-stream wood and other vegetation (k)	Removal of habitat wood for aesthetic or navigational reasons (k) Climate change-related loss of tree species (ecological changes or pests/disease) (p)
		Native habitat out competed by invasive species (s)	Availability and preference for invasive perennials at nursery and landscaping stores (s) Lack of awareness and/or concern (s) Lack of restrictions on boat travel (s) *(*See Invasive Species section above)*

Environmental Stressor or Pollutant	Impaired or At Risk Use	**Sources** K = known, S = suspected, P = potential	**Causes** K = known, S = suspected, P = potential
Nutrients	*Coldwater Fishery *Other Indigenous Aquatic Life *Total/Partial Body Contact *Public Water Supply	Urban/Agricultural/ Rural Storm Water (k)	Inadequate storm water management practices (k) Development (k) Climate change-related storm frequency and precipitation amounts (k)
		Lack of Riparian Buffer (k)	Development (k) Clearing by landowner (k) Lack of adequate shoreline setbacks (k) Climate change-related loss of tree species (ecological changes or pests/disease) (p) Improper landscaping practices on private waterfront residential properties that leaves large amounts of biomass to decompose at the end of the growing season (s)
		Septic Systems (k)	Poorly designed, grandfathered, and sited (k) High density/age of systems (k) Lack of maintenance/inspections (k) Illicit connections (bypassing septic system) (p)
		Reduction of Wetlands (k)	Development and filling (k)Stream degradation causing floodplain reduction (k)
		Agriculture (p) (fertilizer, manure, & livestock)	Improper manure and fertilizer application (amt., timing, freq., location) (p) Improper storage/handling/application (p) Close proximity to Bay/Tributaries (p) Grazing near stream edge (p)
		Animal Waste (k)	Geese/ducks along shore & beach areas (k)
		Decomposition (k)	Cemeteries (p) Dead salmon in streams after spawning (k) Excessive yard waste getting into waterways (k)
		Air Deposition (k)	Vehicle combustion (k) Industrial, commercial, municipal, agricultural facilities (k) Meteorological events (smoke from fires out west, dust storms in south, etc.)
		Residential or Commercial Fertilizer Use (k)	Improper application (amount, timing, frequency, location, method, P content) (k)
		WWTP (p)	Discharge of nutrients in waste water (p)

Environmental Stressor or Pollutant	Impaired or At Risk Use	Sources K = known, S = suspected, P = potential	Causes K = known, S = suspected, P = potential
Toxic Substances **(Pesticides, Herbicides, Oils, Gas, Grease, Etc.)**	*Coldwater Fishery *Other Indigenous Aquatic Life *Total/Partial Body Contact *Public Water Supply	Urban/Agricultural/ Rural Storm Water (k)	Poor storm water management practices (k) Infiltration to groundwater from improper storage and over use (p) Climate change-related storm frequency and precipitation amounts (k)
		Improper Chemical Use and Disposal (s)	Poor public knowledge of consequences (s) Lack of disposal facilities and/or limited hours of operation (s) Lack of restrictions and enforcement (s)
		Road Salt and Airport De-icing in Winter (k)	Runoff from roads and airport de-icing (k)
		Industrial/Municipal Discharges (k)	Discharge limit violations (k) Contaminated sediments (k)
		Contaminated Sediments/ Groundwater (k)	Historical spills, disposals, discharges (k) Use of fire-fighting foam containing PFOAs (p)
		WWTP discharge (k)	Technology to treat/remove not available (k)
		Underground Storage Tanks (p)	Leaking tanks (p)
		Motor Boats (k)	Inefficient (2cycle) or poorly maintained watercraft motors (k) Fuel spills (p)
		Decomposition (k)	Cemeteries (p) Dead salmon after spawning (k) Excessive yard waste (k)
		Invasive Species (k)	Refers to invasive species that exude toxins *(*See Invasive Species section above)*
		Oil, Gas, Hydrocarbon, and Underground Injection Wells (p)	Maintenance (p), Accidents (p), Brine Storage (p) Abandoned Wells (leaking, uncapped) (p) Natural Gas Fracking operation (p), Inadequate fracking fluid storage (p)
		Water Wells (p)	Abandoned wells (leaking, uncapped) (p)
		Atmospheric Deposition (k)	Vehicle combustion (k) Industrial, commercial, municipal, agricultural facilities (k) Meteorological events (smoke from fires out west, dust storms in south, etc.)

Environmental Stressor or Pollutant	Impaired or At Risk Use	Sources K = known, S = suspected, P = potential	Causes K = known, S = suspected, P = potential
Pathogens (***E. Coli*** **and Fecal Coliform indicators)**	*Total/Partial Body Contact *Public Water Supply	Urban/Agricultural/ Rural Storm Water (k)	Poor storm water management practices (k) Climate change-related storm frequency and precipitation amounts (k)
		Animal Waste (k)	Geese/ducks along shore & beach areas (k) Riparian Grazing (p) Livestock crossings/access to streams (s) Poorly managed livestock operations adjacent to water bodies (p)
		Septic Systems (p)	Poorly designed, grandfathered, and sited (k) High density/age of systems (k) Lack of maintenance/inspections (k) Illicit connections (bypassing septic system) (p)
		WWTP/Sanitary Sewer System (p)	Uncontained leaks, spills, accidents (p) Regulated discharge (p) Accidental sewer line break (p) Illicit connections to storm sewers (p)
		Illegal Discharges from Boats (p)	Lack of enforcement (p) Lack of public knowledge on impact (k)
		Contaminated animals i.e fish with Viral Hemorrhagic Septicemia (s)	Pet/Bait release (s)
Invasive Species	*Coldwater Fishery *Other Indigenous Aquatic Life *Public Water Supply *Total/Partial Body Contact	Anthropomorphic introduction. (k)	Lack of restrictions on boat travel, awareness and/or concern, resources for proper disposal, enforcement of existing regulation (k) Not properly cleaning boats and other equipment between lakes (k) Development in wetlands and undisturbed habitat (p) Intentional release (k) Changes in suitable habitat and species migration range related to climate change (p)
		Landscaping/ Aquascaping practices (k)	Availability and preference for invasive perennials at nursery and landscaping stores (k) Lack of awareness and/or concern (s) Abandoned agricultural fields (k)
		Other Biota (i.e. birds, frogs) (k)	'Hitching' a ride (k)
Thermal Pollution	*Coldwater Fishery *Other Indigenous Aquatic Life	Urban/Agricultural/ Rural Storm Water (k)	Poor storm water management practices (k) Increased development (k) Climate change-related storm frequency and precipitation amounts (k)
		Lack of Streamside or Shoreline Canopy (k)	Development (k) Clearing by landowner (k) Climate change-related loss of tree species (ecological changes or pests/disease) (p)
		Sedimentation in stream channel (s)	*(*See Sediment section above)*
		Ponds, impoundments, and other water control devices (k)	Top draw structures (k) Hydrology – low flows at times (k) Poor maintenance (p)

5.3 Priority Pollutant Ranking

Watershed pollutants and environmental stressors were ranked and prioritized based on how they most affect (or have the potential to affect) the watershed's "at risk" designated uses (Tables 44-45). The ranking also took into account priorities from the 2005 Grand Traverse Bay Watershed Protection Plan, which ranked all pollutants/stressors and differentiated between the watershed and the bay.

For the Grand Traverse Bay Coastal Watershed Plan, the Steering Committee chose to note the top four most important pollutants and environmental stressors on a watershed-wide scale rather than numerically rank anything. These top four pollutants and stressors are (in alphabetical order): Changes to Hydrologic Flow, Loss of Habitat, Nutrients, Sediment.

<u>Top Four Priority Pollutants/Stressors:</u>

- **Changes to Hydrologic Flow**
- **Loss of Habitat**
- **Nutrients**
- **Sediment**
- **<u>Pathogens</u> for locations with noted impairments.**

Additionally, pathogens are a noted priority pollutant for the Mitchell Creek, West Bay Shoreline, and East Bay Shoreline subwatersheds due to existing *E. coli* impairments (Table 40).

Changes to hydrologic flow, mainly due to stormwater inputs are a concern throughout the coastal watershed as much of the development is located along the Bay's shoreline. Additionally, all of the stream systems that make up the Coastal Watershed area are small in size and changes to hydrologic flow may severely impact their natural stream function. Along with hydrologic changes, stormwater may carry an excessive amount of nutrients, sediments, and toxins to the bay and its tributaries.

Nutrient levels are elevated at some river mouths, but not generally high throughout the entire coastal watershed tributaries. Maintaining the low productivity and oligotrophic status for Grand Traverse Bay will require minimizing the amount of nutrient pollution that enters the lake from adjacent properties and tributaries. And, even though the bay is oligotrophic and low in nutrients overall, excessive nutrient loading is still a threat, especially to the shallow, near shore areas along the bay where excessive nutrients have already caused increased algae and plant growth. As the nutrients get washed out into the deeper bay areas, there is some dilution; therefore nutrient levels still remain low. However, if excessive inputs of nutrients continue, nutrient levels in the deeper, open water areas of the bay could increase, causing drastic and harmful changes to the bay's ecosystem. Additionally, excessive nutrients may accumulate in the sediment lining the bottom of the bay, causing sharp increases in plant growth.

As stated previously, nutrients often attach to soil particles, thereby linking sediment and nutrient pollution. Sediment is a priority pollutant in the coastal watershed areas due to streambank erosion and the resulting impacts to aquatic habitat in the small streams along the bay.

Development pressure has continued to increase over the past 15 years, and loss of habitat is a key problem that coastal area must recognize. Historic wetland losses shown in Table 13 in Section 3.5 are substantial.

Priority Pollutants to Great Lakes and Grand Traverse Bay Open Water

Grand Traverse Bay is in Lake Michigan and is part of the Great Lakes system and thus has differing priorities for pollutants and environmental stressors than the land-based area that makes up the coastal watershed. It is important to realize that the bay and its watershed are connected, but inherently different. While the watershed itself encompasses rivers, streams, lakes, and hundreds of square miles of land, the bay is a large open body of water that is connected to the Great Lakes. Certain pollutants have more of an impact on streams and lakes than on larger bodies of water like Grand Traverse Bay (i.e., thermal pollution and sediment), while other pollutants are more of a concern for the Grand Traverse Bay. The Steering Committee also identified two priority environmental stressors to Grand Traverse Bay itself – invasive species and toxic substances (including emerging contaminants). Additionally, as discussed above, elevated nutrients in the nearshore area may cause localized problems in the bay.

Top Pollutants/Stressors to GRAND TRAVERSE BAY:

- **Invasive Species**
- **Toxic Substances**

Another key point to remember is that the East Arm of Grand Traverse Bay is the main source of drinking water for Traverse City, and any water degradation could put the Public Water Supply designated use at risk.

More information on issues and pollutants of concern for Lake Michigan can be found on the EPA's website titled "Lakewide Action and Management Plans for the Great Lakes." Lakewide Action and Management Plan (LAMP)s are plans of action to assess, restore, protect and monitor the ecosystem health of each Great Lake and its connecting river system. It coordinates the work of all the government and non-government partners working to improve the lake's ecosystem. A public consultation process ensures that the LAMP is addressing the public's concerns.

Prioritized Pollutants for At Risk Designated Uses

Each pollutant has a different effect on the "at risk" designated uses for the Grand Traverse Bay Coastal watershed (Table 44). For example, large amounts of bacteria in the water make the water unsafe for swimming and total body contact, but bacteria has little if any effect on the coldwater fishery. Table 44 shows each "at risk" designated uses for the Grand Traverse Bay Coastal watershed and the specific environmental stressor that may affect it, as well as a prioritized ranking.

Table 44: Pollutant Priorities for At Risk Designated Uses
Grand Traverse Bay Coastal Watershed

At Risk Designated Use	Pollutant or Environmental Stressor	Priority Ranking
Coldwater Fishery	Sediment Changes to Hydrologic Flow Loss of Habitat Thermal Pollution Nutrients Toxic Substances Invasive Species	1 2 3 4 5 6 7
Other Indigenous Aquatic Life	Sediment Changes to Hydrologic Flow Loss of Habitat Invasive Species Thermal Pollution Nutrients Toxic Substances	1 2 3 4 5 6 7
Total/Partial Body Contact	Pathogens Nutrients Toxic Substances Invasive Species	1 2 3 4
Public Water Supply	Invasive Species Toxic Substances Pathogens Nutrients	1 2 3 4

The project Steering Committee noted that it is difficult to rank all the pollutants and environmental stressors in the watershed because all are important and should be priorities for maintaining the health of the bay. The pollutant ranking really depends on which area of the watershed is analyzed. In some places, sediment may be the biggest threat, while in others it could be pathogens. Almost always, the pollutants and stressors are interconnected with each other and changes in one causes changes to the others. For instance, increasing the hydrologic flow in a stream could increase the amount of sedimentation and erosion, which may then increase thermal pollution and the amount of nutrients entering the system. Additionally, losing valuable habitat in a stream could itself be the result of excessive sedimentation and subsequently affect the amount of nutrients and toxins entering the stream, as well as pave the way for invasive species to populate the area.

Prioritized Sources for Each Pollutant

The project Steering Committee has decided that the specific sources for each pollutant and stressor are the most important items to rank and prioritize in this protection plan because that is where one can actually stop pollution from entering waterways (Table 45). Additionally, as noted above, because most of the pollutants and stressors are interconnected, dealing with one source and its causes could actually reduce a number of different pollutants and stressors from affecting a stream or waterbody.

Table 45: Pollutant Source Priority Ranking

Environmental Stressor or Pollutant	Sources	Priority Ranking
Sediment	Road Stream Crossings (k)	1
	Bank/Shoreline Erosion (k)	2
	Urban/Agricultural/Rural Storm Water (k)	3
	Soil exposed to stormwater runoff (k)	4
	Livestock (p)	5
	Oil and gas well development (k)	6
	Wetland Filling (k)	7
	Dams, Lake-level Control Structures (p)	8
Changes to Hydrologic Flow	Fluctuating Water Levels (k)	1
	Sedimentation (k)	2
	Road Stream Crossings (k)	3
	Loss of Flood Water Storage Capacity (k)	4
	Dams, Lake-level Control Structures (k)	5
	Reduction of Groundwater Recharge (k)	6
Loss of Habitat	Development (k)	1
	Shoreline Erosion and Hardening (k)	2
	Conversion of forested areas to developed land uses (s)	3
	Sedimentation (k)	4
	Removal of in-stream wood and other vegetation (k)	5
	Native habitat out competed by invasive species (s)	6
Nutrients	Urban/Agricultural/Rural Storm Water (k)	1
	Lack of Riparian Buffer (k)	2
	Septic Systems (s)	3
	Reduction of Wetlands (k)	4
	Agriculture (p) (fertilizer, manure, & livestock)	5
	Animal Waste (k)	6
	Decomposition (k)	7
	Air Deposition (k)	8
	Residential/Commercial Fertilizer Use (k)	9
	Wastewater Treatment Plants (p)	10

Environmental Stressor or Pollutant	Sources	Priority Ranking
Toxic Substances (Pesticides, Herbicides, Oils, Gas, Grease, Etc.)	Urban/Agricultural/Rural Storm Water (k)	1
	Improper Chemical Use/Disposal (s)	2
	Road Salt and Airport De-Icing in Winter (k)	3
	Industrial/Municipal Discharges (p)	4
	Contaminated Sediments/ Groundwater (k)	5
	WWTP discharge (k)	6
	Underground Storage Tanks (p)	7
	Motor Boats (k)	8
	Decomposition (k)	9
	Invasive Species (s)	10
	Oil, Gas, Hydrocarbon & Underground Injection Wells (p)	11
	Water Wells (p)	12
	Atmospheric Deposition (k)	13
Pathogens *(E. Coli and Fecal Coliform indicators)*	Urban/Agricultural/Rural Storm Water (k)	1
	Animal Waste (k)	2
	Septic Systems (p); Wastewater Treatment Plants (p); Sanitary Sewer Systems (p)	3
	Illegal Discharges from Boats (p)	4
	Contaminated animals (i.e fish with Viral Hemorrhagic Septicemia) (s)	5
Invasive Species	Anthropomorphic introduction (k)	1
	Landscaping/ Aquascaping practices (k)	2
	Other Biota (i.e. birds, frogs) (k)	3
Thermal Pollution	Urban/Agricultural/Rural Storm Water (k)	1
	Lack of Streamside and Shoreline Canopy (k)	2
	Sedimentation in stream channel (s)	3
	Ponds, impoundments, and other water control devices (i.e. dams) (k)	4

5.4 *A Note About Stormwater*

One of the major pathways by which many types of pollutants get to lakes and streams is through stormwater runoff. Stormwater runoff results when drops of rain fall to the ground, or snow melts, and the resulting water that does not infiltrate into the ground flows over the surface of the land. This stormwater flow often dislodges and carries soil or sediment particles (causing streambank erosion in some places) to which many pollutants are attached. The stormwater flow may also directly move the pollutant itself (i.e., garbage, oils, grease, gas, pesticides, etc.). The amount of stormwater runoff that occurs is dependent upon a variety of conditions including storm intensity and duration, topography, time of year, soil moisture levels, soil permeability, vegetative cover types, the extent of vegetated cover, and the amount of impervious surfaces.

Road and roof runoff are two sources of stormwater.

Urban locations, like Traverse City, Elk Rapids, and Suttons Bay, often produce greater amounts of stormwater flow due to the increased amount of impervious surfaces in these urban areas relative to more rural settings within the watershed. Impervious surfaces are those areas on land that cannot effectively absorb or infiltrate rainfall or snowmelt. Areas such as these may include roads, streets, sidewalks, parking lots, and rooftops. Research suggests that there is a threshold to the amount of impervious cover that can occur within a watershed at which the degradation of aquatic systems occurs. Findings reveal that stream degradation consistently occurs when impervious surface levels in a watershed reach between 10-20% (CWP 1994).

TWC completed a rough impervious surface assessment of several urban locations along the Grand Traverse Bay shoreline using a 2003 guidebook published by the Huron River Watershed Council as reference (HRWC August 2003 – Part III Calculating Impervious Surface Capacity). This process uses land uses and associated "impervious coefficients" to calculate an estimate of the percent imperviousness for each area (impervious coefficients used from Table III-1 from publication). Impervious surface percentages were calculated for the Villages of Northport, Suttons Bay, Elk Rapids, as well as for the City of Traverse City and Greilickville (Table 46). Results show that all of these urban areas have impervious surface levels about the 10% threshold note previously, with some approaching 40%.

Table 46: Percent Impervious Surface for Select Urban Locations

Urban Area	Percent Impervious (estimated)
Village of Northport	12%
Village of Suttons Bay	21%
Greilickville	39%
City of Traverse City	38%
Village of Elk Rapids	29%

Stormwater entering the Bay and its tributaries from storm drain outlets contributes a significant amount of pollution. However, runoff may also enter waterways through ditches and other overland sources, as well as at road stream crossings. When added up, inputs from all these small, single inputs of stormwater can result in a massive amount of pollution entering Grand Traverse Bay. Most often the pollution coming from these storm drains is at its worst during heavy rain and snowmelt events.

Data from the Rouge River National Wet Weather Demonstration Project (Cave et al. 1994) in Southeast Michigan present the typical pollutant concentration in stormwater from various land uses (Table 47). As expected, developed land uses (such as residential and commercial) and impervious surfaces (i.e. roads) have noticeable higher concentrations of pollutants compared to forest and open spaces.

Table 47: Typical Stormwater Pollutant Concentrations from Land Uses in SE Michigan

Land Use	Pollutant (mg/L)			
	Total Phosphorus	***Total Nitrogen***	***Total Suspended Sediment***	***Lead***
Road	0.43	1.82	141	0.014
Commercial	0.33	1.74	77	0.049
Industrial	0.32	2.08	149	0.072
Low Density Residential	0.52	3.32	70	0.057
High Density Residential	0.24	1.17	97	0.041
Forest	0.11	0.94	51	0.000
Urban Open Space	0.11	0.94	51	0.014
Pasture, Agriculture	0.37	1.92	145	0.000

(Source for data in table: Cave et al., 1994)

Stormwater runoff from coastal urban areas along the Grand Traverse Bay shoreline can also cause localized elevated levels of nutrients in the nearshore area compared to the lower levels seen offshore. The effect of the nutrient inputs on the nearshore zone of west Grand Traverse Bay can be seen in a 2009 study TWC conducted on macrophyte bed growth in the bay (TWC 2010). TWC conducted aquatic plant surveys in Grand Traverse Bay in 1991, 1998, and 2009, and completed a variety of water and sediment testing for nitrogen and phosphorus at locations with and without macrophyte beds and the mouths of several tributaries to the bay. These surveys showed a six-fold increase in the number of plant beds identified between 1991 and 2009 (1991: 64 beds; 1998: 124 beds; 2009: 402 beds). Most of the macrophyte beds were concentrated in embayments, such as Northport and Omena bays, as well as the southern end of west Grand Traverse Bay, where the Boardman River drains (Figure 15). This growth is attributed to rapid development and nutrient flushing from stormwater inputs, particularly the amount of phosphorus entering the bay.

Stormwater also contributes directly to thermal pollution. As stormwater runs over the land, it can be warmed by the land surface and may cause significant increases in water temperatures when it is deposited into a stream or other body of water. Spikes of warm temperatures in streams can be fatal to fish and other aquatic life.

Harmful bacteria and pathogens like *E.coli* are also carried to waterbodies via stormwater. Many urban areas see spikes in bacterial levels in nearby recreational waters after rain events. This is discussed at length in the "Pathogens" section below.

Any reductions to stormwater flow, as well as better management of stormwater, will decrease the amount of sediment, nutrients, thermal pollution, toxins, and pathogens that enter area waterbodies.

City of Traverse City

Due to a high amount of impervious surfaces, the City of Traverse City generates the largest amount of stormwater input to Grand Traverse Bay during rain and snow melt events and city officials there consider stormwater to be a high priority issue. The City has approximately 50 stormdrain outlets that empty into Kids Creek, the Boardman River, and Grand Traverse Bay. As noted previously, Kids Creek is on the State's Impaired Waters List and experiences severe changes in flow due to stormwater inputs during rain events. The creek exhibits signs of flashiness and causes regular flooding upstream of a number of culverts within the city limits. This flashiness has led to scoured stream bottoms and increased sedimentation (from eroding stream banks) within the stream. This is one of the main reasons that Kids Creek is said to be in "nonattainment" (see Section 4.2). Stormwater issues in Kids Creek and the Boardman River are discussed in further detail in the Boardman River Watershed Prosperity Plan (TWC and PSC 2016). However, since the city has a number of outlets that empty directly into Grand Traverse Bay, stormwater issues will be discussed here as well.

The City of Traverse City completed a Stormwater Management Plan for their stormdrain system in 2017 as part of a MDEQ Stormwater, Asset Management, and Wastewater (SAW) grant. The final report identified baseline conditions, evaluated open water channels (Kids Creek and Boardman River), conducted a capacity analysis for the open channels, identified water quality concerns, and developed a Capital Improvement Plan to address problems (TC 2017). TWC assisted with this plan and it is available on the city's website at: http://www.traversecitymi.gov/downloads/final_compiled_2017_stormwater_management_report.pdf.

The report outlines a comprehensive list of actions/projects to reduce the impact of stormwater in Kids Creek, along with other restoration activities designed with the ultimate goal of getting it removed from the Impaired Waters List. Additionally, the Capital Improvement Plan (CIP) states that, "…the City's main focus with regard to stormwater quality should be with reducing total phosphorus (TP) and *E.coli* while increasing the quantity and quality of stormwater sampling. With this in mind, all applicable future projects, public and private, should consider the use of BMPs and green infrastructure to improve water quality within the City. All projects need to consider operational and maintenance requirements and cost. Projects need to consider available maintenance equipment and trained staff," (TC 2017).

The CIP also states:

> "Along with the general maintenance and upkeep of stormwater quality utilities, municipalities should have a number of environmental stewardship programs in place.

Environmental stewardship programs are programs aimed to increase the quality of the environment and prevent higher cost maintenance and environmental concerns down the road. These programs are sometimes a collaborative effort between the City and property owners, such as leaf pickup, or are the sole responsibility of the City, such as catchbasin cleanout. The City of Traverse City currently has a number of environmental stewardship programs in place. These programs include:

- Fall Leaf Pickup: To reduce the amount of leaves entering the storm system and to prevent the clogging of catchbasin inlets and storm sewers.
- Spring Cleanup: To reduce the amount of organic matter entering the storm system, which clogs existing treatment systems and can lead to algae plumes.
- Annual Clean Up and Green Up Recycling Event: Residents may bring a number of items to be recycled, repurposed, or reused to a designated location in the City for collection, free of charge.
- Street Sweeping: To reduce the amount of road sediment and debris from entering the storm system during rain events.
- Catch Basin Cleanout: To remove suspended solids including nutrients, pathogens and toxins, which was demonstrated to be effective in reducing overall pollutant loading associated with solids via stormwater. The City invests $270,000 to $350,000 annually towards street sweeping, catch basin cleaning, and cleaning water quality treatment systems."

Considerations for prioritization of sites to receive stormwater quality improvements within the City of TC should include attention to areas that are:

- Near public beaches and parks
- Adjacent to surface waters
- Known for water quality issues
- In Central Business Districts
- Easily funded by grants

As part of the Stormwater Management Plan, TWC also summarized available water quality sampling results from the city's stormdrains from several available reports. Water quality results from a select number stormdrains in the City from 2009-2015 were averaged from 10 locations for Nitrate, Total Phosphorus (TP), and Total Suspended Solids (TSS). Results were as follows:

- TP average = 0.10 mg/l (100ug/L)
- Nitrate average - 0.47 mg/L
- TSS average = 96 mg/L.

Data sources are from TWC-led studies including stormdrain testing program with City of Traverse City funds (2009), GLRI Project at Bryant Park (2011/2012), and BMP effectiveness testing at GLRI East Bay Park project (2013-2015).

Comparisons of stormwater results were also made on select storm drains with data from the 1990s to more recent results from 2009-2015. At these select sites Nitrates appear to have increased since the 1990s, TP has decreased, TSS was inconclusive (Table 48).

Table 48: Stormwater Pollutant Concentrations from Five Storm Drains in Traverse City (Historic: 1991, 1992, 2000; Recent: 2009-2015)

Location	timeframe	Nitrate (mg/L)	TP (mg/L)	TSS (mg/L)
8th Street	Historic	0.01	0.27	30
	Recent	0.56	0.1	49
Bryant Park	Historic	0.10	0.20	43
	Recent	0.66	0.08	68
East Bay Par (north)	Historic	0.29	0.56	76
	Recent	0.29	0.12	47
East Bay Park (south)	Historic	4.5	0.20	n/a
	Recent	n/a	0.09	145
Hannah Park	Historic	0.01	0.46	91
	Recent	0.42	0.095	59

Data sources are from Shuey et al 1992; GLEC 2001;City of TC 1992; and TWC-led studies including stormdrain testing program with City of Traverse City funds (2009), GLRI Project at Bryant Park (2011/2012), and BMP effectiveness testing at GLRI East Bay Park project (2013-2015).

However, it should be noted that caution should be taken when comparing stormwater results from locations where only grab samples were taken. Grab samples are taken once during a rain event and represent a snapshot in time of the water quality at that particular storm drain. During rain events there are typically fluctuating volumes of water and concentrations of different types of pollutants coming out of a drain, which in turn will affect the pollutant load coming out of each drain (pollutant load calculated by multiplying volume by concentration). The higher the concentration of pollutant or the volume of water coming out of the drain, the higher the pollutant load will be. Only thorough sampling during multiple rain events will lead to a clear picture of pollutant loadings to a watershed. Care should be taken not to make broad assumptions on stormwater quality in an urban area based solely on grab samples taken at a particular time during a rain event.

Water quality results from surrounding waters in the Boardman River and Grand Traverse Bay reveal much lower levels of TP and Nitrogen than those found in Traverse City stormwater samples. In general we are most concerned with Phosphorus levels in local waters because it's the growth limiting nutrient for the bay. This is because nitrogen/phosphorus ratios exceed 10:1 in Grand Traverse Bay and therefore Phosphorus input will drive plant growth. In general, TP values greater than 0.01 mg/L (10 ug/L) in water bodies such as lakes and rivers are indicative of impaired water quality and contribute to increased plant growth. As shown in Chapter 3.9, average phosphorus levels in Grand Traverse Bay are 0.005 mg/L (5 ug/L), which are well below that threshold and indicate excellent water quality and oligotrophic conditions. In contrast, TP values in storm drains range between 0.03 - 0.2 mg/L, with an average of about 0.1 mg/L (see table above). This is an average of twenty times higher than water in Grand Traverse Bay.

Other Coastal Communities

While Traverse City generates a significant amount of stormwater due to its highly urbanized areas, there are other coastal communities along Grand Traverse Bay that contribute stormwater inputs as well. These are the Villages of Northport, Suttons Bay, and Elk Rapids, along with Acme Township and Elmwood Township (Greilickville).

Between 2009-2014, TWC completed broad-scale stormwater assessments for each of these communities and drafted ***Stormwater Action Plans*** for them. The purpose was to help those local governments begin to address pollution stemming from stormwater runoff in their communities in order to protect water quality. The assessments were twofold: 1) identify major points of stormwater entry to waterbodies, and 2) identify and prioritize best management practices (BMPs) that could be implemented to strategically manage stormwater runoff. This included noting potential sites for green infrastructure installation projects (Table 49).

Some items for general management considerations for communities with Action Plans include:

- Use Phosphorus-free fertilizers on village property (on areas currently being fertilized)
- Install porous pavement where possible: paver stones, porous concrete
- Consider, for large parking areas (i.e. marina and school lots), installing infiltration islands to direct runoff into
- Routinely remove sediment from catch basins
- Maintain existing curb cutouts by removing excess vegetation and sediment deposits for increased drainage effectiveness (see photo at right)
- Where businesses, developments, and the municipality have ditches for stormwater control that are planted with grass, consider vegetating them with native plants to increase water infiltration and add attractiveness (see photos below).

Curb cutouts to be cleaned out (above)
Grassy stormwater basins that could be converted to rain gardens (left-below)

Table 49: Summary of Stormwater Action Plans for Coastal Communities

Community	Major Findings from Stormwater Action Plan
Village of Northport 2010	• Smith Ave Drain – excessive erosion at outlet, getting into coastal wetland • Village office – parking lot catch basin discharges directly to Northport Creek • Parking Lot and Road Runoff – no stormdrain system along major village roads, even downtown; could be diverted into rain gardens or bioswales • Excessive sand use in winter – road sweeping is crucial • Northport Creek – significant runoff entering at road crossings • *Received funding and completed two projects to date* o *Smith Ave Drain* o *Nagonaba Street (tree boxes and underground infiltration trench)*
Village of Suttons Bay 2011	• Three major storm drains responsible for draining a significant portion of the stormwater generated in the downtown and surrounding area of the village, empty at or near public beaches – recommended some type of green infrastructure BMP or an end of pipe treatment (see note below) • Suttons Bay Yacht Club and Port Sutton – buffer along shoreline, rain garden at storm outlets, rain gardens in upper drainage area • Various locations where grassy basins could be converted to rain gardens/biodetention basins • Waterwheel Creek and M22 crossing – vegetated buffer along creek • *TWC received funding and completed a large-scale stormwater reduction project at all three stormdrains in village – 18 rain gardens and 3/4mile of underground infiltration trench installed* • *Currently working on restoration plan for Waterwheel Creek*
Greilickville (Elmwood Twp) 2011	• Focused only on M22 corridor from M72 at south end to Cherry Bend Road on north end, western boundary at TART trail • Most runoff from M22 highway and commercial businesses • Greilickville Harbor Park has existing GI stormwater practices • Elmwood Twp Marina and GT Yacht Club have major direct sources of stormwater input to bay • Numerous areas found where biodetention basins could go
Acme Twp 2013	• 3 major MDOT drain outlets, most stormwater is being directed to those drains • Action plan development combined with a local placemaking discussion looking at future potential uses to Acme's US31 corridor; suggested stormwater BMP improvements where possible • MDOT Roadside Park – small buffer recommended between parking lot and grassy picnic area • Bunker Hill Road End Boat Launch – severe gully erosion, MDOT drain; recommendation to stabilize outlet and add canoe/kayak launch • Bunker Hill Intersection and Businesses – ditches to bioswales, infiltration islands • Acme Bayside Park – occasional *E. coli* issues; Suggested stormwater management features for the park as planned including rain gardens or parking lot infiltration, islands for parking lot runoff, porous pathways; Natural shoreline buffer suggested • *Township demolished Mountain Jack's site and put land into protection*

Community	Major Findings from Stormwater Action Plan
Village of Elk Rapids 2014	• Runoff considered in Bass Lake, Elk Lake, Elk River, and GT Bay • Consider "Catch Basin Conversion" - Where no curbs and gutters exist and stormdrain inlets are grates flush with the ground, convert the surrounding area to a rain garden by excavating around the inlet and planting the basin; runoff will sheet flow into rain garden and overflow to existing storm system once garden fills up • Consider "Catch Basin Diversion" – Where a curb and gutter system is in place with curb cutouts to storm drain catch basins, a rain garden could be installed with inlets to it located upstream of the runoff into the storm system (see examples from Suttons Bay below). As rain gardens will up, water will start bypassing the garden and go straight to existing catch basins. Would work well in downtown area. • Areas of rock lined detention basins could be converted to rain gardens to increase infiltration capacity • Spruce Street drain outlet – convert to biodetention basin/wetland • Noble/Cedar Street Parking Lot – utilize green infrastructure such as infiltration island or pervious pavement • Marina – Build bioswale along west side

Photos from Stormwater Action Plan for Elk Rapids:
Right – Spruce Street Drain
Below – Example of potential "Catch Basin Conversion"

5.5 *Pollutants of Concern*

Sediment

Sediment is fine inorganic soil or sand particles and sedimentation is the process whereby sediment is deposited in a stream or lake bottom. It occurs naturally in all stream and lake environments due to land erosion by wind and water. However, excessive sedimentation can severely degrade an entire riparian system (Waters 1995) and has been identified as a major cause of degradation to aquatic life in many Michigan streams and rivers. Excessive sediment deposition in many of Michigan's streams also severely impacts the amount of suitable habitat needed to support healthy and diverse communities of fish and other aquatic organisms. When sediment enters a stream it covers gravel, rocky, and woody habitat areas, thereby leading to decreases in habitat diversity and aquatic plant production. Sedimentation caused by streambank erosion may increase channel widening and cause changes in stream water temperatures.

Significant sources of sediment to streams include activities that cause streambank erosion such as transportation crossings (roads, railroads tracks, trails), increased flow levels (rapidly changing stream levels), and other land use activities including removing streamside vegetation, users entering and exiting the river, recreational trails that cross streams, and historic logging practices. Other sources are clearing land for agriculture, development, or other purposes. This also creates a host of other erosion related problems including flooding, polluted runoff, loss of topsoil from surface runoff, and a reduction in fisheries and channel depth. Any kind of excavation, earth moving, drainage, bridging, tunneling, or other activity in which soil is disturbed can result in sediment transport to nearby streams. Alexander and Hansen (1988) report that increases in sediment erosion from development are detrimental to aquatic communities. Increased sediment loads from development activities may also continue past the construction phase due to the resulting increase in stormwater runoff from newly created impervious surfaces. Roads, rooftops, and parking lots are examples of impervious surfaces that replace rural and forested land during development. Development may result in decreased water-retention capacities, increased flood frequencies, and rapid filling of stormwater detention systems.

During construction, vegetation is cleared and the development site is graded to prepare for construction. With the trees and topsoil removed, soils are particularly susceptible to erosion. Photo Copyright 2000, Center for Watershed Protection

Agricultural grazing on or near streambanks is known to cause a significant increase of sediment in streams. Most effects of grazing in riparian areas include bank degradation, loss of vegetation, and compaction of soils that leads to overland flow and severe erosion. This in turn causes increased deposition on the streambed, channel widening, and mass bank failures, especially during storm events.

Sediment is identified as a major pollutant present in the Coastal Grand Traverse Bay watershed based on field inspections and inventories conducted throughout the watershed, as well as through existing research and historical evidence. Significant known sources of sediment include streambank and channel erosion, road/stream crossings, stormwater, livestock (from unlimited access to streams), and construction zones.

Road Crossing and Streambank Erosion Inventories

Conducting inventories to determine the severity of erosion at road stream crossings and along streambanks is a common way to calculate potential sediment loading to streams. Depending on the severity and number of erosion sites and road stream crossings, a significant amount of sediment, and, subsequently, phosphorus and nitrogen may be released into river systems. There are over 500 road stream crossing sites in the entire Grand Traverse Bay watershed. The vast majority of those are located in the Boardman River and ERCOL subwatersheds, and a thorough discussion of them, as well as stream bank erosion sites, is found in their corresponding watershed plan.

Road stream crossings, like this one shown on the Rapid River in Kalkaska County, are a common source of sediment to streams. Photo courtesy of the Kalkaska Conservation District

All of the Coastal Grand Traverse Bay watershed road stream crossings were surveyed and updated in Summer 2020 (West Bay Shoreline Tributaries, East Bay Shoreline Tributaries, and Mitchell, Acme, Tobeco, and Yuba Creeks) by the Conservation Resource Alliance. Old Mission Peninsula was not surveyed because that subwatershed does not have any road stream crossings. Results are found on the http://www.northernmichiganstreams.org/gtbayws.asp website for review.

A total of 227 road stream crossings were surveyed with results compiled and ranked as minor, moderate, or severe (Table 50, Figure 24). A total of 81severe sites were found, followed by 64 moderate, and 82 minor. By far the subwatershed with the most severely ranked sites was the West Bay Shoreline and Tributaries watershed which had almost half of its sites ranked as severe. Additionally, although Acme Creek watershed only has 15 total crossings, over half of them (9) are severe as well. The road stream crossing inventory also calculated the estimated soil erosion for each ranked site by tons/year (Table 50). All sites combined contribute about 145 tons of sediment to streams and creeks in the Coastal Grand Traverse Bay watershed each year. About half of that total is from the West Bay Shoreline and Tributaries watershed, which makes sense as that watershed contains about half of the inventoried crossings.

Immediate impacts from severe and moderate ranked road stream crossings are more harmful to smaller streams like those found in the Coastal Grand Traverse Bay watershed. Larger river systems like the Boardman River have stronger flows that have the ability to flush the sediment along the river and transport it out of the system, unlike the smaller creeks which do not receive this 'flushing flow'. Sediment will tend to linger in these smaller streams longer because flows will not be strong enough to transport it out of the system.

Only river systems that are navigable with a canoe or kayak are typically inventoried for streambank erosion due to concerns with accessibility for conducting the survey. Since most of the tributaries to Grand Traverse Bay, other than the Boardman River and ERCOL are small, this information is lacking in the Coastal Grand Traverse Bay watershed area.

Typical Impacts from Sedimentation

Impact #1: *Sand and sediment harm aquatic life by covering natural stream and lake substrate, which fish and prey species rely upon for spawning and feeding.*

Impact #2: *Sediment also increases turbidity, decreasing visibility and clogging fish and insect gills. Turbid stream flow also dislodges fish eggs and insect prey.*

Impact #3: *When more sand and sediment is deposited than can be moved by stream flow, water levels are raised, causing streambank erosion and potential flooding. Excessive sedimentation may also fill lakes, ponds, and wetlands.*

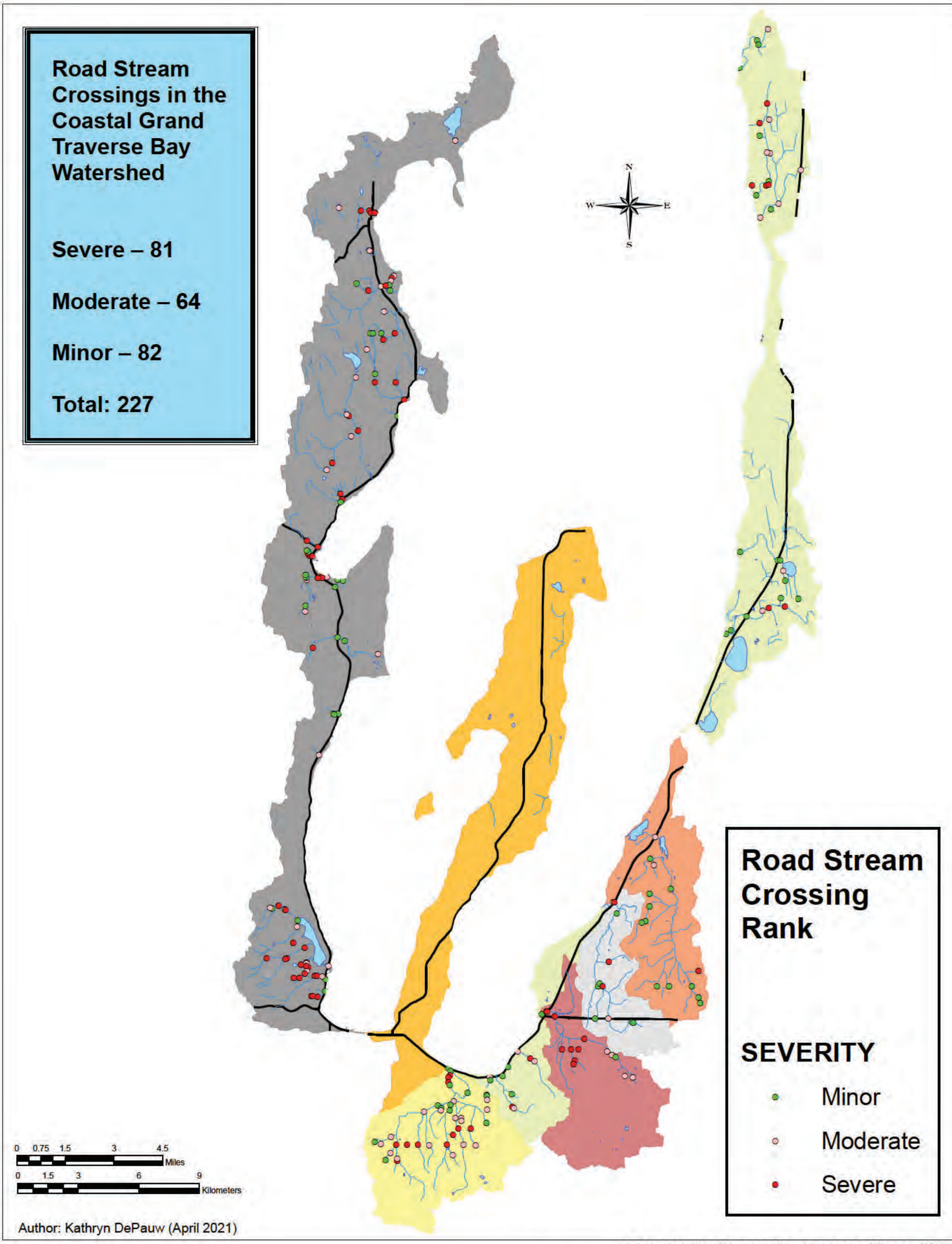
Impact #4: *Nutrients, heavy metals, and other pollutants can attach to finer sediment particles and enter the water when suspended.*

Impact #5: *Excess sedimentation can potentially impair navigation by making the water too shallow for boats and boat access.*

Table 50: Road Stream Crossing Analysis by Subwatershed

Subwatershed	Rankings Summary				Total Erosion Summary (tons/yr)			
	Severe	Moderate	Minor	*Total*	Severe	Moderate	Minor	*Total*
East Bay Shoreline and Tributaries	9	16	23	*48*	6.577	12.826	5.963	*25.37*
Acme Creek	9	4	2	*15*	3.773	1.560	0.296	*5.63*
West Bay Shoreline and Tributaries	48	26	29	*103*	52.044	13.364	7.070	*77.48*
Mitchell Creek	11	14	11	*36*	21.251	10.907	1.555	*33.71*
Tobeco Creek	1	2	11	*14*	0.216	2.810	3.362	*6.39*
Yuba Creek	3	2	6	*11*	0.421	0.583	1.166	*2.17*
Old Mission Peninsula*	n/a	n/a	n/a	*0*	n/a	n/a	n/a	*0.00*
Grand Total	81	64	82	*227*	84.282	42.051	19.412	*145.74*

*Old Mission Peninsula has no road stream crossings.



Layer Credits: Conservation Resource Alliance (2020)
For More Information on Each Site, Visit: northernmichiganstreams.org

Legend

Lakes & Ponds
Rivers & Streams
State Roads
Acme Creek Watershed
East Shore Watershed
Mitchell Creek Watershed
Old Mission Watershed
Tobeco Creek Watershed
West Shore Watershed
Yuba Creek Watershed

GRAND TRAVERSE BAY COASTAL WATERSHED

FIGURE 24: ROAD STREAM CROSSINGS

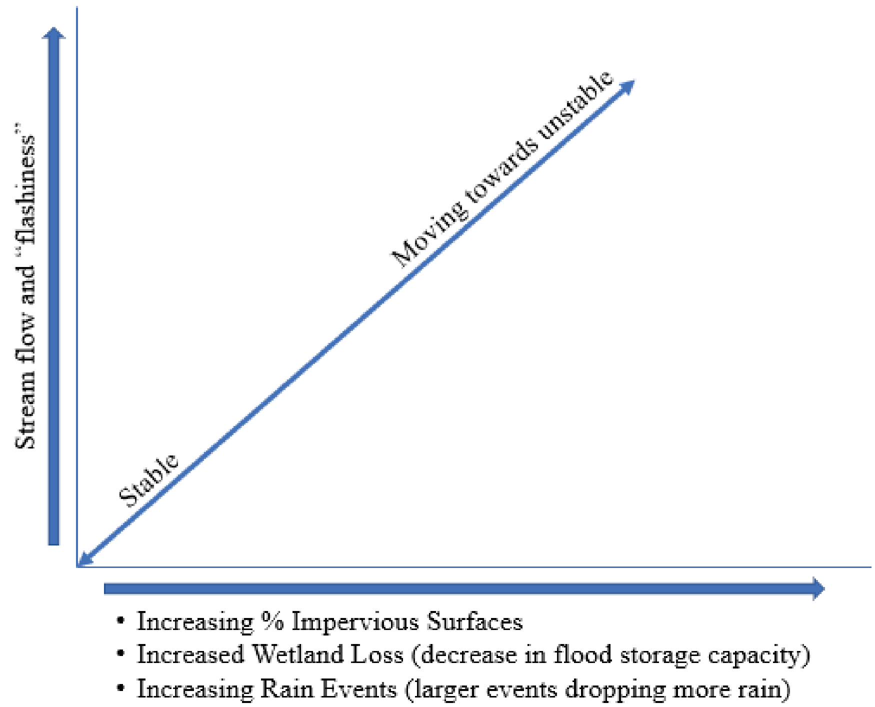
Changes to Hydrologic Flow

Sometimes excessive hydrologic flow in a watershed system may cause problems. The term hydrologic flow encompasses all the factors affecting the stream flow and discharge in a watershed. By far, the most notable and significant alteration in stream flow is caused by urban and stormwater runoff (see Hydrology, Climate, and Water Levels discussion in Section 3.7 and Stormwater discussion in Section 5.4). Stream channel shape, meander pattern, base flow, and storm flow characteristics are largely determined by watershed runoff characteristics.

In addition to development and the resulting increase of impervious surfaces, the following also cause fluctuations in hydrologic flow: loss of wetlands; lake-level control structures; excessive sedimentation (either through runoff or erosion); and channelization by road culverts. Excess stormwater leads to unstable, flashy streams (Section 3.7) which can cause unstable bottom substrates, streambank erosion and bottom scouring, and flooding and sedimentation, which can all destroy aquatic habitats and cause property damage (while also changing stream hydrology further).

The graphic to the right, shown previously in Section 3.7, shows the relationship between the increase of impervious surfaces, wetland loss, and intensity of rain events from climate change and their effects on stream flow and flashiness and how that affects stream stability.

Some factors contributing to stream instability and increased stream flow are climate change (i.e. increasing frequency and intensity of rain events), loss of wetlands (Figure 8A), urban and agricultural land development (increased impervious surfaces-Table 46), logging, and lake-level control structures (Figure 27).



Changes in hydrologic flow may also be affected by the amount of groundwater recharge in the watershed. As more and more development paves over forests and fills wetlands, valuable recharge areas are cut off, and stream base flows may eventually be affected. Freshwater ecosystems, such as the Grand Traverse Bay watershed, have specific requirements in terms of the quantity, quality, and seasonality of their water supplies. In order for the system to be sustainable, it must fluctuate within a range of natural variation. If the quantity of the water flow through a system is disrupted, long-term sustainability within the system will be lost.

Typical Impacts from Changes to Hydrologic Flow

Impact #1: *Deviations in storm flow caused by increased runoff from paved surfaces or channeled flow through culverts often causes erosion of the stream channel, which leads to sedimentation problems.*

Impact #2: *In some stream reaches, storm surges can spill over banks causing localized flooding, endangering humans and causing widespread economic damage.*

Impact #3: *Severe fluctuations in stream flow may disrupt aquatic habitat and strand aquatic organisms, while also interfering with recreational uses of the river.*

Loss of Habitat

The Grand Traverse Bay Coastal watershed is blessed with public land and miles of Lake Michigan shoreline that provides high-quality habitat (aquatic and upland) to the coastal watershed. However, rapid development in the Grand Traverse region and suburban sprawl along the coast of Grand Traverse Bay has resulted in habitat loss and fragmentation. This can negatively affect wildlife populations and water quality (loss of natural pollutant filtration). As the region continues to grow, the need to balance economic development with habitat protection will be very important to preserving the region's water quality and wildlife.

Section 3.5 discusses land use changes in the watershed over the past decade, including decreases in forested and agricultural areas combined with an increase in urban areas (Table 12). Particularly concerning are the significant decreases to wetland areas. Wetlands are a vital part of the coastal ecosystem and perform important ecological functions. In addition to removing excessive nutrients, sediments, and other pollutants (like heavy metals) from the water, wetlands provide valuable habitat for fish and wildlife by providing spawning and breeding grounds, sources of food, migratory resting places, and safety zones for fish and wildlife. Most freshwater fish depend on wetlands during some part of their life cycle and nearly all of Michigan's amphibians are wetland dependent, especially for breeding. More than one-third of all threatened and endangered animal species in the United States are either located in wetland areas or dependent on them. Total wetland loss in the Grand Traverse Bay coastal watershed area since pre-settlement times is almost 40%, with some subwatersheds experiencing more substantial wetland losses compared to their watershed size. Both Acme Creek and Old Mission Peninsula subwatersheds have lost over half of their pre-settlement wetlands, with East Bay Shoreline, Mitchell Creek, and Yuba Creek at just under a 50% loss (Table 13).

Habitat can also be threatened by riparian property owners installing shoreline hardening devices (such as seawalls or rock walls), removing vegetation along the shoreline, and/or removing important in-stream woody debris along the banks of their properties.

Instream habitat fragmentation is also critical issue. In addition, perched or improperly designed transportation crossings add significantly to the fragmentation issue. Perched culverts, where the water flow drops from the outlet of the culvert, are an obvious barrier to fish and insects. Other crossings, where the culvert is improperly designed or placed, may accelerate the water flow, making it difficult for younger age class fish to swim upstream. A brook trout cannot swim against flows greater than 3 feet per second without what is called darting cover. Darting cover includes rocks, logs, and other instream features that provide areas of refuge or rest out of the main flow. Culverts or crossings with a bottom do not provide a natural stream bottom or areas of refuge, therefore fragmenting the upper sections of the stream system. Open bottom culverts, bridges, or culverts that are oversized and buried, allowing for a natural stream bottom, are a much better option.

Nutrients

Nutrients are elements such as nitrogen, phosphorus, carbon, sulfur, calcium, potassium, iron, manganese, boron, and cobalt that are essential to the growth of living things. In particular, nitrogen and phosphorus are critical nutrients for all types of plants, including aquatic species. The nitrogen requirements of these species are typically about 10 times that of phosphorous. Because nitrogen/phosphorous ratios exceed 10:1 in most freshwater systems (including Grand Traverse Bay watershed), nitrogen is not usually the limiting nutrient. In Michigan, rooted aquatic vegetation and algal growth are most commonly limited by the amount of phosphorous in the water column. Ordinarily, as the amount of phosphorous in the water column increases, rooted plant and algal growth increase as well.

Rooted aquatic plants (bulrushes) in Grand Traverse Bay

Generally speaking, total phosphorous concentrations greater than 10ug/L in lakes and ponds may contribute to increased aquatic plant growth and are indicative of impaired water quality. Average phosphorus levels in Grand Traverse Bay are 0.005 mg/L (5 ug/L), which is less than that threshold, but there is evidence of locally increased concentrations of nutrients in the nearshore areas along the bay. This is shown by the four-fold increase of aquatic plant beds in the bay from 1991 to 2009 (TWC 2010). Most of the aquatic plant beds were concentrated in embayments, such as Northport and Omena bays, as well as the southern end of west Grand Traverse Bay, where the Boardman River drains. This growth is attributed to rapid development and nutrient flushing from stormwater inputs, particularly the amount of phosphorus entering the bay.

Aquatic plants found on anchor pulled out of Grand Traverse Bay at a macrophyte bed site.

When elevated levels of phosphorous occur in the water column, rooted plant and algae growth can be quite excessive, resulting in nuisance conditions. Blooms of algae resulting from nutrient enrichment eventually die and decompose, removing oxygen from the water and potentially leading to levels of dissolved oxygen that are insufficient to sustain aquatic life (Allan 1995). In terms of water quality, nutrients have a negative impact on the system when their concentrations exceed natural background levels. This condition can effectively reduce the recreational value of the waters by making the water unpleasant and undesirable for swimming, fishing, or boating due to increased algae and aquatic plant growth.

Nutrients speed up the natural aging process of lakes and ponds. This process is called eutrophication. The signs of an aging water body are deeper bottom sediments and heavy weed growth. This aging process would normally be measured in hundreds of thousands of years if not for the added sediments, fertilizers, and other organic wastes supplied by runoff from a developed watershed.

Additionally, to control eutrophication, the USEPA recommends that total phosphorus not exceed 50 ug/L in a stream at a point where it enters a lake or reservoir (http://pubs.usgs.gov/circ/circ1136/circ1136.html#CONCERNS). Results of water sampling for total phosphorus for major tributaries to Grand Traverse Bay did not indicate any exceedances of this standard. However, total phosphorus concentrations in water samples collected at the mouth of the Boardman River, Mitchell Creek, and Yuba Creek, indicated elevated levels of total phosphorus (more than twice as high) as compared to samples taken from Elk River, and Acme Creek, Cedar Creek, and Leo Creek.

Major sources of nutrients to the Grand Traverse Bay watershed resulting from human activities include:

- Stormwater runoff from urban, residential, and agricultural areas (see Chapter 5.4 for a discussion on stormwater)
- Lack of riparian buffers that filter out nutrients before they reach a waterbody (discussed in Chapter 8.2)
- Septic systems (discussed below)
- Reduction of wetlands (discussed in Chapter 3.5)
- Agriculture (manure storage, livestock in and near water, crop tillage practices)
- Animal waste (geese, ducks, domesticated pets).

The 2005 GTBWPP listed residential fertilizers as a priority source of nutrients to the watershed, however, the State of Michigan has since passed the Michigan Fertilizer Law (1994 PA 451, Part 85, Fertilizers) effective in the beginning of 2012. This law restricts the use of phosphorus fertilizers on residential and commercial lawns, including athletic fields and golf courses statewide. Both homeowners and commercial applicators must follow the phosphorus application restrictions. Some exceptions apply to this law for agriculture, gardens, trees, and shrubs. Due to this law in effect, residential fertilizer use has dropped in priority ranking in this watershed plan, however it may still be an issue with improper application and violation of this law. More information can be found at the following links:
https://www.canr.msu.edu/news/new_phosphorus_fertilizer_amendments
https://www.michigan.gov/documents/mdard/phosphorus_flyer_2-9-11_376295_7.pdf

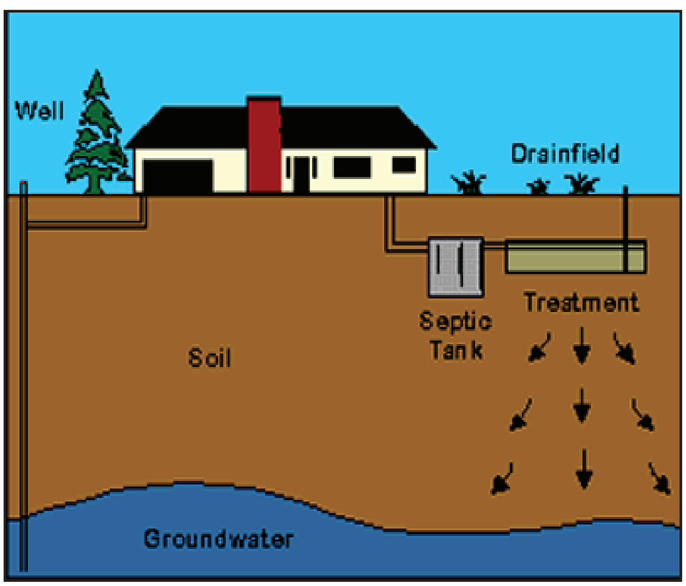
Fertilizers and other chemicals used on agricultural lands in the watershed may also be of concern, especially if they make their way to bodies of water and groundwater sources. Agricultural lands comprise 16% of land cover in the Grand Traverse Bay watershed, with just over half of it as pasture and permanently seeded areas (58%), with orchards/vineyards comprising another 30% (Table 8). Looking at the agricultural lands on a watershed map (Figure 6C), one can clearly see that orchards (mostly cherries and apples) and vineyards dominate agricultural land uses surrounding the bay in the Coastal Grand Traverse Bay Watershed. Orchards and vineyards by nature do not get fertilized often and do not have a high potential for soil erosion, although there is significant potential for 'wind drift' of sprayed on pesticides. Other types of agriculture lands, like row crops and permanent pasture areas, however, may potentially have high soil erosion and nutrient runoff rates. Row crops (i.e., potatoes, hay, corn, small grains, etc.) are mainly found in outlying watershed areas of Antrim, Kalkaska, and Grand Traverse Counties. More discussion on agriculture land uses is found in Chapter 3.5.

The potential for nutrient pollution coming from fertilized land largely depends on the frequency, rate, and time of year fertilizer is applied, runoff rates, and the proximity to a water source.

Aerial shot of small farms in Leelanau County with orchards, crops, and windbreaks. Photo courtesy USDA-NRCS

Onsite Wastewater Disposal Systems (Septics)

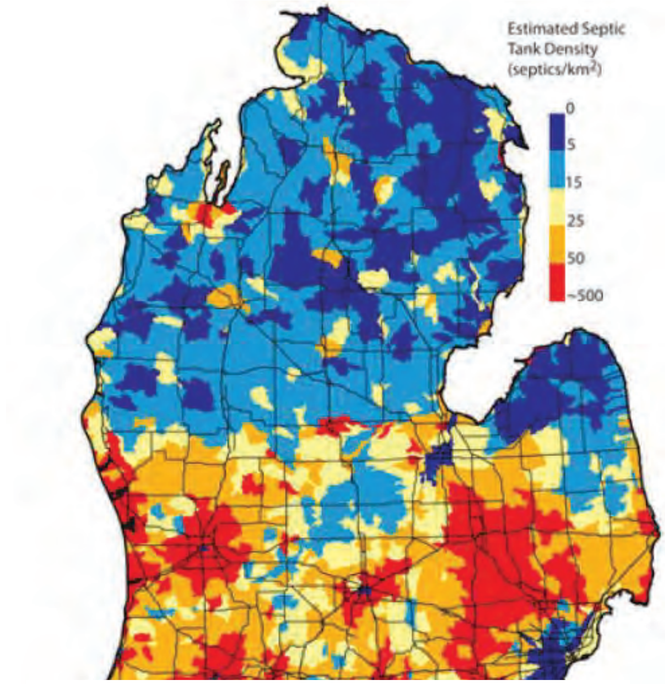
Another potential source of nutrient enrichment in the Coastal Grand Traverse Bay watershed is from septic systems. Septic systems are used to treat and discharge wastewater from toilets, wash basins, bathtubs, washing machines, and other water-consumptive items, many of which can be source of high pollutant loads. They are particularly common in rural or large lot settings, where centralized wastewater treatment systems are not economical. Nationally, one out of every four homes uses some form of septic system, with a combined discharge of over one trillions gallons of waste each year to subsurface and surface waters (NSFC 1995).



A septic system consists of two basic parts: a septic tank and a soil absorption field or drainfield. Wastes flow from the house into the septic tank where most solids are separated to the bottom and are partially decomposed by bacteria to form sludge. Some solids float and form a scum mat on top of the water. The liquid effluent from the septic tank, carrying disease-causing organisms and liquid waste products, *is discharged into the soil absorption field. In the absorption field, the water is further purified by filtration and decomposition by microorganisms in the soil. The semi-purified wastewater then percolates to the groundwater system.*

Image and information courtesy of MSU Institute for Water Research:
www.iwr.msu.edu/edmodule/water/septic

The graphic to the right from a MSU study shows the density of septic tanks across Michigan. If you look closely, much of the Coastal Grand Traverse Bay watershed has a density between 25-50 systems/km^2 (10-20 systems/mi^2). This is because of the strong desire for development along the entire coastal Grand Traverse Bay area even though municipal systems only exist for the Villages of Northport, Suttons Bay, and Elk Rapids. Additionally, while Traverse City is served by a wastewater treatment plant, the outlying areas often are not, and, as the graphic shows, densities of septic systems can reach up between 50-500 systems/km^2 (20-190 systems/mi^2) in the urban sprawl areas outside of the city.



SOURCE: Alexander 2013, courtesy of Hydrogeology Group, Geological Sciences Department, Michigan State University

More in-depth research is required to get a better idea of the specific amount of pollution coming from failing septic systems in the watershed. Although not identified as a known pollutant in the watershed, failing and improperly maintained septic systems are a concern in rural places of the watershed with no sewer service and increasing development along the coast of Grand Traverse Bay in Antrim and Leelanau Counties and Old Mission Peninsula. Based on information found in the EPA report titled "Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters" (specifically Chapter 4, Section V regarding onsite disposal systems), areas with septic systems having a density of more than 32 systems per square mile may be at a greater risk for septic pollution (EPA 1993). The EPA report also cites proximity to a waterbody as a threshold factor in potential septic pollution, with systems located within 1,300 feet of a waterbody having a greater impact than those found further away.

Using housing information from the last census, and assuming all housing units located outside of municipal wastewater service areas are utilizing a septic system, Figure 25 shows areas in the Coastal Grand Traverse Bay watershed where the density of septic systems is greater than the EPA threshold of 32 systems/ mi^2. This information was also paired with hydrologic soil group information (Figure 9C) to identify areas that have the density of 32 systems/ mi^2 located on potentially poor draining soils (groups containing "D" soils), which could put areas at an even greater risk of experiencing septic pollution. Figure 25 shows the greatest areas for potential septic pollution in the Coastal Grand Traverse Bay watershed are found in the Mitchell Creek area, as well as areas near Suttons Bay and the northern part of the East Bay Shoreline Subwatershed. *(All data shown in Figure 25 is subject to field verification and should be used for planning purposes only.)*

A failing septic system is considered to be one that discharges effluent with pollutant concentrations exceeding established water quality standards. According to an online news report from Bridgemi.com, "...there are about 1.3 million on-site wastewater treatment systems in

Michigan, most of which are septic systems for single-family homes. State officials estimate that 10 percent of those (130,000) have failed and are polluting the environment… Over the course of a year, that amounts to 9.4 billion gallons of untreated wastewater flowing into failed treatment systems, DEQ estimates," (Alexander 2013). Identifying and eliminating these possible failing septic systems in the Grand Traverse Bay Coastal watershed will help control contamination of ground and surface water supplies in the watershed from untreated wastewater discharges.

The best way to prevent septic system failure is to ensure that a new system is sited and sized properly and to employ appropriate treatment technology and maintenance. Design requirements will vary according to local site factors such as soil percolation rate, grain size, and depth to water table.

The effectiveness of septic systems at removing pollutants from wastewater varies depending on the type of system used and the conditions at the site. The fact is, even a properly operating septic system can release more than 10 pounds of nitrogen per year to the groundwater for each person using it (Septic System Fact Sheet – Matuszeski 1997). The average pollutant removal effectiveness for a conventional septic system is as follows: total suspended solids – 72%, biological oxygen demand – 45%, total nitrogen – 28%, and total phosphorus – 57% (EPA 1993). This shows that even properly operating conventional septic systems have relatively low nutrient removal capability, and can be a cause of eutrophication in lakes and coastal areas. Failed septic systems are a concern because human sewage is loaded with pathogens that can threaten the health of people who swim in polluted waters or drink contaminated well water. Several experts interviewed for the report mentioned above said water pollution from failed septic systems is a serious, but under-appreciated, problem across Michigan (see Pathogens section later).

Another potential concern related to onsite wastewater disposal systems are holding tanks, which are often required where the water table is within two feet of the ground. These areas are located along rivers, streams, lakes, and wetlands. Holding tanks are expensive to have pumped and maintained leading some landowners to seek alternative treatment or disposal methods that may or may not adequately filter nutrients and waste. Some landowners have been known to dispose of their "gray water" by other means, including direct discharge into the river.

Typical Impacts from Excessive Nutrients

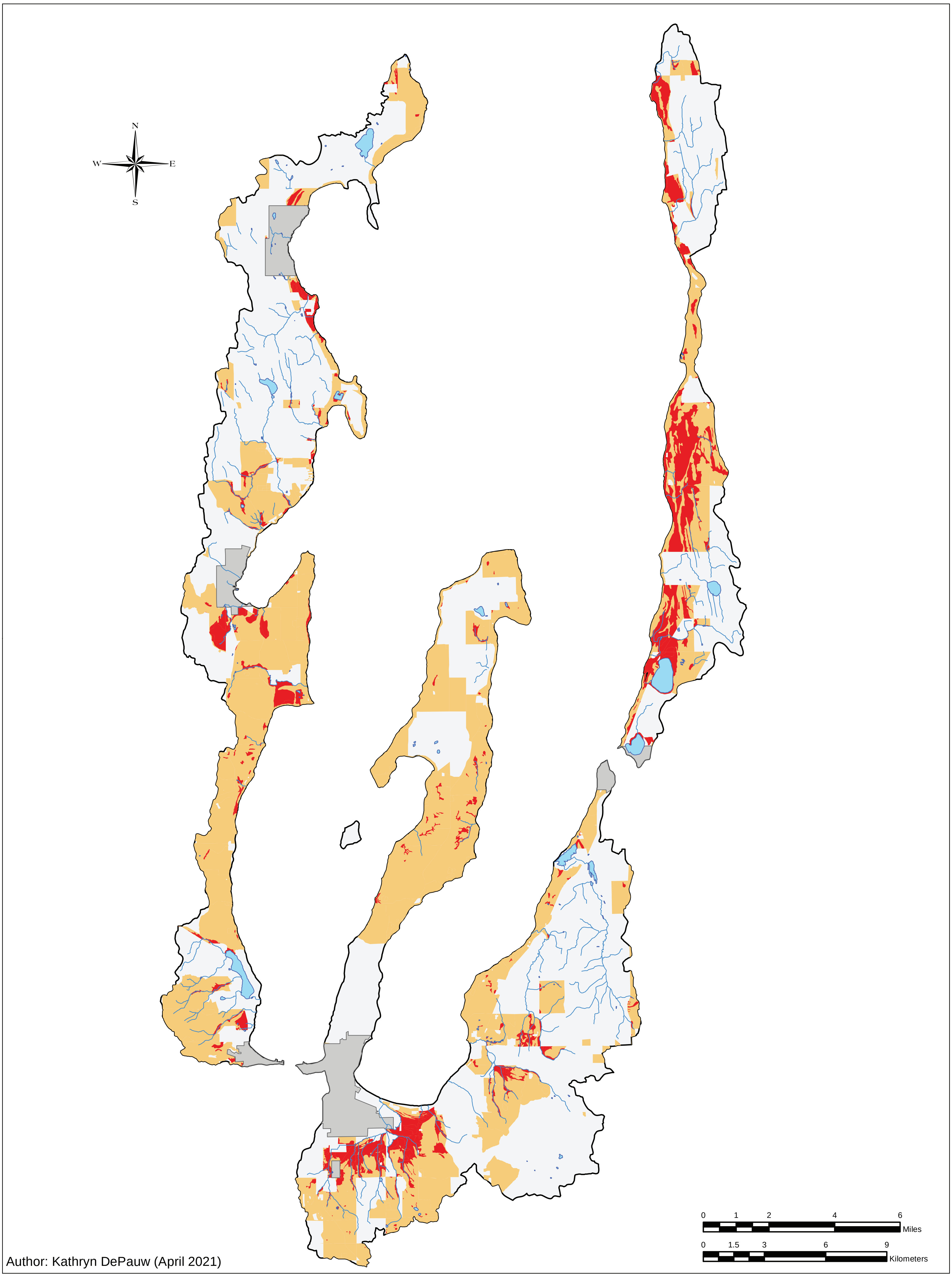
Impact #1: *Increased weed and algae growth impact water recreation and navigation.*

Impact #2: *Decomposition of algae and weeds removes oxygen from lakes, harming aquatic life and reducing the recreational and commercial fishery.*

Impact #3: *Exotic plant species like Eurasian Watermilfoil and Purple Loosestrife can better compete with native plants when nutrients are abundant.*

Impact #4: *Some algae (i.e., blue-green algae) are toxic to animals and humans and may cause taste and odor problems in drinking water.*

Impact #5: *High nitrogen levels in drinking water are a known human health risk.*



Layer Credits: US Bureau of the Census (2010 Census) and US Department of Agriculture, NRCS (gSSURGO 2019)

Legend

Coastal Subwatershed

Lakes & Ponds

Rivers & Streams

Cities & Villages

32+ Housing Units (Per Square Mile)

Low Drainage Soils (A/D, B/D, C/D, D) With 32+ Housing Units (Per Sqaure Mile)

GRAND TRAVERSE BAY COASTAL WATERSHED

FIGURE 25: AREAS AT RISK FOR SEPTIC POLLUTION

Toxins

Toxic substances such as pesticides, herbicides, oils, gas, grease, and metals often enter waterways unnoticed via stormwater runoff. These types of toxins are perhaps the most threatening of all the watershed pollutants because of their potential to affect human and aquatic health. It is highly probably that at any given moment, somewhere in the watershed there is a leaking automobile radiator, a landowner applying herbicides or pesticides to their lawns, or someone spilling gasoline while filling up their car. Every time it rains, these toxic pollutants are washed from the roads, parking lots, driveways, and lawns into the nearest storm drain or road ditch, eventually reaching nearby lakes and streams. Each winter, hundreds of tons of road salt and sand are spread over area roadways. When spring arrives, if not cleaned up in time, the remaining sand and salt are washed into the nearest waterway. Additionally, farms, businesses, and homes throughout the watershed are potential sites of groundwater contamination from improperly disposed and stored pesticides, solvents, oils, and chemicals.

Most of the pollution from toxic substances in the watershed comes from stormwater and urban runoff containing oils, grease, gasoline, and solids (more information in stormwater discussion in Chapter 5.4). Urban areas along the coast of the bay with high amounts of imperviousness such as those found in Traverse City, Elk Rapids, Suttons Bay, and Northport all contribute toxic substances to the watershed during storm events when water runs off streets, parking lots, and roofs, and enters storm drains leading directly to Grand Traverse Bay.

To better understand road salt impacts to Kids Creek, Trout Unlimited's Great Lakes Program and TWC installed two remote water quality monitoring stations along Kids Creek in December 2020. The "Mayfly Monitoring Stations" measure temperature, depth, and conductivity (a surrogate for chloride) in real time. These stations will monitor water quality and streamflow in Kids Creek over the course of the next several years and help determine potential impacts from road salts and other pollutants that affect conductivity. In the short time since the stations were installed researchers have already noted large spikes in conductivity after snowmelt events. Data at: monitormywatershed.org/browse/

There is rising scientific concern that deicing salts are causing impairments to surface water bodies. The fate of salt applied to roadways is concerning as it either runs off directly into a body of water causing spikes in chloride levels, or soaks into the ground. In the sandy soils of northern Michigan, salt-saturated water may leach into groundwater where it stays and builds over years until it discharges to the bed of streams, leading to chronic toxicity problems. Indications that chlorides could be contaminating groundwater and impacting the Kids Creek macroinvertebrate community are evident in EGLE monitoring results that show a non-existent burrowing insect community in sections where habitat was deemed 'good' and both geomorphology and hydrology are stable. It is possible that chloride-contaminated groundwater could be venting into the stream in these sections and killing macroinvertebrates. Even with sufficient habitat present, chronic chloride contamination could be impacting macroinvertebrates that are an important food source for brook trout. Drainage of road salt into streams is often unpredictable and subject to increases in temperature (melt events), precipitation events, the timing of road-salt application, and area geology. Due to those factors, concentrations of chloride in surface and groundwater can vary greatly over a short period of time.

One particular set of toxins that has been getting recent attention in the watershed is from coal tar-based sealant products applied at both commercial and residential settings. Coal tar-based sealants have significantly higher levels of poly-aromatic hydrocarbons (PAHs) and related compounds, which can leach into surface waters through stormwater runoff.
PAH's are toxic to humans, other mammals, birds, fish, amphibians and plants. Long-term health effects of PAHs exposure on humans may include cataracts, kidney and liver damage, jaundice and even cancer (shown in laboratory animals). More concerning however, are the effects of PAHs in the aquatic environment, with aquatic invertebrates being particularly susceptible, especially those that live in the mud causing. PAH's in these situations can cause inhibited reproduction, delayed emergence, sediment avoidance, and mortality. Other adverse effects on fish include fin erosion, liver abnormalities, cataracts, and immune system impairments. EGLE conducted monitoring in Traverse City in 2018 that included scrapings of local parking lots, as well as water and sediment samples looking for PAH contamination from coal tar sealants. Results show PAHs in the majority of samples. Some were in low levels, but others were at "concerning" rates. With this small amount of sampling, it is likely spread throughout the entire Grand Traverse Bay watershed. Results of this study are summarized in Appendix B.

Some parts of the watershed have experienced industrial activities which may have associated contamination with them, some of which many contain leaking underground storage tanks. Part 201 Environmental Remediation and Part 213 Leaking Underground Storage Tanks of Michigan's Natural Resources Environmental Protection Act (NREPA) are the primary tools the state uses for addressing remediation of contaminated sites. EGLE tracks enforcement and compliance with Parts 201 and 213 to ensure they are remediated and cleaned up. Figures 26A and 26B show current Part 201 remediation sites and leaking underground storage tank sites in the Grand Traverse Bay Coastal watershed area.

As noted previously, for the purposes of this watershed plan, we are including "Emerging Contaminants of Concern" with the Toxics category throughout the plan. Emerging contaminants are potentially harmful substances that have not yet been rigorously studied or have standards developed for water quality protection. They are often unregulated and are concerning because we do not yet know their fate in the watershed and the full extent of the risks they may pose to both humans and aquatic life and other wildlife. Specific emerging contaminants of concern in the Grand Traverse Bay Coastal Watershed include: per- and polyfluoroalkyl substances (PFAS); microplastics, microfibers, and microbeads; and pharmaceuticals and other personal care products (see Chapter 5.1 for more details on Emerging Contaminants).

There is also widespread atmospheric mercury deposition into Michigan's surface waters. The organic form of mercury, methylmercury, is a highly bioaccumulative toxic pollutant that is hazardous to wildlife and human health. Elemental mercury is converted to the organic form through natural processes, particularly in inland lakes. This has caused elevated mercury concentrations in inland lake sediments (Evans et al., 1991) and fish tissues (Day 1997) throughout the state. As a result, there is a statewide, mercury-based fish consumption advisory that is applied to all of Michigan's inland lakes (DNR 1997).

Typical Impacts from Toxins

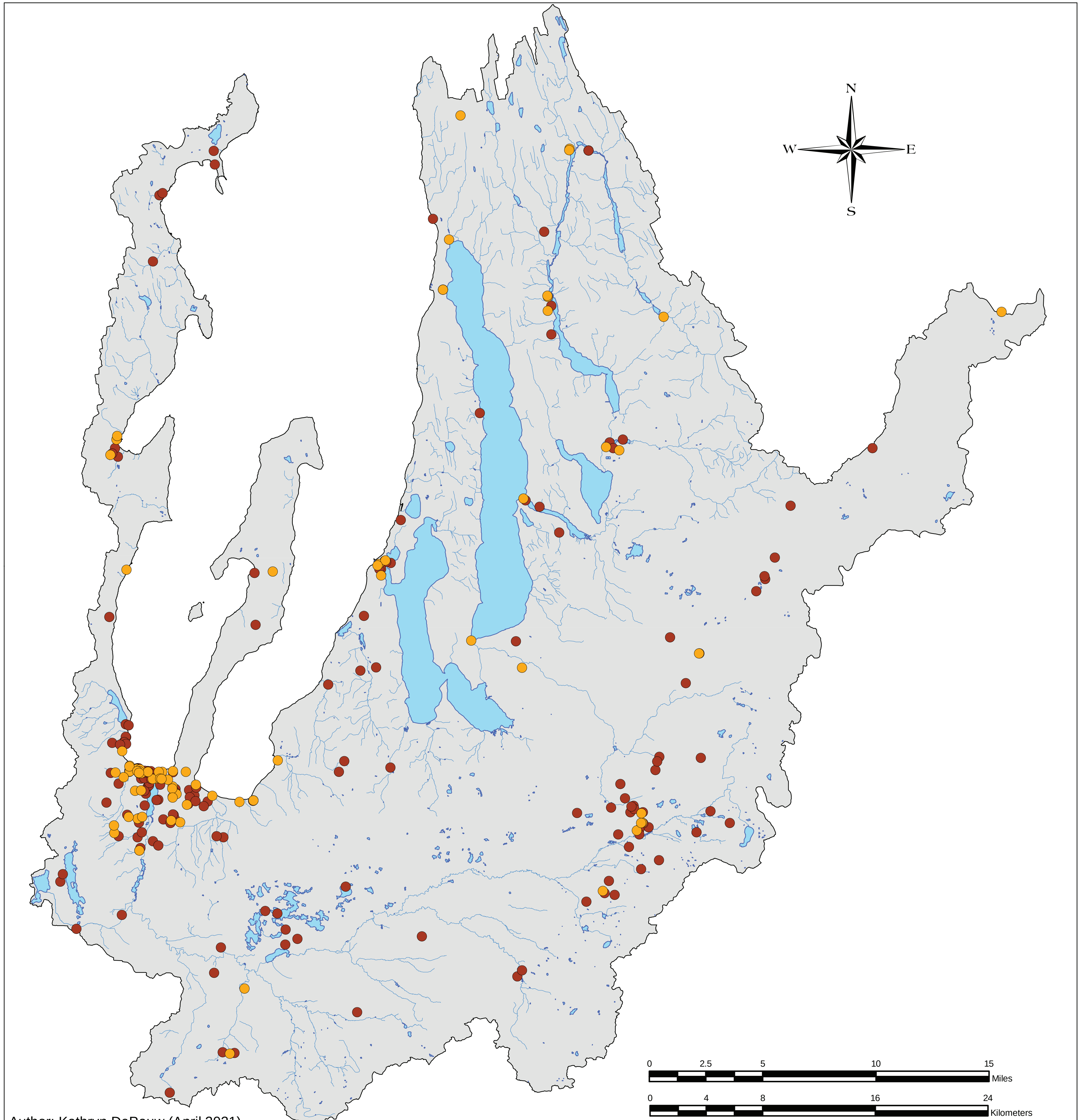
Impact #1: *Toxic chemicals entering waterbodies harm stream life, potentially causing entire reaches of a stream to be killed off if the concentrations of contaminants are high enough.*

Impact #2: *Persistent toxic pollution in a stream may put human health and recreation at risk.*

Impact #3: *Contaminated groundwater may pose a problem for homes and businesses throughout the watershed that rely upon groundwater wells for their drinking water. This poses a risk to human health and often requires difficult and costly cleanup measures.*

GRAND TRAVERSE BAY WATERSHED

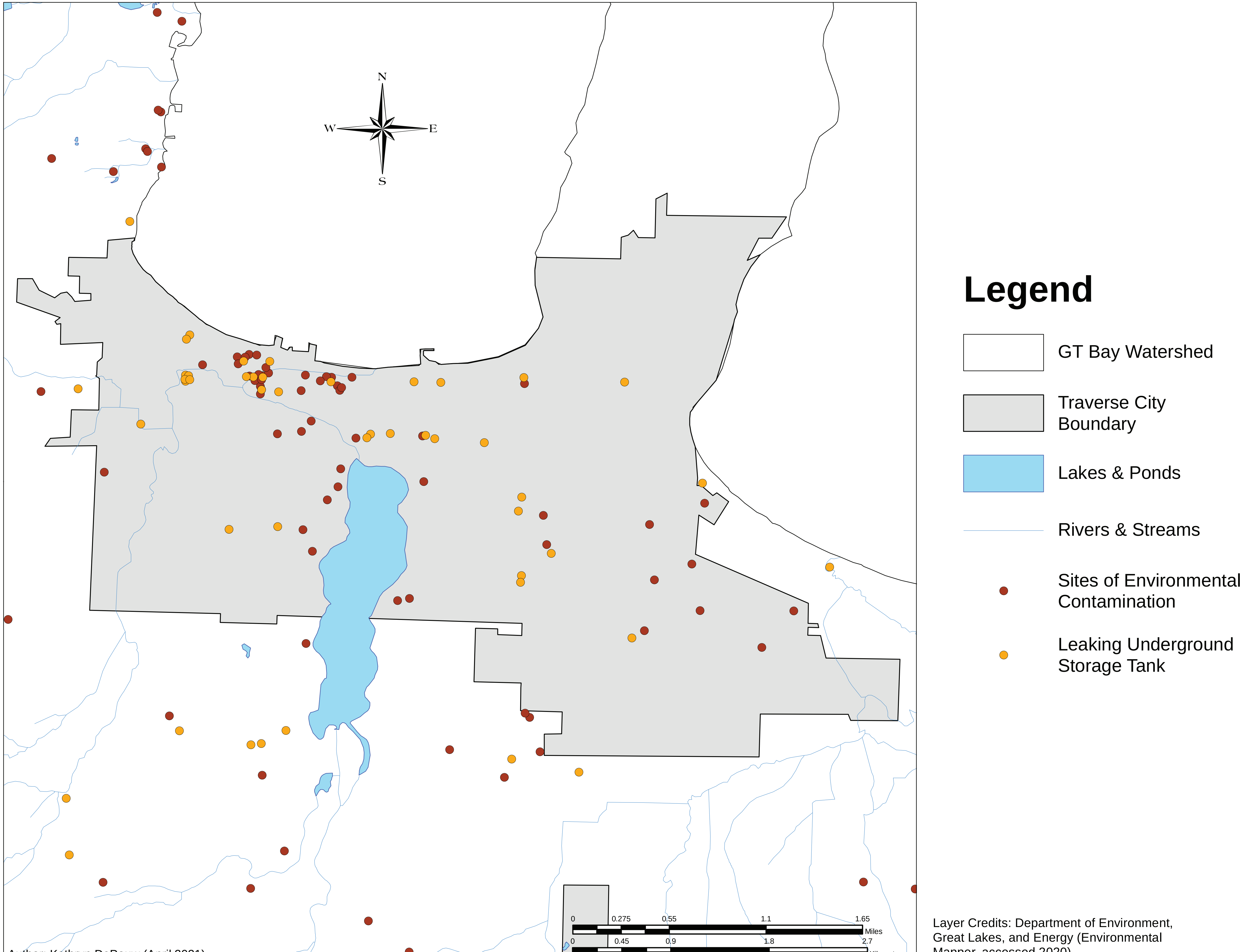
FIGURE 26A: PART 201 & 213 ENVIRONMENTAL REMEDIATION SITES



Legend

- GT Bay Watershed
- Lakes & Ponds
- Rivers & Streams
- Leaking Underground Storage Tank
- Sites of Environmental Contamination

Layer Credits: Department of Environment, Great Lakes, and Energy (Environmental Mapper, accessed 2020)



Layer Credits: Department of Environment, Great Lakes, and Energy (Environmental Mapper, accessed 2020)

GRAND TRAVERSE BAY WATERSHED

FIGURE 26B: PART 201 & 213 ENVIRONMENTAL REMEDIATION SITES

- TRAVERSE CITY -

Pathogens

Pathogens are organisms that cause disease and include a variety of bacteria, viruses, protozoa and small worms. These pathogens can be present in water and may pose a hazard to human health. The US Environmental Protection Agency (EPA) recommends that freshwater recreational water quality be measured by the abundance of *Escherichia coli* (*E. coli*) or by a group of bacteria called *Enterococci*. Michigan has adopted the EPA's *E. coli* water quality standards. *E. coli* is a common intestinal organism, so the presence of *E. coli* in water indicates that fecal pollution has occurred. However, the kinds of *E. coli* measured in recreational water do not generally cause disease; rather, they are an indicator for the potential presence of other disease-causing pathogens. EPA studies indicate that when the numbers of *E. coli* in fresh water exceed water quality standards, swimmers are at increased risk of developing gastroenteritis (stomach upsets) from pathogens carried in fecal pollutions. The presence of *E. coli* in water does indicate what kinds of pathogens may be present, if any. If more than 130 *E. coli* are present in 100mL of water in 5 samples over 30 days, or if more than 300 *E. coli* per 100mL of water are present in a single sample, the water is considered unsafe for swimming.

EGLE Water Quality Standards for Microorganisms

R 323.1062 Microorganisms. Rule 62.

(1) All waters of the state protected for total body contact recreation shall not contain more than 130 Escherichia coli (E. coli) per 100 milliliters, as a 30-day geometric mean. Compliance shall be based on the geometric mean of all individual samples taken during 5 or more sampling events representatively spread over a 30-day period. Each sampling event shall consist of 3 or more samples taken at representative locations within a defined sampling area. At no time shall the waters of the state protected for total body contact recreation contain more than a maximum of 300 E. coli per 100 milliliters. Compliance shall be based on the geometric mean of 3 or more samples taken during the same sampling event at representative locations within a defined sampling area.

(2) All waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1,000 E. coli per 100 milliliters. Compliance shall be based on the geometric mean of 3 or more samples, taken during the same sampling event, at representative locations within a defined sampling area.

Fecal pollution entering the Grand Traverse Bay Coastal watershed mainly comes from urban stormwater runoff. Other sources may include inadequately treated wastewater, agricultural runoff, illegal sewage discharge from boats, or from animals on the land or in the water. Another source of possible *E. coli* contamination is from improperly functioning septic systems. Due to the unknown nature of groundwater flow in some watershed areas and the relatively random location of septic systems, it is very difficult to accurately assess their impact to the watershed. Failing septic systems are a suspected source of contamination for parts of the Grand Traverse Bay watershed, especially where there is a high density of residential development using septic systems. However, it is uncertain how much contamination, especially pathogens, are making their water to surface waters.

Peak *E. coli* concentrations in coastal streams often occur during high flow periods when floodwater is washing away possible contaminants along the streambank such as waste from ducks and geese. Streams such as Mitchell Creek, Kids Creek, and Northport Creek have exhibited high *E. coli* counts at times during storm events (results found in TWC's interactive water quality database: www.gtbay.org/wqquery.asp). In fact, two creeks in the Grand Traverse Bay Coastal Watershed area are listed as impaired due to *E.coli* levels. Both creeks are named Mitchell Creek, but they are in two different counties. Mitchell Creek in Antrim County is a very small ephemeral stream and is most likely impacted due to wildlife and potentially land application of septage waste which has since been halted since its inclusion on the Impaired Waters List. The other Mitchell Creek is a significant costal tributary to Grand Traverse Bay in Grand Traverse County that drains 16 mi^2 of land, with a significant portion of its downstream area in an urban setting in Traverse City and East Bay Township. Significant monitoring efforts undertaken by TWC in 2015 led to its inclusion in the Section 303(d) report (see Chapter 3 9 for more information). Data collected by EGLE staff in summer 2018 also indicate Northport Creek has high E.coli levels at one location and will likely be listed as impaired for its Total Body Contact designated use as of EGLE's 2020 Integrated Report (personal communication with Molly Rippke, EGLE-WRD on 12/11/2019). There are a number of public beaches on the bay near the outlets of these streams and high counts of *E. coli* pose a risk to beachgoers in these areas.

The City of Traverse City has documented extremely high levels of *E.coli* bacteria in its stormdrains during rain events. A summary of results from 11 outfalls for the City's Stormwater Management Plan confirm this (Appendix C). The highest results were noted at 8th Street, Bryant Park, East Bay Park, Sunset Park where results for *E.coli* during rain events were routinely documented in the tens of thousands of colonies per 100mL. Some results have even reached over 100,000 col/100mL. This can be a major problem as many of the City's stormdrains outlet adjacent to public lands and designated beaches which pose a risk to beachgoers. The source of much of the bacteria pollution in Traverse City is from pet waste runoff and wildlife and waterfowl droppings. Stormdrains, especially on east side of Traverse City, have large numbers of raccoons living in them. In fact, the City has done camera work in drains and found multiple piles of raccoon droppings; and city workers cleaning out fire hydrants routinely see raccoon families coming in and out of catch basins.

Stormwater inputs along the coast of Grand Traverse Bay can also contribute significant amounts of bacteria to urban waters during rain events, specifically from stormdrain systems in coastal areas like the Villages of Northport, Suttons Bay, and Elk Rapids. These stormdrain systems, like those in Traverse City, often outlet adjacent to public lands and designated beaches which pose a risk to beachgoers.

TWC has been working with the Grand Traverse and Benzie-Leelanau District County Health Departments and Traverse City officials since 2001 to monitor various Great Lakes and inland beaches in the Grand Traverse Region for bacterial/pathogen pollution during the summer swimming season. Results are posted to EGLE's BeachGuard database (http://www.deq.state.mi.us/beach/). In 2006 and 2008, Grand Traverse County modified its advisory system for notifying the public of beach contamination, which in turn generated an increased level of interest in beach health from the public, especially

Beach monitoring sign at a beach in Traverse City

Traverse City residents (see box at right). As a result of this public concern TWC drafted an Action Plan for Healthy Beaches in September 2007 which outlined a plan to reduce health threats and related beach advisories associated with high *E. coli* readings. The Action Plan for Healthy Beaches proposed a series of actions to reduce the levels of *E. coli* at area beaches in three phases. Phase 1 involves immediate steps such as ordinance development, public education and behavior change. Phase 2 involves conducting a detailed sanitary survey and source tracking study. Phase 3 involves implementing additional stormwater controls once the sources of contamination are more accurately defined. Just after TWC drafted this Action Plan, the Grand Traverse County Health Department began holding monthly Beach Stakeholder meetings to discuss the beach monitoring program in the Grand Traverse Region (Grand Traverse and Benzie/Leelanau Counties included). Members include the County Health Departments, Traverse City officials, National Park Service officials (Sleeping Bear Dunes), State Park officials, and local water quality lab representatives. This beach stakeholder group still meets monthly to discuss beach issues and monitoring efforts.

Level	Bacteria Level	Advisory
Level 1	Below 300 col/100mL	None
Level 2	300 – 999 col/100mL	No contact above waist
Level 3	1,000+ col/100mL	No contact of any kind
Level 4	Known, gross contamination	No contact of any kind

Since 2007 TWC has worked to implement portions of the Action Plan as part of their Healthy Beaches Program. Sanitary surveys for Great Lakes Beaches were completed in 2007 and 2012, and source tracking efforts in conjunction with Michigan State University and Environmental Canine Services started in 2008. In 2008 TWC received an EGLE grant to provide funding for the implementation of a large-scale outreach program which included a media advertising component to educate the public about a variety of issues in the Grand Traverse Bay Watershed, including topics on healthy beaches. Additionally, TWC worked with Traverse City officials to implement an ordinance banning the feeding of waterfowl within 100 feet of any water body. Final activities for this grant also included the installation of numerous "Healthy Beaches" educational signs at parks along Grand Traverse Bay, which includes messaging on how to keep beaches clean - i.e., don't feed waterfowl, throw away trash/cigarettes, change baby diapers, pick up dog waste, etc. TWC has also successfully completed beach restoration projects using EPA Great Lakes Restoration Initiative funding (both in partnership with EGLE and independently) to reduce bacterial contamination at local Great Lakes beaches including at the Village of Northport, Village of Suttons Bay, and Bryant and East Bay Parks in Traverse City.

Typical Impacts from Pathogens

Impact: *High levels of potential pathogens in the water pose a threat to human health and can reduce the recreational value of lakes and the bay.*

Invasive Species

An invasive species is "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health" as per Executive Order 13112: Section1. Definitions (https://www.invasivespeciesinfo.gov/invasive-species-definition-clarification-and-guidance). Invasive species (also called exotic, alien, or non-native species) have threatened the Great Lakes ever since Europeans settled in the region. They are organisms that are introduced into areas where they are not native. While many invasive species are introduced accidentally, others are intentionally released, often to enhance recreational opportunities such as sport fishing. Species are considered a nuisance when they disrupt native species populations and threaten the ecology of an ecosystem as well as causing damage to local industry and commerce. Without pressure from the competitors, parasites, and pathogens that normally keep their numbers in check, invasive species, may undergo large population increases.

Since the 1800s, more than 180 non-native aquatic species have been introduced in the Great Lakes including plants, fish, algae, and mollusks. Fortunately, most of them either did not establish populations or are barely noticeable in the ecosystem. A small fraction of these non-native species became invasive and established abundant populations that have had negative consequences for the existing ecosystem (http://www.glfc.org/invasive-species.php). As human activity has increased in the Great Lakes watershed, the rate of introduction of invasive species has increased as well. More than one-third of the current invasive species have been introduced in the past 30 years, a surge coinciding with the opening of the St. Lawrence Seaway. Once introduced, invasive species must be managed and controlled as they are virtually impossible to eradicate.

The Great Lakes ecosystem has been severely impacted by the arrival of a variety of non-native and invasive species. While many non-native species have no serious ecological impact, the introduction of a single key species, such as the sea lamprey, can cause a sudden and dramatic shift in the entire ecosystem's structure. New species can significantly change the interactions between existing species, creating ecosystems that are unstable and unpredictable.
Species such as the zebra mussel, quagga mussel, round goby, sea lamprey, and alewife reproduce and spread rapidly, ultimately degrading habitat, out-competing native species, and short-circuiting food webs. Non-native plants such as purple loosestrife and Eurasian watermilfoil have also harmed the Great Lakes ecosystem. Some of these species, including the zebra mussel, quagga mussel, spiny water flea, and round goby, have had a dramatic impact on fish and invertebrate populations, as well as nutrient and contaminant cycling in the Grand Traverse Bay Watershed in the past two decades. Unfortunately, the damage caused by invasive species often goes beyond the ecological. They can threaten human health and hurt the Great Lakes economy by damaging critical industries such as fisheries, agriculture, and tourism. It is extremely difficult to control the spread of an invasive species once it is established, which makes prevention the most cost-effective approach to dealing with organisms that have not yet entered or become established in the Great Lakes. Table 51 lists the most prevalent aquatic invasive species in the Grand Traverse Bay Coastal Watershed and includes widely known invasives like sea lamprey and rusty crayfish, but also new ones like the New Zealand mudsnail and the bloody red shrimp. The table also includes invasive aquatic and terrestrial plant species like Eurasian watermilfoil, curly leaf pondweed, Eurasian phragmites, and garlic mustard.

Table 51: Major Invasive Species in the Grand Traverse Bay Watershed (2019)*

Aquatic	Wetland/shoreline
Bloody red shrimp	Autumn olive
Fishhook waterflea	Bohemian knotweed
Freshwater jellyfish	Common buckthorn
New Zealand mudsnail	Dame's rocket
Quagga mussel	Eurasian phragmites
Round goby	European marsh thistle
Rusty crayfish	Garlic mustard
Sea lamprey	Giant knotweed
Spiny waterflea	Glossy buckthorn
Zebra mussel	Japanese barberry
Alewife	Japanese knotweed
Common carp	Lyme grass
Curly leaf pondweed	Multiflora rose
Eurasian watermilfoil & hybrid milfoil	Narrow leaf cattail & hybrid cattail
	Purple loosestrife
	Reed canary grass
	Wild parsnip
	Yellow flag iris

**List Prepared by TWC on 5-17-2019. Information compiled from resource professionals, USGS NAS database (nas.er.usgs.gov/queries/stco.aspx), and MISIN's database www.misin.msu.edu/browse/)*

There are two organizations in the Grand Traverse Bay Coastal Watershed area that deal with invasive species – the Northwest Michigan Invasive Species Network (ISN) and the Charlevoix, Antrim, Kalkaska and Emmet Cooperative Invasive Species Management Area (CAKE CISMA).

- The Northwest Michigan Invasive Species Network (ISN) was founded in 2005and is a Cooperative Invasive Species Management Area (CISMA) or Cooperative Weed Management Area (CWMA). ISN reached its current form through the merger of the Grand Traverse Regional Invasive Species Network and the Northwest Michigan CWMA in 2012. ISN works directly with over 40 partners in Benzie, Grand Traverse, Leelanau, and Manistee Counties to manage populations of invasive species that threaten northwest Michigan's high-quality natural areas. https://www.habitatmatters.org/
- The CAKE CISMA is the Charlevoix, Antrim, Kalkaska and Emmet Cooperative Invasive Species Management Area. It is a cooperative effort between local conservation districts and other environmental entities to inform the public on invasive species concerns and assist landowners in managing against invasive species. To do this, the CAKE CISMA offers education and outreach events as well as a cost sharing treatment program for landowners. The Antrim Conservation District serves as the fiduciary for this regional cooperative and houses the CAKE CISMA office. https://cakecisma.wixsite.com/mysite

Web resources:

- Northwest Michigan Invasive Species Network – Top 20 Terrestrial Invasive Species List https://www.habitatmatters.org/top-20.html
- Early Detection Watch Lists: Contains invasive species that have been identified as posing an immediate or potential threat to Michigan's economy, environment or human health. These species either have never been confirmed in the wild in Michigan or have a limited known distribution. Species on ISN lists have proven invasive in other areas in the midwest, but are not yet established in northwest lower Michigan. Land managers and invasive species professionals are continually on the lookout for these species so that early and rapid treatment and control is possible if populations become established
  - State of Michigan - https://www.michigan.gov/invasives/0,5664,7-324-68002_74188---,00.html
  - Northwest Michigan Invasive Species Network - https://www.habitatmatters.org/early-detection-species.html
- State of Michigan Prohibited and Restricted Species List: If a species is prohibited or restricted, it is unlawful to possess, introduce, import, sell or offer that species for sale as a live organism, except under certain circumstances
  - https://www.michigan.gov/invasives/0,5664,7-324-68002_74282---,00.html
- Michigan Sea Grant https://www.michiganseagrant.org/topics/ecosystems-and-habitats/invasive-species/

Fisheries Impacts from Invasive Species

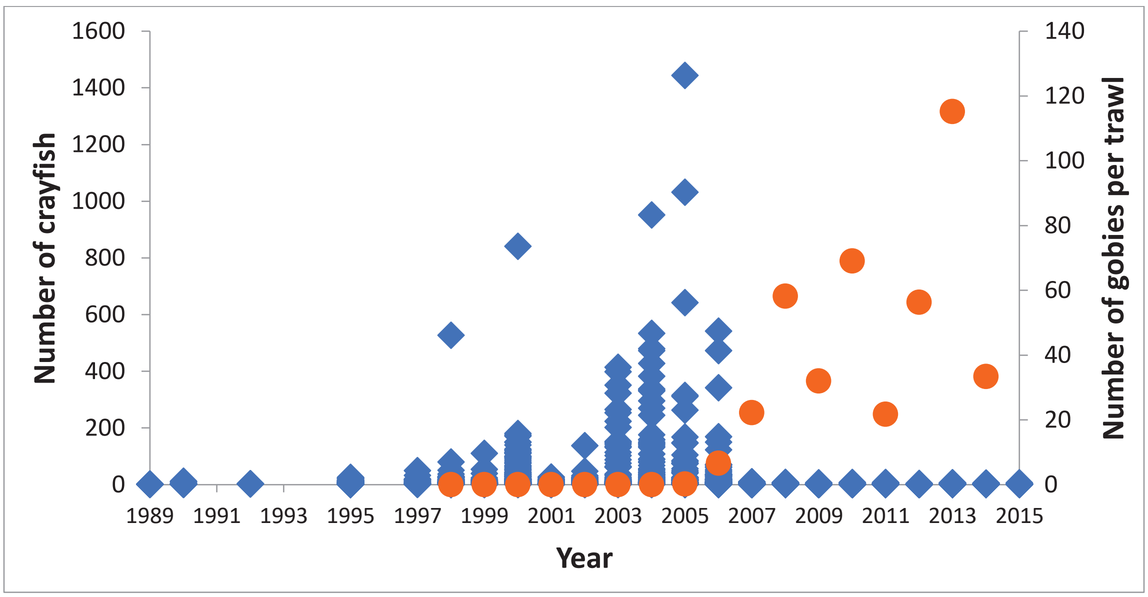
As stated earlier, the Great Lakes ecosystem has been severely impacted by invasive species. The most destructive species include Zebra and quagga mussels (known collectively as *Dreiseena* mussels), round goby, and the spiny water flea.

Zebra and quagga mussels (*Dreiseena*) are closely related mussels native to Eurasia that colonize lake bottoms and out-compete other native filter feeding organisms, including native mussels. They are believed to have been transported to the Great Lakes through ballast water from a trans-oceanic vessel and were first documented in the Great Lakes in the late 1980s. The area a stark example of the explosive growth potential of the introduction of a non-native species. These *Dreissena* mussels re-direct energy and nutrients to the lake bottom, making it less available for other organisms in the water column and well as increase water clarity that may increase nuisance algae growth. *Dreissena* mussels also incorporate contaminates from the water column into their tissue, clog water intake structures, and are thought to promote the growth of the bacterium that releases the botulism toxin.

Zebra Mussels

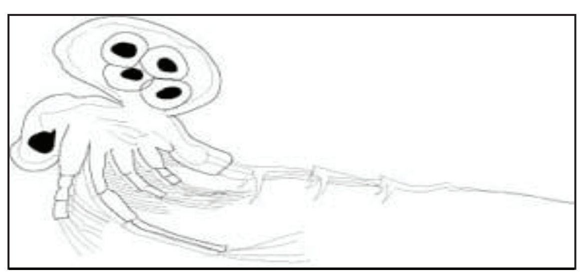
Freshwater mussels of the family Uniondae, referred to as Unionids, are one of the most threatened organisms in North America. In the Great Lakes, Unionids, already in decline from habitat loss and pollution, have been significantly threatened by the arrival of invasive *Dreissena* mussels. These invasive mussels attach to the shell of Unionids, impeding reproduction, feeding and respiration. In a 2012 study titled *Assessment of remnant unionid assemblages in a selection* *of Great Lakes coastal wetlands*, no live unionids were found in the three sampled locations in Grand Traverse Bay (https://www.sciencedirect.com/science/article/pii/S0380133013000348).

Round goby, also believed to have been introduced through ballast water, were originally discovered in Lake St. Clair in the 1990s and have since invaded other Great Lakes waters. Round gobies are bottom-feeders and zebra and quagga mussels can make up significant portions of their diets. Round gobies have voracious appetites and an aggressive nature which allows them to dominate over native species. Round gobies also have a competitive advantage over native species due to a well-developed sensory system that allows for enhanced water movement detection and the ability to feed in complete darkness. In the Great Lakes, they are believed to reduce native species of fish and other invertebrate and may have a role in exasperating botulism outbreaks by bioaccumulating the botulism toxin and passing it along to its predators. Inland Seas Education Association (ISEA) conducts regular trawls at two locations in Grand Traverse Bay as part of their volunteer education program. The table below shows a distinct correlation between the discovery and explosion of the numbers of round gobies in the bay compared to the rapid decline of native crayfish (gobies are orange dots, crayfish are blue diamonds).



**Graph from 2016 presentation at TWC's annual Freshwater Summit Conference*

Spiny water flea, an invasive zooplankton native to Europe and Asia, likely arrived in the Great Lakes through ballast water in the 1980s. The spiny water flea is a small shrimp-like zooplankton that grows to an average of 10 millimeters (0.4 inch) in length and feeds on other small aquatic animals. It has powerful limbs for swimming and grasping food items, and a large pigmented eye for seeing light and images in the water. This carnivorous zooplankton could have profound effects on Great Lakes food web because it feeds on other zooplankton, such as Daphnia, which are important food sources for native juvenile fish. Spiny water fleas themselves are a poor food source for most small and young fish because their spines

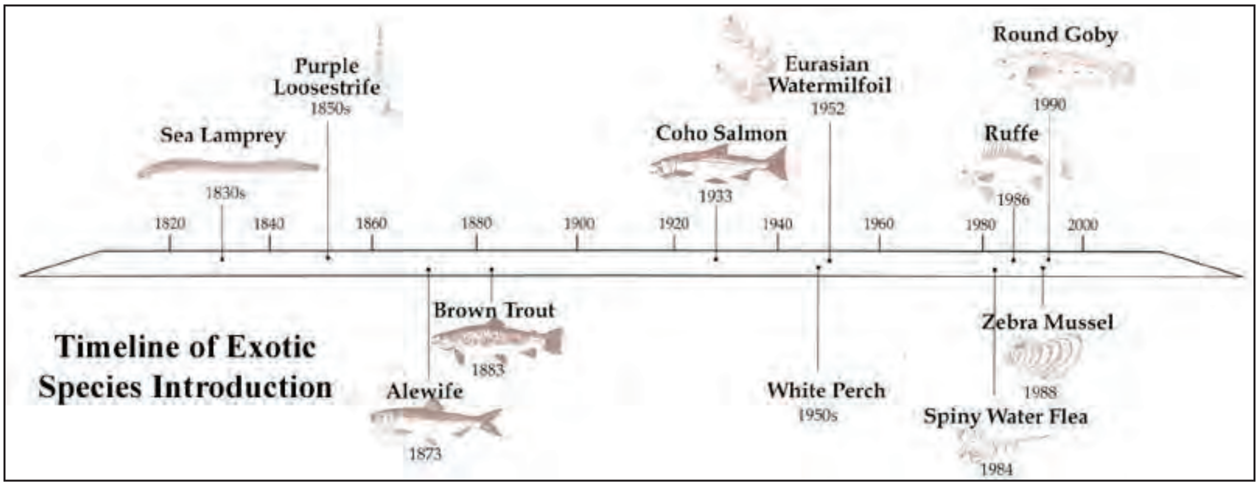


Spiny Water Flea

and tail make them difficult to eat, however, recent data suggest that some larger species are utilizing spiny water flea as a food source.

There is a general decline in the overall fish prey-base in Lake Michigan due to the arrival of the above described invasive species. *Dreissena* mussels are reducing phytoplankton populations, which serve as the primary food source for *Diporeia*, a native shrimp-like crustacean and important base in the Great Lakes food web. This is resulting in a shortage of food for many foraging fish. In addition, the improved water clarity is adding more stress by hindering small prey fish's ability to hide from predators.

Below is a timeline listing the introduction of some major invasive species into the Great Lakes.



Typical Impacts from Invasive Species

Impact #1: *Invasive species often have no natural predators and can out-compete native species for food and habitat.*

Impact #2: *Introduction of a single key species can cause a sudden and dramatic shift in the entire ecosystem's structure. New species can significantly change the interactions between existing species, creating ecosystems that are unstable and unpredictable.*

Impact #3: *In some instances invasive species can interfere with recreation in the watershed For example, rows of zebra mussel shells washed up on shore can cut beach walkers' feet, and <u>Eurasian watermilfoil</u> can get tangled up in boat propellers.*

Thermal Pollution

Not normally thought of as a pollutant, heated stormwater runoff and elevated stream temperatures are a concern in developing watersheds like the Coastal Grand Traverse Bay watershed where there are an abundance of small streams entering the bay. When water temperature increases, its ability to hold dissolved oxygen decreases, thereby reducing the available amount of oxygen in the water to fish and other aquatic life. Temperature also influences the rate of physical and physiological reactions such as enzyme activity, mobility of gases, diffusion, and osmosis in aquatic organisms. For most fish, body temperature will be almost precisely the temperature of the water. So, as water temperature increases, a fish's body temperature increases, which changes their metabolic rate and other physical or chemical processes as well. When thermal stress occurs, fish cannot efficiently meet these energetic demands (Diana 1995).

By far, the greatest amount of thermal pollution in the Coastal Grand Traverse Bay watershed is the result of heated runoff from paved surfaces and the removal of shade vegetation along streams and lake shorelines (more information in stormwater discussion in Chapter 5.4). Thermal pollution also occurs through industrial discharges of warmed process water, solar warming of stagnant pond water and stormwater, and from discharges of warmed water behind dams and other lake-level control structures. The only major dams in the Grand Traverse Bay watershed include hydro-electric dams along the Boardman River and in the Elk River Chain of Lakes, which are thoroughly discussed in their corresponding watershed plans. However, there are other small dams located throughout the rest of the Coastal Grand Traverse Bay watershed as indicated in a 2015 study in Leelanau and Grand Traverse Counties completed by The Watershed Center (TWC) that included man-made earthen dams and beaver dams (Figure 27). Survey results show at least 11 man-made small dams in Leelanau County (West Bay Shoreline and Tributaries subwatershed) and at least two more in the Mitchell Creek subwatershed. Each of these man-made dams has the potential to contribute to thermal pollution of downstream waters.

Identified Small Dam: Northport Creek Mill Pond Dam in Northport, MI

Photo courtesy of: Comfort and Kelly 2017

Excessive inputs of sediment into streams and lakes may also contribute to thermal pollution. Sediment inputs can fill stream pools and lakes, making them shallower and wider and, consequently, more susceptible to warming from solar radiation.

Changes in climate due to global activities also may enhance the degree of thermal pollution in a watershed. Average global surface temperatures are projected to increase by 1.5ºC to 5.8ºC by the year 2100 (Houghton et al. 2001). Increases in surface temperatures may increase stream water temperatures as well, although impacts will vary by region. Overall, increases in stream water temperature will negatively affect cold-water aquatic species. For example, cold-water fish, such as trout and salmon, are projected to disappear from large portions of their current geographic range in the continental United States due to an increased warming of surface waters (Poff et al. 2002). See Chapter 5.6 below for a more thorough discussion on climate change concerns.

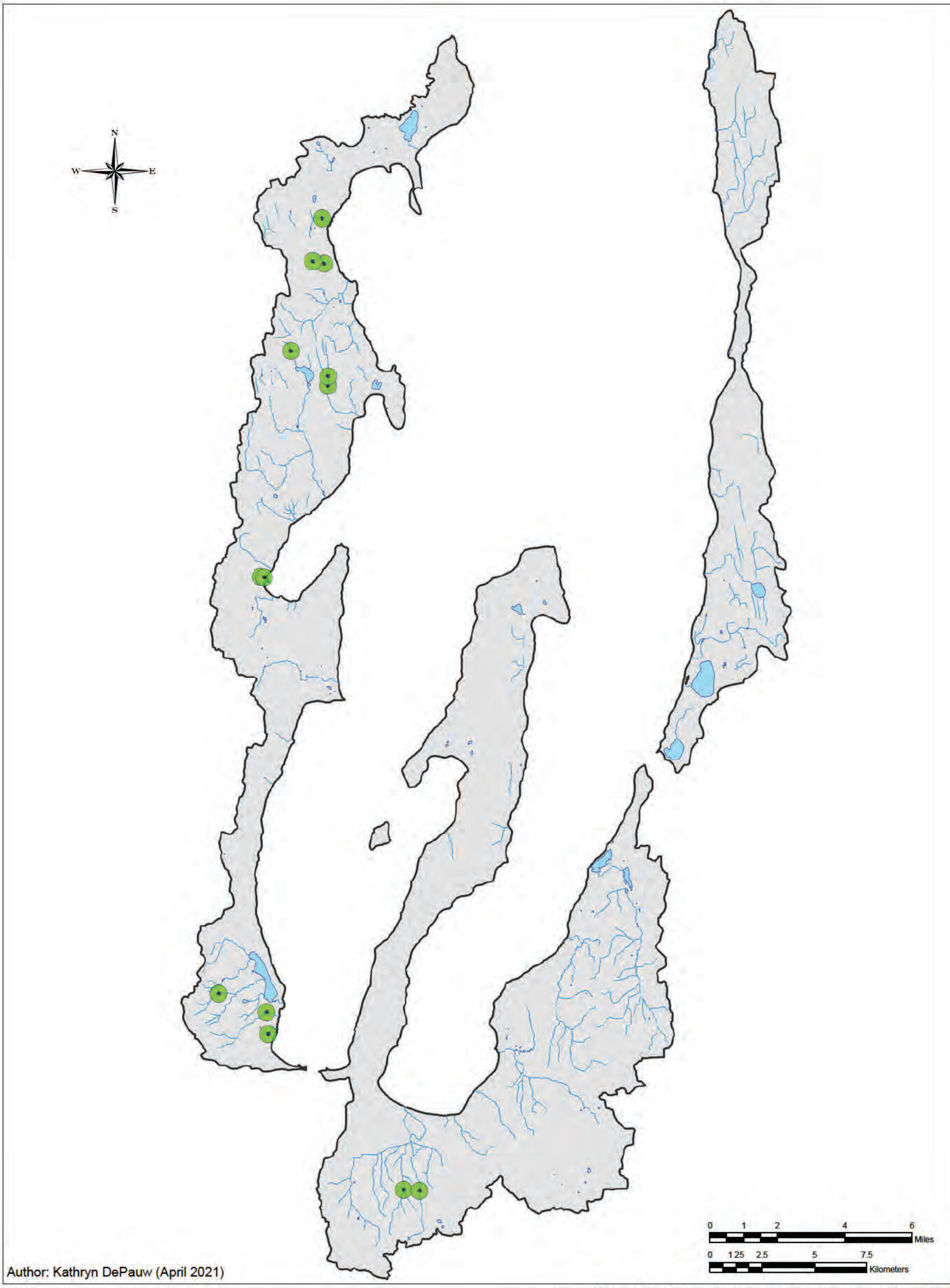
Typical Impacts from Thermal Pollution

Impact #1: *Surges of heated water during rainstorms can shock and stress aquatic life, which have adapted to cold water environments. Aquatic diversity is ultimately reduced. Constant heating of rivers and lakes ultimately changes the biological character and thus the fishery value.*

Impact #2: *Thermal pollution decreases the amount of oxygen available to organisms in the water, potential suffocating them.*

Impact #3: *Warm water increases the metabolism of toxins in aquatic animals.*

Impact #4: *Algae and weeds thrive in warmer waters.*



Layer Credits: The Watershed Center Grand Traverse Bay (2020)

Legend

Coastal Subwatershed
Rivers & Streams
Lakes & Ponds
Small Dams

GRAND TRAVERSE BAY COASTAL WATERSHED

FIGURE 27: SMALL DAMS

5.6 Climate Change Concerns

Communities along the Grand Traverse Bay shoreline should increasingly be evaluating and planning for the potential impacts on water quality associated with climate change, including warming water temperatures, more frequent and severe storm events, increased stormwater runoff, drought conditions, and flooding. In this way climate change could be considered a cause for the sources of pollutants/stressors in the watershed as noted in Chapter 5.3 Pollutants of Concern. For example, increased storm events would increase stormwater volumes and outputs, resulting in more pollutants like sediments and nutrients entering the watershed, as well as altering the hydrologic flow. Communities in the Great Lakes must prepare for these impacts and develop adaptation measures. Table 52 discusses potential watershed changes due to climate change and the resulting pollutants that could be increased.

Table 52: Pollutants/Stressors Affected by Climate Change

Climate Change Result	Pollutant/Stressor Increased
Increased intense storm events and greater occurrence of precipitation during late winter and early spring on frozen/bare ground *Both resulting in flashier streams with periodic high flows and increased stormwater runoff*	Sediments Nutrients Changes to hydrologic flow Thermal pollution Toxins Pathogens
Loss of tree species to ecological changes or pests/disease	Nutrients Loss of habitat Thermal pollution
Warmer air temperatures	Invasive species Thermal pollution
Changes in suitable habitat and species migration range expansion	Invasive species
Decreases in wetlands, groundwater recharge, and 1st and 2nd order stream levels due to less summer precipitation	Thermal pollution Changes to hydrologic flow

The Watershed Center partnered with Michigan State University in 2016 to complete a Climate Change Integrated Assessment through Michigan Sea Grant funding. That project conducted an Integrated Assessment to help communities in the Grand Traverse region understand how climate knowledge can inform planning in a realistic way by evaluating the vulnerabilities and assessing strategies to increase resilience against anticipated climate change impacts. The assessment was able to quantify changes in temperature, precipitation, ice cover, lake levels, streamflow, and water quality, as well as project future conditions and assess the impacts of those changes. It also developed and assessed adaptive management strategies, such as the mitigation benefits of stormwater projects such as the ones TWC is currently conducting. The results of this study will help Grand Traverse Bay shoreline communities understand management options for adapting to climate change over time (Hyndman et.al 2016).

A 2015 USEPA report, *Climate Change in the United States: Benefits of Global Action*, estimates the physical and monetary benefits to the U.S. of reducing global greenhouse gas emissions. This report summarizes results from the Climate Change Impacts and Risks Analysis

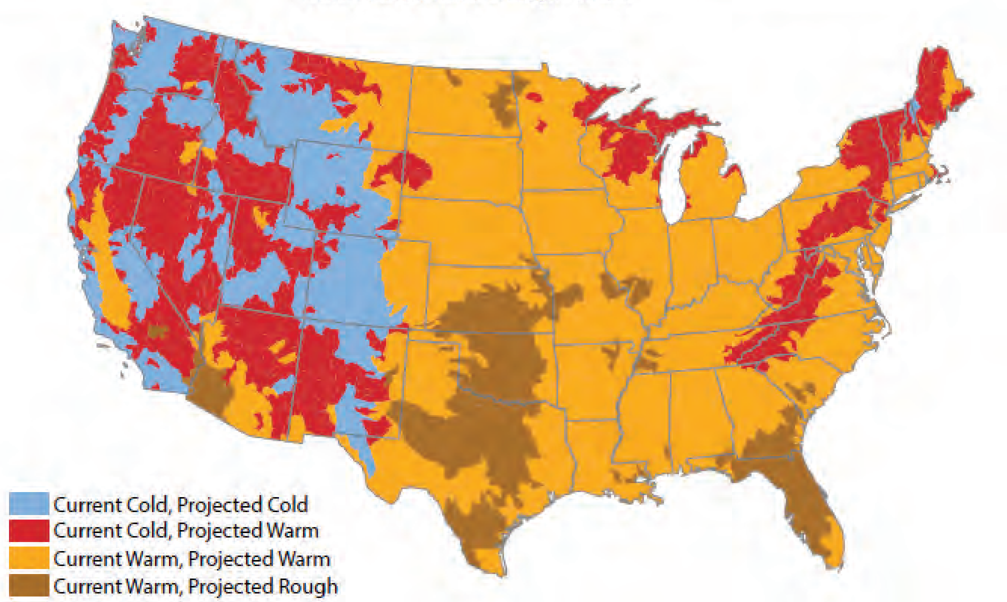
(CIRA) project, a peer-reviewed study comparing impacts in a future with significant global action on climate change to a future in which current greenhouse gas emissions continue to rise (USEPA 2015). The report states that, among a host of other things,

> "...climate change will result in increased intensity of precipitation events, leading to heavier downpours. Therefore, as climate change progresses, many areas are likely to see increased precipitation and flooding, while others will experience less precipitation and increased risk of drought. Some areas may experience both increased flooding and drought. Many of these meteorological changes, along with their associated impacts, are already being observed across the U.S." (USEPA 2015).

Climate change is also likely to have numerous effects on water quality due to increases in river and lake temperatures and changes in the magnitude and seasonality of river flows, both of which will affect the concentration of water pollutants. These physical impacts on water quality will potentially have substantial economic impacts, since water quality is valued for drinking water and recreational and commercial activities such as boating, swimming, and fishing. Additionally, these changes, combined with demographic, socioeconomic, land use, and other changes, affect the availability, quality, and management of water resources in the U.S.
For example, freshwater fishing is an important recreational activity in the Grand Traverse region. In the freshwater fish category, the USEPA report states that most fish species thrive only in certain ranges of water temperature and stream flow conditions. Climate change threatens to disrupt these habitats and affect certain fish populations through higher temperatures and changes in river flow. In fact, increasing stream temperatures and changes in stream flow could make coldwater habitats more suitable to warmwater fish species, and coldwater species are projected to be replaced in many areas by less economically valuable fisheries over the course of the 21st century. The graphic below (taken from the report) shows a map that has Northwest Lower MI projected to change from coldwater fish habitat to a mostly warmwater fish habitat. If kept on the current track, without any reduction in greenhouse gases that potentially cause changes in climate, coldwater fish habitat could decline by as much as 62 percent in the next 80 years.

Figure 1. Projected Impact of Unmitigated Climate Change on Potential Freshwater Fish Habitat in 2100

Change in distribution of areas where stream temperature supports different fisheries under the Reference scenario using the IGSM-CAM climate model. Results are presented for the 8-digit hydrologic unit codes (HUCs) of the contiguous U.S.



5.7 Priority Protection and Critical Areas

In addition to ranking priority pollutants and their sources, the Steering Committee identified several areas in the Grand Traverse Bay Coastal watershed as critical areas or those needing priority protections. Recommendations will be aimed at protecting land from future development or protecting water quality from future potential impairment. High priority locations for these actions are placed into either “Priority Areas” (for protective actions) or “Critical Areas” (for restoration actions). Priority areas are those that are particularly vulnerable to degradation or development pressure and should be protected from future harm. Critical areas are those in need of restoration that are contributing a significant amount of pollutants to the watershed (currently or in the future) and are considered targets for future water quality improvement efforts.

Priority Areas for Protection

In order to maintain the high-quality resources of the Grand Traverse Bay Coastal watershed, it is essential to address known sources of pollution while at the same time working towards the reduction of future sources of pollution and watershed disturbance. Protecting priority areas associated with Grand Traverse Bay and its tributaries through purchase, donation, or conservation easements are excellent strategies to meet this objective. Permanent protection of high-quality natural lands will help to maintain high water quality by preventing conversion to residential use and thereby preventing increases in nonpoint source loading of phosphorus, nitrogen and sediment into the nearby wetlands or waterbodies. Protection of these lands will also help maintain critical habitat for many native species of flora and fauna.

There are two local land conservancies using these strategies to protect land in the Grand Traverse Bay Coastal watershed - the Grand Traverse Regional Land Conservancy (GTRLC) and the Leelanau Conservancy (LC). In cooperation with these entities, private parcels of land in the coastal watershed areas of Grand Traverse, Antrim, and Leelanau County were reviewed for their potential contribution to improving the water quality of Grand Traverse Bay and its watershed, among other factors. Both conservancies utilized geographic information systems (GIS) to assist in delineating priority areas for the watershed.

The GTRLC’s Priority Land Atlas (PLA) identifies parcels with high conservation value within each subwatershed in their service area in the Grand Traverse Bay Coastal watershed (Grand Traverse and Antrim Counties). These areas were prioritized through a scoring process based on criteria (conservation drivers) including parcel size, adjacency to protected land, length of shoreline, wetlands, habitat fragmentation and presence of rare species. Parcels were ranked in a three-tiered system based on their cumulative scores with the highest scores representing priorities for protection (Figures 28a-f). There are just over 500 acres of high priority land (Tier 1) for protection in their service area, with the bulk falling in the Yuba Creek, Tobeco Creek, and East Bay Shoreline subwatershed (Table 53). The Conservancy acknowledges priorities identified though the PLA are subject to ground-truthing and may not identify all parcels worthy of protection.

The Leelanau Conservancy's Priority Protection map identifies land that is integral to maintaining high water quality in West Grand Traverse Bay (Figure 29, Table 53). Land within 500 feet of waterbodies and wetlands (totaling 20,324 acres) is prioritized for permanent land protection efforts to help retain intact riparian corridors, upland forests, and native groundcover. Maintaining and improving natural ecological communities along riparian corridors is the most cost-effective way of maintaining high quality systems and preventing increases from nonpoint source sedimentation and nutrients. These riparian corridors are prioritized for permanent conservation easement acquisition due to their direct influence on water quality conditions. In addition to prioritizing riparian areas, LC has also identified lands that contain soil types prone to severe erosion. These are referred to as "Highly Erodible Priority Protection Areas" and total an additional 3,139 acres (Figure 29, Table 53). These areas have the greatest potential for water quality impacts from sedimentation or nutrient inputs since soil in these areas is much more easily mobilized by stormwater. Priority Protection parcels must meet permanent land protection criteria to qualify for permanent conservation easement funding. These projects are entirely voluntary. Interested landowners should contact the Leelanau Conservancy to determine if their land qualifies

Table 53: Acreage of Priority Areas by Subwatershed*

<table>
<tr><th>Subwatershed</th><th colspan="2">Tier 1
High</th><th colspan="2">Tier 2
Medium</th><th>Tier 3
Low</th></tr>
<tr><td>Acme Creek</td><td colspan="2">0</td><td colspan="2">1,178</td><td>1,110</td></tr>
<tr><td>East Bay Shoreline</td><td colspan="2">122</td><td colspan="2">3,790</td><td>5,723</td></tr>
<tr><td>Mitchell Creek</td><td colspan="2">75</td><td colspan="2">1,637</td><td>2,057</td></tr>
<tr><td>Old Mission Peninsula</td><td colspan="2">0</td><td colspan="2">438</td><td>849</td></tr>
<tr><td>Tobeco Creek</td><td colspan="2">127</td><td colspan="2">573</td><td>2,269</td></tr>
<tr><td>Yuba Creek</td><td colspan="2">185</td><td colspan="2">1,374</td><td>1,529</td></tr>
<tr><td>Total (GTRLC service area)</td><td colspan="2">509</td><td colspan="2">8,990</td><td>13,537</td></tr>
<tr><td></td><td colspan="3">Land in 500ft Riparian Buffer</td><td colspan="2">Highly Erodible Lands</td></tr>
<tr><td>West Bay Shoreline
(LC service area)</td><td colspan="3">20,324</td><td colspan="2">3,139</td></tr>
</table>

**For ease of viewing, table combines priority acreage from both conservancies. However, it is noted that they used different methods to determine their priority lands and the Leelanau Conservancy did not break into tiers.*

It should be noted that conservancy criteria for land protection prioritization generally include a lot of factors that are good to consider for their organization's goals, but not all of them may relate directly to water quality protection. When these and other organizations seek water quality related funds to protect priority parcels, water quality protection factors will be emphasized in deciding which parcels to pursue.

Additional Priority Areas for Protection

In addition to priority areas noted by each conservancy as priorities for their land protection efforts, there are a number of other areas in the Grand Traverse Bay Coastal watershed that should be protected (Figure 30). They are as follows:

- **Critical Dunes:** These are two sections of Grand Traverse Bay shoreline recognized as Critical Dunes in Chapter 3.5. This includes a 3.8-mile section of shoreline in Torch Lake Township (Antrim County) from approximately Bay Colony Road north to Manitou Trail, as well as a 1.1-mile section of shoreline in Leelanau County north of the Village of Northport and west of Mud Lake, starting at Pine Crest Drive.
- **Undeveloped Parcels Along Grand Traverse Bay Shoreline:** Because of its sheer size and ability to affect the water quality of the bay, the shoreline of Grand Traverse Bay is important for protection and restoration. Much of the shoreline has been developed already, and there are many areas already preserved. However, privately owned undeveloped areas along the shoreline are a priority for protection efforts.
- **High Groundwater Recharge Areas:** These are found in the headwater areas of Acme Creek and Cedar Lake where groundwater recharge rates are up to 20 in/yr.
- **Wetlands:** Wetlands are a vital part of the coastal ecosystem and perform important ecological functions like pollutant removal and providing wildlife habitat. Total wetland loss in the Grand Traverse Bay Coastal watershed area since pre-settlement times is almost 40%, with some subwatersheds experiencing more substantial wetland losses compared to their watershed size.
- **Grand Traverse Bay Spawning Reefs –** In consultation with DNR the following areas are categorized as priority areas for protection for fish spawning or other reasons:
    - **Elk Rapids reef sites:** Three areas offshore of Elk Rapids, 1) the point adjacent to the beach area and south of the channel, 2) a reef immediately off the mouth of the channel, and 3) the restored reef site on the shoreline north of the channel.
    - **Ingall's Point:** On the west shore of West Grand Traverse Bay, near Omena. DNR has long-term data on fish spawning and egg deposition at this location.
    - **Shoreline from Acme to Yuba:** On the east shore of East Grand Traverse Bay. DNR has data on smallmouth bass use of various sites along this stretch.
    - **Lee Point (west shore of West Grand Traverse Bay), Old Mission Point, Northport (Cherry Home vicinity), and Ingall's Bay (identified above):** These are reefs identified and sampled in a published paper by Bronte et al 2007.

Figure 28A: Priority Areas for Protection – Acme Creek Subwatershed

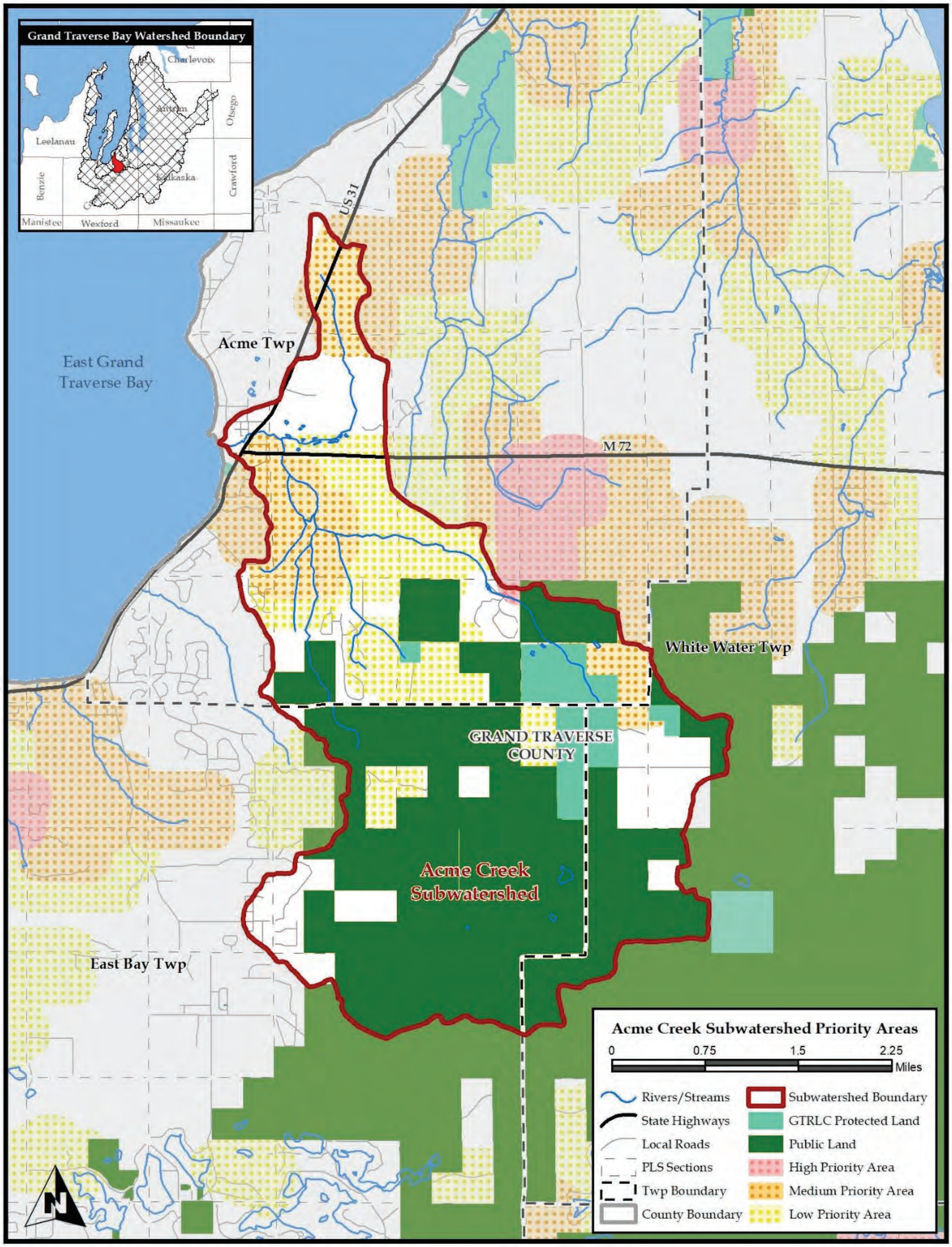


Figure 28B: Priority Areas for Protection – East Bay Shoreline Subwatershed

Figure 28C: Priority Areas for Protection – Mitchell Creek Subwatershed

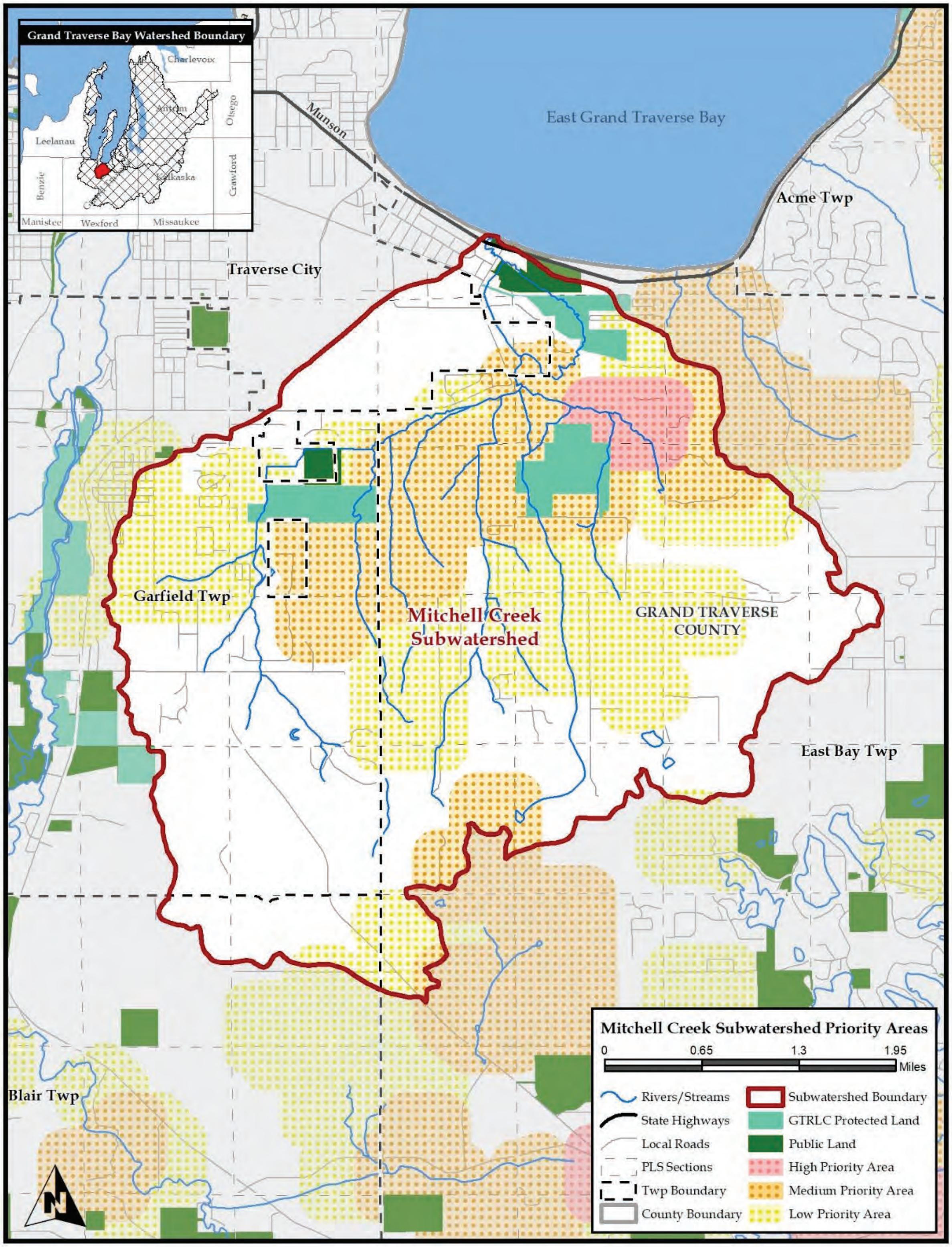


Figure 28D: Priority Areas for Protection – Old Mission Peninsula Subwatershed

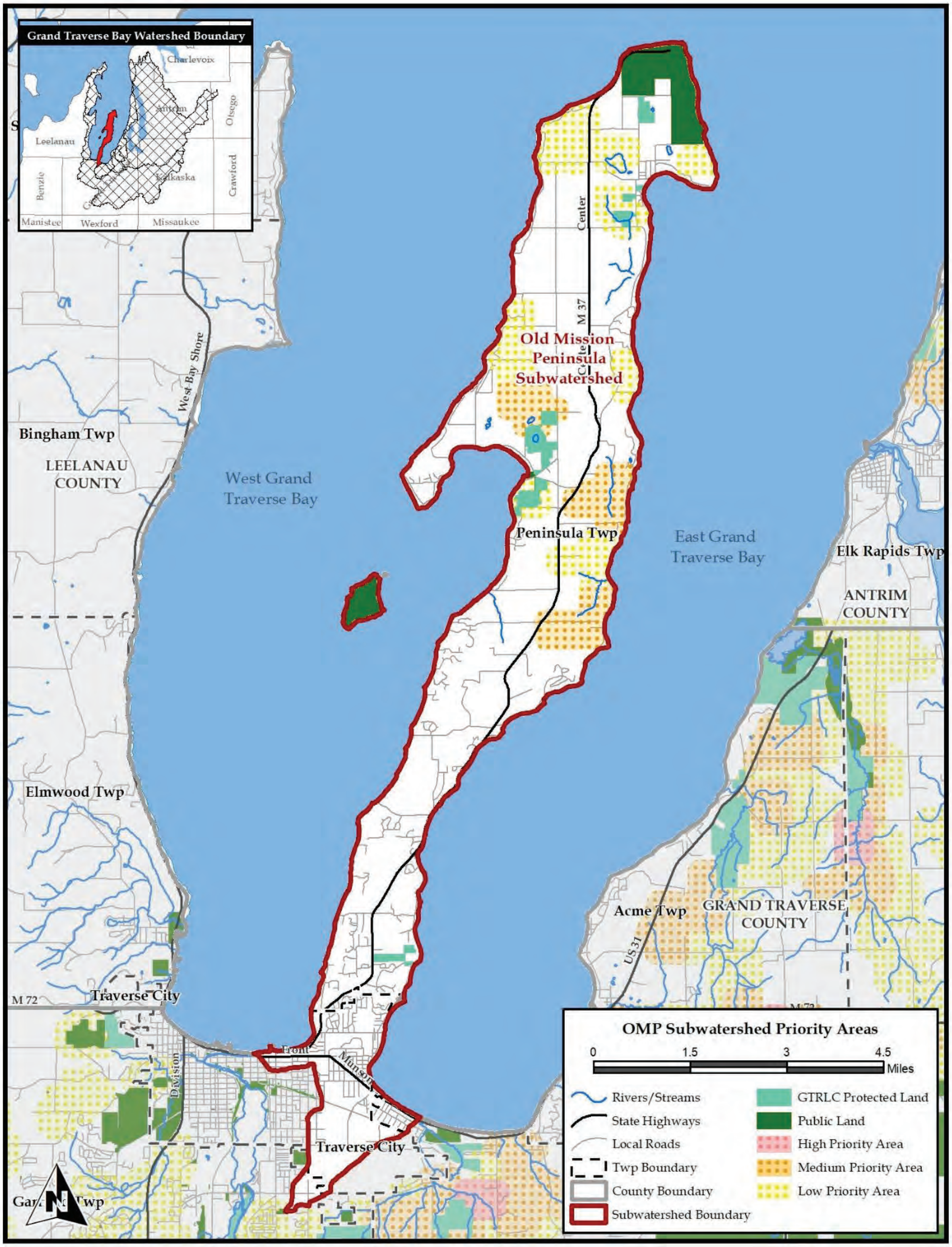


Figure 28E: Priority Areas for Protection – Tobeco Creek Subwatershed

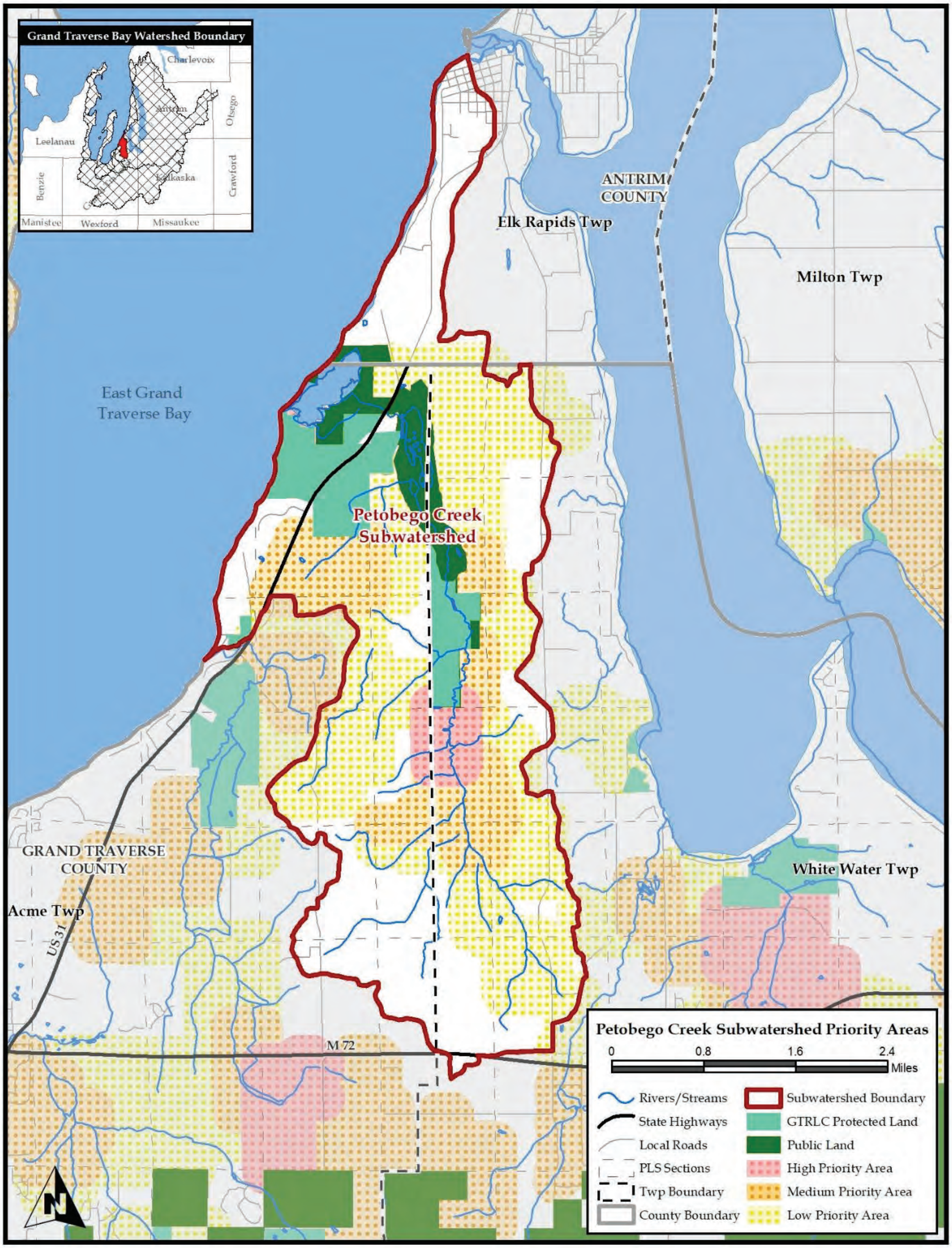
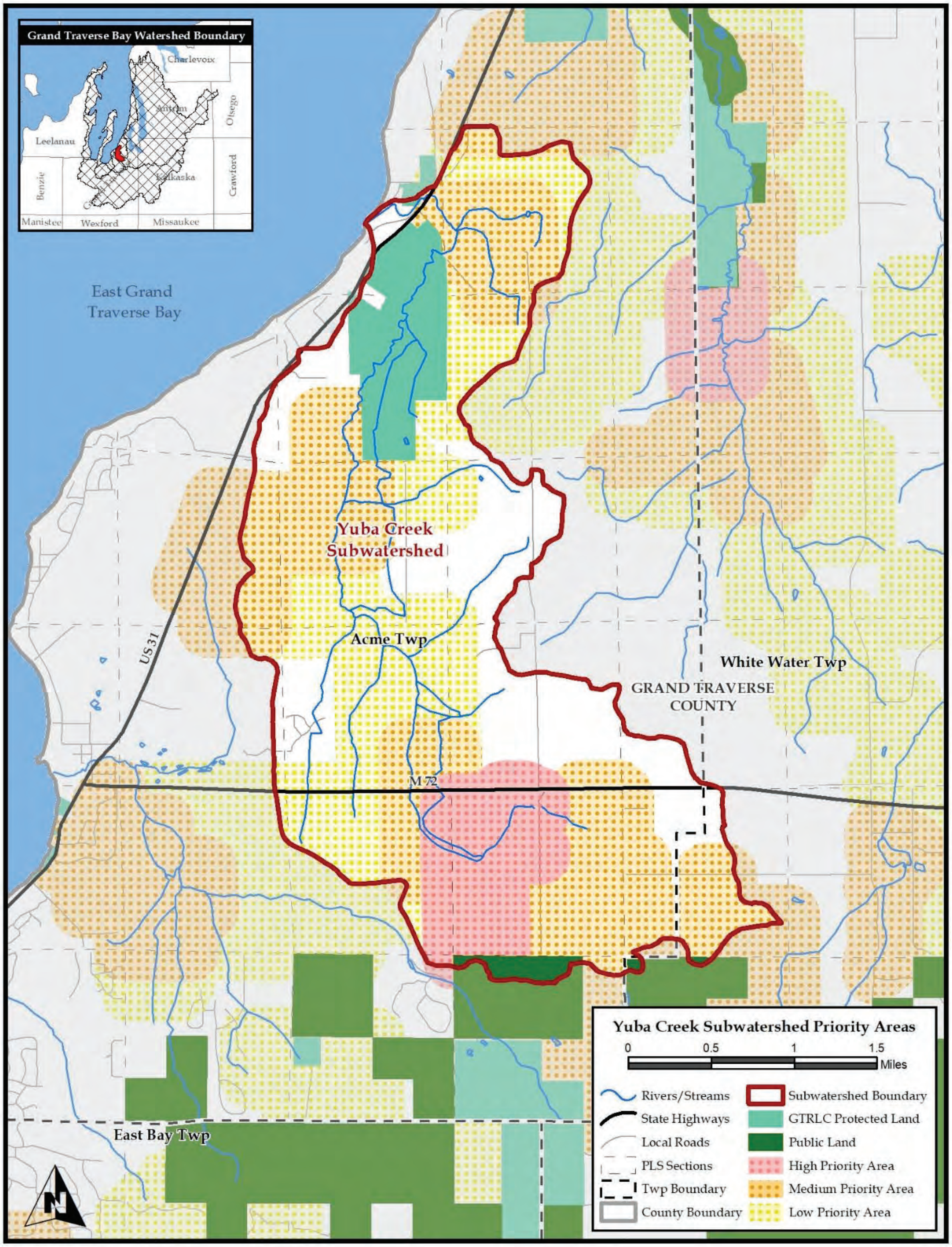
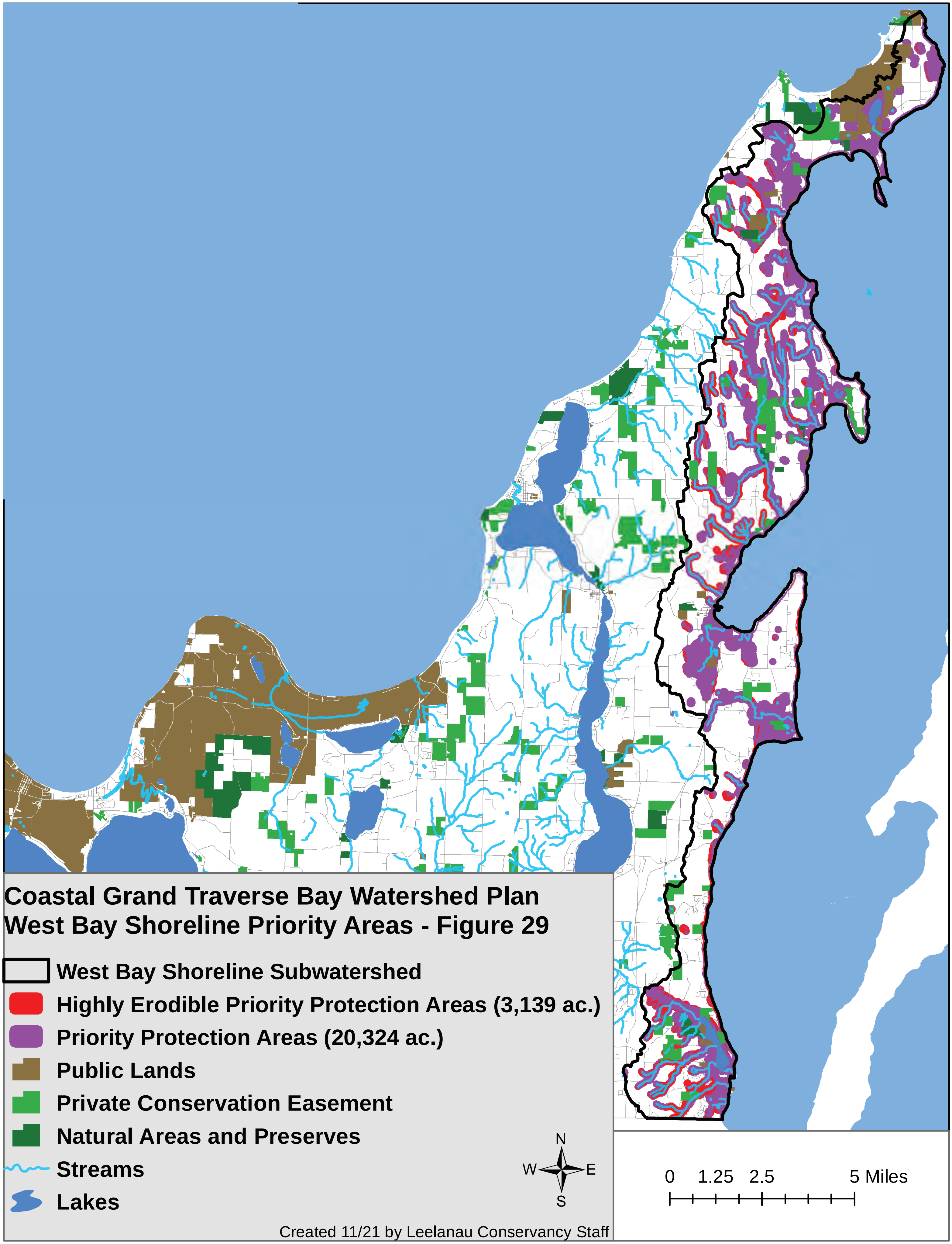
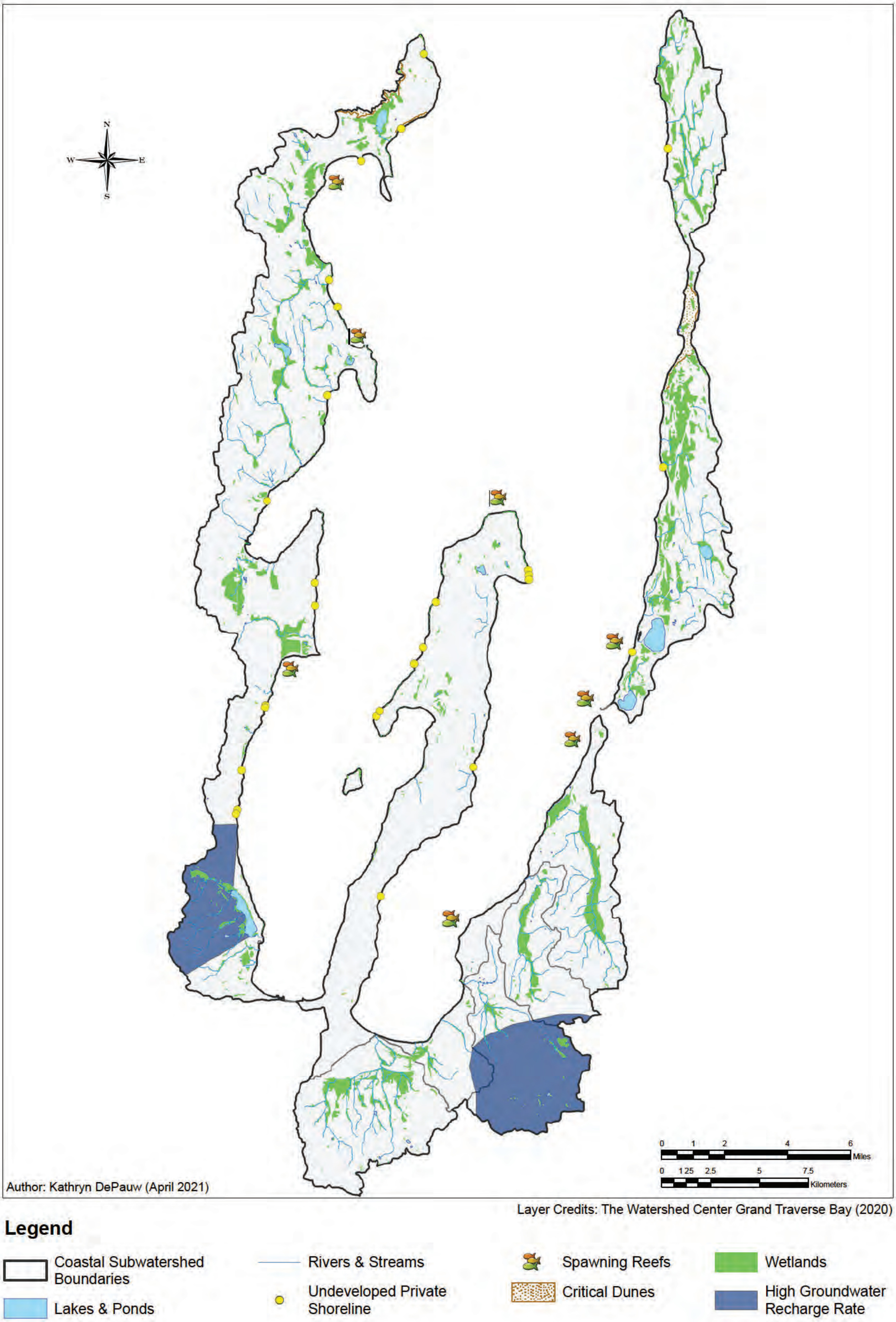


Figure 28F: Priority Areas for Protection – Yuba Creek Subwatershed




Coastal Grand Traverse Bay Watershed Plan
West Bay Shoreline Priority Areas - Figure 29
West Bay Shoreline Subwatershed
Highly Erodible Priority Protection Areas (3,139 ac.)
Priority Protection Areas (20,324 ac.)
Public Lands
Private Conservation Easement
Natural Areas and Preserves
Streams
Lakes
N
W
E
S
0
1.25
2.5
5 Miles
Created 11/21 by Leelanau Conservancy Staff



GRAND TRAVERSE BAY COASTAL WATERSHED

FIGURE 30: ADDITIONAL PRIORITY AREAS FOR PROTECTION

Critical Areas

Critical areas for the Grand Traverse Bay Coastal watershed are the areas in which management measures need to be implemented to achieve load reductions identified in the plan. They also refer to locations where actions are needed to address ongoing sources of nonpoint source pollutants. The process of identifying critical areas relies on a combination of methods, including resource inventories, GIS, and reports from resource managers and others familiar with a particular aspect of the watershed.

The critical areas identified in the Grand Traverse Bay Coastal watershed reflect the primary sources of nonpoint source pollution in the coastal watershed area only (Figures 31, 32). This includes urban stormwater, development, and shoreline management; shoreline/bank erosion; agriculture; road/stream (or other transportation) crossings; and malfunctioning septic systems. These are also known locations of contamination where nonpoint source Best Management Practices need to be established. Additional critical areas have been identified for the Boardman and Elk River Chain of Lakes subwatersheds and are available for review in their respective watershed plans. Critical areas are shown at two levels: general critical areas and specific critical areas. General critical areas represent broader areas where attention is generally needed, whereas specific critical areas encompass a more defined area (Figures 31, 32).

General Critical Areas (Figure 31)

- **Grand Traverse Bay Shoreline:** The shoreline along Grand Traverse Bay experiences significant development pressure. Due to historic high-water levels at the time of the development of this management plan, the shoreline is experiencing unprecedented erosion and increased demand for shoreline hardening which might harm the ecosystem in the long-term. The shoreline's critical area reflects a 100-foot buffer along the entire Grand Traverse Bay shoreline an includes two Critical Dune Areas. This specific critical area is discussed in detail below.
- **Riparian corridors:** Areas within 100 feet of bodies of water (i.e. creeks, streams, lakes, wetlands).
- **City and village centers:** Urban areas contribute significant stormwater runoff to the Grand Traverse Bay and its coastal tributaries. Although each urban area's individual contributions vary according to many factors, including total impervious surface, implementation of stormwater best management practices, and types of development, it is reasonable to assume they are all contributing nonpoint source pollutants to some extent and therefore should be continually managed to reduce their loadings. Includes: Northport, Omena, Peshawbestown, Suttons Bay, Traverse City, and Elk Rapids.

Specific Critical Areas (Figure 32)

- **Areas of Bacterial Impairment:**
  a. **Mitchell Creek – Grand Traverse County:** This urban creek on the east side of Traverse City was recently listed as impaired due to bacterial contamination from *E.coli*. Previous research indicates potential human sources (among others) for bacteria. However, a more recent study in 2021-2023 indicates pig and canine sources may be impacting the creek as well (Appendix E). The western tributaries had higher occurrences of pig markers while the central main branch had more human

marker influence. The canine marker that includes wild animals such as fox and coyote is also widespread.

b. **Mitchell Creek – Antrim County:** This small creek in Milton Township was listed as impaired due to *E.coli* contamination more than 10 years ago. Additional testing needs to confirm either that there is still a problem and what sources may be.

c. **Northport Creek:** This creek will be listed as impaired due to bacterial contamination from *E.coli* as of the EGLE 2020 Integrated Report. Additional sampling in conjunction with source tracking efforts must be done to pinpoint the sources and causes of the contamination.

- **Urban Sprawl:** In addition to urban areas defined by city/village boundaries, urban sprawl areas area also included in this critical area category. These lands are perhaps even more critical than the already developed existing urban areas. As urban sprawl occurs, undeveloped and rural land uses are converted to residential and commercial uses, which increases impervious surfaces and nonpoint source pollution inputs. Urban sprawl critical areas are the zones directly east and west of Traverse City that are experiencing increased development including the downstream portion of the Mitchell Creek subwatershed, Acme Township area (portions of East Bay Shoreline and Acme Creek subwatershed), and Greilickville in Leelanau County.
- **Severe Road Stream Crossings:** The degree of severity of road-stream and other transportation crossings vary; consequently, the impacts to the resources vary as well. Severe and moderate crossing sites are included as critical areas because of their potential to contribute large amounts of sediments and change hydrologic flow.
- **High Risk Erosion Areas:** There are a number of townships along the Grand Traverse Bay shoreline that contain High Risk Erosion Areas as defined by EGLE (Chapter 3.5). While this information from EGLE is outdated and has not been updated recently, we acknowledge that there may be many more areas along the bay's shoreline at risk for erosion, especially during these high-water years. However, it is still important to note them as critical areas for restoration in this plan.
- **Wetland Development Pressure:** Wetlands are a vital part of the coastal ecosystem and perform important ecological functions like pollutant removal and providing wildlife habitat. Total wetland loss in the Grand Traverse Bay Coastal watershed area since pre-settlement times is almost 40%, with some subwatersheds experiencing more substantial wetland losses compared to their watershed. In addition to listing all wetlands in general as priority areas for protection, wetlands along the coastal areas of Grand Traverse Bay are at a higher risk of development and are considered critical areas for restoration as well as protection. Areas noted as under increased threat of development and filling are anecdotally noted here by TWC staff and occur close to urban areas where commercial development is happening, or further away from developed areas but along prime real estate along the Bay where there is an increased demand for residential homes.
- **Coastal Infrastructure Challenges (high-water years):** High water levels can present challenges to municipally owned coastal infrastructure features (i.e. roads, gazebos, park structures, etc.) located close to the water. Erosion and receding shorelines may cause considerable damage to these structures.
- **Grand Traverse Bay – Macrophyte Bed Clusters:** Most of the macrophyte beds in the bay found in the 2009 study are concentrated in embayments, such as Northport, Omena, and Suttons bays, as well as the southern end of west Grand Traverse Bay, where the

Boardman River drains. This growth is attributed to increased developed areas and nutrient flushing from stormwater inputs, particularly the amount of phosphorus entering the bay. Additionally, sediment tests completed at macrophyte bed sites reveal a trend towards higher nitrogen and phosphorus levels.

- **Compromised At-Risk Streams:** The water quality summary section reveals that there are a number of coastal streams that have elevated nitrogen/phosphorus levels and/or poor macroinvertebrate populations and/or elevated bacteria levels. Additionally, some coastal streams are in urban areas with increased amount of impervious surface or have experienced significant wetland loss (Table 54). These are the most critical coastal streams for restoration efforts and include Northport, Ennis, Leo, Waterwheel, Brewery, Mitchell, Acme, Baker, and Yuba creeks.
- **Small Dam Locations:** As stated earlier, small dams can be a cause for thermal pollution to downstream water bodies. Survey results show at least 11 man-made small dams in Leelanau County and at least two more in the Mitchell Creek Subwatershed. Each of these man-made dams has the potential to contribute to thermal pollution of downstream waters
- **Agricultural Lands – Tobeco and Mitchell Creek headwater areas:** While there are a considerable amount of agricultural areas in the coastal watershed area, much of it is orchards and vineyards, which typically have a low potential for sediment and nutrient runoff. However, other types of agriculture such as pasture and croplands have a higher potential for sediment and nutrient inputs. These agricultural land types are concentrated in the headwater areas of Mitchell and Tobeco Creeks and makes the potential nutrient and sediment inputs to these small streams a high priority

Figure 32 shows a map containing all of the above noted specific critical areas. When looking at this map, it is apparent that there are several areas where various critical areas are clustered and overlap. These include areas surrounding Mitchell Creek (GT County), Cedar Lake/Creek area just north of Traverse City, Suttons Bay area and south, and the Village of Northport. Special care should be taken for these areas and they should be prioritized for restoration activities.

Table 54: Compromised At-Risk Streams in the Coastal Watershed Area

Streams	Elevated Phosphorus	Elevated Nitrogen	Poor Aquatic Insects	High *E.coli*	High Wetland Loss*	Urban Stream
Yuba Creek	✓	✓	✓		✓	
Acme Creek			✓		✓	✓
Baker Creek	✓	✓				✓
Mitchell Creek ***(GT County)***	✓	✓	✓	✓	✓	✓
Brewery Creek			✓		✓	✓
Leo Creek		✓			✓	✓
Waterwheel Creek				✓		✓
Ennis Creek	✓	✓			✓	
Northport Creek	✓	✓		✓		✓

**From Figure 8B*

Special Critical Area: Grand Traverse Bay Shoreline

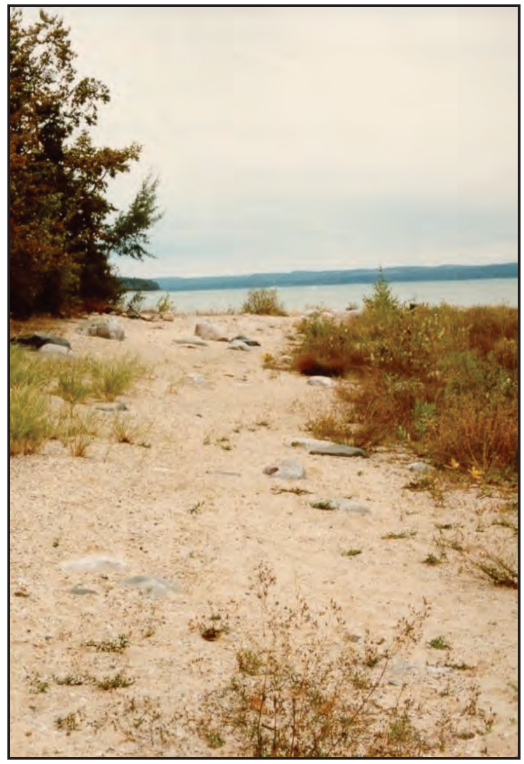
Because of its sheer size and ability to affect the water quality of the bay, the entire shoreline of Grand Traverse Bay is deemed a critical area. Development pressure along the bay continues to threaten water quality in the nearshore area due to the added stormwater inputs from impervious surfaces. Increased development along the bay may also lead to loss of critical habitat and wetlands for animals that depend on this area for survival. In addition, as discussed in Section 3.7, water levels in the Great Lakes fluctuate naturally daily, seasonally, and annually in response to weather and climate. Wave action, storms, wind, ground water seepage, surface water runoff, and frost are contributing factors to changing and reshaping the shoreline. Since 2014, lake levels in Lake Michigan have been on the rise. These high-water levels have led to increased shoreline erosion, which can cause financial property loss as well as public losses to recreation facilities, roads and other public works.

Example of shore hardening using large rock rip-rap.

As part of the original Grand Traverse Bay Watershed Protection Plan, The Watershed Center (TWC) completed a shoreline inventory of the entire 132-mile shoreline of the Grand Traverse Bay in 2003 to assess the current conditions surrounding the bay. Results for this survey were compiled into a final report (Appendix A). During the survey, features such as nearshore substrate, endangered and exotic plant species, streams, seeps, public access, human impact (shore hardening, beach alterations), and beach characteristics were noted recorded. Of note is that more than one hundred small streams were observed flowing into the bay.

The 2003 inventory found significant increases in shoreline hardening compared to a similar study done in 1958 by the MSU Department of Resource Development's Agricultural Experiment Station. Other changes include the building of groins and the "creation" of beaches by moving the stones into groins, as well as the construction of marinas, both public and private, with their associated dredging.

Also noted were considerable increases in algae growth on benthic substrates, including significant carpets (or mats) of cladophora and chara growing on the substrate. Intense development increases the amount of stormwater discharge to the bay, due to increases in impervious surfaces. Numerous stormwater discharge pipes were noted entering the bay in Traverse City, as well as significant increases in the amount of impervious surfaces covering land adjacent to the bay. Stormwater runoff from coastal urban areas along the Grand Traverse Bay shoreline can cause localized elevated levels of nutrients in the nearshore area compared to the lower levels seen offshore.



"In the past many activities have been undertaken in these beach areas with little or no awareness of the dynamic, ever changing properties of a shoreline area. Use must be planned in accordance with the natural characteristics and natural changes; otherwise the user may expect problems that are not only unpleasant, but expensive," (MSU 1958 historical shoreline inventory).

The effect of the nutrient inputs on the nearshore zone of west Grand Traverse Bay can be seen in a 2009 study TWC conducted on macrophyte bed growth in the bay (TWC 2010). TWC conducted aquatic plant surveys in Grand Traverse Bay in 1991, 1998, and 2009, and completed a variety of water and sediment testing for nitrogen and phosphorus at locations with and without macrophyte beds and the mouths of several tributaries to the bay. These surveys showed a six-fold increase in the number of plant beds identified between 1991 and 2009 (1991: 64 beds; 1998: 124 beds; 2009: 402 beds). Most of the macrophyte beds were concentrated in embayments, such as Northport and Omena bays, as well as the southern end of west Grand Traverse Bay, where the Boardman River drains. This growth is attributed to rapid development and nutrient flushing from stormwater inputs, particularly the amount of phosphorus entering the bay.

The Grand Traverse Bay shoreline critical area also includes 2 locations identified by EGLE as Critical Dune Areas. The first is a 1.1-mile shoreline section in Leelanau County north of Northport and east of Mud lake that runs from approximately Pinecrest Drive to Forest Beach Shores Road. The second section is a 3.8-mile section in Torch Lake Township, Antrim County that runs from approximately Bay Colony Road up to Manitou Trail. More information on Critical Dune Areas is found in Section 3.5.

Pollutants/Sources in Critical Areas

Table 55 lists the pollutants/environmental stressors that are being contributed at each type of critical area. As the table shows, many different types of pollutants can enter the watershed at these critical areas from a variety of sources including development, stormwater, and road crossings. The top four pollutants to the watershed – sediment, changes to hydrologic flow, loss of habitat, and nutrients – affect almost all the critical areas listed.

Table 55: Pollutants and Sources Affecting Critical Areas in the Grand Traverse Bay Coastal Watershed

Critical Area	Pollutant(s) Contributing	Priority Sources
Grand Traverse Bay Shoreline	Loss of Habitat Nutrients Invasive Species Pathogens Toxic Substances	Development, Stormwater, Lack of buffers, Road crossings, Fertilizer, Shoreline erosion/hardening, Septics, Animal waste
Riparian corridors	Sediment Changes to Hydrologic Flow Loss of Habitat Nutrients Invasive Species Toxic Substances Pathogens Thermal Pollution	Road crossings, Bank erosion, Stormwater, Wetland filling, Development, Septics, Lack of buffers, agriculture
City and Village Centers AND Urban Sprawl AND Wetland Development Pressure	Changes to Hydrologic Flow Nutrients Pathogens Sediment Thermal Pollution Toxic Substances	Stormwater, Development, Road crossings, Animal Waste
Areas of Bacterial Impairment	Pathogens	Stormwater, Animal Waste, Septic systems
Road Stream Crossings (RSXs)	Sediment Changes to Hydrologic Flow Nutrients Thermal Pollution	(RSXs themselves are classified as a source) Causes: Misaligned/undersized/failing culverts, Lack of erosion control, Steep approaches
High Risk Erosion Areas	Sediment Nutrients	Shoreline erosion along GT Bay
Macrophyte Bed Clusters	Nutrients	Stormwater, Development
Compromised At-Risk Streams	Sediment Changes to Hydrologic Flow Loss of Habitat Nutrients	Lack of habitat, Lack of riparian buffer, Excessive sediment in stream, Stormwater, Road crossings, etc.
Small Dam Removal Locations	Thermal pollution Nutrients	Small dam
Agricultural Lands – Tobeco and Mitchell Creek headwater areas	Sediment Nutrients	(Agricultural lands are classified as a source) Causes: Improper manure and fertilizer storage/handling/application, Close proximity to Bay/Tributaries, Grazing near stream edge

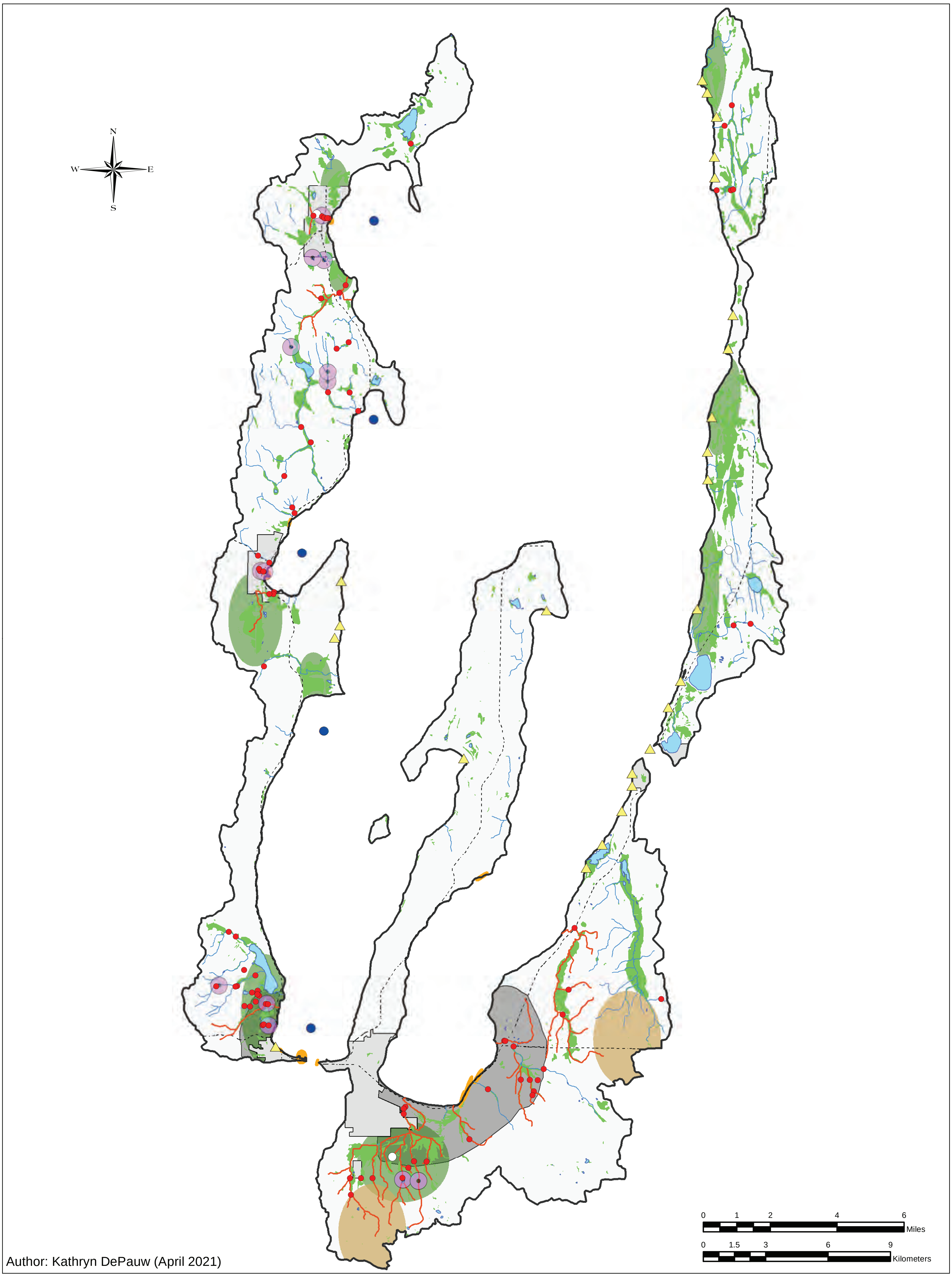
Layer Credits: The Watershed Center Grand Traverse Bay (2020)

Legend

- Watershed Boundary
- Lakes & Ponds
- Cities & Villages
- Riparian Corridor: 100 ft buffer
- Wetlands

GRAND TRAVERSE BAY COASTAL WATERSHED

FIGURE 31: GENERAL CRITICAL AREAS



Layer Credits:The Watershed Center Grand Traverse Bay (2020)

Legend

Watershed Boundary	State Roads	Small Dams	High Risk Erosion
Lakes & Ponds	Urban Sprawl	Compromised Streams	High Water Challenges
Rivers & Streams	Agricultural Threats	Bacterial Impairment	Wetlands
Cities & Villages	Severe Road Crossing	Macrophyte Bed Cluster	Wetland Development

GRAND TRAVERSE BAY COASTAL WATERSHED

FIGURE 32: SPECIFIC CRITICAL AREAS

CHAPTER 6 EXISTING WATERSHED PLAN SUMMARIES

The Grand Traverse Bay watershed has nine unique subwatersheds that have specific natural features, issues, and threats. As stated previously, TWC and local partners have written management plans for the two largest of these - the Elk River Chain of Lakes (ERCOL) and the Boardman River. Together these plans account for nearly 81% (786 mi^2) of the land area in the Grand Traverse Bay watershed and provide greater detail on issues specific to each watershed, as well as detailed recommendations for watershed protection efforts. A summary for each of these plans is found below.

6.1 Boardman River Watershed Prosperity Plan

The Boardman River Watershed Prosperity Plan (BRWPP) is a vision and roadmap for the future management of one of Michigan's most beautiful watersheds. It meets the community's desire to have a management plan that goes well beyond traditional watershed studies to provide a blueprint for multijurisdictional cooperation to improve the environmental, economic, and social prosperity of the watershed region. Approved by the DEQ and EPA in February 2019, it is one of the first intentional planning initiatives in Michigan to bridge the gap that often exists between natural resource protection and economic prosperity.

The Boardman River watershed is just beginning to undergo substantial change with the removal and modification of four dams on the river. The scale of dam removal is unprecedented in Michigan and elsewhere in the United States. The dam removal project will return 3.4 miles of the Boardman River to a free-flowing river and restore over 250 acres of wetlands. Returning the Boardman River to its natural flow will have a significant impact on water quality, fish and wildlife, recreation, and business opportunities. It will also present many new challenges and trade-offs in terms of resource use, economic prosperity, and quality of life in the region. The Prosperity Plan helps distinguish some of these needs and challenges, and identifies strategies for protecting and enhancing the watershed's ecological, social, and economic resources.

The Prosperity Plan identifies prosperity for the watershed as achieving economic well-being for its residents, protecting and maintaining a high-quality environment, supporting healthy lifestyles, helping people connect and engage with the environment and with each other, and offering a diverse range of social and cultural opportunities.

Water Quality Issues

The Boardman River and its tributaries are largely meeting water quality standards for designated uses (MDEQ 2014). The only exceptions are "Fish Consumption" in all waterbodies and the "Other Aquatic Life and Wildlife" designated use for Kids Creek, a major tributary to the

Boardman River. Currently an approximate 4-mile section of Kids Creek near its confluence with the Boardman is not supporting this designated use due to flow regime alterations, sedimentation/siltation, and other human caused substrate alterations, all caused by stormwater. Although a Total Maximum Daily Load (TMDL) plan for Kids Creek is not currently scheduled to be drafted as part of the MDEQ's 2016-2022 "Prioritization Framework for the Long-Term Vision for Assessment, Restoration, and Protection under the Clean Water Act Section 303(d) Program," it remains on the 303(d) non-attainment list as needing a TMDL. Additionally, there is an ongoing, multimillion-dollar Kids Creek Restoration Project which has begun addressing many of the pollutants contributing to the creek's poor water quality.

While there have been historical inputs of toxic pollutants and thermal modifications from the dams, the highest priority sources of pollution or other stressors that currently affect or could affect the Boardman River watershed are sediment, nutrients, loss of habitat, and pathogens. Sediment inputs to the Boardman River likely come from road stream crossings, urban/suburban stormwater, construction activities, recreation access along the river and tributaries, forestry practices, and livestock in streams. The most likely sources of nutrient loads are failing septic systems, residential and agricultural fertilizer, and lack of riparian buffers. Loss of habitat, generally from development and suburban sprawl, has already and could continue to significantly impact water quality in the watershed. Finally, pathogen threats are due mainly to failing septic systems, stormwater runoff (particularly in urban areas), and livestock in streams.

Priority and Critical Areas

Priority and critical areas were identified to help develop goals and objectives and to guide future monitoring, planning, and management efforts. These areas of concern were identified based on either current sources of pollutants or areas that are most susceptible to activities that could degrade water quality or valuable aquatic habitats.

Specific priority protection areas are:

- Natural lands of high conservation value/priorities for protection. The top priority areas for natural land protection are the Brown Bridge Quiet Area and the bottomlands for Brown Bridge, Boardman and Sabin dams. Additionally, groups like the Grand Traverse Regional Land Conservancy have developed specific criteria for conservation easements and nature preserves to ensure that lands acquired or put into easements are leveraging other protection areas and meeting broader watershed conservation goals.
- Wild and Scenic designated areas along Boardman River. These areas are a priority for maintaining and protecting designation status and high quality.
- Boardman River channel from "The Forks" down to Brown Bridge Quiet Area. Wildlife and aquatic habitat in this area need protection because of potential overuse from recreation.

In addition to the areas identified above, other general priority areas include:

- Ridgelines and other areas with expansive viewsheds of the Boardman River (privately owned) that provide wildlife habitat, contribute to the region's rural character and quality of life, and help recharge groundwater.
- Headwaters of tributaries. These areas are a priority for extending the Natural Rivers designation and its protective zoning to protect their wild and scenic properties. The top

priorities for headwater protection are the north and south branches of the Boardman River.

The critical areas identified in the BRWPP reflect the primary sources of nonpoint source pollution, including urban stormwater, dam removal activities, development and shoreline management, agriculture, transportation crossings, and malfunctioning septic systems. Critical areas are shown at two levels: general critical areas and acute critical areas. General critical areas represent broader areas where, in general, attention is needed. Acute critical areas are the priority locations where attention is needed first and foremost.

General Critical Areas:

- Riparian corridors. Areas within approximately 1,000 feet of Boardman River or tributaries that drain to the river.
- Wetlands. All wetlands and areas within 1,000 feet of wetlands identified in the National Wetlands Inventory for the Boardman River watershed.
- City and village centers. Urban areas that contribute significant stormwater runoff to the Boardman River and its tributaries. Although each urban area's individual contributions vary according to many factors, including total impervious surface, implementation of stormwater best management practices, and pollutant loadings, it is reasonable to assume they are all contributing nonpoint source pollutants to some extent, and therefore, should be continually managed to reduce their loadings.
- Transportation Crossings. The degree of severity of road-stream and other transportation crossings on the Boardman River and its tributaries varies; consequently, the impacts to the resources vary as well. Severe and moderate crossing sites are included as critical areas because of their potential to contribute large amounts of sediments and other nonpoint source pollutants.
- Agricultural Lands. Agricultural areas are included because water quality monitoring in other watersheds has shown higher levels of nitrates in areas where agricultural practices are hydrologically connected via groundwater or runoff. The application of nitrogen-rich fertilizers, particularly in sandy, well-draining soils, is suspected as one of the sources of these nitrates.

Acute Critical Areas:

1. Bottomlands and impacted upstream areas from Brown Bridge, Boardman, and Sabin dam removals. As dam removal projects are completed, concurrent restoration of the bottomlands and associated upstream impacted areas is critical to prevent soil erosion and sediment contribution, protect and enhance in-stream habitat, and control invasive species.
2. North Branch of the Boardman River from Kettle Lake Road downstream to the confluence of Failing Creek. Water quality and ecological function in this stretch of the river is severely impacted for several reasons, including temperature and sediment.
3. Inland lakes with hydrologic connection to the Boardman River and/or increased residential development, including Silver, Arbutus, and Spider lakes. Development (historic and new) along these lakes may be causing increased pollutant contributions

from greater amounts of impervious surface, bank erosion, and aging or undersized septic systems.

4. <u>Traverse City and surrounding urban area, roughly defined by the land area encompassed by South Airport Road, Garfield Avenue, US31 North to Grand Traverse Bay (includes Traverse City and Garfield Township).</u> This highly urbanized portion of the watershed in Traverse City contributes pollutants to the river and Grand Traverse Bay via stormwater runoff. While a number of stormwater reduction and filtration projects have been implemented, there is still a significant need to reduce the amount of oils, greases, litter, and other pollutants to the river in this portion of the watershed.

5. <u>Kids Creek subwatershed.</u> Kids Creek is the only impaired waterbody on MDEQ's 303(d) list. Water quality in the creek is severely impacted by stormwater and sedimentation. TWC launched a large-scale Kids Creek Restoration Project a number of years ago that included stormwater reduction BMPs on tributaries A and AA of the creek, streambank stabilizations, and "daylighting" a portion of Tributary A. Restoration efforts must continue on Kids Creek to further aid in efforts for its removal from the impaired waters list.

6. Boardman Lake shoreline. The lake has had significant historic sediment contamination from previous industrial activities around the lake and is vulnerable to increasing sediment load as upstream dams are removed.
7. Severe streambank erosion sites and transportation crossings. As previously described, the Grand Traverse Conservation District identified more than 600 eroded sites along the Boardman River and its tributaries in the Boardman River Watershed Report. Since 1993, more than 300 of the 600 identified sites have been restored, but there are still many severe road crossing and streambank erosion sites that need to be restored to protect and improve the Boardman River watershed. Particular attention should be around streambank erosion sites around the dams as they are removed.
8. Village of Kalkaska. As the second largest urbanized area in the watershed, the Village of Kalkaska contributes stormwater runoff from urban areas to the headwaters of the Boardman River. Monitoring in the area has indicated negative impacts on benthic macroinvertebrate communities.
9. Agricultural lands – Fife Lake/Kingsley/Garfield Township areas. Agriculture in the watershed is centered on these headwater areas and makes the potential nutrient and sediment inputs to these small streams a high priority.
10. Small dam removal. As stated earlier, dams are a known cause for thermal pollution to their downstream waterbodies. Survey results show at least 10 man-made small dams in the Boardman River and its tributaries, each with the potential to contribute to thermal pollution of downstream water. When feasible and with owner approval, these dams should be removed.

Economic, Community, and Quality-of-Life Issues

The economies of the communities in the Boardman River watershed are based largely on recreation, tourism, agriculture, forestry, services, light manufacturing, and oil and gas production. There is a significant disparity in economic prosperity, however, among these watershed communities. The western watershed, comprising Traverse City and surrounding communities (particularly Garfield Township), is fairly prosperous and supports almost 70 percent of the 2,410 businesses in the watershed. Communities in the eastern portion of the watershed (particularly Kalkaska County) capture less than 4 percent of the taxable value of commercial property in the watershed.

The BRWPP team, informed by community members and previous planning efforts, identified four important economic uses for the watershed: 1) Strong "knowledge-based" economy, 2) Viable local agriculture, 3) Diverse business/jobs base, and 4) Tourism-serving industry. The BRWPP identifies 17 indicators of prosperity and compares five different watershed communities and the state as a whole in terms of how well they are performing on those indicators. These measures will be an ongoing part of evaluating the impact of the Prosperity Plan's goals, objectives, and strategies as they are implemented.

In addition to water quality, natural resources, and economic uses, the BRWPP identifies community quality-of-life issues that are a critical part of the region's prosperity. These are:

- Abundant, diverse, and high-quality outdoor recreation amenities that provide health and enjoyment benefits for residents and help attract visitors to the region.

- Available entertainment and cultural opportunities, clustered in downtown areas, which are important for attracting residents and visitors to the Boardman River watershed area.
- Available multimodal transportation options.
- Charming, walkable, compact downtowns.
- High-quality education facilities.

Watershed Goals

To achieve the vision of the BRWPP, five broad goals were identified:

1. Protect, restore, and enhance the high-quality water and other natural resources that are the backbone of social and economic prosperity in the watershed.
2. Support a sustainable economy that benefits and strengthens all of the watershed communities.
3. Improve the quality of life and advance greater social equity throughout the watershed to retain and attract businesses, a talented workforce, and student and retiree residents.
4. Provide managed expansion and improvement of recreation opportunities in the watershed to attract a talented workforce, student and retiree residents, and visitors from around the world.
5. Through education and engagement efforts, create community ownership of the Prosperity Plan and community capacity that will assure implementation of recommended actions an achievement of the goals and objectives.

Implementation Strategies

The BRWPP identifies implementing strategies that residents, businesses, and communities in the Boardman River watershed will undertake to achieve the plan's goals and objectives. The strategies are broken down by five smaller watershed zones in addition to watershed-wide actions to help focus on specific geographies and consider the unique needs and resources of each part of the watershed. The actions will require collaboration among communities, and focus on building capacity of watershed stakeholders of all ages.

In an effort to successfully accomplish the goal of protecting and restoring the high-quality water and other natural resources that are the backbone of social and economic prosperity in the watershed, specific and tangible recommendations were developed based on the prioritization of watershed pollutants, sources, and causes, while also looking at the priority areas in the watershed. Water quality and environmental tasks were also divided into the following categories:

1. Shoreline and Streambank Protection
2. Stormwater
3. Transportation/Stream Crossings (i.e. roads, railroads, etc.)
4. Planning, Zoning, and Land Use
5. Land Protection and Management
6. Habitat, Fish, and Wildlife
7. Human Health Strategies
8. Hydrology and Groundwater
9. Water Quality Monitoring
10. Wetland
11. Invasive Species
12. Agriculture
13. Wastewater and Septics

The total estimated cost of the implementation actions is more than $88 million over the next 10 years. As some of the proposed actions are further planned and designed, the total cost estimates will be updated. Of these total estimated costs, approximately $42.5 million is for water quality and environmental activities, $44 million for sustainable economic development activities, and $1.5 million for improved recreational efforts.

Next Steps

Work will continue on the monumental dam removal process that will bring substantial ecological, economic, and recreational improvements and opportunities to the watershed. This work will include not only dam removal efforts, which are slated to be completed by 2018, but streambank stabilizations, invasive species management, and land protection that go along with it as well. Additionally, continued invasive species monitoring, erosion control, and instream habitat improvements will be necessary over the next 10 years.

TWC will continue work on their Kids Creek Restoration Project, targeting restoration and water quality improvement in the watershed's only impaired water body. This work is already well under way and will be a critical element of improving water quality in the Boardman River watershed. Planned tasks in the next several years include a variety of Low Impact Development installations throughout the Kids Creek subwatershed designed to improve the quality and reduce the quantity of stormwater runoff into the creek.

Additional future efforts for the Boardman River watershed include:

- Building partnerships and seeking funding for implementation activities.
- Conducting urban stormwater improvement BMPs in Traverse City.
- Restoring and improving severe transportation crossings and streambank erosion sites.
- Working with local communities to improve water quality-related zoning ordinances.
- Participation in regional and local planning efforts to ensure habitat connectivity and water quality issues are considered.
- Ongoing monitoring to assess environmental conditions.
- Implementing information and education initiatives.

Evaluation and Oversight

As projects and tasks identified in the BRWPP are implemented, they will be monitored and evaluated for success. The plan will be evaluated both in terms of progress in implementing proposed tasks and in success improving and protecting water quality, as well as overall environmental, economic, and social prosperity in the watershed.

6.2 Elk River Chain of Lakes Watershed Plan

The Elk River Chain of Lakes (ERCOL) is an extremely important natural resource that warrants the utmost protection due to its ecological, recreational, and economic value. The ERCOL watershed is the largest sub-watershed in the Grand Traverse Bay watershed and covers over 500 square miles of land, has over 60 square miles of open water, and 200 miles of shoreline. The 14-interconnected lakes and streams found in this watershed are some of the most pristine inland waterbodies in the entire country and provide a multitude of recreational and economic benefits for both full time residents and tourist. Despite continual efforts to protect the watershed, emerging issues such as land development pressures, invasive species, failing septic systems, and barriers to hydrologic connectivity threaten to impair these waters and degrade their ecological and economic treasures.

The Elk River Chain of Lakes Watershed Implementation Team (ERCOL-WPIT) is a diverse set of stakeholders that first convened in 2010 with the primary focus of implementing projects coming out of the Grand Traverse Bay Watershed Protection Plan. These individuals and organizations serve as ambassadors for the watershed and the development of the ERCOL Watershed Management Plan (ERCOL-WMP) helps substantiate their current momentum in protecting the region's water resources.

An initial draft of the ERCOL-WMP was completed by a master's project team from University of Michigan's School of Natural Resources and Environment, which included data organization, extensive fieldwork and stakeholder engagement, and data analysis. After that, Tip of the Mitt Watershed Council (TOMWC) and The Watershed Center Grand Traverse Bay (TWC) worked together in conjunction with the ERCOL-WPIT to complete the remaining sections of the plan.

Water Quality Issues

The ERCOL watershed is largely meeting water quality standards for designated uses (MDEQ 2016). The only exceptions are "Fish Consumption" in several waterbodies from contamination (mercury, PCBs, Dioxin) and the "Total Body Contact" designated use on two tributaries to Torch Lake due to elevated *E. coli* levels. While the majority of assessed surface waters in the ERCOL are currently meeting all of the designated uses of the State, it should be noted that the watershed remains vulnerable to nonpoint source pollution and other environmental stressors. Existing and future activities will invariably create risk of degradation to some or all of the designated uses and it is critical to enact preventative and restorative actions to ensure future use of watershed resources.

The ERCOL-WPIT team identified and ranked the top physical structures and human driven actions that are occurring within the watershed that have jeopardized or may jeopardize uses of the ERCOL. These threats include:

1. Lake/shoreline development/use
2. Impervious surfaces/stormwater runoff
3. Invasive species
4. Road stream crossings
5. Failing septic systems
6. Riverbank development/use
7. Agricultural runoff
8. Climate change
9. Industrial waste/oil and gas
10. Water control infrastructure
11. Recreational activity.

Priority and Critical Areas

Priority and critical areas were identified to help develop goals and objectives and to guide future monitoring, planning, and management efforts. These areas of concern were identified based on either current sources of pollutants or areas that are most susceptible to activities that could degrade water quality or valuable aquatic habitats.

Priority Areas:
Two separate priority parcel analyses were completed within the ERCOL watershed. The first, *Priority Parcel Analysis – Watershed Protection*, was conducted by a team of graduate students from the University of Michigan School of Natural Resources and Environment in consultation with Tip of the Mitt Watershed Council, and is principally focused on water resource protection. The second, *Priority Parcel Analysis – Land Conservation*, was conducted by the Grand Traverse Regional Land Conservancy and focuses on highlighting areas with highest conservation potential. There are noticeable similarities between these two analyses, both in the criteria utilized and spatial output. Neither prescribe a narrow course of action, but suggest generalized spatial prioritization. Additional information regarding the criteria utilized and the analysis process, as well as the final maps for each composite analysis, can be found in the ERCOL-WMP.

Critical Areas:
The critical areas identified in the ERCOL-WMP reflect the primary sources of nonpoint source pollution, including agriculture, aquatic invasive species, urban areas, shoreline development, hydrologic manipulation (dams), severe impact road/stream crossings, recreational boat launches and septic systems. They were identified by using a set of threat factors including amount of riparian vegetation present and proximity to severe road crossings, high impact agricultural sites, dams, erosion sites, invasive species and armored shorelines, among others. The critical areas were then organized into 10 general areas:

A. Eastport to Ellsworth and northern tip of watershed: The area between and north of the villages of Eastport and Ellsworth is filled with a large number of agriculture parcels on sharply sloped terrain. While many farmers use best management practices to limit environmental impacts, others utilize techniques that cause environmental degradation and create risk to the designated uses of the watershed. Around half of the highest impact farms found in the agriculture survey were identified in this area. Problems could include tilling and mowing techniques that increase sediment and nutrient runoff, orchards that use high amounts of pesticides that quickly make their way into surface water, and livestock farms that do not contain manure and keep it out of the surface water pathways. The villages of Ellsworth and Eastport also contain high amounts of impervious surfaces and residential areas with minimal riparian buffers. A number of streams run through these villages, picking up the impacts of the impervious surfaces and reduced riparian vegetative buffers. Two creeks in this area have impaired designated uses due to high *E. coli* levels, possibly resulting from the issues mentioned above.
B. Scotts Lake to Central Lake: surface waters including lakes, connecting channels, and adjacent streams and tributaries: The lakes and connecting channels between Scotts Lake and Central Lake have a number of high priority structural/action based threats. These shallow lakes have a large number of sites in which invasive species can be found, primarily Eurasian watermilfoil and purple loosestrife. *Phragmites Australis* and

Dreissenid mussels are also present in these lakes. At least 6 public boat launches in this area increase the risk of transfer and spread of non-native species. Small streams directly adjacent to a number of the lakes are also at risk for impairment from poor road stream crossing structures. Eleven structures with a severe impact rating are in this area, two of which rank in the top ten worst within the watershed. Numerous areas along the lakeshore in this area have reduced riparian vegetative buffers.

C. Torch Lake: riparian area and adjacent stream and tributaries: The areas around Torch Lake experience some of the most intense development pressures in the watershed, both historically and presently. New residencies and remodeling of existing properties has reduced riparian vegetative buffer zones in many areas. Many of these homes utilize synthetic fertilizers and pesticides for lawn care, together leading to an increase in sediment erosion and nutrient and pesticide loads along lakefront properties. Inadequate septic treatment is also potentially increasing nutrient and *E. coli* loads to the lake. The small streams and tributaries around the lake are found on highly steeped slopes running through sandy soils. At least three main culverts are not placed properly and have 1-3 feet perches on the downstream side. These were ranked as three of the worst crossings in the entire watershed. Eight public boat launches, several private marinas, and hundreds of private docks display the prevalence of recreational boating in this area. While boats can be low impact, high wakes, loud engines, and waste from recreational boats carry risk of negative impacts.

D. Far east arm of watershed: agricultural area along highway 131: A large number of potato farms and other agricultural crops are grown along the flat lands in this arm of the watershed. This area is an important groundwater recharge area for the watershed and improper use of fertilizers and pesticides could seriously jeopardize groundwater health.

E. Cedar River south branch: The south branch of the Cedar River has a number of severe road stream crossings. The highest sediment loads come from a road crossing near the headwaters of the river. Naturally high velocities combined with inadequately sized culverts creates increased sediment loads.

F. Shanty, Cold and Finch Creeks and tributaries: These creeks have problems resulting from development pressures, water control infrastructures, and road stream crossing infrastructure. A significant acreage has been converted from forest to human landscapes such as lawns, roads, and golf courses. Clearing of vegetation within the riparian buffer on residential properties leads to increased sediment and nutrient loading. Four small dams are in this area, two of which were found to be nearly completely failing while the other two each had structural integrity issues. The breaking or leaking of these dams also contributes to increased sediment loading. Five severe impact road stream crossings are in this area, with undersized culverts limiting fish passage. All three of these creeks are designated as coldwater fisheries, but sediment loading and fish habitat fragmentation put this use at high risk

G. Area between Elk Lake and Torch Lake south to Kewadin: This area has topography with high elevation and steep slopes and a large number of high impact agricultural sites. Some of these sites are likely to have a negative impact on nearby surface waters. This problem is compounded by the fact that the lakeshore areas around this land are highly developed with limited riparian vegetative buffers.

H. Village of Elk Rapids: Increased impervious surfaces and complexities of sewage treatment due to higher population density lead to impairments caused by nutrient and sediment pollutions. In addition a number of dams at the outlet of Elk Lake create a potential barrier to aquatic species and create habitat fragmentation.

I. Rapid River: connecting tributaries and riparian land area: The Rapid River faces risks of degradation from aging water control infrastructure and inadequate road stream crossing structures. The Rugg Pond dam, just downstream of where the two main branches of the river converge, has faced problems from lack of maintenance and large sediment back-ups behind the dam. A failure of this dam could cause severe environmental degradation and impair many of the river's designated uses. Road stream crossings too narrow to accommodate the swift and wide river alter flow regimes and contribute to increased sediment loading, leading to sediment build up issues along several portions of the river

J. Williamsburg Creek and community of Williamsburg: This creek has two dams and four severe impact road stream crossings, similar issues to the Rapid River on a smaller scale. In addition, the unincorporated community of Williamsburg is a small urban area that has been seeing increased development pressure potentially leading to increased nutrient, pesticide and sediment runoff

Watershed Goals

The ERCOL watershed contains a network of exceptionally high-quality water bodies and the ultimate purpose of the ERCOL-WMP is to have all lakes, rivers, and streams within the watershed support appropriate designated uses while maintaining their distinctive environmental characteristics and aquatic health. The overarching goals of this plan are outlined as follows.

1. Protect the diversity of aquatic habitats.
2. Protect and improve water quality.
3. Enhance and maintain recreational opportunities that preserve water quality and support the local economy.
4. Promote sustainable land management practices that conserve and protect the natural resources, character, and heritage of the watershed.
5. Develop and maintain effective education and outreach efforts to support watershed protection.
6. Integrate climate-resilient practices and efforts throughout the watershed.

Implementation Strategies

The ERCOL plan's implementation strategy provides a comprehensive approach to reducing existing sources of nonpoint source pollution and preventing future impairments to the watershed. Prioritizing implementation actions while continuing to build partnerships, helps coordinate efforts across stakeholder groups and leverage competitive funding opportunities. The implementation steps are organized around stated goals and objectives. Tasks were also divided into the following categories:

1. Water Quality Monitoring
2. Wetlands
3. Shoreline and Streambank Protection
4. Stormwater Management
5. Planning and Zoning
6. Land Use
7. Road Stream Crossings
8. Land Protection
9. Ecosystem Health
10. Recreation, Safety, and Human Health
11. Hydrology and Groundwater
12. Aquatic Invasive Species
13. Threatened/Endangered Species
14. Septic Systems
15. Emerging Issues and Future Threats

The total estimated cost of the implementation actions is more than $21 million over the next 10 years. As some of the proposed actions are further planned and designed, the total cost estimates will be updated.

Education and Outreach

The plan states that most valuable assets in protecting the ERCOL Watershed are the residents and tourists who live, work and play within its boundaries. A wide range of community members are already deeply involved in protecting the lakes, rivers and streams within the watershed. But in order to achieve commitment to the large-scale vision laid out within the plan, there will need to be a concerted effort to organize, communicate, and educate community members around the shared vision of protecting water resources. The plan's Watershed Goal #5 highlights the commitment to developing and maintaining effective education and outreach strategies in the watershed and states "Develop and maintain effective education and outreach efforts to support watershed protection."

The education section of the ERCOL watershed plan summarized a social indicators survey administered over the course of 2016-2017 in the watershed by the Tip of the Mitt Watershed Council. (This survey will be used in to inform the Outreach section of the Coastal Grand Traverse Bay Watershed Plan as well and is discussed in Chapter 8.6.) A communications and implementation strategy for the watershed was outlined as well. Specific outreach tasks were included in the larger implementation task table in the previous section.

Evaluation and Oversight

As projects and tasks identified in the ERCOL watershed plan are implemented, they will be monitored and evaluated for success. The plan will be evaluated both in terms of progress in implementing proposed tasks and in success improving and protecting water quality and land resources and habitat throughout the watershed.

CHAPTER 7 WATERSHED GOALS AND OBJECTIVES

The Grand Traverse Bay watershed is a high-quality waterbody of international significance and should be protected and maintained as such. The overall mission for the Grand Traverse Bay Coastal Watershed Protection Plan is to provide guidance for the implementation of actions that will reduce the negative impact that pollutants and environmental stressors have on the designated watershed uses in the coastal watershed area. These goals work in conjunction with those identified in the companion subwatershed plans for the Boardman River and Elk River Chain of Lakes subwatersheds.

The envisioned endpoint is to have Grand Traverse Bay and all lakes and streams within its watershed support appropriate designated and desired uses while maintaining their distinctive environmental characteristics and aquatic biological communities.

Using suggestions obtained from stakeholder meetings conducted throughout the watershed and examples from other watershed management plans, the project steering committee developed seven broad goals for the Grand Traverse Bay Coastal watershed:

1. Protect the integrity of aquatic and terrestrial ecosystems.
2. Protect and improve water quality.
3. Establish and promote land and water management practices that conserve or protect natural resources.
4. Encourage and support a sustainable local economy with diverse recreational and commercial opportunities that are compatible with a healthy watershed.
5. Develop and maintain effective education and outreach efforts to support watershed protection.
6. Preserve the distinctive character, cultural heritage, and aesthetic qualities of the watershed.
7. Integrate climate-resilient practices and efforts throughout the watershed.

Working to attain these goals will ensure that the at-risk designated uses described Chapter 4 are maintained or improved. Table 56 shows each goal the specific designated use it may affect, as well as the pollutants addressed. This table shows that many of the watershed goals address all the at-risk designated uses and their pollutants that are outlined in Chapters 4 and 5. Specific objectives for the Grand Traverse Bay Coastal watershed are outlined in Table 57.

Table 56: Coastal Grand Traverse Bay Watershed Goals

Goal	Designated Use Addressed	Pollutant(s) Addressed
1. Protect the integrity of aquatic and terrestrial ecosystems.	Coldwater Fishery Other Aquatic Life	All
2. Protect and improve water quality.	Coldwater Fishery Other Aquatic Life Public Water Supply Total Body Contact	All
3. Establish and promote land and water management practices that conserve or protect natural resources.	Coldwater Fishery Other Aquatic Life	All
4. Encourage and support a sustainable local economy with diverse recreational and commercial opportunities that are compatible with a healthy watershed.	Coldwater Fishery Total Body Contact	All
5. Develop and maintain effective education and outreach efforts to support watershed protection.	Coldwater Fishery Other Aquatic Life Public Water Supply Total Body Contact	All
6. Preserve the distinctive character, cultural heritage, and aesthetic qualities of the watershed.	Desired Use	All
7. Integrate climate-resilient practices and efforts throughout the watershed.	Coldwater Fishery Other Aquatic Life Public Water Supply Total Body Contact	All

Table 57: Goals and Objective for the Grand Traverse Bay Coastal Watershed

Goal 1: Protect the integrity of aquatic and terrestrial ecosystems.	
1.1	Protect and restore aquatic, riparian, and terrestrial habitats and preserve biodiversity.
1.2	Minimize human-induced hydrologic/hydraulic flow alterations and protect and restore natural hydraulic connectivity.
1.3	Protect and restore riparian corridors, floodplains and wetland areas.
1.4	Work to reduce or stop wetland and other types of lowland filling and hydrologic/hydraulic fragmentation.
1.5	Reduce and prevent excessive sediment inputs to streams, rivers, lakes, and wetlands.
1.6	Control and contain the spread of existing invasive species and prevent the introduction and spread of new species and populations.
1.7	Establish voluntary perpetual conservation easements on parcels of importance to preserve water quality and habitat.
Goal 2: Protect and improve water quality.	
2.1	Reduce and/or prevent the input of pathogens, toxic substances, and excessive nutrients and sediments into surface water and groundwater.
2.2	Reduce and/or prevent stormwater runoff to waterbodies.
2.3	Reduce and/or prevent thermal pollution inputs.
2.4	Reduce and/or prevent soil erosion.
2.5	Maintain dissolved oxygen levels that support cold-water fish and other aquatic species in waterbodies.
2.6	Minimize air deposition of contaminants into surface water from sources including vehicles and industrial and commercial facilities.
2.7	Establish voluntary perpetual conservation easements on parcels of importance to preserve water quality and habitat.
Goal 3: Establish and promote land and water management practices that conserve or protect natural resources.	
3.1	Establish voluntary perpetual conservation easements on parcels of importance to preserve natural resources.
3.2	Implement master plan and ordinance language that protects water quality and natural resources.
3.3	Encourage local units of government to consider the importance of water quality in all decision making.
3.4	Establish and promote stormwater management practices, such as green infrastructure, that reduce the amount and/or prevent harmful effects of stormwater entering waterways.
3.5	Promote use of voluntary management practices that prevent or reduce environmental and water quality degradation in riparian or other sensitive areas.
3.6	Increase awareness of local governments and developers on the impacts of development on natural resources and biological communities.
3.7	Identify, promote and protect wildlife corridors.
3.8	Protect groundwater recharge and headwater areas and discourage water withdrawals that negatively impact the sustainability of the aquatic system and water supply.

Table 57: Goals and Objective for the Grand Traverse Bay Coastal Watershed Cont'd

Goal 4: Encourage and support a sustainable local economy with diverse recreational and commercial opportunities that are compatible with a healthy watershed.	
4.1	Maintain desirable sport and tribal fisheries.
4.2	Work with water-dependent commercial enterprises to improve watershed health.
4.3	Ensure access to beaches, lakes, and streams for public use that does not jeopardize the integrity of the resource.
4.4	Ensure safe and clean areas for public swimming and other types of water recreation.
4.5	Reduce the impact of invasive species on recreation and, conversely, the impact recreation may have on the spread of invasive species.
4.6	Minimize the potential negative effects of pollutants such as toxins and pathogens from watercraft.
4.7	Minimize the potential negative physical effects such as erosion and uprooting of vegetation from watercraft and their wakes.
4.8	Acquire and manage land for public recreation and natural resource protection.
Goal 5: Develop and maintain effective education and outreach efforts to support watershed protection. ***This goal is specifically addressed by the public Information and Education (IE) Program developed for the entire Grand Traverse Bay watershed. This public IE strategy is outlined in Chapter 9 in the watershed plan.***	
5.1	Maintain a working knowledge of current and emerging issues affecting the watershed.
5.2	Educate watershed users and the general public about the community value of the watershed and bay and of their responsibility to be stewards of this community asset.
5.3	Regularly inform the public about research, projects, and opportunities for contribution and/or collaboration (organization to public).
5.4	Provide focused information to residents, visitors, local governments, and other target groups on priority topics (organization to individual).
5.5	Involve citizens, public agencies, user groups and landowners in implementation of the watershed plan through meetings and workshops with individuals or groups.
5.6	Develop and maintain innovative programs to engage stakeholders in preventative and corrective actions that address current and emerging issues in the watershed.
5.7	Promote awareness and use of voluntary best management practices that prevent or reduce environmental and water quality degradation in riparian or other sensitive areas.
Goal 6: Protect the distinctive character, cultural heritage, and aesthetic qualities of the watershed.	
6.1	Preserve sites of Anishinabek (Native American) cultural importance.
6.2	Maintain quality viewsheds to and from the water while supporting landowner desires for property use, privacy, and security.
6.3	Maintain open space, parks, greenways, natural areas, and the distinctive character of the region for public enjoyment.
Goal 7: Integrate climate-resilient practices and efforts throughout the watershed.	
7.1	Maintain a working knowledge of models and projections that describe regional climate change within the context of historic climate data.
7.2	Develop adaptive management strategies based on climate predictions and observed patterns.
7.3	Protect, restore, and enhance coastal wetlands and their adjacent intact upland natural communities.
7.4	Develop infrastructure resilient to increased storm severity and climate variability.
7.5	Encourage municipalities to adopt coastal resiliency adaptation and mitigation strategies.

CHAPTER 8 IMPLEMENTATION TASKS

8.1 Introduction

As stated previously, none of the designated uses for the Grand Traverse Bay watershed are impaired on a watershed-wide scale. As such, this plan will focus on protecting the watershed from future degradation rather than reducing pollutant loads to meet water quality standards. The following implementation strategy provides a comprehensive approach to reducing existing sources of nonpoint source pollution and preventing future impairments to the watershed.

In an effort to successfully accomplish the goals and objectives listed in Chapter 7, specific and tangible recommendations were developed based on the prioritization of watershed pollutants, sources, and causes while also looking at the priority and critical areas in the watershed (Tables 42-45, Figures 28-32). These implementation tasks include structural, vegetative, managerial, and educational elements and represent an integrative approach, combining watershed goals and covering more than one pollutant at times, to reduce existing sources of priority pollutants and prevent future contributions. Effective watershed management relies upon an integrative approach and in addition to structural practices must also encompass information and education components as well as the development of partnerships, community consensus building, and work with local governments.

8.2 Best Management Practices (BMPs)

BMPs are any structural, vegetative, or managerial practices used to protect and improve surface water and groundwater. Each site must be evaluated, and specific BMPs can be selected which will perform under the site conditions. For BMPs to be effective, the correct method, installation, and maintenance need to be considered for each site. Addressing each of these factors will result in a conservation practice that can prevent or reduce nonpoint source pollution.

Types of BMPs

Structural BMPs are physical systems that are constructed for pollutant removal and/or reduction. This can include rock check dams along a steep roadway or detention/retention basins, oil/grit separators, microbial filters, underground infiltration trenches and porous asphalt for stormwater control.

Vegetative BMPs include a number of landscaping practices designed to prevent or reduce pollutants from entering a watershed. These BMPs include buffers, filter strips, grassed swales and rain gardens. They can be placed in a variety of areas from residential to highway medians. In addition to reducing pollutants from reaching waterways, these BMPs help reduce peak runoff downstream through infiltration and storage.

Managerial and Educational BMPs include education and public involvement programs, land use planning, natural resource protection, regulations, operation and maintenance or any other initiative that does not involve designing and building a physical structure. Although these types of BMPs are difficult to measure quantitatively in terms of overall pollutant reduction and other parameters, research demonstrates that they have a large impact on changing policy, enforcing protection standards, improving operating procedures and changing public awareness and behaviors to improve water quality in a watershed over the long term. Moreover, they target source control which has been shown to be more cost effective than end-of-the-pipe solutions (i.e. "An ounce of prevention is worth a pound of cure"). Therefore, these BMPs should not be overlooked, and in some cases, should be the emphasis of a water quality management program.

It is important to note that installing a single BMP has the potential to reduce more than one type of pollutant and its source. For example, installing a riparian buffer will reduce sediment, nutrient, and toxins, as well as reduce impacts from fertilizer use and streambank erosion. Also, installing more than one BMP at a single site will increase the likelihood of pollutant reduction, but the effects will not be *cumulative*.

EGLE's BMP Manual

EGLE has put together a helpful document called the Nonpoint Source Best Management Practices Manual (BMP Manual) that provides guidance on dealing with nonpoint (NPS) pollution to restore impaired waters and protect high-quality waters in Michigan (DEQ 2017). The original 1998 manual was recently updated in 2017 and while much of the information from the original publication regarding the planning, design, construction, and maintenance of stormwater BMPs has been retained and updated as necessary, the revised manual attempts an increased emphasis on pollution prevention to minimize the amount of subsequent stormwater management or treatment required, as well as storm water infiltration practices and natural channel design. The BMP Manual consists of two parts – the main document containing introductory and background material, and a series of separate documents for individual BMPs. The document is only available electronically on EGLE's website and can be found here: https://www.michigan.gov/egle/0,9429,7-135-3313_71618_3682_3714-118554--,00.html. This website also contains other helpful manuals and technical guidance documents for pollutant reduction and water quality protection.

Highlights from the BMP Manual include a discussion on how to best approach stormwater management and use what is referred to as a "treatment train" approach. EGLE prefers the following stormwater steps (in descending order):

1. Prevention, Maintenance, Infiltration
2. Treatment
3. Mitigation

"The priority to infiltrate, or prevent or minimize the generation of, storm water makes sense for various reasons. If no storm water is generated, no further steps are needed—no treatment of contaminated storm water prior to discharge, nor the mitigation of any downstream impacts, such as erosion or sedimentation. This is beneficial not only to receiving water quality; it is also economical, in that it can save capital and operation and maintenance costs, of any management practices that would otherwise be required," (DEQ 2017). In addition, when the generation of stormwater is inevitable, the use of a "treatment train" approach should be used where a series of stormwater BMPs are used together with each practice targeting a specific pollutant or aspect of runoff.

Additionally, the BMP Manual includes a discussion about a series of managerial BMPs steps to take during the site development process:

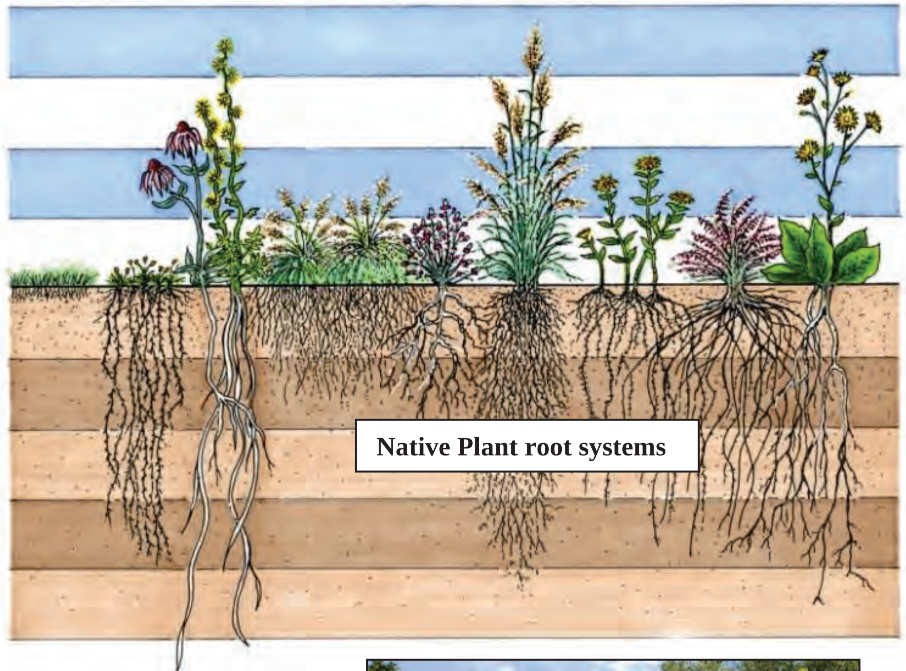
1. Evaluate Site and Collect Data
2. Review Water Quality Goals or Requirements
3. Develop Site Base Map
4. Develop Soil Erosion Sedimentation Control (SESC) Plan
5. Obtain All Necessary Permits
6. Install SESC BMPs
7. Stabilize Site After Construction
8. Maintain Permanent BMPs

Green Infrastructure

Of particular importance are the more innovative stormwater BMPs known collectively as green infrastructure (GI) techniques. GI is a set of small-scale stormwater management practices that mimic and work with nature to reduce stormwater runoff onsite. This strategy uses things such as green space, native landscaping, and other techniques to encourage water to infiltrate into the ground rather than conveying it through costly infrastructure to an “end-of-pipe” facility or waterbody. Since most pollutants are carried to waterbodies by stormwater, GI can significantly reduce the amount of pollution entering a watershed because it reduces or eliminates runoff from a site. Additionally, since GI reduces stormwater leaving a site, it can help reduce flooding, channel erosion, and scouring downstream. At the city or county scale, GI can be a patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the neighborhood or site scale, stormwater management systems that mimic nature soak up and store water.

GI is applicable to new and existing development and can be integrated into virtually any site, from the residential scale to larger sites such as commercial areas. The range of techniques continues to expand and new advances in design provide greater water quality benefits. According to the U.S. Environmental Protection Agency, GI practices save substantial money for property owners, communities, and developers while also improving water quality. GI methods decrease the amount of expensive below ground drainage infrastructure required and reduce or eliminate the need for other stormwater-related facilities such as curbs, erosion control measures, catch basins and outlet control structures. In addition to water quality benefits, GI also provides ecosystem services and associated economic benefits that conventional stormwater controls (like detention basins) do not. Ecosystem services are the many and varied benefits that humans freely gain from the natural environment and from properly functioning ecosystems. Examples of ecological services include purification of air and water, maintenance of biodiversity, decomposition of wastes, soil and vegetation generation and renewal, pollination of crops and natural vegetation, groundwater recharge through wetlands, seed dispersal, greenhouse gas mitigation, and aesthetically pleasing landscapes.

GI also stresses the use of native plants, which typically have much deeper root systems than turf grass. This dramatically increases infiltration at a site, as well as uptake of nutrients (see photo at right).



Examples of GI practices include rain gardens, rain barrels, pervious pavement, downspout planter boxes, green roofs, and storm tree boxes (see photos this page and next).

TWC has already installed numerous GI techniques throughout the Grand Traverse Bay watershed.

GI examples:

- *Top-left – rain garden in Suttons Bay*
- *Top-right – Storm tree box along Medical Campus Drive in Traverse City*
- *Left – Downspout planter box installation at building on Munson Medical Center campus in Traverse City*

<u>*GI examples:*</u>

- *Top-left – underground infiltration trench at Bryant Park in Traverse City*
- *Top-right – Bioinfiltration basin on Medical Campus Drive in Traverse City*
- *Below – Green roof installation at Cowell Family Cancer Center on Munson Medical Center campus in Traverse City*

Riparian Buffers

Riparian buffers are widely considered one of the best ways to control and reduce the amount of non-point source pollution entering a water body. Also called vegetated stream buffers, filter strips, or greenbelts, these buffers consist of strips of trees, shrubs, and other vegetation lining a stream corridor or lakefront. These linear strips of vegetation serve as a stream's last line of defense against human activities such as agriculture and urban development. The buffer can consist of existing or planted vegetation, or both. Buffer vegetation can be grasses, shrubs, trees, or other types, in any combination. Buffers are meant to be relatively undisturbed; activities within buffers should be limited to maintenance, or other approved activities that do not impede buffer functionality. Riparian buffers help to reduce the impact of almost all the pollutants that currently threaten the watershed: sediment, nutrients, toxins, thermal pollution, pathogens, changes to hydrology, and loss of habitat.

Streamside areas lacking a riparian buffer have a reduced filtering capacity and do not effectively filter out watershed pollutants. While the lack of a riparian buffer along a stream or lakefront does not *add* any pollutants to the watershed and is technically not a *source* of pollution, the lack of a buffer significantly increases the possibility of pollutants reaching a body of water. The actual sources of the pollution are coming from another place and the buffer only reduces their effects on the watershed. Therefore, for the purposes of this protection plan, <u>the lack of a riparian buffer (and streamside canopy) is referred to as a source of pollution and environmental stress in the watershed</u>, with the general understanding that increases in the amounts of riparian buffers will decrease the amount of various pollutants entering the watershed.

Benefits of riparian buffers include:

<u>Stabilization of Streambanks</u> – The deep-rooted vegetation binds the soil along streambanks, which prevents bank erosion during periods of high runoff.

<u>Improved Water Quality</u> – Trees, shrubs, and grasses along streams remove sediment, nutrients, pesticides, pathogens, and other potential pollutants before they enter surface water. Fertilizers and other pollutants that originate on the land are taken up by tree roots and stored in leaves, limbs and roots of the vegetation instead of reaching the stream. Studies have shown dramatic reductions of 30% to 98% in nutrients (nitrogen and phosphorus), sediment, pesticides, and other pollutants in surface and groundwater after passing through a riparian forest buffer (Chesapeake Bay Program website: <u>www.chesapeakebay.net</u>).

<u>Reduced Flooding and Sedimentation</u> – Trees and shrubs help to retain runoff longer, improve infiltration, and filter out sediment that might otherwise be delivered downstream during floods.

<u>Reduction of Thermal Pollution (Stream Warming)</u> – The canopy provided by the leaves of the vegetation provide shading to the stream, which moderates water temperatures and protects against rapid fluctuations that can harm stream health and reduce fish spawning and survival. Cool stream temperatures maintained by riparian vegetation are essential to the health of aquatic species. Elevated temperatures also accelerate algae growth and reduce the amount of dissolved oxygen the water can hold, further degrading water quality. In a small stream, temperatures may rise 1.5 degrees in just 100 feet of exposure without a leaf canopy. The leaf canopy also improves air quality by filtering dust from wind erosion, construction or farm machinery.

Enhanced Wildlife Habitat – The trees and shrubs contained in a riparian buffer supply a tremendous diversity of habitat and travel corridors for many wildlife species in both the aquatic and upland areas. Travel corridors are particularly important where habitat is limited. In addition, woody debris (fallen trees and limbs) in the stream provides both habitat and cover for fish and other macroinvertebrate species. Leaves that fall into a stream are trapped on woody debris and rocks where they provide food and habitat for small bottom-dwelling creatures (i.e. crustaceans, amphibians, insects and small fish), which are critical to the aquatic food chain.

Improved Scenery (Desired Uses) – Strips of trees and shrubs along streams add diversity and beauty to the landscape.

Riparian buffers vary in character, effectiveness, and size based on the environmental setting, proposed management, level of protection desired and landowner objectives. To protect water quality, a buffer at least 55 – 100 feet wide should be preserved or created around all bodies of water and wetlands, with strip widths increasing with increasing slope. Research shows that when the buffer is less than 100 feet, stream quality begins to diminish (DEQ 2001).

Most riparian buffers are composed of three zones, the width of each determined by site conditions and landowner objectives. This three-zone concept provides a conceptual framework in which water quality, habitat, and landowner objectives can be accomplished. The recommended minimum filter strip width ranges from 20 to 216 feet, depending on a number of factors. In more developed areas, the minimum recommended width is 25 feet. In residential areas, the vegetation in this zone often consists of turf grass (such as a back yard). Property owners should be encouraged to plant other dense herbaceous species to provide increased filtering capacity. Figure 33 shows a synthesis of the various multi-zone systems that ties together the various recommended minimum widths, vegetation types, land use restrictions, and allowances (taken from EGLE's BMP Manual and the USDA-NRCS website www.mi.nrcs.usda.gov):

- Zone 1 – The Streamside Zone: This zone is usually made up of mature trees and shrubs that provide shade, leaf litter, and woody debris to the stream, as well as erosion protections. The minimum width of this zone is 15 – 25 feet. Land uses in this zone should be limited to footpaths and neither livestock access nor timber harvesting are recommended. The mature forest along the edge of the water maintains habitat, food, and water temperature and helps to stabilize streambanks, reduce flood impact, and remove nutrients.
- Zone 2 – The Middle Zone: This zone extends from the outer edge of the streamside zone and protects the stream's ecosystem by providing a larger protective area between the stream and upland development. Ideally, this zone will also be composed of mature trees and shrubs and has a recommended with of 50 feet, with widths increasing to ensure the 100-year floodplain, steep slopes, adjacent wetlands, and higher-order streams. A primary function of Zone 2 is to filter runoff by removing sediment, nutrients and other pollutants from surface and groundwater. In some cases Zone 2 can be a managed forest, in which selected, minimal timber harvesting is allowed, primarily for maintaining the health of the stand, and as an economic incentive. No livestock access is recommended.

- Zone 3 – The Outer Zone: The outer zone extends from Zone 2 to the nearest permanent structure and is composed of grass and other herbaceous cover. This is the main filtering part of the riparian buffer strip. The vegetation included in this zone is useful in spreading and filtering runoff that may be transporting sediment, nutrients, or pesticides. In agricultural areas, this zone typically consists of a filter strip. In agricultural areas where there are no streamside trees, filter strips are still often established adjacent to water bodies, in which case this practice comprises the entire riparian buffer. Conversely, in areas with existing riparian forest buffers (i.e., Zones 1 and 2), if the adjacent up-slope land is grassland, forest, or other area that does not produce sediment, nutrients, pesticides, or other pollutants, then a filter strip may not be necessary.

Figure 33: Riparian Buffer Strip Zones

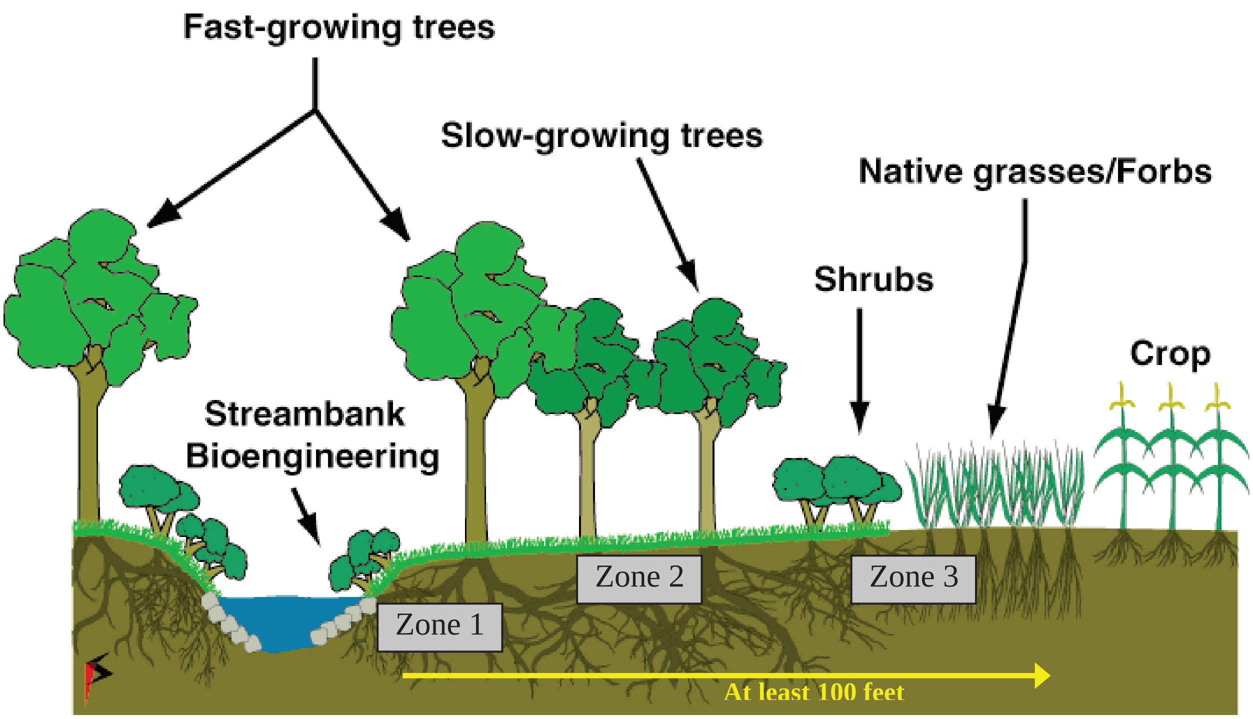


Illustration courtesy of the ISU Forestry Extension Website

Selecting BMPs

Table 58 lists potential systems of commonly used BMPs that deal with various types of pollutant sources.

Table 58: BMP Examples by Source

Source	Potential System of BMPs	
Road/Stream Crossings	• Extend or enlarge culverts • Install runoff diversions to direct runoff	• Install box culverts or elliptical culverts • Install clear-span bridges
Streambanks/Lakeshores (erosion and lack of buffer)	• Biotechnical erosion control • Vegetative buffer strips • Rock riprap	• Tree revetments • Land conservation easements
Stormwater	• Green infrastructure (i.e, rain gardens, bioswales, etc.) • Runoff diversions • Infiltration basins or trenches	• Sand filters • Oil/grit separators • Pervious pavers
Recreation	• Runoff diversions • Walkways/stairways • Parking lot barriers • Biotechnical erosion control	• Rock riprap • Tree revetments • Canoe landings
Lawn/Shoreline Care	• Zero-phosphorus fertilizers • Vegetative buffer strips (greenbelts)	• Soil testing
Agriculture – Livestock, Manure, Fertilizers	• Vegetative buffer strips • Grassed waterways • Cover crops • Fencing • Alternative watering devices • Nutrient management • Watercourse crossings	• Animal waste storage • Manure application plan • Grade stabilization structures • Conservation crop rotation and tillage • NRCS Cost Share programs • Land conservation easements • Spill centers for fueling stations
Septic	• Regular maintenance (includes education on how to maintain)	• Mandatory inspections • Proper design
Development/Construction	• Implement proper soil erosion measures • GI BMPs to reduce runoff	• Various construction BMPS (barriers, staging/scheduling, grading, etc.) • Promote open space and land preservation
Wetland Filling	• Restoration of wetlands	
Dams	• Dam removal • Cold water outlet installation	• Bypass for fish ladder
Invasive Species (introduction)	• Boat washing stations • Education re prevention of introduction	

The following table (Table 59) suggests general guidelines to use when deciding specific locations to install or use BMPs in the Grand Traverse Bay Coastal watershed depending on the amount of development and impervious surfaces. The last row on the table suggests different areas within the coastal watershed to apply types of BMPs.

Table 59: General Guidelines for Locating BMPs

Amount of Development	***Undeveloped***	***Developing***	***Developed***
Philosophy	Preserve	Protect	Retrofit
Amount of Impervious Surface	< 10%	11 – 26%	> 26%
Water Quality	Good	Fair	Fair – Poor
Stream Biodiversity	Good – Excellent	Fair – Good	Poor
Channel Stability	Stable	Unstable	Highly Unstable
Stream Protection Objectives	Preserve biodiversity; Channel stability; Maintain key elements of stream quality; Minimize pollutant loads	Maintain key elements of stream quality; Minimize pollutant loads	Minimize pollutant loads delivered to downstream waters and GT Bay
Pollutants to Address	• Sediment • Nutrients • Hydrologic Flow • Loss of Habitat	• Sediment • Nutrients • Hydrologic Flow • Loss of Habitat • Toxics	• Sediment • Nutrients • Hydrologic Flow • Toxics • Pathogens
BMP Selection and Design Criteria	• Maintain pre-development hydrology and prevent loss of habitat • Minimize sediment and nutrient inputs • Emphasize filtering systems	• Maintain pre-development hydrology and prevent loss of habitat • Maximize pollutant removal • Emphasize filtering systems	• Focus on stormwater management • Maximize pollutant (sediment, nutrients, toxics) removal and quantity control • Implement systems that reduce hydrologic instability • Emphasize filtering systems
Example Locations in Designated Priority Areas	• Northern Antrim Co. • Northern Leelanau Co. • Headwater areas – Yuba and Acme Creek	• Sprawl Areas: East Bay, Acme, and Elmwood Townships	• Urban Areas: City of Traverse City, Village of Elk Rapids, and Village of Suttons Bay

Table concept taken from Mill Creek Watershed Management Plan (HRWC 2003); BMP location guidelines are adapted from the rapid watershed assessment protocol of the Center for Watershed Protection (CWP 1998)

BMP Effectiveness and Pollutant Reductions

BMP effectiveness, or efficiency, is determined by the size of the BMP implemented (e.g., feet of vegetated buffer or acres of stormwater detention ponds), contributing drainage area, and how much pollution was initially coming from the source. The Center for Watershed Protection has compiled a considerable amount of information regarding the effectiveness of selected stormwater BMPs. Most are listed by percentages of effectiveness, because, as stated above, the actual amount of pollutants reduced depends on the size of the BMP installed. For more specific information on these stormwater BMPs, see the Center for Watershed Protection's Stormwater Center website at www.stormwatercenter.net. Many BMP effectiveness listings are shown as percentages. This is a much more useful way of displaying the data rather than using specific values, which can be deceiving depending on the size of BMP implemented or installed. This is because specific values for pollutant removal depend on 1) the size of BMP implemented (feet of riparian buffer installed or acres of stormwater detention ponds), and 2) how much pollution was initially coming from the source.

There are also several ways to calculate the actual pollutant load reductions for installed BMPs. Monitoring project effectiveness and pollutant load reductions for stormwater and green infrastructure projects is usually done through stormwater modeling methods. This is because stormwater runoff and its resulting pollutant loading to a watershed is highly variable and dependent upon a variety of factors including weather patterns, rainfall intensity, time of year, and soil conditions (i.e. dry or saturated), among others. In addition, by their very nature GI projects are designed to reduce or eliminate stormwater running off a site, making it difficult to measure water quality parameters "post-implementation" because there is often nothing to measure. Commonly used modeling programs in Michigan include EPA's National Stormwater Calculator, EPA's Spreadsheet Tool for Estimating Pollutant Load (STEPL), and Michigan's Pollutants Controlled Manual and Spreadsheet. Most often the following metrics are measured to determine project success for stormwater BMPS:

- Gallons of stormwater infiltrated annually (using EPA Stormwater Calculator) and gallons of stormwater storage added (calculated as the volume of water that can be held in ponding and bioretention soil)
- Square feet of bioretention installed (calculated from as-built construction documents)
- Pounds of Phosphorus, sediment, and Nitrogen avoided annually (using STEPL and MI Pollutants Controlled Spreadsheet).

The EPA Stormwater Calculator is used to estimate both the amount of stormwater runoff coming from a project site as well as stormwater reductions from the installation of various stormwater BMPs. Specifically, the Stormwater Calculator estimates the annual amount of rainwater and frequency of runoff from a specific site based on local soil conditions, land cover, and historic rainfall record. This program can be accessed and download online at https://www.epa.gov/water-research/national-stormwater-calculator. It accesses several national databases that provide soil, topography, rainfall, and evaporation information for a chosen site. The user supplies information about the site's land cover and selects BMP controls they would like to use (including seven GI practices such as rain gardens, green roofs, infiltration basins, and porous pavement).

The STEPL is a model supported by EPA to calculate reductions in nonpoint source pollution that will be achieved as a result of installing BMPs in a particular watershed. The program can be accessed and the latest version download from the EPA's website at: https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl. The model employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various BMPs. GI installations and other stormwater projects can be modeled in STEPL using the "Urban BMP Tool." Various data inputs needed to run the STEPL model include geographic information, size of watershed, land use, potential septic systems, hydrologic soil group, and the type of BMP to be installed.

The Michigan Pollutants Controlled Manual provides instruction on calculating and documenting pollutant reduction for EGLE's Nonpoint Source Program (DEQ 1999). It can be used in watershed projects that treat the sources of sediment and nutrient pollutants using similar systems of Best Management Practices (BMPs). The purpose is to standardize the progress reporting in order that water quality impacts and statewide achievements can be systematically represented. The accompanying spreadsheet (in Microsoft Excel format) makes calculating load reductions easy by clicking and filling out forms for various types of BMPs, with stormwater BMPs in the "Urban Runoff" tab. The Manual and Spreadsheet can be accessed online at: https://www.michigan.gov/egle/0,9429,7-135-3313_71618_3682_3714-118554--,00.html.

In addition to calculation pollutant load reductions for stormwater, EPA's STEPL and Michigan's Pollutants Controlled Manual and Spreadsheet can also estimate reductions for a wide variety of other BMPs including gully and bank stabilizations and agricultural filter strips. For example, erosion from streambanks and shorelines can vary widely and, in general, one can calculate the sediment saved from entering a stream from a streambank stabilization BMP by utilizing the Channel Erosion Equation from the Pollutants Controlled Manual (DEQ 1999):

Sediment Reduced (T/yr) = Length (ft.) x Height (ft.) x LRR (ft./yr.) x Soil weight (ton/ft^3)

LRR: Lateral Recession Rate
Soil weight: Values available in MDEQ Pollutants Controlled Manual (DEQ 1999)

In turn, phosphorus and nitrogen attached to soil particles will be saved from entering the stream. The following calculations may be used to estimate the amount of phosphorus and nitrogen reduced by repairing an erosion source.

Phosphorus Reduced (lb/yr) =
Sediment reduced (T/yr) x 2000 lb/T x 0.0005 lb P/lb of soil x correction factor
Nutrient Reduced (lb/yr) =
Sediment reduced (T/yr) x 2000 lb/T x 0.001 lb N/lb of soil x correction factor

Correction factor: Soil texture correction factors available in MDEQ Pollutants Controlled Manual (DEQ 1999)

8.4 Previous Efforts in the Watershed

In 2005, The Watershed Center Grand Traverse Bay (TWC) developed a comprehensive watershed management plan for the Grand Traverse Bay watershed that was approved to meet EGLE and EPA requirements: www.gtbay.org/resources/watershed-protection-plan/ (TWC 2005). The plan looked at the nine subwatersheds in the Grand Traverse Bay watershed and characterized baseline conditions, described designated and desired uses, evaluated sources and causes of pollution in the watershed, and identified goals and strategies for addressing threats to water quality. The plan stated that focusing on reducing and/or eliminating pollution stemming from stormwater runoff, streambank erosion, road stream crossings, fertilizer use, lack of riparian buffers, and the reduction of wetlands would address the bulk of pollution entering Grand Traverse Bay and its surrounding watershed. Additionally, implementing a widespread and effective Information and Education Strategy was one of the most critical and important long-term tasks to accomplish (TWC 2005).

Since the initial Grand Traverse Bay Watershed Protection Plan (GTBWPP) was drafted, TWC has steadily worked with partner organizations to implement key recommendations from the plan. Stormwater is a major concern throughout the watershed, and TWC has focused on decreasing harmful effects from stormwater runoff entering waterways through educational campaigns, ordinances, source tracking analyses on *E. coli*, stormwater assessments for small communities, and inventorying and restoring riparian buffers and eroding stream banks.

To date, TWC has received more than $11.3 million in funding to implement key portions of the plan that annually prevents 1,726 tons of sediment, 1,482 pounds of phosphorus, and 4,604 pounds of nitrogen from entering Grand Traverse Bay and its watershed.

Priority Tasks Implemented by TWC

TWC has completed work on various grant-funded projects to restore eroding streambanks and road stream crossings, establish stormwater Best Management Practices (BMPs), and plant filter strips. This work includes funding through many EGLE and EPA grants. Since 2004, TWC has completed the following improvements and BMP installations:

- Restored 35 streambank stabilization sites totaling 4,302 feet (including 200 feet on Grand Traverse Bay)
- Installed 23,151 feet^2 of riparian filter strips/buffers
- Installed 31 rain gardens/bioinfiltration basins (18 in Suttons Bay, 13 in other locations)
- Established 3 stormwater wetland areas (various sizes)
- Installed 6,820 feet^2 of pervious pavement
- Installed 8,542 feet of underground infiltration trenches (Bryant Park, Munson Cancer Center, Suttons Bay, Northport)
- Installed 3 Downspout Planter Boxes (Munson Medical Center Campus)
- Installed 9 oil/grit separators (all in Traverse City)
- Installed 10 Storm Tree boxes (Munson Medical Center and Northport)
- Installed 3 drywells (Grand Traverse Commons campus)
- Restored 8 road crossings
- Daylighted 900 feet of Kids Creek Tributary A and restored 1,200 feet of Kids Creek Tributary AA (both involved floodplain reconnection and riparian buffer installation)

- Installed 6,500 $feet^2$ of green roofs at Munson Medical Center's Cancer Center and Main Building
- Managed sediment during Brown Bridge Dam removal (one-time removal of 390,000 tons of sediment, 331,500 lb of Phosphorus, and 663,000 lbs Nitrogen)

Stormwater Initiatives

Stormwater is a major concern throughout other areas of the watershed as well, and TWC has been working steadily on decreasing harmful effects from stormwater runoff entering waterways through educational campaigns, ordinances, source tracking analyses on bacterial contamination, stormwater assessments for small communities, inventorying and restoring riparian buffers and eroding streambanks, and discussing the possibility of a stormwater utility and approaches to improve preservation of urban vegetation resources for stormwater management in Traverse City. In 2013, TWC kicked off the large-scale Kids Creek Restoration Project that focused on reducing stormwater inputs to Kids Creek from urban areas using green infrastructure with the goal of having it eventually removed from the State's Impaired Waters List. This project is discussed in further detail below.

In addition, TWC completed four EPA-GLRI grants to reduce bacterial inputs related to stormwater at local beaches to protect public health. These projects were at Bryant and East Bay parks in Traverse City, the Village of Suttons Bay, and the Village of Northport (see accompanying photos).

Village of Northport Stormwater Reduction Project Pictures:

- *StormTree Boxes (above) and*
- *Underground Infiltration (left)*

Information and Education Initiatives

IE initiatives are an essential component to implement the GTBWPP. In 2007, TWC completed a benchmarking social survey, and in 2009 TWC completed a Core Values study assessing public awareness, attitudes, and behavior related to watershed protection to help develop better messages to initiate behavior change. TWC has been steadily working on an IE campaign over the past 12 years and have produced a stormwater toolkit and an award winning Low Impact Development Guidebook for the region. They have also continued to disseminate information about the watershed and its threats through the following outlets: Baykeeper® Tugboat Tour; local conference (Freshwater Summit); informational cards (Healthy Beaches, Clean Boating, etc.); newsletter, newspaper, and radio advertising; social networking; online blogs and videos; online water quality database; and educational watershed signs. TWC also recognized that working with townships was an integral part of protecting water quality in the region and have been addressing education gaps and other barriers to water quality protection for townships in the watershed (specifically in the Boardman River Valley, Chain of Lakes subwatershed, Old Mission Peninsula, Garfield Township, and Acme Township).

Land Conservation

Local land conservancies conducted priority work outlined out in the GTBWPP as well. Both the Leelanau Conservancy and Grand Traverse Regional Land Conservancy have received millions of dollars to purchase more than 50,000 acres of conservation easements throughout the watershed.

Monitoring Tasks

Monitoring projects are key to track known or new sources of pollution. Completed monitoring projects over the past 10 years include a 2009 macrophyte bed survey of Grand Traverse Bay, stormwater analyses for selected urban areas, a small dam inventory, and updated road crossing information at various locations. Additionally, TWC has conducted bacteria monitoring at local beaches between June - August at local beaches since 2001. TWC also completed bacteria monitoring on Mitchell Creek, a mid-sized stream located in Grand Traverse County that typically experiences high *E. coli* levels. As a result of an extensive monitoring program conducted by TWC in 2015, this creek was be listed as 'impaired' in the EGLE 2018 Integrated Report (EGLE June 2019).

Boardman River Subwatershed

TWC led a team of local organizations and developed the Boardman River Watershed Prosperity Plan, which was approved by EPA in February 2019. In addition to the required watershed plan components, the Prosperity Plan reflects economic and community development in the watershed, focuses on its long term protection, and addresses the issues of business and job creation.

Examples of successful pollutant reductions and resource protections in the Boardman River subwatershed are discussed in detail in Chapter 10.1 of the Prosperity Plan (TWC ####). A few of the major accomplishments in the Boardman River watershed over the past 10 years include:

- Restoration of over 150 streambank erosion sites
- Restoration of over 50 public access sites
- restoration of over 50 transportation crossings, including road and railroad

- Evaluation and initiation of the Boardman dams removal/ modification project, the largest dam removal project in Michigan's history and the biggest wetland restoration project in the Great Lakes basin (see below for further details)
- Development of water quality action plans in nine local townships, villages, and/or counties that made recommendations for changes to zoning ordinances and local policies that would better protect the river from pollutants (See Chapter 3.2 for more information).

Of special note is that nearly 300 streambank erosion sites have been stabilized/restored throughout the Boardman River watershed since the early 1990s. This effort was led by the Grand Traverse Conservation District (GTCD) and TWC, with support from other partner organizations.

The Boardman River Dam Restoration Project was an effort that removed three dams along the Boardman River - Brown Bridge (2012), Boardman (2017), and Sabin (2018) dams. A fourth dam, Union Street Dam is planned for modifications in 2021-2023. This is the largest river restoration project in Michigan and the largest ecological restoration project in the Grand Traverse Bay watershed. The dam removal project returned three impoundments to 5 miles of free-flowing river and reconnected 19 miles of river to another 31 miles upstream. Engineers estimate that 2.5 million cubic yards of sediment had accumulated in the former impoundments since the dams were built over 100 years ago; 700,000 cubic yards of sand and muck were moved and managed to recreate the river, its floodplain, and nearby wetlands and upland. Additionally, almost 10,000 feet of in-stream wood was placed for bank stabilization and habitat. Returning the Boardman River to its natural flow has had positive impacts on water quality and temperatures, aquatic insect life, fish and wildlife, recreation, and business opportunities. Major partners on that effort included the City of Traverse City, Grand Traverse County, Grand Traverse Conservation District, Grand Traverse Band of Ottawa and Chippewa Indians, Conservation Resource Alliance, and TWC.

Elk River Chain of Lakes Subwatershed

To provide greater detail for implementation and water quality protection, TWC and Tip of the Mitt Watershed Council drafted a subwatershed management plan for the Elk River Chain of Lakes (ERCOL), the largest subwatershed in the Grand Traverse Bay watershed. The first draft of the plan was completed by graduate students from the University of Michigan. A draft of the ERCOL watershed plan was submitted to EGLE in December 2020.

Specific work completed in the ERCOL in the past 10 years is summarized in Chapter 5 of the ERCOL Watershed Management Plan (TOMWC and TWC 2020).

Kids Creek Restoration Project Summary

TWC worked with EGLE, EPA, and many other partners to implement an Action Plan for the 303(d) listed waterbody of Kids Creek, which addressed water quality issues and highlighted priority tasks aimed at helping to remove it from the State's Impaired Waters List. Work on daylighting a portion of Kids Creek Tributary A on Munson Medial Center's campus was completed September 2013. This was the start of TWC's large-scale Kids Creek Restoration Project that focused on reducing stormwater inputs to Kids Creek from urban areas using green infrastructure techniques. Efforts have also begun on the next phases of the restoration project to work within the channel to restore in-stream habitat and provide floodplain storage during periods of high flow. TWC has received more than $5 million in EGLE, EPA-GLRI, and private funding to implement key portions of the Kids Creek Restoration Project. A summary of BMPs either completed or to be completed as part of the Kids Creek Restoration Project is here:

<u>*Munson Medical Center*</u>

- Relocated 900 feet of underground culverts and channelized ditches of Kids Creek Tributary A to a natural meandering channel 1,275 feet in length and eliminated 72,000 ft^2 of impervious surfaces. Restored natural sinuosity, meanders, riffles, and pools as well as established a native riparian buffer of 15-30 feet along the entire new section of creek and more than 27,000 ft^2 of vegetated floodplain. *(completed)*
- Installed green roof, underground infiltration trenches, and rain garden at the Cowell Family Cancer Center. *(completed)*
- Installed 4 downspout planter boxes, converted parking lot to pervious pavers, and retrofitted existing detention basin to a rain garden at Building 29 on west side of parking garage. *(completed)*
- Retrofitted ~3,100 ft^2 of roof on Munson Hospital Tower A to a green roof (see photo at right). *(completed)*
- Installed bioretention basins and pervious pavement around the Munson Medical Center helipad parking lots. *(completed)*
- Installed 5 tree box planters and 3 large rain gardens to reduce stormwater runoff from Medical Campus Drive. *(completed)*
- Excavated and enlarged the wetlands on the corner of Elmwood Avenue and Medical Campus Drive so more water can enter during storm events and be slowly released into Kids Creek. *(completed)*
- Installed underground storage and slow-release stormwater BMP at new parking garage on main Munson parking lot. *(completed)*
- Replaced undersized culverts at Kids Creek Tributary A road crossing entrance to Emergency Room to open bottom structure (see before and after photos below); Restored natural stream function and connected creek to floodplain in immediate upstream/downstream areas (5,000 sq ft floodplain, 30-40 ft buffer). *(completed)*

Green Roof at Munson Hospital

Before (left) and After (right) photos of road stream crossing replacement at Munson Emergency Room entrance

Grand Traverse Pavilions

- Restored the natural floodplain and installed a buffer on Tributary AA between the Grand Traverse Pavilions and Grand Traverse Commons (see photo at right). *(completed)*
- Installed rain garden to collect and filter parking lot and road runoff around Grand Traverse Pavilions entrance. *(completed)*

Stream Restoration along Kids Creek Tributary AA

Grand Traverse Commons

- Converted lined and rock-filled detention areas off of Cottageview Drive into functioning rain gardens. *(completed)*
- Reduced erosion and runoff issues by paving Yellow Drive and directing stormwater into a series of rain gardens. *(completed)*

Other

- Completed sediment basin reconstruction work at West Front Primary Care to prevent direct sediment input from parking lot runoff into Kids Creek Tributary A. *(completed)*
- Installed a rain garden to collect and infiltrate water from the parking area of the Traverse City State Office Building. *(completed)*
- Reduced sediment and stormwater runoff from industrial business near headwaters of Tributary A. *(completed)*
- Installed bioswale to receive stormwater from the 14th Street stormwater drainage ditch (see photo at right). *(completed)*
- Removed two undersized culverts that are restricting hydrologic flow on the main branch of Kids Creek in the City of Traverse City and replaced with pedestrian trail crossings *(to be completed 2021)*
- Replaced three undersized culverts that are restricting hydrologic flow with open bottom bridge structures on the main branch of Kids Creek in the City of Traverse City. *(to be completed 2021)*

Bioswale receiving stormwater from 14th Street stormdrain ditch.

8.5 *Implementation Tasks*

The following table (Table 60) includes a comprehensive list of proposed tasks and actions that, if implemented, will result in water quality protection or improvements and work towards achieving the watershed plan's goals and objectives. As a reminder, this is the Grand Traverse Bay Coastal Watershed Plan and implementation tasks specific to the Boardman River and Elk River Chain of Lakes subwatersheds can be found in their respective watershed plans. The tasks in the will focus specifically on the remaining portions of the Grand Traverse Bay watershed coastal areas.

The project steering committee found it helpful to summarize the implementation tasks by the pollutant and/or source it deals with, placing all implementation tasks into various categories. In this way, organizations may work on a specific issue (i.e., urban stormwater or shoreline restoration) that may contribute more than one type of watershed pollutant and meet more than one watershed goal. Please note that not all task categories may be relevant in all subwatershed tables.

The categories are as follows:

1. Shoreline Protection and Restoration
2. Stormwater Management
3. Transportation/Stream Crossings
4. Planning, Zoning, and Land Use
5. Land Protection and Management
6. Habitat, Fish and Wildlife
7. Recreation, Safety, and Human Health
8. Hydrology and Groundwater
9. Monitoring
10. Wetlands
11. Invasive Species
12. Agriculture
13. Wastewater and Septics
14. Emerging Issues

The project steering committee looked at the major sources of pollution in the watershed and carefully considered the impacts of each and measures that need to be taken to reduce their impacts. Feasibility of task implementation and its likelihood of pollutant reduction were considered as well. It was decided that focusing on reducing and/or eliminating the following pollutant sources will address the bulk of pollution entering the Coastal Grand Traverse Bay and its surrounding watershed (listed in no particular order):

- Development
- Lack of ordinances to protect water quality and natural resources
- Lack of riparian buffer
- Reduction of wetlands
- Road stream crossings
- Streambank and shoreline erosion
- Stormwater

Each implementation task identifies the following: watershed goal/objective addressed; priority level; potential milestones; estimated costs; potential partners; and timeline.

Timeframe: A timeframe of 10 years was used to determine the scope of activities and the estimated costs for implementing the tasks. Tasks that should be done in the short term were given a timeframe of 3 years. Tasks that should be undertaken annually were given a timeframe of "ongoing."

Estimated Costs: For costs associated with salaries, an average watershed technician rate of $35/hour was applied and rounded to the nearest $500 increment. Tasks that will be done on a yearly or site by site basis are noted as such ($X/yr or $X/site). Tasks for structural BMPs include estimated costs for engineering and construction. Further details are noted where applicable.

Priority Level: Each task and action has been assigned a priority level based on one or more of the following factors: urgency to correct or reduce an existing problem; need to enact a specific task or action before a problem develops; availability of funds, partner(s), or program(s) ready to implement; and the overall need to balance low, medium, and high priorities over the course of ten years.

Milestones: Project milestones for specific tasks were established where feasible to identify key tasks that need to be completed in order to complete the overall task on time. They are meant to guide implementation priorities and measure progress.

Partners: For each action step, the organization(s) best suited to help implement the task along with estimated costs to implement each item has been identified where possible. The potential partners specified are those who have the interest or capacity to implement the task or action; they are not obligated to fulfill the task or action. It is expected that they will consider pursuing funds to implement the task or action, work with other identified potential partners, and communicate any progress with the project steering committee.

Organization Acronyms:

ACD – Antrim Conservation District
CDs – All Conservation Districts
CGOV – County Governments
CRA – Conservation Resource Alliance
MDNR – Michigan Department of Natural Resources
EGLE – Michigan Department of Environment, Great Lakes, and Energy
EPA – Environmental Protection Agency
GTB – Grand Traverse Band of Ottawa and Chippewa Indians
GTCD – Grand Traverse Conservation District
GTRLC – Grand Traverse Regional Land Conservancy
HD – Local Health Departments
ISN – Northwest MI Invasive Species Network
LC – Leelanau Conservancy
LCD – Leelanau Conservation District
LGOV – Local Governments
MDOT – Michigan Department of Transportation
MISG – MI Sea Grant
MSU-E – Michigan State University Extension
NN – Networks Northwest
NMC – Northwestern MI College
NRCS – USDA Natural Resources Conservation Service
RCs – County Road Commissions
TAAR – Traverse Area Association of Realtors
TART – Traverse Area Recreational and Transportation Trails Inc.
TC – City of Traverse City
TOMWC – Tip of the Mitt Watershed Council
TWC – The Watershed Center Grand Traverse Bay

Table 60: Implementation Tasks

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Shoreline Protection and Restoration																
SPR-1	Inventory coastal streams for streambank erosion and enter data to online River Restoration in Northern Michigan database accordingly (http://www.northernmichiganstreams.org/boardmansbe.asp). (CRA, N.d.)	1.1, 1.2, 1.5, 2.1-2.5, 3.6	High	Funding – 2024 Inventory – 2025 Database – 2026	$50,000	CD TWC CRA										
	Notes: Funding obtained by 2024; Field inventory completed by end of 2025; Quality data checks and database update by 2026															
SPR-2	Work with public and private landowners to stabilize and restore eroding streambank sites at priority sites with biotechnical and soft engineering techniques.	1.1, 1.2, 1.5, 2.1-2.5, 3.6	Medium	Complete 500 linear feet (LF) by 2030	$100/LF; Total $50,000	CD TWC CRA										
	Notes: Work with partners to confirm sites (from inventory in above task) for stabilization-2027; Funding obtained-2028; Complete engineered designs and start construction-2029															
SPR-3	Inventory riparian corridors to identify a list of priority riparian buffer installation or restoration sites, including along the bay's shoreline.	1.1, 1.2, 1.5, 2.1-2.5, 3.6	High	Complete by 2025	$50,000	TWC CD										
	Notes: Funding obtained by 2023; Field inventory completed by end of 2024; Data analysis and final report by 2025															
SPR-4	Install native vegetated riparian buffers on public and private property in identified priority areas, with particular emphasis on tree preservation (where trees exist) or tree planting (where no or insufficient tree canopy exists)	1.1, 1.2, 1.5, 2.1-2.5, 3.6	High	Average 1 site/yr, total of 10 by 2030	Costs vary Estimate $25K/site Tot: $250,000	TWC CDs										
	Notes: Sites may be completed by varying partners but will consist of the following tasks on a 2-3 year basis for each site: Obtain funding and complete engineering (first/second year); Obtain permits and complete construction activities (third year)															
SPR-5	Work with public and private landowners to stabilize and restore eroding Great Lakes shorelines along Grand Traverse Bay in identified priority areas using bioengineering techniques	1.1, 1.2, 1.5, 2.1-2.5, 3.6, 7.3	High	Average 1 site every 2 years, total of 5 sites by 2030	Costs vary Estimate $50K/site Tot: $250,000	TWC										
	Notes: Sites may be completed by varying partners but will consist of the following tasks on a 2-3 year basis for each site: Obtain funding and complete engineering (first/second year); Obtain permits and complete construction activities (third year)															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
PZL-1	Assist local units of government in adopting or updating ordinances that ensure best management practices are utilized on private property along with water's edge, including building and impervious surface setbacks, deep lot requirements, riparian buffers, fertilizer restrictions, and tree preservation. *See Planning, Zoning, and Land Use*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PZL-5	Coastal Resiliency: Work with municipalities and townships to consider changing lake levels and ensure public infrastructure projects utilize coastal resiliency best practices including water's edge setbacks, deeper lot sizes, tree and vegetation preservation, properly sized stormwater management systems, etc. *See Planning, Zoning, and Land Use*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Stormwater Management																
SM-1	Work with local governments, area businesses, and property owners in coastline communities to install GI and other stormwater BMPs where possible (may include the following Specific Stormwater Project tasks).	1.2, 1.5, 2.1-2.5, 4.4, 7.2, 7.4	High	Average 1 site/yr, total of 10 by 2030	Costs vary Estimate $500K/site Tot: $5mil	TWC LGOV GTRLC CDs										
	Notes: Sites may be completed by varying partners but will consist of the following tasks on a 2-3 year basis for each site: Obtain funding and complete engineering (first/second year); Obtain permits and complete construction activities (third year)															
SM-2	<u>Specific Stormwater Project:</u> Work with Village of Northport to install priority GI BMPs outlined in their SAW report	1.2, 1.5, 2.1-2.5, 4.4, 7.2, 7.4	Medium	Funding-2024 Design-2025 Construction-2026	TBD	TWC LGOV										
	Notes: Work with Village to determine sites and start applying for funding by 2023, Funding obtained by 2024, Engineering/Design/Permits by 2025, Construction started by 2026															
SM-3	<u>Specific Stormwater Project:</u> GI along Jefferson Street in Village of Suttons Bay for runoff into Waterwheel Creek	1.2, 1.5, 2.1-2.5, 4.4, 7.2, 7.4	Medium	Funding-2024 Design-2025 Construction-2026	$500K	TWC LGOV										
	Notes: Work with Village to determine GI practices and start applying for funding by 2023, Funding obtained by 2024, Engineering/Design/Permits by 2025, Construction started by 2026															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
SM-4	<u>Specific Stormwater Project:</u> Continue GI program in the Village of Elk Rapids – includes installations of BMPs and review/revisions to GI management practices	1.2, 1.5, 2.1-2.5, 4.4, 7.2, 7.4	High	4 sites total: -Complete 2 GI sites by 2024 -Complete 2 more GI sites by 2029	$1.5mil	TWC LGOV										
	Notes: 2024 Completed sites – Determine sites by 2020, Funding obtained by 2021, Engineering/Design/Permits by 2022, Construction started by 2023/completed by 2024 2029 Completed sites - Determine sites by 2025, Funding obtained by 2026, Engineering/Design/Permits by 2027, Construction started by 2028/completed by 2029															
SM-5	<u>Specific Stormwater Project:</u> GI at outlet of Rose St drain in Sunset Park in Traverse City	1.2, 1.5, 2.1-2.5, 4.4, 7.2, 7.4	High	Funding-2028 Design-2029 Construction-2030	$500K	TWC LGOV										
	Notes: Work with City to determine GI practices and start applying for funding by 2027, Funding obtained by 2028, Engineering/Design/Permits by 2029, Construction started by 2030															
SM-6	<u>Specific Stormwater Project:</u> GI for stormdrain outlet at Bryant Park (east side) in Traverse City	1.2, 1.5, 2.1-2.5, 4.4, 7.2, 7.4	Medium	Funding-2028 Design-2029 Construction-2030	$500K	TWC LGOV										
	Notes: Work with City to determine GI practices and start applying for funding by 2027, Funding obtained by 2028, Engineering/Design/Permits by 2029, Construction started by 2030															
SM-7	<u>Specific Stormwater Project:</u> Install rainwater capture & reuse at proposed Conservation Campus for GTRLC (on Mitchell Creek, GTCounty)	1.2, 1.5, 2.1-2.5, 4.4, 7.2, 7.4	Medium	Funding-2026 Design-2027 Construction-2028	$50K	GTRLC TWC										
	Notes: Start applying for funding by 2025, Funding obtained by 2026, Engineering/Design/Permits by 2027, Construction completed by 2028															
PZL-2	Update applicable ordinances provisions for local governments to accommodate and encourage more innovative forms of stormwater management, including GI. Work with communities that don't have stormwater management ordinances to adopt protective ordinance provisions. *See Planning, Zoning, and Land Use*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Transportation/Stream Crossings																
RSX-1	Complete coastal watershed road stream crossing (RSX) inventory and update individual site information as construction projects are completed. Update inventory every ten years to reflect newly identified RSX and streambank erosion sites. Update online River Restoration in Northern Michigan database accordingly (http://www.northernmichiganstreams.org/boardmansbe.asp). (CRA, N.d.)	1.1-1.3, 1.5, 2.1-2.5	High	Funding-2028 Inventory-2029 Database-2030	$25K	CRA TWC CD										
	Notes: Funding obtained by 2028; Field inventory completed by end of 2029; Quality data checks and database update by 2030 (database updates from completed construction projects will be ongoing as they are completed)															
RSX-2	Where priority RSX crossings have been identified, improve, repair, or replace outdated, failing, or eroding crossings by implementing appropriate BMPs to improve hydrology, erosion control, and fish passage.	1.1-1.3, 1.5, 2.1-2.5	High	Average 1 site/yr, total of 10 by 2030	Costs vary Estimate $500K ea. Tot: $5mil	CD TWC CRA										
	Notes: Sites may be completed by varying partners but will consist of the following tasks on a 2-3 year basis for each site: Obtain funding and complete engineering (first/second year); Obtain permits and complete construction activities (third year)															
Planning, Zoning, and Land Use																
PZL-1	Assist local governments with drafting and updating zoning ordinances and master plans to protect water quality and natural resources. Examples of topics include building setbacks, minimizing development clearings and vegetation removal, stormwater management, reducing impervious surfaces near water bodies, establishing riparian buffers along waterways, prohibiting the feeding of waterfowl near water bodies, and protecting wetlands. *Also in Shoreline Protection and Restoration Tasks*	1.1-1.5, 2.1-2.5, 3.2-3.6, 7.5	High	Assist 1 local government with update each year	Staff: $10,000/yr Tot:$100K	TWC LGOV										
	Notes: As local governments undertake the tasks of updating their zoning ordinances/master plans TWC staff will review drafts when available and comment as necessary, providing language and technical advice when requested															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
PZL-2	Update applicable ordinances provisions for local governments to accommodate and encourage more innovative forms of stormwater management, including green infrastructure. Work with communities that don't have stormwater management ordinances to adopt protective ordinance provisions.	1.1-1.5, 2.1-2.5, 3.2-3.6, 7.5	High	2 updates by 2025 3 more by 2030	Staff: $10,000/yr Tot:$100K	TWC LGOV										
	Notes: Make list of and contact potential communities by 2022, Begin discussions with those that are interested by 2023, Draft ordinances by 2024 and present for adoption by 2025. Repeat this process starting again in 2027: Contact potential communities-2027, Discussions-2028, Draft documents-2029 and present for adoption by 2030															
PZL-3	Encourage local governments to establish policies and undertake projects that prioritize the protection of water quality on public land, including streets, roads, parking lots, and park land. This includes implementing GI into the planning and design phases of capital projects related to publicly owned infrastructure, such as street maintenance, building renovations, parking lot surfacing, and landscaping.	1.1-1.5, 2.1-2.5, 3.2-3.6, 7.5	High	Ongoing	Staff: $10,000/yr Tot:$100K	TWC LGOV										
	Notes: This task will be completed on an ongoing basis – TWC staff will annually review capital projects planned by local governments to determine potential for water quality protection activities that could be associated with it.															
PZL-4	Assist local units of government in adopting or updating ordinances that ensure best management practices are utilized on private property along with water's edge, including building and impervious surface setbacks, deep lot requirements, riparian buffers, fertilizer restrictions, and tree preservation.	1.1-1.5, 2.1-2.5, 3.4, 3.5, 7.5	High	2 updates by 2025 3 more by 2030	Staff: $10,000/yr Tot:$100K	TWC LGOV										
	Notes: Make list of and contact potential communities by 2022, Begin discussions with those that are interested by 2023, Draft ordinances by 2024 and present for adoption by 2025. Repeat this process starting again in 2027: Contact potential communities-2027, Discussions-2028, Draft documents-2029 and present for adoption by 2030															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
PZL-5	Coastal Resiliency: Work with municipalities and townships to consider the changing lake levels and ensure public infrastructure projects utilize coastal resiliency best practices including water's edge setbacks, deeper lot sizes, tree and vegetation preservation, properly sized stormwater management systems, etc. *Also in Shoreline Protection and Restoration and Emerging Issues Tasks*	1.1-1.5, 2.1-2.5, 3.4, 3.5, 7.2-7.5	High	Choose communities-2021 Funding-2022 Policies adopted by at least 4 communities-2025	$100K	TWC LGOV										
	Notes: Develop project and choose communities to work with (at least 4) by 2021; Obtain funding by 2022; Develop policies for adoption by 2025															
PZL-6	Work with local governments to author and adopt wetland protection ordinances and/or wetland setback provisions. *Also in Wetland Tasks*	1.1-1.5, 2.1-.5, 3.4, 3.5, 7.3	Medium	Choose communities-2026 Funding-2027 Policies adopted by at least 4 communities-2030	$100K	LGOV CD TWC										
	Notes: Choose communities to work with (at least 4) by 2026; Obtain funding by 2027; Develop policies for adoption by 2029; Adopted by 2030															
PZL-7	Ensure that zoning ordinances in all watershed communities include provisions to identify and protect scenic vistas, agricultural lands, and historic or cultural sites.	6.2, 6.3	Low	Review Zos-2028 Language-2029 Adoption-2030	$25K	LGOV CD GTRLC LC										
	Notes: Begin review of ZOs by 2028; Contact local governments that need provisions for protection by 2029 and offer suggested language; Adoption by 2030															
PZL-8	Work with appropriate local government agencies (i.e., County Drain Commission) to recommend BMP's for developers on construction sites and to ensure compliance with those BMP's	1.1-1.5, 2.1-2.5, 3.4, 3.5	Low	Recommendations by 2026 Distribute-2028 Annual check-in through 2030	$25K	LGOV CD TWC										
	Notes: Develop recommendations-2026; Contact gov't agencies with recommendations-2028; Check in annually after to ensure compliance															
PZL-9	Work with local governments to adopt a coal tar sealant ban ordinance and/or registration process and corresponding public education campaign.	1.1-1.5, 2.1-2.5, 3.4, 3.5	Low	Choose communities-2026 Funding-2027 Develop policies-2029 Adoption-2030	$25K	LGOV CD TWC										
	Notes: Choose communities to work with (at least 3) by 2026; Obtain funding by 2027; Develop policies for adoption by 2029; Adopted by 2030															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
PZL-10	Proactively review development proposals in priority communities to ensure compliance with local zoning and state and federal standards. Work with local governmental boards and commissions to ensure policies and laws are applied and enforced.	1.1-1.5, 2.1-2.5, 3.4, 3.5	High	Ongoing	Staff: $10,000/yr Tot:$100K	TWC LGOV										
	Notes: Because of the nature of this task, it will be completed on an as-needed, ongoing basis. TWC staff will review proposals from priority communities as they are presented at local government meetings for review to ensure it complies with local zoning and state/federal standards. Comments will be made during review period as appropriate/necessary. The task will be completed as part of the TWC Baykeeper Program activities.															
Land Protection and Management																
LPM-1	Work with local units of government to develop and promote local initiatives that preserve open space and sensitive/important natural areas.	3.2, 3.3, 3.7	Medium	Ongoing	$25K	GTRLC LC LGOV										
	Notes: Choose local governments to work with by 2027; Begin meetings with local governments to discuss initiatives in 2028; Finalize initiatives and promote to community 2029/30															
LPM-2	Identify and prioritize priority private lands for conservation and work with interested landowners to acquire conservation easements or other permanent protection of these priority parcels.	1.7, 2.7, 3.1	High	Two easements by 2025 Four by 2030	Staff: $2,500/yr Tot:$25K Land Cost Varies: Estimate $625K/ea. Tot: $2.5mil	GTRLC LC										
	Notes: 2025 project: Choose priority land parcels by 2021; apply for and obtain funding by 2023; work with landowners and purchase land by 2025 *2030 project: Choose priority land parcels by 2026; apply for and obtain funding by 2028; work with landowners and purchase land by 2030*															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Habitat, Fish, and Wildlife																
HFW-1	Collect information that exists, and conduct stream inventories where needed, to evaluate appropriate sites for in-stream habitat improvement projects. Criteria to be assessed includes: woody debris, bank stability, floodplain connectivity, riparian vegetation, in-stream cover, flow dynamics, and fish population structure	1.1-1.3, 2.5	High	Choose streams-2022 Funding-2023 Inventory-2025 Results-2025	Staff: $2,500 per stream Est. 25 streams Tot: $62,500	CD TWC CRA DNR GTB										
	Notes: Choose study sites-2022; Develop study and obtain funding-2023; Conduct inventories-2024/25; Summarize results and prioritize-2025															
HFW-2	Install in-stream habitat improvements where appropriate, according to the inventory above.	1.1-1.3, 2.5	Medium	5 total sites by 2030	Costs vary Estimate $50K ea. Tot: $250K	CD TWC CRA DNR GTB										
	Notes: Choose priority sites and begin applying for funding-2026; Funding obtained by 2028; Site engineering and begin construction-2029															
HFW-3	Complete above task specifically for Mitchell Creek in Grand Traverse County.	1.1-1.3, 2.5	High	Funding-2021 Summarize results-2022	$50,000	TWC CRA GTRLC GTCD										
	Notes: Develop study and obtain funding-2021; Conduct study and summarize results 2022															
HFW-4	Install in-stream habitat improvements where appropriate, according to the Mitchell Creek inventory in Task HFW-3.	1.1-1.3, 2.5	High	Choose sites-2023 Funding-2025 Construction-2026	$100,000	TWC CRA GTRLC GTCD										
	Notes: Choose priority sites and begin applying for funding-2023; Funding obtained by 2025; Site engineering and begin construction-2026															
HFW-5	Pursue additional reef restoration efforts on the coastline north of Elk Rapids to enhance fish habitat and protect the shoreline.	1.1, 4.1	Low	Discussions start-2029 Pursue funding-2030	Costs vary	TWC DNR										
	Notes: Start discussions on potential sites-2029; Pursue funding by 2030															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
HFW-6	Continue to implement the Conservation Resource Alliance's Wild-Link program and Wild Roots Initiative to protect and enhance fish and wildlife habitat and provide climate and flood resiliency on private and public lands within ecological corridors throughout the watershed.	1.1-1.3, 2.5, 3.7	Low	100,000 trees planted by 2023 *(in all CRA service area)*	$1mil	CRA										
	Notes: CRA has already obtained funding for this program and will continue to implement 2021-2023															
Recreation, Safety, and Human Health																
MON-5	Continue annual beach *E. coli* monitoring program for public beaches in the Grand Traverse Region *(See Monitoring Task below for details)*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RSHH-1	Implement measures to reduce bacteria and other pathogen contamination at beaches where monitoring indicates a problem.	2.1, 4.3, 4.4	High	TBD from monitoring	TBD	TWC HD LGOV										
	Notes: This task is solely determined by monitoring results from task above, therefore timing for milestones and completion of tasks will vary. Monitoring results will be reviewed on an annual basis to determine the need for BMP measures at beaches to remediate problems. If problem arises the project will be developed and funding sources will be determined.															
RSHH-2	Mitchell Creek *E. coli* Impairment (GT County): Conduct source tracking study to determine sources of bacteria impairment and identify and prioritize steps that should be taken to reduce bacteria input to the creek.	2.1, 4.3, 4.4	High	Monitoring-2021 Analyze results-2022 Targeted monitoring-2022 Final results-2023	$150K	TWC HD LGOV										
	Notes: Funding for this task has already been obtained by TWC through a EGLE-NPS grant															
RSHH-3	Mitchell Creek *E. coli* Impairment (GT County): Implement measures and Best Management Practices identified in above task to reduce bacteria inputs to Mitchell Creek, resulting in its removal from Impaired Waters List.	2.1, 4.3, 4.4	High	Funding-2026 Design-2027 Construction-2030	Costs vary Estimate $1mil	TWC HD LGOV										
	Notes: Begin looking for funding sources-2024; funding obtained by 2026; BMP design/engineering-2027; BMP implementation begin in 2027, finish in 2030															
RSHH-4	Northport Creek *E. coli* Impairment: Conduct source tracking study to determine sources of bacteria impairment and identify and prioritize steps that should be taken to reduce bacteria input to the creek.	2.1, 4.3, 4.4	Medium	Source tracking study start by 2025	$150K	TWC HD LGOV										
	Notes: Develop study-2023; Look and apply for funding sources-2024; Funding obtained, and study started by 2025; Final results and report-2027															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
RSHH-5	Northport Creek *E. coli* Impairment: Implement measures and Best Management Practices identified in above task to reduce bacteria inputs to Northport Creek, resulting in its removal from Impaired Waters List.	2.1, 4.3, 4.4	Medium	BMP Implementation start by 2026	Costs vary Estimate $1mil	TWC HD LGOV										
	Notes: Begin looking for funding sources-2028; funding obtained by 2029; BMP design/engineering-2030; BMP implementation after 2030															
WS-6	Work with the City of Traverse City to identify and fix problems with sanitary sewer system that have resulted in sewage overflows during heavy rain events that lead to human health advisories and beach closures. *See Wastewater and Septics*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RSHH-6	Work with area marinas to install and promote BMPs (like spill response carts containing brooms, pads and absorbents; bilge sponges; emergency shut-off valves; and stormwater detention areas and buffer strips) that will reduce the amount of pollution coming from boat fuels, wastewater, erosion, and lack of riparian buffers	2.1, 4.2, 4.6	Low	Choose BMPs-2028 Funding-2029 Install-2030	Staff: $1,000/yr Tot:$10K BMPs: $30K	TWC MISG LGOV										
	Notes: Begin discussions with marinas on potential BMPs-2027; Begin looking for funding for chosen BMPs-2028; Funding obtained by 2029; BMPs installed by 2030															
RSHH-7	Minimize stormwater contamination from vehicle fuel by installing and maintaining spill containment kits for gas and other fueling stations where necessary	2.1, 4.2, 4.6	Low	Two kits installed by 2030	$10,000	TWC MISG LGOV										
	Notes: Begin looking for funding-2028; Funding obtained by 2029; Kits installed by 2030															
Hydrology and Groundwater																
HG-1	Work with owners and operators of small dams and lake-control structures to ensure these structures are operated so that they mimic natural flow conditions of the river. Where possible, seek permission for removal.	1.1, 1.2, 2.3, 2.5, 4.2	Low	Begin contact-2025 Complete 2/annually after	Staff: $1,000/yr Tot:$10K	CDs TWC LGOV										

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
HG-2	Remove inoperative, failing, or economically unfeasible small dams as well as priority dams that are blocking fish passage. Utilize 2015 small dam inventory as resource.	1.1, 1.2, 2.3, 2.5, 4.2	Low	Begin looking for funding-2027 Obtain funding-2029 Design-2029 Removal-2030	Costs vary Est: $250K	TWC CRA GTB LGOV DNR EGLE										
	Notes: After contact with landowners begins, start looking for funding-2027; obtain funding by 2028; Design-2029; Dam removal by 2033															
HF-3	Complete a hydrologic and feasibility study for Mitchell Creek (GT County) to determine flow and discharge in the creek to inform potential RSX improvement projects as well as re-routing of stream back to original flow in the east Main Branch Mitchell Creek. *(Pair with stream assessment study from Habitat, Fish, and Wildlife section: HFW-1, HFW-3)*	1.2	High	Funding-2021 Summarize results-2022	$200K	TWC CRA GTRLC										
	Notes: Develop study and obtain funding-2021; Conduct study and summarize results 2022															
HF-4	Depending on result of feasibility study above for Mitchell Creek, install water control structure where flow is diverted a ditch (West Main Branch Mitchell Creek) to restore main flow of creek through East Main Branch Mitchell Creek.	1.1-1.3	Medium	Begin funding search-2023 Funding obtained-2026 Design-2027 Construction-2028	$250K	TWC CRA GTRLC										
	Notes: Begin looking for funding 2023; Funding obtained by 2026; Design/Engineering-2027; Construction complete by 2028															
HF-5	Inventory and summarize the status of wellhead protection plans. Support groundwater/wellhead protection programs for municipal drinking water supplies	2.1, 1.2	Low	Inventory by 2028 Support ongoing	$10K	LGOV TWC HD CDs										
	Notes: Gather partners and develop inventory program-2026; Begin gathering wellhead protection plans-2028; Summarize status in final report-2028															
HF-6	Eliminate improperly or uncapped abandoned wells to prevent contaminants from moving into and among groundwater aquifers via this route. Tasks will be to 1) inventory existing abandoned wells through surveys, well logs, and landowner interviews and 2) properly plug the abandoned wells.	2.1, 4.2	Low	Inventory by 2028 Well plugging started by 2030	$25,000 (well inventory)	MSUE HD EGLE										
	Notes: Gather partners and develop inventory program-2027; Complete inventory tasks-2028; Summarize results and find funding for plugging necessary wells-2029; Plugging activities started by 2030															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Monitoring																
MON-1	Implement coastal tributary monitoring program as outlined in Table 64 to regularly monitor standard water quality parameters (e.g., TP, TN, DO, Conductivity, Temperature) in various streams.	2.1-2.6	High	Dev. program-2021 Funding-2022 Begin-2022 Continue annually thereafter	$25k/yr Tot:$250K	TWC CDs LC LGOV										
	Notes: More details in Table 64 in Chapter 10.4 Water Quality Monitoring Plan. Initial work will start in 2021 to develop and finalize program details and tasks as well as acquire funding; Once funding is acquired (2022 targeted) monitoring will begin and continue annually through 2030; Monitoring reports will be summarized and distributed annually															
MON -2	Continue TWC's Adopt A Stream program and expand to include additional streams.	1.1, 2.5, 5.1, 5.5	High	Add least two sites by 2025 Monitor all sites twice/year	$10K/yr Tot:$100K	TWC										
	Notes: More details in Table 64 in Chapter 10.4 Water Quality Monitoring Plan. TWC conducts this monitoring program on an annual basis with varying funding sources; Currently 8 coastal creeks are included in the monitoring program: Acme, Baker, Brewery, Cedar, Leo, Mitchell, Water Wheel, Weaver, and Yuba creeks; Two sites added by 2025 See website for specific locations (http://www.gtbay.org/our-programs/adopt-a-stream/).															
MON -3	Continue EGLE collection and identification of macroinvertebrates from selected stations on a 5-year rotating schedule, consistent with present sampling program.	1.1, 2.5	High	2023 2028	No Cost	EGLE										
	Notes: Completed as part of EGLE's 5-year rotating monitoring program; GT Bay scheduled for 2023 and 2028; TWC will work with EGLE to request various monitoring sites as outlined in Table 64 in Chapter 10.4 Water Quality Monitoring Program.															
MON -4	Continue EGLE trend monitoring program in Grand Traverse Bay Trend (4 stations, 3x/yr). Both nutrient and other parameters.	2.1-2.6	High	Monitor yearly	No Cost	EGLE										
	Notes: More details in Table 63 in Chapter 10.4 Water Quality Monitoring Plan and Table 20 in Chapter 3.9. Grand Traverse Bay Trend Monitoring is conducted by EGLE through their Water Chemistry Monitoring Program at four fixed stations in Grand Traverse Bay since 1998. EGLE will continue the monitoring program and analyze and report on patterns as resources allow.															
MON -5	Continue annual beach *E. coli* monitoring program for public beaches in the Grand Traverse Region	2.1, 4.3, 4.4	High	Monitor yearly	$20K/yr Tot:$200K	TWC HD										
	Notes: TWC and local health departments conduct this monitoring on a yearly basis with funding provided by EGLE's BEACH Program; Beaches tested are noted in Table 63															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
MON -6	Update appropriate online databases as new water quality information becomes available (eg: TWC, MiCorps, northernmistreams.org, BeachGuard, Water Quality Portal, etc.)	all	Low	Update as needed	Staff: $2,500/yr Tot:$25K	TWC CRA CDs USGS										
	Notes: Various organizations complete monitoring at various timeframes; TWC and partners will discuss ways to keep these databases up to date															
RSHH-2 and RSHH-4	Research the causes/sources of bacteria impairment in Mitchell Creek (GT County) and Northport Creek (Leelanau County). *(See Recreation, Safety, and Human Health Tasks)*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MON -7	Conduct monitoring to determine if Mitchell Creek in Antrim County is still experiencing bacteria impairment.	2.1, 4.4	Medium	Develop study-2026 Funding-2027 Monitoring and results-2028	$10,000	TWC CD LGOV										
	Notes: Develop study, identify partners and sample sites-2026; Secure funding-2027; Conduct monitoring and summarize results-2028															
MON -8	Update shoreline inventory of Grand Traverse Bay (last completed 2003)	1.3, 4.1, 7.3	High	Develop study-2022 Funding-2023 Results-2025	$50,000	TWC										
	Notes: Develop study, identify partners-2022; Secure funding-2023; Conduct monitoring-2024; Summarize and distribute results-2025															
MON -9	Update GTBay macrophyte bed survey (last completed in 2009); include sediment analysis	1.1, 4.1	High	Develop study-2022 Funding-2023 Results-2025	$100K	TWC										
	Notes: Develop study, identify partners and sample sites-2022; Secure funding-2023; Conduct monitoring-2024; Summarize and distribute results-2025															
MON -10	Continue DNR fish sampling in the bay for Various Fish Parameters as outlined in Table 63 in Chapter 9.4. Monitoring includes population dynamics; cisco and lake whitefish movement and recruitment surveys; smallmouth bass abundance/mortality/movement; lakewide adults fish and forage fish assessments, and lakewide creel and charter boat surveys.	1.1, 4.1	High	Monitor yearly	No Cost	DNR										
	Notes: More details in Table 63 in Chapter 10.4 Water Quality Monitoring Plan															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
MON -11	Update small dam inventory (last completed in 2015) for <u>entire</u> Grand Traverse Bay watershed.	1.1, 1.2, 2.3	Medium	Develop study-2026 Funding-2027 Monitor-2028 Summarize and distribute-2030	$100K	TWC CD										
	Notes: Develop study, identify partners and sample sites-2026; Secure funding-2027; Conduct monitoring-2028/29; Summarize and distribute results-2030															
MON -12	Continue TWC's Beach Rangers program to track avian botulism impacts along Grand Traverse Bay.	1.1, 4.1, 4.4, 5.1, 5.5	High	Annually, each fall	Staff: $2,500/yr Tot:$25K	TWC										
	Notes: TWC conducts this monitoring program on an annual basis with varying funding sources															
MON -13	Monitor coastal streams for impacts from road salt application and poor snow storage practices.	1.1, 2.1, 5.1	High	Develop study and secure funding-2021 Monitor-2024 Summarize-2025	$60,000	TWC EGLE										
	Notes: Develop study-2021; Apply for and secure funding-2023; Conduct monitoring starting 2024; Summarize results-2025															
MON -14	Conduct baseline monitoring of Mitchell Creek to capture pre and post restoration data/impacts	1.1-1.3	Medium	Develop study, secure funding-2021 Monitor-2022	$10K	GTRLC TWC CRA										
MON -15	Continue annual volunteer monitoring efforts conducted by Inland Seas Education Association as part of their Schoolship Program. Includes forage fish counts, water chemistry (temperature, pH, and DO), secchi depth, and presence/absence of zebra and quagga mussels. Two fixed sites – Suttons Bay and Old Coal Dock in Greilickville.	1.1, 1.6, 4.1, 4.5, 5.2, 5.5	Medium	Monitor yearly	$25K	ISEA										
	Notes: Inland Seas Education Association (ISEA) is a nonprofit group based in Suttons Bay that provides hands-on experiences aboard traditionally-rigged tall ship schooners along the shores of the Great Lakes. Various monitoring efforts are done on a regular basis by volunteers leading groups of people on educational experiences. ISEA (as of 2020) is reorganizing and restructuring their science and data collection process, so parameters noted above are subject to change.															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Wetlands																
WET-1	Conduct Landscape Level Wetlands Functional Analysis for Watershed, ground-truth to confirm high-value wetlands	1.3, 1.4, 7.3	High	Contact EGLE, begin discussion-2021 Begin analysis-2023	No Cost	EGLE										
	Notes: Contact EGLE representatives to discuss work- 2021; Work with EGLE representatives to push for this completion by 2024															
WET-2	Ground-truth wetlands identified through Landscape Level Wetlands Functional Analysis to confirm high-value wetland status and identify other wetlands of particularly high value, based on plant/animal species, etc.	1.3, 1.4, 7.3	Medium	ID areas for work-2025 Fieldwork-2026 Summary-2027	Staff: $10K	TWC EGLE										
	Notes: After analysis completed in previous task, identify priority areas for ground-truthing and project partners in 2025; Fieldwork done in 2026; Summary-2017															
PZL-1 PZL-4 PZL-6 LPM-2 INV-5	Protect and restore existing wetlands through the use of setback buffers, enforcement of wetlands regulations, permanent preservation of priority parcels, and removal/management of invasive species. *See related tasks listed to left.*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PZL-6	Work with local governments to author and adopt wetland protection ordinances and/or wetland setback provisions. *See Planning, Zoning, and Land Use*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Invasive Species																
INV -1	Monitor GT Bay shoreline for Phragmites and other emergent and terrestrial invasive species at least once per 3 years, especially those on State and CISMA Early Detection and Watch lists	1.6, 4.5	High	~45miles/year Totals 134 miles (GTBay shoreline) every three years	Staff: $5,000/yr Tot:$50K	ISN CAKE										

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
INV -2	Monitor GT Bay for submersed/aquatic invasive species, especially those on the Michigan Watch List	1.6, 4.5	High	At least one effort per year	Staff: $5,000/yr Tot:$50K	TWC ISN CAKE										
	Notes: Partners will convene annually and decide which species to monitor the next year. Funding for effort will continually be sought after.															
INV-3	Survey additional areas in the watershed (terrestrial and aquatic) for invasive species, especially those on State and CISMA Early Detection and Watch lists whenever possible	1.6, 4.5	Low	Ongoing	Staff: $2,000/yr Tot:$20K	ISN CAKE										
	Notes: ISN and CAKE will discuss and prioritize and decide which additional areas will be surveyed each year when possible. Task will be dependent upon funding.															
INV -4	Report introductions and spread of invasive species within the watershed to at least one tracking database (USGS, MISIN, *etc*.).	1.6, 4.5	High	Annually report – by December each year	Staff: $3,000/yr Tot:$30K	TWC ISN CAKE										
INV -5	Implement on-the-ground management projects to either remove them completely from a site or stop the introduction, spread, and distribution of invasive species within the watershed. Work with local governments and resource agencies as needed.	1.6, 4.5	High	Implement at least 20 private and/or public property projects by 2030	Varies by site & project	TWC ISN CAKE LGOV										
	Notes: Implementation will occur on a rotating basis and will involve the following tasks to be repeated for each funded project: Prioritize projects with partners; apply for and acquire project funding; work with partners to implement															
INV-6	Work with local governments and businesses to install boat washing stations at area marinas and public boat launches to avoid spread of invasive species	1.6, 4.5	Low	2 stations by 2025 ID locations-2022 Funding-2024 Installation-2025	~$10K/ea Tot:$20K	ISN CAKE LGOV										
	Notes: Identify locations-2022; Secure funding-2024; Install stations-2025															
INV -7	Work with local governments, businesses, and landowners to require decontamination of equipment and supplies before entering or exiting a construction site	1.6, 4.5	Medium	Discussions started by 2024 Requirements implemented in 5 locations by 2027	Staff: $2,000/yr Tot:$8K	TWC ISN CAKE LGOV										
	Notes: Begin discussions in priority locations-2024; Continue discussions and work with locations on what requirements should be and how to implement-2025; Implement in at least 5 locations by 2027															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Agriculture																
AG-1	Continue to work with and support farmers through the Michigan Agriculture Environmental Assurance Program (MAEAP) to evaluate their entire operation and to help them make sustainable, science-based management decisions that balance environmental, economic, and societal factors.	1.1-1.5, 2.1-2.5	High	Verify 10 new farms per year.	Staff: $15K/yr Tot:$150K	CDs NRCS										
AG-2	Develop Conservation Plans, Resource Management Plans, or Progressive Plans for all farms in the watershed that do not currently have one. In addition, Conservation Plans that are more than 3 years old should be reviewed and updated to keep them eligible for USDA cost-share programs	1.1-1.5, 2.1-2.5	High	One plan/yr	$200K/yr Tot:$2mil	NRCS CDs MSU-E										
AG-3	Work with agricultural producers that have an approved Conservation Plan to implement USDA-NRCS cost-share programs that provide cost incentives and/or rental payments to farmers who implement eligible conservation practices on their land. Examples of these types of programs include: Environmental Quality Incentives Program (EQIP), Conservation Security Program (CSP) and the Conservation Reserve Program (CRP). More information on these and other cost-share programs are on the USDA-NRCS website at http://www.nrcs.usda.gov/.	1.1-1.5, 2.1-2.5	High	One project/yr	$200K/yr Tot:$2mil	NRCS CDs MSU-E										
	Notes: For each project - Identify potential projects and ag producers; secure funding; develop site plan; installation															
AG-4	Install Ag BMPs (i.e., cover crops, spill containment centers, fencing livestock out of stream, riparian buffers, etc.)	1.1-1.5, 2.1-2.5	Low	One BMP by 2025 One more by 2030	Est. $50K	NRCS CDs										
	Notes: 2025 Project – Identify project-2023, secure funding-2024, construction-2025; 2030 project – Identify project-2028; secure funding-2029, construction-2030															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Wastewater and Septics																
WS-1	Complete shoreline cladophora surveys along GT Bay to determine potential sites where there may be improperly working septic systems. Work with Health Departments and landowners to conduct dye testing to determine which septic systems are leaking, if any, in potential sited areas	1.1, 2.1, 4.4	Low	ID locations-2025 Funding-2017 Survey-2028	$50,000	TWC CDs HD LGOV										
	Notes: Identify priority locations and develop survey program-2025; Funding secured by 2027; Survey completed and results summarized by 2028															
WS-2	Offer advice and assistance to riparian landowners to help identify malfunctioning septic systems.	1.1, 2.1, 4.4	Medium	Ongoing	Staff: $2,500/yr Tot:$25K	TWC HD CDs LGOV										
WS-3	Work with local governments and health departments to establish regular, mandatory septic system inspections through ordinances (i.e. time of sale, mandatory pumping/inspection) or by other means in communities without centralized wastewater treatment systems	1.1, 2.1, 2.5, 3.2, 3.3, 4.4	Medium	ID communities-2023 Draft ordinances-2024 Adopt by 5 communities-2030	Staff: $75,000	TWC HD CDs LGOV										
	Notes: Identify potential communities that are both a priority and interested in participating-2023; Start discussions and draft ordinance language-2024; Work with communities to get ordinances adopted assumed timeframe for adoptions is 2025-2030															
WS-4	Select and install demonstration projects utilizing alternative onsite wastewater treatment systems	1.1, 2.1, 2.5, 4.4	Low	ID potential projects- 2026 Funding-2028 Construction-2029	$500K (estimate)	TWC HD CDs LGOV										
	Notes: Identify potential communities that are both a priority and interested in participating-2026; Develop one demo project and secure funding-2028; Begin construction-2029															
WS-5	Replace septic systems with a community wastewater conveyance and treatment system where there is a high density of old or improperly working septic systems.	1.1, 2.1, 2.5, 4.4	Low	One site by 2030 ID location-2025 Funding-2028 Design-2029 Construction-2030	$500K (estimate)	TWC HD CDs LGOV										
	Notes: Identify potential locations-2025; explore funding sources and acquire funding-2028; Site design-2029; Construction-2030															

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
WS-6	Identify and fix problems with the sanitary sewer system the City of Traverse City that have resulted in sewage overflows during heavy rain events that lead to human health advisories and beach closures.	2.1, 4.3, 4.4	High	Problems identified by 2022 Implementation start by 2023	Costs vary Estimated $3mill	TWC TC GTCHD										
	Notes: As of summer 2020 the city has already begun investigations for problems and started implementing initial fixes; TWC, GTCHD, and the city will work together to continue activities to identify problems through 2022; partners will the work together to find solutions fix the identified problems-2023; Design and implementation-2023 through 2025															
WS-7	Pursue replacing individual septic systems with a community wastewater conveyance and treatment system at Inwood Harbor (north of Elk Rapids) to eliminate nutrient inputs and algal blooms.	1.1, 2.1, 2.5, 4.4	Medium	Discuss/develop project-2025 Funding-2026 Design-2027 Construction-2028	$1mill (estimate)	TWC HD LGOV										
	Notes: Begin discussions with residents and Village of Elk Rapids and develop project-2025; Obtain funding- 2026; Design-2027; Complete-2028															
WS-8	Work with EGLE and local governments to support actions to minimize nutrient and pathogen discharges from municipal wastewater treatment plants, industrial/commercial facilities, and sanitary sewer overflows	1.1, 2.1, 2.5, 4.4	Low	Ongoing	Staff: $2,500/yr Tot:$25K	TWC HD CDs LGOV EGLE										
RSHH-2	<u>Mitchell Creek (GT County):</u> Conduct source tracking study to determine if bacteria impairment is from leaking septics. *See Recreation, Safety, and Human Health*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
WS-	Mitchell Creek: If sources and locations of contamination are identified as failing septic systems, work with GTCHD and municipalities to remediate the causes and develop a comprehensive approach to find and fix failing on-site septic systems ***Related to Task: RSHH-2 & RSHH-3***	1.1, 2.1, 3.2, 3.3, 4.4	High	Funding-2026 Design-2027 Construction-2030	Costs vary Estimate $2 mil	TWC HD GTCHD										
	Notes: Begin program development and look for funding sources-2024; funding obtained by 2026; Program implementation starts in 2027; finish in 2030															
Emerging Issues																
EI-1	Advocate at the state and federal level for increased and widespread home well testing, research and development of human health standards for unknown PFAS compounds, and innovative and thorough restoration technologies.	2.1	Low	Ongoing	Staff: $2,500/yr Tot:$25K	TWC										

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
	Notes: This task will be conducted by various partners on an ongoing basis whenever possible and will be dependent on activities/development at the state and federal level,															
EI-2	Work with municipal drinking water and wastewater treatment plants to install appropriate filters to reduce microplastics in drinking and wastewater.	2.1	Low	Filters installed at 4 plants by 2028	Tot:$25K	TWC										
	Notes: Identify interested communities and begin discussions with plants re potential filters and logistics of installing them-2025; Identify funding and apply as necessary-2026; funding secured and filters purchased/installed-2028															
PZL-5	Coastal Resiliency: Work with municipalities and townships to consider the changing lake levels and ensure public infrastructure projects utilize coastal resiliency best practices including water's edge setbacks, deeper lot sizes, tree and vegetation preservation, properly sized stormwater management systems, etc. *See Planning, Zoning, and Land Use*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EI-3	Coastal resiliency: Advocate for better research and development of natural shoreline stabilization techniques on high energy sites on the Great Lakes.	1.1, 1.5, 2.1, 2.4, 4.3, 7.2, 7.4	High	Focus 2021-2023	Staff: $2,500/yr Tot:$7,500	TWC CD LGOV MISG										
	Notes: Because of the nature of this task, it will be completed on an ongoing basis whenever possible and opportunities arise. The task will be completed as part of the TWC Baykeeper Program activities.															

CHAPTER 9 INFORMATION AND EDUCATION STRATEGY

9.1 Introduction

This Information and Education (IE) Strategy addresses the communication needs associated with implementing the Grand Traverse Bay Coastal Watershed Plan. The most valuable assets in protecting a watershed are the residents and tourists who live, work, and play within its boundaries. To achieve commitment to the vision laid out within this Watershed Management Plan there will need to be a concerted effort to organize, communicate, and educate community members around the shared vision of protecting water resources. Developing and carrying out a regional vision for stewardship of water resources will require the public and community leaders to become more knowledgeable about the issues and solutions, more engaged and active in implementing solutions, and committed to both individual and societal behavior changes.

The outreach strategy and tasks in this chapter are guided by Watershed Goal #5 in Table 57 in Chapter 7: Watershed Goals and Objectives – see excerpt below for specific watershed goal and its corresponding objectives.

Excerpt from Table 57: Goals and Objectives for the Grand Traverse Bay Coastal Watershed

Goal 5: Develop and maintain effective education and outreach efforts to support watershed protection.	
5.1	Maintain a working knowledge of current and emerging issues affecting the watershed.
5.2	Educate watershed users and the general public about the community value of the watershed and bay and of their responsibility to be stewards of this community asset.
5.3	Regularly inform the public about research, projects, and opportunities for contribution and/or collaboration (organization to public).
5.4	Provide focused information to residents, visitors, local governments, and other target groups on priority topics (organization to individual).
5.5	Involve citizens, public agencies, user groups and landowners in implementation of the watershed plan through meetings and workshops with individuals or groups.
5.6	Develop and maintain innovative programs to engage stakeholders in preventative and corrective actions that address current and emerging issues in the watershed.
5.7	Promote awareness and use of voluntary best management practices that prevent or reduce environmental and water quality degradation in riparian or other sensitive areas.

9.2 Stakeholder Input and Social Indicators Survey

A variety of means were used to assess stakeholder knowledge of watershed issues and concerns. These include:

- **Community Outreach Activities for Watershed Planning Grant:** Simple, unscientific assessments done in conjunction with the watershed planning grant associated with this management plan.
- **2007 Benchmark Survey:** Conducted by TWC and NMC Business Research Services to assess behaviors, attitudes, and values concerning watershed issues.
- **City of Traverse City Residential Survey – Kids Creek Outreach Project:** A scientific survey of Traverse City residents conducted in 2017 to evaluate citizen awareness levels of stormwater and other water quality issues and determine the general effectiveness of a recent advertising/education campaign.
- **Elk River Chain of Lakes (ERCOL) Social Indicators Survey:** A social indicators survey administered over the course of 2016-2017 by Tip of the Mitt Watershed Council to understand community member's and leader's stance on issues surrounding ERCOL watershed resources.

Community Outreach Activities for Watershed Planning Grant

During the process of developing this update to the Grand Traverse Bay Watershed Protection Plan, TWC held a series of meetings for both the public and governmental officials in summer 2018 where attendees were asked to share their thoughts and concerns for the watershed. Additionally, TWC created on an online community conversation form and invited the public to share their thoughts. This link was also emailed to employees and officials in every coastal municipality along Grand Traverse Bay. It should be noted that this process was 'unscientific' and gives only a general perception of those either in attendance at the meeting or choosing to fill out an online form. A summary of highlights from each of these meetings and online responses is in Appendix D. The top three comments and concerns heard are as follows:

1. There is general concern regarding rapid growth of the past decade; they are concerned that the increase in population (both overall population and summertime population), as well as real estate development are negatively impacting water quality, and thus quality of life.
2. There is concern over the impact of boating on the bay and inland lakes; this could reflect when the meetings were held, which was peak summer.
3. There is concern over Enbridge's Line 5, a 65-year-old pipeline carrying light crude oil and natural gas that runs underneath the Straits of Mackinac; may people reported this as a primary concern.

Through these meetings, TWC identified opportunities for public education on water-related topics, such as wetlands and their importance, impacts of sprawl and real estate development, boating rights and etiquette on the Great Lakes and inland lakes, and sharing information on statewide water issues such as Line 5 and Nestlé's water withdrawal permits.

2007 Benchmark Survey

TWC partnered with NMC Research Services to conduct a telephone survey in 2007 to assess behaviors, attitudes, and values concerning watershed issues (TWC 2007). Participants were asked about their recreational water usage and perceptions of the health of the watershed, willingness to support actions to maintain/improve water quality, and current behaviors related to water quality.

At the time, TWC planned to use the data to provide benchmark levels to measure change in attitudes and behaviors over time. However, after that survey was conducted EPA and EGLE came out with new guidance regarding social surveys that outlined a step-by-step system, called the Social Indicator Planning and Evaluation System (SIPES), for using social indicators to help plan, implement, and evaluate NPS outreach and education projects. The benefits of standard social monitoring protocols include better education and outreach components of watershed management plans, standardized protocols for social surveys across watersheds in Michigan, standardized assessments of the effectiveness of NPS outreach efforts, and comparability at the watershed, regional, and state scale. While data from this social survey did not use the standardized SIPES protocols and can therefore not be compared to future social surveys, the information collected is still useful to determine behaviors and thoughts of residents at that point in time.

As commonly noted in most surveys (scientific and nonscientific) done in the Grand Traverse Bay region, responses indicated that residents overwhelmingly view the watershed is important in contributing to the region’s environmental quality, economic health, and quality of life. More than half of the respondents also indicated the watershed held and important cultural value as well as an impact on their decision to live there. Among other things, the survey revealed that more than 3/4 of residents in the region use water for recreational activities, with Grand Traverse Bay as their most frequently used water body. The survey found that while more people thought the water quality at that time in the Grand Traverse Bay had worsened rather than improved, the bulk of respondents indicated they felt that was due to low water levels the region was experiencing at that time, as well as due to *E.coli* contamination at beaches.

State and local governments, along with individuals, were the top three responses for “who should take primary responsibility for protecting/preserving the quality of Grand Traverse Bay watershed.” Respondents also indicated some level of willingness to support the following actions: ordinance requiring buffer zones along bodies of water, ordnance to limit commercial or residential development, millage increase to fund watershed protection efforts, and voluntary contribution of time and money to local watershed groups.

City of Traverse City Residential Survey – Kids Creek Outreach Project

TWC conducted a mail survey in 2017 to 900 random households in the 49684 zip code in the City of Traverse City using a “five wave design” process that followed the SIPES procedures noted above (TWC 2017). At that time, TWC had completed a variety of restoration efforts in Kids Creek as part of our Kids Creek Restoration Project (discussed previously). TWC had also finished implementing an outreach campaign in the Grand Traverse Region focusing on general stormwater education and awareness, the issues related to Kids Creek, what is being done to restore Kids Creek, and what people can do to reduce their stormwater impact on the creek and the watershed. The campaign included radio, newspaper, and magazine advertising; digital and print signage in local hot spots; and posts on social media including Facebook and Twitter. This survey helped us evaluate citizens’ awareness levels of stormwater and other water quality issues and helped us determine the general effectiveness of the advertising/education campaign. Our goal was to evaluate the success of the education and outreach campaign, better understand the public’s general awareness of stormwater and water quality issues, and learn what subjects/areas should be addressed in future campaigns.

Upon reviewing the survey results, TWC staff gleaned five key insights:

1. **There is room for continued education on Kids Creek**
2. **Scenic beauty is an important factor when it comes to water resources -** When presented between various water-based activities, nearly a third of respondents (31.4%) said that scenic beauty is most important to them.
3. **There is a clear connection between quality of life and clean water -** 95.7% of respondents agreed or strongly agreed that the quality of life in their community depends on good water quality in local streams, rivers, and lakes. This presents an opportunity for TWC to build off that sentiment, as well as cultivate the existing appreciation of scenic beauty, to further engage residents in activities that improve water quality.
4. **Community appears ripe for a dedicated place to learn about environmentally friendly homeowner practices and see demonstrations -** 43.1% reported they do not know where to get information about practices they could undertake at home. Additionally, nearly half of respondents (44.7%) said that not being able to see a demonstration of the practice was limiting their ability to make a change.
5. **Opportunity to leverage trust -** The top three most-trusted sources in the community were The Watershed Center (“Local watershed project”), Michigan State University Extension (“University extension”) and City of Traverse City (“local government”).

Elk River Chain of Lakes (ERCOL) Social Indicators Survey Results

A social indicators survey was administered over the course of 2016-2017 by Tip of the Mitt Watershed Council in the ERCOL watershed to understand community members' and leaders' stance on issues surrounding watershed resources. Surveys of three distinct audiences within the watershed were conducted: Watershed Residents, Local Officials, and Shoreline Property Owners. In all three surveys, respondents believed the following:

- Quality of our water is "good"
- There are few watershed impairments
- Economic stability depends on good water quality
- Not okay to reduce water quality to promote economic development
- Quality of life in their community depends on good water quality.

A full summary and explanation of this social indicators study is found in Chapter 8.2 of the Elk River Chain of Lakes Watershed Plan (TOMWC and TWC 2020), and an excerpt of this chapter is included with this plan in Appendix D. Because of the ERCOL watershed's proximity to the rest of the Coastal Grand Traverse Bay watershed, results from this survey will be extrapolated to the watershed and will inform educational efforts for the coastal watershed as well. Based on the results from this survey, recommendations include:

1. General awareness education programs do not need to persuade residents or local leaders about the importance of good water quality, nor the relationship between water quality and economic development.
2. Education programs should focus on specific pollutant and source risks, especially invasive species, phosphorus, and sedimentation (dirt and soil) in the water.
3. Education programs targeting homeowners should concentrate on information, skills, and demonstrations of specific practices.
4. Septic system maintenance is an area ripe for education and outreach. Over half of watershed residents indicate that they have their systems pumped on a regular basis, but most also indicated that there no significant factors limited their ability to implement this practice. Specifically, respondents to the watershed residents survey did not see a need for septic system oversight by either the Health Department or local governments. However, shoreline property owners indicated the opposite and responded they would like a reminder to inspect and maintain their systems.
5. Knowledge of riparian buffer maintenance is lacking.
6. Focused attention is needed to increase awareness of watershed residents regarding newer practices such as rain gardens and porous pavement. Even though these techniques have been promoted and described in educational materials for some time, understanding and adoption rates of these practices is low.
7. Education programs for watershed residents and shoreline property owners should focus on newsletters/brochures/fact sheets, where most of them seek info about water quality issues.
8. Education programs for local officials should continue to focus on written materials and workshops/demonstrations/meetings.
9. Water quality education efforts for local officials should facilitate communication and coordination of water quality between neighboring communities.
10. To reduce barriers to adoption or revision of water quality-related plan or zoning ordinance changes, education efforts could emphasize public participation in exploring options and crafting new/changed regulations.

9.2 Target Audiences and Message Development

Target Audiences

Effective communication is the vehicle for education that can ultimately change attitudes leading toward better water quality protection efforts. Several diverse regional audiences have been identified as key targets for IE communication strategies. Descriptions are as follows:

- **Households –** The general public throughout the watershed.
- **Riparian Landowners –** Due to their proximity to a specific waterbody, communication strategies for riparian landowners should be more comprehensive.
- **Business and Industry –** There is a diverse mix of business and industry segments within the Coastal Grand Traverse Bay watershed, although fortunately very little traditional "smokestack" type industry is present. Tourism, agriculture, retail, and other service industries dominate the mix, with manufacturing and construction following.
- **Contractors, Developers, Realtors –** Members of the development industry segment play a crucial role in this growth and providing ongoing education opportunities about their role in protecting water quality and environmental health is critical.
- **Agriculture Industry–** Agriculture represents a significant economic segment within the Grand Traverse Bay watershed. Fruit orchards and vineyards dominate significant portions of the landscape and row crops such as potatoes and corn are also well represented.
- **Tourists –** Tourism is one of the largest industries in the Grand Traverse region. This area is known for its scenic beauty and recreational opportunities and it is estimated that the Grand Traverse region plays host to more than hundreds of thousands of visitors in any given year. This influx of people puts a noticeable strain on area infrastructure and often the environment. There is a growing concern that this important economic segment is possibly destroying the very reason why it exists, and that the region's tourism "carrying capacity" may soon be reached. Steering committee members and attendees at both public and government stakeholder meetings cited the need to "educate tourists about their role in protecting our environment."
- **Boaters:** Grand Traverse Bay and the many inland lakes and streams that make up its watershed see a lot of use from private motorized watercraft owned and operated by both full-time and seasonal residents, as well as tourists. Special messages targeted directly at this audience can help reduce the impact of motorized watercraft on the surface waters.
- **Anglers:** The watershed provides a wealth of angling opportunities and providing targeted communications to help limit the spread of invasive species, limit physical impacts to waterbodies and riparian zones, and bring anglers in as partners in conservation and restoration activities is needed.
- **Quiet Water Recreation Enthusiasts:** Kayaking, sailing, canoeing, wind surfing, paddle boarding, etc. These are just a few of the non-motorized types of activities that take place on in the watershed. This segment of enthusiasts should be targeted with communication strategies to help limit impact of these activities as well as to bring alongside partners for collaborative activities.

- **Educators:** Area educators and students from K-12 primary education to community colleges and local universities.
- **Local Government Officials –** There are a wide variety of village, city, township, and county officials that work within the watershed. These comprise both elected and appointed individuals including township, village, city, and county commissioners; planning commissions; zoning boards of appeals; road commissioners; drain commissioners; planners, managers, township supervisors; zoning administrators; etc.

A final target group for communication is the many different partner groups. The Grand Traverse Bay watershed region boasts an impressive list of watershed partner groups with a broad range of expertise and important ongoing protection, restoration, and education programs. Targeted messaging is not as important to this group as much as inter-communication and effective partnerships are.

Message Development

General messaging outlines have been established for each target audience described above (Table 61). These messages may be refined as implementation moves forward. They may also be modified or customized depending on the message vehicle. Some things to consider when developing and refining messaging components is that it is important to address the emotional connection needed to let people know why they should care, why the issue is relevant and should be important to them, that there are effective solutions, and what they can do about it. Additionally, many environmental threats such as loss of habitat and wetlands are viewed by the public as long-term issues and concerns surrounding them need to be communicated in a way that makes them more tangible. It may also be important to include a reality check on "real threats" for some target groups. For example, TWC has noted that many survey respondents indicated they think boaters are a top source of pollution to the watershed (for bacteria and other types of pollutants). However, TWC has conducted research and monitoring and has found that there is no evidence to support this.

Table 61: Messaging for Target Audiences

Target Audience	Messages
Households (general public)	• General watershed education: watershed awareness, key pollutant sources, how individual behaviors impact the watershed, etc. • Proper septic system maintenance • Establish a buffer of native plants between your lawn and the water to absorb pollutants from runoff, prevent shoreline erosion, and provide fish and wildlife habitat • To help reduce *E. coli* bacteria, do not feed waterfowl and put pet waste in the trash immediately • Put all litter, including cigarette butts, in trash • Do not dump motor oil, litter, or cigarettes in storm drains • Direct runoff from your property onto vegetated areas instead of onto your driveway or the street • Housekeeping practices and the disposal of toxic substances • Avoid using coal tar-based sealants to coat your driveway and parking areas and instead look for less toxic asphalt-based products for sealing surfaces • Check local government meeting agendas to stay up to date on decisions and policies that may affect your area • Properly dispose of medications
Riparian Landowners	• Riparian land management including the importance of riparian buffers • Water quality-friendly lawn and garden practices • Proper septic system maintenance • Housekeeping practices and the disposal of toxic substances • BMPs to reduce erosion and manage stormwater
Business and Industry	• General watershed education: watershed awareness, key pollutant sources, how individual behaviors impact the watershed, etc. • Using green infrastructure and other opportunities for stormwater management • Proper toxic chemical use, storage, and disposal • The leadership role area businesses can play in protecting the watershed • Water quality-friendly lawn practices
Contractors, Developers, Realtors	• Using green infrastructure and other opportunities for stormwater management • Alternatives to shoreline hardening and wetland development • Education regarding current regulations that affect development (Federal/state regulations, local ordinances) • Identification and protection of key habitats and natural features including riparian buffers, trees, wetlands, steep slopes, etc. • Advantages of and opportunities for open space protection and financial incentives for conservation • Impact of earthmoving activities, importance of soil erosion and sedimentation control practices, construction BMPs

Target Audience	Messages
Agriculture Industry	• The importance of establishing sound agricultural BMPs • Advantages of and opportunities for buffers and filter strips • Impacts of fertilizer/pesticide use and mitigation options • Effectively treat animal waste • Farmland conservation opportunities
Tourists	• Help us protect the beauty that you enjoy when you are a guest • Use designated restroom facilities • Put all litter (including cigarette butts and pet waste) in trash receptacles • Do not feed waterfowl • Stay on designated trails • Use clean boating practices • Clean, drain, and dry watercrafts, trailers, and other boating equipment before entering another waterbody
Boaters and Anglers	• Use designated restroom facilities • Clean, drain, and dry watercrafts, trailers, and other boating equipment before entering another waterbody • Properly dispose of bait • Never release fish, plants, or pets into another water body or storm drain • Respect no wake areas
Quiet Water Recreation Enthusiasts	• Clean, drain, and dry watercrafts, trailers, and other boating equipment before entering another waterbody • Put all litter (including cigarette butts and pet waste) in trash receptacles
Educators	• General watershed education: watershed awareness, key pollutant sources, how individual behaviors impact the watershed, etc. • Active participation in watershed protection activities and stewardship
Local Government Decision Makers	• The leadership role that local governments can play in protecting the watershed • Economic impact and advantages of environmental protection • The importance of establishing sound, enforceable natural resource protection ordinances • Enforce current laws • Strengthen local riparian buffer and septic ordinances • Incentivize homeowners who apply BMPs on their property • Reduce climate emissions • Use BMPs to reduce stormwater runoff on public property

Various forms of delivery mechanisms may be used for the messaging to target audiences described above. These include:

- Print media
- Social media
- Paid advertising (traditional and social)
- Community meeting or events
- Text networks
- Billboards
- Signage
- Lawn signs
- Flyers
- Newsletters or other educational literature

Additionally, the use of trainings and special meetings may be used for specific target audience like local government officials and developers.

9.4 Information and Education Outreach Implementation Tasks

A list of initial outreach tasks by category follows this narrative (Table 62). The table will be viewed as a working document with continual evaluation and addition of necessary outreach efforts as they are identified and prioritized.

Education and outreach implementation will be conducted using the general lesson planning principles of backwards design, a well-supported method for designing effective education lesson plans. This methodology is also being used in the ERCOL Watershed Management Plan's outreach strategy and is broken into three main components:

1. **Objective creation:** Each education and outreach implementation task, while fitting underneath Watershed Goal #5, should fall under at least one objective for the goal (see excerpt from Table 57 above). Each outreach task will most likely be more specific than the objective it falls under. Task objectives should be clear, measurable, and describe an actionable, behavioral, or physical outcome desired from participants of the outreach task.
2. **Evaluation method:** After creating an objective for the outreach task, a process or method of evaluating the achievement of that objective should be created. This could take the form of pre- and post-surveys, behavior or action monitoring, or personal interviews. Evaluation methods should directly evaluate the achievement of a specific objective.
3. **Education and outreach lesson/event plan**: After a clear outreach task objective and evaluation method have been outlined, the event or lesson or materials should then be created. The plan should be clear and concise and should allow for the carrying out of that outreach task.

Following these three steps to creating an education and outreach implementation plan will help increase the chance for a successful experience.

Several critical areas for the Coastal Grand Traverse Bay watershed have been identified and the plan for rolling out the IE Strategy will correspond to targeted audiences either using or residing in these critical areas (Table 55, Figures 31 and 32). Additionally, the IE Strategy will support implementation efforts to control the following pollutant sources as outlined in Chapter 8.5:

- Development
- Lack of Ordinances to Protect Water Quality and Natural Resources
- Lack of Riparian Buffer
- Reduction of Wetlands
- Road Stream Crossings
- Streambank and Shoreline Erosion
- Stormwater

Outreach tasks are divided into the same fourteen categories used to outline the implementation tasks in Chapter 8.5, with the addition of a general one for efforts that do not fit into designated categories. As with the implementation tasks in Chapter 8.5, each outreach task identifies the following that have previously been defined: watershed goal/objective addressed, priority level, potential milestones, estimated costs, potential partners, and timeline. In addition, each outreach task has an extra column added for the target audience it intends to reach (some tasks may reach multiple target audiences).

It should be noted that timelines for milestones for these tasks were harder to define because many of the tasks are ongoing. Additionally, the best way to conduct outreach activities is continually evolving and depends on the audience one is trying to reach. Therefore, as noted above, the outreach tasks in Table 62 may be revised in the future. The key messages for target audiences outlined previously in Table 61 will be used to develop future outreach tasks utilizing the general lesson planning principles of backwards design process described above.

Additionally, we would like to note that funding for many outreach activities is becoming more difficult to acquire, as well as more expensive. This is because funding agencies are more often requiring follow up surveys and documentation to show the outreach activity worked and changed behaviors; this in turn raises outreach costs significantly because expensive surveys may need to be performed. Also, many funding agencies are switching their funding priorities and focusing more on “on-the-ground” restoration activities which have more tangible and faster water quality results.

Table 62: Information and Education Outreach Implementation Tasks

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Target Audience*	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
General																	
IE-GEN-1	Produce and distribute summary version of Grand Traverse Bay Coastal Watershed Protection Plan.	5.1, 5.2	High	Funding-2021 Print/distribute-2022	$10K	TWC	ALL										
	Notes: Obtain funding-2021; Design publication, print, and begin distribution-2022; Copies will be kept on-hand and distributed when possible																
IE-GEN-2	Create interactive Grand Traverse Bay coastal watershed storymap and publish on TWC's website	5.1, 5.2	High	Funding-2022 Publish-2022	$15K	TWC	GEN										
	Notes: Obtain funding by 2022; Develop content and publish on website -2022																
IE-GEN-3	Establish and/or update educational signage and kiosks throughout the watershed at parks, demonstration projects, beaches, marinas, boat launches, etc. to display a variety of environmental messaging.	5.1, 5.2, 5.4	High	ID locations and secure funding-2025 Content-2026 Install-2028	$8K/sign Tot: $80K	TWC TOMWC LGOV CDs	GEN, TOUR, BOAT, ANG, QRC										
	Notes: Identify project partners, locations, and messaging-2023; Secure funding-2025; Develop content- 2026; Install at least 10 signs by 2028																
IE-GEN-4	Provide training to local citizens regarding environmental advocacy and the Clean Water Act.	5.1, 5.2, 5.6	Medium	One training/yr (10 total)	Staff: $2,000/yr Tot:$20K	TWC	GEN										
	Notes: This will be done as part of TWC's Grand Traverse Baykeeper Program. Initial training materials are currently being drafted (as of 2020). Trainings will start in 2021.																
IE-GEN-5	Develop educational videos in partnership with Nature Change about priority watershed issues. www.naturechange.org	5.1-5.3	Low	1 video every two years, 5 total	~$8k/vid Tot: $40k	ALL	GEN										
	Notes: Videos will be made by various project partners teaming together for specific themed videos. Timing for videos will vary, but the goal is to have 5 completed by the end of 2030 (one every two years). Each video project will have the following tasks: Identify project partners and messaging; Secure funding; Develop content; Produce and distribute videos																
Shoreline Protection and Restoration																	
IE-SPR-1	Provide riparian property owners with assistance, site visits, and resources as they relate to shoreline and streambank management.	5.4 - 5.7	High	10 assessments/yr Tot: 100	Staff: $10,000/yr Tot:$100K	TWC TOMWC CDs	RIP										
	Notes: This task will be conducted whenever possible and on an as-needed basis when requested. At least 10 site assessments/year.																

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Target Audience*	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
IE-SPR-2	Provide education to general public and policy makers on environmentally friendly shoreline management and stream bank protection (including water quality friendly lawn/garden practices, BMPs to reduce erosion and manage stormwater). Will include information for Great Lakes, inland lakes, and river shorelines.	5.3, 5.5-5.7	High	Develop-2023 Funding-2023 Materials-2024 Conduct outreach-2025-2030	$20K	TWC LGOV MSUE CDs	GEN, RIP, LGOV										
	Notes: Contact potential partners, develop program, identify and secure funding – 2023; Create materials – 2024; Conduct outreach activities – 2025-2030 *Existing publications will be used when possible, such as the "Shoreline Living" document from the Midwest Glacial Lakes Partnership or those done by the Michigan Natural Shoreline Partnership*																
IE-SPR-3	Conduct property owner outreach in conjunction with shoreline erosion projects noted in Implementation Task Table SPR-2, 4, and 5 (Table 60).	5.4 - 5.7	High	Gather materials-2021 Outreach starts-2022	$10K (printing)	TWC	RIP										
	Notes: Gather existing materials and/or develop new materials as needed – 2021; Begin distribution when meeting with landowners in noted Implementation tasks – 2022-2030																
IE-SPR-4	Promote better public understanding of cyclical nature of Great Lakes water levels and importance of natural shorelines along Great Lakes	5.3 - 5.7	High	Messaging-Winter 2021 Begin outreach-Spring 2012	Staff: $2,000/yr Tot:$4K	TWC MISG	GEN, RIP, BI, CDR, BOAT, ANG,QRC, LGOV										
	Notes: Develop messages beginning of 2021; Utilize digital methods (i.e. social media, press releases, e-newsletters) to disseminate messages starting in Spring 2021 and continuing through at least 2022.																
IE-SPR-5	Continue existing native landscaping education programs including workshops, demonstrations, and brochures	5.3 - 5.7	High	1 workshop/yr (10 total) Materials to 50 people/yr (500 people total)	Staff: $5,000/yr Tot:$50K	CDs ISN	GEN, RIP, BI, CDR, LGOV										
	Notes: Many partners currently have native landscaping education materials and programs that can be readily reused. This type of education should be done on an annual basis. Goal of 1 workshop/yr and distribute existing materials to at least 50 people/yr																
IE-SPR-6	Promote the Michigan Shoreland Stewards program (from the Michigan Natural Shoreline Partnership), distribute existing riparian and/or shoreline landowners' guidebooks (many of which are electronic). **Note – This task applies to "inland lake" property owners and not GTBay lakefront property owners.*	5.4 - 5.7	Medium	Printing funds-2023 Print and distribute start-2024	Staff: $5,000/yr Tot:$50K Reprint: $30,000	TWC TOMWC ISN CDs	RIP										
	Notes: In general, this task will be conducted whenever possible as partners talk to riparians through a variety of means. Funds will be sought to reprint existing materials (in hand by 2023 and reprinted in 2024); once new materials are available, they will be distributed when possible.																

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Target Audience*	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Stormwater Management																	
IE-SM-1	Produce brochure or other media for a 'self-guided' walking tour of Kids Creek BMPs installed as part of Kids Creek Restoration Project.	5.1, 5.3	High	ID Funding-2022 Draft docs-2023 Produce/distribute-2024	$5K	TWC Munson Hospital GTC GTCD	GEN										
	Notes: Identify funding source and obtain by 2022; Compile and draft documents by 2023; Produce/distribute in 2024																
IE-SM-2	Promote green infrastructure (GI) to watershed residents to increase stormwater awareness and implementation of onsite GI practices.	5.1, 5.3, 5.5-5.7	High	ID Funding-2022 Draft docs-2023 Produce/distribute-2025	$25K	TWC	GEN, RIP, BI, CDR										
	Notes: Develop program and secure funding by 2022, Develop materials in 2023; Distribution 2024-2025 (to a minimum of 5,000 watershed-wide residents)																
IE-SM-3	Provide stormwater education for local units of government that stresses the benefits of 1) Green infrastructure (GI), 2) reduced impervious surfaces, and 3) wetlands that provide temporary holding of stormwater	5.4, 5.7	High	ID Funding-2022 Draft docs-2023 Produce/distribute-2025	$15K	TWC	LGOV										
	Notes: Develop program and secure funding by 2022, Develop materials and/or presentations in 2023; Distribution 2024-2025 (to a minimum of 10 coastal government entities)																
IE-SM-4	Host workshops, lunch seminars, and site tours to educate contractors, developers, and realtors on proper stormwater and sediment management during new and retrofit developments.	5.4, 5.6, 5.7	Medium	ID Funding-2022 Draft docs-2023 Produce/distribute-2025	$10K	TWC	CDR										
	Notes: Develop program and secure funding by 2025, Develop materials and/or presentations in 2026; Host at least one workshop/lunch/tour a year – 2026-2030																
Transportation/Stream Crossings																	
IE-RSX-1	Host workshops for County Road Commissioners to provide education regarding possible BMPs to establish at road crossings to reduce the harmful effects of sedimentation and stormwater runoff	5.4, 5.7	Medium	Funding-2025 Develop materials-2026 Host workshops-2026-2030	$5,000	TWC CDs RCs CRA	LGOV										
	Notes: Develop program and secure funding by 2025, Develop materials and/or presentations in 2026; Host at least one workshop/lunch/tour a year – 2026-2030																

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Target Audience*	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Planning, Zoning, and Land Use																	
IE-PZL-1	Design and implement a grass-roots citizen action program that focuses on local land use advocacy, better understanding local decision making around water, and fosters and empowers passionate citizens to join local elected and appointed boards and commissions and other leadership roles	5.2, 5.3, 5.5	High	Design program-2021 Begin implementation and continue each year-2022	Staff: $5,000/yr Tot:$50K	TWC LGOV	ALL										
	Notes: This work will be conducted as part of TWC's Grand Traverse Baykeeper Program. The program will be designed in 2021 and implementation will begin immediately and continue annually.																
IE-PZL-2	Inform local planning and zoning officials regarding up-to-date information on planning, zoning, and design innovations relating to the protection of water quality. This will be done by tracking new projects being proposed/reviewed at local government meetings and providing comments regularly as appropriate. *Note: This task is similar to Implementation Tasks PZL-3 and PZL-10 from Table 60.*	5.4, 5.7	High	Ongoing	Staff: $10,000/yr Tot:$100K	TWC LGOV	LGOV										
	Notes: Because of the nature of this task, it will be completed on an as-needed, ongoing basis. TWC staff will review proposals from priority communities as they are presented at local government meetings for review to ensure it complies with local zoning and state/federal standards. Comments will be made during review period as appropriate/necessary. The task will be completed as part of the TWC Grand Traverse Baykeeper Program activities.																
IE-PZL-3	Develop and distribute information packet for local realtors that contains basic information regarding environmental laws (wetlands, beach maintenance, onsite wastewater treatment, etc.) that might impact new homeowners and the activities they can do to improve/protect water quality on their property.	5.4, 5.6, 5.7	Medium	Develop program/obtain funding-2022 Materials-2023 Distribute-2024	$15K	TWC TOMWC TAAR	CDR										
	Notes: Discuss/develop program with project partners and obtain funding-2022; Gather and/or draft/print new materials and compile packet-2023; Begin distribution-2024 (to at least 100 local realtors)																

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Target Audience*	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Land Protection and Management																	
IE-LPM-1	Provide landowner education regarding voluntary conservation easements and other land protection measures as they relate to protecting and maintaining water quality utilizing social media, email, phone, publications, etc.	5.4, 5.7	Medium		$50,000/yr Tot:$500K	GTRLC LC CDs	GEN, RIP										
	Notes: Local land conservancies have readily available materials and established outreach programs. This task will be to continue that work, which will be conducted on an annual basis.																
IE-SPR-2	Provide education to general public and policy makers on environmentally friendly shoreline management and stream bank protection (including water quality friendly lawn/garden practices, BMPs to reduce erosion and manage stormwater). *(See Shoreline Protection and Restoration task above for details)*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Notes:																
Habitat, Fish, and Wildlife																	
IE-HFW-1	Educate riparian landowners about importance of natural shoreline to promote healthy habitat for fish and wildlife *Can be done in conjunction with Tasks IE-SPR-1 and 2 above.*	5.4-5.7	High	Develop-2023 Funding-2023 Materials-2024 Conduct outreach-2025-2030	$20K	TWC LGOV CDs	RIP										
	Notes: Contact potential partners, develop program, identify and secure funding – 2023; Create materials – 2024; Conduct outreach activities – 2025-2030																
IE-HFW-2	Educate the public regarding Conservation Resource Alliance's Wild-Link/Wild Roots programs through 1) conducting tours on landowner properties enrolled in Wild-Link Program or Wild Roots Initiative and 2) Provide outreach through informational brochures/fliers to potential landowners regarding best management practices for specific land uses and/or maintenance of specific tree species.	5..3, 5.5-5.7	Low	Contact 15 landowners/year	N/A	CRA	GEN										
	Notes:																

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Target Audience*	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Recreation, Safety, and Human Health																	
IE-RSHH-1	Conduct "Healthy Beaches" educational campaign aimed at education re sound practices to follow to ensure local beaches stay heathy and open for recreation. Messages include: Don't feed waterfowl; Pick up pet waste; Don't litter *Note: This task should be in conjunction with local beach monitoring for harmful bacteria.*	5.2, 5.3, 5.7	High	Develop program-2022 Funding-2022 Begin program and continue yearly-2023	$50K/year Tot: $400K	TWC HDs LGOV	GEN, TOUR, BOAT,										
	Notes: Develop program and obtain funding by 2022 (program will consist of a mix of messages and methods including advertising, signage, and other TBD); Begin implementing program during summer months and continue annually-2023. Since the area receives so much tourism the Healthy Beaches messaging must be done annually to reach new visitors to the area. Long-term funding sources will be sought.																
IE-RSHH-2	Conduct "Clean Boating" campaign aimed at educating boaters and marina operators on environmentally friendly boating and fueling practices including avoiding fuel spills, preventing sewage and graywater discharges, and engine maintenance.	5.4-5.7	Medium	Develop program-2024 Funding-2025 Begin program and continue yearly-2030	$25,000	TWC DNR MISG USCG	BOAT										
	Notes: Develop program and materials by 2024; Obtain funding program by 2025; Begin outreach and continue through 2030.																
IE-RSHH-3	Distribute information on the proper disposal of hazardous waste and electronic devices and promote periodic drop off events hosted by counties.	5.3, 5.7	Medium	Ongoing	Staff: $500/yr Tot:$5K	TWC TOMWC	GEN										
	Notes: Each county in the watershed hosts multiple hazardous waste drop of events throughout the year. These events are well publicized and watershed partners will help counties promote these events through social media postings.																
Hydrology and Groundwater																	
IE-HG-1	Develop and implement outreach and education strategy targeting owners of priority small dams. Focus on ecosystem impacts, dam removal options, and available assistance.	5.4-5.7	Medium	Materials-2024 Engage-2025-28	$5,000	TWC TOMWC CRA CDs											
	Notes: Develop materials packet for distribution by 2024; Engage with at least 10 priority small dam owners by 2028.																

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Target Audience*	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Monitoring																	
IE-MON-1	Conduct follow-up public attitude survey periodically to determine and monitor the public's awareness regarding watershed and water quality issues.	5.1, 5.2	High	Funding-2024,2029 Survey-2025,2030 Report-2026,2031	$25K/ea Tot: $50K		ALL										
	Notes: Plan to conduct follow up surveys in 2025 and 2030; For each survey steps will be to obtain funding (yr1), develop survey protocol (yr2), conduct survey (yr2, 2025 and 2030), and summarize results into report (yr3).																
IE-MON-2	Continue hosting annual "Freshwater Summit" for regional stakeholders to address priority issues impacting water quality, review implementation efforts and accomplishments, share resources, etc	5.1, 5.2	High	Ongoing See Notes	$5K/yr Tot: $50K	TWC GTCD NMC MISG ISEA	ALL										
	Notes: This task will be conducted annually. Timeline each year for planning as follows – May-August: Decide on topics for presentations, Begin contacting potential presenters; Reserve event venue – September: Finalize agenda, Begin advertising event – October: Begin registration for event; Finalize details with event center; Conduct event; November-December: Summarize event evaluations and report to partners																
IE-MON-3	Provide monitoring results to public to help them better understand results and make them aware of projects. Methods used include social media, eNews,	5.1, 5.2	Medium	Ongoing, See Notes	Staff: $1,000/yr Tot:$10K	TWC TOMWC CDs CRA	ALL										
	Notes: This task will be conducted on an as needed, ongoing basis as monitoring results are obtained and evaluated. Each entity completing monitoring activities will be responsible for disseminating their results if they would like. Costs for dissemination are minimal as most methods will be through electronic distribution.																
Wetlands																	
IE-WET-1	Educate local governments, developers, contractors, and others regarding the ecological consequences of developing unregulated wetland areas, especially in headwater/recharge areas and along the Grand Traverse Bay shoreline. Outreach methods include workshops, presentations, press releases, and brochures.	5.4-5.7	High	Funding-2023 Develop material-2024 Outreach-2025-30	$10K	TWC MISG LGOV TOMWC	LGOV CDR RIP										
	Notes: Develop program and secure funding by 2023, Develop materials and presentations by 2024; Begin outreach 2025 and continue through 2030. At least one workshop/yr; Three press releases/yr; One presentation/yr																

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Target Audience*	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
IE-WET-2	Provide education to Great Lakes shoreline owners about the value and proper care of emergent coastal wetlands. Outreach methods include dissemination of existing brochures, mailing letters, hosting 'town hall' discussions	5.4-5.7	Medium	Funding-2023 Develop material-2024 Outreach-2025	$20K	TWC TOMWC MISG	RIP										
	Notes: Develop program and secure funding by 2023, Develop materials by 2024; Conduct outreach 2025. Brochures/letters mailed to at least 1,000 property owners, At least three town hall discussions (in Leelanau, Grand Traverse, and Antrim counties)																
IE-WET-3	Establish educational signage at restored or established wetlands.	5.2	High	ID locations-2023 Funding-2025 Content-2026 Install-2028	$8k/sign Tot:$40K	TWC TOMWC LGOV CDs											
	Notes: Identify project partners, locations, and messaging-2023; Secure funding-2025; Develop content- 2026; Install at least 5 signs by 2028																
Invasive Species																	
IE-IS-1	Raise awareness of crowd-sourced citizen science invasive species reporting efforts (MISIN)	5.3, 5.7	Medium	Develop program-2024 Implementation-2025-30	Staff: $2,000/yr Tot:$14K	ISN CAKE	GEN, RIP, BOAT, ANG, QRC										
	Notes: Develop program-2024; Begin implementation 2025 and continue through 2030 Outreach will consist of regular public outreach on social media (4x/yr) and at least one training event each year																
IE-IS-2	Work with local governments and businesses to install Clean Drain Dry/Clean Boats Clean Waters signage at all launch sites	5.4, 5.6	Medium	ID locations and secure funding-2025 Content-2026 Install-2028	$1K/site Tot:$10K	ISN CAKE TWC	LGOV										
	Notes: Identify locations and secure funding by 2025; Develop content- 2026; Install at least 10 signs by 2028																
IE-IS-3	Host training sessions with Antrim County Road Commission staff and crew training on invasive plant identification and appropriate mowing practices to reduce the inadvertent spreading of invasive species along roadways.	5.4-5.7	Medium	One session/yr (10 total)	Staff: $2,000/yr Tot:$20K	CAKE	LGOV										
	Notes: Staff needs - 2 hours of meetings and annual training sessions/yr, plus 2-3 hours for coordinator preparation and scheduling																

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Target Audience*	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
IE-IS-4	Provide property owners with assistance and resources with invasive species management through site assessments, distribution of resources, and other outreach.	5.4-5.7	High	5 assessments/yr (50 total) 1 article/yr (10 total)	Staff: $5,000/yr Tot:$50K	ISN CAKE	GEN RIP LGOV										
	Notes: This task will be conducted on an as needed basis and partners are planning on doing at least 5 site assessments each year. Project partners will each year's article will focus on, articles will be disseminated by e-newsletters or other digital means.																
IE-IS-5	Conduct volunteer-based boater education program through Clean Boats, Clean Waters and MI Paddle Stewards program.	5.4-5.7	Medium	Recruit volunteers-2024 Training-2025 Outreach-2025-30	Staff: $2,000/yr Tot:$14K	TWC TOMWC GTCD ACD MSUE EGLE	BOAT ANG QRC										
	Notes: Develop program and recruit volunteers-2024; Host training and conduct boater outreach at popular launches-2025-30																
Agriculture																	
IE-AG-1	Educate farmers on best management practices for manure management (properly designed and maintained storage facilities; application methods) and nutrient management (routine soil and plant tissue testing; basing nutrient applications test results and specific crop nutrient removal rates).	5.4-5.7	High	ID and work with at least 1 farm/yr with problem to be addressed	Staff: $2,000/yr Tot:$20K	NRCS CDs	AG										
	Notes: Outreach to farms in the region is done on a continual basis as part of NRCS and Conservation District staff. They often refer farms to each other depending on the issues to be addressed. Outreach costs to farms is minimal as materials are produced and distributed on a statewide scale.																
IE-AG-2	Promote the volunteer Michigan Agriculture Environmental Assurance Program (MAEAP) that reduces pollutants from agricultural practices and work to get new farms verified. *Note: This task should be in conjunction with regular Implementation Task AG-1, costs for verifications are included there.*	5.4-5.7	High	ID 10 new farms/yr to work with to get MAEAP verifications in NWMI	Local Staff: $2,000/yr Tot:$20K	NRCS GTCD	AG										
	Notes: Costs here are minimal as outreach for MAEAP is a statewide effort – they send out postcards, newsletters, etc. to growers around MI. Statewide partners for general outreach for MAEAP include Michigan Farm Bureau; Peterson's Processing; MSU, NRCS																

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Target Audience*	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
Wastewater and Septics																	
IE-WW-1	Conduct "Septic System" outreach campaign aimed at education re proper septic design and maintenance, alternative systems when traditional septics are not optimal, and the benefits of various types of septic ordinances.	5.3, 5.5-5.7		ID partners and program-2022 Funding-2022 Develop materials-2023 Begin program and continue yearly-2024	$50K/year starting 2023 Tot: $400K	TWC TOMWC HDs LGOV MSUE	GEN RIP LGOV										
	Notes: Identify project partners, develop program, and obtain long-term funding by 2022; Develop outreach materials-2023 (program will consist of a mix of messages and methods including advertising, mailings, free septic inspections or discounts, and other TBD); Begin implementing program continue annually starting in 2024. *Long-term funding sources will be sought.*																
Emerging Issues																	
IE-EI-1	Foster greater understanding of the cyclical nature of Great Lakes water levels and the need for coastal resilient planning at the parcel and community-level. Messaging includes changing lake levels, climate change impact; natural erosion; advocating for better research and development of natural shoreline techniques on high energy sites. Outreach methods include workshops, presentations, press releases, and brochures.	5.1, 5.2, 5.3	High	*This task has already begun	$25K	TWC MISG	GEN RIP LGOV BOAT ANG QRC										
	Notes: As of 2020 Grand Traverse Bay is experiencing high water levels, this task will be imperative to accomplish in the near term and will start immediately in 2020. If high lake levels persist, this task may need to be repeated in later years. *Individual tasks include: Develop program, Identify project partners, Obtain necessary funding, and Conduct outreach program-2020-2022*																

Task #	Implementation Task	Goal/Obj.	Priority	Milestones	Costs	Partners	Target Audience*	Y1: 2021	Y2: 2022	Y3: 2023	Y4: 2024	Y5: 2025	Y6: 2026	Y7: 2027	Y8: 2028	Y9: 2029	Y10: 2030
IE-EI-2	Provide education to public re the hazards of coal tar-based sealants and suggest the use of less toxic asphalt-based products for sealing surfaces. This will be done in conjunction with Implementation Task PZL-9 which involves the adoption of ordinances to ban the use of coal tar sealants (Table 60). Education activities will be done in conjunction with the entity considering the ordinance and may include advertisements and inserts in monthly bills.	5.4-5.7	Low	Choose communities-2026 Funding-2027 Develop policies-2029 Adoption-2030	$25K (with Table 60)	LGOV CD TWC	GEN BI LGOV										
	Notes: Choose communities to work with (at least 3) by 2026; Obtain funding by 2027; Develop policies for adoption (and conduct outreach activities) by 2029; Adopted by 2030																
IE-EI-3	Develop and execute a microplastics educational campaign that targets local businesses, municipalities and townships, and citizens	5.3, 5.5-5.7	Low	Develop-2026 Funding-2027 Outreach-2028	$15K	TWC ISEA MISG	GEN										
	Notes: Develop program-2026; Obtain funding-2027; Conduct outreach TBD-2028																

Target Audiences Include: General Households (GEN); Riparian Landowners (RIP), Business and Industry (BI); Contractors, Developers, Realtors (CDR); Agriculture Industry (AG); Tourists (TOUR); Boaters (BOAT); Anglers (ANG); Quiet water recreation enthusiasts (QRC); Educators (ED); and Local Government Officials (LGOV)

CHAPTER 10 EVALUATION

10.1 Introduction

An evaluation strategy will be utilized to measure progress during the Grand Traverse Bay Coastal Watershed Protection Plan's implementation phase and to determine whether or not water quality is improving. The timeline for the evaluation is approximately every 5 years, with ongoing evaluation efforts completed as necessary. The first aspect of the evaluation strategy measures how well the watershed plan is being implemented and whether or not project milestones are being met. The second aspect will evaluate water quality protection efforts. The following sections address each of these issues.

10.2 Evaluating Completion of Implementation Tasks

An evaluation strategy for plan implementation will be used to determine progress in completing the recommended actions and tasks identified in the plan. The evaluation will be ongoing and will be conducted through the existing Steering Committee. The Steering Committee will meet once a year (virtually or in-person) to assess progress on plan implementation and to learn and share information about existing projects throughout the watershed. In addition, plan tasks, priorities, and milestones will be assessed every 5 years to ensure that the plan remains current and relevant to the region and that implementation is proceeding as scheduled and is moving in the right direction.

The evaluation will be conducted by analyzing the existing watershed management plan goals and objectives, as well as the implementation tasks and 'milestones' in Sections 8.5 and 9.4 to determine progress. The proposed timeline for each task will also be reviewed to determine if it is on schedule. Other anecdotal evidence (not attached to specific plan milestones) also will be noted that indicates the protection plan is being successfully implemented, such as an increase in the amount of updated or new zoning ordinances that deal with water quality and natural resource protections in watershed townships and municipalities.

Evaluating the tasks and milestones accomplished is also known as evaluating "non-environmental monitoring parameters." Many examples of these non-environmental monitoring parameters to track are found in the Milestone column in Table 60. Examples include:

- Complete stabilization of 5 eroding Great Lakes shorelines by 2030 (Task SPR-5)
- Install 10 green infrastructure or other stormwater BMPs in coastline communities by 2030 (Task SM-1)
- Completion of 10 severe road stream crossing sites by 2030 (Task RSX-2)
- Acquire conservation easements or other permanent protection for at least four priority parcels for conservation by 2030. (Task LPM-2)

Additionally, a number of other evaluation tasks will be completed due to the variety of tasks involved in the watershed plan. They will include but are not limited to the following:

- Document the effectiveness of BMP implementation by taking photographs, completing site data sheets and gathering physical, chemical and/or biological site data. Work with

partners to develop a standardized methodology implementation (see proposed comprehensive monitoring program outlined in Section 9.4).
- Use focus groups to evaluate specific projects throughout plan implementation as needed.
- Conduct targeted surveys of project partners by direct mail, phone or by website to assist in information gathering.
- Maintain a current list of future target projects, the status of ongoing projects, and completed projects, along with their accomplishments. Keep track of the number of grants received and the dollars committed in the watershed region to implement aspects of the plan.

The purpose of the evaluation strategy is to provide a mechanism to the Steering Committee to keep track how well the plan is being implemented and what can be done to improve the implementation process. Additional development of the strategy will occur as the implementation phase unwinds.

10.3 Effectiveness of Outreach Efforts

Chapter 9 outlines an Information and Education Strategy (outreach strategy) that addresses the communication needs in the watershed. The strategy is important because developing and carrying out a regional vision for stewardship of the region's water resources will require the public and community leaders to become more knowledgeable about the issues and solutions, more engaged and active in implementing solutions and committed to both individual and societal behavior changes. Residents, local officials, riparian landowner, and others must be educated and motivated to adopt behaviors and implement practices that result in water quality improvements.

In this respect, it is important to measure and keep track of the social impacts of the Grand Traverse Bay Coastal Watershed Protection Plan. While implementing an outreach strategy, project leaders must find out what types of outreach are working in their communities and what types aren't, along with how people's attitudes and behaviors are impacted. And, just how much is social behavior changing because of the plan implementation? To answer this question, social impacts must be included when evaluating the progress of plan implementation.

Key social evaluation techniques that will be used to assess the implementation of the IE Strategy, as well as other watershed BMPs, include:
- Continued cooperation between area organizations submitting proposals to implement aspects of protection plan
- Social surveys (and follow up surveys) for homeowners, local officials, students, farmers, etc. to determine watershed and water quality awareness
- Determining any increases in 'watershed friendly' design and construction (anecdotal)
- Increased awareness (from both the general public and local government officials) regarding stormwater management and available techniques
- Increase in the number of communities implementing stormwater ordinances
- Determine number of environmental efforts/projects in the watershed and how many organizations are currently working to protect water quality in the area. Maintain a list of ongoing projects and completed projects, along with their accomplishments. (This task is also found in next section relating to evaluating the water quality improvements.)

10.4 Evaluating Effectiveness in Improving and Maintaining Water Quality

It is essential to the success of this watershed planning effort that water quality in Grand Traverse Bay and its coastal tributaries be maintained and improved in critical areas. There must be no deterioration in the quality of the water throughout the watershed.

The EPA dictates that watershed management plans must outline a set of criteria to determine whether proposed load reductions in the watershed are being achieved over time and that substantial progress is being made towards attaining water quality standards. In the case of the Grand Traverse Bay Coastal watershed, overall water quality is good (Section 3.9) with some pollutant threats and specific areas of contamination; therefore no overall watershed goals were made regarding load reductions. Most watershed goals outlined in Chapter 7 seek to maintain or improve the current state of water quality and habitat, as well as increase awareness of this valuable resource.

Evaluating the effectiveness of improving and maintaining water quality throughout the watershed will be assessed through the results of monitoring efforts relative to established criteria and existing conditions. In order to accurately assess the state of waters within Grand Traverse Bay and its coastal tributaries, it is necessary to implement efficient water quality monitoring programs and coordinate efforts. Success will be evaluated by comparing monitoring results to water quality standards/criteria as well as existing conditions outlined in Chapter 3.9. Parameters monitored and monitoring locations will be driven by the monitoring programs identified previously in Chapter 3.9 and in the proposed comprehensive monitoring program outlined below.

Criteria for Effective Water Quality Protection

A set of criteria were developed using existing water quality standards/criteria as well as existing conditions outlined in Chapter 3.9, to determine if water quality is being maintained or improved in Grand Traverse Bay and its coastal tributaries. Detailed criteria that will be used to determine whether these metrics are being achieved include:

1. No statistically significant increases in bay-wide averages of Phosphorus or Nitrogen concentrations in Grand Traverse Bay (TP average 5 ug/L; Nitrate-N 0.23 mg/L)
2. Total Phosphorus concentrations in Coastal Grand Traverse Bay tributaries remain below EPA Sub-ecoregion threshold levels 0.015 mg/L. Of monitored tributaries, currently five are above: Northport, Ennis, Mitchell, Baker, and Yuba creeks, as well as mouth of Boardman River.
3. Nitrogen concentrations in coastal Grand Traverse Bay tributaries remain below EPA Sub-ecoregion threshold levels (TN 0.71 mg/L; TKN 0.65 mg/L).
4. Monitoring results that indicate no harmful changes to water quality or biological indicators measured throughout the watershed.
5. Documented decrease (or no statistically significant change) in the areal extent or number of macrophyte weed beds in Grand Traverse Bay.
6. Dissolved oxygen levels in all waterbodies remain above 7 parts per million.
7. Reduce nutrient inputs from stormwater in urban areas. The EPA's Spreadsheet Tool for Estimating Pollutant Loads will be used to determine the reduction in nutrient (TP and TN) inputs from stormwater reduction BMPs implemented.

8. Maintain or reduce sediment loads in tributaries and stormwater draining into Grand Traverse Bay. The EPA's Spreadsheet Tool for Estimating Pollutant Loads or other similar models will be used to determine the reduction in sediment inputs from BMPs implemented.
9. Water temperatures are maintained at a level to support coldwater species during the summer in coastal tributaries designated as trout streams.
10. No *E. coli* levels exceeding Michigan water quality standards for both single day measurement (>300 *E. coli* per 100mL of water) and 30-day geometric mean measurement (>130 *E. coli* per 100mL of water in five samples over 30 days) at Grand Traverse Bay beaches and coastal tributaries.
11. Reduce *E. coli* concentrations in Mitchell and Northport creeks to the point where they can be removed from Impaired Waters List per EGLE regulations.
12. Reduce *E. coli* concentrations by 50% in stormdrains in Traverse City.
13. Maintain low conductivity levels in coastal Grand Traverse Bay tributaries (150 - 500 μmhos/cm, or 0.15 mS/cm – 0.5 mS/cm)
14. Maintain or improve aquatic macroinvertebrate community diversity in streams that have been monitored and expand monitoring efforts to document and assess aquatic macroinvertebrate diversity in other streams throughout the watershed.
15. Fish populations represent healthy and diverse fish communities that meet local management objectives for the DNR.

As discussed in Section 4.2, a statewide *E. coli* TMDL was approved by the EPA in 2019 that provides a general legal framework for reducing pollutant loads in areas identified throughout the state where there is a bacterial impairment from *E. coli*. The goal of the Statewide *E. coli* TMDL is to meet the *E. coli* WQS as well as the total and partial body contact designated uses in each water body. Therefore, the numeric targets for all potential sources are equal to the total body and partial body contact WQS. More information on the statewide E. coli TMDL can be found at www.mi.gov/ecolitmdl. This plan will address nonpoint source contributions to bacterial impairments listed for the three creeks in the Grand Traverse Bay Coastal Watershed (Table 40) and follow recommendations in the statewide TMDL (pertaining to metrics #10 and #11 above).

Water Quality Monitoring Plan

Monitoring is essential to evaluate effectiveness of the collective watershed efforts or individual actions, assess baseline conditions to better understand change, and identify new threats. Meeting the metrics for the evaluation strategy described above to determine any water quality improvements from implementing this watershed plan hinges upon continued and expanded monitoring in Grand Traverse Bay and its coastal tributaries.

It is important for all future monitoring to have consistently sampled parameters, especially when measuring nutrients like nitrogen and phosphorus. The water quality summary in Chapter 3.9 shows a wide variety of nitrogen and phosphorus parameters measured and reported in various units using various methods. To consistently compare sample results and track any changes or trends, it is important for the same parameters to be measured consistently in the watershed. Additionally, it is important that all monitoring programs follow appropriate and similar

Standard Operating Procedures (SOPs), protocols, quality assurance project plans (QAPP), and control measures when collecting, analyzing, and interpreting samples.

TWC drafted a comprehensive monitoring plan for Grand Traverse Bay and its coastal tributaries that includes parameters and locations that should be monitored as part of ongoing monitoring programs or proposed new ones (Tables 63 and 64). The monitoring plan includes a variety of water quality parameters, as well as bacteria (*E. coli*), aquatic insects (benthic macroinvertebrates), and fish parameters such as population dynamics, abundance, mortality, recruitment and movement. Table 63 shows the monitoring plan for Grand Traverse Bay and Table 64 shows the plan for the coastal tributaries.

TWC will continue their annual volunteer monitoring program (Adopt-a-Stream) in the watershed following Michigan MiCorps Program procedures that utilize volunteers to sample and identify macroinvertebrates in streams twice a year. These surveys are volunteer-driven and not as in-depth as the P51 survey procedures EGLE uses to assess macroinvertebrates for their five-year cycle monitoring, but they do produce valuable data that can indicate general information on stream health. EGLE will also continue benthic macroinvertebrate monitoring at requested sites using their P51 method as part of their five-year cycle monitoring (next one scheduled for 2023) as well as their annual trend-monitoring in Grand Traverse Bay.

Weekly beach monitoring of Great Lakes beaches during summer months will also continue as a partnership between TWC, Grand Traverse County Health Department, Benzie-Leelanau Health Department, and Health Department of Northwest Michigan. Water samples are tested for *E. coli* once a week during the swimming season (typically from Memorial Day to Labor Day) at various public beaches. Results are entered into EGLE's BeachGuard database (http://www.deq.state.mi.us/beach/). Currently, there are 17 Great Lakes beaches that are monitored along Grand Traverse Bay in Leelanau, Grand Traverse, and Antrim counties.

Table 63: Monitoring Plan for Grand Traverse Bay

Parameters	Organization	Monitoring Plan (if known)
Nutrients – Phosphorus and Nitrogen	EGLE	Grand Traverse Bay Trend Monitoring – 4 stations, 3x/yr Nutrient parameters include TP, ortho-P, TKN, NH3, NOx (See Table 20 in Chapter 3.9 for more details)
Other Parameters	EGLE	Grand Traverse Bay Trend Monitoring – 4 stations, 3x/yr Other parameters include chlorophyll a, pH, turbidity, DO, alkalinity, hardness, SC, TSS, TDS, TOC, calcium, magnesium, potassium, sodium, chloride, sulfate, lead, chromium, copper and mercury (See Table 20 in Chapter 3.9 for more details)
E. coli	TWC, Local Health Depts.	Continue monitoring the following beaches and add new ones as necessary: 1. Northport Beach 2. Suttons Bay Beach 3. Suttons Bay Marina Park Beach 4. Greilickville Harbor Park 5. West End Beach 6. Volleyball Beach 7. Clinch Park 8. Senior Beach 9. Sunset Park 10. Bryant Park 11. East Bay Park 12. Traverse City State Park 13. Acme Bayside Park 14. Sayler Park 15. Elk Rapids Veterans Memorial Park 16. Elk Rapids North Beach 17. Barnes Park
Various Fish Parameters	DNR - Charlevoix Fisheries Research Station	Population dynamics of native fish and aquatic invasive species on northern Lake Michigan reefs Frequency: Annually, March - November Locations: Nearshore reefs at Elk Rapids, Charlevoix, Harbor Springs Analysis: Diving, adult fish collections, egg and juvenile collections for native species (lake trout, lake whitefish, cisco, smallmouth bass) and invasive species (rusty crayfish, round goby) Partners: Central Michigan University, The Nature Conservancy
		Cisco and lake whitefish movement in Grand Traverse Bay Frequency: Annually, January - December Locations: Grand Traverse Bay Analysis: Fixed acoustic telemetry receivers placed throughout bay and in connecting waters; signals from tagged fish passing receiver location are recorded and regularly downloaded; species currently tagged include cisco and lake whitefish,smallmouth bass and others to be added Partners: U.S. Geological Survey, Great Lakes Acoustic Telemetry Observation System (GLATOS)
		Smallmouth bass abundance, mortality, and movement Frequency: Annually, May - August Locations: Acme, Charlevoix, Beaver Island, Waugoschance Point Analysis: Trap nets used to collect and jaw-tag adult smallmouth bass; tag returns collected in surveys and from anglers Partners: Central Michigan University

Parameters	Organization	Monitoring Plan (if known)
		Juvenile lake whitefish and cisco recruitment survey Frequency: Annually, April - June Locations: Various sites in northern Lake Michigan, including Elk Rapids Analysis: Seining and trawling at nearshore sites; abundance and growth of age-0 and age-1 cisco and lake whitefish, as well as incidental species
		Lakewide spring adult fish assessment Frequency: Annually, April - June Locations: Lakewide (St. Joseph to Petoskey), including Elk Rapids Analysis: Gill net assessment of adult fish populations (relative abundance, age and growth, diet, health); focal species lake trout, lake whitefish, yellow perch Partners: Other Lake Michigan resource agencies (similar assessment conducted concurrently throughout lake)
		Lakewide forage fish assessment Frequency: Annually, August - September Locations: Lakewide (St. Joseph to Petoskey), including Elk Rapids and Grand Traverse Bay Analysis: Hydroacoustic assessment of forage fish populations (relative abundance, age and growth); focal species alewife, bloater chub, rainbow smelt Partners: Other Lake Michigan resource agencies
		Lakewide creel and charter boat surveys Frequency: Annually, April – October, winter/ice fishing surveys in some locations including Grand Traverse Bay Locations: Lakewide (St. Joseph to Petoskey), including Elk Rapids and Grand Traverse Bay Analysis: MDNR creel clerks interview anglers at Great Lakes ports to measure fishing effort and harvest of all species; MDNR charter boat program collects and compiles mandatory reports of fishing effort and harvest from charter boat operations

Table 64: Monitoring Plan for Coastal Tributaries

Parameters	Organization	Monitoring Plan (if known)
Aquatic Insects	EGLE	Every 5 years, various locations from Table 21 in Chapter 3.9 including Northport, Leo, Mitchell, Baker, Acme, and Yuba creeks.
	TWC	Adopt-A Stream: Currently 8 coastal creeks are included in the monitoring program: Acme, Baker, Brewery, Cedar, Leo, Mitchell, Water Wheel, Weaver, and Yuba creeks. TWC has plans to add at least two more sites to this list in the next 5 years. Sites are monitored twice/year for macroinvertebrate diversity and abundance (down to Order, i.e. Trichoptera, Ephemeroptera) and are rated as either Excellent, Good, Fair, or Poor. See website for specific locations (http://www.gtbay.org/our-programs/adopt-a-stream/).
Nutrients – Phosphorus and Nitrogen	Leelanau Conservancy	Parameters: NH3, NOx, TKN, TP Frequency: Varies on yearly basis. Locations: Northport, Ennis, Belanger, Leo, Cedar/Hines creeks
Nutrients – Phosphorus and Nitrogen AND Other Parameters (DO, Conductivity, Temperature)	TBD	**ADD TO MONITORING PROGRAM:** Parameters (at a minimum): TP, TN, DO, Conductivity, Temperature Frequency: Spring and Fall, yearly Locations (at least 2/creek): *Leelanau County – 12 tributaries* Northport Creek, Ennis Creek, Weaver Creek, Belanger Creek, Waterwheel Creek, Leo Creek, Lee Creek, Brewery Creek, Cedar/Hines Creek, and three unnamed tributaries to GT Bay: North of Ingalls Bay along Shady Trails Rd Near Jacobson/Setterbo Roads Along M204 in Suttons Bay *GT County – 3 tributaries* Mitchell Creek, Baker Creek, Acme Creek *Antrim County – 8 tributaries* Yuba Creek, Paradine-McGuire Creek, Mitchell Creek, Creswell Creek (north and south), Guyer Creek, Antrim Creek, and one unnamed tributary north of Banks Twp Park **Cost estimated at: $25,000/annually** *Analysis estimate - $17,600* *(22 creeks x 2sites/creek x 2 trips/yr x ~$200 analysis/trip)* *Staff estimate – 75hrs/yr x $50/hr = $3750; Mileage - $1,000* **Note – Leelanau Conservancy samples some of the sites in Leelanau County for some of the suggested parameters. The list here is all inclusive of sites that should be tested*
Fish Parameters in Coastal Tribs	DNR	Parameters: Backpack electrofishing surveys (population, size, etc.) Frequency: Once in 2020, will compare to 2012 survey results Locations: Acme, Mitchell, Tobeco, Yuba creeks

CHAPTER 11 CONCLUSIONS AND NEXT STEPS

11.1 Conclusions

The original Grand Traverse Bay Watershed Protection Plan has proven to be highly successful, with many organizations utilizing it to shape their restoration activities over the past 15 years. In fact, TWC has been steadily working to implement key recommendations from the plan since it was initially drafted in 2003 and has received more than $10 million in funding to implement key portions of the plan that annually prevent 1,726 tons of sediment, 1,482 pounds of phosphorus, and 4,604 pounds of nitrogen from entering Grand Traverse Bay and its watershed. Watershed plans have been approved recently for the two largest subwatersheds in the Grand Traverse Bay Watershed: the Elk River Chain of Lakes (ERCOL) and the Boardman River. Together these plans account for nearly 81% (786 mi^2) of the land area in the Grand Traverse Bay watershed. The plans provide greater detail on issues specific to each watershed, as well as detailed recommendations for watershed protection efforts. The plan presented in this document focuses on the remaining, smaller drainage areas of the Grand Traverse Bay watershed, with a specific focus on protecting water quality in Grand Traverse Bay. It includes the coastal subwatershed areas of Mitchell, Tobeco, Acme, and Yuba creeks, as well as areas along east and west Grand Traverse Bay and Old Mission Peninsula, totaling almost 190 mi^2. This area is referred to as the Grand Traverse Bay Coastal Watershed.

There are five waterbodies in the overall Grand Traverse Bay Watershed that are classified as 'impaired', two of which are in the Coastal Grand Traverse Bay watershed. Coincidentally, both are named Mitchell Creek – one in Grand Traverse County and the other in Antrim County. Additionally, Northport Creek in Leelanau County is also listed as impaired. All are impaired due to elevated *E.coli* levels and are not meeting their total body contact designated use (Table 40).

At-risk designated uses were also identified to protect in order to maintain water quality throughout the Grand Traverse Bay and its coastal watershed. These are the Coldwater Fishery; Other Indigenous Aquatic Life; Total Body Contact; and Public Water Supply at point of intake (for Traverse City municipal intake on East Bay only).

The top four pollutants affecting the at-risk designated uses in the coastal watershed area are (in alphabetical order): changes to hydrological flow; loss of habitat; nutrients; and sediment. The Steering Committee also identified two priority environmental stressors to Grand Traverse Bay itself – invasive species and toxic substances (including emerging contaminants). Other issues that may affect the at-risk designated uses include pathogens and thermal pollution. All of these factors degrade water quality, destroy aquatic habitat, and reduce the number and diversity of aquatic organisms. A list of sources and causes for each of these pollutants was developed in a comprehensive watershed management table (Table 43) to identify water quality problems and provide guidance for future implementation projects to protect the quality of the watershed. Major sources for these pollutants include road stream crossings; shoreline erosion; stormwater; reduction of wetlands; lack of riparian buffers/streamside canopy; and septic systems.

Priority and critical areas in the watershed were delineated to identify specific areas in the watershed that are most sensitive to environmental impacts and have the greatest likelihood to affect water quality and aquatic habitat. Priority areas are those that are particularly vulnerable to degradation or development pressure and should be protected from future harm (Figures 28-30). Critical areas are those in need of restoration that are contributing a significant amount of pollutants to the watershed (currently or in the future) and are considered targets for future water quality improvement efforts (Figures 31 and 32). It is in these areas that the bulk of implementation efforts should be focused.

The Steering Committee decided that focusing on reducing and/or eliminating the following pollutant sources will address the bulk of pollution entering the Coastal Grand Traverse Bay and its surrounding watershed (listed in no particular order):

- Development
- Lack of Ordinances to Protect Water Quality and Natural Resources
- Lack of Riparian Buffer
- Reduction of Wetlands
- Road Stream Crossings
- Streambank and Shoreline Erosion
- Stormwater

Priority should also be given to implementation tasks (both BMPs and educational initiatives) that work to reduce the effects from these sources. Additionally, there are several areas where various critical areas are clustered and overlap. These include areas surrounding Mitchell Creek (GT County), Cedar Lake/Creek area just north of Traverse City, Suttons Bay area and south, and the Village of Northport. Special care should be taken for these areas and they should be prioritized for restoration activities.

The Coastal Grand Traverse Bay Watershed Plan is meant to assist decision-makers, landowners, residents, and others in the watershed in making sound decisions to help improve and protect water quality in their area. Chapter 8 discusses recommendations (structural, managerial, and educational) on how to reduce the negative impact that pollutants and environmental stressors have on the threatened designated uses in the Grand Traverse Bay watershed. A full list of tasks is found in Table 60 in Chapter 8.5.

Additionally, the Information and Education Strategy in Chapter 9 highlights the actions needed to successfully maintain and improve watershed education, awareness, and stewardship for the Grand Traverse Bay watershed. It lays the foundation for the collaborative development of natural resource programs and educational activities for target audiences, community members, and residents. A full list of outreach tasks is found in Table 62 in Chapter 9.4.

Costs for implementing all the tasks outlined in Tables 60 and 62 reach into the tens of millions. Table 65 below breaks down implementation and outreach costs for tasks in Table 60 and 62 by each listed category. Implementation tasks total more than $34 million, with the most expensive tasks in the categories containing stormwater management, road stream crossings, and septic systems.

Outreach costs are much less at just over $2 million; however, these amounts can be difficult because a majority of the tasks are for ongoing educational campaigns and require long-term funding.

Table 65: Implementation Costs

Category	Implementation Costs	Outreach Costs
Shoreline Protection and Restoration	$650,000	$264,000
Stormwater Management	$8,050,000	$55,000
Transportation/Stream Crossings	$5,025,000	$5,000
Planning, Zoning, and Land Use	$775,000	$165,000
Land Protection and Management	$2,550,000	500,000
Habitat, Fish and Wildlife	$1,462,000	$20,000
Recreation, Safety, and Human Health	$2,350,000	$430,000
Hydrology and Groundwater	$745,000	$5,000
Monitoring	$955,000	$110,000
Wetlands	$10,000	$70,000
Invasive Species	$178,000	$108,000
Agriculture	$4,200,000	$40,000
Wastewater and Septics	$7,175,000	$400,000
Emerging Issues	$57,500	$40,000
General	n/a	$165,000
Total:	$34,183,000	$2,377,000

11.2 Current Work and Future Efforts

There is a lot of work going on throughout the Grand Traverse Bay watershed and the current list of projects is constantly changing as various projects finish and new ones are added each year. As of 2020, The Watershed Center Grand Traverse Bay and its partners have recently completed a number of projects on Kids Creek involving stormwater management as part of their Kids Creek Restoration Project (see Chapter 8.4 for more details). Upcoming work over the next 4 years includes replacement of 5 undersized culverts and installation of green infrastructure BMPs to reduce stormwater inputs to the creek. Technically, this work falls in the Boardman River subwatershed.

Recently installed bioswale at marina in Village of Elk Rapids (October 2020)

Currently for the Coastal Grand Traverse Bay watershed TWC and its partners are working on two major efforts. The first effort is addressing stormwater inputs to Grand Traverse Bay in the Village of Elk Rapids by installing green infrastructure BMPs (specifically rain gardens and underground infiltration trenches) throughout the village (Implementation Task SM-4, Table 60).

Secondly TWC, the Grand Traverse County Health Department (GTCHD), and local governments will be conducting a source tracking study in Mitchell Creek to help determine the source of bacterial contamination. If sources are found to come from septic systems, TWC will also work with GTCHD and associated municipalities to remediate the causes and develop a comprehensive approach to find and fix failing on-site septic systems. This work addresses Implementation Tasks RSHH 2-3 and WS-9 (Table 60). ****June 2024 update – This source tracking study has been completed and a report can be found in Appendix E.****

Additionally, project partners including TWC, Grand Traverse Regional Land Conservancy (GTRLC), Grand Traverse Conservation District (GTCD), and Conservation Resource Alliance (CRA) will begin a hydrologic and habitat study on Mitchell Creek to evaluate appropriate sites for in-stream habitat improvement projects. The GTRLC recently purchased a large parcel of land in the heart of the Mitchell Creek subwatershed with intent to restore sections of the property as needed. This purchase spurred additional partners to begin discussions on what potential work could be accomplished (in addition to the source tracking work mentioned above) in the entire Mitchell Creek subwatershed. The work will also include a hydrologic and feasibility study to determine flow and discharge in the creek to inform potential road crossing improvement projects as well as re-routing of stream back to original flow in the east Main Branch Mitchell Creek. Baseline monitoring will also be conducted in Mitchell Creek to capture pre- and post- restoration data/impacts. This work addresses Implementation Tasks HFW 1-4; HF 3-4; and MON 14 (Table 60).

TWC also plans to continue its advocacy work throughout the coastal area and track new and proactively review development proposals in priority communities to ensure compliance with local zoning and state and federal standards. Additionally, TWC will continue assisting local governments with drafting and updating zoning ordinances and master plans to protect water quality and natural resources when possible. This work addresses Implementation Tasks PZL 1-4 and 10 (Table 60).

The Inland Seas Education Association (ISEA), located on the shores of West Grand Traverse Bay, educates both students and adults on Great Lakes issues and provides first-hand training and experience in the Great Lakes ecosystem. They provide a unique experience by conducting educational sessions on Grand Traverse Bay aboard tall sailing ships. To date, more than 125,000 students have participated in ISEA's shipboard programs.

Future Efforts

Over the next ten years The Watershed Center and other project partners will continue to strengthen existing partnerships with various groups throughout the watershed. Funding sources will be sought for future projects to implement recommendations made in this watershed plan in Chapters 8.5 and 9.4. These may include government, foundation, and corporate grant sources, along with potential new mechanisms for funding by local communities.

The initial implementation phase for the 2005 Grand Traverse Bay Watershed Protection Plan was for 10 years and it is expected that the implementation phase for this updated plan will run for more than 10 years as well, with some efforts expected to be conducted on a yearly basis indefinitely. The Coastal Grand Traverse Bay Watershed Project Steering Committee should continue to meet yearly during the implementation period. Structures are already in place for watershed committees for the ERCOL and Boardman River watersheds to meet on a regular basis to discuss accomplishments and future projects for those areas.

As stated previously, the project Steering Committee looked at the major sources of pollution in the watershed and decided that focusing on reducing and/or eliminating pollution stemming from stormwater runoff, streambank and shoreline erosion, road stream crossings, lack of riparian buffers, the reduction of wetlands, and a lack of ordinances to protect water quality will address the bulk of pollution entering the Grand Traverse Bay and its surrounding watershed. Priority should be given to implementation tasks (both BMPs and educational initiatives) that work to reduce the effects from these sources.

In addition to the current work in critical areas outlined above, future priority work that should be conducted over the next several years is as follows, in no particular order:

- Streambank and shoreline erosion stabilization projects
- Establish riparian buffers in priority areas
- Install green infrastructure and other stormwater BMPs in urban areas to reduce stormwater runoff
- Road crossing improvements using BMPs
- Assist with developing or revising Master Plans and Zoning Ordinances to include more water quality protection, including stormwater ordinances

- Continue successful initiatives by local conservancies to preserve open space and wildlife corridors
- Implement measures to reduce bacteria contamination of local waters – this includes efforts by the City of Traverse City to reduce sanitary sewer overflows during heavy rain events
- Wetland assessment, restoration, and protection
- Continue tracking the introduction and spread of invasive species and implement programs to reduce and eliminate their spread
- Continue developing Conservation Plans for farms
- Continue priority monitoring programs.
- Continue outreach and education efforts outlined in the IE strategy.

Additionally, outreach and education efforts should be continued as outlined in the IE Strategy in Chapter 9. Environmental awareness, education, and action from the public will continue to grow as the IE Strategy is implemented and resident awareness of the watershed about various issues increases. Implementing the IE Strategy is a critical and important long-term task to accomplish.

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APPENDICES

Coastal Grand Traverse Bay Watershed Plan

APPENDIX A

FIELD ASSESSMENT OF THE GRAND TRAVERSE BAY SHORELINE

Grand Traverse Bay Watershed Planning Project

Field Assessment of the Grand Traverse Bay Shoreline

March 2003
The Watershed Center Grand Traverse Bay

Introduction

As part of the Grand Traverse Bay Watershed Planning Project, The Watershed Center (TWC) completed a shoreline inventory of the entire 132-mile shoreline of the Grand Traverse Bay. The Grand Traverse Baykeeper, John Nelson, along with TWC staff and local volunteers, walked and inventoried the bay's shoreline in order to assess the current conditions surrounding the bay.

"To have walked the 132 mile shoreline of Grand Traverse Bay was as much an adventure as it was a task. The magnificence of Grand Traverse Bay was exhibited on each of the thirty-two days needed to complete the survey," (John Nelson, Grand Traverse Baykeeper). "The process to inventory the shoreline competes in interest and importance with the actual data and information collected. Of the thirty-two days only eleven were walked solo. Over 13 very qualified volunteers offered their observations on the other twenty-one days."

John Nelson, Grand Traverse Baykeeper, on the Antrim County Shoreline.

Methods and Protocols

The development of the survey protocol began in Fall 2001 and consisted of the following activities:

- Christopher Wright (TWC), John McKinney (MSU Sea Grant), Pam Smith (Great Lakes Environmental Center), Anne Hansen (TWC) and John Nelson (TWC) walked the shoreline from the Leelanau Lighthouse to Northport Point and noted potential significant features to record. (October 2001)
- Doug Fuller (Tip of the Mitt Watershed Council) shared his experience, survey techniques, protocols and advice. (January 2002)
- Field survey forms from the Northwest Michigan Council of Governments (NWMCOG), Michigan Department of Environmental Quality (MDEQ) and the World Wildlife Federation as well as a historical shoreline classification study, completed by the Michigan State University (MSU) Department of Resource Development's Agricultural Experiment Station in 1958, were reviewed.
- Dr. Ted Cline, a local environmental activist and aerial photographer (now deceased), screened his aerial video of the Grand Traverse Bay shoreline and offered his advice. (January 2002)

- Advice and input was also solicited from the Grand Traverse Band of Ottawa and Chippewa Indians, Michigan Department of Natural Resources, The Grand Traverse Bay Monitoring Group, Inland Seas Education Association, and NWMCOG. (January and February 2002)

A draft feature inventory sheet was prepared and tested on two walks in early February 2002. The results were shared with the Project Steering Committee and a working inventory protocol was prepared. The first field trial with this protocol was in April 2002. This inventory protocol was then used with minor additions for the remainder of the survey (Appendix A).

The feature inventory field sheets were used in conjunction with 1992 series USGS digital ortho-quad aerial photographs. One hundred fourteen photos were used. Water levels of Lake Michigan were 579.2 ft in 1992 and 578.3 ft for most of the inventory. The level of the bay was 11 inches lower than the level when the photographs were taken.

The shoreline was divided into segments containing similar characteristics during the inventory. Features such as nearshore substrate (clay, sand, stones, rock, macrophytes, etc.), endangered and exotic plant species, streams, seeps, public access, human impact (shore hardening, beach alterations), and beach characteristics (sand/stone/rock, bluffs, dunes, wetland, beach width) were noted as either specific points or as general segment characteristics. A specific point was noted if it was only seen a few times along a segment, otherwise, if a feature was common it was noted as a segment characteristic. Features and beach segments were indicated by letters on the photos and keyed by letter on the inventory sheets.

The field data has been entered into a digital database and is available on the Internet at **www.gtbay.org**. The field notes, including the aerial photographs and field inventory sheets, are available for review at The Watershed Center.

The MSU Department of Resource Development's Agricultural Experiment Station completed a previous shoreline classification study in 1958. The results from this inventory were reviewed in detail for this summary. The shoreline in these reports was characterized by 10 shoretype descriptions. The descriptions of the physical characteristics of the shore are as valuable and accurate today as they were in 1958.

Example of Beach Dunes Along Old Mission Peninsula

For purposes of this summary of the shoreline features inventory, standard common sense definitions of beach, bluff, dunes, and upland dunes can be used. (Written definitions can be found in the glossaries of the 1958 MSU shoreline inventory reports and the MSU Department of Resource

Development's 1964 Water Bulletin #14 titled *Lake Terminology*, authored by C.R. Humphrys and J.O. Veatch.) "Nearshore" areas were observed from the water's edge and have variously been defined as the area of land from the water's edge to a depth of anywhere between 2 to 6 meters. Except for observations by kayak from the Leelanau Lighthouse to Northport Point, "nearshore" was from the water's edge to what could be visually observed offshore. For the most part, the inventory followed the wet beach. From time to time, the dry beach was investigated for particular points of interest.

For purposes of respecting riparian privacy, former Attorney General Frank J. Kelley's "1978 Opinion Number 5327" was studied. The 1966 notice by the Department of Conservation (now equivalent to the MDNR) titled "Riparian Rights and the Public Trust in Michigan Public Lakes and Streams" as well as the passage "Basic Law for Shore Users" in Walter J. Hoggman's <u>Field Guide to Great Lakes Coastal Plants</u> were also read. We encountered only great curiosity and support for our effort from people we met along the shoreline.

Great Blue Heron – Antrim County Shoreline

Shoreline Features Summary

Leelanau Lighthouse to Traverse City – West Side

Lighthouse to Cherry Home (Figure 1)

Stones and rock covered a gradual nearshore and dry beach from the lighthouse to the northern limit of the Cherry Home (Figure 1, Point A) residential area. The upland was natural and much of it was parkland. The shore along the Cherry Home area was a mix of sand, stones, and rock with the rock and stones dominating nearshore. Zebra mussel shells were found in abundance on shore. Also thick layers of decaying algae were encountered. This stretch is 100% developed with cultured and natural upland. Some shore hardening exists as many homes are close to eroding banks.

Cherry Home to Northport Point (Figure 1)

South of Cherry Home two beautiful crescent sand beaches exist. Wide sand beaches with upland dunes run for a mile to Northport Point. These beaches are very natural with most development set back in the upland dunes and woodlands. An extensive rocky reef separates the beaches. With the low water levels a bermed beach has developed in some areas with emergent wetlands forming upland from the berm. Northport Point shoreline is highly developed. It is an old summer colony dating to the 1930's. Beautiful old cottages sit side by side with expansive new summer homes. The beach is mostly rock and stone with one small crescent beach tucked in between Stoney Point and Northport Point. The nearshore is also mostly rock and stone. The upland is cultured in a way that compliments the natural beach. Milfoil was significant on the west shore of the Point.

Northport Point to Village of Northport (Figure 1)

The shoreline into the Village of Northport is mostly rock and stone on the beach and nearshore. Two exceptions are Hall's Bay beach (Figure 1, Point B) and the half-mile long beach at the "bight" (a curve or bend in a beach shoreline). These beaches are gradual sand beaches with sandy, barred nearshore areas. The stony, rock beaches are highly vegetated with sedges, rushes and common shore grasses and plants.

From the "bight" to Northport Village the shore is mostly developed with cottages and homes and two marinas. Major seeps and small streams exist along Northshore Drive, draining wetlands to the west. One drains Woolsey Lake (Figure 1, Point C), or Mud Lake, and another empties into Hall's Bay. Northport Village hosts a full service marina, two small public sand beaches and riparian homes. The beaches in the village are mostly sand, as is the nearshore. Northport Creek enters the bay at the marina in town. A number of stormdrains discharging into the bay exist in the village as well. Several small streams exist between the Leelanau Lighthouse and the Village of Northport.

Village of Northport to Ingalls Bay (Figure 1)

The shoreline from the Village of Northport to Ingalls Bay (Figure 1, Point D) is very much developed. The nearshore is mostly stone and rock, as is the dry beach area. There are several small pocket sand beaches, and a half mile sand beach with adjacent sandy nearshore south of Ennis Creek (Figure 1, Point E). This shoreline has many small streams and extensive groundwater seeps entering the bay. Three private marinas exist with many small dredged basins in the nearshore. Numerous small groins exist along with many attempts to harden the shoreline with rock or seawalls. Ennis Creek is the most significant stream entering the bay south of Timber Shores. Along this stretch of shoreline there are occasional 5 to 10 foot bluffs. Ingalls Bay is a north facing sand beach with sandy nearshore. It is a gradual beach with a natural upland and a good number of cottages.

Ingalls Bay to Village of Omena (Figure 1)

From Ingalls Bay to the Village of Omena the nearshore is mostly stones and rock with one small sandy nearshore area. The dry beaches are a mix of stone, sand and rock. A 5 – 10 foot bluff exists along much of the west shore of Omena Point. The upland is highly developed with cottages and homes. Similar to the shoreline north of Ingalls Bay, several private marinas and many small dredged areas are located along this shoreline area as well. Much shore hardening exists, mostly of rock but several major steel seawalls. Several spots containing groundwater seeps occur on the east shore of Omena Point. The residents of the Village of Omena enjoy a beautiful sand beach with a sandy nearshore. Several stormwater discharge pipes move water under M-22 to the bay. The village also houses a small private marina.

Village of Omena to Sutton's Bay (Figure 1 and 2)

Just south of the Village of Omena is a small sand beach with barred sandy nearshore. Weaver Creek (Figure 1, Pont G) enters at this beach. From this sand beach to Belanger Creek (Figure 1, Point H), which enters just south of McKeese Road, the dry beach is composed of stone and rock and is narrow with many small streams and groundwater seeps. Much of the shoreline in this area belongs to the Grand Traverse Band of Ottawa and Chippewa Indians. It is mostly a natural upland with a few homes near the shore and one marina (the Art Duhamal Marina) that services the tribe. The nearshore is comprised mostly of stones and rock.

The nearshore from Belanger Creek to Sutton's Bay is mostly stones with a little sand. The beach is narrow with a stone and sand mix. Several small streams and many groundwater seeps enter the bay along this shore. A dense mat of plant growth occurs where the seeps exist. This shoreline is heavily vegetated and the upland is very developed. Some shore hardening and groin building exists. Heavy shore hardening with rocks occurs where M-22 is adjacent to the shoreline. In addition, there are numerous stormwater discharge pipes crossing the road.

Example of a Groundwater Seep Entering the Bay

Village of Sutton's Bay (Figure 2)

A private marina has been built north of Sutton's Bay Village with significant shore impact. The upland is very cultured in this development. Sutton's Bay has developed a large boat access and parking lot at the junction of M-22 and M-204. Residents of the village also enjoy a public marina and sandy public bathing beach. Sutton's Bay Creek (Figure 2, Point A) enters the bay at the marina and has exhibited high *E.Coli* counts (Monitoring Results from The Watershed Center: Fall 2002-Summer 2003). Several stormwater pipes drain runoff from the village directly to the bay. The Inland Seas Education Association is located on the shoreline just south of the Sutton's Bay marina. Their educational schooner, *Inland Seas*, is docked on a private pier.

Village of Sutton's Bay to Stoney and Lee Points (Figure 2)

South and east of Sutton's Bay Village the beach and nearshore area are both sandy. This area is highly developed and cultured above the beach. Leo Creek also enters along this beach. The nearshore substrate quickly becomes more stone north to Stoney Point. The dry beach is narrow and combines stones and sand. The upland is developed with some open areas and upland farms. Stoney Point Road is adjacent to the shore for a long stretch. Several smaller streams enter the bay on this shoreline. The north end of Stoney Point has a wide, gradual stone and rock beach with stone and rock substrate nearshore. The houses are set back in the woods. Significant beach altering was done along the north end of Stoney Point. From Vic Steimal Park (Figure 2, Point B) to the road end of Nanagosa Trail the dry beach is mostly narrow and consists of stones with a little sand. There are very significant, thick layers of decaying algae in many areas. Many homes exist above the low bluff. There are also several small streams and significant groundwater seeps occurring. Sixty to seventy foot bluffs occur along the beach south of the end of Nanagosa Trail. This beach is very narrow. The bluffs are mostly clay, and groundwater seeps occur along the beach. The beach and nearshore substrate is mostly stones with areas of silt and sand. Thick clay, silt areas exist along the beach below eroded the bluffs. Homes have been built above the bluffs. The bluff tapers down to Lee Point.

Example of a Clay/Silt Beach Area

At Lee Point the dry beach widens and becomes sandier. The nearshore is a stony, sand mix. Lee Point has a very wide sand, pebble beach with a developed but natural upland. The beach from Lee Point to M-22 is sandy with a nearshore sand substrate. The beach is gradual up to a developed upland that is a mix of natural and cultured. A small bluff exists, above which is Lee Point Road. Homes here are built across the road from the beach. Several culverts under the road drain the wet areas from the north. Emergent wetlands are extensive on a bermed beach.

Lee Point to Cedar Creek (Figure 2)

From the Lee Point Road intersection with M-22 the beach can be generalized to Cedar Creek (Figure 2, Point C) in Elmwood Township. M-22 dominates the upland area. The highway is frequently adjacent to the shoreline. When development occurs between the highway and the shoreline, it usually is on a narrow lot. The dry beach is, for the most part, a mix of stones and sand. It is narrow, often with a 5 – 10 foot bluff above the beach. The beach is highly vegetated with emergent wetlands growing along much of the shore. Several small streams and groundwater seeps exist. There are also many groins, seawalls and rock erosion barriers. The shoreline here is developed to its maximum.

Where M-22 is next to the shoreline, heavy rock riprap along with stormwater discharge pipes and culverts are evident. There are three DNR scenic turnouts, discharging stormwater to the bay from paved surfaces. One sand beach exists with sandy nearshore just north of Crain Hill Road. There are areas of significant, thick layers of decaying organic matter, as seen near the DNR scenic turnout near Crain Hill Road. The nearshore substrate is mostly stones and rock with a little sand and silt.

Cedar Creek to M-72 (Traverse City – West Side) (Figure 3)

Near Cedar Creek (Figure 3, Point A) to the Harbor West (Figure 3, Point B) breakwall the dry beach is sandy and wide. A mat of decaying organic matter was in the water over a sandy, stony nearshore substrate.

From the Harbor West breakwall to M-72 the shoreline is highly modified by man. Marinas, dredged areas, piers, and public beaches are all located on a beach that naturally would be similar to that north of Sutton's Bay. Brewer's Creek (Figure 3, Point C) is the significant stream entering the bay near Elmwood Marina (Figure 3, Point D).

The shoreline from Northport Village to Traverse City is vegetated with sedges, rushes, grasses and other common shoreline plants whenever the stones and rock predominate. Where sand is the dry beach and nearshore substrate emergent wetlands appear when a berm is created at the water's edge.

Traverse City – West Side (Figure 3)

A significant stream enters the bay at M-72 and is culverted under the road. The dry beach from M-72 to the Traverse City Light and Power Plant (Figure 3, Point E) is sandy and varying in width. It is public land with public beaches and parking areas (West End Beach – Figure 3, Point F). The nearshore is a gradual sandy substrate. Grandview Parkway is adjacent upland and is armored with riprap in several spots. Three stormwater culverts empty into the bay along this area.

The Clinch Park Marina and Open Space (Figure 3, Points G & H) are located to the west of the Clinch Park public beach area. The shoreline along this area has significant shore hardening with concrete and large rip-rap. The Boardman River (Figure 3, Point I) empties into the bay just east of Clinch Park. The dry beach and nearshore are gradual in gradient and are sandy to Bryant Park (Figure 3, Point J) at the southwest corner of West Bay. The Maritime Academy Marina is a major dredged harbor on this stretch, with single-family homes located on sandy beaches between the Academy and Bryant Park. Two stormwater discharge culverts empty to the bay between the Maritime Academy Marina and Bryant Park. The entire section of the West Bay shoreline located in Traverse City is generous in its public access to this extraordinarily beautiful sandy beach shoreline.

Clinch Park Marina – aerial shot

Old Mission Peninsula

Traverse City – West Side to Bower's Harbor (Figure 3)

The shoreline of Old Mission Peninsula to Bower's Harbor, approximately eleven miles, is fairly uniform. Peninsula Drive runs adjacent to the beach. The shoreline is heavily developed with homes mostly located on the other side Peninsula Drive, but many have been built between the road and the beach. There are new homes being built on very marginal land on the waterside of the road that have the potential to impact the bay. The dry beach is, for the most part, narrow from the water's edge to a 5 – 15 foot bluff. This Nipissing Bluff is an ancient wave cut beach. The dry beach is a mix of sand and stones with much of this shoreline exhibiting vegetative growth of sedges, bulrushes, grasses and other common shoreline plants. There are numerous groins and small dredged areas where rocks have been pushed aside. The nearshore substrate is mostly stones and small rocks. There were several pockets of decaying organic mats observed. This shoreline is heavily developed. Several small streams and numerous groundwater seeps were observed.

Bower's Harbor to Old Mission Point

A private marina is in Bower's Harbor with a DNR boat launch adjacent to it. The dry beach that extends about one half-mile west is a wide, gradual sandy beach with emergent wetlands where a berm has been created by wave action. The nearshore is a gradual sand substrate. The upland on the beach is natural and cultured with many cottages. From this beach to Neahtawanta Point the dry beach narrows and the Nipissing Bluff reappears. The dry beach is a mix of sand and stones and is heavily vegetated with extensive emergent wetland. The upland is natural bluff with homes set back from the bluff. From Neahtawanta Point to Old Mission Lighthouse the shoreline is much less developed. The dry beach widens and is for the most part a mix of sand and stones. The Nipissing Bluff parallels the shore at various elevations the whole length this shoreline. The nearshore area is composed of mostly stones and rock with some sand. Human impact on the beach is limited with a few spots of shore hardening where the beach narrows. M-37 abuts the shoreline for a substantial distance near Old Mission Point and is hardened with riprap. Old Mission Point is largely public access land and shoreline with a township and state park.

Old Mission Point to Haserot Point and Old Mission Harbor (Figure 3)

The shoreline from Old Mission Point to Haserot Point (Figure 3, Point K) is very natural and undeveloped. The dry beach is wide and gradual with mostly stones, rock and some sand. The nearshore substrate is stones and rock with a gradual slope to deeper water. The dry beach is vegetated with grasses and some emergent wetland plants. The Nipissing Bluff is present on the upland at varying heights for the entire shoreline and is quite steep and high at Haserot Point. Some bluffs are up to 30 feet in height.

From Haserot Point around Old Mission Harbor the dry beach is a mix of sand and stones with a beautiful, sand beach at the Township Park. The nearshore is a gradual substrate of stones and sand. Several hundred yards of the North end of the harbor is hardened with brick and steel seawall.

Old Mission Harbor to Traverse City – East Side (Figure 3)

The shoreline from Haserot Park in Old Mission Harbor to the East Bay Park Beach (Figure 3, Point L) in Traverse City can be summarized by a general description. The Nipissing Bluff is present along most of the fifteen-mile shore at varying heights, usually 5 to 15 feet. The nearshore is primarily stones and rock with little sand. Some pocket sand beaches do exist. The dry beach is narrow and mostly stones with some sand. This shore is very much developed with homes above the bluff or across the road when the road is adjacent to the shore. There is significant shore hardening, small dredged areas, and numerous groins. Much of the beach is vegetated. Just north of Bluff Road heavy beach erosion control efforts (rock riprap) have occurred below a 30-foot bluff.

Example of shore hardening using large rock rip-rap.

Traverse City – East Side to Eastport

East Bay Park to Mitchell Creek and the State Park (Figure 4)

The dry beach from the East Bay Park (Figure 4, Point A) to the southeastern corner of East Bay is a sandy, 25 - 100 foot wide gradual beach. US-31 parallels the beach with heavy developed property between the road and beach. This “miracle mile” is some of the most valuable real estate in the region. The value in 2003 of $7000 per front foot is quite high when compared with the “up to $100 per front foot” noted in 1958 (MSU historical shoreline inventory). The nearshore in this area is a gradual, barred, sandy substrate. Three major stormwater discharge pipes are located at the west end of the beach. The Traverse City State Park (Figure 4, Point B) occupies about a quarter mile of this beach. Commercial and residential land uses share the beach with commercial use replacing residential where zoning allows. The southeast end of the beach has been built on fill over the years and the nearshore is shallow for several hundred yards from the water's edge. Emergent wetlands are lush and numerous here. Mitchell Creek (Figure 4, Point C) enters the bay just west of the State Park.

Mitchell Creek to Acme Creek (Figure 4)

A relatively overlooked small watershed is that of Baker's Creek (Figure 4, Point D), which drains the wetlands in the southeast corner of East Bay. Significant layers of decaying organic matter were observed on the southeastern corner of East Bay as well. US-31 dominates the shoreline for a mile north from the foot of the bay. The dry beach is narrow to non-existent with heavy riprap protecting the road bank. Two streams are culverted under the road. The nearshore is mostly stones and rock. The shoreline through the Village of Acme is heavily developed with commercial establishments. The dry beach is narrow and a mix of sand and stones. The nearshore is mostly sand and stones. The dry beach exhibits many emergent wetland areas. There is a DNR Roadside Park (Figure 4, Point E) and a private commercial marina. As in most marinas, milfoil and other macrophytes are numerous. There are several rock and steel seawalls. The beach to the north end of the village is where Acme Creek (Figure 4, Point F) enters the bay.

Acme Creek to Deepwater Point (Figure 4)

The beach from Acme Creek north has been kept relatively natural up to the Deepwater Point Nature Preserve. Along this stretch the dry beach is wide, gradual and primarily stones and sand. Homes above the beach exhibit cultured and natural settings. Significant milfoil was observed on the beach. The nearshore is mostly stones and drops off sharply to deep water.

Deepwater Point to Ptobego Natural Area (Figure 4)

The dry beach north of Deepwater Point is wide and gradual. A bluff arises and the developed land is set back from the beach or is above the bluff. The beach is very natural and is mostly sand with some stones. The nearshore is also sand with some stones. The shoreline along this area has many points (projections of land into the water). At each point, the sand gives way to more stones and extends in to the water to stony reefs.

Ptobego Creek and Pond Natural Area – aerial shot

This shoreline type continues to the Ptobego Natural Area (Figure 4, Point G). Yuba Creek (Figure 4, Point H) enters the bay on this shoreline. There are significant groundwater seeps to the bay along the shoreline as well. The Ptobego mile stretch of shoreline is a spectacular example of a natural Lake Michigan shoreline. It is a wide, gradual, sandy, dry beach with both beach and upland dunes. The nearshore is a mix of sand and stones. Ptobego Creek (Figure 4, Point I) empties into the bay here.

Ptobego Natural Area to the Village of Elk Rapids (Figure 4)

The human impact on the shoreline from Acme Creek to Elk Rapids is minimal, probably because of the westerly winds, unprotected shoreline, and dynamic nature of the natural beach. From the Ptobego Natural Area to the Village of Elk Rapids the dry beach narrows to 25 – 100 feet. It is mostly sand with stones and rock. The beach gradually blends to the upland, which is developed to Elk Rapids. The nearshore is a mix of stones and sand. A fair amount of macrophytic growth occurs on the nearshore substrate. Emergent wetlands occur where a berm has formed but are not extensive.

The Village of Elk Rapids has, as do other urban areas, a diverse developed shoreline. Several public parks and open areas exist. A public marina is available which has been recently dredged. Three stormwater discharge pipes service the village. Milfoil and other macrophytes grow in the marina. The Elk River carries some 60% of the total surface water input to Grand Traverse Bay at Elk Rapids Village.

Village of Elk Rapids to Norwood (Figure 4, 5)

North of Elk Rapids the dry beach varies in width, usually 25 – 100 feet. The dry beach is sand and some stones and the nearshore substrate is comprised of stones with sand. An upland bluff that varies from 5 – 15 feet characterizes the shoreline. When the beach widens, beach dunes covered with beach grass and upland dunes occur. Development is residential homes and cottages. The development is consistent along the shore of Antrim County and is broken up by conserved land and public parks. Where development occurs, some dredging, groin building and shore hardening has occurred, especially on the narrow beach stretches, but not nearly as intense as on the Leelanau County side or the shoreline of Old Mission Peninsula. One private, dredged marina was observed along with one community, west of Williams Drive, that had a dredged harbor prohibiting access along the shoreline. Where a berm was created by the wave action, emergent wetlands occurred.

Twenty-four small streams were observed from Elk Rapids to Norwood. Many groundwater seeps were observed as well. The most interesting and beautiful seeps were observed north of Eastport seeping from the blue Antrim Shale Bluffs. Significant layers of decaying organic matter, chara, and chladophera were observed when caught on the lee side of reef points.

Close-Up of Antrim (Blue) Shale Bluff

North of Eastport to Norwood the beach narrows and becomes more stones than sand. The most unique observations of the whole shoreline inventory are the areas of exposed Antrim shale. The blue shale bluffs, the shale fragments on the beach and the layers of blue shale extending into the lake substrate were very impressive.

Power Island (Figure 6)

The last segment of the shoreline inventoried was Power Island in June 2003. Power Island, located in the central portion of West Grand Traverse Bay, is a public preserve owned and operated by Grand Traverse County. The shoreline of Power Island is a natural shoreline, which includes examples of many of the natural shore types surrounding Grand Traverse Bay.

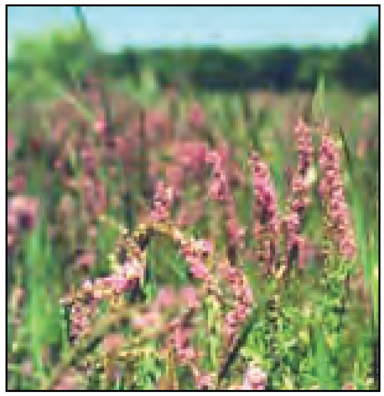
From the public dock, located on the southeast side of the island, south to the middle of the southern shore, the nearshore is a mixture of sand and stones, as is the beach. The upland is natural with public picnic areas. The western end of the south shore has a mixture of stones and clay on the nearshore and beach areas with a 20-40 foot bluff to the upland. The western shoreline exhibits large rocks and stones both in the nearshore and on the beach. A 20-foot bluff runs above the beach for about 2/3 of the length of the western shoreline.

The north 1/3 of the island is low and flat with upland wetlands. These wetlands output groundwater into the bay in small streams and seeps. Some ephemeral ponds exist on the beach and emergent wetlands are found along most of this shoreline.

Bassett Island is connected to Power Island at the northeast tip. The beach and nearshore in this area is low, flat, and gradual with a mix of clay and stones. Except for the eastern shore near the public dock the nearshore is shallow shoal water. Near the public dock the nearshore drops off to deep water close to shore.

Endangered and Exotic Species

Exotic species observed during the shoreline inventory included purple loosestrife and zebra mussels. Purple loosestrife grows extensively along the shoreline. It mostly occurs where it is sheltered from direct wave action and on stony, rocky substrate. It may also occur on sandy substrate, although not as common, as demonstrated at the foot of West Bay and along the Boardman River. With relatively low lake levels, purple loosestrife has taken hold in some of the emergent wetland areas.



Purple Loosestrife

Zebra mussel shells were observed on the shoreline throughout much of the survey. Most shells were observed north of the 45-degree parallel. Some windrows of shells three feet deep were observed north of Northport and on the western side of Old Mission Peninsula.

Zebra Mussels

Pitcher thistle was the only endangered plant species observed and was found at one location north of Northport on the Leelanau Peninsula and at several locations north of the Village of Elk Rapids to Eastport.

Pitcher's Thistle

Other Areas of Concern

The areas of decaying detritus and organic matter (where the layers were of concern to riparian owners) occurred mostly on the Leelanau side of the bay. Some layers were 2 to 3 feet thick and resembled septage. Where the layers could be identified, the macrophytes were chara and chladophera.

Additional Inventory of Selected Tributaries

The Grand Traverse Baykeeper walked and explored four sub-watersheds. The Woolsey Lake (Figure 1) outlet was explored to its mouth at Seven Pines Road on the bay. The lake and much of its surrounding land is protected with conservation easements or public lands. The outlet of Woolsey Lake consists of a wetland complex that flows into the bay at Seven Pines Road.

Phil von Voigtlander of Northport hosted a walk from the mouth of Northport Creek (Figure 1, Point I) to its headwaters in the wetlands and springs off of Johnson Road. Phil and his neighbors have protected these headwaters with conservation easements. Northport Creek winds its way through woodland and fields to the Village of Northport where it finds its way to an old Mill Pond and then to the marina at its mouth. The hospital in Northport has a National Pollutant Discharge Elimination System (NPDES) permit to discharge wastewater into the Creek. The Village of Northport is also actively discussing wastewater issues in the village where only septic tanks handle wastewater.

Kid’s Creek was walked with Sarah U’Ren from its headwaters to its entry into the Boardman River (Figure 3) in Traverse City. Kid’s Creek is now an urban stream surrounded and encroached upon by development. Eroded stream banks and sedimentation impair the lower stream. Extensive wetlands remain adjacent to this stream and should be protected. There is an effort by Garfield Township, private sector interests, and non-profit organizations to restore and repair the impacted and impaired portions of Kid’s Creek.

Larry Quimby hosted a walk of Baker Creek (Figure 4) that flows into East Bay at its southeast corner. This starts off as a small stream that drains from the high uplands to the South and East. The wetlands just south of US-31 are exquisite and deserve protective attention. These wetlands are under intense development pressure and are only a few hundred yards from East Bay.

Summary

In 1958 the MSU Department of Resource Development's Agricultural Experiment Station completed a similar shoreline inventory for Leelanau, Grand Traverse, and Antrim Counties (Humphrys et al. 1958) that identified 'shoretypes' in each county. The shoreline in these reports was characterized by 10 descriptive categories: location, length, access, use, erosion, services, upland, bluff, and dry beach and wet beach. For Leelanau County eleven shoretypes were identified and characterized. Grand Traverse County had four shoretypes and Antrim County only one.

The shoreline inventory that was completed for the Grand Traverse Bay Watershed Planning Project is much more detailed in its field observations than the 1958 MSU study. However, the general shoreline character remains essentially similar to 1958. The changes are mostly due to increased use and human impact. A significant increase in shore hardening is evident. The building of groins and the "creation" of beaches by moving the stones into groins is another significant change. Marinas have been constructed, both public and private, with their associated dredging. With lower water levels and increasing development along shoreline areas consisting of rock and stones or coastal wetlands, there is now evidence of activity to alter the shoreline to accommodate riparian landowner desires.

The upland lots along the Leelanau shoreline are close to 100% developed, meaning there is some sort of home or business along the entire shoreline. The shoreline itself has various degrees of human disturbance, with some areas left natural. If hardening, groins, and beach altering are included in the disturbance category, certainly more than half of the shoreline would be considered disturbed.

The Old Mission Peninsula shoreline is much the same as the Leelanau. From Bowers Harbor south to Traverse City, the human impact is much more significant, probably close to 80% disturbed. The East shoreline of the Old Mission Peninsula from Old Mission Harbor south is similarly disturbed. The Antrim shoreline is the least disturbed as it is open to the westerly wind effect of Lake Michigan.

Based on anecdotal evidence from the Inland Seas Education Association and the Leelanau Conservancy, as well as from riparian owners along the bay, there appears to be a significant increase in algae growth on benthic substrates in the bay over the past 10 years. A kayak trip taken by the Baykeeper in July 2003 just north of Northport Point and in Northport Point Bay in the nearshore area revealed observations of significant carpets (or mats) of cladophora and chara growing on the substrate, especially in water deeper than 3 meters, where wave action has less of an effect. These mats are extensive, covering most of the substrate along this shoreline. When these algal mats break loose from the bottom, they create large areas of rotting organic matter on shore, in some areas a half-meter thick and extending two to three meters off shore. Causes are probably numerous, interconnected, and complex. Zebra mussels have filtered the lake water, increasing clarity and allowing light to penetrate deeper. The increased nutrients carried to the benthic layers by the zebra mussels' filter activity have effectively fertilized the benthos of the bay. The increased growth shows up as increased decaying organic matter on the shoreline.

Over one hundred small streams were observed flowing into the bay; a list of these is found in Appendix B (Figure 7). Each stream is very important to those who live near it and cumulatively important to the health of the Grand Traverse Bay. Anecdotally, these small watersheds are under intense pressure from human activity and development. They must be protected. A minimum 25-foot setback and true riparian buffer could be established to protect these streams with little impact on the development rights of the landowner. Impairments of these streams are an impairment of the bay, by small incremental acts. Protection of the riparian wetlands of the bay is equally important as is evidenced by the observed frequency of groundwater seepage into the bay. If taken cumulatively, the small streams and significant groundwater seeps are found on 70-80% of the shoreline (Figure 8).

Both land development as well as economic development place pressure on the need for small shoreline communities to properly dispose of their wastewater. The discharge of wastewater, from both failing septic systems and over-taxed treatment facilities, has the potential to dramatically degrade the water quality of the bay. Added nutrients from wastewater would increase the amount of algae and plants noted in the water, causing even more of an increase than what was noted in this survey. At this time, the Northport Point Cottage Owners' Association, the Village of Northport, and the Village of Sutton's Bay are actively pursuing solutions to their wastewater issues. However, this will continue to be an important issue for all communities along the 132-mile shoreline.

Intense development increases the amount of stormwater discharge to the bay, due to increases in impervious surfaces. Numerous stormwater discharge pipes were noted entering the bay in Traverse City, as well as significant increases in the amount of impervious surfaces covering land adjacent to the bay. Increases in impervious surfaces increase the amount of stormwater and runoff directly discharged to the bay. Stormwater may contain harmful pollutants and excessive amounts of nutrients, both of which may harm aquatic life and pose health risks. Because of this, stormwater management must be of the utmost concern for growing shoreline communities.

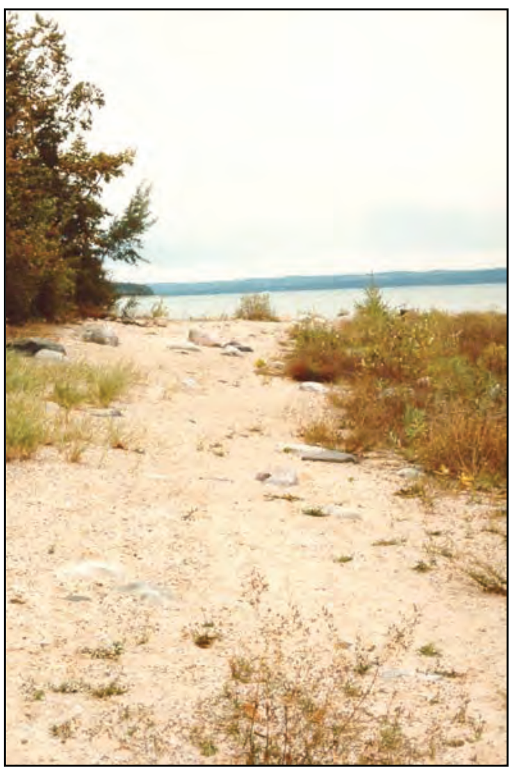
Conclusions

Grand Traverse Bay's shoreline remains a beautiful commons for all to treasure. Increasingly, however, this concept of a commons is being segmented into a parcel-by-parcel view of what each riparian owner envisions for the shore. Cumulatively this is shortsighted and damaging to the long-term integrity of the shoreline of the bay.

Of increasing concern is the altering of the shoreline as development occurs in the shoreline that traditionally has been less desirable for homes and cottages. These are the shoreline segments of stones, rocks and coastal wetlands or marshes. One good example is the southeast shore of the East Arm of Grand Traverse Bay. This shoreline is an integral part of the Traverse City complex of the Lake Michigan coastal wetlands, as described in Hoagman 1994. This complex comprises 184 acres of wetlands to include the Baker Creek watershed.

In the Traverse City wetland complex area, this shoreline inventory identifies six small streams and very significant groundwater seeps in an approximate one-mile stretch. The nearshore here is shallow to 1000 feet offshore, before reaching a depth of 6 feet. This shoreline's beach and nearshore feature the growth of Great Lake wetland plants such as rushes and sedges. Development pressure has begun to alter this shoreline, attempting to create "sandy" beaches. The other examples are where homes are built on a stone, rock beach and equipment is used to scrape the stony, rocky material to the side to, again, attempt to create a "sandy" beach.

The water-land interface of Lake Michigan, and in particular Grand Traverse Bay, is a very dynamic space. The shoreline changes from day-to-day, year-to-year, and decade-to-decade. We can observe this dynamic change. What human activity occurs on a small part of the shoreline affects the shoreline adjacent to it for long stretches. The cumulative effect of many shoreline-altering acts eventually affects the erosion, habitat, and water quality of the bay. If these alterations continue, the natural beauty of this resource will eventually be destroyed and we will all suffer its loss. The public must protect its right to oversee shoreline altering as proscribed by law.



"In the past many activities have been undertaken in these beach areas with little or no awareness of the dynamic, ever changing properties of a shoreline area. Use must be planned in accordance with the natural characteristics and natural changes; otherwise the user may expect problems that are not only unpleasant, but expensive," (MSU 1958 historical shoreline inventory).

Thanks to Volunteers

The Watershed Center wishes to thank the following volunteers who accompanied the Grand Traverse Baykeeper on shoreline inventory walks:

Cory Arsnoe – Antrim Conservation District
Anne Brasie – Executive Director, The Watershed Center
Mike De Agostino – Grand Traverse Resort & Spa
Jerry Dennis – Poet and Author
Anne Hansen – Office Manager, The Watershed Center
Cal Karr – Teacher
John McKinney – MSU Sea Grant
Melody Myers – Biologist, Grand Traverse Band of Ottawa and Chippewa
Larry Quimby – Resident of Baker Creek Watershed
Christine Sleeman – Biologist
Pam Smith – Botanist, Great Lakes Environmental Center
Sarah U'Ren – Project Coordinator, The Watershed Center
Phillip von Voigtlander – Northport Resident and Scientist
Heather Wilson – Antrim Conservation District
Christopher Wright – Doctoral Student, MSU Department of Agriculture

Transportation to Power Island provided by:
Jay Craft – Bay Breeze Yacht Charters
Matt Heiman – Leelanau Conservancy

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Appendix A
GRAND TRAVERSE BAY WATERSHED
SHORELINE INVENTORY DATA COLLECTION FORM

NORTHWEST MICHIGAN COUNCIL OF GOVERNMENTS

MAP NAME:_____________

DATE COLLECTED:____________________

NAME OF SURVEYOR(S):____

Location	(I). Near-shore Features	(II) Flora	(III) Groundwater	(IV) Public Access	(V) Human Impact	(VI) Beach	Comments

Key to data codes:

(I) Nearshore Features: 1-cladophora 2-other algae 3-macrophytes 4-silt/clay/detritus 5-sand 6-stones 7-rock
(II) Flora: 1-endangered 2-exotics
(III) Groundwater: 1-seeps 2 streams
(IV) Public Access: 1-pedestrian 2-boatlaunch 3-permanent pier 4-auto (end-of-road)
(V) Human Impact: 1-shore hardening: a-steel b-stone c-groin
2-beach altering: a-landscaping b-erosion c-raking d- clearing e-dredging
3-stormwater drainage discharge
4-private permanent pier
5-water withdrawing
(VI) Beach: 1-sand 2-stones 3-rock 4-gradual 5-bluff 6-dunes 7-algae deposition 8-wetland
9-width: a-less than 25' b-between 25'-100' c-more than 100'
10-adjacent upland: a-natural b-cultured c-paved d-bluff e-dune

Other keys:
(+) = present
(++) = abundant

sand < 1/12"
stones 1/12" – 10"
rock > 10"

Appendix B
Streams Draining Directly to Grand Traverse Bay

Antrim County		
Data Sheet	**Number of Streams**	**Location**
?	1	Elk River at Elk Rapids
ANT 6	2	Just North and South of Winters Road
ANT 8	2	South of Erickson Road
ANT 9	1	Intermittent stream North of Erickson Road
ANT 10	1	South of Croswell Road
ANT 11	1	North of private marina north of Croswell Road
ANT 12	1	North of Croswell Road
ANT 13	2	
ANT 16	2	South of Core Road
ANT 17	4	Includes Guyer Creek
ANT 18	3	
ANT 19	2	Antrim Creek, 1 stream South of Antrim Creek
ANT 20	1	At Bank Township Park Road
ANT 22	1	At Norwood
Total	**24**	

Grand Traverse County		
Data Sheet	**Number of Streams**	**Location**
GTC 1	1	
GTC 2	1	
GTC 5	2	
GTC 8	2	
GTC 10	2	
GTC 11	1	
GTC 12	1	
GTC 16	3	
GTC 28	1	
GTC 29	1	
GTC 30	2	
GTC 37	1	
GTC 40	1	Mitchell Creek
GTC 41	3	Includes Baker Creek
GTC 42	3	
GTC 43	3	Includes Acme Creek
GTC 47	1	Yuba Creek
GTC 49	2	Includes Ptobego Creek
Total	**31**	

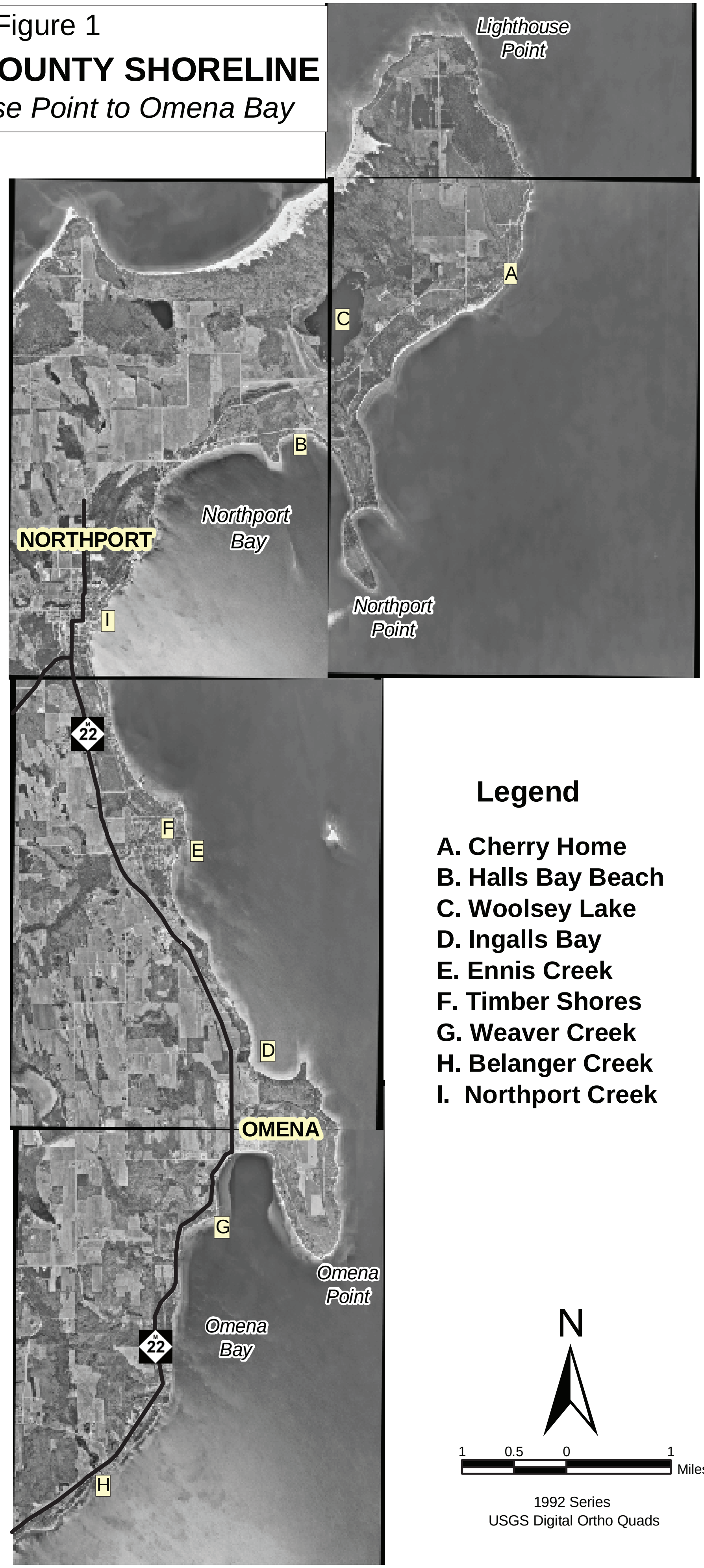
STREAMS DRAINING DIRECTLY TO GRAND TRAVERSE BAY CONT'D

Leelanau County		
Data Sheet	**Number of Streams**	**Location**
LEE 2	2	At Cherry Home
LEE 5	1	Woolsey Lake Outlet
LEE 8	2	Halls Bay
LEE 10, 11	8	Including Northport Creek, many draining wetlands West of Northshore Drive
LEE 12	4	
LEE 13	2	Including Innes Creek
LEE 14	1	
LEE 15	1	
LEE 20	2	Including Weaver Creek
LEE 21	1	
LEE 22	1	Belanger Creek
LEE 23	3	
LEE 24	2	
LEE 25	2	
LEE 26	3	
LEE 27	1	
LEE 30	6	
LEE 31	2	
LEE 32	3	
LEE 33	1	
LEE 34	1	
LEE 35	2	
LEE 36	1	
LEE 42	2	
LEE 43	3	
Total	**57**	

Figure 1

LEELANAU COUNTY SHORELINE

from Lighthouse Point to Omena Bay



Legend

A. Cherry Home
B. Halls Bay Beach
C. Woolsey Lake
D. Ingalls Bay
E. Ennis Creek
F. Timber Shores
G. Weaver Creek
H. Belanger Creek
I. Northport Creek

N

1 0.5 0 1 Miles

1992 Series
USGS Digital Ortho Quads

Figure 2

LEELANAU COUNTY SHORELINE

from Suttons Bay to Greilickville

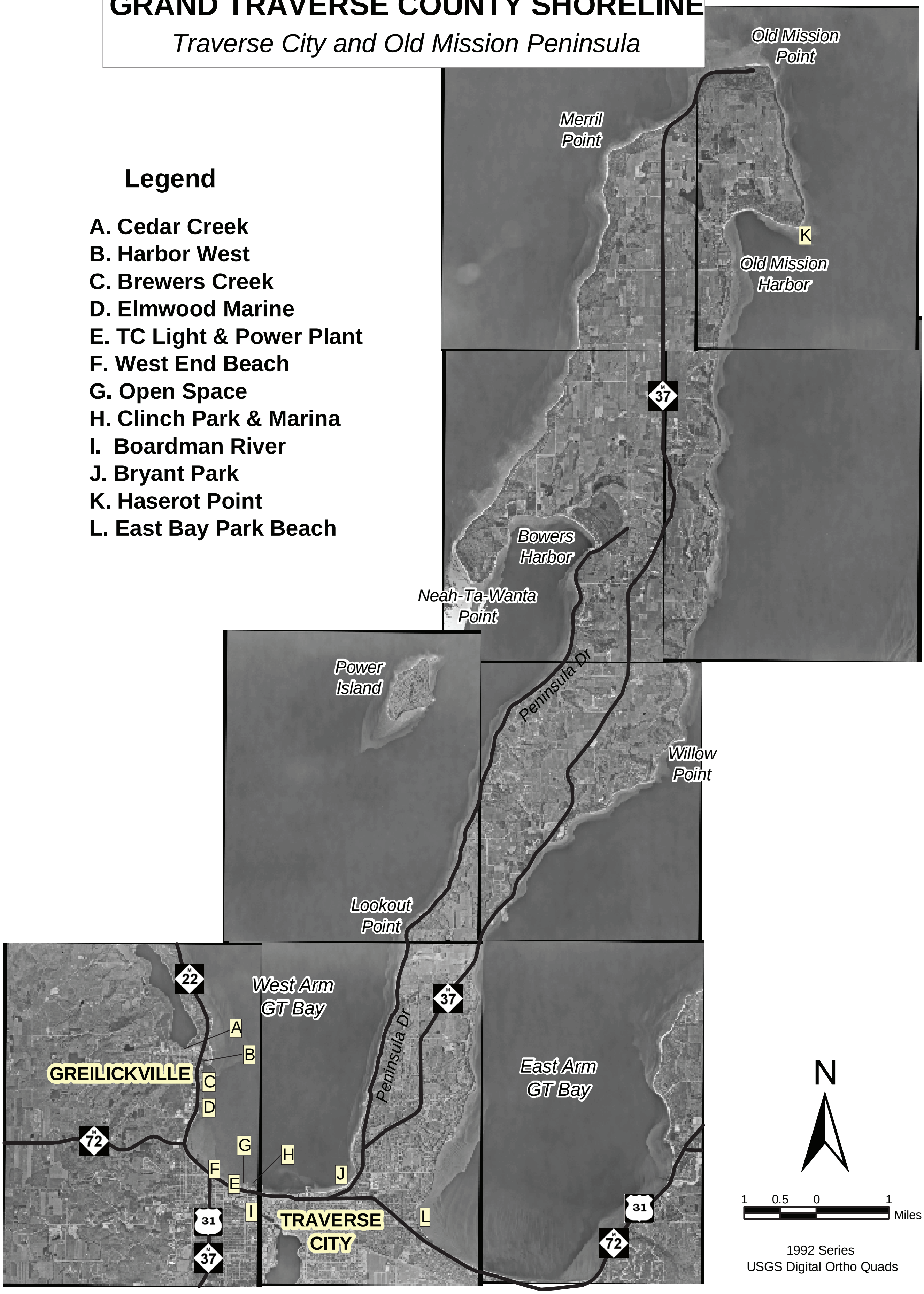
Figure 3

GRAND TRAVERSE COUNTY SHORELINE

Traverse City and Old Mission Peninsula

Legend

A. Cedar Creek
B. Harbor West
C. Brewers Creek
D. Elmwood Marine
E. TC Light & Power Plant
F. West End Beach
G. Open Space
H. Clinch Park & Marina
I. Boardman River
J. Bryant Park
K. Haserot Point
L. East Bay Park Beach



1992 Series
USGS Digital Ortho Quads

Figure 4

ANTRIM COUNTY SHORELINE

from Acme to north of Elk Rapids

Legend

A. East Bay Park Beach
B. TC State Park
C. Mitchell Creek
D. Baker's Creek
E. DNR Roadside Park
F. Acme Creek
G. Ptobego Natural Area
H. Yuba Creek
I. Ptobego Creek

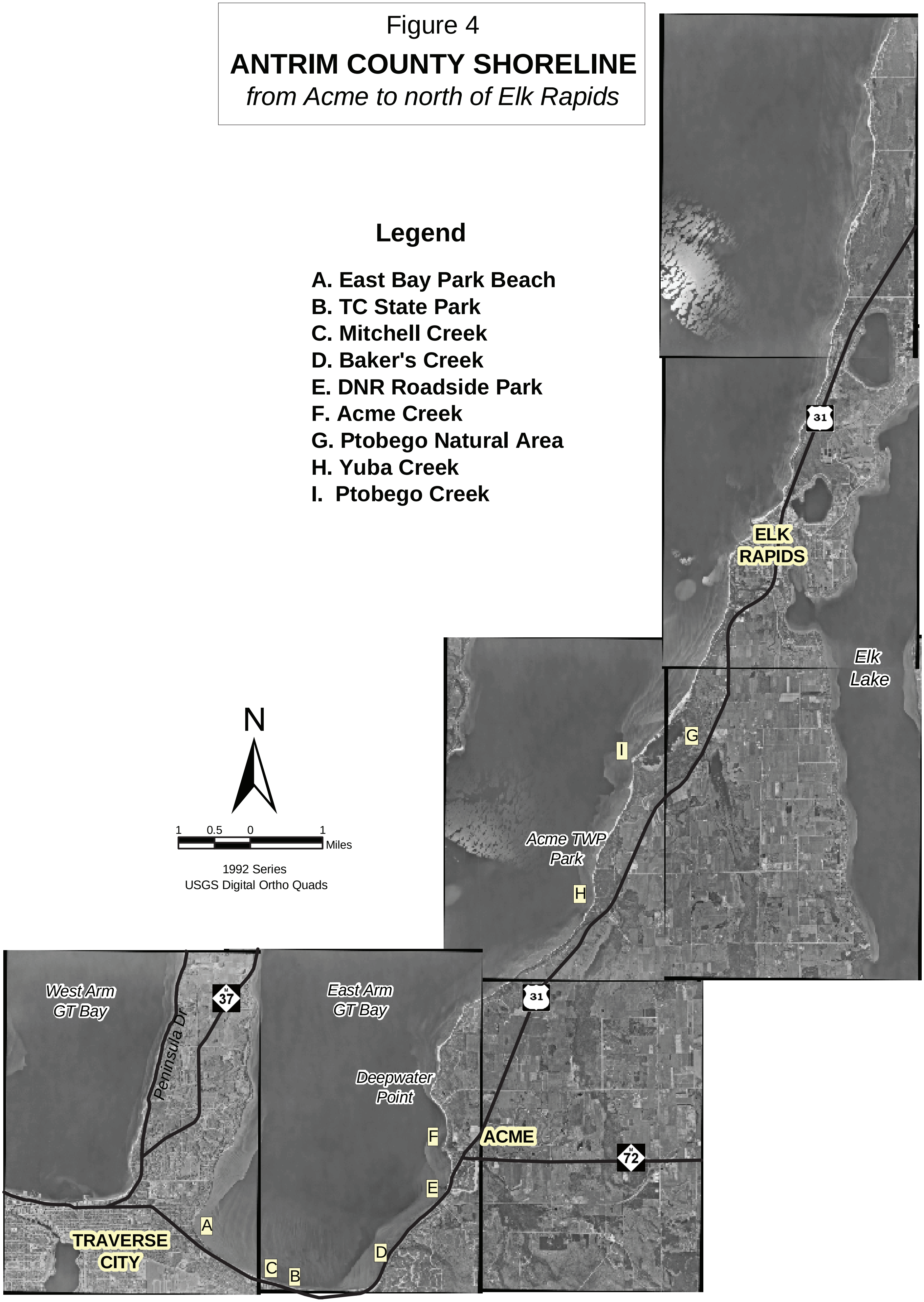


Figure 5

ANTRIM COUNTY SHORELINE

from north of Elk Rapids to Norwood

1992 Series
USGS Digital Ortho Quads

Figure 6

GRAND TRAVERSE COUNTY SHORELINE

Power (Marion) Island

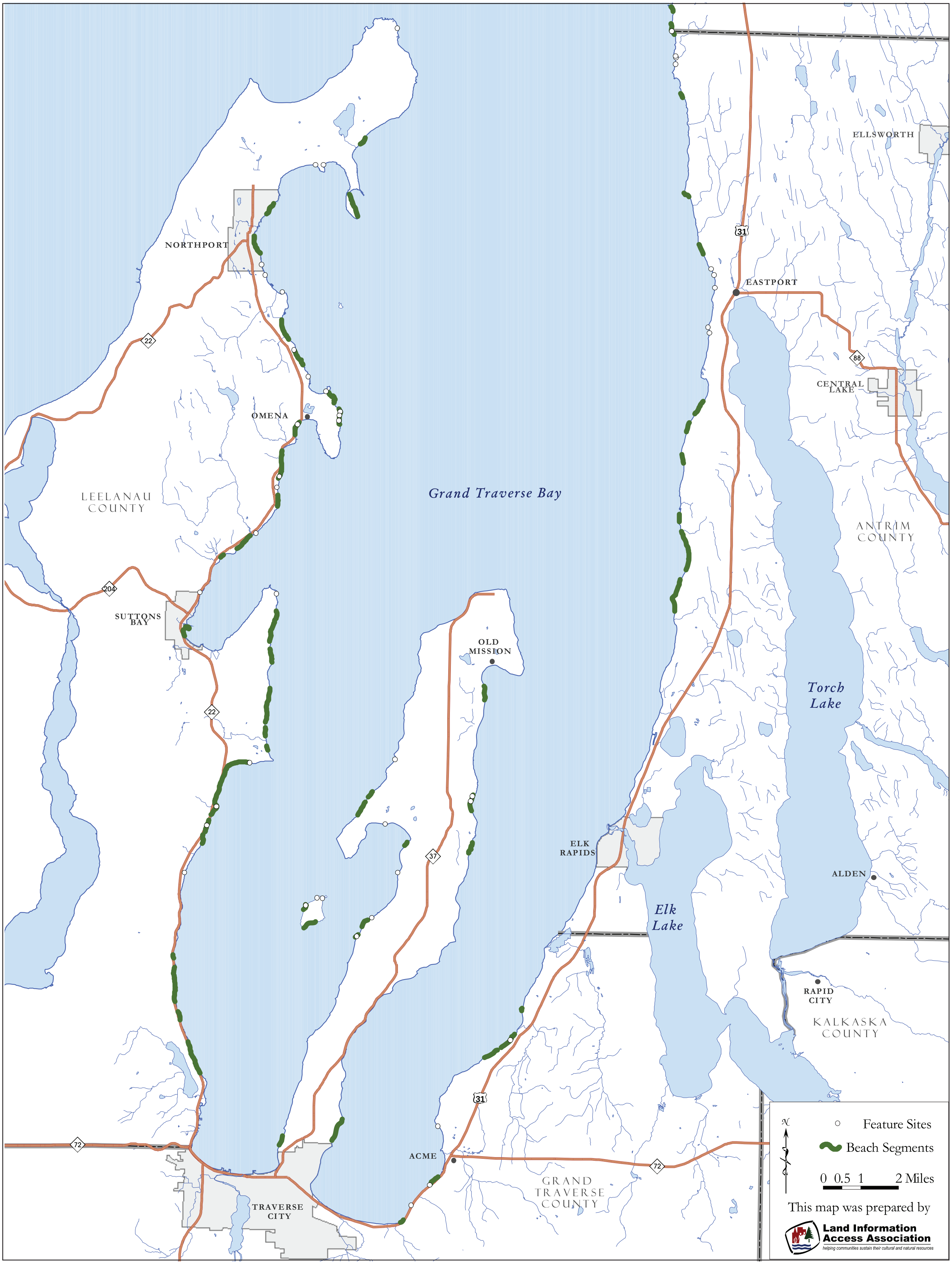


FIGURE 7: FEATURE SITES AND BEACH SEGMENTS WHERE STREAMS WERE OBSERVED ENTERING THE GRAND TRAVERSE BAY

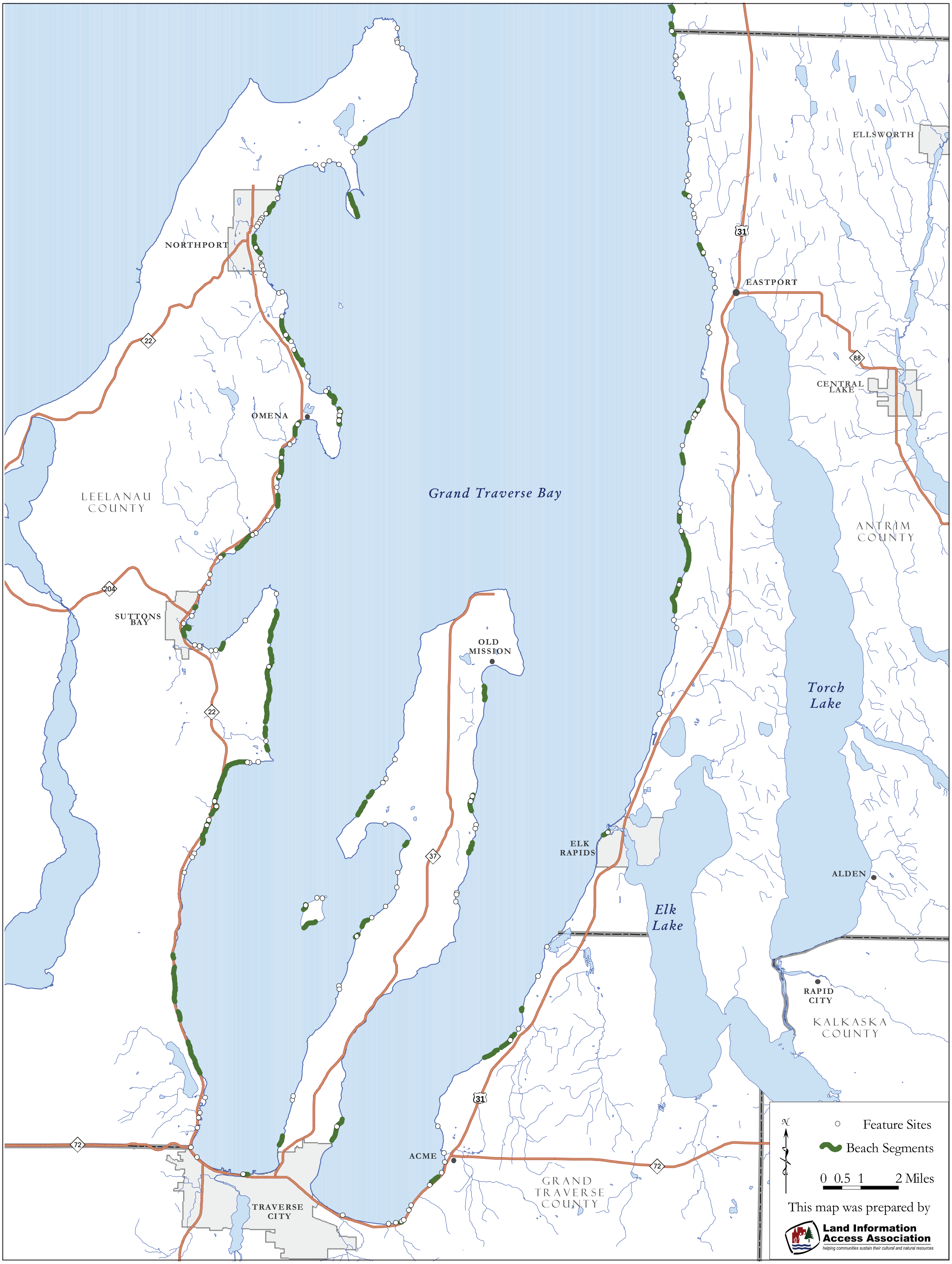


FIGURE 8: FEATURE SITES AND BEACH SEGMENTS WHERE STREAMS AND/OR GROUNDWATER SEEPS WERE NOTED

Click Here to Return to the
Grand Traverse Bay Watershed
Protection Plan

Appendix B

Summary of EGLE PAH Monitoring

Appendix B:
Summary of EGLE PAH Monitoring
(Memo from TWC to the City of Traverse City)

MEMO

TO: Stormwater Utility Ad Hoc Committee, Richard Lewis
FROM: The Watershed Center Grand Traverse Bay, Christine Crissman
DATE: March 25, 2019
SUBJECT: Summary of DEQ Sediment Testing for PAHs in Traverse City

In late August 2018, a team from the Michigan Department of Environmental Quality (DEQ) analyzed 20 locations in Traverse City for contamination in the sediments. In November 2018, The Watershed Center was provided the following results.

Ten surface lots were chosen to be scraped and analyzed using the quick field method that tests for the presence or absence of coal tar sealants. Of the 10 sites selected, 4 were not able to be sampled. All of the remaining 6 sites tested positive for coal tar sealants. Site-specific results are found in Table 1 (site location details available upon request).

Table 1. Results of surface scrapings of parking lots using the quick field method

Central United Methodist	Riverview Terrace	J&S Hamburger	City Lot	Kids Creek	Munson	Munson North	Bill Marsh Hyundai	McDonalds	Vet Counseling
Not sampled (not sealed)	Mixed asphalt – coal tar sealant	Not sampled (small, low impact lot)	Not sampled (not sealed)	Coal tar sealant	Not sampled (ramp construct-ion)	Coal tar sealant	Coal tar sealant	Coal tar sealant	Coal tar sealant

Ten separate locations were selected for analysis of chemicals to calculate Total PAH17. Total PAH17 was analyzed for both Probable Effects Concentration (PEC; concentration that adverse effects are expected to occur more often than not) and Threshold Effect Concentration (TEC; concentration below which adverse effects are not expected to occur). As shown in Table 2, only one location exceeded the PEC for Total PAH17 (Kids Creek Trib A south of the Elmwood Street culvert). This suggests potential PAH contamination and impacts to benthic communities. The remainder of the sample locations showed TEC exceedances.

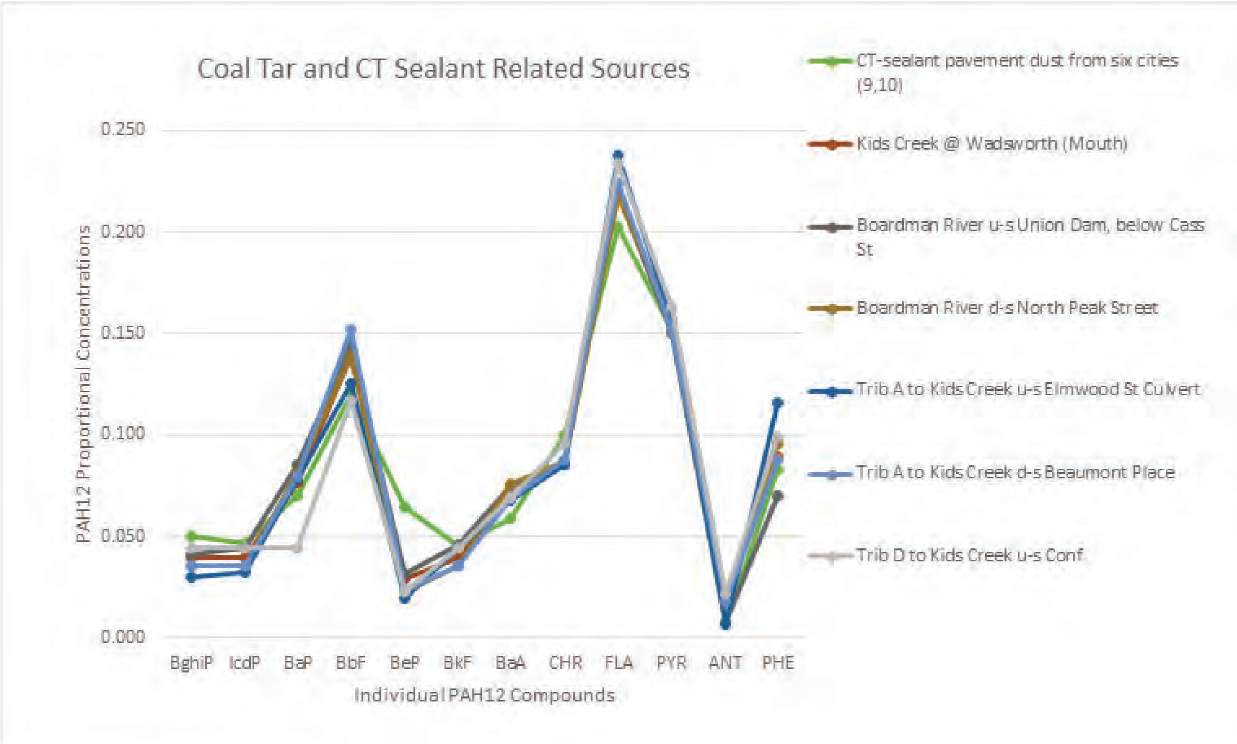
Table 2. PAH evaluation of sediments from Kids Creek, Trib A, Trib D, and Boardman River (red=exceeds PEC; yellow=exceeds TEC)

	Kids Creek at Wadsworth (mouth of creek)	Boardman Rv. u-s Union Dam	Boardman Rv. d-s Park St.	Trib A Kids Creek u-s Elmwood St.	Trib A Kids Creek u-s 6th St	Trib A Kids Creek d-s Beaumont Pl.	Kids Creek u-s 7th St	Trib D Kids Creek u-s confluence	Kids Creek u-s confluence of Trib D	Trib D Kids Creek d-s McDonalds
Total PAH17	9,815	20,620	12,975	30,575	10,820	14,090	5,275	9,985	5,715	7,810

Concentrations below the PEC are locations the DEQ generally does not have a concern with. However, there are some individual PAH analyses within these locations that exceed their individual PECs, which is an indication there may be some contamination issues happening at these sites. Further analyses were conducted at these sites, and results are available upon request.

To understand if these elevated PAH levels were the result of coal tar sealant pavement dust, the DEQ compared results from these locations to a six city average established by Van Metre et al. 2008 (Figure 1). The data which best captures the sediment results and the relation to the coal tar six city average are below. The DEQ concluded this analysis suggests the best fit source as coal tar dust compared to a six city and seven city average from previous studies.

Figure 1. PAH12 Proportional concentrations.



Conclusion

These results show that PAH levels are elevated in our riverine sediments in both Kids Creek and the Boardman River. In one location on Trib A of Kids Creek, PAH levels exceeded the concentration where adverse effects are expected to occur more often than not. In all other locations, PAH levels exceeded the concentration below which adverse effects are not expected to occur. Data indicates it is highly likely that the source of these elevated levels is coal tar sealant products.

APPENDIX C

E. COLI RESULTS FOR VARIOUS STORMDRAINS IN TRAVERSE CITY (BY LOCATION)

Appendix C:
E. coli Results for Various Stormdrains in Traverse City (by location)

Date	Site	Ecoli, MPN col/100mL	Turbidity	Rainfall in previous 24 hours
11/9/2000	8th Street	51,330		
7/22/2009	8th Street - #1 u/s	>2419		rain event (hard rain)
8/3/2009	8th Street - #1 u/s	>2419		rain event
7/22/2009	8th Street - #2 d/s	>2419		rain event (hard rain)
8/3/2009	8th Street - #2 d/s	>2419		rain event
9/19/2013	8th Street Drain u/s og separator	2,950		yes
9/19/2013	8th Street Drain d/s og separator	15,530		yes
10/3/2013	8th Street Drain u/s og separator	72,700		yes
10/3/2013	8th Street Drain d/s og separator	38,700		yes
7/3/2012	8th Street Drain	61,300	10.3	0.3 Inches
7/25/2012	8th Street Drain	21,430	39.6	0.2 inches
8/16/2012	8th Street Drain	241,920	41.9	0.65 inches
9/7/2012	8th Street Drain	198,630	12.8	0.25 in
11/9/2000	Bryant Park	15,300		
7/22/2009	Bryant Park	>2419		rain event (hard rain)
8/3/2009	Bryant Park	1,203		rain event
8/10/2010	Bryant Park (drain #1)	35		
8/12/2010	Bryant Park (drain #1)	210		
8/19/2010	Bryant Park (drain #1)	>2419		
9/1/2010	Bryant Park (drain #1)	>2419		
9/2/2010	Bryant Park (drain #1)	>2419		
9/20/2010	Bryant Park (drain #1)	387		
9/23/2010	Bryant Park (drain #1)	899		
10/26/2010	Bryant Park (drain #1)	>4838		
8/2/2011	Bryant Park (drain #1)	9,208		
9/19/2011	Bryant Park (drain #1)	3,448		
9/21/2011	Bryant Park (drain #1)	10,460		
12/14/2011	Bryant Park (drain #1)	>2419		
3/12/2012	Bryant Park (drain #1)	4,654		
8/19/2010	Bryant Park (drain #2)	>2419		
9/1/2010	Bryant Park (drain #2)	>2419		
9/2/2010	Bryant Park (drain #2)	1,046		
9/23/2010	Bryant Park (drain #2)	3,921		
10/26/2010	Bryant Park (drain #2)	>4838		

Date	Site	Ecoli, MPN col/100mL	Turbidity	Rainfall in previous 24 hours
8/2/2011	Bryant Park (drain #2)	19,863		
9/19/2011	Bryant Park (drain #2)	17,329		
9/21/2011	Bryant Park (drain #2)	5,040		
12/14/2011	Bryant Park (drain #2)	>2419		
8/2/2011	East Bay Drain North	6,867		
9/19/2011	East Bay Drain North	>24,192		
9/21/2011	East Bay Drain North	32,550		
12/14/2011	East Bay Drain North	>2419		
3/12/2012	East Bay Drain North	445		
5/2/2012	East Bay Drain North	3,090		
7/3/2012	East Bay Drain North	14,700	7.13	0.3 Inches
7/25/2012	East Bay Drain North	19,180	29.2	0.2 inches
8/16/2012	East Bay Drain North	19,350	20.1	0.65 inches
9/7/2012	East Bay Drain North	241,920	3.78	0.25 in
7/22/2009	East Bay Park - #1 u/s	>2419		rain event (hard rain)
8/3/2009	East Bay Park - #1 u/s	>2419		rain event
11/9/2000	East Bay Park	80,000		
8/2/2011	East Bay Drain South	17,329		
9/19/2011	East Bay Drain South	24,192		
9/21/2011	East Bay Drain South	6,500		
12/11/2011	East Bay Drain South	>2419		
3/12/2012	East Bay Drain South	160		
5/2/2012	East Bay Drain South	4,570		
7/3/2012	East Bay Drain South	13,100	7.22	0.3 Inches
7/22/2009	East Bay Park - #2 d/s	>2419		rain event (hard rain)
8/3/2009	East Bay Park - #2 d/s	1,986		rain event
7/22/2009	Hannah Park - #1 u/s	1,986		rain event (hard rain)
8/3/2009	Hannah Park - #1 u/s	1,733		rain event
7/22/2009	Hannah Park - #2 d/s	>2419		rain event (hard rain)
8/3/2009	Hannah Park - #2 d/s	921		rain event
8/3/2009	Holiday Inn - #1 u/s	5		rain event
8/3/2009	Holiday Inn - #2 d/s	26		rain event
11/9/2000	Hope Street	487		
11/9/2000	Maple Street	2,700		

Date	Site	Ecoli, MPN col/100mL	Turbidity	Rainfall in previous 24 hours
8/18/2015	Sunset Drain	3		yes
8/19/2015	Sunset Drain	517		yes
8/24/2015	Sunset Drain	100		yes
9/3/2015	Sunset Drain	620		yes
7/3/2012	Sunset Park Drain	130,000	3.78	0.3 Inches
7/25/2012	Sunset Park Drain	5,760	44.2	0.2 inches
8/16/2012	Sunset Park Drain	111,990	9.22	0.65 inches
9/7/2012	Sunset Park Drain	7,890	4.98	0.25 in
7/22/2009	West End	1,986		rain event (hard rain)
8/3/2009	West End	326		rain event
7/3/2012	West End Drain	1,200	22.1	0.3 Inches
7/25/2012	West End Drain	1,850	9.4	0.2 inches
9/7/2012	West End Drain	19,180	150	0.25 in
9/7/2012	West End Drain #2 (West)	9,600	29.4	0.25 in
7/3/2012	West End West Drain	4,400	17.8	0.3 Inches
7/25/2012	West End West Drain	1,850	10.7	0.2 inches
8/16/2012	West End West Drain	5,460	15.1	0.65 inches
9/7/2012	West End West Drain	12,740	20.2	0.25 in

- Data sources:
  - *TWC Stormwater Project with City of Traverse City funds (2009)*
  - *TWC Beach testing with City of Traverse City funds (2015)*
  - *TWC - GLRI Project at Bryant Park (2011/2012)*
  - *TWC - GLRI Project at East Bay Park (2011/2012)*
  - *USGS funded stormdrain study 2010-2012*

APPENDIX D

STAKEHOLDER INPUT AND SOCIAL INDICATORS SURVEY SUMMARIES

Appendix D:
Stakeholder Input and Social Indicators Survey Summaries

Summary of Findings from Community Outreach Activities for Watershed Planning Grant

Meeting	Highlights
Antrim County Community Meeting **20 Attendees**	• Viewed the watershed as a source of recreation (such as swimming, boating, fishing, kayaking, ice skating, cross-country skiing) and enjoy the wildlife it supports. • Value the uniqueness of the watershed and its natural beauty and tranquility. • Concerns over invasive species, stormwater runoff, loss of wildlife, and wetlands. • They also reported being concerned about direct human impacts, such as a lack of education, especially among those who are new to the area, use of phosphorus fertilizer, and a sense of complacency. • Reported seeing poor farming techniques, inappropriate disposal of human waste (both directly and through septic systems and boats), and hardscaping along the water's edge. • Priority concerns are harmful behavior on inland lakes, as well as stormwater runoff
Grand Traverse County Community Meeting **60 Attendees**	• View the watershed as a source of recreation (such as sailing, swimming, fishing, and socializing) as well as a utilitarian asset (such as a source of drinking water and resource for agriculture, transportation, and tourism). • Appreciate the spiritual aspects, such as the bay, and see it as a key economic driver • Concerns and threats align with what has been portrayed in the news, including Line 5, Nestlé's withdraw of groundwater, and plastic pollution • Also expressed concerns over pharmaceuticals in the water, a lack of code enforcement from all levels of government, climate change, land use and population growth, and the impact of increased development. • Believe that major local events (such as Cherry Festival) and niche audiences (such as the boating community) degrade water quality - multiple mentions of illegal dumping of waste (both trash and fecal matter) into the bay from boats. (NOTE: Further research into this may support these concerns, but at a minimum, it highlights the need for increased education regarding this matter.) • Priority actions related to Line 5, stormwater treatment, and septic systems. Priority locations were broad and included the Boardman River, Mitchell Creek, the bottom of west bay, and industrial parks
Leelanau County Community Meeting **4 Attendees**	• View the watershed as a place for urban access and wildlife haven • Value the woods, water, and recreational opportunities and see the watershed as a place people chose to live because of the water; concerned that others do not value nature for its intrinsic value; rather, they only see it as something that increases property value. • Concerned over shrinking natural areas, paving of dirt roads, storm sewers, and septic systems. • Priority actions include prioritizing stormwater, adding trees and "wild spaces," and public education on maintaining water quality. NOTE - This was least attended community meeting and the highlights are reflective of the small group; NONE of the attendees live or work in Leelanau County but do live in the watershed.

Meeting	Highlights
Local Government Officials – Survey Findings **21 Respondents**	• Like many other respondents, local government officials feel that water is a defining characteristic of our region and is valuable to residents and tourists for recreation and quality of life. It is one of the most important assets in our area. They believe that our watershed provides natural, economic, and social benefits. • Top noted concerns were sediment, nutrients, invasive species and development. • Officials responded that comments at a public hearing or community meeting was the top way to make them look further into a water quality issue. Second to that were letters and phone calls. • Respondents were aware of many activities going on in the watershed including beach monitoring, the Boardman River Dams Project, stream restoration work, green infrastructure, and road stream crossing improvements. • They see the following as issues that degrade water quality in the community: septic systems, stormwater runoff, lack of riparian buffers, culvert sizes at road crossings, lack of erosion control activities during construction, lack of proper shoreline protection and/or stormwater runoff measures.

Excerpt from the Elk River Chain of Lakes Watershed Management Plan

Chapter 8.2 Social Indicators Survey

A social indicators survey was administered over the course of 2016-2017 by Tip of the Mitt Watershed Council to understand community members' and leaders' stance on issues surrounding ERCOL Watershed resources. The results of this survey are summarized below and are used to inform the following sections of the Watershed Management Plan.

The long-term protection of the Elk River Chain of Lakes (ERCOL) Watershed largely depends on the actions of its residents and visitors. Educating and increasing awareness of how their actions impact water quality is a priority. Effective communication is the vehicle for education, and ultimately, to change attitudes that lead to better water quality protection efforts.

Seasonal and permanent riparian property owners, landscape professionals, local government officials, developers, and many other groups comprise the overall ERCOL Watershed audience; however, more narrow, or target, audiences should be addressed through the appropriate information and education lens.

A significant step toward better understanding current attitudes of Watershed citizens was made from 2017-2019, as part of the EGLE 319-funded "Elk River Watershed Protection" grant. Tip of the Mitt Watershed Council coordinated the Social Indicators Survey component of the grant. Surveys of three distinct audiences within the Watershed were conducted. The surveys were designed to assess the attitudes and practices of watershed residents, local elected and appointed officials, and shoreline property owners.

The survey response rates were good. Survey information for the more rural watersheds in Michigan, like the ERCOL Watershed, is not typically available. Therefore, this insight is very valuable for formulating information and education actions.

Watershed Residents Survey, October-December 2017
Sent: 932; received responses: 233 = 25% return
The majority of the 233 responses came from homeowners, with less than 1% responding that they are renters. The majority lived in an isolated, rural, non-farm residence, followed by those who lived in a town, village, or city. 66% were male, 34% female. Most respondents were in the age range of mid-50s to mid-70s.

Local Officials Survey, March-June 2018
Sent: 246; received responses: 74 = 30% return
Of the 74 responses, 57% were male, 43% female. Most respondents were in the age range of late-50s to early-70s. 53% were elected officials, 34% were Planning Commissioners, and 13% served on Zoning Boards of Appeal. The majority of respondents were township officials at 54%, followed by 32% from villages and 14% from the county.

Shoreline Property Owners Survey, November 2018 – March 2019
Sent: 807; received responses: 323 = 40% return
The 323 responses came from homeowners who live here both year-round and for some part of the year: 44% of responses were from people who live here as their primary residence, and 56% use this home as a secondary residence. 65% were male, 35% female. Most respondents were in the age range of mid-50s to mid-70s.

Summary of All Surveys Conducted
In all three surveys, watershed residents, shoreline property owners, and local officials all believe the following:

- ✓ Quality of our water is “good”
- ✓ There are few watershed impairments
- ✓ Economic stability depends on good water quality
- ✓ Not okay to reduce water quality to promote economic development
- ✓ Quality of life in their community depends on good water quality – lakes, rivers streams

Based on the results from the survey, the recommendations include:

1. General awareness education programs do not need to persuade residents or local leaders about the importance of good water quality, nor the relationship between water quality and economic development. Survey results indicate that watershed residents, shoreline property owners, and local officials have very positive attitudes about the value of water quality in the ERCOL Watershed. They strongly agree that both economic development and quality of life depends on good water quality.

2. Education programs should focus on specific pollutant and source risks, especially invasive species, Phosphorus, and sedimentation (dirt and soil) in the water. Although most survey respondents perceived few watershed impairments, all three groups viewed invasive aquatic plants and animals as the biggest problem. For watershed residents, this was followed by

concerns over sedimentation in the water. Shoreline property owners were next worried about Phosphorus. Local officials were next concerned about sedimentation.

3. Education programs targeting homeowners should concentrate on information, skills, and demonstrations of specific practices. The survey indicated that watershed residents are very willing to make changes to their lawn and garden practices, and perceive few limitations to doing so. Regarding fertilizer instructions, if it was relevant to use on their property, 43% of watershed residents said they are currently using them. 75% said they are willing to try this practice or already do so. There were no significant factors limiting their ability to implement this practice.

4. For watershed residents who have septic systems, 58% stated they have their systems pumped every 3-5 years to remove sludge, effluent, and scum from the tank. 77% either already use this practice or are willing to try it. This is another area ripe for education and outreach because importantly, they noted that no significant factors limited their ability to implement this practice.

Unfortunately, the watershed residents do not see a need for septic system oversight by either the Health Department or local governments. When asked if they wanted a reminder from the Health Department to get septic systems pumped or inspected, 73% of watershed residents said no; 10% said yes; and 17% said they did not know. When asked if a local government agency should handle inspection and maintenance of septic systems, 58% said no; 19% said yes; and 23% did not know.

By contrast, shoreline property owners were much more open to oversight by the Health Department or local governments. 66% said they would like a reminder to inspect and maintain septic systems; 33% said no; and 1% did not know. Local officials were opposed to Health Department oversight, but more open to local government oversight, answering 34% yes; 44% no; 22% did not know.

Since 86% of septic system owners have not had problems, the prevailing attitude is that things are fine. However, given the research done on this topic by the Watershed Council over the past few years, this is a topic in need of outreach and education. Watershed residents and local officials generally need more information on septic system health and oversight.

5. Knowledge of riparian buffer maintenance is lacking. This practice is for shorelines, so it is not unexpected that some watershed residents are unaware of this. However, we hope the general public will understand best practices for water quality and support their use on public lands, as well as private. For shoreline property owners, riparian buffer maintenance is more familiar. 56% said they currently use it. Those who do not use it said they never heard of it; were somewhat familiar; they know how to use it but do not; or it is not relevant. If not relevant, things like seawalls were noted. Only 5% said they are unwilling to try this practice, meaning broad outreach and education efforts should have a good chance of succeeding.

6. Focused attention is needed to increase awareness of watershed residents regarding newer practices such as rain gardens and porous pavement. Even though these techniques have been promoted and described in educational materials for some time, understanding and adoption rates

of these practices is low. Shoreline property owners were more aware of the use of rain gardens and the use of riparian buffer strips or greenbelts than watershed residents.

7. Education programs for watershed residents and shoreline property owners should focus on newsletters/brochures/fact sheets, where most of them seek information about water quality issues. Attractive web sites for local organizations should be a top feature, as the internet was their next source of information, followed by workshops, demonstrations, and meetings as a primary source.

8. Education programs for local officials should continue to focus on written materials and workshops/demonstrations/meetings. Written materials are the most common source of water quality information for local officials, followed by workshops, demonstrations, and meetings.

9. Information and education materials and education efforts should continue to be hosted and branded by the Antrim Conservation District, MSU Extension, and Tip of the Mitt Watershed Council, The Watershed Center Grand Traverse Bay, local Lake Associations, and the ERCOL-WPIT. These organizations have a long history of water quality education and the surveys indicated they are trusted information sources for watershed residents, shoreline property owners, and local officials.

10. Water quality education efforts for local officials should facilitate communication and coordination of water quality between neighboring communities. Even though cooperation between governmental units has been promoted by organizations and agencies, only 24% of local officials reported that they knew how to coordinate their water quality zoning provisions with neighboring communities, and just 27% indicated that their community uses the practice.

11. To reduce barriers to adoption or revision of water quality-related plan or zoning ordinance changes, education efforts could emphasize public participation in exploring options and crafting new/changed regulations. Local officials reported that the top barriers to changing planning and zoning practices to protect water quality are resistance to new regulations, concern about economic impacts, expense to develop new regulations, and approval by community residents. Public engagement throughout the process may help reduce those barriers.

12. The surveys of local officials and shoreline owners should be repeated periodically to assess change and effectiveness of educational programs. Surveys should be repeated every 3-5 years.

APPENDIX E

MITCHELL CREEK SOURCE TRACKING PROJECT FINAL REPORT

Coastal Grand Traverse Watershed Plan – Appendix E:

Mitchell Creek Source Tracking Project

Addendum to Coastal Grand Traverse Bay Watershed Plan

(EGLE Grant #2020-0006)

May 2024

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PROJECT INTRODUCTION

The Coastal Grand Traverse Bay Watershed Plan states that Mitchell Creek is currently experiencing problems with *E. coli* bacteria and as shown in Chapter 3.10, has levels above Michigan water quality standards. Mitchell Creek was added to the State's Impaired Waters List after an extensive monitoring program conducted by The Watershed Center Grand Traverse Bay (TWC) in 2015 (for results, see Tables 26 and 27 and Figure 12 in the coastal watershed plan). Prior to the 2015 sampling, TWC worked with Michigan State University (MSU), United States Geological Survey, Environmental Canine Services, and others to complete bacteria monitoring and source tracking studies that found high *E. coli* levels in Mitchell Creek and local beaches. Those studies indicated that some of the pathogen inputs found in Mitchell Creek and local beaches may be from human sources (for details, see Section 4.2 in the coastal watershed plan). As such, a high priority task listed in the coastal watershed plan was to "conduct a source tracking study to determine sources of bacteria impairment and identify and prioritize steps that should be taken to reduce bacteria input to the creek" (Recreation, Safety, and Human Health – RSHH Task 2). Mitchell Creek outlets into the east arm of Grand Traverse Bay next to Traverse City State Park Beach so there is a concern for public health, especially if the bacterial contamination is coming from human sources such as septic systems.

Shortly before the Coastal Grand Traverse Bay Watershed Plan was finalized, TWC was awarded a Department of Environment, Great Lakes and Energy (EGLE) Nonpoint Source Program grant in September 2020 to address RSHH-Task 2 (EGLE Grant #2020-0006). The goal of that project was to conduct a bacteria monitoring and source tracking study at select locations on Mitchell Creek to pinpoint the potential sources of contamination to address the bacterial impairment. The main objective was to determine if septic systems are impacting Mitchell Creek and are the cause of impairment. Secondarily, we wanted to determine if other sources of bacteria are adding to the impairment from canines, cows, pigs, or gulls.

A project team was formed with representatives from TWC, Grand Traverse County Health Department (GTCHD), MSU, and EGLE. This team met periodically to discuss project efforts and determine courses of action for completing the monitoring study. Since specific courses of action depended on initial results, this team met as frequently as necessary to determine the next steps. Progress reports were also given to the three municipalities that cover portions of the Mitchell Creek watershed – East Bay Township, Garfield Township, and City of Traverse City.

Since this project was still ongoing at the time the Coastal Grand Traverse Bay Watershed Plan was approved in May 2021, TWC is providing a summary of the results of this monitoring project as an appendix to the coastal watershed plan. Other supporting documents from this project include the Quality Assurance Project Plan (QAPP) that explains specific sample collection and analytical procedures, as well as a project summary report provided by staff from the MSU Environmental and Molecular Microbiology Laboratory (dated 12/28/2023). Both reports are available through TWC or EGLE. The MSU report provides a detailed summary and discussion of all analytical results in a comprehensive 97-page document including multiple tables and figures. Since that document is thorough and available upon request, our summary in this appendix will highlight major findings as well as key discussion points pertinent to the bacterial impairment.

SAMPLING OVERVIEW

The source tracking project consisted of surface water sampling at select locations on Mitchell Creek and groundwater flow determination and sampling at five locations. The project was broken up into the phases described below. Specific details on sample collection and analytical procedures are found in the project's Quality Assurance Project Plan (QAPP) and associated Addendums on file with EGLE. All water quality analyses were done by MSU's Environmental and Molecular Microbiology Laboratory except for *E. coli*, which was conducted by SOS Analytical.

- Phase 1a: Surface Water Sampling from Mitchell Creek: June 2021 – June 2022
  Six sample collection events were completed consisting of two wet weather and four dry weather events. A total of 10 surface water sites were chosen to isolate various tributaries and branches of Mitchell Creek for source tracking (Figure 1, Table 1). Samples were collected in triplicate (left, center, right) at each stream location. Initial tests run on all samples included *E. coli*, Coliphages, and *Clostridium perfringens*. Additionally, the project team determined that any sample with *E. coli* levels 300 col/100mL or higher would be run for source tracking analysis, which included markers for human, pig, gull, canine, and cow sources.

- Phase 1b: Groundwater Well Installation and Flow Determination: December 2021 – April 2022
  Groundwater wells were drilled in five locations around a subdivision in the Mitchell Creek watershed to determine groundwater flow direction (Figure 2, Table 2). This is an area where septic systems are suspected of sitting at or below groundwater levels and potentially contributing to elevated bacteria levels. Determining the direction of groundwater flow helped us understand where groundwater was going after leaving the subdivision and where it was potentially entering the creek. Two water level gauging events were completed (12/9/2021 and 4/20/2022) to assess potential variations to the direction of groundwater flow resulting from seasonal fluctuations to the groundwater table.

- Phase 2: Groundwater Well Water Quality Sampling: June – October 2022
  After surface water samples were collected, initial source tracking analyses were run, and the groundwater flow determination was completed, the project team met to discuss results. At that time, the project team deemed it necessary to sample the groundwater wells. Two samples were collected from each of the five groundwater wells established in Phase 2b (October 2022 and May 2023). All samples were run for *E. coli*, Coliphages, and *Clostridium perfringens*, as well as the human marker for microbial source tracking (regardless of *E. coli* level).

- Phase 3: Additional Surface Water Sampling from Mitchell Creek: July – October 2023
  After completing all surface water sampling, the project team decided it would be beneficial to conduct additional wet weather sampling in late 2023. This sampling included microbial source tracking (MST) analyses for human and pig markers only, as well as the addition of virus testing to assess the potential threat to public health from surface water sites exhibiting elevated *E. coli* levels in Mitchell Creek. Initial tests run on

all samples included *E. coli*, Coliphages, and *Clostridium perfringens*. Any sample with *E. coli* levels 300 col/100mL or higher were run for microbial source tracking analysis (humans and pigs only) as well as Enterovirus, Adenovirus, and Norovirus. This additional wet weather sampling included three additional sites in the upper tributaries of Mitchell Creek to determine the potential extent of bacterial contamination (Sites #11, #12, and #13 in Table 1 and Figure 1). Three sites (Sites #7, #9, and #10 in Table 1 and Figure 1) were also dropped from the original sampling set because of cost considerations as well as the low indication that pigs or human sources are a problem at these sites.

Table 1: Mitchell Creek Sampling Locations

Site ID	Stream Name	Location	Location: Lat., Long.
MC-1	Mitchell Creek (East Main Branch)	Off 3 Mile Rd, north side of parking lot at State Farm Insurance building	44.747881, -85.558112
MC-2	Mitchell Creek (West Main Branch)	Runs parallel to 3 Mile Rd, west side of parking lot at State Farm Insurance building	44.747950 -85.558462
MC-3	Mitchell Creek (Main Branch)	East side of intersection of S. Airport and 3 Mile roads, ~100ft south of intersection	44.735566, -85.556148
MC-4	Mitchell Creek (Main Branch)	d/s of Townline Rd crossing (south of S. Airport Rd)	44.73008, -85.575003
MC-5	Unnamed Trib to Mitchell Creek	d/s of Chesapeake Ct road crossing off Townline Rd	44.728672, -85.573334
MC-6	Mitchell Creek (Main Branch)	u/s of Woodcreek Blvd road crossing, near entrance to Woodcreek Subdivision entrance off S. Airport Rd	44.732859, -85.566212
MC-7*	Unnamed Trib to Mitchell Creek	In Woodcreek Subdivision on Woodcreek Blvd near Teal Ln *NOTE: This site was dry the entire sampling period*.	44.731451 -85.564291
MC-8	Unnamed Trib to Mitchell Creek	In Woodcreek subdivision u/s of Woodcreek Blvd road crossing near Buttermilk Loop	44.733364, -85.558630
MC-9*	Vanderlip Creek	d/s of road crossing under driveway to Mitchell Creek Meadow Preserve off Three Mile Rd	44.727273, -85.555397
MC-10*	Four Mile Creek	u/s of road crossing on Vanderlip Rd *NOTE: there are two tributary crossings of Mitchell Creek on Vanderlip Road; this is the EAST one, just west of 90-degree turn*	44.722750, -85.545572
MC-11**	Mitchell Creek (West Main Branch)	Hughs Dr crossing u/s of Hammond Rd	44.708995, -85.591226
MC-12**	Unnamed Trib to Mitchell Creek	Hammond Rd crossing east of Townline Rd	44.715195, -85.578160
MC-13**	Unnamed Trib to Mitchell Creek	Hammond Rd crossing west of Townline Rd (by Elmbrook Golf Course)	44.715210, -85.571519

*Not sampled in summer/fall 2023
**New sample site for summer/fall 2023

Figure 1: Mitchell Creek Sampling Locations

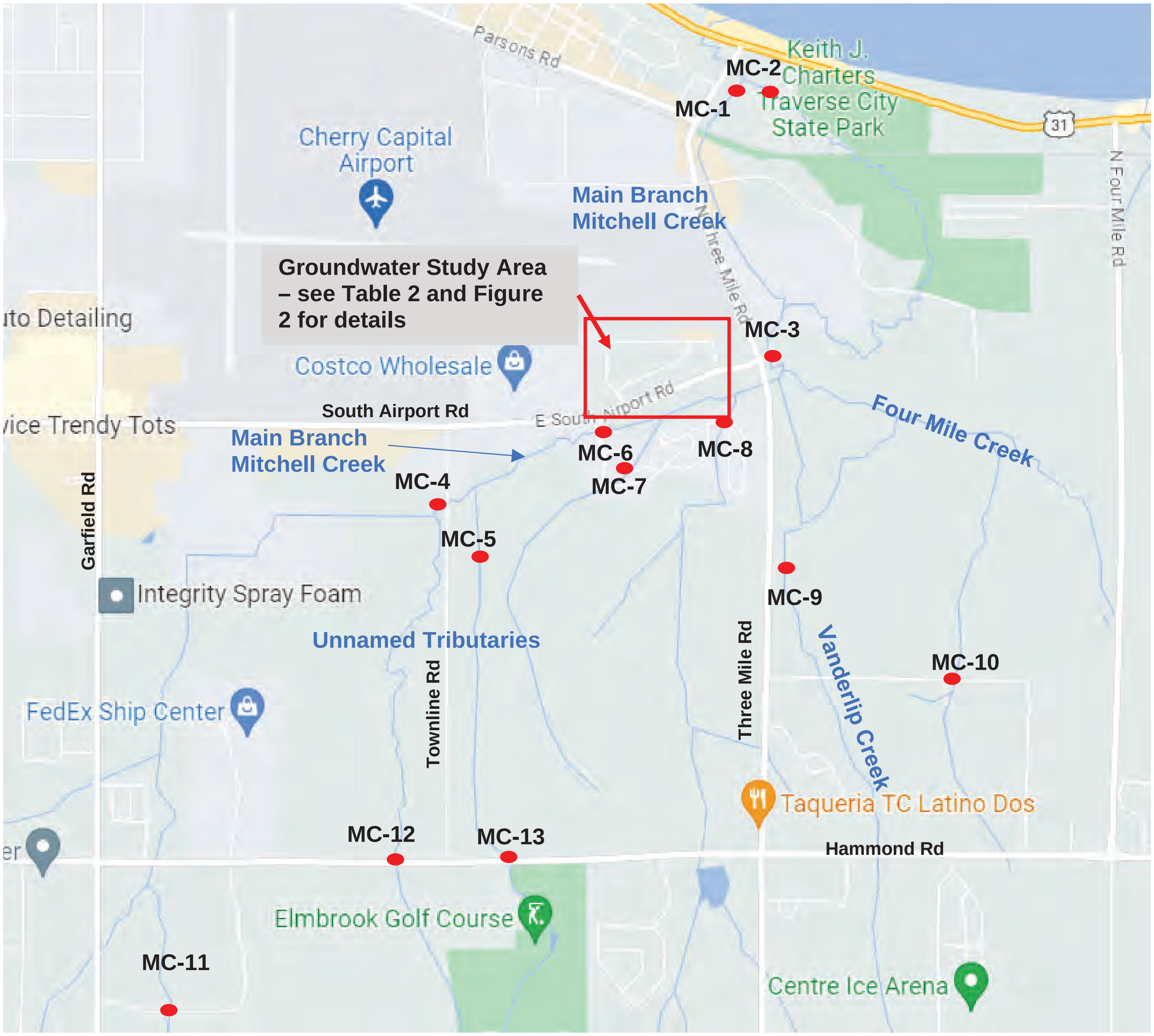
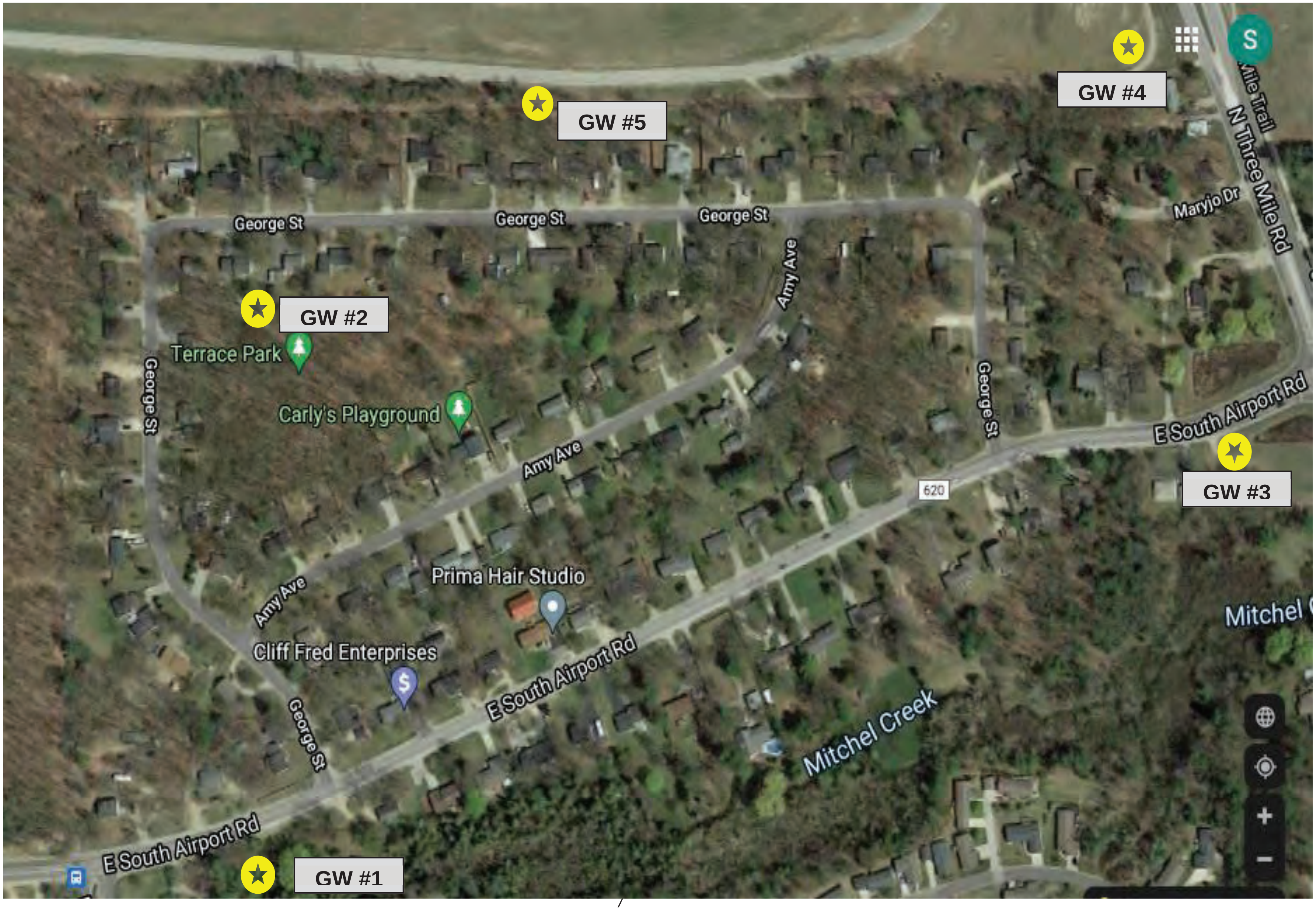


Table 2: Mitchell Creek Groundwater Well Locations

Site ID	Location	Location: Lat., Long.
GW #1	Woodland Creek Estates property on south side of S Airport Rd, just east of entrance at Woodland Creek Blvd,	44.733314, -85.565750
GW #2	Backyard near treeline of private residence at 572 George St	44.736177, -85.565338
GW #3	SW corner of S Airport Rd and Three Mile Rd on Grand Traverse County Road Commission Right of Way between existing detention area and concrete driveway	44.735587, -85.557558
GW #4	Cherry Capital Airport property, close to SW corner of property near Three Mile Rd	44.737571, -85.558540
GW #5	Cherry Capital Airport property, along southern border approximately 380 yards west of GW #4	44.737269, -85.562873

Figure 2: Mitchell Creek Groundwater Well Locations
(see Figure 1 for overall location in the watershed)



RESULTS & DISCUSSION

Surface Water Sampling

A total of 82 samples were obtained for *E. coli* analysis (40 dry weather, 42 wet weather). This included duplicate samples taken for quality control purposes. Results are shown in Appendix 1. A total of 74 samples (excluding duplicates) were sent to MSU's lab for fecal indicator analysis for Coliphages (Somatic and F-specific) and *Clostridium perfringens*. Of those 74 samples, 47 were above the 300 col/100mL threshold for *E. coli* and were chosen for microbial source tracking (MST) analysis for human, cow, pig, gull, and canine markers (15 dry weather, 32 wet weather). Table 3 provides a summary of the samples collected as well as the number and types of MST samples run. MC-4, MC-5, and MC-8 had the most occurrences of samples above that threshold, even during dry weather.

A list of the MST marker sequences and their literature references can be found in Appendix 2, as well as a compilation of sensitivity and specificity studies available for these markers. As stated previously, staff from the MSU Environmental and Molecular Microbiology Laboratory wrote a comprehensive, detailed summary report and discussion of all results from this study. Our summary here will highlight major findings and key discussion points from that report.

When interpreting results, it is helpful to know general characteristics of each of the fecal indicators tested in our study – see box below.

Indicators for fecal contamination:

- ***E. coli*:** Bacteria that is the State of Michigan standard for recreational and impaired waters associated with fecal contamination.
- ***Clostridium perfringens:*** Bacteria found in intestinal tracts of animals (not specific to humans). Forms spores so it may persist for years in nature. Often used to indicate "older pollution" and materials resuspended from sediments.
- **F-specific and Somatic Coliphage Viruses:** Both are viruses found on *E. coli* (not specific to humans). Somatic usually persists longer than F-specific. Both may be indicative of recent fecal pollution because neither regrows in the environment.

****When interpreting MST results, it is helpful to compare them to the fecal indicator results for *Clostridium perfringens* and the Coliphage viruses to determine if the pollution source might be new/fresh or older. ****

Table 3: Summary of Sample Collection

Date	Wet/Dry	Total Samples Collected (not including duplicates)	Total Samples Chosen for MST	MST Markers Run
7/12/2021	Dry	9	5	All*
8/4/2021	Dry	9	7	All*
9/20/2021	Dry	9	3	All*
10/4/2021	Wet	9	8	All*
10/18/2021	Dry	9	0	N/A
6/7/2022	Wet	9	9	All*
9/12/2023	Wet	10	8	• *B. theta* and HF183 • Pig • Viruses
10/25/2023	Wet	10	7	• *B. theta* and HF183 • Pig • Viruses
Totals	**4 Dry** **4 Wet**	**74 (36 dry, 38 wet events)**	**47 (15 dry, 32 wet events)**	

*MST markers include the following: human *B. theta* and HF193, pig, cow, canine, and gull

Fecal Indicators – *E. coli*

While the sampling program for *E. coli* in this study differs from TWC's intensive 5-week study performed in 2015 that led to Mitchell Creek being added to the Impaired Water List, results indicate that Mitchell Creek is still impaired and experiences elevated bacteria levels.

This study shows elevated levels of *E. coli* above state water quality standards (WQS) at almost all sites at some point during both wet and dry weather sampling events (Table 4). In fact, 88% of wet weather samples collected during Phase 1 and 74% of samples in Phase 3 exceeded WQS for at least partial body contact. Almost half (46%) of samples collected during the Phase 1 sampling for dry events exceeded WQS as well.

Sites MC-4, MC-5, and MC-8 had the most instances of *E. coli* above WQS with samples exceeding 88% of the time. Those sites even exceeded WQS during most dry weather sampling. MC-1 and MC-2 were the next highest, with 75% of samples over WQS. Sites MC-9 and MC-10 had the least amount of *E. coli* during Phase 1 sampling, while MC-10 had no exceedances and MC-9 only exceeded WQS during wet events. The headwater sites of MC-11, MC-12, and MC-13 that were added for wet weather sampling in Phase 3 had one exceedance at site MC-13, the rest were below WQS.

Table 4: Summary of *E. coli* Water Quality Standards Exceedances by Site and Sample Type

Sample Type	Date	Location											
		MC-1	MC-2	MC-3	MC-4	MC-5	MC-6	MC-8	MC-9	MC-10	MC-11	MC-12	MC-13
Phase 1 Sampling													
dry	7/12/2021	326	743	289	403	519	284	449	141	150	--	--	--
dry	8/4/2021	310	306	305	425	442	414	480	243	91	--	--	--
dry	9/20/2021	168	170	256	337	454	237	722	13	38	--	--	--
wet	10/4/2021	7,854	6,368	7,569	4,785	3,657	6,132	4,782	785	275	--	--	--
dry	10/18/2021	98	76	152	161	54	143	179	15	37	--	--	--
wet	6/7/2022	1,476	500	1,255	707	647	1,068	1,506	750	113	--	--	--
Phase 3 Sampling													
wet	9/12/2023	1,278	577	1,093	611	1,058	880	1,183	--	--	126	78	816
wet	10/25/2023	2,587	1,248	2,402	2,179	579	2,757	2,496	--	--	151	35	43
Number of exceedances		**6/8**	**6/8**	**5/8**	**7/8**	**7/8**	**5/8**	**7/8**	**2/6**	**0/6**	**0/2**	**0/2**	**1/2**

(light grey)	Exceeds Daily Partial Body Contact Standard (300col/100mL)
(dark grey)	Exceeds Daily Total Body Contact Standard (1,000col/100mL)

Percentage of Partial/Total Body Contact Exceedances by Type of Sample Event (Dry and Wet)

	MC-1	MC-2	MC-3	MC-4	MC-5	MC-6	MC-8	MC-9	MC-10	MC-11	MC-12	MC-13
% of all events	75%	75%	63%	88%	88%	63%	88%	25%	0%	0%	0%	50%
% of wet events	100%	100%	100%	100%	100%	100%	100%	100%	0%	0%	0%	50%
% of dry events	50%	50%	25%	75%	75%	25%	75%	0%	0%	n/a	n/a	n/a

Fecal Indicators – Coliphages and *Clostridium perfringens*

In dry weather sampling events, the Somatic Coliphage was generally present at low concentrations in surface waters and the F-specific Coliphage detection was sporadic and low when found (Figures 3a and 3b). Since neither regrows in the environment and they do not persist for a long time, this indicates a low level of fresh fecal contamination is being introduced to the watershed at all times. This is not surprising as animals can access the creek and wildlife will always be contributing to the load.

However, during wet weather events, Somatic Coliphage concentrations were higher than in dry events (Figure 3a). Additionally, a higher percentage of sites were also positive for F-specific Coliphage during wet weather events (Figure 3b). This indicates that rainfall is driving an increase in contamination levels of fresh fecal pollution.

Figure 3a: Somatic Coliphage Concentrations in Mitchell Creek Surface Water Sites

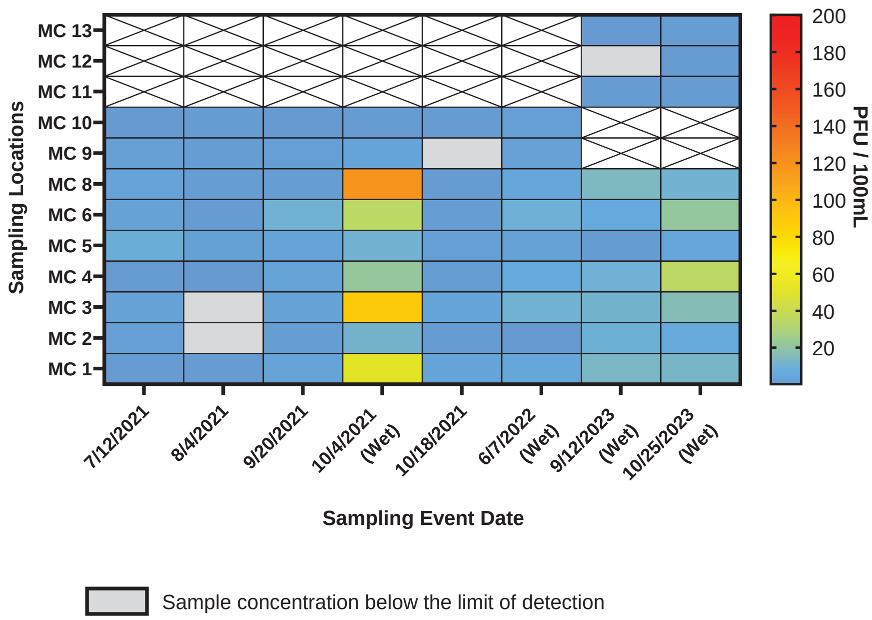
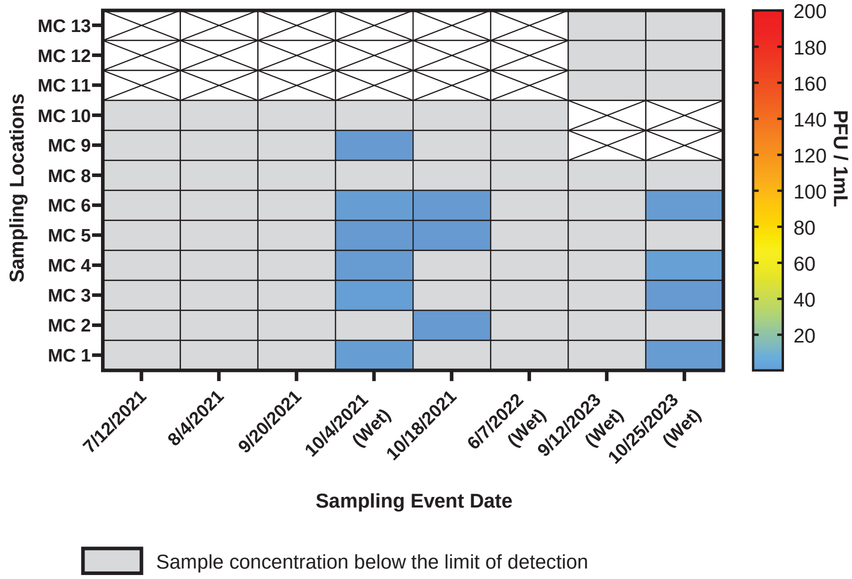
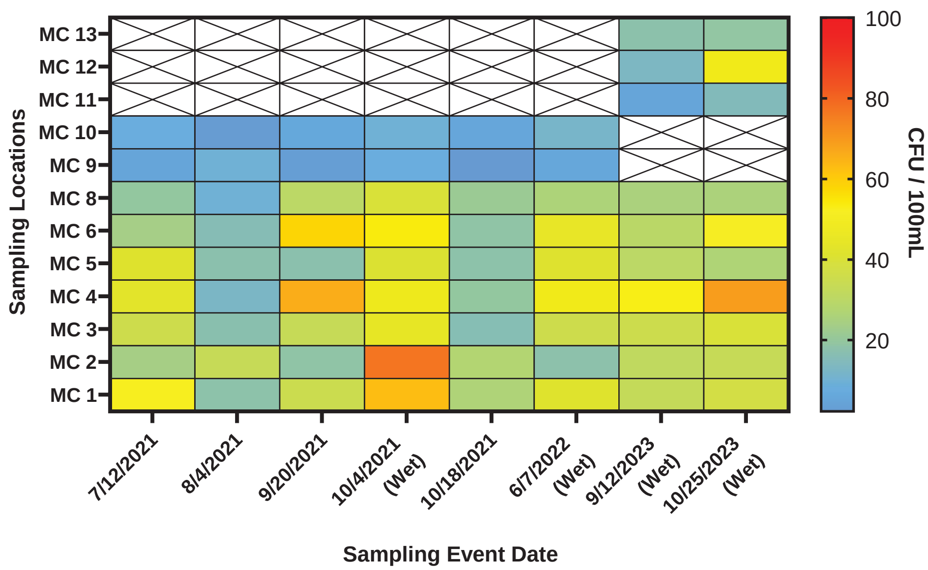


Figure 3b: F-specific Coliphage Concentrations in Mitchell Creek Surface Water Sites



Clostridium perfringens was detected in 100% of the surface water samples, with the highest concentrations observed during the four wet weather sampling events (Figure 4). The lowest concentrations were observed at sites MC-9 and MC-10 that are the eastern headwater tributaries, as well as MC-11 in the western headwaters. Although *Clostridium perfringens* detection was widespread, concentrations were generally low suggesting the presence of old contamination, contamination via aged/composted fecal material, or disturbances of sediments that release the organism's spores from an environmental reservoir.

Figure 4: *Clostridium perfringens* Concentrations in Mitchell Creek Surface Water Sites



Human Specific Markers

There are two types of *Bacteroides* human markers available for MST analysis – *B. theta* and HF183. The *B. theta* marker indicates more recent pollution since it is more sensitive and degrades faster than HF183. Initially, the project team intended to only run the *B. theta* marker; however, after reviewing initial results the project team decided to also run the HF183 marker on all the samples.

Both human markers were only present during wet weather sampling. The *B. theta* marker was only found in two samples at sites MC-3 and MC-6 on the main branch during a 2021 rain event (Figure 5a). The HF183 marker was found in nine samples at sites MC-1, MC-2, MC-3, MC-4, MC-5, MC-6, MC-8 (Figure 5b). Two of those nine samples were found at the same date and location as the *B. theta* (Figure 5b). Due to the stability of the HF183 marker in the environment, it is not surprising that seven samples were positive for HF183 but non-detect for *B. theta*.

When the project team met in 2022 to discuss running the HF183 marker on specific samples, we also decided to add two additional wet weather sampling events in 2023 because of the potential human sourced contamination found in previous samples. It is important to note that NO human markers were found in any wet weather samples taken in 2023.

Figure 5a: *B. theta* Human MST Marker Concentrations in Mitchell Creek Surface Water Sites

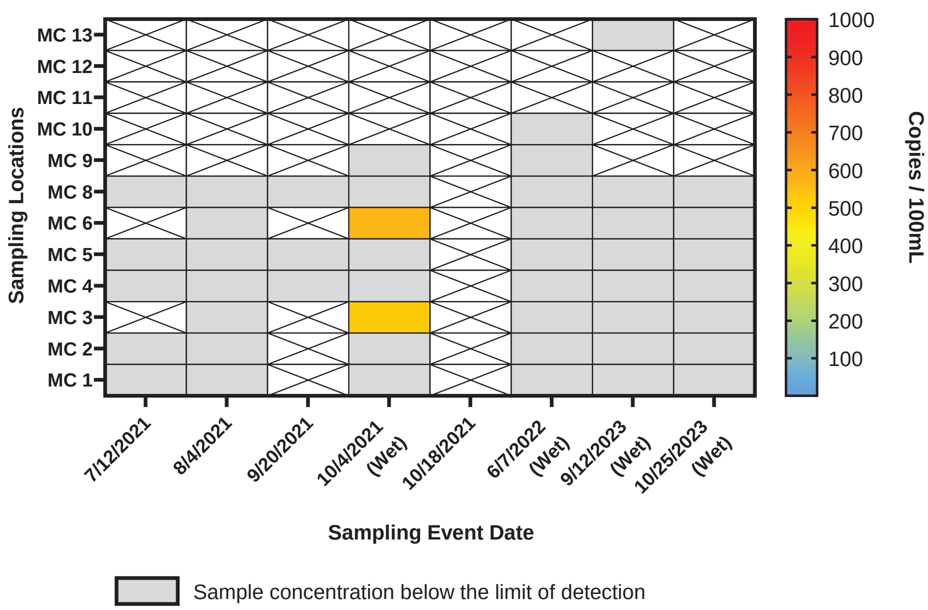
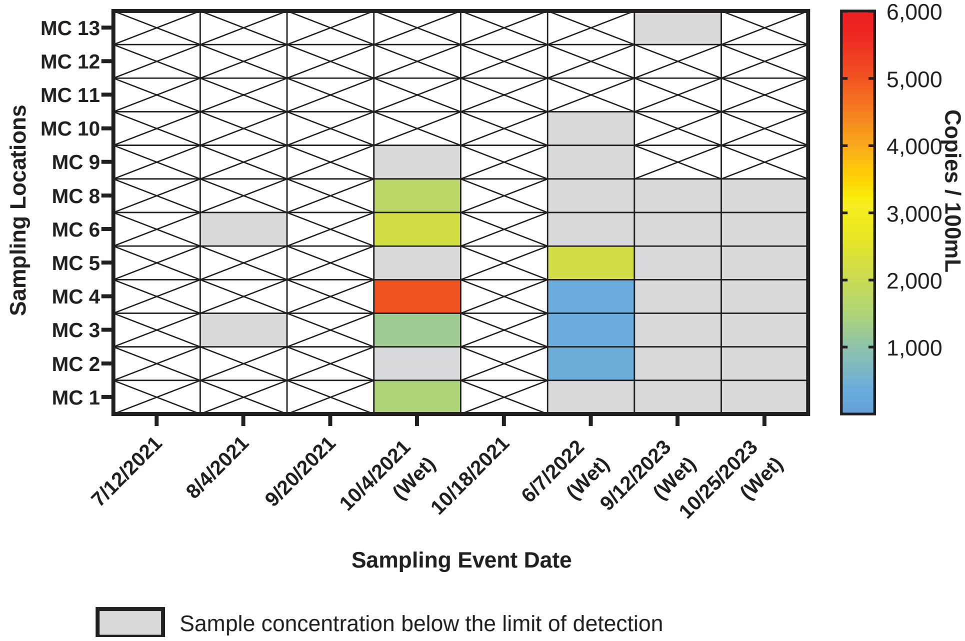


Figure 5b: HF183 Human MST Marker Concentrations in Mitchell Creek Surface Water Sites



Looking at the human MST results compared to the fecal Coliphage indicators during the 10/4/2021 wet weather sampling event, there were elevated levels of Somatic Coliphage, *B. theta*, and HF183 at sites MC-3 and MC-6 that suggests human fecal contamination was freshly introduced at these sites during wet weather (Figures 3, 5a, and 5b). Additionally, sites MC-1, MC-4, and MC-8 also tested positive for HF183 (but not *B. theta*) and had elevated Somatic Coliphage on 10/4/2021. For the wet weather sampling event on 6/7/2022, low levels of Somatic Coliphage were found with the HF183 human marker at sites MC-2, MC-3, MC-4, and MC-5.

However, occurrences of either fecal Coliphage indicator paired with human MST marker concentrations were not observed in the 9/12/2023 and 10/25/2023 wet weather sampling events.

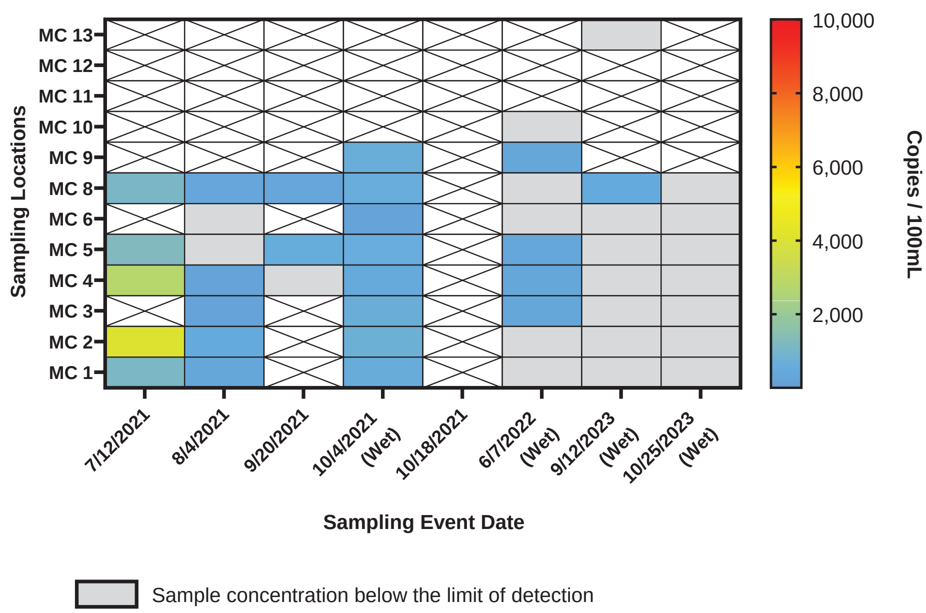
Pig (Porcine) Specific Marker

The pig marker is known to be fairly stable in the environment, persisting in freshwater for approximately 27 days. The longevity of the pig marker is affected by environmental conditions and how high the level was when the fecal material was fresh. Sediments may also act as an environmental reservoir, releasing the marker as sediments are disturbed and extending the detection time of pollution for months to a year.

The pig specific marker was detected in about half of the surface water samples, during both wet and dry weather sampling events (Figure 6). The pig marker was detected in 80% of the dry weather samples, 41% of the wet weather samples, and in every sample tested for the October 2021 wet weather sampling event. Elevated levels of Somatic Coliphage (Figure 3) and detection of the pig marker from the October 2021 wet weather samples suggest pig fecal contamination was being freshly introduced at those sites during this wet weather event. However, this pattern was not repeated in subsequent wet weather sampling; paired increases in the Somatic Coliphage and pig marker were lower in the June 2022 wet weather event and no pig markers were observed in either of the 2023 wet weather events.

Elevated levels of the pig marker at sites MC-2, MC-4, MC-5, and MC-8 during the July 2021 dry weather sampling event without observing a paired increases in either Coliphage concentration suggests an older pollution source, which would be consistent with land application of pig waste that has been properly aged/composted in storage prior to being land applied. In this case, the pig marker would persist and be observed but the accompanying fecal indicators would not. Except for MC-2, these sites are in the western tributaries.

Figure 6: Pig Specific Marker Concentrations in Mitchell Creek Surface Water Sites

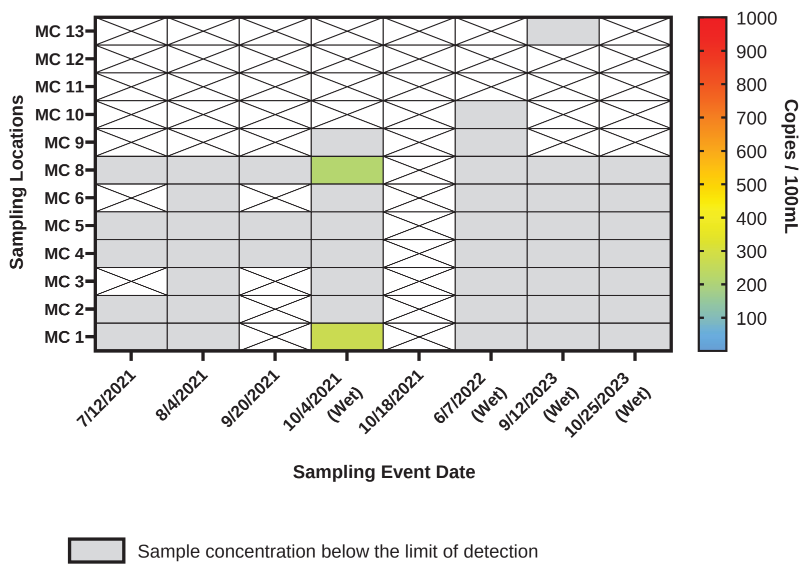


We also noted that the pig marker was found in almost all the samples tested in 2021 regardless of wet or dry weather sampling, most often at sites MC-8, MC-5, and MC-4 in the western tributaries. Because of the widespread detection of the pig marker in 2021 samples, the project team decided to test for the pig marker in additional wet weather samples collected in 2023. However, the pig marker was only found in a single sample at MC-8 in 2023.

Cow (Bovine) Specific Marker

The cow marker was virtually non-existent and only found at two locations, MC-1 and MC-8, during the 2021 wet weather sampling event (Figure 7). Elevated levels of Somatic Coliphage for those same samples could indicate possible cow fecal contamination was being freshly introduced at those sites during this wet weather event.

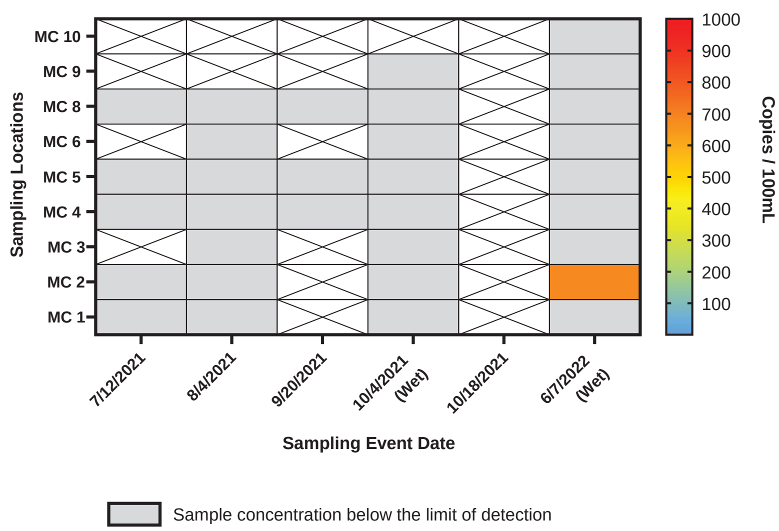
Figure 7: Cow Specific Marker Concentrations in Mitchell Creek Surface Water Sites



Gull (*C. marimmamalium)* Specific Marker

The gull marker was virtually non-existent and only found in one sample at MC-2 in the June 2022 wet weather sample (Figure 8).

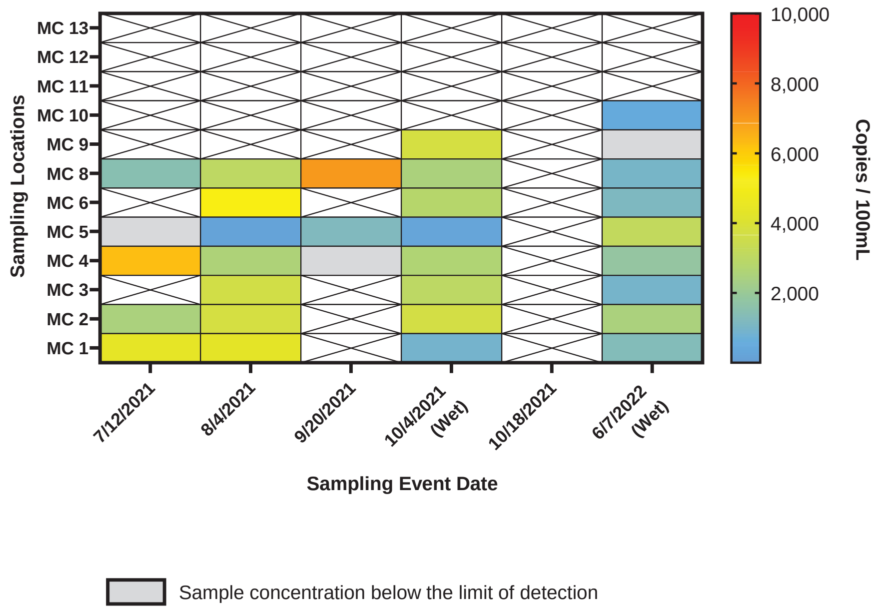
Figure 8: Gull MST Marker Concentration in Mitchell Creek Surface Water Sites



Canine Specific Marker

The canine marker used in this study detects dog fecal signatures but may also detect coyote and fox fecal signatures. The canine marker was widespread and found in almost all samples tested. It was found equally abundant in wet and dry weather sampling events. The high concentrations of the canine marker were not always paired with increases in the fecal indicator Coliphages (Figure 3), which suggests that at least some of the canine specific marker is being released from environmental reservoirs, such as sediment, from older contamination events.

Figure 9: Canine Specific Marker Concentration in Mitchell Creek Surface Water Sites



Virus Testing – Adenovirus, Enterovirus, Norovirus GII

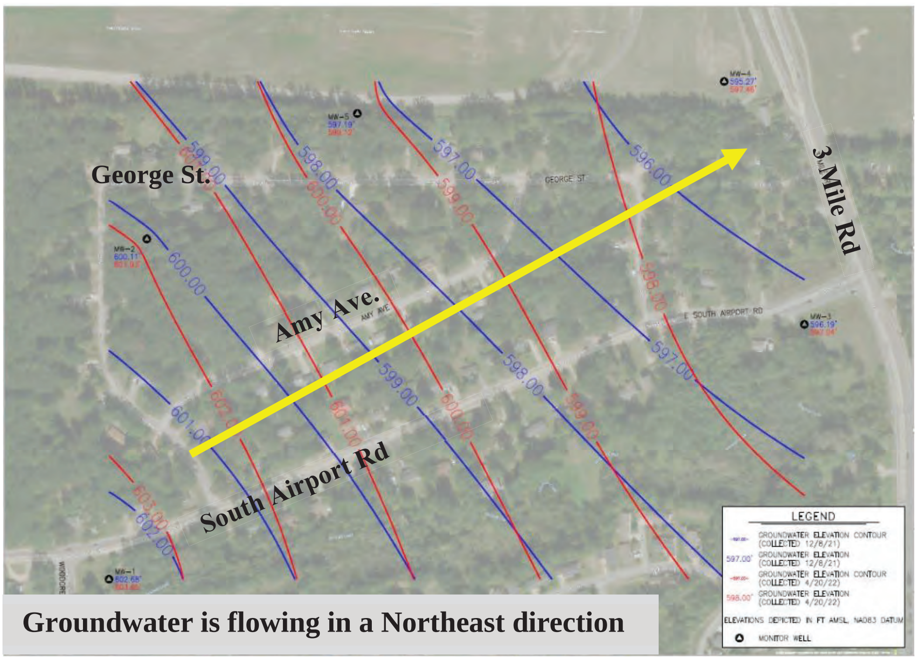
As stated previously, the project team decided to add virus testing for two additional wet weather sampling events in fall 2023 to assess the potential threat to public health from surface water sites in Mitchell Creek exhibiting elevated *E. coli* levels. Any sample with *E. coli* levels 300 col/100mL or higher was run for Enterovirus, Adenovirus, and Norovirus GII.

Neither the Adenovirus nor Norovirus GII molecular gene targets were detected in surface waters from either of the 2023 wet weather sampling events. The Enterovirus molecular gene target was detected in a single sample at MC-2 during the October 2023 sampling event, which suggests a potential input of fresh fecal material of human origin at this site. However, the HF183 and *B. theta* human marker genes were not detected at this site concurrently with the Enterovirus and Coliphages. The lower limit of detection of the Enterovirus assay was slightly more sensitive than the HF183 and *B. theta* human MST assay, which may explain this discrepancy in detection.

Groundwater Flow Analysis and Sampling

Water level gauging events for the five groundwater wells were completed in December 2021 and April 2022 to determine the directional flow of groundwater in the neighborhood. Septic systems in this neighborhood are suspected to be sitting at or near groundwater. Determining the flow of groundwater helped us determine if pollutants from these systems are making their way to and impacting the creek. Figure 10 shows results of the groundwater analysis and reveal that groundwater is flowing in a northeasterly direction out of the neighborhood. This is important to note because, looking at the neighborhood's location in the overall sampling map in Figure 1, if contamination is being transported via groundwater from this area, it wouldn't make it to the creek and be measured until sampling sites MC-1 and MC-2, and possibly MC-3.

Figure 10: Directional Groundwater Map for Study Area



Water samples were collected from all five groundwater wells in October 2022 and May 2023. All samples were run for *E. coli*, Coliphages, and *Clostridium perfringens*, as well as the two human markers for MST. *E. coli* levels were near or at zero for both sampling events (raw data in Appendix 1). Somatic and F-specific Coliphage concentrations were below the level of detection in the groundwater samples as well. *Clostridium perfringens* was observed in two groundwater sites (GW #2 in October 2022, GW #5 in May 2023) at extremely low levels. For these two sites, the absence of the two Coliphages and low *E. coli* detection, paired with low detection levels of *Clostridium perfringens*, suggest the contamination is from a previous event or due to aged fecal material rather than a recent contamination event with fresh fecal material.

Additionally, the human *B. theta* marker was not found in any groundwater samples and the human HF183 marker was found only once at site GW #2 during the October 2022 sampling event. Overall, fecal indicators and human markers were sporadically observed in Mitchell Creek's groundwater wells.

<u>CONCLUSIONS</u>

Overall, this study found continual high values of *E. coli* throughout the watershed during both wet and dry weather sampling events. This was expected as previous studies found similar results and the creek was subsequently placed on the State's Impaired Water's List. While the sampling program for *E. coli* in this study differs from TWC's intensive 5-week study performed in 2015 that led to Mitchell Creek being added to the Impaired Water List, results indicate that Mitchell Creek is still impaired and experiences elevated bacteria levels. Monitoring in this study showed elevated bacteria levels of *E. coli* above water quality standards (WQS) at almost all sites during both wet and dry sampling events (Table 4). In fact, 88% of wet weather samples collected during Phase 1 and 74% of samples in Phase 3 exceeded WQS for at least partial body contact. Almost half (46%) of samples collected during the Phase 1 sampling for dry events exceeded WQS as well. Sites MC-4, MC-5, and MC-8 had the most instances of *E. coli* above WQS with 88% of samples exceeding.

Results show a clear temporal pattern in Mitchell Creek that is rainfall driven where *E. coli* levels are elevated as well as the fecal indicators *Clostridium perfringens* and Somatic Coliphage. This indicates a mix of old and fresh bacterial contamination sources. It is possible that *E. coli* bacteria has accumulated in creek sediment over time and is being continually released, especially during rain events, and adding to the impairment.

Fecal indicator and microbial source tracking (MST) analysis conducted in this study has not led to any obvious or consistent sources or locations of bacterial contamination and it is difficult to determine remediation steps to reduce the impairment.

We have also noted that most of the bacterial contamination is occurring in the western portion of the creek's watershed, with little to no bacteria, fecal indicators, or MST markers found in the eastern tributaries of Vanderlip and Four Mile creeks. Additionally, the headwater areas of the western tributaries (south of Hammond Road) do not appear to have consistent bacterial contamination issues. Human markers were found in the western and central main branches of Mitchell Creek, with pig markers found in the unnamed tributaries leading to the western main branch. It is difficult to distinguish bacterial contamination sources from the furthest downstream sites, MC-1 and MC-2, due to the influence of upstream waters; both sites showed occurrences of human and pig markers.

Human Sources

Even though both types of human MST markers were found, they were generally low and not widespread and only showed up during wet weather sampling in 2021 and 2022. The *B. theta* marker was found in only two samples on the central main branch during a 2021 rain event that paired with elevated Coliphage levels. This indicates a fresh source of contamination may have been entering the creek during this sampling event. However, MST analysis in subsequent years shows no *B. theta* and little to no HF183, suggesting human contamination may have occurred in the past but may not be occurring any longer.

The Coastal Grand Traverse Bay Watershed Plan states that the Mitchell Creek area has a greater potential for septic system pollution than other areas in the watershed due to the density of systems combined with soil types. An excerpt from a map showing areas at risk for septic pollution is shown in Figure 11.

The plan states:

> *"Using housing information from the last census, and assuming all housing units located outside of municipal wastewater service areas are utilizing a septic system, Figure 25 shows areas in the Coastal Grand Traverse Bay watershed where the density of septic systems is greater than the EPA threshold of 32 systems/ mi^2. This information was also paired with hydrologic soil group information (Figure 9C) to identify areas that have the density of 32 systems/ mi^2 located on potentially poor draining soils (groups containing "D" soils), which could put areas at an even greater risk of experiencing septic pollution. Figure 25 shows the greatest areas for potential septic pollution in the Coastal Grand Traverse Bay watershed are found in the Mitchell Creek area, as well as areas near Suttons Bay and the northern part of the East Bay Shoreline Subwatershed. (All data shown in Figure 25 is subject to field verification and should be used for planning purposes only.)"*

Figure 11: Excerpt of Figure 25 from Coastal Grand Traverse Bay Watershed Plan – Areas At Risk for Septic Pollution

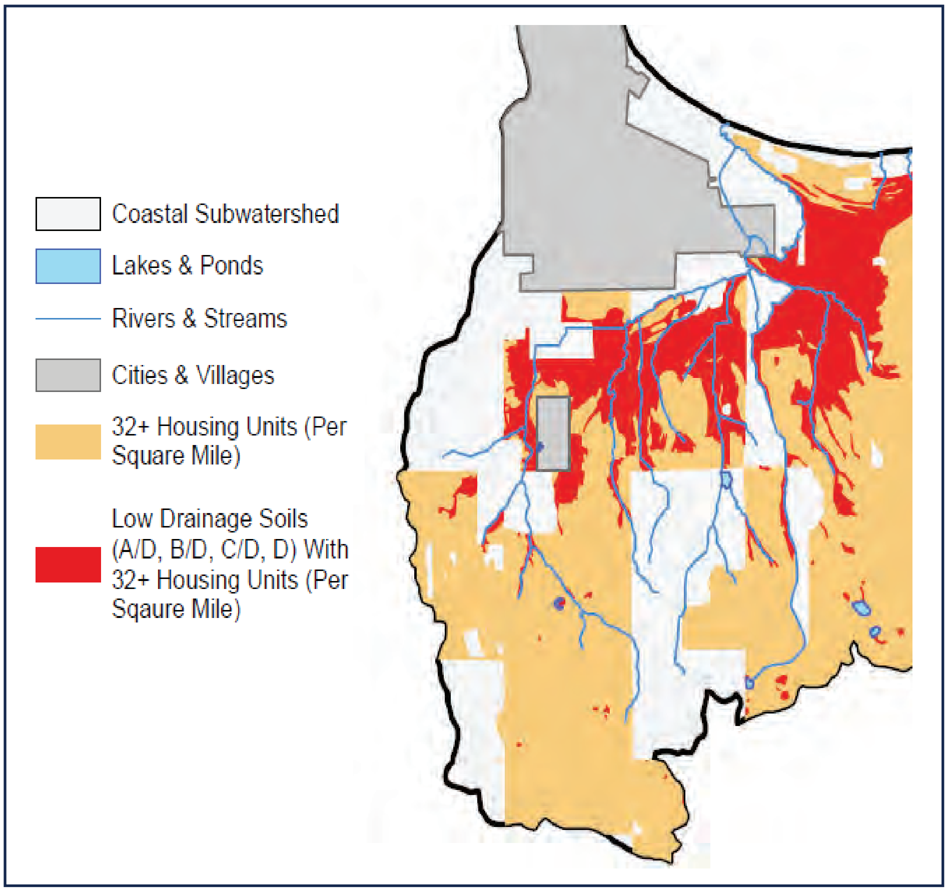


Figure 11 shows a high potential for septic pollution in the Mitchell Creek watershed. As such, TWC and Grand Traverse County Health Department (GTCHD) staff investigated the potential for older, leaking, or failing septic systems near Mitchell Creek in early 2023. We identified all parcels with septic systems on the south side of South Airport Road along Mitchell Creek between Townline and 3 Mile roads, as well as those on the west side of 3 Mile Road north of the intersection with South Airport Road. These parcels were put into a GIS map and categorized for various forms of septic system knowledge (i.e., permit on record, no permit on record, permit on record but no information on depth to groundwater, etc.). This map helped us determine areas with septic systems that could potentially be leaking or failing. Using this information, the project team decided to conduct additional water quality sampling in some of the unnamed tributaries further upstream to determine if there was potential human input coming from septic systems. Sites MC-11, MC-12, and MC-13 were added to the 2023 sampling program, though these sites had low *E. coli* levels and no human markers.

Due to the sporadic and inconsistent findings for the human marker, combined with the fact that no human markers were found in either 2023 wet weather sampling events, we cannot conclusively say at this time that leaking or failing septic systems are a consistent, major problem causing widespread impairment in the watershed. However, improperly installed or maintained septic systems may be a source of bacterial contamination since human markers were found occasionally.

Pig Sources

Pig markers were found throughout the Mitchell Creek watershed, but most often and in higher concentrations in the unnamed western tributaries of the watershed. While the October 2021 rain event indicated a fresh source of contamination, most of the time the pig marker was found it was not paired with increases in indicator Coliphages. This suggests older event releases from sediments or land application of pig waste that has been properly aged/composted in storage prior to being land applied.

To find out more information about potential pig input to the watershed, TWC staff, with the assistance of the Natural Resources Conservation Service and a technician from the Michigan Agriculture Environmental Assurance Program (MAEAP), checked the area for farms that either kept pigs or could be applying pig manure.

We learned that there are no large pig farms in the western tributaries of the watershed, but there is a small farm with a small number of pigs upstream of sites MC-4 and MC-5. The MAEAP technician had already conducted a site visit to that farm and confirmed they are following the Generally Accepted Agricultural and Management Practices (GAAMPs) at this time (see box at right). TWC staff also checked with the local 4-H program and determined that they have no knowledge of members raising pigs in the Mitchell Creek watershed. However, these findings do not rule out the possibility of pigs on other properties in the watershed.

Generally Accepted Agricultural and Management Practices (GAAMPs)

- GAAMPs are guidelines for farm management that help promote a positive image of Michigan agriculture. They were developed and adopted by the Michigan Commission of Agriculture and Rural Development because of the Michigan Right to Farm Act, P.A. 93, enacted in 1981.
- These farm management practices are scientifically based and updated annually to utilize current technology promoting sound environmental stewardship on Michigan farms.
- By utilizing GAAMPs, farmers and Michigan residents benefit through environmental protection of natural resources, sound management of agricultural inputs, and sustaining a strong and stable agricultural industry.

GAAMPs Generally Accepted Agricultural Management Practices

We also learned that there is no way to track the land application of fresh or aged pig manure. Some pig farmers may store it onsite and eventually land apply it on their own property. The manure would most likely be stored onsite for less than a year due to lack of storage space during the winter months when land application should not occur. In this case, the pig marker would persist long enough (one year or less) to be observed during MST analysis, but the accompanying fecal indicators noting fresh contamination (i.e., Coliphages) would not be present. Other farmers may sell their pig manure to other farms that use it on land as fertilizer. For example, there is a landowner that owns a large tract of agricultural land that is not being used to farm pigs upstream of MC-8; we are unaware of their fertilizing practices, but it could include pig manure that could have led to the detection of the pig marker at MC-8. However, if farms are following all GAAMPs for manure application, they are less likely to be affecting water quality in the creek and the marker may just be showing up through properly aged/composted runoff with a low bacterial and viral risk that is not harmful to human health.

The pig marker was found at nearly all the sites tested during dry and wet weather events in 2021 but was only found in a single sample in 2023. This may suggest that pig manure land application occurred in 2021 and was making it to the creek, but that the application practice has been modified or stopped, leading to a reduced marker signal in 2022 and eventually a disappearance of the marker in 2023.

Canine Sources

It is worth noting that the canine marker was widespread throughout the watershed and found in almost all samples tested, regardless of wet or dry conditions or locations. In addition to dogs, the marker may also be detecting canines like coyote and fox. This means we cannot confirm that fecal material from dogs specifically is a widespread concern for Mitchell Creek. What we do know is that the overall canine contribution to Mitchell Creek's impairment may be significant since it was found virtually everywhere. If caused by coyotes and foxes and not just dogs, it will be difficult to address the issue.

Cow and Gull Sources

Both markers were virtually non-existent in this study and are not considered a threat at this time.

Groundwater Sources

Overall, fecal indicators and human markers were sporadically observed in the groundwater study area in the Mitchell Creek watershed. At this time, we have no strong evidence that the septic systems in the study area are influencing groundwater in a negative way. However, we cannot conclusively say that septic systems are not an issue because *E. coli* was observed in several of the wells and fecal indicators and a human marker was found in at least two of the wells, albeit at low levels. Homes in this area are on a municipal water system that receives its drinking water from a well at a different location so there is no concern for drinking water in this area either.

TAKE AWAYS - RECOMMENDATIONS

While this study did not find any conclusive evidence and specific locations of sources that need immediate remediation that will reduce bacteria input to the creek, we do know that several sources are of concern in differing general areas as discussed above. The western tributaries have higher occurrences of pig markers while the central main branch has more human marker influence. The canine marker is widespread but may include wild animals like foxes and coyotes.

The project team recommends the following list of general Best Management Practices (BMPs) to reduce additional or existing input of bacterial sources in Mitchell Creek:

- Ensure all farms are following GAAMPs, implement agricultural BMPs to reduce fecal input to creek where needed.
- Provide education regarding septic systems including maintenance, right-sizing, replacing aged systems, and proper use.
- Conduct continual maintenance of the City of Traverse City's sanitary system and extend service to new homes, when possible.
- Provide education regarding the importance of picking up and properly disposing of dog poop.
- Preserve existing forested and vegetated wetlands that have the ability to reduce bacteria in the watershed, and restore wetlands when possible.

Appendix 1: *E. coli* Raw Data

Values are in colonies/100mL, GeoMean is the geometric mean of the Left, Right, and Center values.
"D" indicates a duplicate sample, regardless of E. coli level these were not sent to MSU for processing.
Numbers in RED indicate that the sample was selected for MST analysis.

Date	Location	Left	Right	Center	GeoMean	*Exceeds Daily Partial Body Contact Standard (1,000col/100mL)*	*Exceeds Daily Total Body Contact Standard (300 col/100mL)*
PHASE 1 - DRY EVENT #1							
7/12/2021	MC-1	313	246	450	326	X	--
7/12/2021	MC-2	862	627	759	743	X	--
7/12/2021	MC-3	275	187	471	289	--	--
7/12/2021	MC-4	472	393	354	403	X	--
7/12/2021	MC-5	487	738	389	519	X	--
7/12/2021	MC-5D	546	645	480	553	X	--
7/12/2021	MC-6	223	292	350	284	--	--
7/12/2021	MC-7				Dry		
7/12/2021	MC-8	554	410	399	449	X	--
7/12/2021	MC-9	175	109	148	141	--	--
7/12/2021	MC-10	121	189	148	150	--	--
7/12/2021	Blank (MC-1)				0		
PHASE 1 - DRY EVENT #2							
8/4/2021	MC-1	520	233	246	310	X	--
8/4/2021	MC-2	345	327	253	306	X	--
8/4/2021	MC-3	369	243	317	305	X	--
8/4/2021	MC-4	495	341	455	425	X	--
8/4/2021	MC-5	583	385	386	442	X	--
8/4/2021	MC-6	309	441	520	414	X	--
8/4/2021	MC-6D	353	397	482	407	X	--
8/4/2021	MC-7				Dry		
8/4/2021	MC-8	379	609	480	480	X	--
8/4/2021	MC-9	379	203	187	243	--	--
8/4/2021	MC-10	73	122	86	91	--	--
8/4/2021	Blank (MC-4)				0		
PHASE 1 - DRY EVENT #3							
9/20/2021	MC-1	161	183	161	168	--	--
9/20/2021	MC-1D	328	187	110	189	--	--
9/20/2021	MC-2	148	181	183	170	--	--
9/20/2021	MC-3	259	231	281	256	--	--
9/20/2021	MC-4	292	341	384	337	X	--
9/20/2021	MC-5	382	479	512	454	X	--
9/20/2021	MC-6	233	199	288	237	--	--
9/20/2021	MC-7				Dry		
9/20/2021	MC-8	759	657	754	722	X	--
9/20/2021	MC-9	20	10	10	13	--	--
9/20/2021	MC-10	52	20	52	38	--	--
9/20/2021	Blank (MC-6)				0		

Date	Location	Left	Right	Center	GeoMean	*Exceeds Daily Partial Body Contact Standard (1,000col/100mL)*	*Exceeds Daily Total Body Contact Standard (300 col/100mL)*
PHASE 1 - WET EVENT #1 (1.2 inches in 24 hours)							
10/4/2021	MC-1	8164	7270	8164	7854	*X*	*X*
10/4/2021	MC-2	7701	4884	6867	6368	*X*	*X*
10/4/2021	MC-2D	3873	6488	6488	5463	*X*	*X*
10/4/2021	MC-3	8164	8664	6131	7569	*X*	*X*
10/4/2021	MC-4	3654	5475	5475	4785	*X*	*X*
10/4/2021	MC-5	4611	2902	3654	3657	*X*	*X*
10/4/2021	MC-6	5172	6131	7270	6132	*X*	*X*
10/4/2021	MC-7				Dry		
10/4/2021	MC-8	5172	6131	3448	4782	*X*	*X*
10/4/2021	MC-9	697	852	816	785	*X*	--
10/4/2021	MC-10	228	374	243	275	--	--
10/4/2021	Blank (MC-5)				0		
PHASE 1 - DRY EVENT #4							
10/18/2021	MC-1	134	63	110	98	--	--
10/18/2021	MC-2	63	109	63	76	--	--
10/18/2021	MC-3	146	199	121	152	--	--
10/18/2021	MC-3D	122	86	109	105	--	--
10/18/2021	MC-4	122	158	216	161	--	--
10/18/2021	MC-5	52	74	41	54	--	--
10/18/2021	MC-6	134	120	183	143	--	--
10/18/2021	MC-7				Dry		
10/18/2021	MC-8	175	243	134	179	--	--
10/18/2021	MC-9	31	10	10	15	--	--
10/18/2021	MC-10	41	31	41	37	--	--
10/18/2021	Blank (MC-3)				0		
PHASE 1 - WET EVENT #2 (1.14 inches in 24 hours)							
6/7/2022	MC-1	1597	1872	1076	1476	*X*	*X*
6/7/2022	MC-2	281	613	727	500	*X*	--
6/7/2022	MC-3	1112	1354	1313	1255	*X*	*X*
6/7/2022	MC-4	733	644	749	707	*X*	--
6/7/2022	MC-4D	612	794	706	700	*X*	--
6/7/2022	MC-5	576	759	620	647	*X*	--
6/7/2022	MC-6	882	1162	1187	1068	*X*	*X*
6/7/2022	MC-7				Dry		
6/7/2022	MC-8	1354	1553	1624	1506	*X*	*X*
6/7/2022	MC-9	744	836	677	750	*X*	--
6/7/2022	MC-10	110	181	73	113	*X*	--
6/7/2022	Blank (MC-2)				0		

Date	Location	Left	Right	Center	GeoMean	*Exceeds Daily Partial Body Contact Standard (1,000col/100mL)*	*Exceeds Daily Total Body Contact Standard (300 col/100mL)*
PHASE 3 - WET EVENT #1 (0.54 inches in 24 hours)							
9/12/2023	MC-1	1274	988	1658	1278	X	X
9/12/2023	MC-2	644	657	455	577	X	--
9/12/2023	MC-3	--	1106	1081	1093	X	X
9/12/2023	MC-3D	1313	--	1354	1333	X	X
9/12/2023	MC-4	504	695	650	611	X	--
9/12/2023	MC-5	1086	1076	1014	1058	X	X
9/12/2023	MC-6	855	561	1421	880	X	--
9/12/2023	MC-8	1153	1246	1153	1183	X	X
9/12/2023	MC-11	121	135	122	126	--	--
9/12/2023	MC-12	74	74	86	78	--	--
9/12/2023	MC-13	845	882	728	816	X	--
9/12/2023	Blank (MC-6)				0		
PHASE 3 - WET EVENT #2 (1.29 inches in 24 hours)							
10/25/2023	MC-1	8664	1616	1236	2587	X	X
10/25/2023	MC-1D	1664	1956	1904	1837	X	X
10/25/2023	MC-2	1334	1354	1076	1248	X	X
10/25/2023	MC-3	1616	1860	4611	2402	X	X
10/25/2023	MC-4	1989	2481	2098	2179	X	X
10/25/2023	MC-5	591	530	620	579	X	--
10/25/2023	MC-6	3076	2987	2282	2757	X	X
10/25/2023	MC-8	1935	2613	3076	2496	X	X
10/25/2023	MC-11	130	221	121	151	--	--
10/25/2023	MC-12	41	52	20	35	--	--
10/25/2023	MC-13	41	31	63	43	--	--
10/25/2023	Blank (MC-11)				0		

Phase 2 - Groundwater Sampling #1				**Phase 2 - Groundwater Sampling #2**		
Date	**Location**	***E. coli***		**Date**	**Location**	***E. coli***
10/18/2022	GW #1	2		5/9/2023	GW #1	0
10/18/2022	GW #1D	0		5/9/2023	GW #2	0
10/18/2022	GW #2	2		5/9/2023	GW #3	0
10/18/2022	GW #2D	3		5/9/2023	GW #4	0
10/18/2022	GW #3	13		5/9/2023	GW #5	0
10/18/2022	GW #4	1				
10/18/2022	GW #5	0				

No exceedances for Total or Partial Body Contact Standards

Appendix 2: Summary of Microbial Source Tracker Marker Information

A2: Table 1: Summary of Oligonucleotide Primer and Probes for ddPCR Assays

MST Target	Assay	Primer and Probe Sequences (5' to 3')	Reference	
Bovine	Cow M2	CowM2F: CGGCCAAATACTCCTGATCGT CowM2R: GCTTGTTGCGTTCCTTGAGATAAT CowM2P: FAM-AGGCACCTATGTCCTTTACCTCATCAACTACAGACA-BHQ	Shanks et al., 2008	Shanks, O.C., Atikovic, E., Blackwood, A.D., Lu, J., Noble, R.T., Santo Domingo, J., Seifring, S., Sivaganesan, M., and Haugland, R.A.(2008) Quantitative PCR for Detection and Enumeration of Genetic Markers of Bovine Fecal Pollution. Applied and Environmental Microbiology, 74:3. p. 745-752.
Porcine	Pig2Bac	Pig2Bac41F: GCATGAATTTAGCTTGCTAAATTTGAT Pig2Bac163Rm: ACCTCATACGGTATTAATCCGC Pig2Bac113MGB: FAM-TCCACGGGATAGCC-BHQ	Mieszkin et al., 2009	Mieszkin S., J.P. Furet, G. Corthier, and M. Gourmelon (2009) Estimation of pig fecal contamination in a river catchment by real-time PCR using two pig-specific Bacteroidales 16S rRNA genetic markers. Appl. Environ. Microbiol. 75:3045–3054.
Dog	BacCan	BacCan-545f1: GGAGCGCAGACGGGTTTT BacUni-690r2: AATCGGAGTTCCTCGTGATATCTA BacUni-690r1: CAATCGGAGTTCTTCGTGATATCTA BacUni-656p: 6-FAM-TGGTGTAGCGGTGAAA-TAMRA-MGB	Kildare et al., 2007	Kildare, B., Leutenegger, C., McSwain, B., Bambic, D., Rajal, V. and Wuertz, S. (2007). 16S rRNA-based assays for quantitative detection of universal, human-, cow-, and dog-specific fecal Bacteroidales: A Bayesian approach. Water Research, 41, 15.
Gull	Gull4	qGull7F: CTTGCATCGACCTAAAGTTTTGAG	Ryu et al., 2012; Lu et al., 2011; Lu et al., 2008	Ryu, H., Griffith, J. F., Khan, I. U. H., Hill, S., Edge, T. A., Toledo-Hernandez, C., Gonzalez-Nieves, J.and Domingo, J. S. (2012). Comparison of Gull Feces Specific Assays Targeting the 16S rRNA Genes of Catellicoccus marimammalium and Streptococcus spp. Applied and Environmental Microbiology, 78, 1909-1916.
		qGull8R: GGTTCTCTGTATTATGCGGTATTAGCA		Lu, J., Ryu, H., Hill, S., Schoen, M., Ashbolt, N., Edge, T. & Domingo, J. 2011. Distribution and potential significance of a gull fecal marker in urban coastal and riverine areas of southern Ontario, Canada. Water Research, 45, 3960-8.
		qGull7P*b*: FAM-ACACGTGGGTAACCTGCCCATCAGA-TAMRA		Lu, J., Santo Domingo, J., Lamendella, R., Edge, T. & Hill, S. 2008. Phylogenetic diversity and molecular detection of bacteria in gull feces. Applied and Environmental Microbiology, 74, 3969-76.
Human	B. theta	B.theta 4515901F: 5'CATCGTTCGTCAGCAGTAACA3' B.theta 4515963R: 5'CCAAGAAAAAGGGACAGTGG3' B.theta Probe : FAM- CAGCA GGT-BHQ1	Yampara-Iquise et al., 2008	Yampara-Iquise, H., Zheng, G., Jones, J.E. and Carson, C.A. (2008) Use of a Bacteroides thetaiotaomicron-specific Alpha-1-6, mannanase quantitative PCR to detect human faecal pollution in water. J Appl Microbiol 105, 1686–1693.
Human	HF183	HF183f: ATCATGAGTTCACATGTCC BacR287r: CTTCCTCTCAGAACCCCTATC BacP234MGB Probe: FAM- CTAATGGAACGCATCC-MGB	US EPA. Method 1696, 2019	EPA (2019) Method 1696: Characterization of Human Fecal Pollution in Water by HF183/BacR287 TaqMan® Quantitative Polymerase Chain Reaction (qPCR) Assay. EPA 821-R-19-002 . Office of Water

A2: Table 2: Compilation of Sensitivity and Specificity Studies Available for Various MST Markers

References on next page

MST Target	Assay	Sensitivity in Sewage	Sensitivity in Faeces	Reference	Additional Reference Information	Specificity	Reference	Additional Reference Information
Bovine	Cow M2		88.90%	Ridley et al., 2014	Harwood et al., 2017 GWPP	100%	Shanks et al., 2010	Harwood et al., 2017 GWPP
			50%	Odagiri et al., 2015		97-100%	Raith et al., 2013	
			50%	Ohad et al., 2015		100%	Ridley et al., 2014	
			100%	Shanks et al., 2008		100%	Odagiri et al., 2015	
			100%	Raith et al., 2013		89%	Ohad et al., 2015	
Porcine	Pig2Bac		100%	Mieszkin et al., 2009	Harwood et al., 2017 GWPP	100	Mieszkin et al., 2009	Harwood et al., 2017 GWPP
			100%	Ohad et al., 2015		~40% to ~90%	Boehm et al., 2013	
			100%	Boehm et al., 2013		100%	Ohad et al., 2015	
Dog	BacCan		80%	Nshimyimana et al., 2017	Harwood et al., 2017 GWPP	87	Gyawali et al, 2020	
			100%	Gyawali et al., 2020		71%	Rytkönen et al., 2021	
						69 - 90%	Schriewer et al, 2013	
						97%	Nshimyimana et al 2017	
						87	Symonds et al., 2017	
Gull	Gull4		86.70%	Ryu et al., 2012	Harwood et al., 2017 GWPP	~100%	Ryu et al., 2012	
Human	B. theta	75 to 100%	100%	Layton et al., 2013	Harwood et al., 2017 GWPP	100% (100% in individual human feces, 100% in sewage)	Yampara-Iquise et al., 2008	Harwood et al., 2017 GWPP
		100%	100%	Yampara-Iquise et al., 2008		75- 100%	Layton et al., 2013	
		100%	Not tested	Srinivasan et al., 2011		100%	Shanks et al., 2008	
Human	HF183	100%	16.70%	Odagiri et al., 2015	Harwood et al., 2017 GWPP	100%	Green et al., 2014	Harwood et al., 2017 GWPP
		85 to 100%	100%	Layton et al., 2013		46-92%	Layton et al., 2013	
		100%	100%	Haugland et al., 2010		Average 29% (16.7% in individual human feces, 100% in sewage)	Odagiri et al., 2015	

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