# Greater Bear Watershed Management Plan

July 19, 2013

***Prepared for***

Manistee County Community Foundation
Manistee, Michigan

***In Coordination with***

Greater Bear Watershed Steering Committee

*and*

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# Section A: Executive Summary

## PURPOSE

The first Bear Creek Watershed Management Plan was completed in July of 2000 by the Conservation Resource Alliance (CRA), Bear Creek Watershed Council (BCWC), and other project partners. The continued success of cooperative planning and management efforts and the growing concerns over potential impairments to Bear Lake led residents in the area to seek resources for the development of a comprehensive watershed management plan that would update the Bear Creek Watershed Management Plan and expand the scope of the original plan to include the entire watershed, including Bear Lake. The purpose of this Greater Bear Watershed Management Plan is to guide and inform the integration of future activities in the watershed to protect and enhance the valuable natural resources essential to the quality of life and economic well-being of residents of the area. Through the development of a consensus plan, the stakeholders have established the basis for seeking additional funding from private and public sources which will be required to implement the goals and objectives.

## PRIOR SUCCESSES

The two primary objectives of the 2000 Bear Creek Watershed Management Plan were to address impairments to the coldwater (trout and salmon) fishery and wildlife in Bear Creek and major tributaries. In the years that followed, groups within the watershed achieved many of the specific goals established in that plan including extensive work to inventory and repair moderately and severely eroded stream bank erosion and road crossing sites along Bear Creek and its tributaries.

While groups such as the CRA and BCWC continued restoration efforts along Bear Creek and tributaries, others focused on Bear Lake. The Bear Lake Property Owners Association (BLPOA) has been involved with volunteer-driven water quality monitoring through the Michigan Clean Water Corps since the 1970s. This sampling has provided annual Secchi disk transparencies, and periodic data on dissolved oxygen, temperature, total phosphorus and chlorophyll *a*. More recently the BLPOA, the Village of Bear Lake, Pleasanton Township, and Bear Lake Township have agreed to support a plan by the District Health Department #10 to sample Bear Lake for E. *coli*, which is an indicator of pathogens that can be harmful to humans. The sampling began in 2013 and is expected to provide valuable information regarding water quality of the lake. New groups also formed that support watershed management activities including the Bear Lake Watershed Alliance, which continues to take an increasingly active role in coordinating watershed activities pertaining to Bear Lake. Additionally, the Bear Lake Improvement Board was established in 2007 as a result of a community-driven process to better manage lake resources and control Eurasian milfoil. In 2008 the board treated approximately 330 acres of Bear Lake for milfoil and since then milfoil has been controlled to significantly lower levels.

## HISTORICAL PERSPECTIVE

The Greater Bear Watershed has undergone significant changes from the time European settlement occurred in the mid-1800s. Prior to the 1836 Treaty of Washington that ceded the land to the United States, the Native American tribes occupying the area relied upon the hunting, fishing, and other low-impact uses of local natural resources (and to a certain extent these uses continue) to sustain settlements concentrated adjacent to lakes and waterways in the watershed. However, soon after statehood, the large virgin pine forests attracted investors to the area and the subsequent clear cutting and related construction of roads, rail, and processing facilities significantly changed the land cover of the area and altered the character of the watershed streams. By the beginning of the 20th century, the extensive pine forests in the watershed had been largely removed and significant physical changes in Bear Creek and major tributaries

occurred. These included increased erosion and stream sedimentation due to the removal of streamside vegetation, use of log rollaways at streamside staging areas, and other bank clearing and widening to accommodate logs transported downriver to the Manistee River. These logs were destined for sawmills located primarily around Manistee Lake which had direct access to Lake Michigan shipping facilities.

The removal of streamside cover, stream widening, and sedimentation increased stream temperatures and reduced available habitat for sensitive aquatic species. Arctic grayling (Michigan grayling) were once abundant and thrived in the Bear Creek watershed streams, but as in other locations, Grayling never recovered following the clear cutting of the pine forest and were extirpated from the Bear Creek Watershed and throughout Michigan's Lower Peninsula by the early 1900s.

As hope for preserving the grayling in Michigan's Lower Peninsula faded, the state began intensive stocking of more resilient brook trout in former Grayling streams throughout the northern Lower Peninsula in the 1880s. Steelhead (rainbow trout) from California were introduced into Michigan's major rivers in the late 1800s, and annual runs of steelhead from Lake Michigan were well established in the Manistee River by the early 1900s and no doubt spawned in Bear Creek. Michigan Fish Commission Biennial Reports indicate that brook trout were planted in Bear Creek as early as 1889 and that steelhead were planted in Bear Creek as early as 1897. Brown trout were introduced from Europe to Michigan in 1883, but apparently were not stocked directly into the Bear Creek watershed until sometime after 1900.

A portion of the land cleared during the removal of both pine and later hardwoods was converted to agricultural use, although a significant portion of the pine forests in the watershed reverted to public ownership and remains as state or national forests today. Evergreen and deciduous forests and woody wetlands now make up more than 55 percent of the land cover in the watershed with 12 percent in cultivated crops and less than 1 percent in highly developed urbanized areas. Most of the urbanized area of the watershed is closely associated with either Bear Lake or Bear Creek. The first platted subdivision adjacent to Bear Lake occurred in 1874, a year after a tramway was constructed that allowed logs harvested from the area around the lake to be transported to a port on Lake Michigan outside of the watershed.

Bear Lake fishing and other water recreation opportunities encouraged many to build residences on the lake in the early 20th century, and as roads were developed summer cottages and retirement homes were built on the shore of the lake. Similarly, as access to the watershed improved, fishing camps and lodges and eventually permanent homes and cottages were established on Bear Creek. A significant portion of the main stream of Bear Creek remains in private ownership. Most properties along the shores of Bear Lake are now developed for use as public access sites and local parks, summer cottages, and permanent homes for residents who work in the area as well as retirees. The remaining undeveloped property around the lake is less suitable for development due to the lack of access and/or the presence of wetlands.

Following the initial logging operations, the focus of the economy throughout the watershed turned to agriculture and later tourism. Throughout the 1900s the watershed provided a major attraction to those seeking outdoor recreation and subsistence opportunities available on Bear Lake, Bear Creek, and the public lands in state and federal forests. In the 1970s, extensive hydrocarbon development for the extraction of oil and natural gas on public and private lands occurred in the watershed. More recently, development of new technologies for the extraction of natural gas has heightened interest in additional well drilling and natural gas production in the watershed. Despite these transitions in the regional economy, local residents are concerned that the current lack of employment opportunities in the watershed and the population trend of increasing numbers of retirees are not in the long-term economic interests of the area and that more attention needs to be focused on creating well-paying jobs that will encourage younger residents to stay in the area.

The introduction of coho salmon in Bear Creek in 1966 and the later introduction of Chinook salmon in the Manistee watershed resulted in a renewed interest in fishing in Bear Creek. While Bear Creek was selected as one of the first streams to receive plants of coho in the state because of its high quality, stable coldwater supply, and favorable spawning habitat accessible to Lake Michigan in order to support a new Lake Michigan sportfishery, the salmon fishery that eventually developed in Bear Creek itself has become a major attraction to wading fishermen. The combination of high-quality fishing for brook and brown trout, as well as steelhead and coho and Chinook salmon, makes Bear Creek one of only a handful of rivers throughout the world, nearly all located in Michigan, where anglers can catch these five, highly prized, naturally reproduced gamefish in a wadeable stream.

Public access to the portion of Bear Creek most attractive to fishermen has created conflict because a significant portion of Bear Creek most desirable for fishing is in private ownership. Private landowners along Bear Creek have expressed frustration over transgressions by some fishermen that interfere with their enjoyment of their riparian cottages and homes located close to the river's edge. The state's acquisition of properties for additional public access to the river has met with considerable local opposition from those property owners who fear additional anglers will begin to use the river and further limit their enjoyment of their property. Resolution of this conflict between the public's right to use Bear Creek and the rights of private owners to enjoy their property is essential to assuring long-term protection and reasonable, sustainable use of this world class trout and salmon fishery by both landowners and the angling public.

## VISION

The vision of the Greater Bear Watershed Management Plan, developed by the stakeholders in the watershed, is to help build a consensus for action by individuals, private organizations, and governmental partners that will achieve common objectives through cooperative, coordinated efforts that support sustainable use and development of the water resources of the watershed, encourage closely related wise land use practices, and preserve historical and cultural amenities that make the area an attractive place to live, work, and recreate for present and future generations.

## STAKEHOLDER INVOLVEMENT

The Greater Bear Watershed Management Plan was initiated by community interests seeking resources to better understand and address concerns related to the sustainability of Bear Lake, Bear Creek, and tributary streams. On behalf of these community interests, and with the encouragement of the Michigan Department of Environmental Quality, the Manistee Community Foundation applied for and was awarded a planning grant through the state-administered, U.S. Environmental Protection Agency's Section 319 Non-Point Source Program in 2011. Soon after the grant award the Community Foundation, with the assistance of the Manistee County Alliance for Economic Success (which together had completed a successful watershed planning effort on the Portage Lake Watershed two years earlier), formed a Bear Lake/Bear Creek committee composed of local stakeholder organizations and governmental partners. Once Public Sector Consultants, Inc. of Lansing, Michigan was selected as the technical consultant, the Greater Bear Watershed Management Plan (GBWMP) Steering Committee was formed. This committee met regularly to guide the development of the plan, establish a technical committee, develop and distribute public information about the planning process, conduct public information meetings in the watershed, and initiate a survey of watershed residents.

The GBWMP Steering Committee met 14 times during the plan development process between 2011 and 2013. The committee meetings were publicized and open to the public. In addition, the committee chaired a series of public meetings at the beginning and end of the planning period to gather public input and comments on the scope of the plan, and to allow public review and comment on the draft plan and draft

goals and objectives. Four public meetings were held in 2011 and 2012 at various locations in the watershed; and at one of the committee meetings a group of about 25 students from the Bear Lake School District attended and were engaged in discussions about the plan and their potential role.

Subsequent to the meeting with students, a plan was implemented to involve the schools in encouraging residents to participate in the survey of watershed households. Sixty-six percent of the responses were collected from a Web-based survey instrument and 34 percent were submitted as hard copies from distributed paper surveys. The survey results were used primarily to guide the development of public information and education objectives contained in the plan, identify the most frequent water-related recreational activities, and to compare various survey results to the responses received at public meetings on priorities and concerns.

## DESCRIPTION OF THE WATERSHED

The Greater Bear Watershed is located in the northwest portion of Michigan's Lower Peninsula primarily in Manistee County with a very small portion of the land area extending into Wexford County in the east and Benzie County to the north, encompassing in total 204 square miles (130,800 acres) of land. The watershed encompasses all or portions of 13 townships, three incorporated villages (Kaleva, Bear Lake, and Copemish), the unincorporated community of Brethren, and lands of interest to the Little River Band of Ottawa Indians (LRBOI). The watershed includes a small portion of the Huron Manistee National Forest in the downstream area close to the confluence of Bear Creek with the Manistee River that subsequently flows into Lake Michigan. The downstream portion of Bear Creek within the Manistee National Forest is designated as a National Scenic River. There are over 32 square miles of state forest properties within the watershed concentrated in the northern headwater areas of Bear Creek. The soils of the watershed are predominantly permeable sandy loams that limit runoff except during heavy storms and sudden snow melts. The highest elevation in the watershed is 1,172 feet above sea level and it reaches its lowest point of 562 feet near the confluence of Bear Creek with the Manistee River.

There are 12 named tributaries to Bear Creek and 12 named natural and impounded lakes in the watershed. Most of these are small with the exception of Bear Lake, which is 1,744 acres and whose single outlet, Little Bear Creek, is a tributary to Bear Creek. The primary water source for Bear Lake, Bear Creek, and its tributaries is groundwater that seeps through the permeable sand and gravel surface glacial materials deposited over 10,000 years ago. The glacial deposits range from 200 feet to over 1,000 feet in depth above the bedrock shale formations. This year-round source of relatively shallow groundwater to the watershed is unique to Michigan's northern Lower Peninsula and is responsible for the exceptional coldwater fisheries habitat in Bear Creek and tributaries. In Bear Lake, the groundwater influence provides temperatures that support popular coolwater species such as walleye, northern pike, and smallmouth bass despite the relatively shallow average depth of the lake. Protection of this uncontaminated, cool groundwater resource is of primary concern to the residents of the area both as the primary source of drinking and irrigation water and its importance in supporting the fisheries in both Bear Lake and Bear Creek and tributaries.

The Greater Bear Watershed supports a number of plant and animal species listed by the state as endangered (1), threatened (3), or of special concern (8). In addition, the watershed is now home to a number of invasive aquatic and terrestrial plant and animal species that threaten native species, and in the case of Eurasian milfoil in Bear Lake, require control measures to prevent impairments to existing human uses.

The current land uses in the watershed include approximately 30 percent deciduous forest, 15 percent woody wetlands, 15 percent grassland/herbaceous cover, 12 percent cultivated crops, 10 percent evergreen forest, with the remaining 18 percent a mix of land cover types and open water. High-intensity development makes up less than 1 percent of the total land cover in the watershed. Comparison of

historical, pre-settlement (1860) land cover with current land cover maps indicates a significant loss of wetlands within the watershed over the past 125 years. Despite significant changes in the shoreline resulting from the construction of permanent and vacation homes, businesses, and transportation corridors, Bear Lake provides high-quality recreation opportunities for swimming, wading, boating, and related water sports, and a popular fishery for a range of species including an assortment of panfish, small and largemouth bass, northern pike, walleye, and a variety of other species.

Demographic information specific to the Greater Bear Watershed is difficult to determine from the U.S. Census information since the census data blocks do not correspond to the watershed boundaries. The census data based on ZIP Codes that most closely correspond to the Greater Bear Watershed boundaries indicate that, from 2000–2010, there was a 5.3 percent increase in the population, a 24.8 percent increase in those aged 65 and older, and an 8.8 percent increase in the number of households. Mean household income was not available for the Greater Bear Watershed using the ZIP Code comparison method, but for Manistee County as a whole mean family income, adjusted for inflation, decreased by 7 percent.

## LOCAL PROGRAMS, PROJECTS, AND PLANNING

Planning and zoning documents for nine jurisdictions within the watershed (Arcadia, Bear Lake, Brown, Cleon, Dickson, Maple Grove, Marilla, Onekema, and Pleasanton townships) were reviewed to assess the effectiveness of each in helping to further watershed plan goals and objectives. These jurisdictions were selected because they encompass Bear Lake and the main stem of Bear Creek and most tributaries. These areas also encompass the majority of the population of the watershed. Some municipalities were not included in this review because of the limited geographic extent of the watershed extending into those jurisdictions. Other municipalities were not included in the review because no zoning ordinances were on file with the Manistee County Planning Department.

The Village of Bear Lake has not adopted zoning to control land use, but has passed ordinances that include controls on the use of land within a prescribed area encompassing municipal groundwater supplies. The Village of Kaleva similarly does not have zoning regulations on file with the county planning office, but has adopted ordinances to protect the groundwater sources of its public water supply.

## EXISTING WATERSHED CONDITIONS

The current condition of Bear Lake, Bear Creek, tributary watercourses, and other waterbodies within the Greater Bear Watershed are assessed in this section. What is known about the condition of the surface water of the Greater Bear Watershed has been compiled from data and information contained in numerous studies and reports as well as from the files of, or direct communications with local, state, and federal agencies; tribal officials; and nonprofit organizations working in the watershed. Local residents have also provided information that was helpful in assessing the current condition of the surface water and groundwater.

Given the large area of the watershed and the varied natural landscapes and human land uses, the existing conditions are best described in terms of the subwatersheds developed through the plan process. The subwatersheds were identified based on public or private land ownership, population centers, hydrology, and other factors.

### *Bear Lake*

The **Bear Lake Subwatershed** encompasses the surface area and related groundwater that drains toward Bear Lake. Bear Lake discharges to its only outlet, Little Bear Creek, which is a tributary to Bear Creek. The current and historical status of Bear Lake was assessed using information from a variety of sources. The analysis of prior studies includes an assessment of the health of the fishery; known invasive species;

and biological and chemical indicators of water quality. Overall, Bear Lake is considered to have high environmental quality and is considered one of the better coolwater fishing lakes in Michigan's northwestern Lower Peninsula.

### *Bear Creek Subwatersheds*

The main stream of Bear Creek is approximately 28 miles long from its headwater area in the northeast portion of the watershed to its confluence with the Manistee River. It has many miles of named and unnamed tributaries as well as significant groundwater inputs as it flows generally in a southerly direction. It is the largest tributary to the Manistee River downstream of Tippy Dam, which is located in the southeast portion of Manistee County about 5 to 10 miles outside the Greater Bear Watershed.

The existing habitat, substrate, water quality, temperature, and flow data on Bear Creek and its tributaries come from a variety of agencies, each of which had specific objectives when conducting its sampling. However, a collective analysis of the data and descriptions from these past studies identifies key attributes that should be routinely monitored in the future and critical information gaps that need to be filled. Based upon the existing information described in the studies and other data sources, a long-term monitoring plan was developed.

The **Headwaters Subwatershed** encompasses Little Bear Creek and several other tributaries including First, Second, and Third creeks and Dutchman Creek. There is extensive state forest land ownership in this subwatershed. Bear Creek and its tributaries have a low gradient with considerable wetlands adjacent to the river in the Headwaters Subwatershed. Fishing is limited to the regular trout season from the last Saturday in April through September. The dividing line between the Headwaters Subwatershed and the Middle Subwatershed is 13 Mile Road, which is the upper stream limit of the portion of Bear Creek that is open to year-round fishing. Lemon Creek enters Bear Creek at 13 Mile Road and is the last downstream tributary of the Headwaters Subwatershed. Available information indicates that water quality in the Headwaters Subwatershed meets or exceeds Michigan Water Quality Standards (WQS) for coldwater (trout) streams.

The **Middle Subwatershed** on Bear Creek itself (between 13 Mile Road and Coates Highway) begins just downstream of the point where Lemon Creek joins Bear Creek. Halls Creek is the first named tributary feeding into Bear Creek in the Middle Subwatershed, followed downstream by Horseshoe, Beaver, Little Beaver, Cedar, Podunk, and Boswell creeks as well as a number of unnamed, smaller tributary streams, nearly all of which are classified trout streams. The relatively high gradient streams in this subwatershed, including Bear Creek itself, provide spawning for steelhead and salmon in exposed gravel areas and offer the best year-round fishing. Bear Creek and tributaries in this subwatershed are difficult to access due to the fact that the vast majority of riparian land is privately owned. Available monitoring data indicate that water quality was determined adequate for a coldwater stream; the glide/pool habitat was rated good (slightly impaired), and the macroinvertebrate populations were determined to be acceptable.

The **Lower Subwatershed** begins at Coates Highway and extends to the point where Bear Creek discharges to the Manistee River. This lower end of the watershed has a low gradient and the stream bottom is dominated by sand and silt with minimal amounts of exposed gravel. Wetlands are common along riparian state and federal forest lands which are extensive in this subwatershed. In general, reports indicate that water chemistry measured in this reach of the Lower Subwatershed is of good quality with the exception of possible sediment issues. Information shows in some areas there is a lack of woody debris and deep pools but overall the fish community in the subwatershed is highly diverse with representatives of coldwater, coolwater, and warmwater species observed.

## DESIGNATED AND PROTECTED USES, THREATS, SOURCES, AND CAUSES

Bear Creek and its tributaries are protected under the WQS as coldwater streams. Current information indicates the WQS for coldwater streams are being met in the Greater Bear Watershed with the exception of three parameters for which there is insufficient information to determine compliance. Further testing is required to determine whether or not minimum dissolved oxygen concentrations, maximum *E. coli* (bacteria), and temperature standards are being met in some specific areas where samples in previous years suggest possible non-compliance. Bear Lake is protected under the WQS as a warmwater lake and further information is also needed on the *E. coli* bacteria levels and dissolved oxygen during the summer period to determine if all standards are being met. The most likely present and future threats to the Greater Bear Watershed surface waters are as follows:

- Human pathogens threats from:
  - pathogens coming from failed on-site wastewater treatment systems (OWTS), uncontrolled runoff from farm-raised animals, household pets, and waterfowl
- Ecosystem health threats from:
  - nutrient loadings (specifically phosphorus) due to waste discharges from OWTS, home and farm fertilizers applications on riparian lands, and storm water discharges
  - habitat degradation related to wetland disturbances, lakeshore and streamside alterations, expanded presence of aquatic and wetland invasive species (such as Eurasian milfoil, zebra and quagga mussels, purple loosestrife, and phragmites), and sedimentation from eroding banks, road crossings, and stormwater runoff
- Hazardous materials threats from:
  - contaminated fish due to air deposition of toxic, bioaccumulative heavy metals (such as mercury) and persistent organic compounds (such as polychlorinated biphenlys)
  - spills of toxic materials from transportation accidents, and household and business use, storage and handling of hazardous materials
  - contaminated runoff from cropland, and orchard and tree farms (such as pesticides, herbicides, and other agricultural chemicals)
  - industrial spills (manufacturing and production waste from hydrocarbon development)

Because groundwater is the dominant source of the water for the lakes and streams in the Greater Bear Watershed as well as the primary source of water for household use and irrigation, the residents of the area identified present and potential threats to groundwater as follows:

- Groundwater threats from:
  - excessive withdrawals related to expanded industrial uses or expanded agricultural irrigation
  - contamination associated with accidental releases of hazardous materials onto the ground
  - major changes in land use that would increase surface water runoff, decrease infiltration, and increase water temperatures of lakes and streams
  - contamination from historical disposal sites, former commercial operations, and agricultural chemical applications

Residents of the watershed identified other issues that they feel affect either the current uses of the water resource or impair the sustainability of the economic well-being and quality of life that attracts many to reside and recreate in the area. These additional threats include the following:

- Increasing land use conflicts
  - between anglers and riparian owners of private land along portions of Bear Creek
  - placement of energy facilities impacting attractive, natural viewscapes

- Declining local businesses and related employment opportunities
  - out-migration of youth in the watershed and increasing population of retirees
  - reduced local services and retail stores
  - reduced local tax base
- Abandoned homes, businesses, and other properties
  - expanded number of blighted properties detracting from the aesthetics of the area
- Uniformity of local planning, zoning, and enforcement
  - reduced protection of valuable natural, cultural, and historical features
  - uncoordinated local economic development planning

## CRITICAL AND PRIORITY AREAS OF CONCERN

Critical and priority areas of concern within the Greater Bear Watershed, along with the known or suspected pollutant or threat, were identified to help develop goals and objectives and to guide future monitoring, planning, and management efforts. Critical areas represent those where restoration may be necessary; priority areas represent those where protection is important. The areas described are either the sources of pollutants identified or those areas most susceptible to activities that could degrade water quality or valuable aquatic habitats.

The critical areas identified are:

- Riparian lake and stream properties where all streamside vegetation has been removed, hardened bank/shore erosion devices have been installed
- Private agricultural lands adjacent to and within 300 feet of Bear Lake, Bear Creek, and tributaries
- Active stream bank erosion sites in Bear Creek and tributaries related to historical logging practices and recreational access on public and private lands
- Road stream crossings along Bear Creek and tributaries
- Locations where the lack of streamside shade and in-stream cover limits trout and salmon abundance
- OWTS located at permanent residences, vacation homes, and businesses adjacent to Bear Lake
- OWTS located at permanent residences, vacation homes, and businesses adjacent to Bear Creek and tributaries

The priority areas identified are:

- Existing undeveloped wetlands adjacent to Bear Lake, Bear Creek, and tributaries
- Properties of conservation significance identified through Grand Traverse Regional Land Conservancy (GTRLC) prioritization process

## GOALS AND OBJECTIVES

There are eight major goals for the Greater Bear Watershed and a series of recommended objectives and actions for each of the goals. Five goals follow the categories established in the report used to identify existing or potential threats to legally protected uses of the surface water and groundwater resources within the watershed. The sixth goal is not directly related to water quality, but reflects the concerns expressed during the public meetings on the lack of youth employment opportunities, the increasing percentage of the population in the watershed over 65, the value of scenic vistas, and the growing evidence of abandoned and blighted properties. The seventh and eighth goals relate to plan implementation and evaluation.

The eight major goals for the Greater Bear Watershed are:

- **Pathogens Affecting Humans**—Minimize presence of organisms that impair swimming, wading, fishing, boating, water skiing and other full or partial body contact water recreation activities. Objectives and actions identified to reach this goal include decreasing sources of and monitoring for human pathogens.
- **Ecosystem Health**—Protect and restore essential physical habitat, and maintain compliance with water quality standards designed to protect fish, wildlife, and other aquatic organisms. Objectives and actions identified to reach this goal include reducing and preventing nutrients and pollutants from entering Bear Lake, Bear Creek, and tributaries as well as protecting and enhancing critical habitat for aquatic species.
- **Hazardous Materials—**Prevent future and reduce current impacts on people (fish consumption advisories) and the environment. Objectives and actions identified to reach this goal include efforts to educate watershed residents, businesses, and visitors and to develop contingency plans to respond appropriately in the event of a spill.
- **Invasive Species**—Control abundance and further distribution of exotic species injurious to protected human uses (swimming, boating, fishing, etc.) and native plants and animals. Objectives and actions identified to reach this goal include efforts to limit the expanse of existing invasive species and prevent the introduction of new invasive species.
- **Groundwater**—Protect quality and quantity of domestic and agricultural water supplies and the source of cool, clean water to surface lakes and streams. Objectives and actions identified to reach this goal include protection of drinking water supplies and monitoring to ensure that withdrawals do not create an adverse resource impact.
- **Joint Planning and Development—**Coordinated local economic and land use planning to preserve and optimize local assets and expand sustainable economic development and related employment. Objectives and actions in this category include efforts to strengthen natural resource–based tourism and collaborative planning efforts.
- **Sustainable Implementation of Greater Bear Watershed Plan—**Formation of Greater Bear Watershed Management Plan Steering Committee and identification of leadership responsibilities. Objectives and actions in this category include the formation of an implementation team to ensure that plan recommendations and goals are achieved.
- **Evaluation and Revision of Management Plan Progress**—Periodic assessment of progress in implementing actions and in meeting objectives, and targets for plan revisions and updates. Objectives and actions in this category include periodic assessment of progress toward plan goals and implementing adjustments as necessary.

## INFORMATION AND EDUCATION

An information and education (IE) plan, based on stakeholder input from public forums, public survey, steering committee members, and relevant reports and information about environmental quality of watershed resources, was developed to advance attainment of watershed goals and objectives. This plan will help increase awareness and understanding about how actions on the land within the Greater Bear Watershed can impact water quality. The purpose of the strategy is to establish and promote education programs that support effective implementation of watershed planning goals, objectives, and actions.

Since the Greater Bear Watershed Management Plan Coordinating Committee is a relatively new group, the strategy focuses on building organizational capacity in the short term by implementing general IE tasks identified in Exhibit 92. The www.bearwaters.org website will become a central repository for educational and informational materials. In the beginning, efforts will focus on compiling existing materials identified in IE tasks and adding them to the website, and developing a contact list for distributing materials in 2013. Following this effort the Implementation Team will target educational

efforts on two individual plan goals in each year of plan implementation. This approach recognizes the importance of IE actions relating to each goal and the limited resources (staff/volunteer time and materials) to implement watershed tasks. The Implementation Team's focus on two goals each year (goals 1-6) will be repeated on a triennial cycle commencing in 2014.

## MONITORING AND EVALUATION

Implementation of watershed plan goals and objectives will require routine monitoring of watershed resources at Bear Lake, Bear Creek, and tributaries. Monitoring is a fundamental component of this plan to ensure that current conditions that support designated and other desired uses are sustained. The proposed monitoring plan will fill information gaps to determine whether or not water quality standards are being met and further establish baseline levels for future comparisons.

The purpose of the monitoring plan is to identify changes in environmental quality before significant impairments occur such that management actions can be implemented to prevent or minimize risk to watershed resources. The monitoring plan focuses on three priorities of the watershed plan: human pathogens and public health, aquatic ecosystem health, and water quality (surface water and groundwater).

Evaluation of monitoring activities will also be necessary to determine the progress and effectiveness of proposed activities. A measure of success will be that all water quality standards continue to be met and designated and desired uses are protected. Successful establishment of the institutional structure of the Greater Bear Watershed Committee is critical to assure implementation of plan recommendations. Organizations represented on the committee need to continue to meet on a regular basis to assure that staff and volunteers of the respective organizations can manage the elements in the monitoring plan and evaluate the results.

The estimated cost of implementing all recommended actions to achieve watershed plan goals and objectives, as well as the information and education actions to achieve watershed plan goals, ranges from a low estimate of $7,654,000 to a high of $9,236,000 over the 10-year horizon of the plan.

# Section B: Stakeholder Involvement

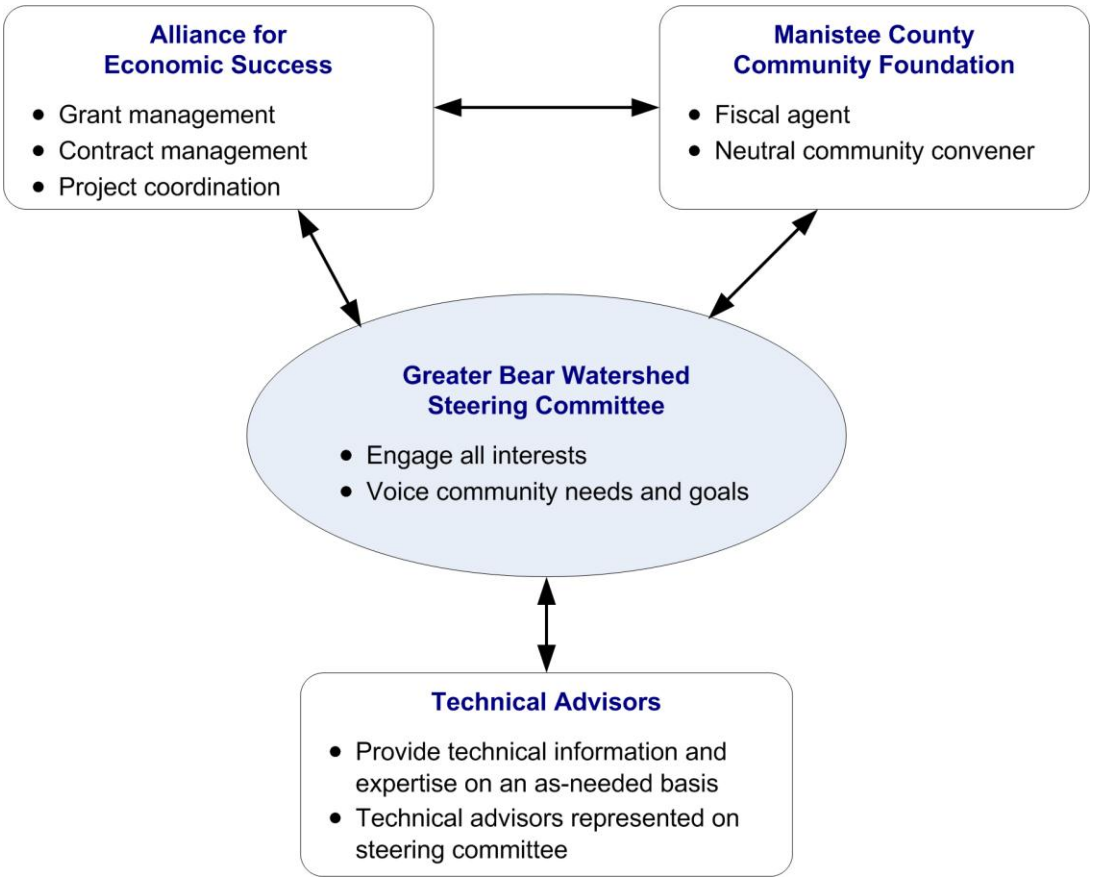
The Greater Bear Watershed Management Plan began with local groups working together to address the needs of the region's natural resources. The Manistee County Community Foundation (MCCF), in collaboration with the Manistee County Alliance for Economic Success (AES) responded to this local interest by submitting a grant application to the Michigan Department of Environmental Quality (MDEQ) to update the previously developed Bear Creek Watershed Plan and expand the scope of the previous plan to include Bear Lake and its tributaries to Bear Creek. A federally funded watershed planning grant administered through the state was subsequently awarded in 2010.

The MCCF and the AES formed a steering committee comprising representatives of the community: local property owner associations; subwatershed organizations; tribal, local, state, regional, and federal government agencies; business owners; and local nonprofit groups. Each of these entities recognizes the importance of sustainable management of watershed resources and its influence on quality of life and the economic vitality of the region.

## ORGANIZATIONAL STRUCTURE FOR PLAN DEVELOPMENT

Numerous community partners provided leadership on different aspects of the plan development. The MCCF served as the fiduciary for plan development and the AES provided contract and project management. The AES engaged Draze Consulting of Kaleva to provide fiscal management and administer a public survey. The steering committee also appointed Jim Draze, Draze Consulting, as chair of the Greater Bear Watershed Plan committee. Laura Heintzelman, executive director of the MCCF, was appointed as the vice-chair. Public Sector Consultants of Lansing, Michigan, was selected as a neutral facilitator to help the community develop the plan. A technical committee of retired professionals and entities represented on the steering committee was formed to share and review relevant technical information about the watershed. The organizational structure that supported the development of the plan is depicted in Exhibit 1.

**EXHIBIT 1:** Organizational Structure for Plan Development




## PUBLIC FORUMS–2011

A series of public forums was held in 2011 at the beginning of the plan development process. The meetings were open to all watershed residents, users, and other stakeholders. The purpose of the meetings was to provide information about the watershed, the development of the plan, and the process by which plan development would proceed; obtain information about concerns, goals, and priorities for management of watershed resources; and build community support for the development and implementation of the watershed plan. The meetings were attended by 54 people (excluding steering committee members and project consultants).

During the 2011 public forums attendees broke into small discussion groups facilitated by steering committee members and were asked three questions to obtain their input on the watershed priorities. A summary of those responses is given below. Detailed responses, as provided by participants, can be found in Appendix 1.

### *What are some of the things that you do in the watershed?*

Participants gave many examples of activities in which they partake in the watershed including those that relate to recreation, residential uses, and economic activity. Recreational activities included both water- and land-based activities such as fishing, swimming, boating, hiking, biking, and snowmobiling, for example.

Many participants indicated that they reside in the watershed and that the natural resources enhance a way of life for them, their family, and their friends. Attendees also indicated that they engage in commerce in the watershed, which is enhanced by the natural resources. Some of the commercial activities are tied directly to natural resources through farming, forestry, and sport fishing; others indicated that natural-resource–based tourism supports other commercial interests in the region such as restaurants and shops.

### *What concerns do you have about the watershed?*

Many participants expressed concern regarding degradation of environmental quality, specifically about nutrients and chemicals entering waterbodies from multiple sources including households, businesses, farms, and other sources.

Other concerns identified by participants included stream bank erosion, sedimentation, invasive species, and the health of the fishery. Participants also discussed concerns related to public access to waterbodies and waterways, in conjunction with private property rights.

The group also expressed concern about the lack of financial resources to implement and achieve goals, as well as the long-term economic vitality of communities within the watershed. Members of the group expressed the opinion that strengthening the coordination and collaboration between and among local, state, and federal government, businesses, and the nonprofit community could help address these concerns.

### *What do you want the watershed to look like in 50 years?*

Participants expressed a multigenerational vision for the Greater Bear Watershed in terms of how they would like it to look in 50 years. Attendees said that they want to see planned growth and management that maintains and enhances the natural resources of the watershed and the sense of place of the communities within the Greater Bear Watershed. Attendees said that this could be achieved through active partnerships among government, business, and nonprofit organizations to realize shared goals, to enhance natural resource assets of the watershed, to help the community retain and attract residents and visitors of all ages, and to support a vibrant economy.

## HOUSEHOLD SURVEY

A survey was developed in the spring of 2011 and administered by Draze Consulting between August and December 2011. The survey was constructed using the U.S. Environmental Protection Agency's (USEPA) survey tool and item bank, and was approved by the MDEQ in July 2011.

The survey asked residents and others who use watershed resources a number of questions that were intended to provide the steering committee with information about how people use watershed resources, their knowledge of various natural resource management practices, their priorities for and concerns about the watershed, as well as other information. The survey was available online and hard copies were made available to individuals without online access. The survey was announced at multiple meetings including:

- Bear Lake Property Owners Association
- Bear Lake Watershed Alliance annual meeting
- Bear Creek Watershed Council meetings
- Big Bear Sportsman Club
- Greater Bear Watershed public forums
- Lion's Club
- Manistee County Planning Commission
- Local municipal government
- Spirit of the Woods Conservation Club meetings

Public announcements of the watershed planning effort and the survey were made in the *Manistee News Advocate*, Bear Lake Watershed Alliance newsletter, Bear Lake Property Owners Association newsletter, Bear Creek Watershed Council newsletter, and the AES electronic newsletter. Hard copies were available at the public libraries; the Bear Lake and Maple Grove Township Halls; and distributed through the Bear Lake and Kaleva Norman Dickson schools. Since respondents were self-selected (not a random sample), survey results are not statistically significant. In other words, the results of the survey provide information about respondents' preferences and the way they use the watershed, but survey results cannot be extrapolated to provide information about all users in the watershed. It is also likely that people who are generally more aware of watershed issues and engaged in the plan process responded to the survey in greater numbers, which likely affected the results.

The results of the survey are still informative because they provide information about how respondents use the watershed, their knowledge of watershed management practices, and their priorities and concerns for natural resources in the region. This information was used to inform the development of the Greater Bear Watershed Management Plan.

When the survey concluded, 165 responses were received online or from paper copies. A complete report containing the survey instrument and results, prepared by Draze Consulting, is included in Appendix 2. In addition to informing the development of the plan as a whole, the survey results were particularly useful in informing the desired uses, priorities, goals, and information and education sections of the report.

## PUBLIC FORUMS–2012

A second series of public forums was held in the summer of 2012 during which sections of the draft plan were available for review and input from watershed residents, users, and stakeholders. More than 70 people attended these meetings (including many of the same people who attended the 2011 forums). The majority of responses indicated that the plan appropriately encapsulated goals and priorities of the community. The plan was revised in some areas based on the input and feedback from these forums.

# Section C: Description of the Greater Bear Watershed

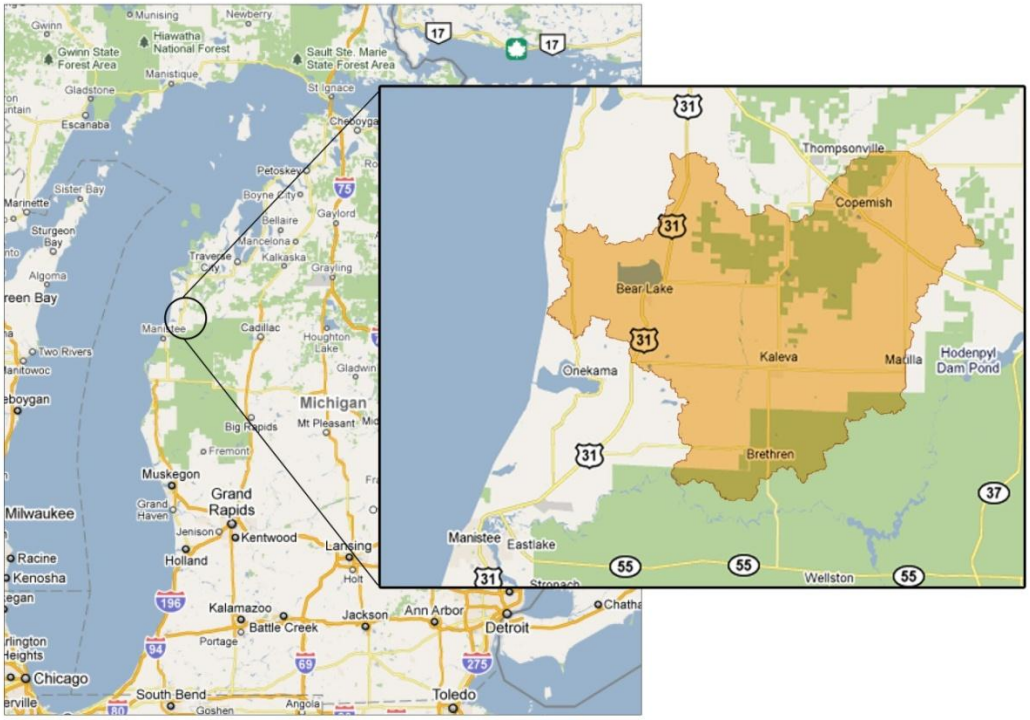
This section provides a comprehensive description of the Greater Bear Watershed, including its physical, political, and environmental setting.

## PHYSICAL AND NATURAL FEATURES

### *Location, Size, and Boundaries*

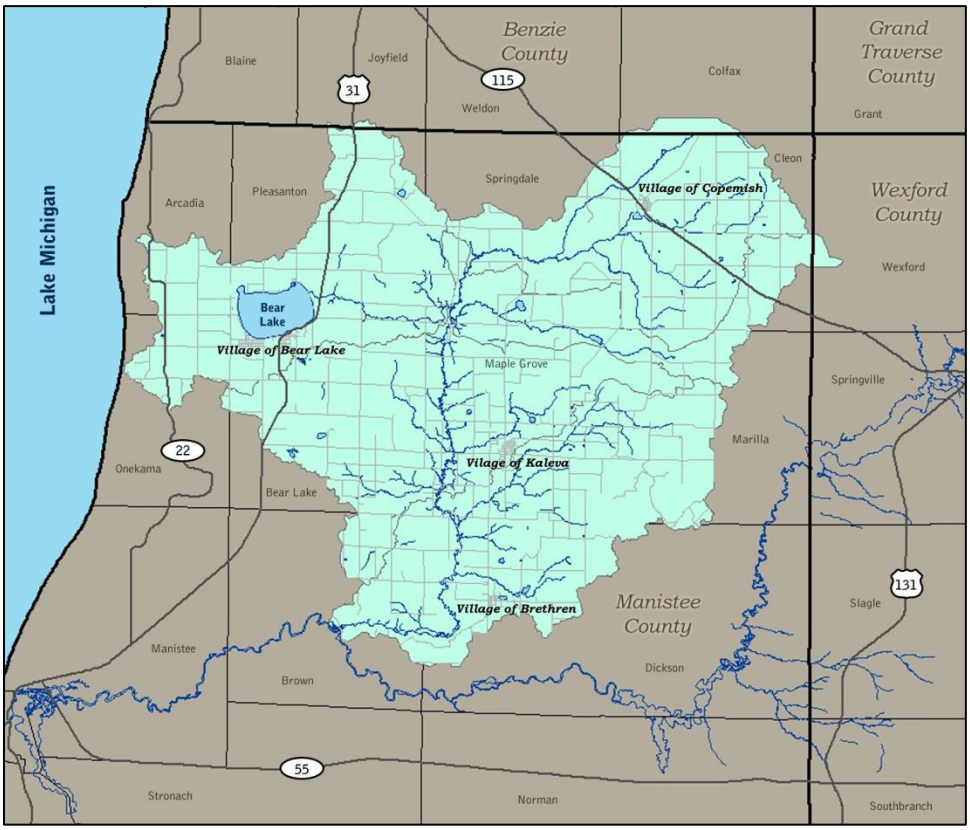
The Greater Bear Watershed is located in the northwest portion of Michigan's Lower Peninsula, primarily in Manistee County, with portions extending into Benzie and Wexford counties (see Exhibit 2). As shown in Exhibits 2 and 3, the watershed encompasses approximately 204 square miles or 130,800 acres; covering all, or portions of, 13 townships (Benzie County: Colfax and Joyfield townships; Manistee County: Arcadia, Bear Lake, Brown, Cleon, Dickson, Maple Grove, Marilla, Onekema, Pleasanton, and Springdale townships; and Wexford County: Wexford Township). The watershed includes three incorporated villages (Bear Lake, Copemish, and Kaleva), the unincorporated community of Brethren, which is located in Dickson Township within the Manistee National Forest, and public lands of interest to the Little River Band of Ottawa Indians (LRBOI) reservation (see Exhibit 4).

**EXHIBIT 2.** General Location, Greater Bear Watershed




SOURCE: Public Sector Consultants Inc., 2012, using data from Google Earth.

## **EXHIBIT 3.** Greater Bear Watershed, Detailed Location




SOURCE: Public Sector Consultants Inc., 2012, using data from Michigan Department of Information Technology, Center for Geographic Information (MDIT/CGI).

**EXHIBIT 4.** Communities in the Greater Bear Watershed*

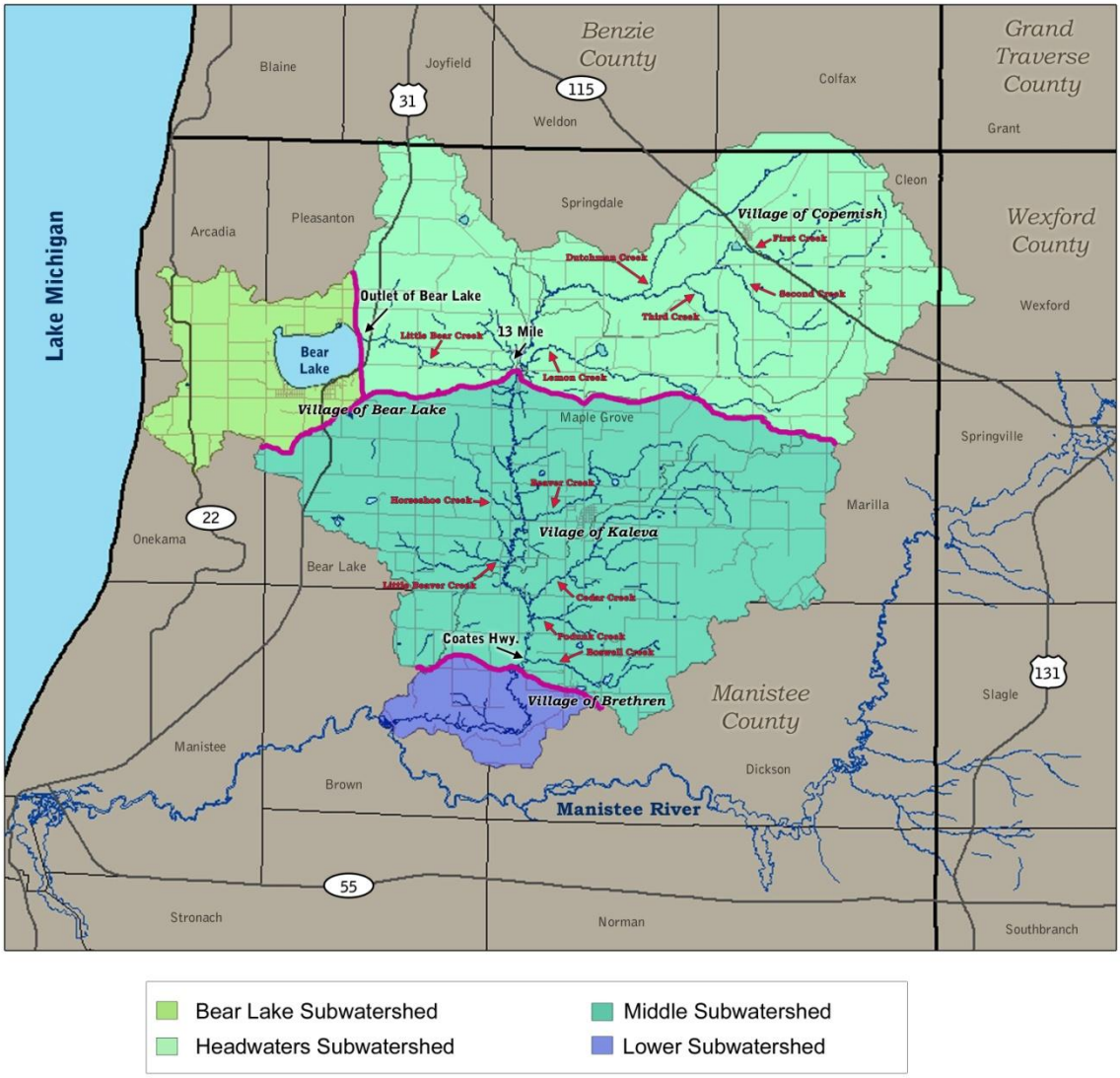
| Jurisdiction | Acres within watershed | Square miles within watershed | % of jurisdiction within watershed | % of watershed within jurisdiction |
|---|---|---|---|---|
| **Benzie County** | **918** | **1** | **<1%** | **<1%** |
| Colfax Township | 804 | 1 | 4 | 1 |
| Joyfield Township | 114 | <1 | 1 | <1 |
| **Manistee County** | **129,535** | **202** | **36%** | **98%** |
| Arcadia Township | 3,471 | 5 | 29 | 3 |
| Bear Lake Township | 18,938 | 30 | 83 | 15 |
| Bear Lake Village | 202 | <1 | 100 | <1 |
| Brethren** | NA | NA | NA | NA |
| Brown Township | 6,247 | 10 | 27 | 5 |
| Cleon Township | 19,053 | 31 | 85 | 15 |
| Copemish Village | 656 | 1 | 100 | <1 |
| Dickson Township | 12,718 | 20 | 28 | 10 |
| Kaleva Village | 670 | 1 | 100 | <1 |
| Maple Grove Township | 22,242 | 36 | 100 | 18 |
| Marilla Township | 12,224 | 19 | 54 | 9 |
| Onekema Township | 4,088 | 6 | 29 | 3 |
| Pleasanton Township | 14,638 | 23 | 65 | 11 |
| Springdale Township | 14,388 | 22 | 63 | 11 |
| **Wexford County** | **337** | **<1** | **<1%** | **<1%** |
| Wexford Township | 337 | 1 | 1 | <1 |

SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.
* All figures are approximate and for descriptive purposes only.
** Brethren is an unincorporated community and is included as part of Dickson Township, Manistee County, Michigan.
NA = not applicable.

## *Greater Bear Subwatersheds*

The Greater Bear Watershed includes four subwatersheds as identified by the steering committee, which are based on land ownership, geographic features, and hydrologic features: (1) Bear Lake, (2) Headwaters, (3) Middle, and (4) Lower (see Exhibit 5). The Bear Lake Subwatershed consists of the area surrounding Bear Lake, generally west of U.S. Highway 31, to the lake outlet, Little Bear Creek. The Headwaters Subwatershed is located upstream of 13 Mile Road within the Pere Marquette State Forest. This reach includes substantial wetlands adjacent to Bear Creek and its tributaries. Bear Creek and tributaries upstream from 13 Mile Road are open to fishing only during the normal trout season, which runs from the last Saturday in April through the last day in September. The Middle Subwatershed is located between 13 Mile Road and Coates Highway and has very limited public access. Bear Creek in the Middle Subwatershed is open to year-round fishing and has many tributaries that are high-quality trout streams. The Lower Subwatershed is located from Coates Highway downstream to the confluence of Bear Creek and the Manistee River. The Lower Subwatershed is within the Huron-Manistee Forest and Bear Creek is designated as a National Scenic River under federal law in this area.

## **EXHIBIT 5.** Greater Bear Subwatersheds

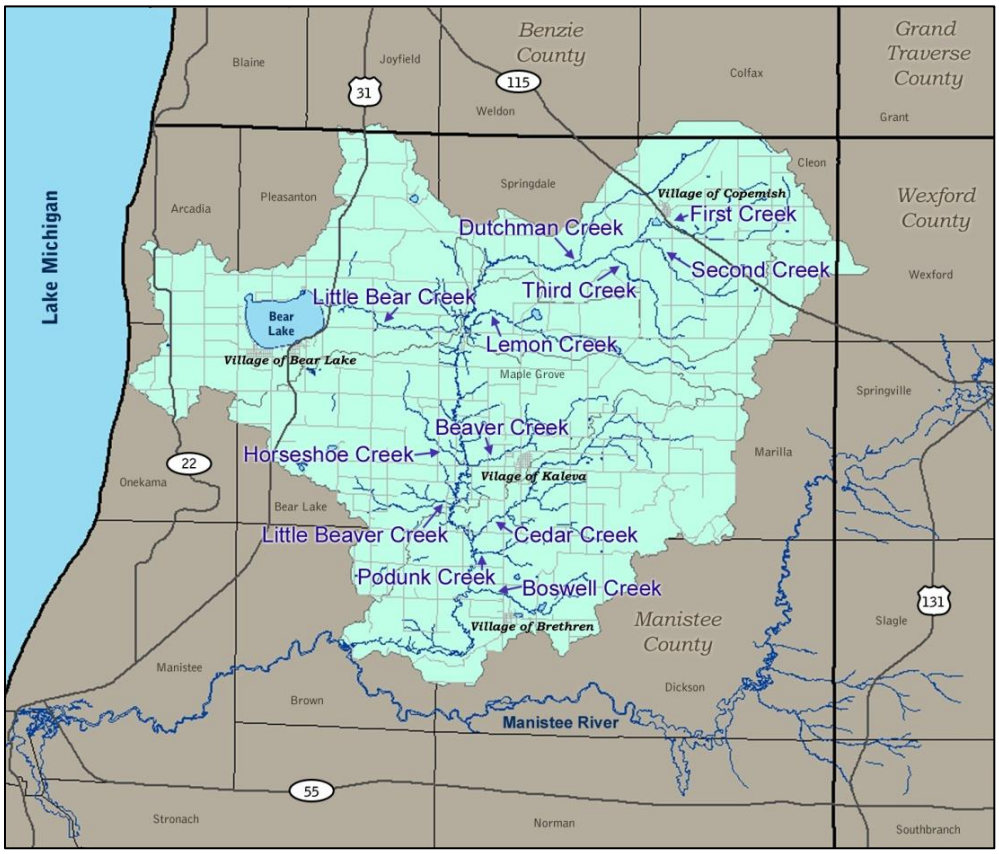



SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI and information from the Greater Bear Watershed Steering Committee, 2011.

### *Water Resources and Hydrology*

The Greater Bear Watershed includes substantial surface water features including Bear Lake, Bear Creek, the creek's 12 named tributaries (see Exhibit 6), and 11 other named lakes.[1]

**EXHIBIT 6.** Named Tributaries




SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.

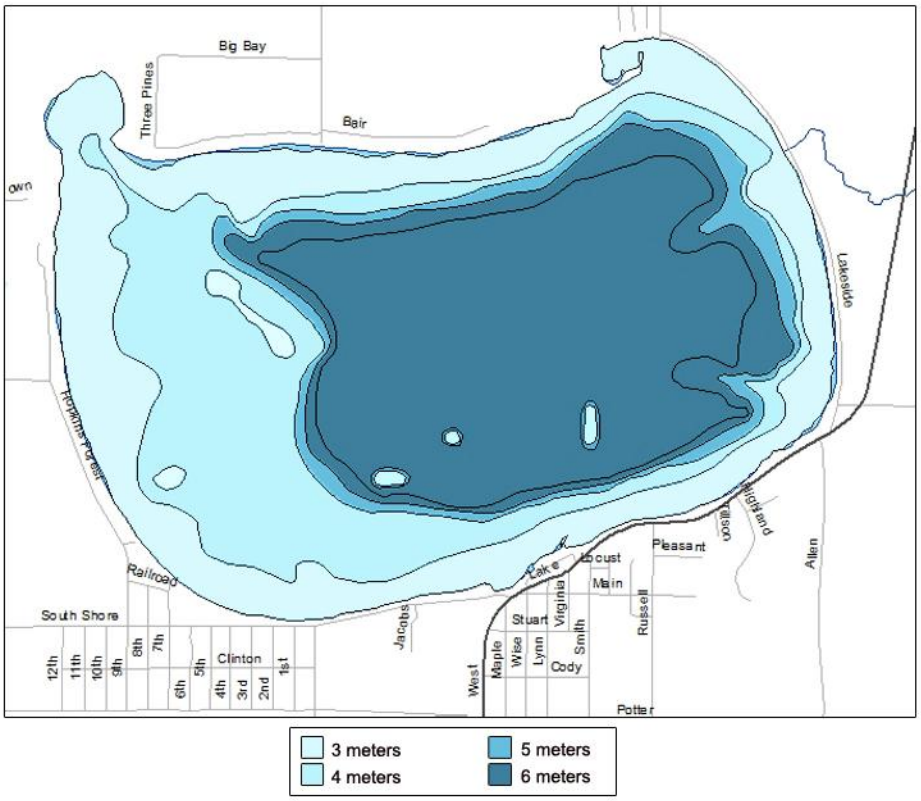
Bear Lake formed naturally during the Wisconsinan glacial stage, or between 10,000 to 75,000 years ago. It covers approximately 1,744 surface acres and is approximately 24 feet deep at its maximum depth (see Exhibit 7). Approximately two-thirds of the lake is less than 20 feet deep (Tonello 2000a). The size and depth of the lake are known to fluctuate based on seasonal and other factors. The volume of Bear Lake is an estimated 26,503 acre-feet, with a hydraulic retention time of approximately 2.19 years.[2] The shoreline of the lake is estimated at 7.62 miles and its widest dimension is approximately 2.38 miles (ASI

[1] Named tributaries of Bear Creek are: First Creek, Second Creek, Third Creek, Beaver Creek, Boswell Creek, Cedar Creek, Dutchman Creek, Horseshoe Creek, Lemon Creek, Little Bear Creek, Little Beaver Creek, and Podunk Creek. Named lakes are: Ball Pond, Center Lake, Clarence Lake, Dickson Lake, Glovers Lake, Healy Lake, James Lake, Lake Eleanor, Lake Salma, Lemon Lake, and Mud Lake (Public Sector Consultants Inc., 2011, using data from ESRI).

[2] Hydraulic retention time is the length of time that it takes for a body of water to completely exchange its contents. In other words, it is a measurement of how long water and soluble compounds stay in a body of water.

Environmental Technologies Inc., 2007a). Little Bear Creek, the only outlet of Bear Lake, is located on the northeast portion of the lake and is a tributary to Bear Creek.

**EXHIBIT 7.** Bear Lake Map and Depth Contours




SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.

The main stream of Bear Creek is approximately 28 miles long from its headwater area in the northeast portion of the watershed to its confluence with the Manistee River. It has a large number of miles of named and unnamed tributaries as well as significant groundwater inputs as it flows generally in a southerly direction. It is the largest tributary to the Manistee River downstream of Tippy Dam, which is located in the southeast portion of Manistee County about 5 to 10 miles outside the Greater Bear Watershed. Exhibit 8 provides available data on Bear Creek and tributaries for flow, width, and depth at various locations and various times of the year.

**EXHIBIT 8.** Bear Creek and Tributaries Hydrology

| Type | Creek Name | Location | Flow (CFS) | Width (Feet) | Avg. Depth (Feet) | Month | Year | Source |
|---|---|---|---|---|---|---|---|---|
| **Headwaters Subwatershed** | | | | | | | | |
| Tributary | First | Copemish Pond | 3.40 | NA | NA | Sept. | 1990 | USFWS |
| Tributary | Second | Yates Rd. | 1.30 | 17 | 0.42 | June | 1999 | MDEQ |
| Tributary | Second | Yates Rd. | 11.10 | NA | NA | Aug. | 1990 | USFWS |
| Tributary | Third | Sec.24SE | 12.10 | NA | NA | Aug. | 1990 | USFWS |
| Tributary | Lemon | Park Rd. | 8.50 | 17 | 0.50 | June | 1999 | MDEQ |
| Tributary | Lemon | Park Rd. | 2.90 | NA | NA | Sept. | 1990 | USFWS |
| **Middle Subwatershed** | | | | | | | | |
| Mainstream | Bear | 13 Mile Rd. | 65.30 | NA | NA | Aug. | 1990 | USFWS |
| Mainstream | Bear | 13 Mile Rd. | 67.30 | NA | NA | Aug. | 1990 | USFWS |
| Tributary | Little Bear | Big Four Rd. | 21.50 | 22 | 0.83 | June | 1999 | MDEQ |
| Tributary | Little Bear | Near 13 Mile Rd. | 4.20 | NA | NA | Sept. | 1990 | USFWS |
| Tributary | Little Beaver | McClellan Rd. | 6.60 | 11 | 0.33 | June | 1999 | MDEQ |
| Tributary | Cedar | Johnson Rd. | 11.30 | 13 | 0.58 | June | 1999 | MDEQ |
| Tributary | Cedar | Johnson Rd. | 10.00 | NA | NA | Aug. | 1990 | USFWS |
| Tributary | Podunk | High Bridge Rd. | 1.80 | 6 | 0.42 | June | 1999 | MDEQ |
| Mainstream | Bear | Kerry Rd. | 151.00 | 55 | 1.25 | June | 1999 | MDEQ |
| Tributary | Boswell | Boswell Cr. | 2.02 | 8 | 0.42 | June | 1999 | MDEQ |
| **Lower Subwatershed** | | | | | | | | |
| Mainstream | Bear | Coates Hwy | 199.60 | NA | NA | June | 1999 | MDEQ |
| Mainstream | Bear | Coates Hwy | 136.60 | NA | NA | Aug. | 1990 | USFWS |

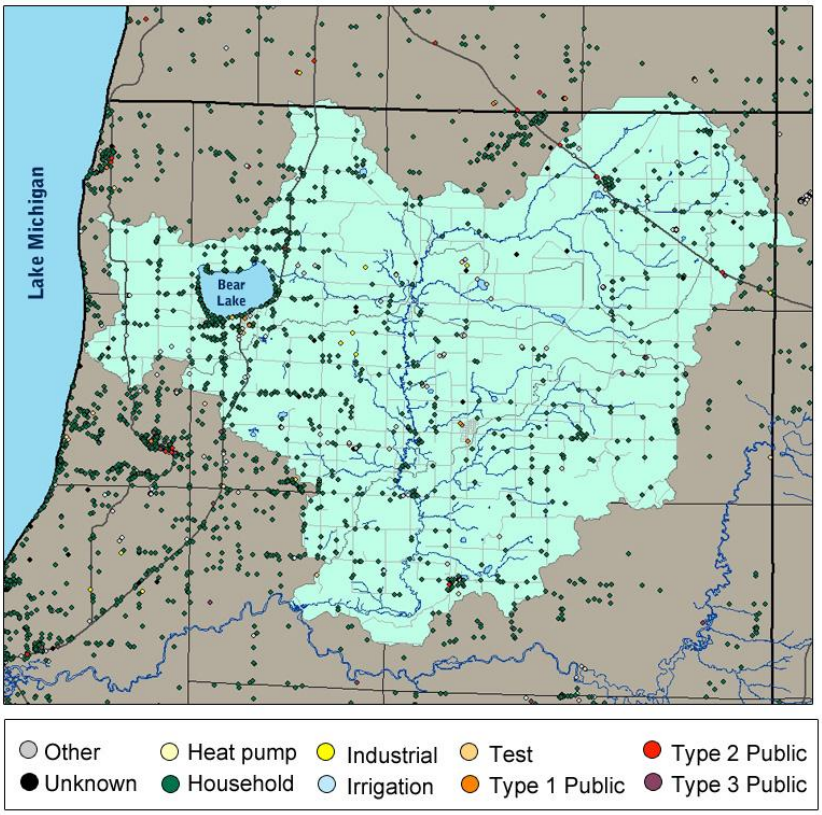
SOURCE: PSC using selected data from field inventory sheets recorded by U.S. Fish and Wildlife Service from August through November of 1990 during sea lamprey pre-treatment reconnaissance surveys, and by MDEQ during biological surveys of selected Bear Creek tributaries. Data collected in June represent close to mean average flow while data collected in August through September represent expected low flow conditions. The data provide a general view of the size of the river and tributaries and typical range of average and low flow.
NA = Not Available.

## *Groundwater Resources*

Groundwater is an important resource in the Greater Bear Watershed. Residents and businesses rely on groundwater for household, commercial, and agricultural uses. The Villages of Bear Lake and Kaleva are served by public water systems (MDEQ 2009). Businesses and residents outside of these areas rely on privately maintained water wells. In the Greater Bear Watershed, there are 961 registered water wells (see Exhibits 9 and 10). Exhibits 9 and 10 shows the distribution of water wells in the Greater Bear Watershed, which indicates the location of residential and commercial dwellings in areas outside of the villages of Bear Lake and Kaleva.

While existing regulations protect groundwater from permitted waste discharges, leaking underground storage tanks and other nonpoint discharges from land uses involving the storage, disposal, transportation, and use of hazardous materials may threaten groundwater resources in the watershed.

## **EXHIBIT 9.** Water Well Locations




SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.

## **EXHIBIT 10** Water Wells in the Greater Bear Watershed, by Type

| Well type | General well description | Number of wells |
|---|---|---|
| Household | Single living unit | 769 |
| Other | Any other water well | 122 |
| Unknown | Not enough information | 17 |
| Irrigation | Provides water for agricultural purposes (e.g., farms, golf courses) | 17 |
| Test Wells | For environmental sampling | 10 |
| Industrial | Water for commercial or industrial use | 7 |
| Type 3 Public | Serves less than 25 people | 7 |
| Type 1 Public | Provides year round service to at least 25 residents (e.g., municipalities, apartments, nursing homes) | 6 |
| Type 2 Public | Provides water to at least 25 people at a place other than their residence (e.g., schools, restaurants, workplaces, hotels, campgrounds) | 5 |
| Heat Pump | Provides water for geothermal or other uses | 1 |
| **Total** | | **961** |

SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.

### *Sites of Environmental Concern*

Sites of concern include open leaking underground storage tank (LUST) sites and Part 201 sites. Open LUST sites are those where a release has occurred and corrective actions have not been completed to meet the appropriate land use criteria. Part 201 sites are those where there has been a release of a hazardous substance or substances in excess of the residential criteria in Part 201 of the Michigan Natural Resources and Environmental Protection Act, Public Act 451 of 1994, and/or where corrective actions have not been completed under Part 201 to meet the applicable cleanup criteria for unrestricted residential use. Exhibits 11–14 provide details about open LUST and Part 201 sites in the watershed.

**EXHIBIT 11.** Open Leaking Underground Storage Tank Sites

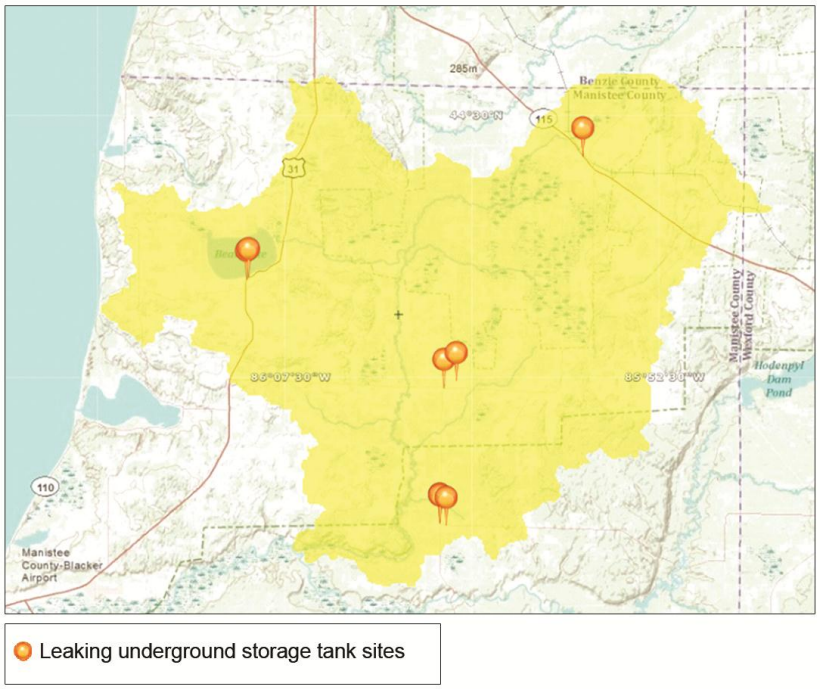
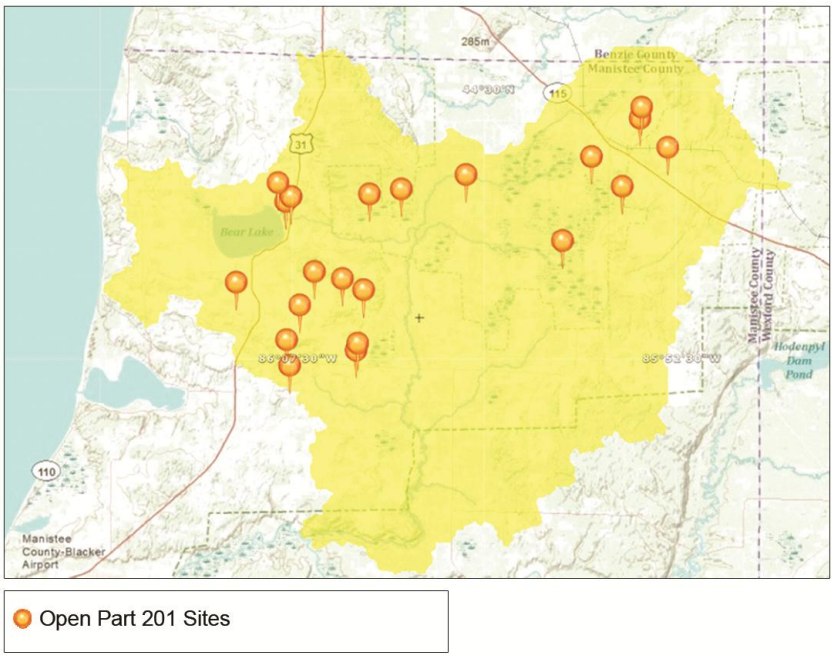



**EXHIBIT 12.** Open Leaking Underground Storage Tank Sites, by Site Name

| LUST Site Name | Substance Released | Facility ID |
|---|---|---|
| Blarney Castle Oil Co. #2 | Gasoline, Diesel | 00011182 |
| Brethren Mini Mart | Gasoline | 00008861 |
| Blarney Castle (Phillips 66) | | 00011170 |
| Brethren 66 Service | Unknown | 00012137 |
| Copemish Pro Hardware | Unknown | 00036966 |
| Country Side Party Store | Unknown | 00019588 |
| Cripe Road (Alexander Res.) | | 50001459 |
| Road Commission Site. Right Of Way Tanks | Gasoline | 50002289 |

SOURCE: Public Sector Consultants Inc., 2012, using data from the MDEQ Storage Tank Information Center, 2011.

## **EXHIBIT 13.** Open Part 201 Sites




## **EXHIBIT 14.** Open Part 201 Sites, By Name

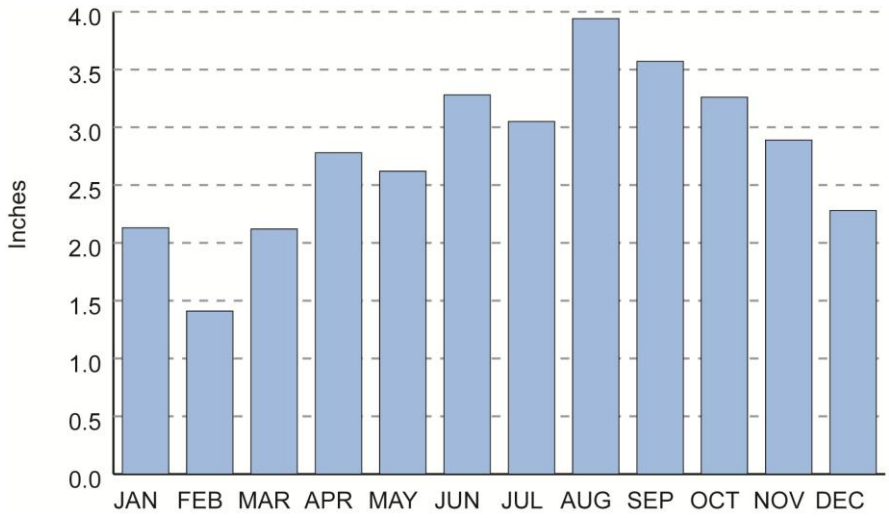
| SITE ID | NAME | SOURCE |
|---|---|---|
| 51000006 | Baugh #1-36 | Natural gas drilling |
| 51000012 | Griner #1-21 | Natural gas drilling |
| 51000013 | Kuenzer #1-14 | Oil & Gas Extraction |
| 51000014 | Refke #1-28 | Oil & Gas Extraction |
| 51000017 | Abshire State Cleon #4-29 | Oil & Gas Extraction |
| 51000019 | Rebman et al #2-16A | Natural gas drilling |
| 51000021 | Rebman #3-16A | Natural gas drilling |
| 51000025 | State-Springdale #8-31A | Natural gas drilling |
| 51000026 | Hilliard #1-26A | Natural gas drilling |
| 51000027 | State-Maple Grove #3-1 | Natural gas drilling |
| 51000028 | Reckow Howes #1-26A | Oil & Gas Extraction |
| 51000084 | State-Cleon #1-19 | Oil & Gas Extraction |
| 51000086 | Res Well Maidens Road | Unknown |
| 51000087 | Springdale 28 CPF | Oil & Gas Extraction |
| 51000089 | Bear Lake 13 CPF | Oil & Gas Extraction |
| 51000093 | Darbee-Brannon #1-10A | Oil & Gas Extraction |
| 51000125 | Vorbau Estate | Private Households |
| 51000061 | Res Well 8 Mile Road | Unknown |
| 51000062 | Res Well Co Rd Bear Lake Twp | Unknown |
| 51000069 | Res Well Pleasanton Hwy | Unknown |
| 51000143 | Weimer Residence | Private Households |

SOURCE: Public Sector Consultants Inc., 2012, using data Michigan State University Remote Sensing and GIS Research and Outreach Services, 2006.

### *Climate and Precipitation*

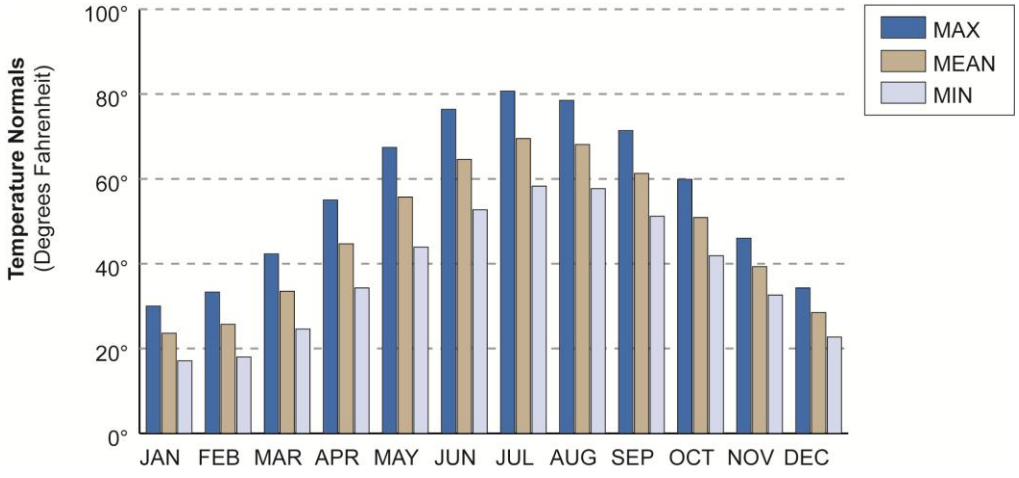
An average of 33 inches of total precipitation falls annually at the Manistee County Blacker Airport, the nearest weather station to the Greater Bear Watershed (NOAA 2000); monthly averages are shown in Exhibit 15. The maximum average precipitation occurs in August (3.94 inches) and the lowest in February (1.41 inches). In January, typically the coldest month of the year, the temperature averages 30 to 17.1 degrees Fahrenheit (ºF). In July, typically the warmest month of the year, temperatures average between 80.7 and 58.3 ºF (NOAA 2000). See Exhibit 16 for monthly temperature averages.

**EXHIBIT 15.** Monthly Precipitation Average at Manistee County Blacker Airport, 1971–2000




SOURCE: Public Sector Consultants Inc., 2012, using data from NOAA, 2000.

**EXHIBIT 16.** Monthly Temperature Average at Manistee County Blacker Airport, 1971–2000

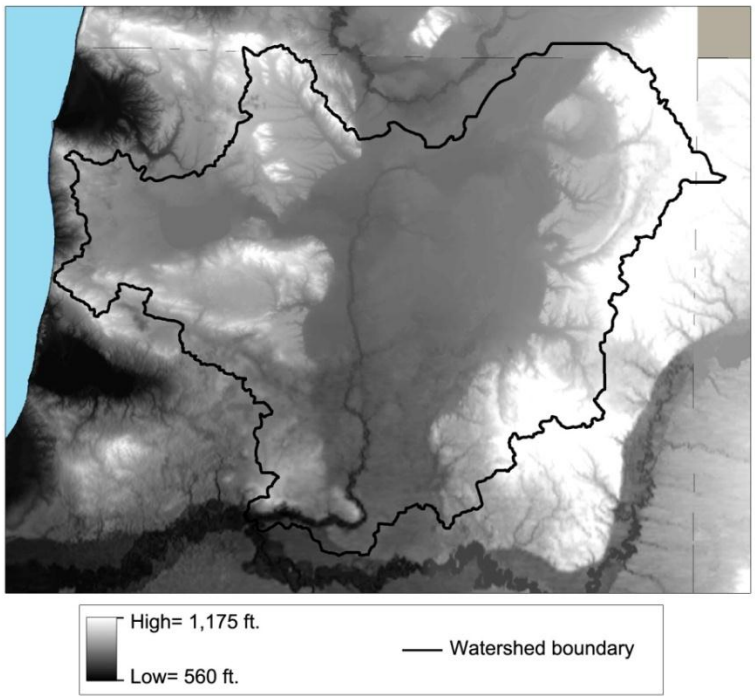



SOURCE: Public Sector Consultants Inc., 2012, using data from NOAA, 2000.

### *Topography and Elevation*

Elevation in Manistee County ranges from approximately 562 feet to 1,172 feet above sea level. The lowest point of the watershed is near the area where Bear Creek joins with the Manistee River. The areas of highest elevation are mostly along the eastern boundary of the watershed (see Exhibit 17).

**EXHIBIT 17.** Greater Bear Watershed Topography*

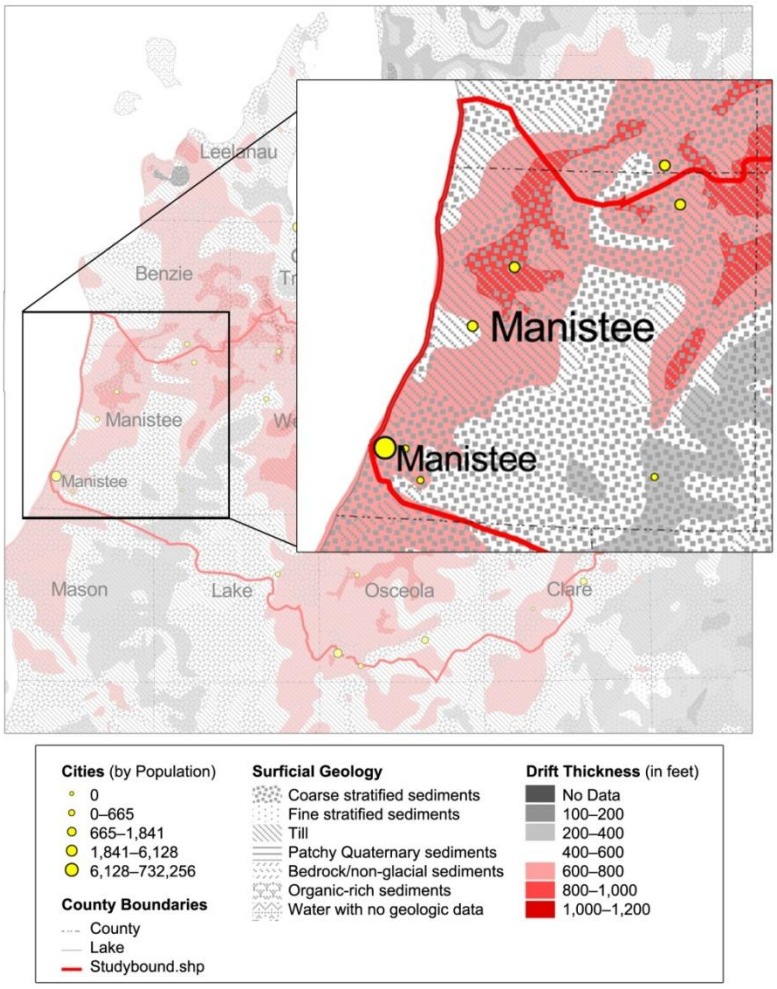



SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.
* Shown in feet above sea level.

### *Geology*

Glacial deposits (the materials left behind as glaciers advanced and retreated throughout the area) vary from 200 to 1,000 feet above the bedrock formations in Manistee County (see Exhibit 18).

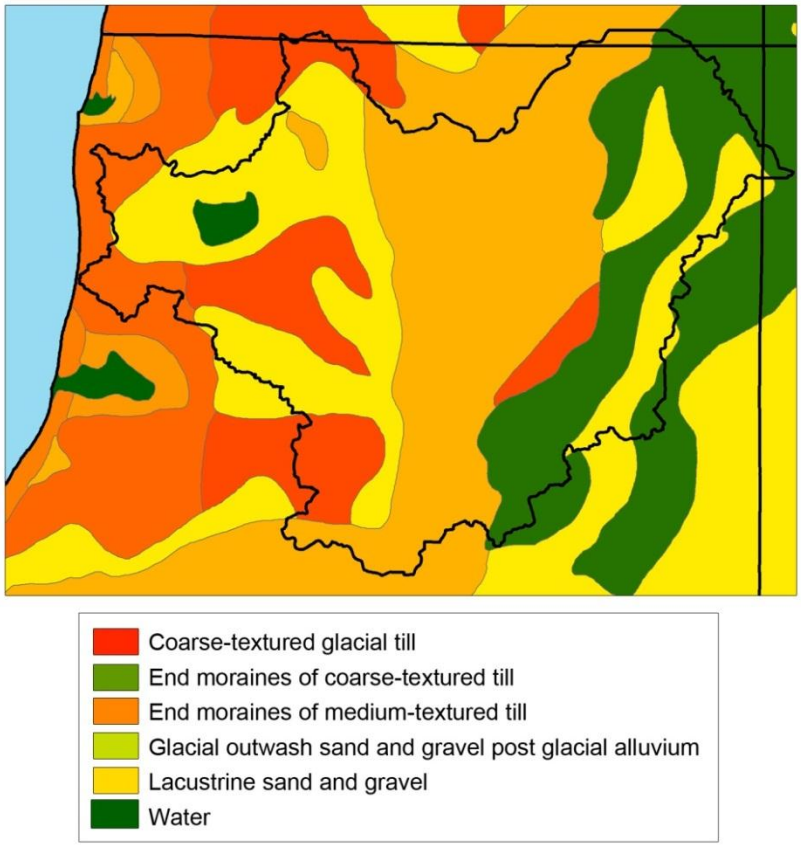
**EXHIBIT 18.** Thickness and Composition of Glacial Deposits in Manistee County




SOURCE: Public Sector Consultants Inc., 2012, using data from U.S. Geological Survey.

A mixture of coarse- and medium-textured end moraines (formed at the edge of the glacial advance leaving in its place a significant amount of material as the glacier retreated), lacustrine sand and gravel (material in this glacial feature is generally sorted by similar size), glacial outwash and post-glacial alluvium (loose material) associated with moraines and other glacial features characterize the near-surface geologic conditions within the Greater Bear Watershed (see Exhibit 19).

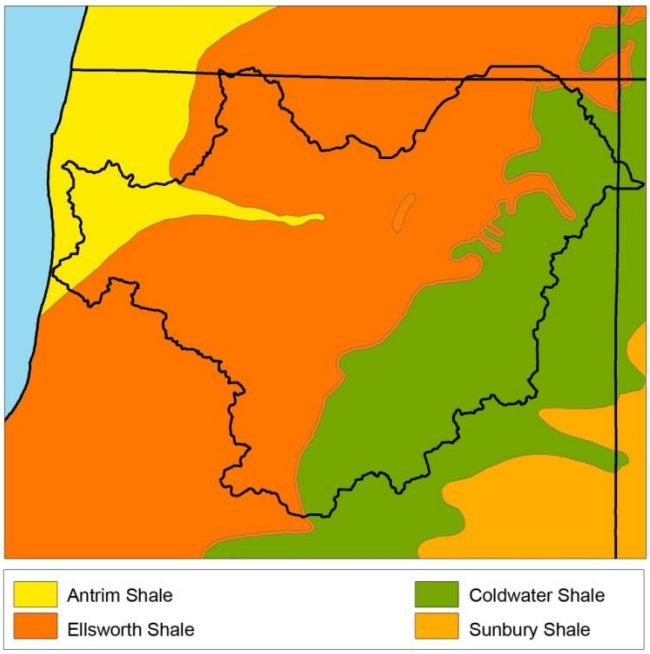
**EXHIBIT 19.** Quaternary Geology (Recent Glacial Deposits)




SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.

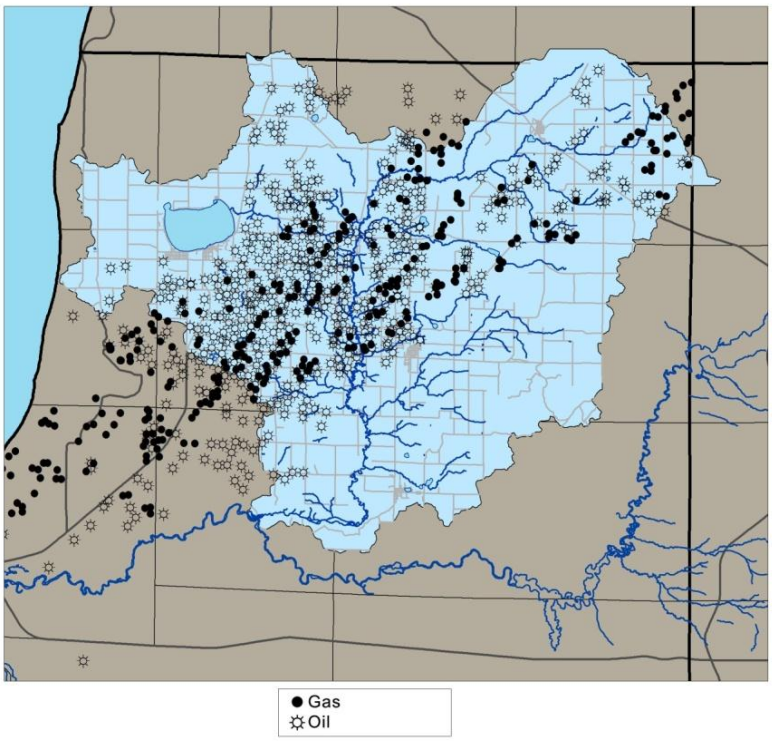
As shown in Exhibit 20, the bedrock beneath the glacial deposits in the Greater Bear Watershed consists of various types of shale (Antrim, Coldwater, and Ellsworth formations). Manistee County and the Greater Bear Watershed are at the rim of the large geologic sedimentary rock feature covering most of the Lower Peninsula of Michigan (the Michigan Basin), the outer edges of which contain significant hydrocarbon deposits. Manistee County ranks second in the state in all-time total production of both oil and natural gas dating back to 1925. Exhibit 21 shows the location of oil and gas wells in the Greater Bear Watershed.

## **EXHIBIT 20.** Bedrock Geology of the Greater Bear Watershed




SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.

## **EXHIBIT 21.** Oil and Gas Well Locations

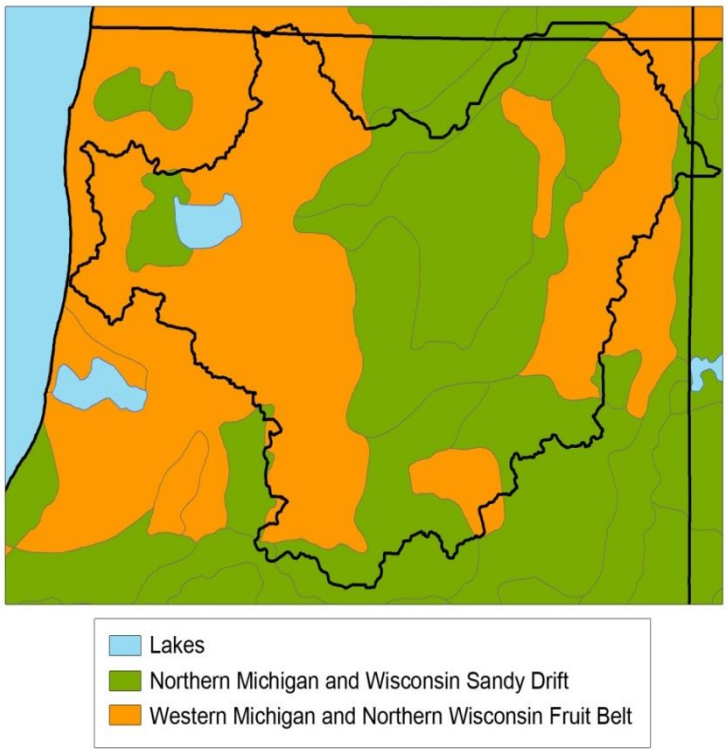



SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.

### *Soils*

The surface soils of the watershed reflect the glacial origins of this area along the Lake Michigan shoreline. In general the soils are well drained (permeable) sandy soils (see Exhibit 22). In general, surface runoff is minimized by the permeability of the soils in the watershed.

**EXHIBIT 22.** General Soils




SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.

### *Threatened and Endangered Species and Species of Concern*

Michigan's endangered and threatened species are protected under the Natural Resources and Environmental Protection Act, Public Act 451 of 1994. The Michigan Department of Natural Resources (MDNR) designates and maintains information on the status and location of threatened and endangered species. This work is coordinated through the Michigan Natural Features Inventory (MNFI), a part of Michigan State University Extension. Federally listed species are protected under the Endangered Species Act of 1973.

Endangered species are species near extinction throughout all or a significant portion of their range. Threatened species are species likely to become classified as endangered within the foreseeable future throughout all or a significant portion of their range. Species of concern are those that are extremely uncommon or have a unique or highly specific habitat requirement, whose status deserves careful monitoring. A species on the edge or periphery of its range that is not listed as threatened may be included as a species of concern along with any species that was once threatened or endangered but now has an increasing or protected, stable population.

Based on information from the MNFI, there is one state-listed endangered species, the Pugnose shiner, in the Greater Bear Watershed (see Exhibit 23). There are three state-listed threatened species within the watershed—Ginseng, the Lake Huron locust, and the Red-shouldered hawk—and eight state-listed species of concern—the Bald eagle, Blanding's turtle, Grasshopper sparrow, Northern goshawk, Northern harrier, Osprey, Wood turtle, and Woodland vole. The Michigan Natural Features Inventory does not identify any species as having federal designation.

**EXHIBIT 23.** Greater Bear Watershed Threatened and Endangered Species and Species of Concern

| Common name | Scientific name | Federal status | State status* |
|---|---|---|---|
| Northern goshawk | *Accipiter gentilis* | — | SC |
| Grasshopper sparrow | *Ammodramus savannarum* | — | SC |
| Red-shouldered hawk | *Buteo lineatus* | — | T |
| Northern harrier | *Circus cyaneus* | — | SC |
| Blanding's turtle | *Emydoidea blandingii* | — | SC |
| Wood turtle | *Glyptemys insculpta* | — | SC |
| Bald eagle | *Haliaeetus leucocephalus* | — | SC |
| Woodland vole | *Microtus pinetorum* | — | SC |
| Pugnose shiner | *Notropis anogenus* | — | E |
| Ginseng | *Panax quinquefolius* | — | T |
| Osprey | *Pandion haliaetus* | — | SC |
| Lake Huron locust | *Trimerotropis huroniana* | — | T |

SOURCE: Public Sector Consultants Inc., 2012, using information from Michigan Natural Features Inventory – Michigan State University Extension.
* Species of Concern (SC), Threatened (T), Endangered (E), No Designation (–).

While the specific locations of these species are not publicly disclosed in order to protect them, the MDNR uses the information to evaluate state or federal permits required for land or water uses. Endangered and threatened species and species of concern in the Greater Bear Watershed, as well as their habitat requirements, are described briefly in the following sections, excerpted from the MNFI website (http://web4.msue.msu.edu/mnfi/explorer/).

### Northern goshawk (*Accipiter gentilis*)

"The Northern goshawk is a large forest bird with long broad wings and a long tail which is rounded on the end. Upper parts of the adult are brown-gray to slate gray. The head has a black cap with a pronounced white eye-line. Under parts are light gray with fine horizontal vermiculations and vertical streaks. Undertail coverts are white, showy, and quite fluffy, especially during the breeding season. Immature birds are heavily streaked below and the undertail coverts are spotted. The goshawk may also be identified by its call which is a sharp and repetitive 'ki ki ki' or 'kak kak kak.'

Northern goshawks utilize a wide range of forested habitats ranging from boreal forests to northern hardwoods and occasionally pine plantations. In Michigan, goshawk nests occur most often in deciduous trees such as aspen, birch, beech, and maple and less frequent in conifers such as white pine, red pine, and jack pine."

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=10941 (accessed June 6, 2011).

## Grasshopper sparrow (*Ammodramus savannarum*)

"The Grasshopper sparrow is a small sparrow 4–5 inches (10.3–13 cm) in length, with an unmarked buffy breast and white belly and a flat head with a white stripe running from the bill to the back of the head. This secretive bird is easily identified from a distance by its high pitched, insectlike buzzy song 'tik-tuk tikeeeeeeeeeeez.' From long distances or on windy days the first syllable, 'tik,',may not be heard.

Grasshopper sparrows may be found in a wide variety of grasslands, cultivated fields, hayfields, and old fields and seem to prefer drier sites as long as there is tall dense grassy vegetation."

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=11220 (accessed June 6, 2011).

## Red-shouldered hawk (*Buteo lineatus*)

"Adult Red-shouldered hawks can be distinguished by the reddish coloration of their underparts and wing linings and their 5–6 narrow, white tail bands. In flight, they show crescent-shaped translucent patches lining the bases of the long, outermost wing feathers (the "primaries"). These patches are sometimes referred to as "windows." The bird's red shoulders are often not readily visible. Their call during the breeding season is distinctive; a loud, rapidly repeated 'kee-yer,' though it is closely imitated by Blue jays.

Red-shouldered hawks will nest in a variety of habitats but seem to be closely associated with mature forests in or adjacent to wet meadows and swamps."

Photo by Michael R. Penskar
*http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=10942.*

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=10942 (accessed June 6, 2011).

## Northern harrier (*Circus cyaneus*)

"Northern harriers are slim bodied, long-legged, and long-tailed hawks. Average harrier length is 17–23 inches (43–58 cm) and the wingspan averages 38–48 inches (96.5–122 cm). They are a sexually dimorphic species in respect to both size and color. Females are heavier and larger than males. The female is brown above and buff-colored with brown streaks below. The male is pale gray above and white below with black outer primary feathers. The white patch at the base of the tail is distinctive for adults and juveniles of both sexes. In flight, harriers usually fly just above the ground with only periodic heavy wing beats, banking and gliding slowly over open habitats. Vocalizations include an alarm or excited call usually described as 'ke-ke-ke' or 'chek-ek-chek-ek.'

Harriers nest and hunt in a variety of open habitats dominated by herbaceous vegetation. Large patches of suitable habitat are important to this ground-nesting raptor."

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=10938 (accessed June 6, 2011).

## Blanding's turtle (*Emydoidea blandingii*)

"The Blanding's turtle is a medium-sized turtle with adult carapace lengths ranging from 6 to 11 inches (15–28 cm). The carapace (top part of shell) is usually black with yellowish spots and streaks and is dome-like, elongated, and smooth. The plastron (bottom part of shell) typically is yellow with a dark blotch at the outer corner of each scute or scale. The Blanding's turtle has a very long neck and a bright yellow chin and throat. The head is dark with brown or yellow spots, and is relatively flat with a short, rounded snout and a notched upper jaw, giving the appearance of a permanent grin.

Photo by Jim Harding
*http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=11490*

Blanding's turtles inhabit clean, shallow waters with abundant aquatic vegetation and soft muddy bottoms over firm substrates. This species is found in ponds, marshes, swamps, bogs, wet prairies, river backwaters, embayments, sloughs, slow-moving rivers, and lake shallows and inlets. Blanding's Turtles also occupy terrestrial habitats in the spring and summer during the mating and nesting seasons and in the fall to a lesser extent. Females nest in open uplands adjacent to wetland habitats, preferring sunny areas with moist but well-drained sandy or loamy soil. They will nest in lawns, gardens, plowed fields, or even gravel road embankments if suitable natural nesting habitat is not available."

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=11490 (accessed June 6, 2011).

## Wood turtle (*Glyptemys insculpta*)

"The Wood turtle is a medium-sized turtle, with adult carapace (top part of shell) ranging in length from 6 to 10 inches (15–25 cm). The broad, low carapace usually has a central keel (a raised ridge running down the center of the shell), and raised, often pyramidal ridges of well-defined concentric growth rings on each scute or scale. The carapace is brown or grayish brown, often with radiating yellow and black lines on the ridges. The plastron (underside of shell) lacks a hinge, and is yellow with dark, oblong blotches along the outer edge. The highly 'sculptured' carapace and unhinged, patterned plastron distinguish this species from other turtles in the state.

Photo by James Harding
*http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=11489*

Wood turtles are found primarily in or near moving water and associated riparian habitats. They prefer clear, medium-sized (range 7–100 ft/2.1–30.5 m), hard-bottomed streams and rivers with sand and/or gravel substrates and moderate flow. Wood turtles also require partially shaded, wet-mesic herbaceous vegetation such as raspberries, strawberries, grasses, willows, and alders along or near the river for foraging. Forested floodplains (deciduous and coniferous) with numerous sunlit openings and a dense mixture of low herbs and shrubs seem to provide ideal habitat for this species. They also have been found in non-forested habitats such as willow and alder thickets,

sphagnum bogs, swamps, wet meadows, and old fields within or near the floodplain. Wood turtles also require sandy or sandy-gravelly areas along the river for nesting but will utilize gravel pits, railroad crossings, clearcuts, roadways, utility right-of-ways, and residential yards and gardens if natural nesting habitat is not available."

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=11489 (accessed June 6, 2011).

## Bald eagle (*Haliaeetus leucocephalus*)

"The Bald eagle is a large bird of prey, with a wingspan ranging from 6–7.5 feet (1.8–2.3m). Mature adults are immediately recognizable by their white head and tail and dark brown body. Their hooked beak and feet are yellow. Juvenile plumages are variable, but head and tail are brown with increasing amounts of white until they attain their adult plumage between 4.5 and 5.5 years of age. Females are larger than males.

Photo by Lee Emery/USFWS
*http://www.fws.gov/midwest/eagle/viewing/eaglepix.html*

Bald eagles will nest in a wide variety of habitats that provide suitable nest sites close to open water. Nests may be placed in snags or large live trees as well as on constructed platforms or utility poles. They are resident (stay year-round) as long as there is open water where they can forage."

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=10937 (accessed June 6, 2011)

## Woodland vole (*Microtus pinetorum*)

"The Woodland vole is a small mouse-like rodent (4–5.5 inches/11–14 cm) with short, dense, reddish-brown fur, small eyes and ears (0.4–0.5 in/1–1.3 cm), and a short tail (0.7–0.9 in/1.8–2.4 cm) barely longer than the hindfoot.

The woodland vole occurs in deciduous woodlands with loose sandy soils, deep humus, and heavy leaf litter. Although it prefers deciduous forests comprised of oak, maple and/or beech, the woodland vole can potentially be found in any forest type. It can also be found in orchards. The woodland vole has a very small home range, generally moving no more than 50–100 feet (15–30 m) from the nest."

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=11452 (accessed June 6, 2011).

## Pugnose shiner (*Notropis anogenus*)

"The pugnose shiner is a small (38–56 mm) straw-colored minnow with a distinctively tiny, almost vertical, upturned mouth. This species has a complete, slightly de-curved lateral line with 34–38 scales and a dark lateral band that extends from the caudal peduncle, through the eye and around the snout. They have eight dorsal rays. In addition, the pugnose shiner has a black peritoneum (lining of body cavity) that can be seen through the body wall of preserved specimens.

The Pugnose shiner inhabits clear vegetated lakes and vegetated pools and runs of low gradient streams and rivers. They appear to be extremely intolerant to turbidity."

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=11316 (accessed June 6, 2011).

## Ginseng (*Panax quinquefolius*)

"Perennial forb [herbaceous flowering plant other than a grass] of rich woods; leaves palmately compound with five leaflets; flowers greenish-white, borne in a cluster on a tall, erect stalk; fruit a red berry; plant seriously threatened by illegal collection of the root.

Ginseng is found in rich shaded forests with loamy soils and heavy canopies. This species is highly threatened from collection of the root, commonly used in herbal remedies. Large colonies have completely vanished due to illegal poaching."

Photo by Susan Crispin
*http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=13373*

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=13373 (accessed June 6, 2011).

## Osprey (*Pandion haliaetus*)

"The Osprey is a large (22–25 in / 56–64 cm) hawk with long, narrow wings, dark brown upper parts and white under parts. Its head is white with a dark eye streak. The dark 'wrist' patches on the underside of its wings are visible in flight. Females may have dark streaking around their necks and immature bards have pale buff edging on the dark feathers of their upper surface.

Historically, Ospreys nested only in trees or snags or on cliffs but they have adapted to use some man-made structures such as utility poles and towers, chimneys, windmills, buoys, and platforms. Preferred nest sites are above or near water. Reintroductions have begun in certain areas in southern Michigan in recent years."

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=10934 (accessed June 6, 2011).

## Lake Huron locust (*Trimerotropis huroniana*)

"The Lake Huron locust is a small ash-gray grasshopper with darker brown and white markings and wings with a prominent dark band. The pronutum (saddle-like structure behind the head) is cut by two narrow grooves (sulci), and a broad (not narrow) black band covers half the inner surface of the hind femora near the body.

This species occurs only in sparsely vegetated, high-quality Great Lakes sand dunes along northern Lake Michigan, northern Lake Huron, and eastern Lake Superior. Ideal habitat includes at least a mile of shoreline with two or more sets of dunes with blowouts. It primarily feeds on dune grass, beach grass, and wormwood, but

Photo by David Cuthrell
*http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=12268*

will eat other forbs also, including the federally threatened Pitcher's thistle (*Cirsium pitcheri*)."

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer/species.cfm?id=12268 (accessed June 6, 2011).

### *Terrestrial Invasive Species*

The Northwest Michigan Cooperative Weed Management Area, a group whose stated mission is to "protect the ecological integrity of natural resources in Northwest Michigan from terrestrial invasive plants through education, inventory, control, and volunteer outreach," has developed a list of targeted invasive terrestrial plant species (see Exhibit 24). Invasive species are non-native species that have been introduced into an ecosystem, either intentionally or inadvertently, which may outperform native species and frequently lack natural controls.

**EXHIBIT 24.** Northwest Michigan Targeted Invasive Species

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| Autumn olive | *Eleagnus unbellata* | Glossy buckthorn | *Rhamnus frangula* |
| Baby's breath | *Gypsophila paniculata* | Honeysuckle | *Lonicera spp.* |
| Barberry | *Berberis thunbergii* | Houndstongue | *Cynoglossum officinale* |
| Black locust | *Robinia pseudoacacia* | Japanese hedge parsley | *Torilis japonica* |
| Black swallow-wart | *Cynanchum nigrum* | Japanese knotweed | *Polygonum cuspidatum* |
| Blue lyme grass | *Leymus arenarius* | Japanese stiltgrass | *Microstegium vimineum* |
| Bull thistle | *Cirsium vulgare* | Kudzu | *Pueraria lobata* |
| Canada thistle | *Cynanchum rossicum* | Leafy spurge | *Euphorbia esula* |
| Common buckthorn | *Rhamnus cathartica* | Lombardy poplar | *Populus nigra var. italica* |
| Phragmites | *Phragmites australis* | Multiflora rose | *Rosa multiflora* |
| Dame's rocket | *Hesperis matronalis* | Oriental bittersweet | *Celastrus orbiculatus* |
| Field hedge parsley | *Torilis arvensis* | Pale swallow-wart | *Cynanchum rossicum* ( |
| Flowering rush | *Butomus umbellatus* | Purple loosestrife | *Lythrum salicaria* |
| Garlic mustard | *Allaria petiolata* | Russian olive | *Eleagnus angustifolia* |
| Giant hogweed | *Heracleum mantegazzianum* | Scotch pine | *Pinus sylvestris* |
| Giant knotweed | *Polygonum sachalinensis* | Tree-of-heaven | *Ailanthus altissima* |
| Wild parsnip | *Pastinica sativa* | | |

SOURCE: Northwest Michigan Cooperative Weed Management Area, Target Species, http://www.garlic-mustard.org/.

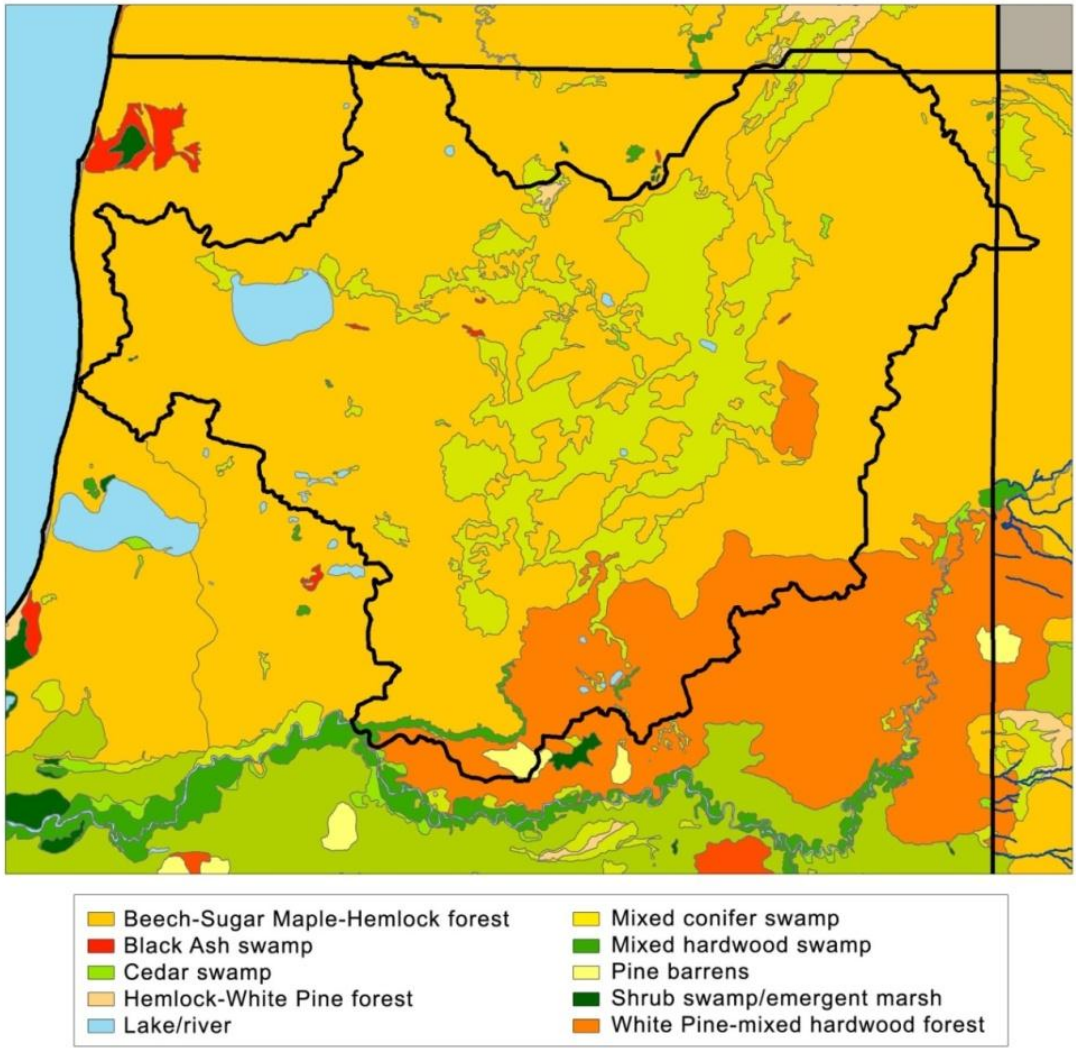
More information about invasive species in Northwest Michigan, which includes the Greater Bear Watershed, is available through the Northwest Michigan Cooperative Weed Management Area website located on the Internet at: http://www.garlic-mustard.org/.

## LAND USE AND LAND COVER

### *Pre-settlement and Current Land Cover*

Exhibit 25 shows pre-settlement land cover as derived by the Michigan Resource Information System (MIRIS) and made available by the State of Michigan. Land cover classes were estimated from original field descriptions of the surveyors between 1816 and 1856.

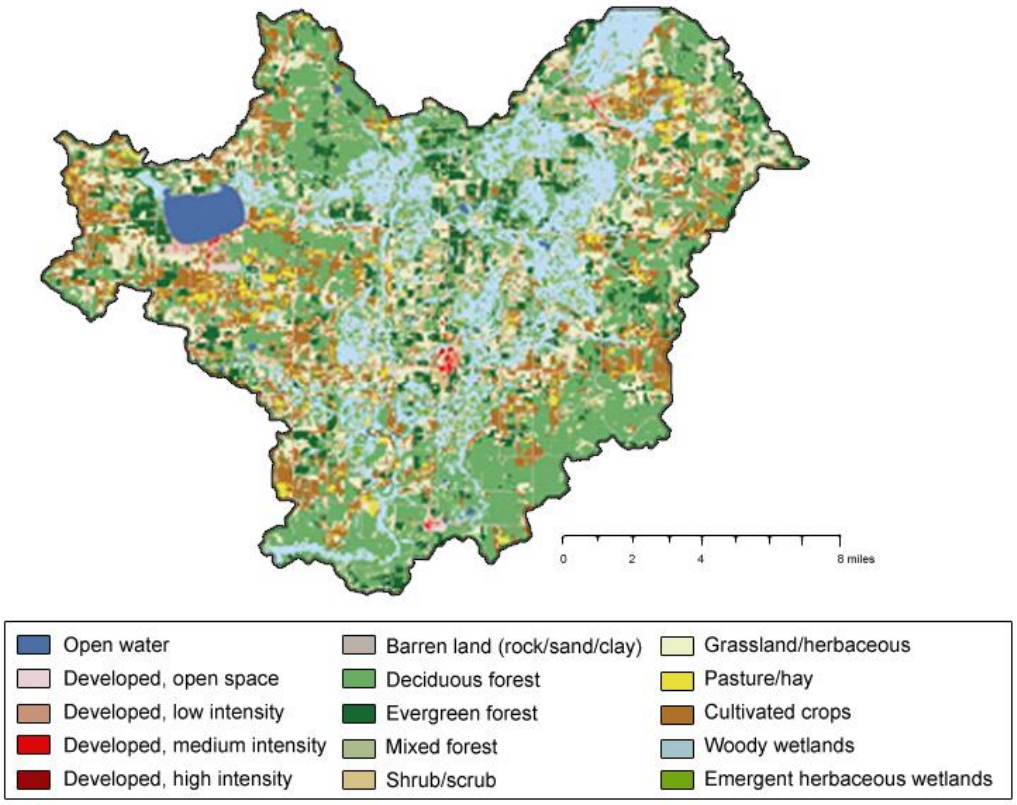
**EXHIBIT 25.** Land Cover, circa 1800




SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.

The U.S. Geological Survey estimates land cover and land uses by analyzing information obtained from satellite imagery. There are multiple land uses in the Greater Bear Watershed (see Exhibits 26 and 27). The most recent data indicate that the watershed is comprised of approximately 45 percent wooded land, 18 percent wetland, 15 percent cultivated cropland or pastureland, and 14 percent grassland; 6 percent of the land is developed in various densities, and 2 percent of the area is open water.

## **EXHIBIT 26.** 2006 Land Use/Cover, by Type




## **EXHIBIT 27.** Land Use/Cover by Land Use Class

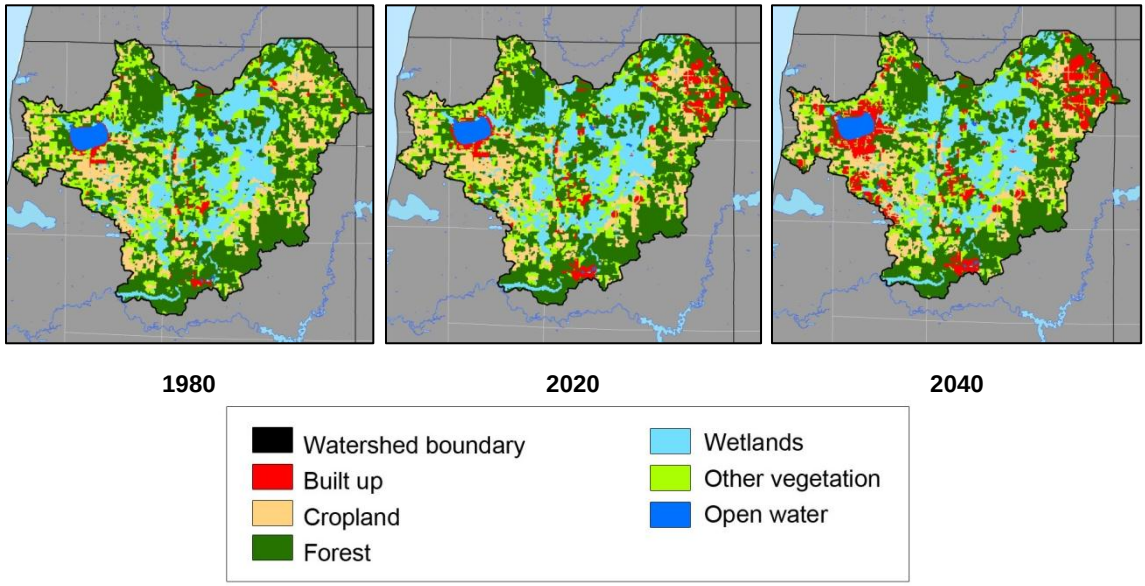
| Land Use Class | Acres* | % of Watershed* |
|---|---|---|
| Deciduous forest | 39,080.3 | 29.9% |
| Woody wetlands | 20,345.3 | 15.5 |
| Grassland/herbaceous | 19,160.9 | 14.6 |
| Cultivated crops | 16,420.1 | 12.5 |
| Evergreen forest | 12,516.8 | 9.6 |
| Shrub/scrub | 5,151.3 | 3.9 |
| Developed, open space | 5,081.7 | 3.9 |
| Pasture/hay | 3,110.6 | 2.4 |
| Emergent herbaceous wetlands | 2,629.4 | 2.0 |
| Developed, low intensity | 2,587.8 | 2.0 |
| Mixed forest | 2,296.0 | 1.8 |
| Open water | 2,121.4 | 1.6 |
| Developed, medium intensity | 182.1 | 0.1 |
| Barren land (rock/sand/clay) | 161.7 | 0.1 |
| Developed, high intensity | 41.4 | 0.0 |
| **Total** | **130,886.9** | **100.0%** |

SOURCE: Land Policy Institute at Michigan State University, 2011.
* Figures are estimates and may be subject to rounding error.

### *Land Use Projections*

In 2001, researchers at Michigan State University developed a spatial trend model to project what Michigan's landscape might look like in the future if land use development trends continued as they had to the point the model was developed. The analysis was conducted on the Michigan base (1980) provided by the MDNR Michigan Resource Information System, the projected land use in 2020, and the projected land use for 2040. The digital maps for these three time periods for the Greater Bear Watershed are shown in Exhibit 28.

**EXHIBIT 28.** Historic and Projected Land Use




SOURCE: Michigan Land Resource Project, Public Sector Consultants Inc., 2001, and the Michigan State University Land Policy Institute Picture Michigan Tomorrow Initiative.

Land use development patterns changed significantly as a result of the 2008 housing market crash and the related economic recession, which is not reflected in the land use projections for 2020 and 2040. The rate at which open space is converted to the built environment has slowed substantially since the model was developed in 2001. Over time, however, the areas depicted in red on the maps are those that are likely to be subject to development pressure. Given past trends and future projections, the need for structured land use planning and protection becomes evident.

### *Greater Bear Wetlands*

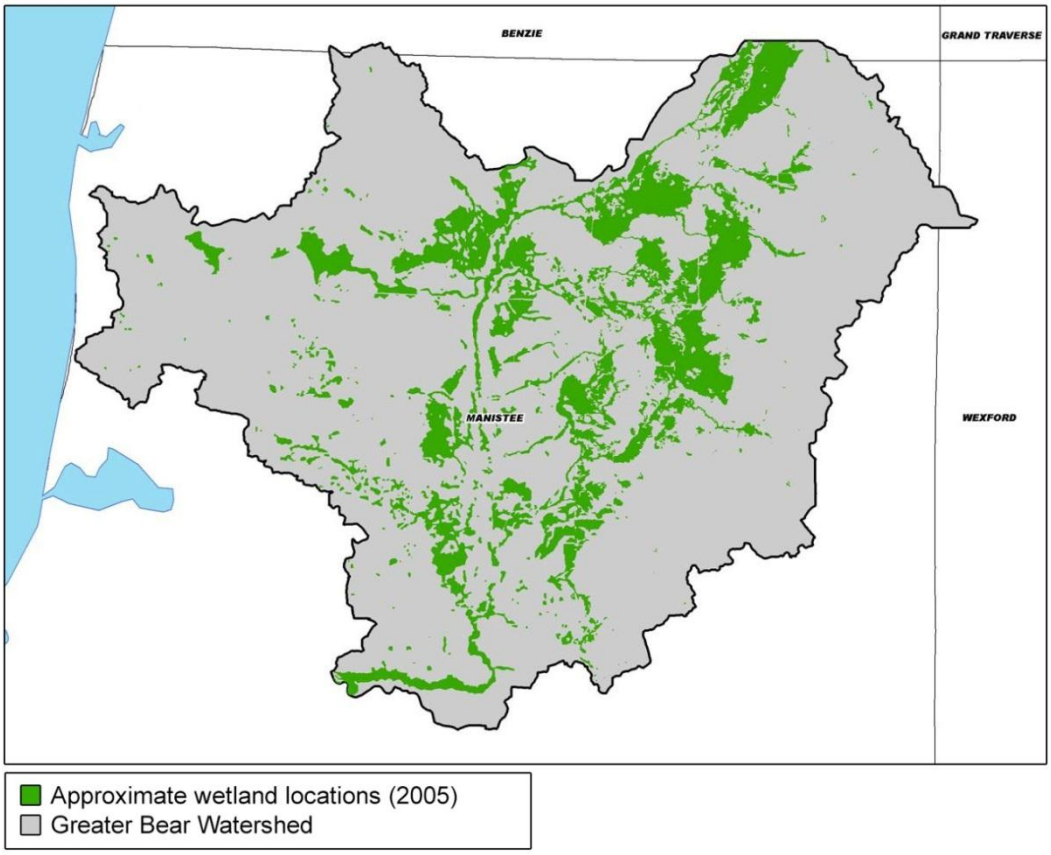
In support of the development of the Greater Bear Watershed Management Plan, the Michigan Department of Environmental Quality (MDEQ) prepared a Landscape Level Wetland Functional Assessment (LLWFA) of the watershed, which was completed in September 2012. The analysis uses the best available data to estimate the location of wetlands before European settlement and the location of currently existing wetlands. The LLWFA includes an evaluation of the ecological functions (e.g. flood water storage, groundwater recharge, stream shading) performed by the wetlands within the watershed. To conduct the analysis, the MDEQ used overlays of data from multiple sources including:

- The National Wetlands Inventory (NWI), conducted by the U.S. Fish and Wildlife Service through interpretation of topographic data and aerial photographs

- Land cover, as mapped by MIRIS, through interpretation of aerial photographs
- Soils, as mapped by the U.S. Department of Agriculture (USDA), Natural Resource Conservation Service
- Michigan Natural Features Inventory Biorarity Index

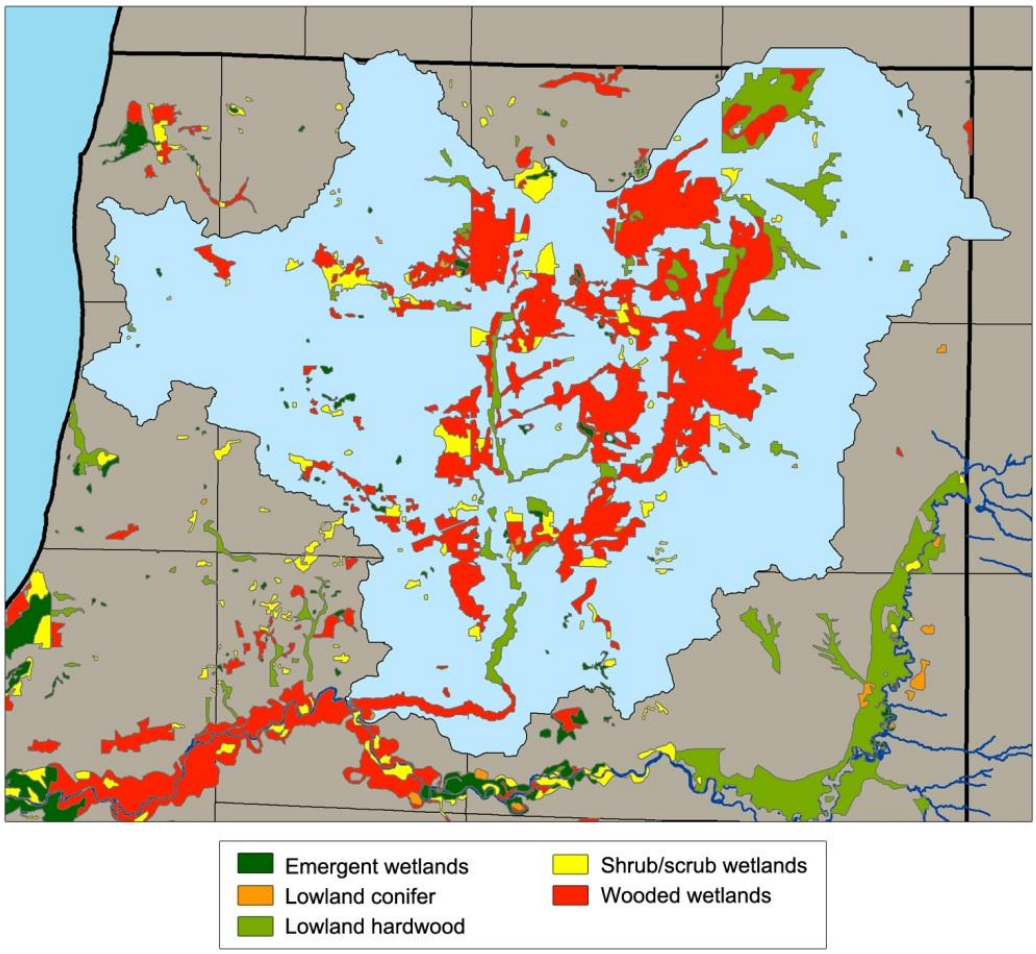
The Greater Bear Watershed wetlands map identifies areas of potential significance, which are located primarily west of Bear Creek and along its tributaries. The map also identifies many lands directly adjacent to Bear Creek as wetlands (see Exhibit 29). Wetlands are designated by type in Exhibit 30.

**EXHIBIT 29.** Approximate Location of Wetlands (2005)




SOURCE: Michigan Department of Environmental Quality, 2012.

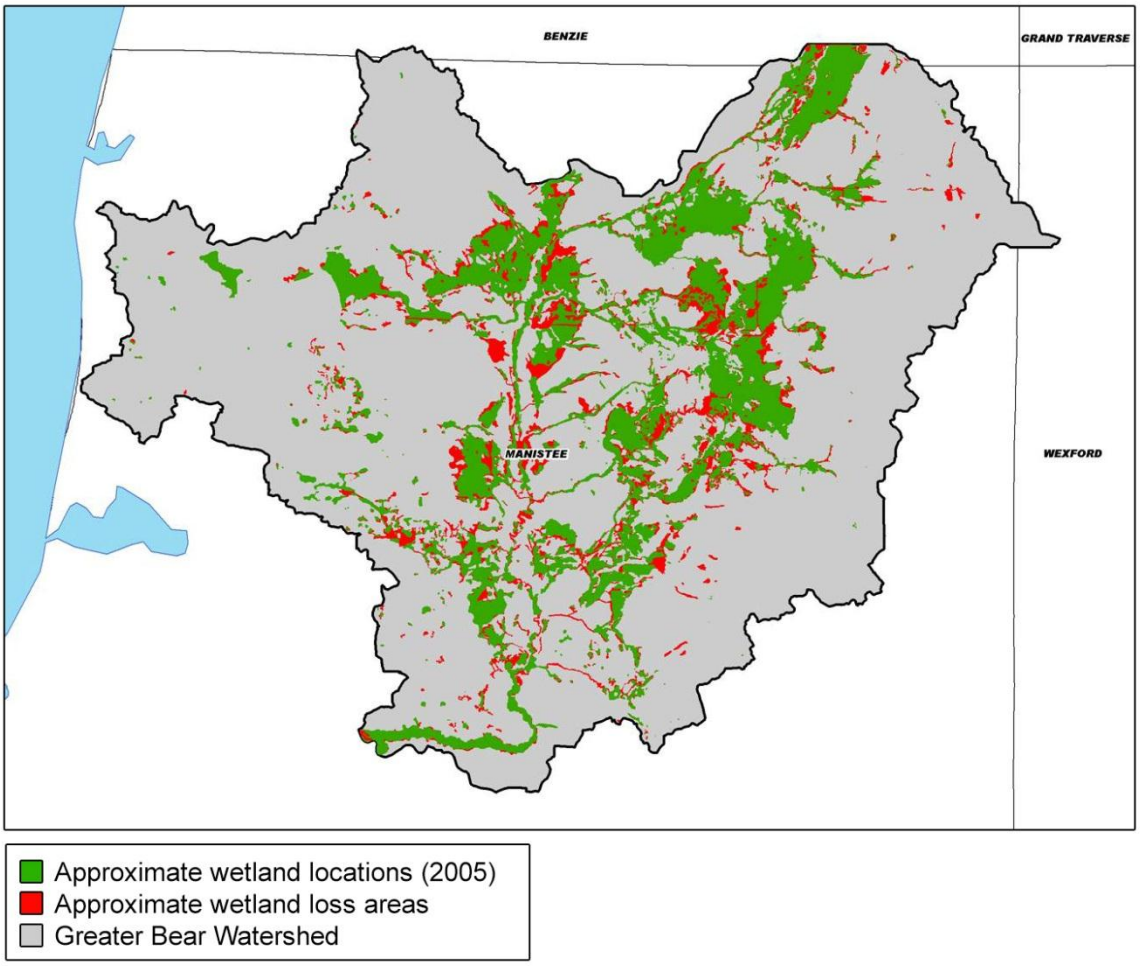
## **EXHIBIT 30.** Wetland Types




SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.

Based upon wetlands maps of land cover conditions in the 1800s developed by the MNFI, Exhibit 31 illustrates the areas of wetland loss in the Greater Bear Watershed.

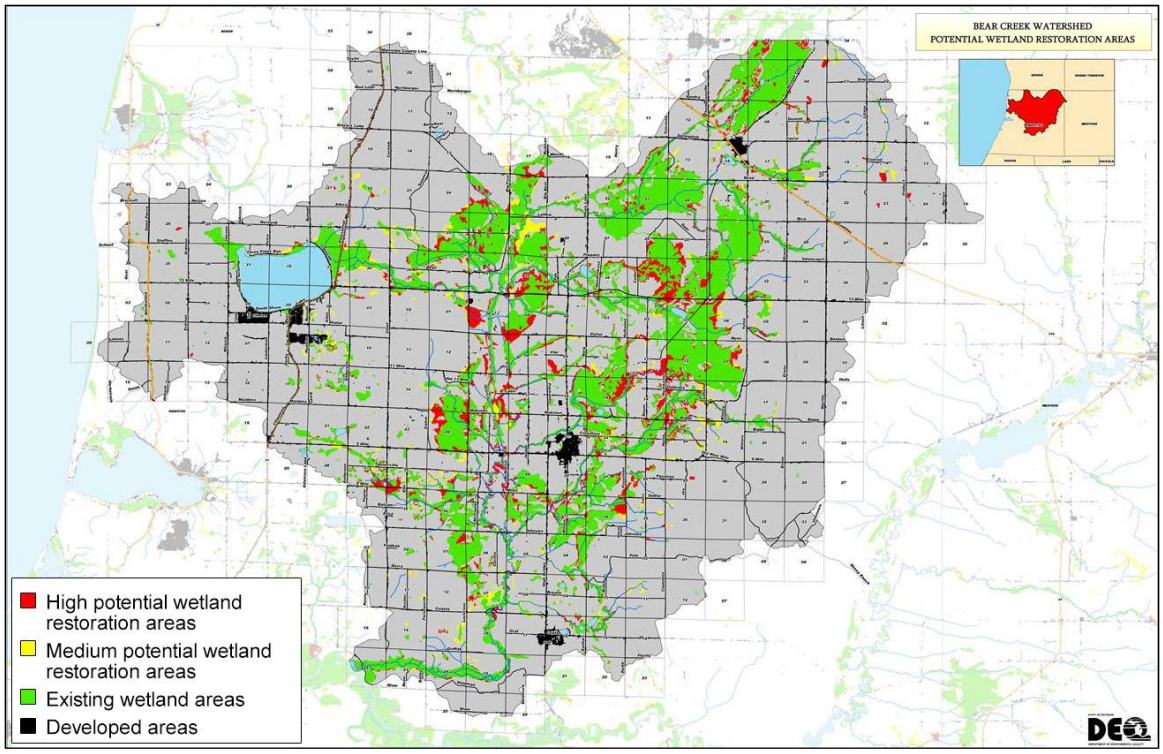
**EXHIBIT 31.** Wetland Loss since 1800s




SOURCE: Michigan Department of Environmental Quality, 2012.

A comparison of wetlands present before European settlement to current conditions can provide useful information about areas that may be well suited to wetland restoration. Exhibit 32 shows the approximate location of these lands. A comparison of acreage from pre-settlement times to 2005 is shown in Exhibit 33.

**EXHIBIT 32.** Potential Wetland Restoration Areas




SOURCE: Michigan Department of Environmental Quality, 2012

**EXHIBIT 33.** Change in Wetland Acres, Pre-Settlement to 2005

| Wetlands Type | Pre-European settlement acres | 2005 acres of wetlands | Net acres remaining |
|---|---|---|---|
| Palustrine Emergent | 0 | 483[a] | 100% |
| Palustrine Forested | 24,198 | 18,820[b] | 77% |
| Palustrine Shrub-Scrub | 2.02[c] | 1,746[d] | 100% |
| Other Palustrine Ponds | 0[e] | 203 | 100% |
| **Total** | **24,200** | **21,252** | **88%** |

SOURCE: Michigan Department of Environmental Quality, 2012.
[a] Includes mixed emergent wetlands classes and mixed communities where subclasses include Forested and Shrub-Scrub Areas.
[b] Includes mixed forested wetlands classes and mixed communities where subclasses include Emergent and Shrub-Scrub Areas.
[c] Includes mixed Shrub-Scrub/Emergent communities.
[d] Includes mixed Shrub-Scrub wetlands classes and mixed communities where subclasses include Emergent, Forested and Shrub-Scrub.
[e] Little acreage in ponds due to mapping differences between Pre-Settlement and Current wetlands coverage.

A comparison of pre-settlement conditions to current conditions by wetland function is shown in Exhibit 34.

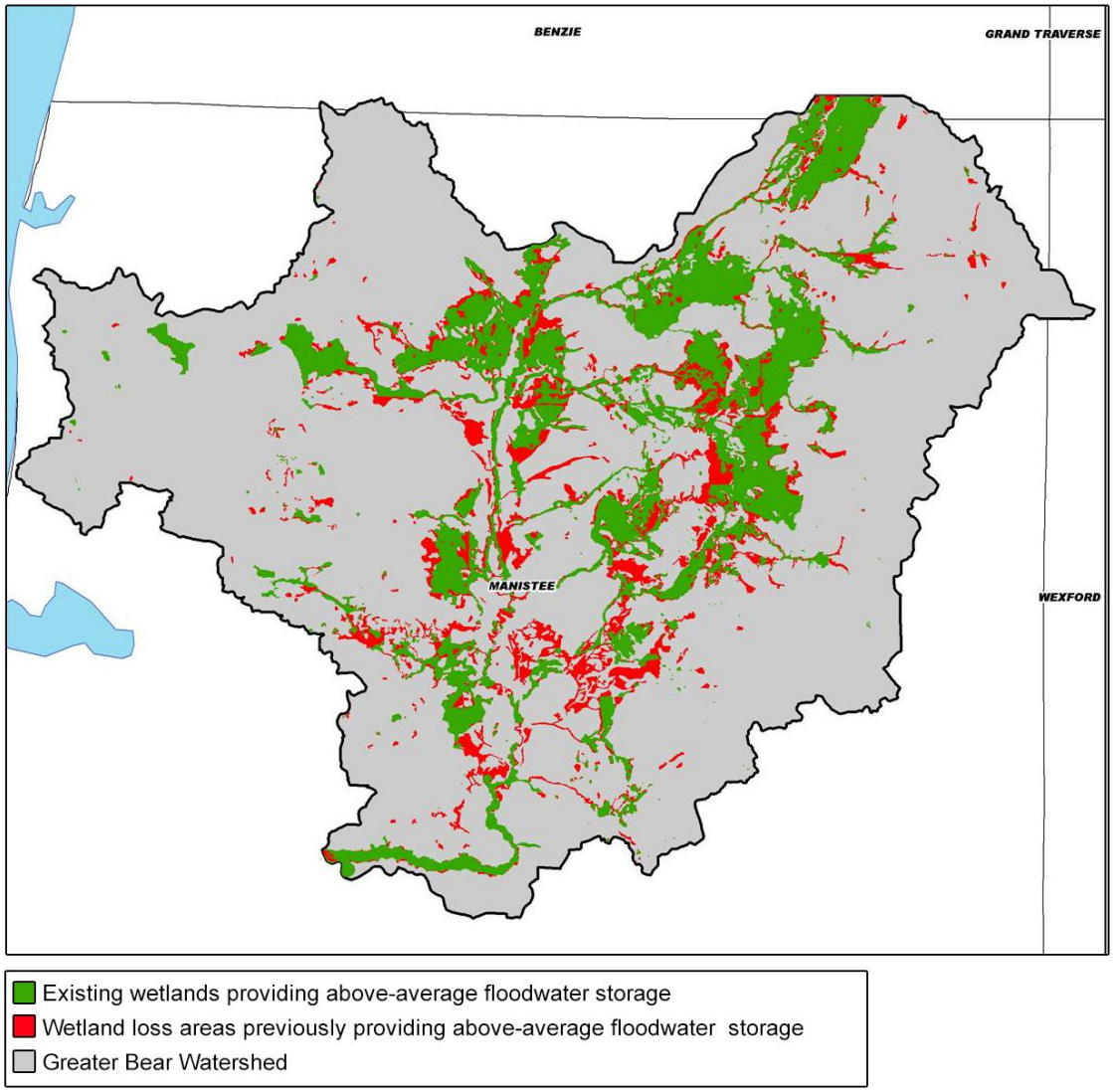
**EXHIBIT 34.** Wetland Functional Acres Comparison

| Function | Pre-European settlement functional acres | 2005 functional acres | Predicted % of original capacity left | Predicted % change in functional capacity |
|---|---|---|---|---|
| Flood water storage | 33,239.80 | 29,466.64 | 89% | -11% |
| Streamflow maintenance | 45,807.50 | 36,049.00 | 79 | -21 |
| Nutrient transformation | 42,089.31 | 29,080.27 | 69 | -31 |
| Sediment and other particulate retention | 28,176.20 | 25,561.25 | 91 | -9 |
| Shoreline stabilization | 29,059.03 | 30,159.68 | 104 | 4 |
| Fish habitat | 47,636.03 | 41,557.29 | 87 | -13 |
| Stream shading | 13,656.15 | 15,114.60 | 111 | 11 |
| Waterfowl and waterbird habitat | 4,658.37 | 9,487.82 | 204 | 104 |
| Shorebird habitat | 24,200.33 | 21,051.08 | 87 | -13 |
| Interior forest bird habitat | 25,195.07 | 23,255.16 | 92 | -8 |
| Amphibian habitat | 22,692.43 | 17,606.84 | 78 | -22 |
| Carbon sequestration | 18,953.51 | 7,898.74 | 42 | -58 |
| Ground water influence | 19,724.56 | 18,531.75 | 94 | -6 |
| Conservation of rare & imperiled wetlands & species | 0 | 31,812.43 | 100 | 100 |

SOURCE: Michigan Department of Environmental Quality, 2012.

An important function of wetlands in the Greater Bear Watershed is their capacity to store water. This function becomes increasingly important during times of high flood potential. Exhibit 35 shows a comparison of pre-settlement to current conditions for wetland areas of flood water storage.

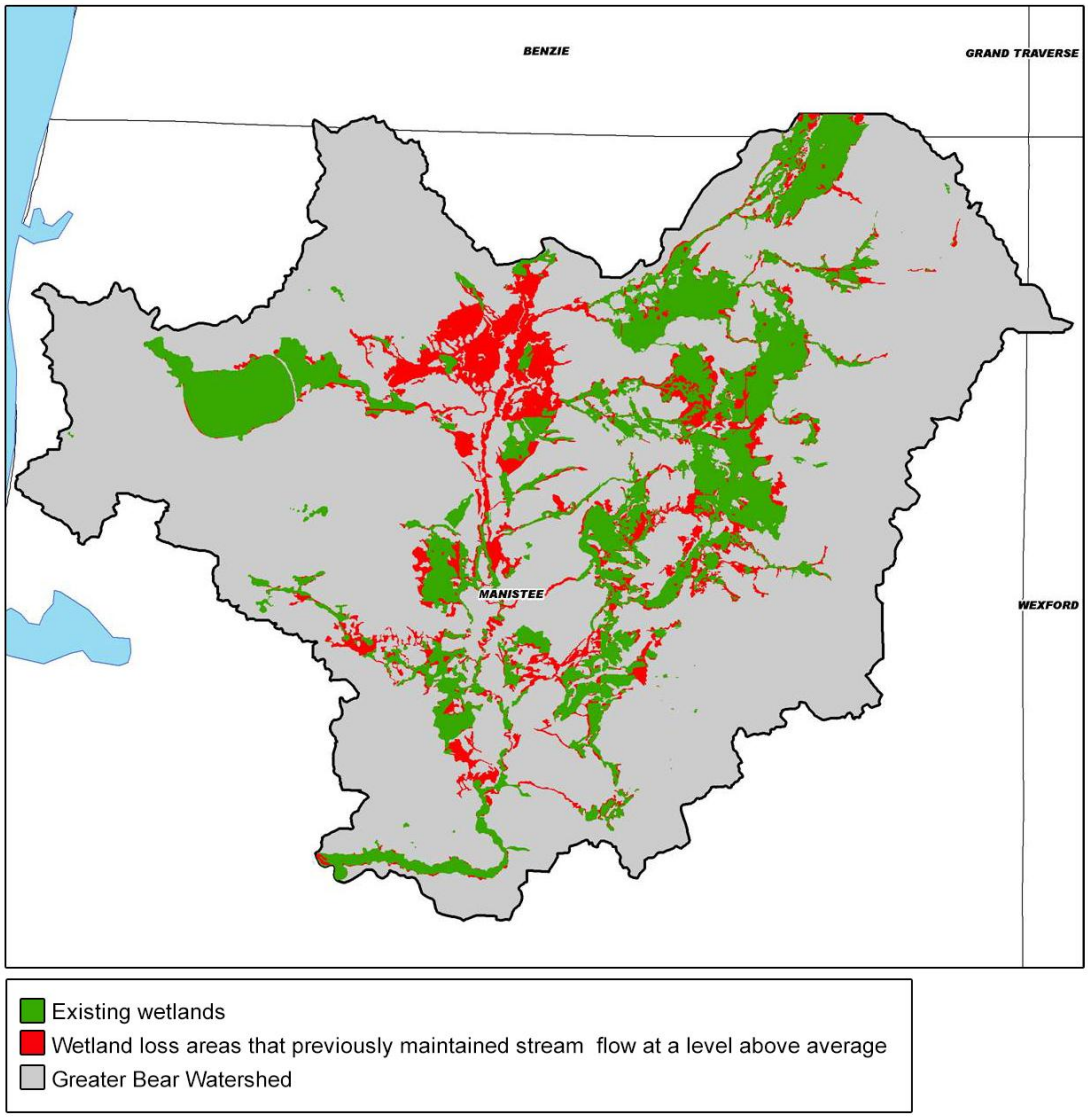
**EXHIBIT 35.** Wetland Flood Water Storage




SOURCE: Michigan Department of Environmental Quality, 2012.

Wetlands frequently play an important role at the land-water interface. Wetlands that provide above-average groundwater discharge and maintain stream flows, as well as wetland loss areas that previously provided this function, are shown in Exhibit 36.

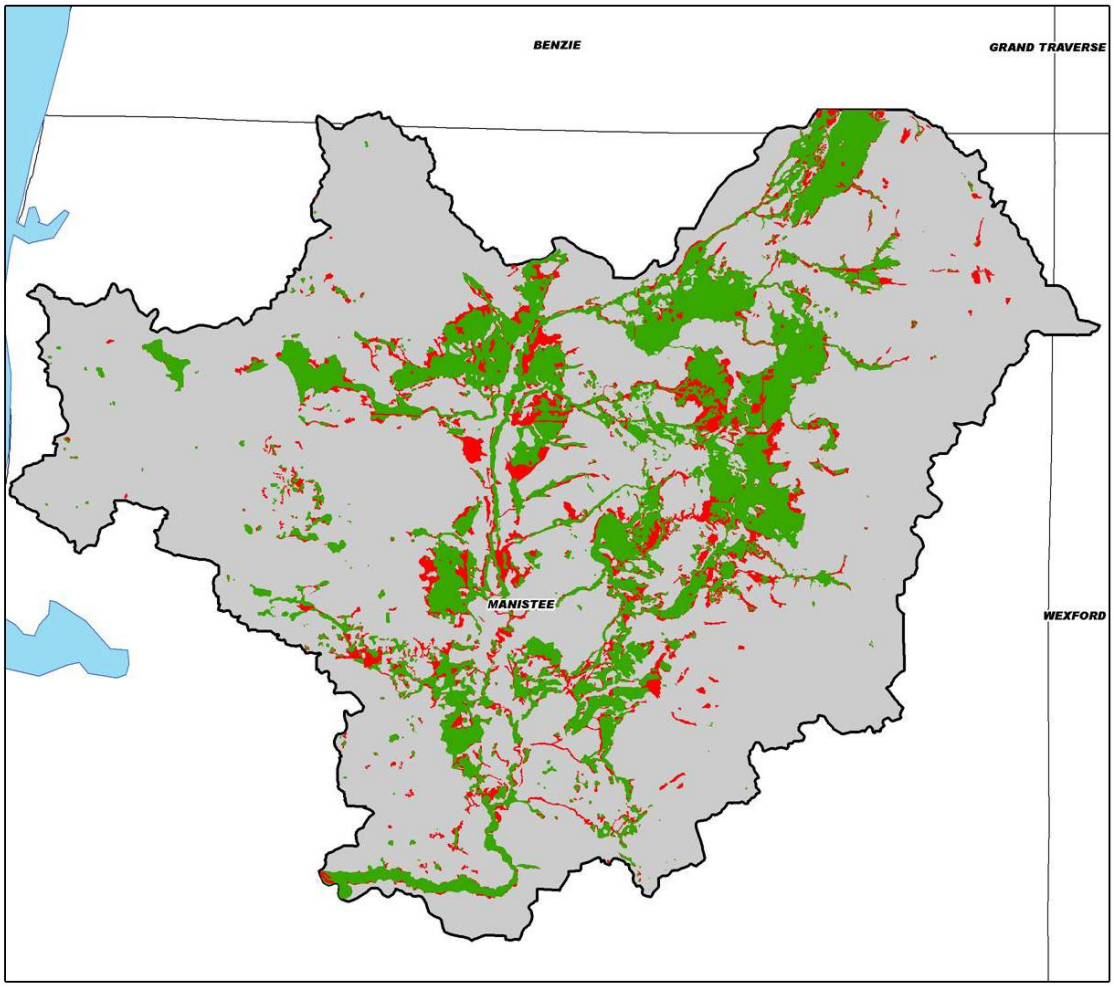
**EXHIBIT 36.** Wetland Stream Flow Maintenance




SOURCE: Michigan Department of Environmental Quality, 2012.

Wetlands can play an important role in nutrient cycles and minimize negative effects of excessive loads. Existing wetlands that provide this function at an above-average level and areas of wetland loss that previously provided this function are shown in Exhibit 37.

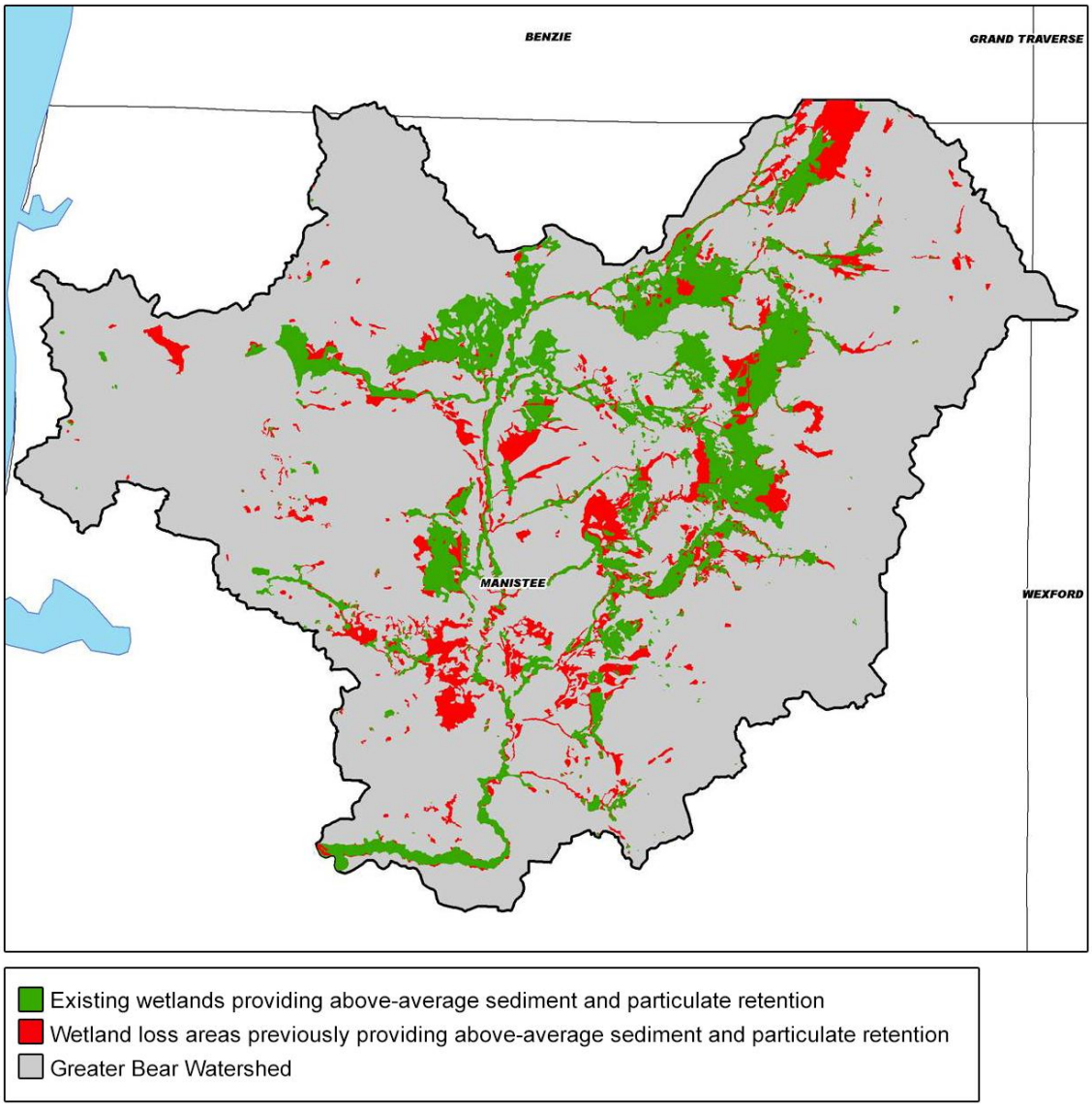
**EXHIBIT 37.** Wetland Nutrient Transformation




SOURCE: Michigan Department of Environmental Quality, 2012.

Wetlands can benefit water quality by containing sediment, including those with fixed ions such as nutrients or metals which can be harmful to environmental quality. Sediment and other particulate retention are important in preserving environmental quality in the Greater Bear Watershed. Exhibit 38 shows existing and former wetlands providing this function at an above-average level within the Greater Bear Watershed.

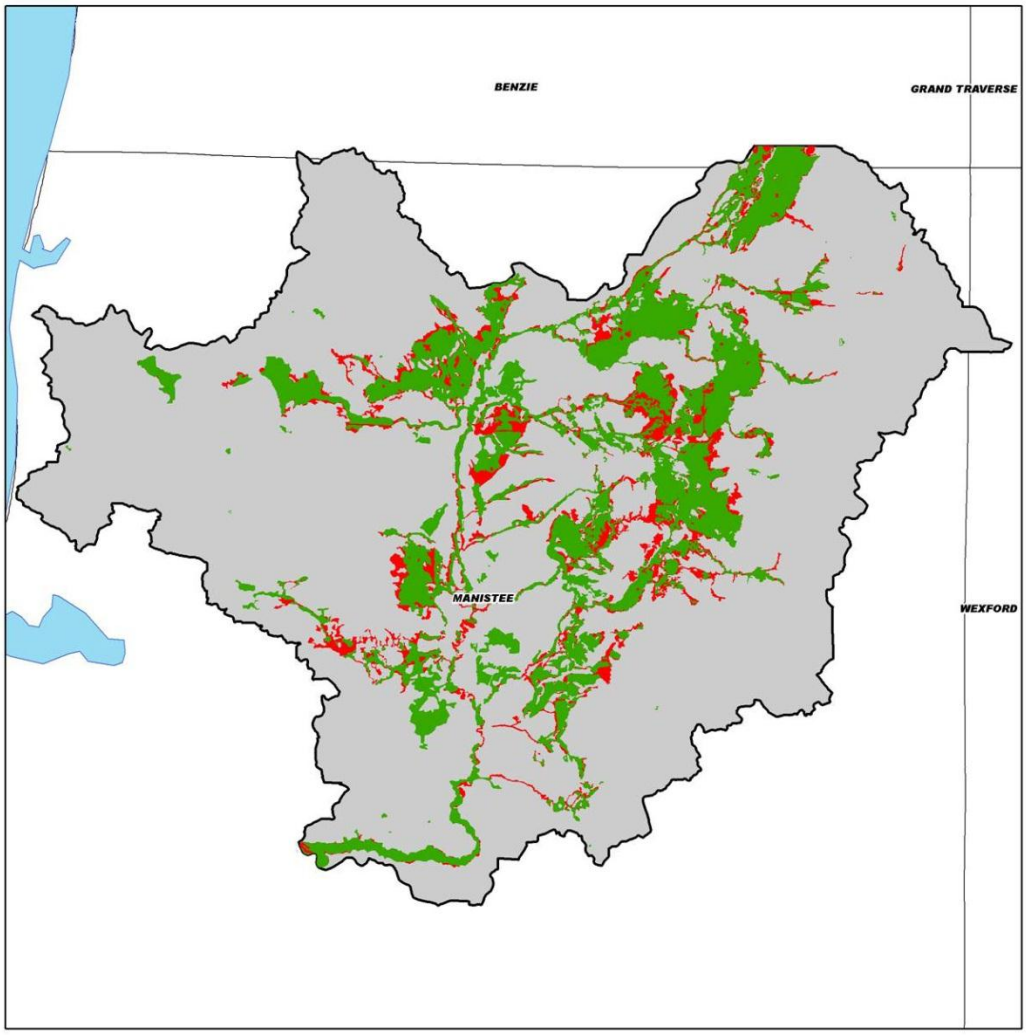
**EXHIBIT 38.** Wetland Sediment and Other Particulate Retention




SOURCE: Michigan Department of Environmental Quality, 2012.

Wetlands with vegetation benefit environmental quality by stabilizing the shoreline and decreasing erosion. Exhibit 39 shows existing and former wetlands providing this function at an above-average level within the Greater Bear Watershed.

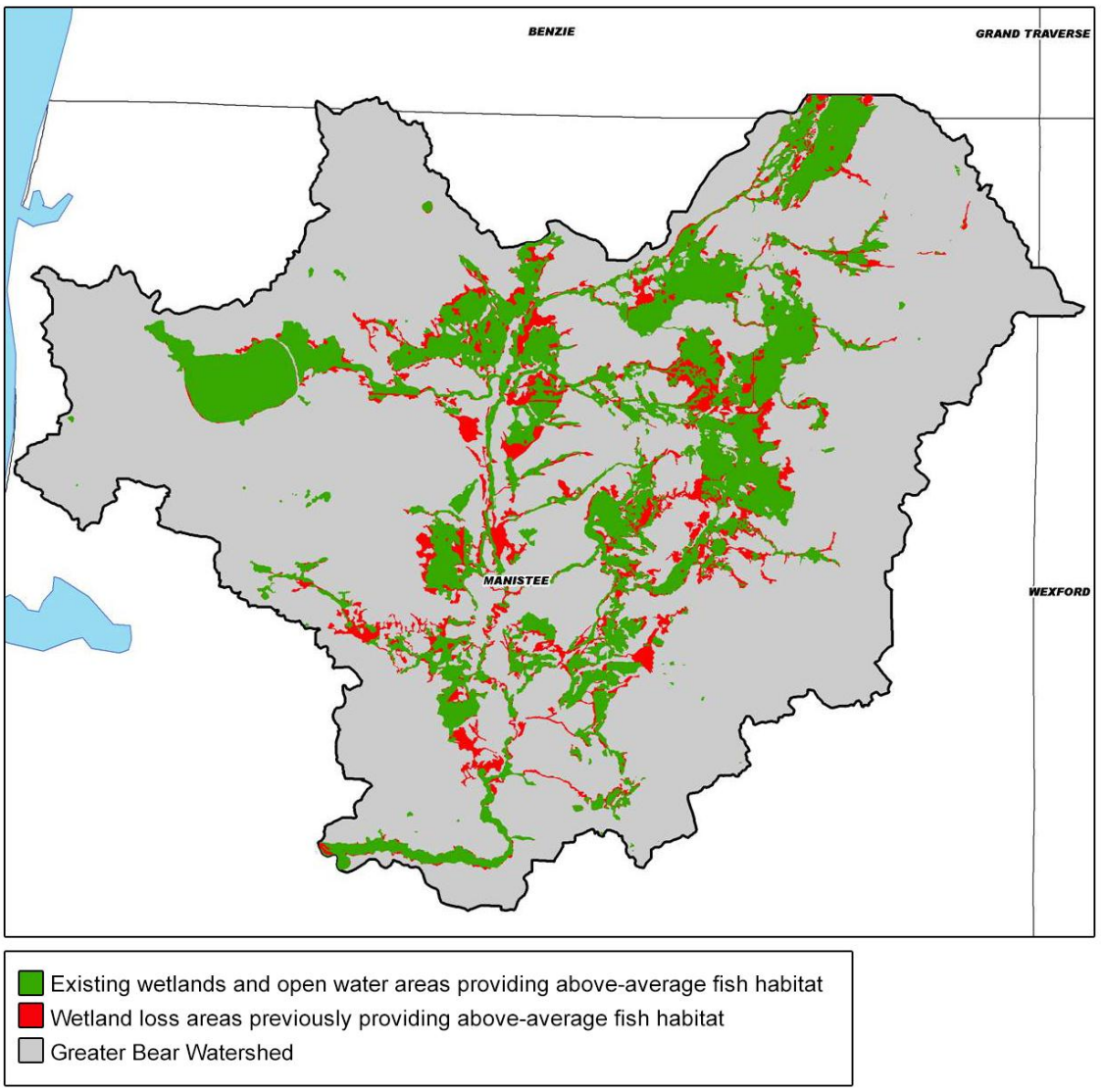
**EXHIBIT 39.** Shoreline Stabilization




SOURCE: Michigan Department of Environmental Quality, 2012.

Wetlands can provide important forage and nursery areas for fish and other aquatic species. Exhibit 40 shows wetlands and open water areas providing this function at an above-average level within the Greater Bear watershed as well as wetland loss areas previously providing this function.

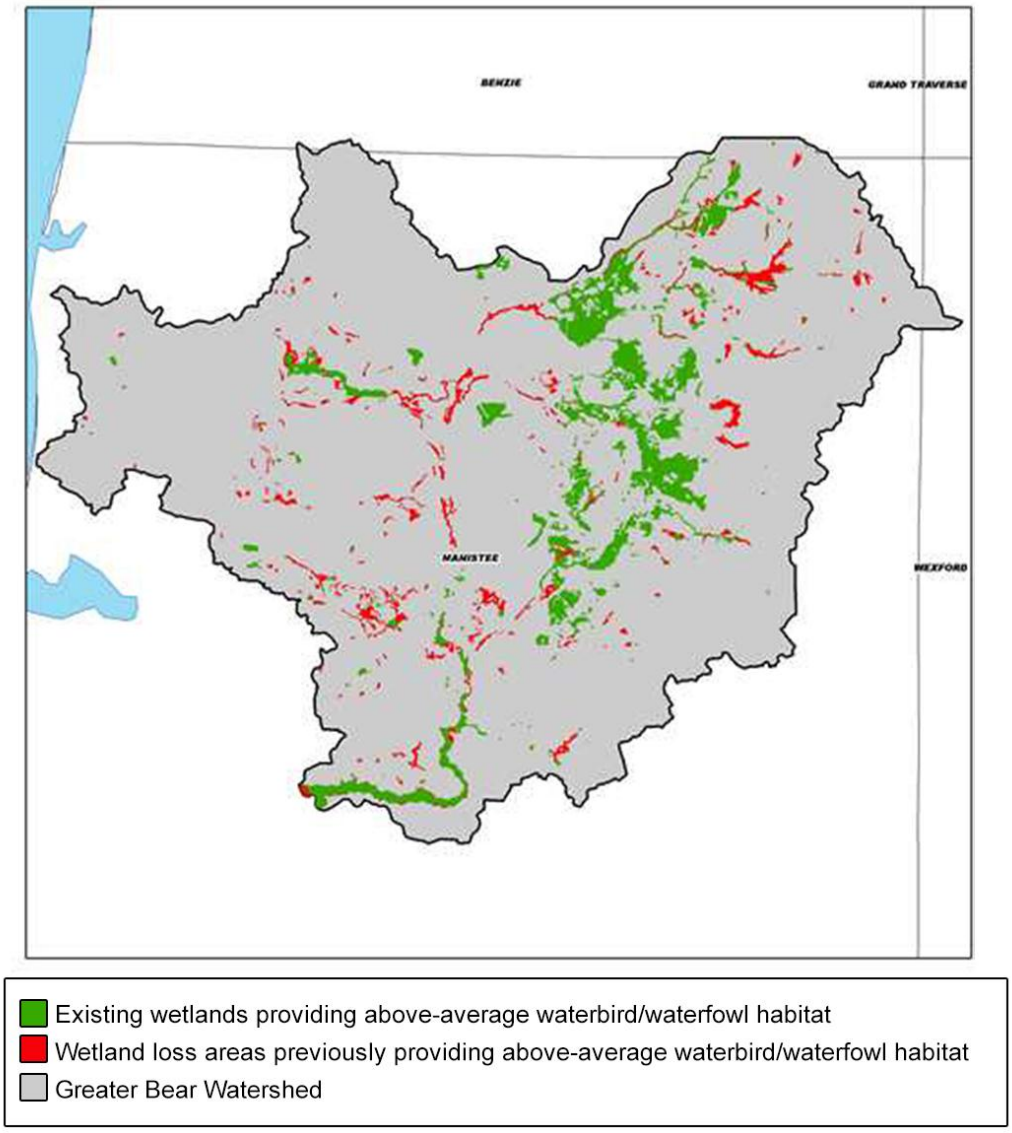
**EXHIBIT 40.** Open Water and Wetlands Fish Habitat




SOURCE: Michigan Department of Environmental Quality, 2012.

Wetlands can provide valuable habitat for waterfowl and waterbirds for nesting and reproduction. Exhibit 41 shows the location of wetlands that provide above-average habitat of this nature and wetland loss areas previously providing this function.

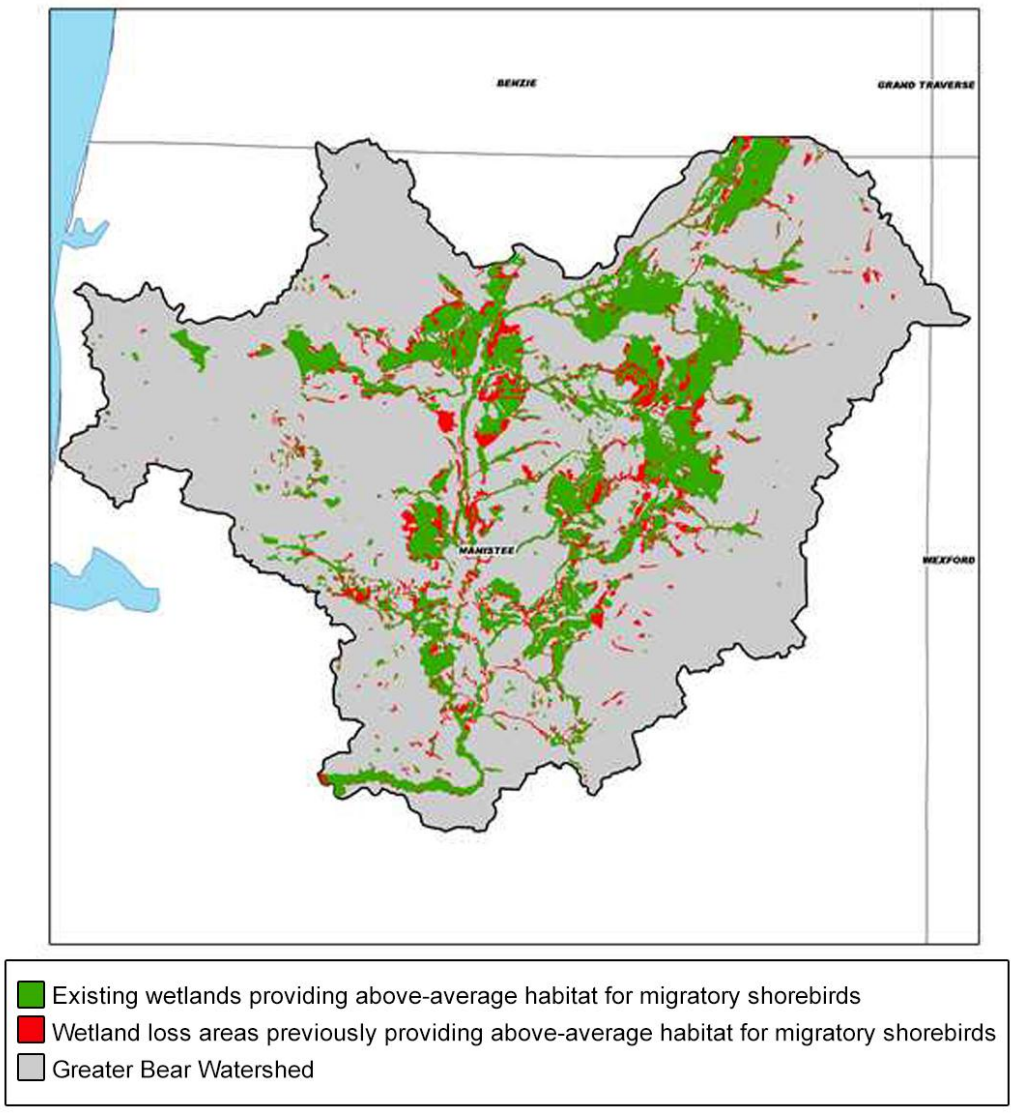
**EXHIBIT 41.** Waterbird/Waterfowl Wetland Habitat




SOURCE: Michigan Department of Environmental Quality, 2012.

Wetlands can provide valuable habitat for migratory shorebirds that feed in coastal and inland areas. Exhibit 42 shows the location of existing and former wetlands providing this function at an above-average level within the watershed.

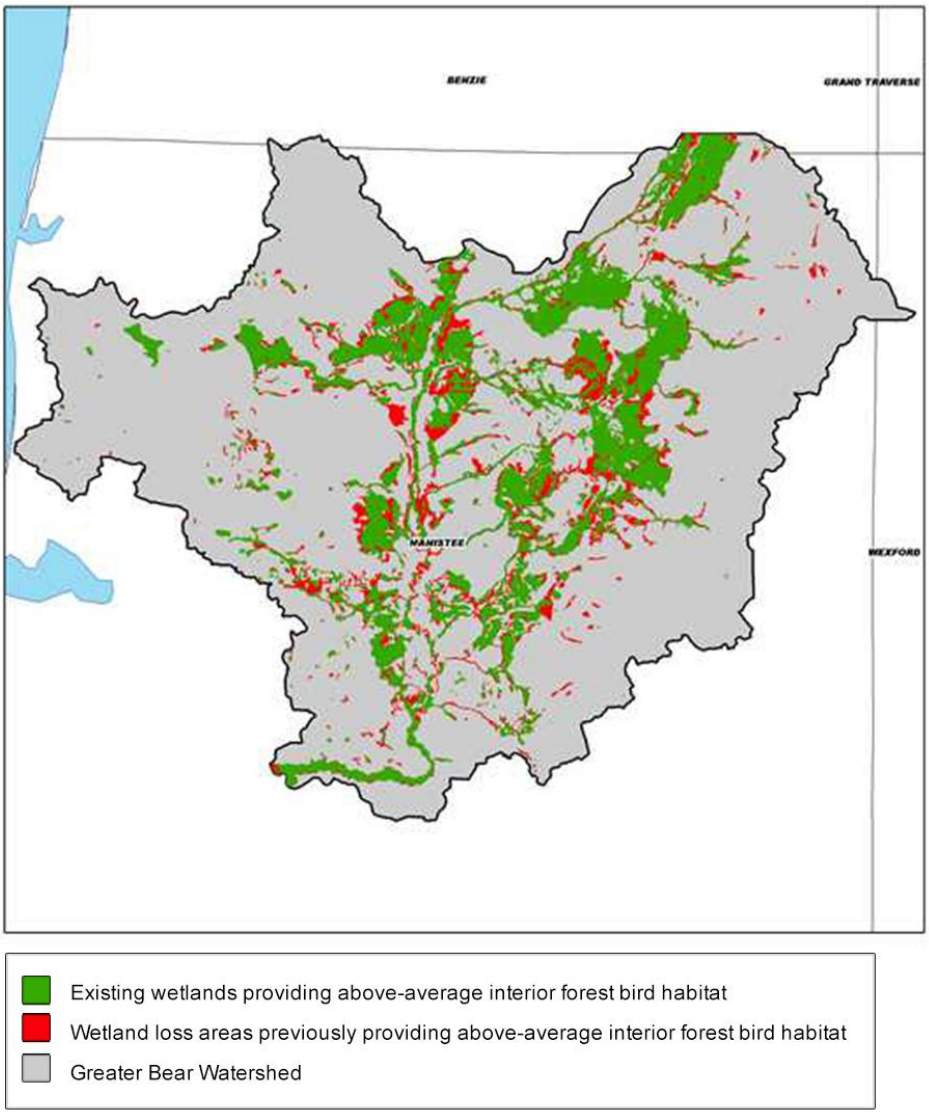
**EXHIBIT 42.** Shorebird Wetland Habitat




SOURCE: Michigan Department of Environmental Quality, 2012.

Wetlands can provide important habitat for interior forest birds. Exhibit 43 shows the location of existing and former wetlands within the watershed that provide this function at an above-average level. It is important to note that upland (non-wetland) areas are also important to interior forest birds. These areas are not depicted by Exhibit 43.

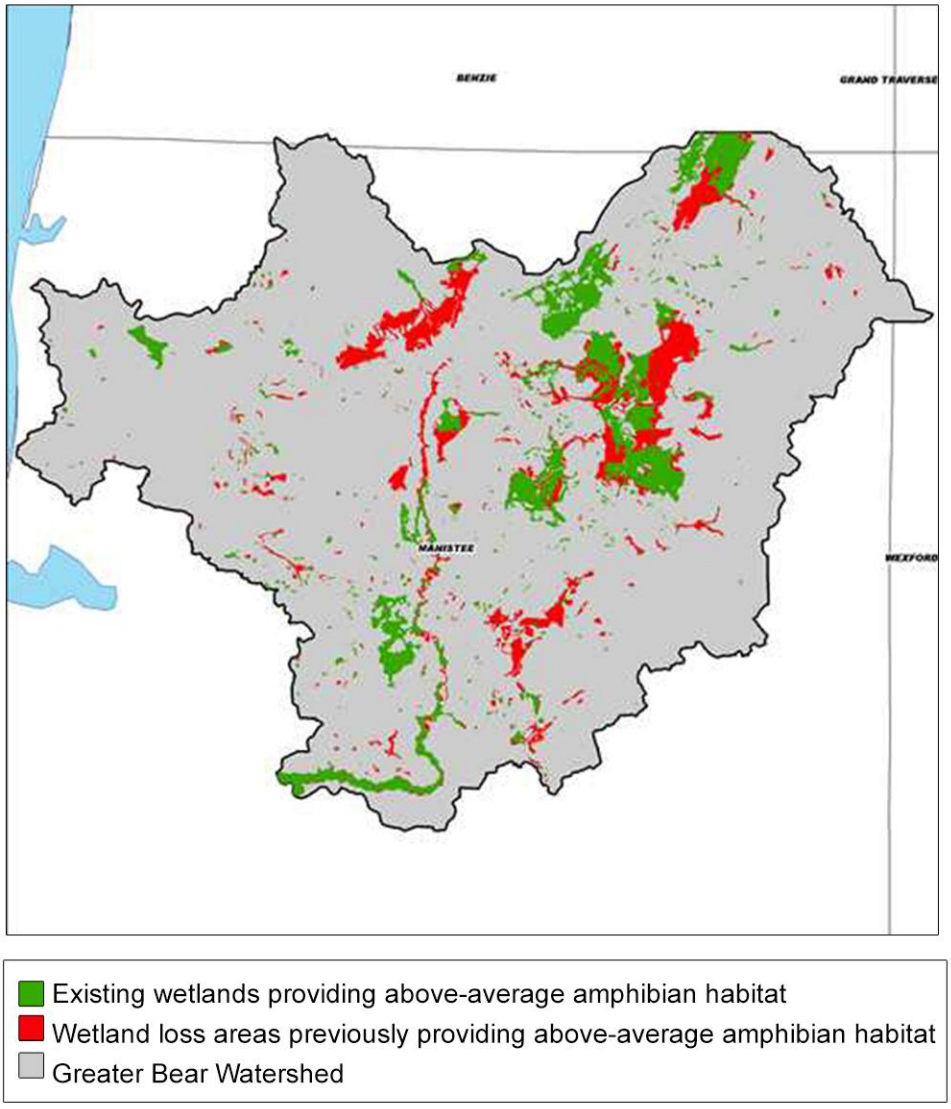
**EXHIBIT 43.** Interior Forest Bird Habitat




SOURCE: Michigan Department of Environmental Quality, 2012.

Wetlands can provide important habitat for amphibians. Exhibit 44 shows the location of existing and former wetlands within the watershed that provide this function at an above-average level and wetland loss areas that previously provided this function.

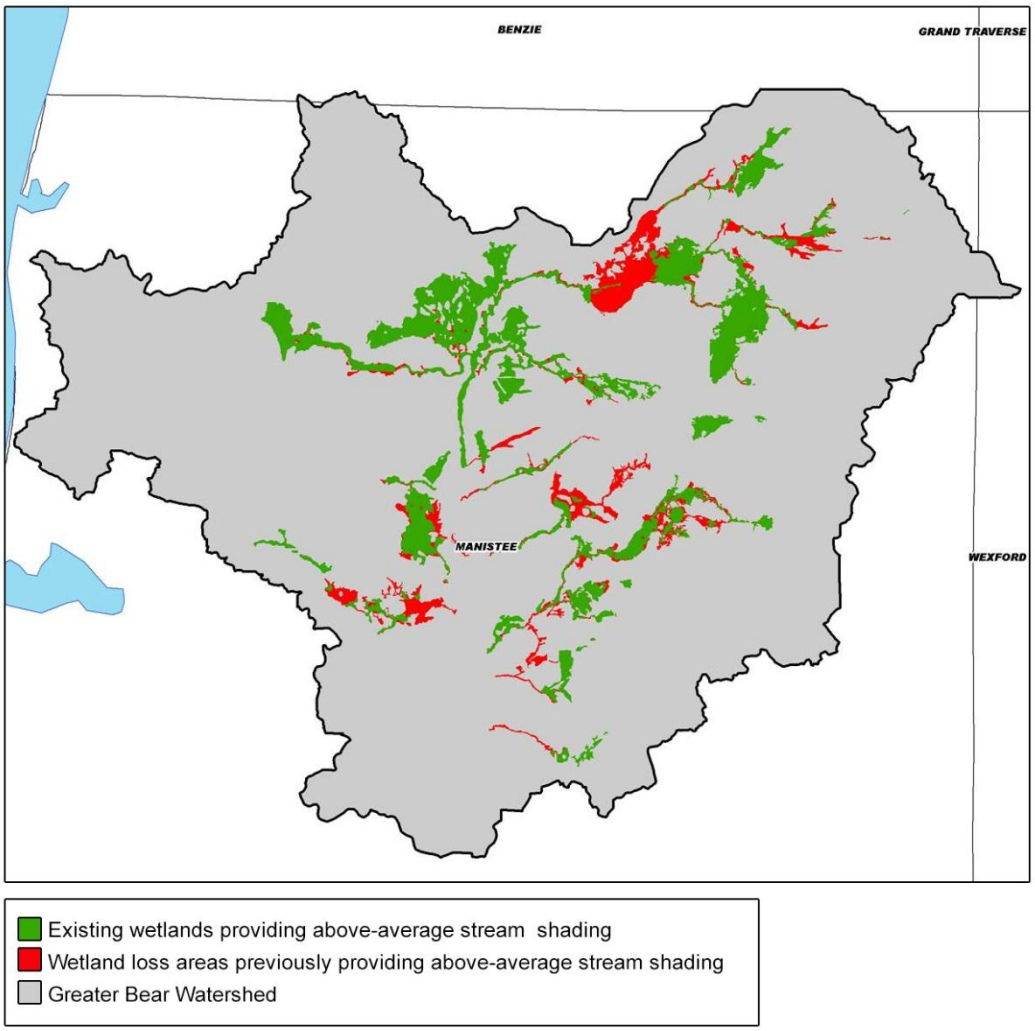
**EXHIBIT 44.** Amphibian Wetland Habitat




SOURCE: Michigan Department of Environmental Quality, 2012.

Forested and other vegetated wetlands can play an important role in water temperature control. Exhibit 45 shows existing and former wetlands providing this function at an above-average level within the Greater Bear Watershed.

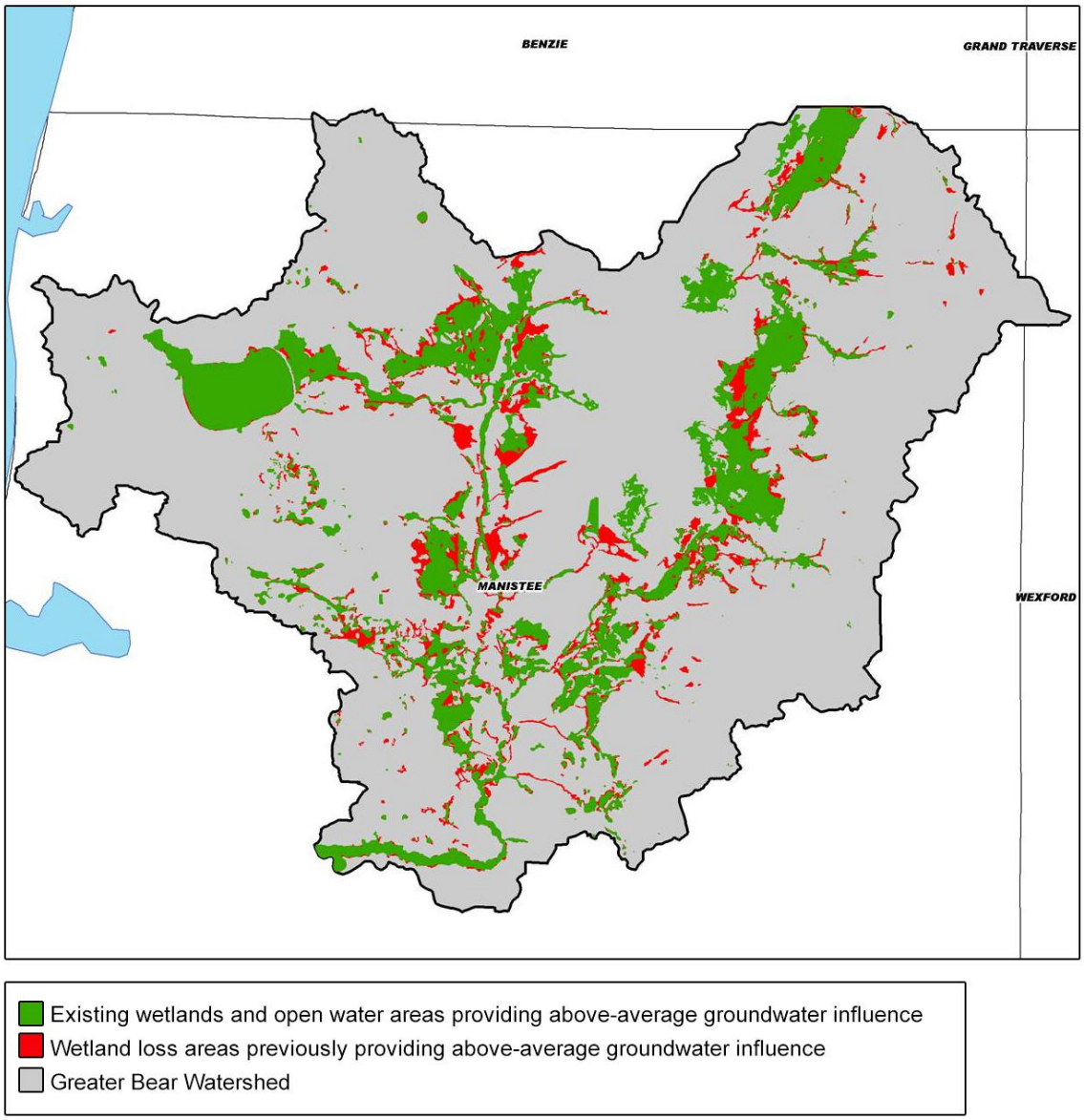
**EXHIBIT 45.** Wetland Stream Shading




SOURCE: Michigan Department of Environmental Quality, 2012.

Existing and former wetlands with above-average connection to groundwater within the Greater Bear Watershed are shown in Exhibit 46. These wetlands maintain stream flow and control temperatures.

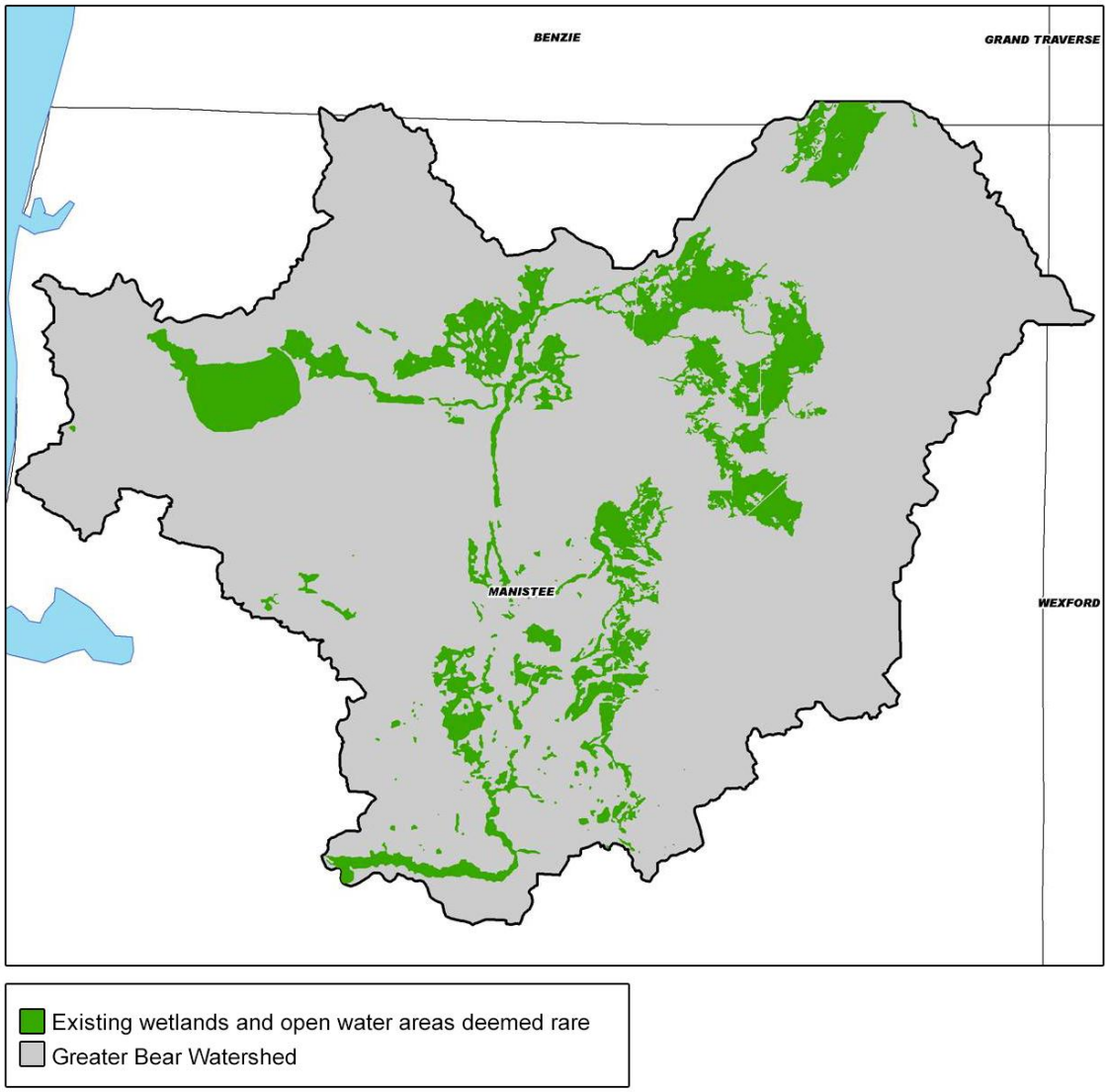
**EXHIBIT 46.** Groundwater Influence




SOURCE: Michigan Department of Environmental Quality, 2012.

The LLWFA used the Michigan Natural Features Inventory which documents the location of threatened, endangered, or special species of concern to identify wetlands that are likely to support these species. These locations were approximated using raster data. Exhibit 47 shows wetlands providing this function at an above-average level within the Greater Bear Watershed.

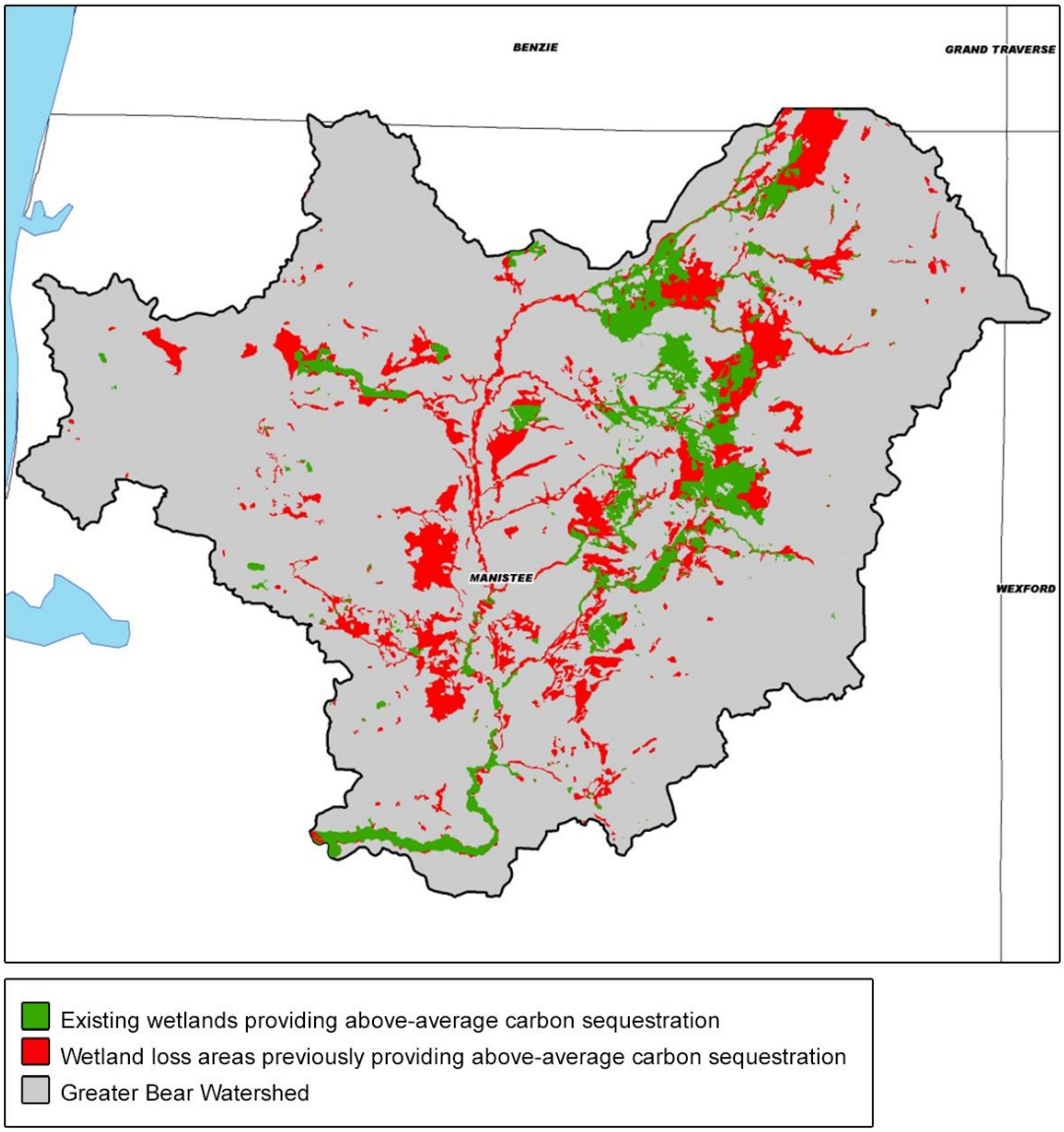
**EXHIBIT 47.** Conservation of Rare Imperiled Wetlands, Open Water Areas and Species




SOURCE: Michigan Department of Environmental Quality, 2012.

Wetlands can benefit the environment by fixing a high volume of carbon due to high rates of primary production. Exhibit 48 shows existing and former wetlands providing this function at an above-average level within the Greater Bear Watershed.

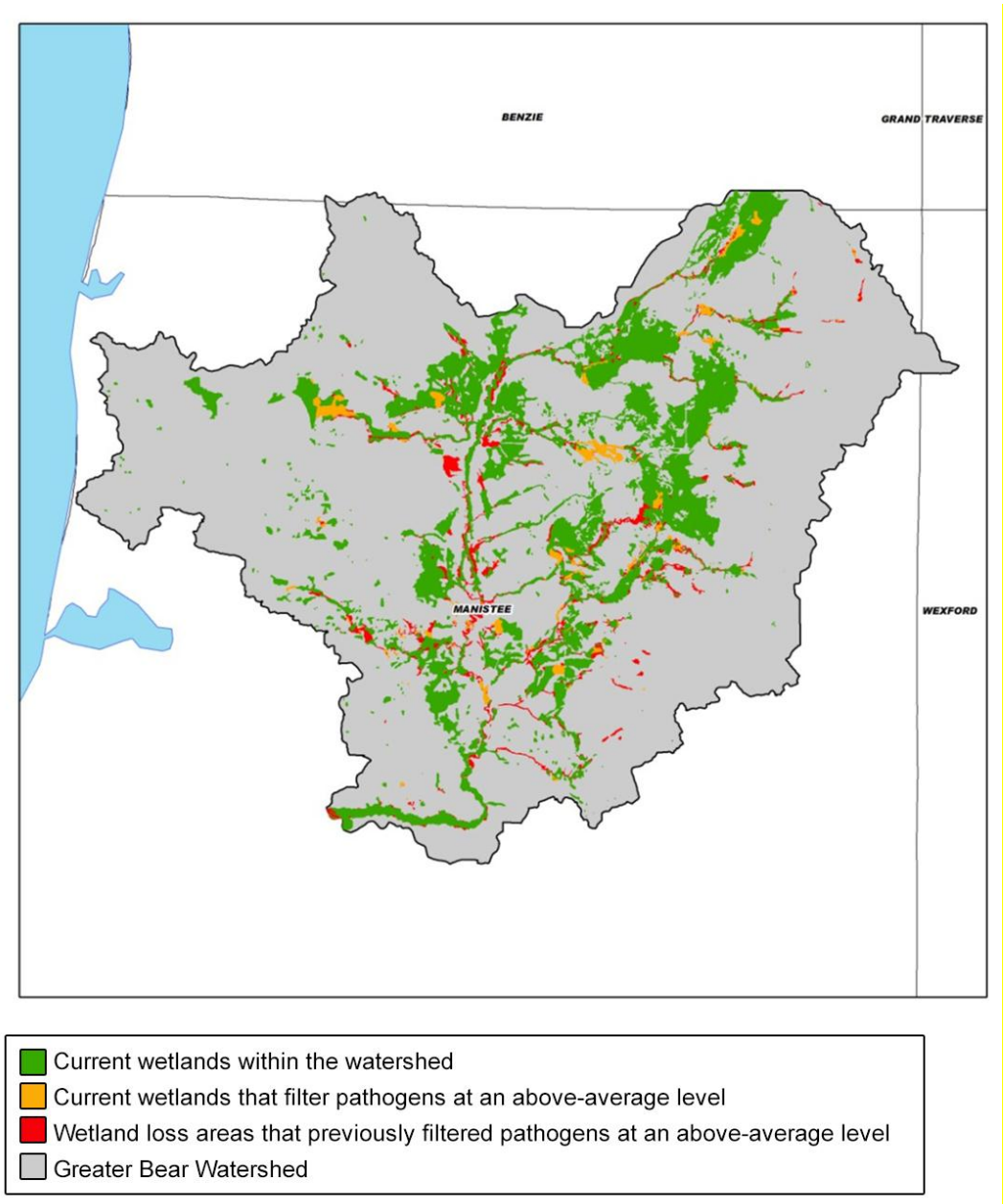
**EXHIBIT 48.** Carbon Sequestration




SOURCE: Michigan Department of Environmental Quality, 2012.

Wetlands can benefit the environment by filtering pathogens harmful to humans and other species. Exhibit 49 shows existing wetland areas, those that filter pathogens at an above-average level, and areas of wetland loss that previously provided this function.

**EXHIBIT 49.** Wetland Pathogen Filtration

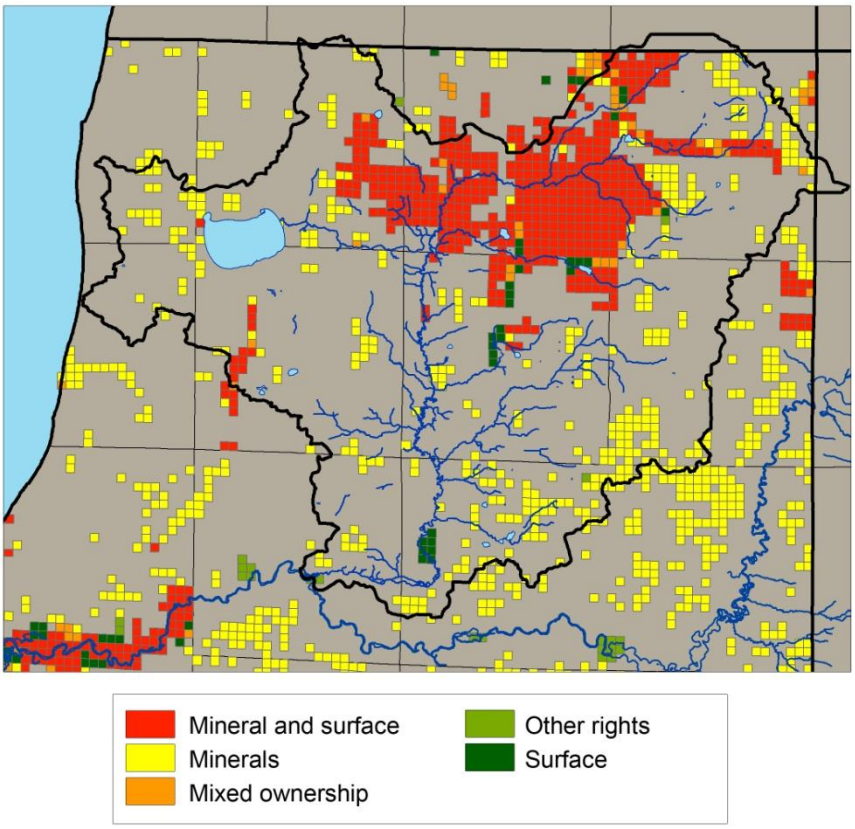



SOURCE: Michigan Department of Environmental Quality, 2012.

### *Conserved and Public Lands*

The State of Michigan owns a substantial amount of land in the Greater Bear Watershed, including surface and mineral rights or a mixture thereof. The MDNR owns approximately 29.8 square miles of lands with surface and mineral rights, 20.9 square miles of mineral rights (the state frequently obtained ownership of this land through tax revision where surface ownership was subsequently sold), 1.7 square miles of mixed ownership, 0.2 square miles of other rights, and 1.7 square miles of surface rights only (see Exhibits 50 and 51).

**EXHIBIT 50.** MDNR Ownership of Land and Mineral Rights, Location




SOURCE: Public Sector Consultants Inc., 2011, using data from MDIT/CGI.

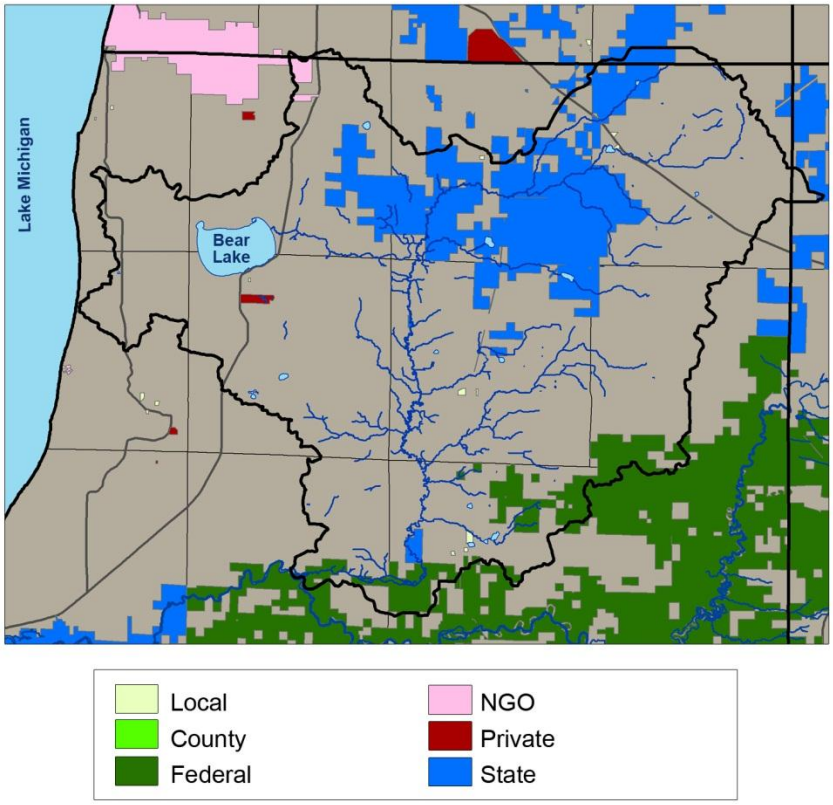
**EXHIBIT 51.** MDNR Ownership of Land and Mineral Rights, Extent

| State ownership | Acres | Square miles |
|---|---|---|
| Minerals and surface | 19,085 | 29.8 |
| Mineral rights | 13,413 | 20.9 |
| Mixed ownership | 1,105 | 1.7 |
| Other rights | 136 | 0.2 |
| Surface rights | 1,094 | 1.7 |

SOURCE: Public Sector Consultants Inc., 2012, using data from MDIT/CGI.

Entities other than the state also own conserved and public lands in the watershed, including federal, county, and local governments, non-governmental organizations (NGOs), and private entities. Exhibit 52 shows conserved lands identified in the conservation and recreation lands (CARL) database maintained by Ducks Unlimited in partnership with many other organizations. Ducks Unlimited requests information from public and private organizations regarding their conservation and public land holdings. The organizations that prefer not to identify their land holdings publicly are not represented in the database or on the map.

**EXHIBIT 52.** Conservation and Recreation Lands




SOURCE: Public Sector Consultants Inc., 2012, using data from Ducks Unlimited.

## *Manistee County Agriculture*

In the same manner that the U.S. Census Bureau provides an estimate of demographic and other information about communities, the Census of Agriculture, prepared every five years by the USDA National Agricultural Statistics Service (NASS), provides estimates on farming operations in the United States. The following information is compiled from the 2007 Census of Agriculture for all of Manistee County. Data for the Greater Bear Watershed alone are not available, and small portions of the watershed located in Benzie County and Wexford County are not included in the Manistee County data.

The NASS estimates that in 2007 there were 358 farms in Manistee County, from which 17,090 acres of crops were harvested. The median farm size was 80 acres; the average farm size was 129 acres (see Exhibit 53). Of these 358 farming operations, the owners of 189 farms (slightly more than half) indicated that farming was not their primary occupation (see Exhibit 54), and 250 farming operations had sales less than $10,000 (see Exhibit 55). The relatively small size of farms and the number of farmers who receive

the majority of their income from non-farm sources indicate that many of the farms may be part-time, hobby, or heritage farms.

## **EXHIBIT 53.** Manistee County Agriculture

| Land Use | Amount | Percentage of Manistee County |
|---|---|---|
| Total number of farms | 358 | — |
| Average farm size (acres) | 129 | — |
| Median farm size (acres) | 80 | — |
| Total acres in farmland* (includes non-cropland land) | 46,034 | 5.0% |
| Total cropland (acres) | 24,835 | 3.0 |
| Harvested cropland (acres) | 17,090 | 2.0 |
| Irrigated land (acres) | 2,262 | 0.2 |

SOURCE: Public Sector Consultants Inc., 2012, using data from: U.S. Department of Agriculture, National Agricultural Statistics Service, the Census of Agriculture, 2009.
* Managed and harvested woodlands are not included as part of farmland or cropland. Farmland figures also include non-harvested lands such as residential areas of a farm.

## **EXHIBIT 54.** Manistee County Farming Primary Operator Occupational Status

| Occupational status | Farm operations |
|---|---|
| Principal occupation non-farming | 189 |
| Farming as primary occupation | 169 |

SOURCE: U.S. Department of Agriculture, National Agricultural Statistics Service, the 2007 Census of Agriculture, 2009.

## **EXHIBIT 55.** Number of Farms, by Value of Sales

| Value of Sales | Number of Farm Operations |
|---|---|
| Less than $2,500 | 181 |
| $2,500 to $4,999 | 28 |
| $5,000 to $9,999 | 41 |
| $10,000 to $24,999 | 47 |
| $25,000 to $49,999 | 24 |
| $50,000 to $99,999 | 19 |
| $100,000 or more | 18 |

SOURCE: U.S. Department of Agriculture, National Agricultural Statistics Service, the 2007 Census of Agriculture, 2009.

The 2007 Census of Agriculture indicates that there are approximately 3,036 head of livestock in Manistee County (see Exhibit 56). As of January 2010, there were no state-registered concentrated animal feeding operations (CAFOs) within Manistee County (MDEQ 2011). Nationally, CAFOs are often cited as a source of excessive nutrients in waterways. The lack of registered CAFOs suggests that farming

operations that maintain livestock do so in relatively small numbers, which is less likely to concentrate excessive nutrients in any one area.

**EXHIBIT 56.** Livestock in Manistee County

| Livestock | Number |
|---|---|
| Cattle and calves inventory | 2,507 |
| Sheep and lamb inventory | 346 |
| Hogs and pigs inventory | 183 |
| **Total** | **3,036** |

SOURCE: U.S. Department of Agriculture, National Agricultural Statistics Service, the 2007 Census of Agriculture, 2009.

Many conventional agricultural operations add chemicals to the land to increase yields or produce enhanced crops. It is important for these applications to be tailored to the specific needs of individual farms to ensure that chemicals are not over applied, which can cause environmental concern when runoff occurs. Of the 24,835 acres of cropland in Manistee County 9,543 acres were treated with chemical fertilizers, lime, or other soil conditioners (see Exhibit 57). Some agricultural operations apply manure to the land in place of chemical fertilizers; some apply manure to the land as a waste disposal method. Nationally, manure applications are known to contribute excessive nutrients and bacteria to waterways. In Manistee County it is estimated that 1,969 acres, approximately 8 percent of cropland in Manistee County, had one or more manure application in 2007.

**EXHIBIT 57.** Fertilizer Application in Manistee County

| Fertilizer | Acres | Percentage of harvested cropland in Manistee County |
|---|---|---|
| Cropland without treatment | 13,323 | 54% |
| Commercial fertilizer, lime, and soil conditioners | 9,543 | 38 |
| Manure | 1,969 | 8 |

SOURCE: Public Sector Consultants Inc., 2012, using data from U.S. Department of Agriculture, National Agricultural Statistics Service, the 2007 Census of Agriculture, 2009.

# DEMOGRAPHICS

The boundaries of the Greater Bear Watershed do not correspond to municipal or Census boundaries so it is difficult to analyze demographic characteristics of the population located within the watershed. Demographic information was collected for Manistee County as a whole. Exhibit 58 provides demographic information of Manistee County from the 2000 and 2010 U.S. Censuses, which can be used to approximate information about residents within the watershed.

Between 2000 and 2010, the population of Manistee County increased very slightly from 24,527 to 24,733, which represents a 1 percent growth rate during this period. In contrast, the population of residents aged 65 and over increased from 4,435 to 5,108, a 15 percent increase during this period.

The total number of housing units increased by 10 percent between 2000 and 2010, from 14,272 to 15,694. Of the total housing units, the number of seasonal housing units increased by 414, which is 29 percent of new housing units in the county. The 2010 U.S. Census indicates that the average household

size for renters and owner-occupied properties in the county was 2.27 people per household, which is not a significant change from 2000.

**EXHIBIT 58.** Demographic Information for Manistee County, 2000 and 2010*

| Characteristic | 2000 Census | 2010 Census | % Increase or decrease |
|---|---|---|---|
| **Total population** | **24,527** | **24,733** | **1%** |
| Population over 65 | 4,435 | 5,108 | 15 |
| **Total housing units** | **14,272** | **15,694** | **10** |
| Seasonal housing units | 3,488 | 3,902 | 12 |
| Average household size (owner occupied) | 2.40 | 2.27 | –5 |
| Average household size (renters) | 2.22 | 2.27 | 2 |

SOURCE: Public Sector Consultants Inc., 2012, using data from U.S. Census Bureau.
*Population data is from the 2000 and 2010 U.S. Census Summary File 1.

Exhibit 59 presents a few metrics that reveal the economic condition of Manistee County. Since the 2010 U.S. Census did not collect information on income and poverty for Manistee County, data from the 2010 three-year American Community Survey were used to estimate how the economic condition of the county has changed between 2000 and 2010.

Median family income and per capita income figures were adjusted for inflation between 2000 and 2010 to better reflect real changes in the economic standing of the county. The adjusted figures show that median family income and per capita income declined by 7 and 3 percent, respectively. The data indicate the number of families below the poverty level increased by 132, which represents a 29 percent increase during this period.

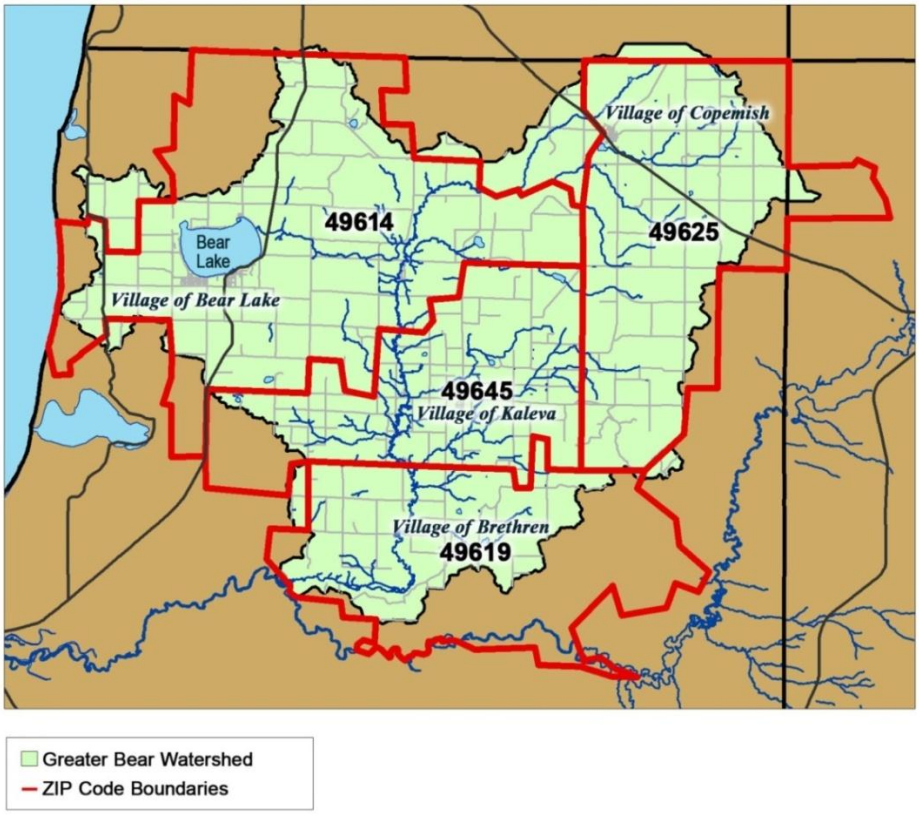
**EXHIBIT 59.** Manistee County Economic Demographics

| | 2000 Census | | 2010 American Community Survey | % Increase or Decrease | |
|---|---|---|---|---|---|
| Characteristic | Unadjusted* | Adjusted for inflation** | 3 Year estimate | Unadjusted | Adjusted for inflation |
| Median family income | $41,664 | $54,532 | $50,699 | 22% | –7% |
| Per capita income | $17,204 | $22,517 | $21,758 | 26% | –3% |
| Population below poverty level | 2,403 | — | NA | NA | — |
| Families | 6,698 | — | 6,882 | 3% | — |
| Families below poverty level | 460 | — | 592 | 29% | — |
| Families below poverty level (%) | 6.9% | — | 8.6% | 25% | — |

SOURCE: Public Sector Consultants Inc., 2012, using data from U.S. Census Bureau, 2000 and 2010 U.S. Census Summary File – 1 & 3 and the 2010 three-year American Community Survey.
*Shown in year 2000 dollars.
** Median family income and per capita income figures from the 2000 Census were adjusted to 2010 dollars using an inflation calculator prepared by the U.S. Bureau of Labor Statistics which is available online at http://www.bls.gov/data/inflation_calculator.htm.
NA: Not Available.
—: Not Applicable

Additional analysis was conducted using geographic information system (GIS) software and ZIP Code boundaries to approximate the borders of the watershed to allow for more detailed comparison of its demographic characteristics. This was done by loading the watershed boundary into GIS software and then comparing it to U.S. Census data available for ZIP Codes in the area.[3] Exhibit 60 shows the watershed boundary and the ZIP Codes used to estimate demographic information for the Greater Bear Watershed. The ZIP Code boundaries and borders of the Greater Bear Watershed align fairly well for the purposes of estimating demographic information about the watershed.

## **EXHIBIT 60.** Greater Bear Watershed ZIP Codes




SOURCE: Public Sector Consultants Inc., 2012, using data from the 2010 U.S. Census and MDIT/CGI.

[3] U.S. Census block data was not used because the 2010 data had not been released for areas within the Greater Bear Watershed at the time of this analysis.

Demographic characteristics for the area of land corresponding to the four ZIP Codes that best represent the Greater Bear Watershed are shown in Exhibit 61.

**EXHIBIT 61.** Demographic Information for the Greater Bear Watershed

| Characteristic | 2000 Census | 2010 Census | % Increase or decrease |
|---|---|---|---|
| **Total population** | **6,565** | **6,911** | **5.3%** |
| Population over 65 | 1,070 | 1,335 | 24.8 |
| **Total housing units** | **4,023** | **4,542** | **12.9** |
| Occupied housing units | 2,624 | 2,854 | 8.8 |
| Vacant housing units (not seasonal) | 250 | 492 | 96.8 |
| Seasonal housing units | 1,149 | 1,196 | 4.1 |
| Number of households | 2,624 | 2,854 | 8.8 |
| Average household size (owner occupied) | 2.50 | 2.35 | –5.8 |
| Average household size (renters) | 2.56 | 2.69 | 5.4 |

SOURCE: Public Sector Consultants Inc., 2012, using data from the 2000 and 2010 U.S. Census and MDIT/CGI.

Between 2000 and 2010 the total population of the approximated Greater Bear Watershed increased by 346 people, which represents a 5.3 percent increase. During this same period, the population aged 65 years and over increased by 265 people, or 24.8 percent. The total number of housing units increased by 12.9 percent, which represents 519 new residential dwellings. During this same period, the number of vacant housing units nearly doubled from 250 to 492 vacant non-seasonal homes, a 96.8 percent increase. The number of seasonal housing units increased by 47 homes or 4.1 percent. The economic indicators referenced above for Manistee County as a whole were not available at the ZIP Code level for the Greater Bear Watershed.

# Section D: Local Programs, Projects, and Planning

## LOCAL GOVERNMENT PLANNING AND ZONING

Land use within a watershed has a significant influence on water quality. In Manistee County, the primary county in which the Greater Bear Watershed is located, the planning department and drain commission as well as District Health Department #10 maintain regulations that affect water quality. Additionally, each township and village within the Greater Bear Watershed can adopt individual plans, zoning requirements, and ordinances that affect watershed resources.

The Manistee County Planning Department administers one ordinance: the Soil and Erosion Control Ordinance that requires a permit and county review for construction on properties within 500 feet of a lake, stream, or wetland, or if the land disturbance is one acre or greater in size. The county drain commission maintains storm water guidelines for site developments within an existing county drainage district or if the site development seeks to connect to a county drain. The District Health Department maintains requirements through the public health code that guide the placement of water wells and wastewater treatment systems, including a requirement that these systems are inspected and in compliance with the code at the time a property is sold.

A comprehensive or master plan is a blueprint or set of long-term goals and policies that a community uses to guide development decisions. A master plan can also be used to assist with special land use and site plan reviews; capital improvement programs; special programs such as economic development, parks, trails, gateway improvements, etc.; 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. Benefits of zoning include local control over land use decisions, the ability to communicate clear expectations to potential developers based on community needs, and the opportunity for local residents to have input on designing the type of community in which they want to live. Local entities can also pass municipal ordinances under the authority of a municipal charter.

Existing plans, zoning regulations, and ordinances were examined for Arcadia, Bear Lake, Brown, Cleon, Dickson, Maple Grove, Marilla, Onekema and Pleasanton townships using information provided by the Manistee County Planning Department (see Exhibit 62). Since these townships encompass the majority of the population and geographic extent of the Greater Bear Watershed, land use in these townships significantly affects water quality within the watershed. Jurisdictions with less than 5 percent of their jurisdictional boundary within the Greater Bear watershed were not included in this review. Some jurisdictions within the watershed do not have zoning codes filed with the Manistee County Planning Department, including the villages of Bear Lake, Copemish, and Kaleva, and Springdale Township. The Village of Bear Lake has not adopted zoning to control land use, but has passed ordinances that include controls on the use of land within a prescribed area encompassing municipal groundwater supplies. The Village of Kaleva similarly does not have zoning regulations on file with the county planning office, but has adopted ordinances to protect the groundwater sources of its public water supply.

**EXHIBIT 62.** Status of Planning and Zoning Documents of Jurisdictions within the Greater Bear Watershed

| Jurisdiction | % of jurisdiction within watershed** | Zoning Review Conducted | Comprehensive or master plan | Zoning ordinance |
|---|---|---|---|---|
| **Benzie County** | **<1%** | Limited geographic extent – not reviewed | | |
| Colfax Township | 4 | Limited geographic extent – not reviewed | | |
| Joyfield Township | 1 | Limited geographic extent – not reviewed | | |
| **Manistee County** | **36%** | **Yes** | **NA** | **NA** |
| Arcadia Township | 29 | Yes | Under development | Amended May 2010 |
| Bear Lake Township | 83 | Yes | Adopted 2008 | Adopted April 11, 1995; Revised June 21, 2007 |
| Bear Lake Village | 100 | No Zoning on File with the County Planning Office | | |
| Brethren* | NA | NA | NA | NA |
| Brown Township | 27 | Yes | Revised April 2013 | Amended May 18, 2005 |
| Cleon Township | 85 | Yes | Unknown | Amended March 3, 2007 |
| Copemish Village | 100 | No Zoning on File with the County Planning Office | | |
| Dickson Township | 28 | Yes | Adopted 2004 | Adopted March 20, 1998; Revised June 13, 2007 |
| Kaleva Village | 100 | No Zoning on File with the County Planning Office | | |
| Maple Grove Township | 100 | Yes | Revised 2011 | Adopted September 13, 1983; Revised September 10, 2007 |
| Marilla Township | 54 | Yes | Revised March 2013 | Amended Oct 21, 2000 |
| Onekema Township | 29 | Yes | Underdevelopment | July 2008 |
| Pleasanton Township | 65 | Yes | Not on file—under development | Adopted March 12, 1991; Revised November 18, 2003 |
| Springdale Township | 63 | No Zoning on File with the County Planning Office | | |
| **Wexford County** | **<1%** | Limited geographic extent – not reviewed | | |
| Wexford Township | 1 | Limited geographic extent – not reviewed | | |

SOURCE: Public Sector Consultants Inc . using data from MDIT/CGI, & Manistee County Planning Department 2013.
* Brethren is an unincorporated community and is included as part of Dickson Township, Manistee County, Michigan.
NA = Not Applicable.

Water quality is significantly influenced by how and where a community develops and, likewise, as in the Greater Bear Watershed, future growth in the region is likely to be influenced by the quality of its water. Fortunately, communities within the Greater Bear Watershed can plan for growth using planning and zoning regulations in a way that protects water quality. Exhibit 63 provides a brief summary of planning and zoning tools that protect water quality.

## **EXHIBIT 63.** Planning and Zoning Tools to Protect Water Quality

| Tool | Description |
|---|---|
| Joint planning | Storm water management in a watershed basin typically involves cooperation and integration among several municipalities, jurisdictions, and planning agencies. Michigan's Joint Planning Act (Public Act 226 of 2003) authorizes local governments to pull together regional planning entities – Joint Planning Commissions. These commissions facilitate cooperation and coordination by overseeing issues for a region, or a portion of a region, in which they may have an interest such as a business district, watershed, or greenway. |
| Storm management ordinance | An ordinance intended to minimize the potential adverse impacts on natural resources and water quality from storm water runoff. It can require low-impact development,* soil erosion and sediment control for development projects, and incentives for best management practices. |
| Mixed-use zoning | Allows residential, office, and retail buildings to be built close to one another, which is typically forbidden in traditional zoning. More intense, compact development works best when different uses are within walking distance, so mixed developments can reduce the amount of land needed per unit. It also supports a range of transportation options and facilitates shared parking, thereby reducing the amount of surface needed for roads and parking lots. |
| Onsite wastewater treatment system point-of-sale ordinance | An ordinance geared to protect water quality by requiring inspections and, if necessary, upgrades to septic systems at the time of property transfer. |
| Compact lot size | Allows land to be used more efficiently by building on smaller lots. Smaller lots also mean smaller lawns – large lawns treated with chemicals are a significant contributor to storm water pollution. |
| Maximum setback | Establishes a maximum distance between buildings and the street. This change encourages more efficient use of space and pedestrian friendliness. |
| Open space planned unit development (PUD) and non-contiguous PUD | Allows local governments to approve a PUD that preserves open space, whether it is connected or not to the rest of the PUD. |
| Purchase of development rights (PDR) | Allows municipalities, individuals, and organizations to purchase just the rights to develop (or not develop) a piece of land, as opposed to buying the land outright. PDR is currently available at both the state and local government level; conservancies and land preservation groups can provide more information about these programs. |
| Urban service district | Municipalities use urban service districts to define the edge of a community by limiting the extension of urban infrastructure. This encourages growth in areas with existing and adequate infrastructure while discouraging growth in undeveloped and environmentally beneficial areas. |
| Watershed alliance | Public Act 517 of 2004 allows two or more municipalities, by resolution of their governing bodies, to establish a voluntary watershed alliance to study problems and to plan and implement activities designed to address surface water quality or water flow issues. |
| Form-based code | A method of regulating development to achieve a specific form – including the relationship of buildings to each other, to streets, and to open spaces – rather than allowing a certain use. "Design is more important than use" is the underlying philosophy behind the form-based code. |

SOURCE: Public Sector Consultants Inc., 2007.
*Low-impact development (sometimes called low-impact design) includes a series of techniques that equip developments to mimic natural storm water filtration, managing rainfall at the source using design techniques that infiltrate, filter, store, evaporate, and de-tain runoff close to its source; tree planting, green roofs, and rain gardens are commonly used techniques.

In order to determine the extent of environmental provisions in place, zoning ordinances were reviewed in the nine primary townships to help determine regulatory coverage for protection of aquatic resources within the Greater Bear Watershed (see Exhibit 64).

## **EXHIBIT 64.** Water Quality Protection Regulations in Zoning Ordinances within the Greater Bear Watershed

| **Water quality protection regulation** | **Arcadia Township** | **Bear Lake Township** (excludes Bear Lake Village) | **Brown Township** |
|---|---|---|---|
| Minimum parcel size | • Agricultural areas; 2 acres<br>• Residential agriculture areas: 1 acre | • Residential areas: 20,000 ft.$^2$<br>• Commercial areas: 40,000 ft.$^2$ | • Big Manistee Corridor District: 10 acres<br>• Agricultural areas: 10 acres<br>• Residential recreation areas: 10 acres<br>• Residential areas (R-1): 140,000 square ft. |
| Minimum parcel width | • Agricultural areas: 175 ft.<br>• Residential agriculture areas: 132 ft. | • Residential areas: 100 ft.<br>• Commercial areas: 150 ft. | • Big Manistee Corridor District: 330 ft.<br>• Agricultural areas: 330 ft.<br>• Residential recreation areas: 330 ft.<br>• Residential areas (R-1): 150 ft. |
| Minimum buildable area | Not addressed | Not addressed | Not addressed |
| Maximum percentage developed or open space | Not addressed | Not addressed | Not addressed |
| Setbacks from water | • Residential areas: 50 ft. from surface water | • Residential areas: 50 ft. (In some cases - the average distance from the water's edge of the four nearest neighboring structures of a type similar to the proposed structure, whichever is less.)<br>• Commercial areas: 300 ft. from the water's edge of any lake, stream, creek, river, or wetland area. | • 200 ft. from surface water |
| Surface water buffer | • 10 ft buffer required. Removal of root structure prohibited | • Within the setback area not more than 10% of vegetation can be removed in a five-year period. | • 50 ft. buffer required. Not more than 10 % of vegetation can be removed. |
| Wetlands | • Not addressed | • Residential areas: 50 ft. (In some cases - the average distance from the water's edge of the four nearest neighboring structures of a type similar to the proposed structure, whichever is less.)<br>• Commercial areas: 300 ft. setback | • Cannot be included in buildable area provisions for districts |

| Water quality protection regulation | Arcadia Township | Bear Lake Township (excludes Bear Lake Village) | Brown Township |
|---|---|---|---|
| Groundwater protection/ hazardous waste | • Not addressed | • Businesses and facilities which use, store or generate hazardous substances in specified quantities must comply with state and federal requirements | • Required provisions for businesses or facilities that generate or use hazardous substances. |
| Waste accumulation /outside storage | • Not addressed | • No accumulation of rubbish or waste materials of any kind without a permit.<br>• No sewage, wastewater or water containing foreign substances shall be deposited or drained into any open ditch, creek stream, lake, pond, or other body of water without approval from state and county health authorities. | Not addressed |
| Storm water | • Not addressed | • No storm water runoff resulting from site development shall be allowed to collect unless part of a properly managed water retention system or natural wetland. | Not addressed |
| Planned unit development | Included | Included | Included |
| Other | • NA | • Keyhole Waterfront Access—allows for shared ownership of parcels adjacent to lakes. | • NA |

SOURCE: Public Sector Consultants Inc., & Manistee County Planning Department 2013.
Note: This review focused on ordinances of relevance to the Greater Bear Watershed. Some jurisdictions have additional requirements applicable to districts outside of the watershed such as the unincorporated village of Arcadia in Arcadia Township.

| Water quality protection regulation | Cleon Township | Dickson Township | Maple Grove Township (excludes Kaleva) |
|---|---|---|---|
| Minimum parcel size | • Residential recreation areas: 5 acres<br>• R-2 Residential areas: 1 acre<br>• Forest and recreation areas: 10 acres | • Big Manistee River Corridor (BMRC): No buildings on parcels less than 10 acres<br>• Ag-Res: No buildings on parcels less than 60,000 ft.$^2$ | • Forest & Ag areas: 5 acres<br>• Residential: 2.5 acres |

| **Water quality protection regulation** | **Cleon Township** | **Dickson Township** | **Maple Grove Township** (excludes Kaleva) |
|---|---|---|---|
| Minimum parcel width | • Residential recreation areas: 330 ft.<br>• R-2 Residential areas: 150 ft.<br>• Forest and recreation areas: 330 feet | • BMRC: 330 ft.<br>• Ag-Res: 150 ft. | • 165 ft. of road frontage |
| Minimum buildable area | Not addressed | BMRC & Ag-Res: 15,000 ft.$^2$ | Not addressed |
| Maximum percentage developed or open space | Not addressed | Not addressed | Not addressed |
| Setbacks from water | • 100 ft. from surface water | • 100 ft. from water's edge. | • All districts: 45 ft. setback from nearest high water of stream, lake, or wetland. |
| Surface water buffer | • 25 ft. buffer required | • 10 ft. vegetated buffer required. | • All districts: 45 ft. setback requires at least 10 ft. of greenbelt along stream lake or wetlands area. |
| Wetlands | • No construction within 100 year floodplain | • BMRC: buffer strip requirements include wetlands | • Forest: No construction allowed on wetlands or flood plains unless permitted by the Michigan Department of Environmental Quality. |
| Groundwater protection/ hazardous waste | • Required provisions for businesses or facilities that generate or use hazardous substances. | • Required provisions for businesses or facilities that generate or use hazardous substances. | • Required provisions for businesses or facilities that generate or use hazardous substances. |
| Waste accumulation /outside storage | • Unlawful to accumulate waste without a permit | • No accumulation of junk without a permit.<br>• No sewage, wastewater, or water containing foreign substances shall be deposited or drained into any water bodies unless approved by state and county health authorities. | • Not addressed |
| Storm water | Not addressed | • No storm water runoff resulting from site development shall be allowed to collect unless part of a properly managed water retention system or natural wetland. | Not addressed |
| Planned unit development | Not Included | Included | Included |

| Water quality protection regulation | Cleon Township | Dickson Township | Maple Grove Township (excludes Kaleva) |
|---|---|---|---|
| Other | • NA | • Big Manistee Corridor District established to "protect the free flowing conditions of the Big Manistee River and Big Bear Creek downstream from Coates Highway."<br>• Central Production Facilities and Sweetening Plants (Oil & Gas): Setback from surface water and wetlands by 600–1,200 ft. Max. density of not more than one per sq. mile. Brine pits or earthen pits not allowed. Pollution prevention plan must be filed with township, county, and state officials. Effluent must meet or exceed state and federal standards. | • Wellhead Protection Overlay district: additional protections for land surrounding Type I water wells. |

SOURCE: Public Sector Consultants Inc., & Manistee County Planning Department 2013.
Note: This review focused on ordinances of relevance to the Greater Bear Watershed. Some jurisdictions have additional requirements applicable to districts outside of the watershed such as the unincorporated village of Arcadia in Arcadia Township.

| Water quality protection regulation | Marilla Township | Onekema Township | Pleasanton Township |
|---|---|---|---|
| Minimum parcel size | • Residential (R1): 40,000 sq ft<br>• Residential (RP1): 40 acres<br>• Residential recreation areas: 10 acres<br>• Commercial areas: 40,000 sq ft | • Agricultural areas: 1 acre | • Residential Ag (RA-1): 2 acres<br>• Residential (R-1): 20,000 ft.[2] |
| Minimum parcel width | • Residential (R1): 150 ft<br>• Residential (RP1): NA<br>• Residential recreation areas: NA<br>• Commercial areas: 150 ft | • Agricultural areas: 200 ft. | • Residential (R-1): 100 ft. |
| Minimum buildable area | Not addressed | Not addressed | Not addressed |
| Maximum percentage developed or open space | Not addressed | Not addressed | Not addressed |

| Water quality protection regulation | Marilla Township | Onekema Township | Pleasanton Township |
|---|---|---|---|
| Setbacks from water | • 100 ft setback requirement | • 40 ft setback requirement | • Residential (R-1): 100 ft. from the water's edge of any stream, creek, river or wetlands.<br>• Residential (R-1): 25 ft. from the water's edge of any lake. |
| Surface water buffer | • Not addressed | • Not addressed | • Within the setback area not more than 10% of vegetation can be removed in a five-year period. |
| Wetlands | • Wetlands may not be drained, filled, etc without approval from MDEQ | • Not addressed | • Residential (R-1): 100 ft. setback from any wetlands.<br>• Wetlands Overlay District: 100 ft. landward from wetlands: requires that onsite sewage disposal permits be for an upland area; MDNR wetlands permit must be obtained to expand or construct a building. |
| Groundwater protection/ hazardous waste | • Not addressed | • Not addressed | • Required provisions for businesses or facilities that generate or use hazardous substances. |
| Waste accumulation /outside storage | • Not addressed | • Unlawful to accumulate waste without a permit | Not addressed |
| Storm water | • Not addressed | Not addressed | Not addressed |
| Planned unit development | Not Included | Included | Included |
| Other | • NA | • As of spring 2013 the township is in the process of updating the master plan.<br>• Impervious surface limitations for parcels within 500 ft of Portage Lake or its tributaries. This requirement does not include tributaries to Bear Creek. | • Keyhole Waterfront Access—allows for shared ownership of parcels adjacent to lakes.<br>• Oil and Gas Processing or Sweeting Facilities: 1,300 ft. setback from surface water and wetlands; access roads to facilities setback 650 ft. from surface water and wetlands; max density of not more than one per square mile; bulk storage and tanks must be enclosed in a berm; any effluent must meet state and federal standards. |

SOURCE: Public Sector Consultants Inc., & Manistee County Planning Department 2013.
Note: This review focused on ordinances of relevance to the Greater Bear Watershed. Some jurisdictions have additional requirements applicable to districts outside of the watershed such as the unincorporated village of Arcadia in Arcadia Township.

## JOINT PLANNING

As identified above in Exhibit 63, joint planning can be an effective tool to address goals that are broader than the interests of a single community within a region. Portions of the Greater Bear Watershed extend into 16 jurisdictions (see Exhibit 62); the large geographic area and the number of municipalities and organizations that have an interest in and effect on water quality underscore the need for collaborative efforts. The Manistee Alliance for Economic Success is coordinating the Lakes to Land Regional Initiative, commenced in January 2012, to develop master plans and collaborative implementation strategies for one city and several townships in Manistee and Benzie counties. These jurisdictions include Arcadia, Bear Lake, Onekama, and Pleasanton townships in Manistee County; the city of Frankfort; and Blaine, Crystal Lake, Gilmore, and Joyfield townships in Benzie County. This joint planning effort presents an opportunity to take a broader regional approach to protecting watershed resources through planning and zoning.

## OTHER AGENCIES AND LOCAL ORGANIZATIONS

A number of local organizations active within the region play vital roles to maintain, protect, and enhance the quality of life, natural resources, and economic vitality of the Greater Bear Watershed. The continued involvement of these organizations will be critical to successful implementation of the Greater Bear Watershed Plan.

In addition to the local units of government discussed in the section above, the following local units of government have portions of the Greater Bear Watershed within their jurisdiction:

- Colfax Township (Benzie County)
- Joyfield Township (Benzie County)
- Arcadia Township (Manistee County)
- Brown Township (Manistee County)
- Cleon Township (Manistee County)
- Copemish Village (Manistee County)
- Kaleva Village (Manistee County)
- Marilla Township (Manistee County)
- Onekema Township (Manistee County)
- Springdale Township (Manistee County)
- Wexford Township (Wexford County)

In addition to local units of government, the following federal, state, and local organizations should continue to be engaged:

- Bear Creek Watershed Council
- Bear Lake Property Owners Association
- Bear Lake Schools
- Bear Lake Watershed Alliance
- Benzie—Leelanau Health Department (serving Benzie County)
- Benzie, Manistee, and Wexford counties
- Conservation Resource Alliance
- District Health Department #10 (serving Manistee and Wexford counties)
- Grand Traverse Regional Land Conservancy

- Kaleva Norman Dickson Schools
- Little River Band of Ottawa Indians
- Manistee County Community Foundation
- Manistee County Road Commission
- Michigan Department of Environmental Quality
- Michigan Department of Natural Resources
- Michigan Department of Transportation
- Natural-resource–based businesses and other area businesses
- Northwest Michigan Council of Governments
- U.S. Department of Agriculture—Forest Service
- U.S. Department of Agriculture—Natural Resource Conservation Service
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service

# Section E: Watershed Conditions

The current condition of Bear Lake, Bear Creek, tributary watercourses, and other water bodies within the Greater Bear Watershed are assessed in this section. What is known about the condition of the surface water of the Greater Bear Watershed has been compiled from data and information contained in the following list of studies and reports as well as from the files of or direct communications with local, state, and federal agencies; tribal officials; and nonprofit organizations working in the watershed. Local residents, through individual contributions and through work with volunteer organizations, have also provided information that was helpful in assessing the current condition of the surface and groundwater of the watershed.

## BEAR LAKE REPORTS AND DATA SOURCES

- ***Bear Lake MDNR Fisheries Report*** (Tonello 2000a). The 2000 *Bear Lake Fisheries Report* summarizes historical water quality and fish population surveys on the lake and makes recommendations for future fish population management by the Michigan Department of Natural Resources (MDNR) based upon studies conducted in the summer of 1999.
- ***Bear Lake–2009 Fisheries Survey Analysis Report*** (Seites 2011). This report, based upon fisheries surveys conducted in 2009, provides a brief background of historical fisheries management on Bear Lake and provides information on existing fish populations. The report makes recommendations for future management of walleye, northern pike, and habitat protection as well as the need for annual fish population monitoring.
- ***Bear Lake–2010 Fisheries Survey Report*** (Tonello 2011d). The report summarizes the walleye management efforts on Bear Lake over the last 20 years and proposes increased stocking of spring fingerling walleyes beginning in 2012 at double the previous rate (from 25 to 50/acre) and every other year rather than every three years.
- ***Bear Lake Eurasian Milfoil Vegetation Survey Investigative Report*** (ASI Environmental Technologies Inc. 2007b). The preliminary assessment documents the spread of Eurasian Milfoil in Bear Lake particularly through the 2006–07 period and recommends actions to control this invasive species including preparation of the Lake Improvement Feasibility Study.
- ***A Lake Improvement Feasibility Study of Bear Lake, Manistee County 2007*** (ASI Environmental Technologies Inc. 2007c). The feasibility study summarizes water quality information on Bear Lake and outlines a recommended integrated approach to the control of Eurasian Milfoil.
- ***Volunteer Bear Lake Water Quality Monitoring Results 1976–2010*** (Michigan Clean Water Corps 1976–2010). Residents in the Bear Lake area have participated in volunteer lake monitoring programs since 1977. Sampling has provided annual Secchi disk transparencies, and periodic data on dissolved oxygen, temperature, total phosphorus and chlorophyll *a*. The volunteer inland lake monitoring for Bear Lake collected data under the auspices of the Michigan Lakes and Streams Association through the Bear Lake Property Owners Association (BLPOA); these data are now part of the Michigan Clean Water Corps Web database where both historical and current sampling results are posted.
- ***Walleye Recruitment Assessments on Portage Lake, Bear Lake, Tippy Dam Pond, and Big Star Lake 2006*** (LRBOI 2006). The tribal walleye assessment for Bear Lake was part of a larger study of walleye recruitment involving several inland lakes within the 1836 Treaty area of northwest lower Michigan by the combined efforts of the Little River Band of Ottawa Indians (LRBOI), the Grand Traverse Bay of Ottawa and Chippewa Indians, and the Little Traverse Bay Bands of Odawa Indians (LTBB). Bear Lake was sampled using electrofishing from boats during October of 2006 by the LRBOI in cooperation with the LTBB. The results of the catch per unit of effort (CPUE) for Age-0 and Age-1 walleye from Portage Lake, Bear Lake, and Tippy Dam Pond are compared. Growth

indices for walleye and northern pike taken from Bear Lake are reported, along with surface water sample results for temperature, dissolved oxygen, specific conductivity, turbidity, and pH.

- ***Storm Drain Report, Bear Lake Property Owners Association, Surface Water Subcommittee*** (Surface Water Subcommittee 2008). Members of the Bear Lake Property Owners Association, Surface Water Subcommittee collected information on the storm drain system entering Bear Lake and prepared a report describing storm drains by location with accompanying maps and findings related to retention areas and potential areas of concern.

## BEAR CREEK AND TRIBUTARIES REPORTS AND DATA SOURCES

- ***A Biological Survey of Bear Creek and First Creek in Manistee County, Michigan, July 1, 1992*** (MDEQ 1999). This biological survey was prompted by the 1989 failure of a dam located on First Creek that resulted in the release of accumulated sediments into Bear Creek. The survey, conducted under the Great Lakes and Environmental Section Procedure 51, documents the fish and macroinvertebrate communities, the physical habitat conditions, and in-stream nutrient concentrations.
- ***A Biological Survey of Bear Creek and Selected Tributaries, Manistee County Michigan June 10–11, 1999*** (MDEQ 2004). This follow-up survey was conducted to document changes in fish and macroinvertebrate communities and physical habitat conditions compared to those recorded in the 1992 survey using the same GLEAS Procedure 51 and water quality testing.
- ***Biological and Water Chemistry Surveys of Selected Stations in the Manistee, Little Manistee, and Big Sable River Watersheds, Grand Traverse, Kalkaska, Lake, Manistee, Mason, Osceola, and Wexford Counties, Michigan, June and July 2009*** (MDEQ 2010). This survey of selected streams includes assessments at two stations on Bear Creek. The primary objectives were to support quality-based effluent limits for National Pollutant Discharge Elimination System (NPDES); identify nonpoint sources (NPS) of water quality impairment; assess the current status and condition of individual water bodies and determine if Michigan Water Quality Standards (WQS) were being met; and evaluate biological integrity trends.
- ***Bear Creek Watershed Management Plan, July 2000*** (Conservation Resource Alliance 2000). In addition to describing protected and desired uses of the Bear Creek Watershed and identifying potential sources of pollution, the plan inventoried road/stream crossings and stream bank conditions. This inventory was later used to apply for a state grant to implement the recommendations of the plan.
- ***Bear Creek Project Updates 2004–2008*** (Conservation Resource Alliance 2004–08). These brief reports document progress in inventorying critical erosion areas and implementing bank stabilization and erosion control best management practices on Bear Creek.
- ***Stream Flow, Water Quality, Stream Depth and Width, and Fish Collections, Bear Creek Michigan*** (USFWS 2011). These Excel data sheets provide a source of information on flows, stream size, water chemistry, and fish species at various locations throughout the Bear Creek system from 2004 to 2009.
- ***Water Quality Program Final Technical Report FY10*** (LRBOI 2010). The technical report is part of a baseline investigation conducted by the Little River Band of Ottawa Indians under a U.S. Environmental Protection Agency (USEPA) grant to assess overall water quality in the Manistee River and its tributaries upstream to and including Tippy Dam Pond. Basic chemistry and nutrient data as well as benthic macroinvertebrates were collected from Bear Creek at a location near its confluence with the Manistee River from May 2002 to October 2010. The nutrient water sample results are compared to ambient Water Quality Criteria Recommendations–River and Streams in Nutrient Ecoregion VIII (USEPA 2011). The macroinvertebrate data were evaluated under the Shannon Index and compared to other Manistee River tributaries.

- ***Bear Creek National Scenic River, Huron Manistee National Forest Management Report*** (Huron-Manistee National Forest n.d.). The management report details the guidelines for U.S. Forest Service activities within the designated river corridor under chapters labeled Information Services, Vegetative Management, Recreation, Heritage Resources, Visual Management, Watershed and Soils Management, Wildlife, Fisheries and Riparian Resources, Threatened, Endangered and Sensitive Plants and Animals, Special Uses, Minerals, Fire Management Law Enforcement, and Land Ownership.
- ***U.S. Forest Service Huron-Manistee Bear Creek Habitat Inventory Sheets*** (Jackovisk 1992). Excel data sheets contain field notes on in-stream and riparian habitat within the portion of Bear Creek within the Huron-Manistee National Forest near the confluence with the Manistee River.
- ***Bear Creek 1983-2007 Fisheries Surveys Leffew Rd. (Old Iron Bridge) Station*** (Tonello 2011b). The field report summarizes the data collected on *salmonid* species (brook and brown trout, rainbow trout [steelhead], coho and Chinook salmon) at a location selected as a Fixed Site in the Status and Trends Program in 2005 (Wills 2006). The report estimates the fish populations for salmonids in terms of pounds and numbers per acre in 1983, 1997, 2005, 2006, and 2007. It also provides information on water temperatures at the index site from continuous recording devices in place during a portion of the 2005, 2006, and 2007 seasons.
- ***Bear Creek 2008 Fisheries and Temperature Survey, Spirit of the Woods Club*** (Tonello 2011c). The Spirit of the Woods Club has over one-half-mile of frontage on Bear Creek and provides public access to anglers on its property to one of the most popular fishing areas on the stream. Estimates of brook trout, brown trout, rainbow trout (steelhead), and coho and Chinook salmon in terms of numbers and pounds per acre were made in 2008. The report summarizes the water temperature data for Bear Creek collected by continuous recording devices by the Little River Band of Ottawa Indians in 2007 and by the Michigan Department of Natural Resources and Environment (now Michigan Department of Natural Resources) in 2008. The report includes recommendations related to stream protection through management of land use practices; designation of this stretch of Bear Creek as part of the Michigan Natural Rivers program; the potential for enhancing brown trout through the addition of woody debris; and the need for additional public fishing access.
- ***Conservation Resource Alliance Inventory of Stream Bank Erosion Sites in Bear Creek Watershed*** (Conservation Resource Alliance 2010). This Web-based application provides interactive maps that inventory stream bank erosion sites within the Greater Bear Watershed and provide detailed photographs and descriptions of each erosion site and potential remedial actions.
- ***Bear Creek Road-Stream Crossing Access Data Base*** (MDEQ 2003). Surveys of Bear Creek and tributary stream crossings were completed by MDEQ staff during 2003. The extensive information on background (color, temperature, size); physical appearance; substrate; in-stream cover; river morphology; stream corridor; road crossing information; and potential sources of pollution was recorded on Watershed Survey Data Sheets that have been subsequently entered into a Microsoft Access database.

# WATER QUALITY, HABITAT AND FISHERIES: SUMMARY OF EXISTING INFORMATION ON BEAR LAKE

## *Types of Lake Classification Systems*

Scientists studying freshwater lakes and streams (primarily limnologists and fisheries biologists) have developed a variety of systems to classify inland lakes over the last century. In their original form, these classification systems were intended to simply categorize lakes based upon selected physical, chemical, or biological parameters. These classification systems, depending upon their design, assist in comparing one lake to another by predicting with limited data the expected biological, chemical, and physical conditions, and also assist in the development of lake management plans to optimize preferred uses. More recently,

lake classification systems have been designed to measure human-induced changes to a lake including changes resulting from: (1) altered land uses in the watershed and on the shoreline; (2) direct or indirect discharges into the lake or upstream tributaries of industrial, municipal, and household waste; and, (3) storm water runoff and snowmelt entering the lake from nearby roads, parking lots, and other impermeable surfaces.

Lake classifications systems fall into three broad types depending upon whether the system uses primarily physical characteristics (such as geologic origin, size, depth, water circulation patterns); biological organisms present (such as fish aggregations, benthic communities, plankton); or productivity (trophic) indices (such as transparency, chlorophyll production, nutrient concentration, net dissolved oxygen production). Each of these classification systems has value in understanding the condition, the limiting management factors, and in some cases the response of the lake to human-induced changes. All have limitations and in some instances cannot be applied to a specific lake because of special circumstances.

Many of these lake classification systems were developed from research conducted on lakes in North America and Europe and are most applicable to temperate climate zones similar to those found in Michigan. Excellent summaries of the attributes, usefulness, and limitation of various lake classifications systems in Michigan were prepared for the Michigan Lake and Stream Associations in its *Michigan Riparian* publication authored by Niles Kevern, Darrell King, and Robert Ring—all professors at Michigan State University (Kevern et al. 1996, Kevern et al. 2004).

Based upon the historical data, Bear Lake can be evaluated in each of the three types of classification system. The following examples illustrate how each type of system could be applied to Bear Lake using specific parameters commonly used to classify lakes in Michigan

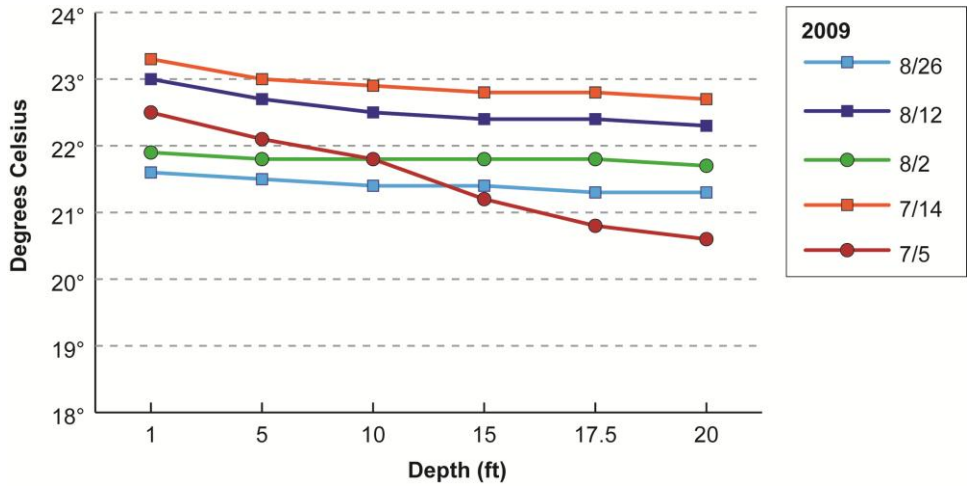
### *Physical: Classification Based on Circulation Patterns*

Based on physical characteristics related to circulation patterns (turnover and mixing), many Michigan lakes are *dimictic*, that is, the water in the lake turns over (or over-turns) and mixes from top to bottom twice a year: in the early spring following loss of ice cover (called ice-out) and in the fall when surface air temperatures begin to cool the lake surface. This lake mixing occurs as a result of density changes of the water on the surface relative to the temperature and density of the deeper water. Water is most dense at approximately 4.0 degrees Celsius (°C) and immediately following ice-out in the early spring; the surface water in lakes in Michigan is colder and denser than the deeper water. The colder, denser surface water sinks while the relatively warmer, less dense water below rises. With wind action the lake soon reaches a uniform temperature (and density) until the early summer period when the surface water warms up considerably faster than the deeper water and the lake becomes stratified with lighter, less dense, warm water on the surface layer (*epilimnion*) and heavier, denser, cooler water on the bottom (*hypolimnion*). The area in between these layers, the *metalimnion*, separates the warmer surface water from the relatively cooler deeper water and the area of rapid temperature change within the metalimnion is called the *thermocline*. In the fall, turnover occurs for a second time as colder air temperatures cool the surface water to below that found in the hypolimnion and the more dense surface water displaces the lighter, relatively warmer water on the bottom. Subsequently, with wind and associated lake turbulence, the lake soon becomes uniform in temperature (and density) for a short time until ice is formed and the water under the ice becomes stratified once again until spring ice-out.

The biannual turnover and mixing of lake waters is very important in evaluating lake chemistry. In typical dimictic lakes, there are two periods in which the lake is at nearly uniform temperature from top to bottom and the nutrients, dissolved oxygen, pH, and carbon dioxide and other physical and chemical components of the lake are nearly uniform from the surface to the bottom. During mid-summer and under ice conditions, dimictic lakes stratify and little or no mixing occurs between the near surface and bottom water layers; thus water chemistry and temperature can be substantially different for samples taken on the same day, time, and location but at different depths.

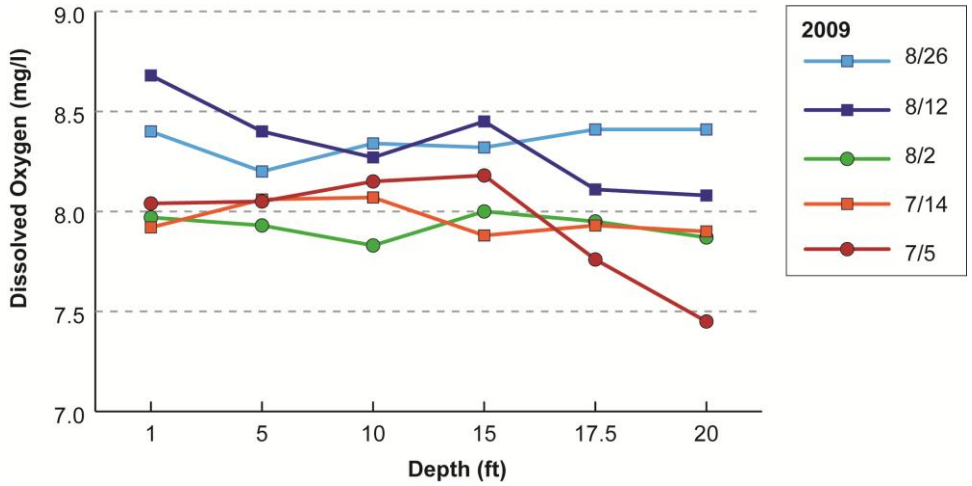
Lakes occupying basins with sufficient depth to allow stratification and formation of hypolimnion can be classified according to the frequency and duration of "mixis" or mixing (Reid 1961). Based upon data collected during one year and other anecdotal reports, Bear Lake is not of sufficient depth to establish and maintain stratification and form a stable hypolimnion during the summer months. Water temperatures measured in Bear Lake during the mid-summer period in 2009 were nearly uniform from top to bottom, with the largest difference between the surface and approximately 20 feet of depth limited to 2°C (see Exhibit 65). Similarly, dissolved oxygen levels for each day sampled during the same period varied less than 1.0 mg/l from the surface to 20-foot depths, again indicating that there was no extended period of stratification and that the water of the lake was well mixed (see Exhibit 66).

**EXHIBIT 65.** Temperature in Bear Lake by Depth during Five Sampling Dates in July and August 2009




SOURCE: Public Sector Consultants Inc., 2011; data from Michigan Clean Water Corps, 1976–2010.

**EXHIBIT 66.** Dissolved Oxygen (mg/l) in Bear Lake by Depth (feet) during Five Sampling Dates in July and August 2009




SOURCE: Public Sector Consultants Inc., 2011; data from Michigan Clean Water Corps. 1976–2010.

Bear Lake has a maximum depth of just over 20 feet (~6 meters) and is frequently exposed to relatively strong and persistent westerly winds. The combination of relatively shallow depths and exposure to strong winds meets the condition outlined in *Lake Classifications Based on Annual Circulation Patterns,* which describes lakes of less than 6 meters in depth (19–20 feet) that would not have a middle or bottom layer (stratification) and "… mix entirely during the summer whenever there are strong winds." The report notes that **"**these (unstratified) lakes behave quite differently from those lakes that are stratified into three layers" (Kevern et al. 2004). Lakes that have frequent mixing and only weak and temporary stratification, such as Bear Lake, are termed *polymictic* (that is, having multiple mixing periods).

Regardless of the classification, it is important to understand that Bear Lake does not **completely** stratify during the summer period and thus is not likely to exhibit the same range of chemical and physical parameters based upon depth commonly reported for the summer period from dimictic lakes in Michigan and in other deeper glacially formed lakes from similar latitudes in Ontario, Wisconsin, and Minnesota. The extent of stratification of Bear Lake during the winter under the ice cannot be determined from existing data.

### *Biological: Classification Based on Aggregation of Fish Species*

Fisheries biologists in Michigan and other states and provinces classify lakes according to the fish species present and/or the potential of a lake to be managed for a particular species or aggregation of fish species. In Michigan the most common classifications are *warmwater* and *coldwater* lakes. Coldwater lakes, also known as trout lakes, are those whose temperature and water chemistry support the survival and growth of lake trout, brook trout, rainbow trout, and/or brown trout and associated coldwater species whose temperature preferences are 10 to 18°C. Warmwater lakes are those that support species such as bass, bluegill, and catfish, whose water temperature preferences are 25°C and warmer. An intermediate classification is used to identify lakes that are suitable for species such as walleye, yellow perch, and northern pike, whose temperature preferences range from 18 to 25°C; these are called *coolwater* lakes. Stratified lakes where surface water temperatures are too high to support trout during the warmest months of the summer, but whose cooler, deeper levels have sufficient oxygen to support trout in the summer, are sometimes described as two-story lakes (Ontario Ministry of Natural Resources 2011).

Fish species have been widely distributed in Michigan through both purposeful introductions by natural resource management agencies and anglers as well as through unintentional invasions. The fisheries classifications often reflect management decisions related to the potential for a lake to support survival and growth of certain species rather than what species or groups of species naturally occur in a lake or whether a species can successfully reproduce. Water quality standards and fish regulations are often set based upon the fisheries classification of a lake. Supplemental stocking is often used to support sport fisheries where natural reproduction may be limited but where growth and survival of a preferred species are good.

Bear Lake has been under active management since at least 1929, when smallmouth bass and bluegill were stocked by the state. Walleye stocking began in 1933 and continued through 1943, along with the planting of yellow perch and shiners. Walleye stocking was resumed for three years beginning in 1960. Since 1984, walleye stocking has been a routine fisheries management practice in Bear Lake. The first fisheries management survey was conducted in 1947, followed by surveys in 1971, 1976, 1990, 1999, 2006, 2009, and 2010, the last five of which focused on growth and survival of walleye (Seites 2011).

A 2000 Michigan Department of Natural Resources Fisheries Division report concluded that Bear Lake is one of northwestern Michigan's better coolwater fishing lakes (Tonello 2000). Bear Lake has a mixture of both warmwater and coolwater species, based on the 2009 survey of fish populations (see Exhibit 67 for species identified in this survey) (Seites 2011). Recent fisheries reports on the Bear Lake walleye population contained recommendations for future management direction based upon the 2009 general fisheries survey (Seites 2011) and the fall walleye data collections by the Little River Band of Ottawa

Indians (LRBOI 2006). The latest report concluded that the Bear Lake walleye fishery must be supported by the stocking of spring fingerlings and recommended that walleye stockings occur every other year beginning in 2012 at 50/acre or 86,000 spring fingerlings (Tonello 2011d).

**EXHIBIT 67.** Number, Weight, and Length of Fish Collected from Bear Lake with the Use of Trap Nets, Inland Gill Nets, Boom Shocking, Minnow Seines, Fyke Nets, and Mini-Fyke Nets in June 2009

| Species | Number | Percentage by number | Weight (pounds) | Percentage by weight | Length range (inches) |
|---|---|---|---|---|---|
| Black Crappie | 63 | 4.1% | 46.1 | 7.3% | 6–13 |
| Bluegill | 68 | 4.4% | 8.6 | 1.4% | 1–10 |
| Bluntnose minnow | 44 | 2.9% | 0.1 | 0.0% | 3–9 |
| Bowfin | 19 | 1.2% | 94.2 | 14.8% | 20–28 |
| Brown bullhead | 15 | 1.0% | 13.2 | 2.1% | 10–13 |
| Common carp | 1 | 0.1% | 10.4 | 1.6% | 28 |
| White sucker | 68 | 4.4% | 65.4 | 10.3% | 1–27 |
| Green sunfish | 2 | 0.1% | 0.5 | 0.1% | 6–7 |
| Johnny darter | 11 | 0.7% | 0.1 | 0.0% | 1–2 |
| Largemouth bass | 50 | 3.2% | 82.0 | 12.9% | 1–18 |
| Northern pike | 51 | 3.3% | 109.6 | 17.2% | 17–25 |
| Pumpkinseed | 38 | 2.5% | 13.4 | 2.1% | 2–9 |
| Rainbow darter | 4 | 0.3% | 0.0 | 0.0% | 2 |
| Rock bass | 137 | 8.9% | 68.8 | 10.8% | 3–11 |
| Sand shiner | 52 | 3.4% | 0.1 | 0.0% | 1–2 |
| Shiner (non-specific) | 500 | 32.4% | 0.0 | 0.0% | 2 |
| Smallmouth bass | 87 | 5.6% | 67.8 | 10.7% | 1–17 |
| Spottail shiner | 104 | 6.7% | 0.5 | 0.2% | 2 |
| Walleye | 13 | 0.8% | 39.1 | 6.2% | 15–26 |
| Yellow perch | 197 | 12.8% | 1.1 | 0.2% | 1–6 |
| Yellow bullhead | 19 | 1.2% | 13.4 | 2.1% | 9–12 |
| **Total** | **1,543** | **100%** | **634.4** | **100.0%** | |

SOURCE: Heather L. Seites, *Bear Lake–2009 Fisheries Survey Analysis Report*, 2011.

### *Trophic Level: Classification Based on Productivity Indices*

Productivity of natural systems is defined as the rate at which energy, most often solar energy, is stored by photosynthesis by primary producers (rooted plants, algae, and diatoms in freshwater) to form organic substances used by other organisms as a source of food (Odum 1959). The classification of freshwater lakes by trophic or productivity levels, ranging from *oligotrophic* lakes (scant of food) to *eutrophic* lakes (rich in food), was developed in Germany in the 1920s and quickly adapted for use in North America; it remains the dominant basis for trophic classification systems used by limnologists throughout the world (Ruttner 1953).

Typical oligotrophic lakes are deep, with the hypolimnion larger in volume than the epilimnion during stratification; they have low primary productivity (for example, very few rooted aquatic plants and relatively low algal concentrations). Oligotrophic lakes generally have high levels of dissolved oxygen even at significant depths that allow for growth and survival of species such as trout and whitefish even during the warmest periods of the year. Biologically classified coldwater or trout lakes are most often

oligotrophic lakes. It terms of ecological succession, oligotrophic lakes are considered geologically young, having changed little from the time of their formation.

Eutrophic lakes are generally shallower, and in terms of ecological succession are considered geologically old. Their average depth is less than that of an oligotrophic lake and the littoral (shallow) zone needed to support rooted aquatic plants is greater. The key to increased productivity of eutrophic lakes, in addition to its shallower average depth, is often the availability of nutrients, particularly phosphorus, that support expanded production and thus increased photosynthesis by rooted plants and algae. Because of the increased use of dissolved oxygen for plant respiration and the oxygen needed to break down organic matter that accumulates on the bottom, eutrophic lakes often show wide swings in dissolved oxygen levels from night to day and from the surface to the bottom during period of stratification. Dissolved oxygen levels in midsummer and in winter on the bottom often approach zero. Warmwater lakes under a fisheries classification system are often the productive eutrophic lakes that contain species such as bass, bluegill, and catfish that prefer warmer temperatures and thrive at lower dissolved oxygen concentrations.

A majority of inland lakes in Michigan fall between eutrophic and oligotrophic classifications. The lakes that fall in the middle of this continuum are classified *mesotrophic* lakes. Depending on where they are within this continuum, mesotrophic lakes can be similar to oligotrophic lakes (with, for example, deep basins greater than 30 feet, high dissolved oxygen levels at significant depths, and relatively low productivity) while others can have characteristics more common to eutrophic lakes (with a significant percentage of depth 20 feet or less, large areas of rooted aquatic plant growth, occasional significant algal blooms, and some depletion of oxygen in the hypolimnion during periods of stratification). Many mesotrophic lakes can support coolwater species (walleye, northern pike, and yellow perch) as well as warmwater fish species.

Numerous methods and parameters have been used to determine where a lake falls on the oligotrophic, mesotrophic, eutrophic scale. Recently the term *hypereutrophic* has been used to describe extremely productive lakes with frequent nuisance algal blooms and frequent fish die-offs, low transparency, and very high overall productivity. Similarly, extremely clear lakes with very little productivity and very low nutrient levels have been termed *hyperoligotrophic*.

Two, three, or even five narratively defined trophic states for lakes do not satisfy those looking for an unambiguous system that can provide a numerical basis for measuring changes in a lake's trophic status (productivity) due to human influences and predicting the lake's responses to efforts to control nutrients. Robert Carlson, while at the Limnological Research Center at the University of Minnesota, conducted studies to develop a numerical trophic status index designed to provide a better means to classify, compare, and monitor lakes (Carlson 1977). This Carlson Trophic Status Index (TSI) is now widely used as originally proposed or in modified forms, particularly in Midwestern states, and is promoted for use by the USEPA to help state, local government, and nonprofit riparian and environmental organizations monitor the status of freshwater lakes.

The TSI is based on the abundance of algae, or algal biomass, and was selected largely because the appearance of algal blooms is often a concern of the public and in some cases the first sign of human-induced over-enrichment with nutrients. Three measurements used in constructing the index (chlorophyll concentration, phosphorus concentrations, and transparency readings) are all indirect indicators of algal biomass and the measurements of all three have been shown to be interrelated. Carlson used a regression analysis of transparency as measured in Secchi disk readings against chlorophyll *a* and total phosphorus in a variety of lakes to determine the relationship of each of these parameters to each other and subsequently developed a formula to generate a numerical index that would represent a trophic index value regardless of which of the three parameters was measured. Thus, under the conditions and assumptions outlined by Carlson, chlorophyll *a*, total phosphorus (P), and Secchi disc transparency measurements from the same lake should produce similar if not the same TSI number. Ideally, all three

parameters should be measured and any significant differences between the TSI numbers should be investigated further. According to Carlson's research, the TSI can be determined using any one of the three measurements. In his 1977 paper, Carlson recommended against averaging the TSI levels as calculated from Secchi disk, chlorophyll, and phosphorus, suggesting that any significant differences in the three measures be examined to determine possible reasons for disagreement (Carlson 1977). For example, phosphorus may not be a limiting factor or rooted aquatic plants may dominate primary productivity rather than algae.

The application of TSI is most applicable to lakes in which phosphorus has been determined to be a factor limiting algal growth and where most of the primary productivity is largely due to algae versus rooted aquatic plants. Each of the three measures also has limitations. In general, Secchi disk readings of transparency are inversely proportional to algal biomass (that is, the greater the Secchi disk reading in terms of feet or meters the lower the algal biomass and vice versa) provided the lake does not have colored water or suspended sediments that interfere with light penetration and thus the transparency during the open water season. According to Carlson's research, the alternative for measuring phosphorus to calculate the TSI that will best match TSI values derived from Secchi disk and chlorophyll *a* is during the mid-summer period with samples taken in the epilimnion. Phosphorus samples taken during spring or fall turnover may not correlate well with Secchi disk or chlorophyll since temperature and light may be limiting factors for algal growth during these periods (Carlson 1977). The concentration of chlorophyll *a* is a measure of photosynthetic activity and is perhaps the most reliable measure of biological productivity and the algal biomass in a water sample taken within the photosynthetic zone (the depth at which sunlight is sufficient to support significant algae growth, approximately between the surface of the lake and the depth of the Secchi disk reading).

Since Secchi disk readings are the simplest and least expensive means available to calculate a TSI, they are the measures most commonly used by state management agencies, lake associations, nonprofit organizations, and others interested in the trophic status of a lake. In Bear Lake, Secchi disk measurements have been made annually since 1977 (with the exception of 1992) by volunteers organized by the Bear Lake Property Owners Association (BLPOA). These Secchi disk readings were taken under guidelines initially provided by the Michigan Lake and Stream Associations of which the BLPOA is a member (Michigan Clean Water Corps 1976–2010). Summer measurements of total phosphorus and chlorophyll *a* in Bear Lake have been made by the state for three consecutive years (2007, 2008, and 2009) in cooperation with the BLPOA. Additional parameters including phosphorus, pH, coliform bacteria, *E. coli*, dissolved oxygen, conductivity and ammonia, nitrate and nitrite nitrogen, and other measurements have been measured periodically in Bear Lake by the state, tribal agencies, and private consulting firms in the course of other investigations.

### *Bear Lake Specific Trophic Level Determination*

The wealth of Secchi disk data from Bear Lake provides the best information upon which to compare the TSI levels in Bear Lake over the last 33 years. TSI values based on periodic total phosphorus and chlorophyll *a* samples in Bear Lake serve as a comparison to the TSI levels calculated from Secchi disk readings. However, there is a problem in using the Secchi disk data collected on Bear Lake in establishing an annual mean value to use in calculating TSI since the samples were taken at a variety of times each year from April through September. Secchi disk readings vary significantly during the open water season, with the lowest readings typically occurring during the warmer summer periods when higher temperatures and greater periods of sunlight favor algal blooms.

Rather than using Secchi disk values from a single year to compare yearly TSI values where samples may be heavily weighted to one or more different periods of the open water season, five-year average mean Secchi disk transparency values were calculated. The example Secchi disk values in Exhibit 68 are based upon average readings from five consecutive years (1977–1981); the date shown represents the midpoint

of a 14-day period and the average Secchi disk for all samples taken in each period. The average Secchi disk readings for each five-year period 1977–1981, 1982–1986, 1987–1991, 1993–1997, 1998–2002, 2003–2007 were calculated in the same way. No Secchi disk readings were taken in 1992. The last period for Secchi disk readings, 2008–2010, represents just a three-year period to avoid any erroneous Secchi disk values that may have resulted from chemical treatment of the lake to control Eurasian milfoil that began in 2008; the release of phosphorus from dying rooted aquatic plants following chemical treatment frequently promotes temporary algal blooms and/or generates short-term, excessive plant debris in the water that can affect the Secchi disk readings.

**EXHIBIT 68.** Example Calculation: Average Secchi Disk Readings for Bear Lake at Midpoint in Each of Eleven 14-day Periods for the Years 1977–1981

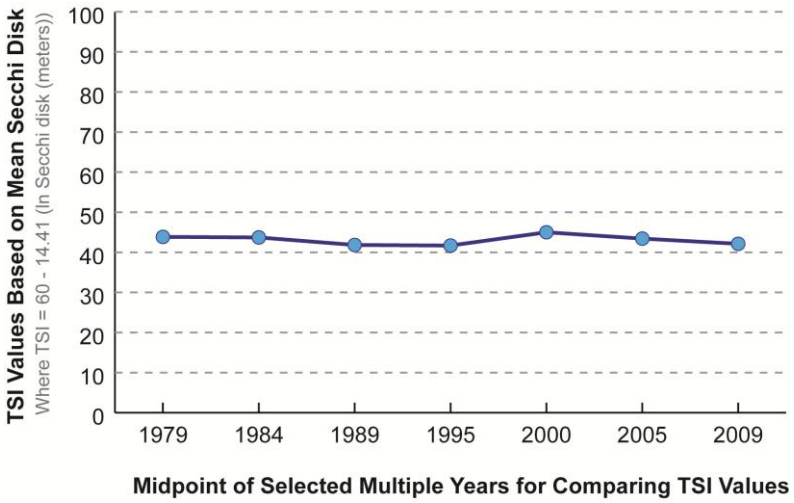
| | April 23 | May 7 | May 21 | June 4 | June 18 | July 2 | July 16 | July 30 | Aug. 13 | Aug. 27 | Sept. 10 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Secchi disk (feet)** | 11.4 | 11 | 10.88 | 10 | 9.88 | 9.75 | 9.67 | 9.9 | 10.63 | 9.1 | 9.1 | **10.12** |

SOURCE: Public Sector Consultants Inc., 2011; data from Michigan Clean Water Corps, 1976–2010.

Basing the mean Secchi disk reading on 14-day periods for multiple years avoids the problem of unintentional weighting of readings for one period of the year, reduces the variability found in any given year, and still allows comparisons to determine whether or not TSI values have changed significantly over a 30-year period in Bear Lake. Using the mean Secchi disk reading for each multiple-year period in Bear Lake (see Exhibit 69), the TSI value can be determined using the formula recommended by the USEPA where:

**Secchi disk TSI = 60 - 14.41 (*log n* Secchi disk mean in meters)** (USEPA 2010)

**EXHIBIT 69.** Secchi Disk TSI for Bear Lake for Six 5-Year Periods and One 3-Year Period, with Midpoint Year for Each Period Plotted against the Calculated Secchi Disk TSI




SOURCE: Public Sector Consultants Inc., 2011.

The Secchi disk transparency readings on Bear Lake drawn from the volunteer efforts of members of the BLPOA for the period 1977–2010 are available on the Web (www.micorps.net/index.html) and range in value from 18.5 feet to 6.5 feet. The five-year (three-year in the case of 2008–2010) mean values for the adjusted Secchi disk readings calculated as described in the previous paragraph range in value from 11.8 feet to 9.3 feet. The calculated Secchi disk TSI values for each five-year period range from 45.0 to 43.9.

Based upon the 34-year history of sampling on Bear Lake, the TSI levels as calculated from Secchi disk readings have not changed significantly from the period 1977–1981 through the period 2008–2010. Any significant changes in TSI levels in a 34-year period would be due to human activity rather than natural succession. Based upon the available data there is no indication that Bear Lake is undergoing human-induced eutrophication.

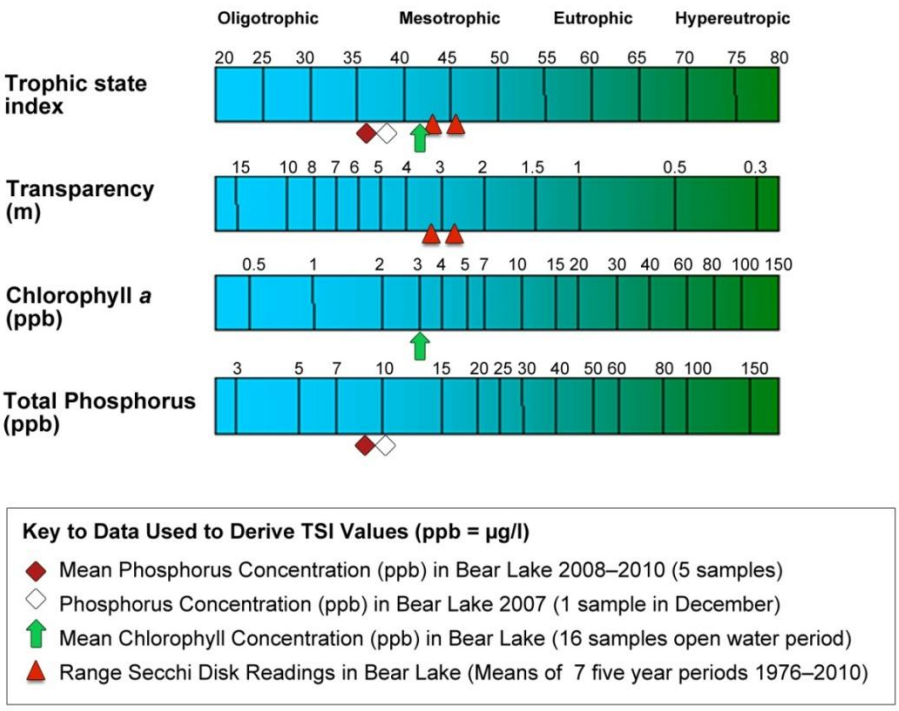
The USEPA formula (USEPA 2010) used to calculate TSI based on phosphorus and chlorophyll *a* as used in this report is as follows:

**Phosphorus TSI = 14.42 (*log n* Total Phosphorus (µg/l) + 4.15**

**Chlorophyll *a* TSI = 9.81 (*log n* Chlorophyll *a* (µg/l) + 30.6**

Exhibit 70 shows the trophic classification of Bear Lake to be mesotrophic based on the Secchi disk TSI calculations; that classification is confirmed by phosphorus and chlorophyll *a* TSI values from sampling that occurred in 2008–2010. The mean chlorophyll *a*–based TSI for the 2008–2009 period appears to closely match the range of the mean Secchi disk TSI measured in multiple-year aggregates from 2007 to 2010. The mean phosphorus-based TSI calculated from samples taken in 2008, 2009, and 2010 produced a lower TSI compared to the TSI calculated from Secchi disk readings, but still in the mesotrophic range. A single sample for phosphorus taken in December of 1974 by the Michigan Department of Environmental Quality (MDEQ) produced a TSI value somewhat closer to that found using Secchi disk readings. The reason for the disparity between the phosphorus-based TSI and those determined by using Secchi disk and chlorophyll *a* is not clear. The small number of phosphorus samples, the time of year the phosphorus samples were obtained, potential interference due to chemical weed control being conducted during the same years, the presence of large amounts of rooted aquatic plants tying up phosphorus, the introduction of zebra mussels, or other factors may be responsible for the observed differences.

**EXHIBIT 70.** Comparison of Bear Lake TSI Values Derived from Secchi Disk, Chlorophyll *a* and Total Phosphorus (ppb = µg/l)




SOURCE: Public Sector Consultants Inc., 2011; adapted from Minnesota Pollution Control Agency, 2011, using data from Michigan Clean Water Corps, 1976–2010 and ASI Environmental Technologies Inc., 2007c.

Additional phosphorus samples from Bear Lake were analyzed by a contracted private laboratory between 1991 and 2007 and the results were appended to the Bear Lake Improvement Feasibility Study (ASI Environmental Technologies Inc. 2007c). The range of values in the midpoint of the lake for phosphorus were reported to be between 1.00 ppm (µg/l) and 242 ppm (µg/l), and, based upon the unusually wide range of reported values, the data were thought not to be reliable and were not used to calculate TSI values.

Basic assumptions justifying the use of TSI to classify lakes are that the productivity of the lake under study is limited by the amount of total phosphorus present and that nitrogen, the other key nutrient, is not a limiting factor in algal productivity. To test the hypothesis that phosphorus is indeed the limiting nutrient in lakes, Downing and McCauley evaluated the algal response of 34 lakes to nitrogen enrichment bioassays with varying total nitrogen to phosphorus ratios (TN:TP) as reported in the literature and came to a number of conclusions. According to their analysis, "… low TN:TP ratios only exist at high total phosphorus levels suggesting that nitrogen limitation is greatest at high total phosphorus levels." They also concluded that, "… phosphorus is a limiting factor in many lakes with TN:TP <14 …" (Downing and McCauley 1992). Based upon limited data collected from Bear Lake, the TN:TP ratio is much greater than 14 and phosphorus is most likely the primary limiting factor in determining algal productivity in the lake.

Downing and McCauley also defined TN:TP in relation to lake productivity status following trophic categories described by Wetzel (Wetzel 1983). Exhibit 71 shows the range of TN:TP for oligotrophic, mesotrophic, and eutrophic lakes (Downing and McCauley 1992). The TN:TP for Bear Lake was variable—total nitrogen ranged from approximately 900 µg/l to just over 500 µg/l in the spring and fall

while total phosphorus levels were at 10 µg/l during the same sampling period. Thus, the TN:TP based on this one sampling period would indicate a range of TN:TP of 50–90 or well within that expected in mesotrophic lakes and most likely indicating that phosphorus is the primary limiting factor.

**EXHIBIT 71.** General Characteristics, Trophic Continuum for Lakes

***Eutrophication –*** Natural succession (thousands of years)

***Cultural Eutrophication –*** Land use changes/addition of nutrients and sediments (decades)

| | Trophic Level | | | | |
|---|---|---|---|---|---|
| **General characteristics** | **Hyper-oligotrophic** | **Oligotrophic** | **Mesotrophic** | **Eutrophic** | **Hyper-eutrophic** |
| Food supply (nutrients) | Extremely limited | Limited | Variable | Rich | Very rich |
| Typical fisheries* (temperate climate) | Coldwater (trout, etc.) | Coldwater (deep lakes), coolwater | Coolwater (walleye, etc.), warmwater | Warmwater (bass, etc.) | Rough Fish (carp, etc.) dominate |
| Quantity of bottom organic sediments | Very low | Low | Variable | High | Very high |
| Range of chlorophyll micrograms/liter (ppb) | <0.9 µg/l** | 0.3–4.5 µg/l* 0.9–2.6 µg/l** | 3.0–11µg/l* 2.6–7.3µg/l** | 3.0–78 µg/l* 7.3–56 µg/l** | 56– >155 µg/l** |
| Range of phosphorus micrograms/liter (ppb) | <6 µg/l** | 3.0–17.7 µg/l* 6–12 µg/l** | 10.9–95.6µg/l* 12–24 µg/l* | 16–386 µg/l* 24–96 µg/l* | 96–384 µg/l** |
| Range Secchi disk transparency (meters) | >8.0 m** | 5.4–28.3 m* 4–8 m** | 1.5–8.1 m* 4–2 m** | <0.8–7.0 m* 2–0.5 m** | 0.5m or less** |
| Range of trophic status index (TSI) | <30** | 30–40** | 40–50** | 50–70** | 70 or greater** |
| Total nitrogen: total phosphorus ratios (TN:TP) | | 21–240*** | 17–96*** | 4.0–71*** | 0.5–9*** |

***Oligotrophication***—Removal of Sediments & Nutrients

SOURCE: Public Sector Consultants Inc., 2011, using data from *Kevern et al., 2004; **Carlson and Simpson, 1996; ***Downing 1992.

TSI numbers for Bear Lake from Secchi disk readings, chlorophyll *a*, and phosphorus are relatively close, indicating that the trophic level of the lake is mesotrophic—closer to oligotrophic rather than eutrophic. Confirming this classification are the limited data on TN:TP, which also show Bear Lake to be mesotrophic. Based on TSI levels calculated from Secchi disk readings, the trophic status of Bear Lake as a whole has not changed significantly in the last three decades as a result of human activities on the riparian lands immediately adjacent to the lake, or in the larger watershed that is the primary source of both surface water and groundwater entering the lake.

Additional water quality parameters measured in previous studies on Bear Lake will be discussed in later chapters comparing available data to state water quality standards and in the identification of data gaps.

### *Influence of Invasive Species on Trophic Status Trends in Bear Lake*

In late summer of 2006, the Michigan Department of Natural Resources advised the Bear Lake Property Owners Association that Eurasian milfoil had been documented in Bear Lake. The BLPOA helped

establish the Community Council to Control Milfoil (CCCM); this group subsequently concluded that the best approach to address the Eurasian milfoil issue was to establish a Lake Improvement Board as provided under state law (1994 PA 451, Part 309). Following several evaluations of Bear Lake, the formation of the lake assessment district, and the hiring of Lakeshore Environmental Inc. to implement the Eurasian milfoil control program, the first chemical treatment occurred in early spring of 2008. Selective application of herbicides has also occurred in 2009, 2010, and 2011 (Bear Lake Improvement Board 2011).

There is very little information on how the invasion of Eurasian milfoil impacts the measurement of the trophic status of inland lakes. This invasive aquatic plant can spread rapidly in lakes with even relatively low nutrient levels. Traditional measures of productivity such as TSIs based on Secchi disk, chlorophyll *a*, or phosphorus are effective measures of lake productivity only when suspended algal biomass is the dominant source for fixing sun energy into plant material. In shallow lakes where rooted aquatic plants are the dominant source of primary production, TSIs are not effective measures of trophic status and do not provide a reliable index for measuring trends. The absence of significant phosphorus in the water column, the low concentrations of chlorophyll *a*, or deep Secchi disk readings may simply reflect the fact that rooted aquatic plants in Bear Lake, now including Eurasian milfoil, have tied up the available phosphorus, reduced algal biomass and associated chlorophyll in the water column, and thus increased the depth of Secchi disk readings. Despite apparently effective control of Eurasian milfoil in Bear Lake as a result of herbicides applied during the past three years (Lakeshore Environmental Inc. 2009), the previously reported results in this management plan showing that TSI levels have remained unchanged over the more than 30 years should be viewed cautiously. It is possible that the trophic level in Bear Lake has increased (that is, moved in the direction of eutrophication) due to the addition of phosphorus from human sources, and the increase in productivity is being expressed in rooted aquatic plants rather than in algal biomass.

Further complicating the issue is the potential abundance of another invasive species, the zebra mussel. There have been documented reports of zebra mussels in Bear Lake beginning at least since 2004. Since their discovery in Lake St. Clair in 1988 from an apparent ballast water discharge of a European ocean freighter, zebra mussels are now found throughout the Great Lakes and in many of the larger Michigan inland lakes where the mussels have been transported by attaching themselves to transient boats, boat trailers, and other watercraft. Once established in large numbers, filter feeding zebra mussels, and more recently the exotic, invasive quagga mussels, can substantially reduce the green algal biomass in the water column and increase water clarity that favors the growth of rooted aquatic plants. It is reasonable to expect that quagga mussels, if they have not already, will eventually find their way to Bear Lake and, that in combination with zebra mussels, may significantly alter the types of algae present, the abundance of rooted aquatic plants, and the quantity of zooplankton and benthos organisms that are the primarily source of food for forage fish in the lake.

Continued monitoring of the density of rooted aquatic plants in Bear Lake to evaluate the effectiveness of Eurasian milfoil control and to determine whether native rooted plants are increasing is critical to understanding the role of changes in the ecosystem that occur following establishment of invasive species. The presence of invasive species also suggests that alternative approaches should be considered to monitor the trophic status and future trends in productivity.

# WATER QUALITY, HABITAT, AND FISHERIES: SUMMARY OF EXISTING INFORMATION ON BEAR CREEK AND TRIBUTARIES

## *General Description of Bear Creek*

The main stream of Bear Creek is approximately 28 miles long from its headwater area in the northeast portion of the watershed to its confluence with the Manistee River. It has a large number of miles of

named and unnamed tributaries as well as significant groundwater inputs as it flows generally in a southerly direction. It is the largest tributary to the Manistee River downstream of Tippy Dam. A number of public agencies and nonprofit organizations have examined portions of Bear Creek and its tributaries over the last 20 years in response to specific management objectives, most of which were related to one of the following topics:

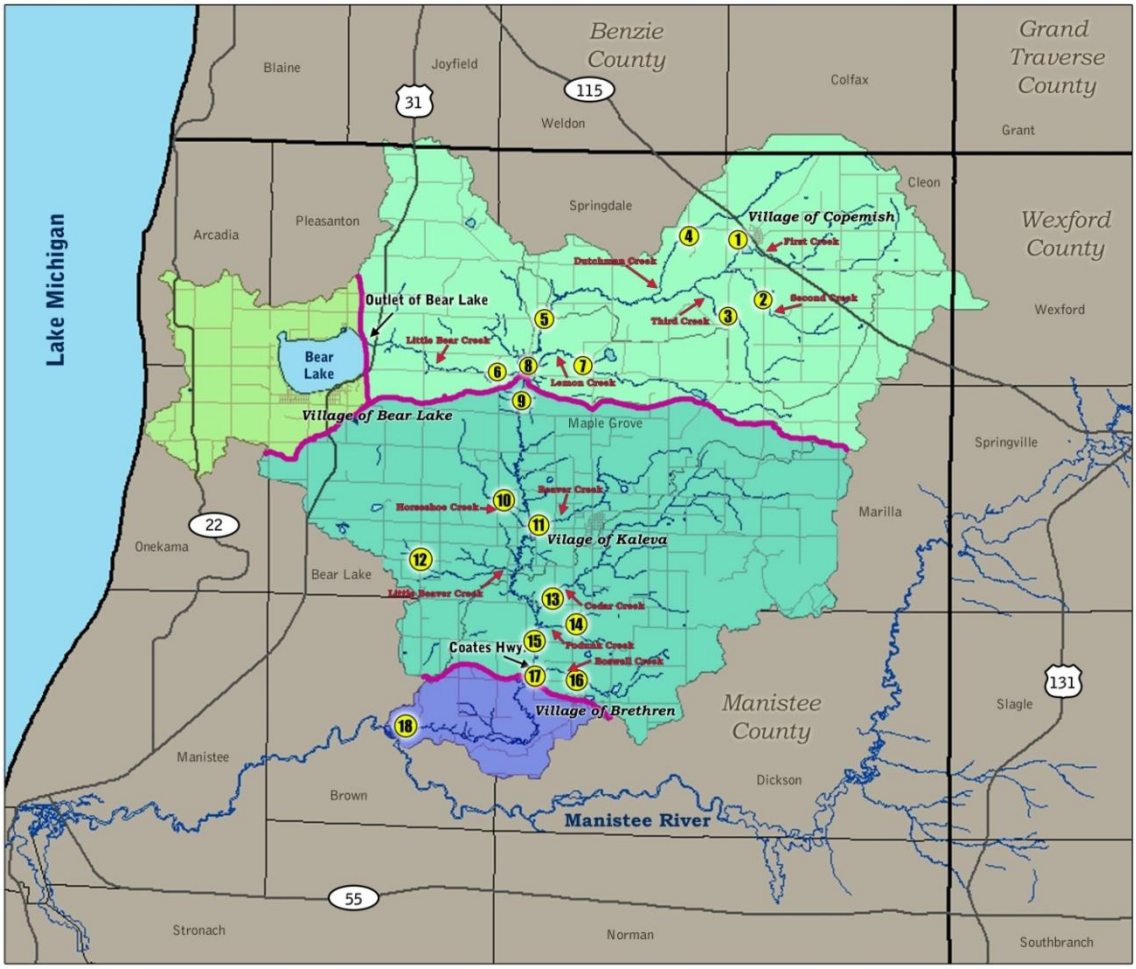
- Growth and survival of trout and salmon (MDNR Fisheries Division, LRBOI)
- Water quality issues related to a dam failure and stream crossings (MDEQ)
- Sea lamprey control activities (USFWS)
- Base-line assessments for the National Wild and Scenic River designation (USFS)
- Inventory and remediation of severe bank erosion sites (Conservation Resource Alliance [CRA])
- Establishing water-quality baseline habitat, macroinvertebrate, and fisheries assessments (MDEQ, MDNR, and LRBOI)

In addition, the first Bear Creek Watershed Management Plan was completed in 2000. The plan identified threats, sources of pollution, and priority areas for the application of best management practices, particularly for remediation of sedimentation from road crossings and other significant bank erosion.

Given the large area of the watershed and the varied natural landscapes and human land uses, the existing condition of Bear Creek and its tributaries is best described in terms of the subwatersheds shown in Exhibits 72 and 73. The exceptions to the subwatershed approach to describe existing conditions are the inventory and proposed remedial actions related to stream bank erosion sites and the stream crossings database on Bear Creek and its tributaries. The Conservation Resource Alliance maintains an interactive website with technical support from the Land Information Access Association (LIAA) which provides a map-based inventory of over 70 bank erosion areas on Bear Creek and tributary streams with site-specific information, photographs, and descriptions of potential remedial actions (CRA 2010). These stream-bank erosion sites can best be reviewed using the interactive website (www.liaa.info/crabmp/bearcreek.asp). The Michigan Department of Environmental Quality also has an extensive inventory of stream-crossing information recorded in a Microsoft Access database that as of the date of this report is not searchable through a geographical information system (GIS) and is not easy to use or summarize even by current MDEQ district staff (MDEQ Cadillac District Office 2003). Ideally, these two databases can eventually be incorporated into a system that will allow users to access, sort, and evaluate information using a GIS platform.

Exhibit 72 shows the Bear Creek sampling locations and Exhibit 73 summarizes the fisheries, habitat, substrate, water quality, temperature, and flow data available for Bear Creek and named tributaries.

## **EXHIBIT 72.** Bear Creek Sampling Locations




| Site ID | Location |
|---|---|
| 1 | First Creek, below former dam site |
| 2 | Second Creek, Yates Road |
| 3 | Third Creek, Thompsonville Road |
| 4 | Dutchman Creek, Tomas Road |
| 5 | Bear Creek, Leffew Road |
| 6 | Little Bear Creek, Big 4 Road |
| 7 | Lemon Creek, Pak Road |
| 8 | Bear Creek, 13 Mile Road |
| 9 | Halls Creek, Lahti Road |

| Site ID | Location |
|---|---|
| 10 | Horseshoe Creek, Big 4 Road |
| 11 | Beaver Creek, Jouppi Road |
| 12 | Little Beaver Creek, Chief Road |
| 13 | Cedar Creek, Johnson Road |
| 14 | Podunk Creek, High Bridge Road |
| 15 | Bear Creek, Kerry Road |
| 16 | Boswell Creek, High Bridge Road |
| 17 | Bear Creek, Coates Highway (Spirit of the Woods Club) |
| 18 | Bear Creek, River Road (near confluence with Manistee River) |

SOURCE: Public Sector Consultants, 2011.

**EXHIBIT 73.** Summary of Habitat, Fish Population, Flow, Temperature, and Water Quality Data for Bear Creek and Named Tributaries from Previously Cited Studies

| | Site # | Location | Substrate | Habitat | Macro-invertebrates | Dominant fish species | Flow | Water quality | Stream temperature |
|---|---|---|---|---|---|---|---|---|---|
| Headwaters Subwatershed | 1 | First Cr., Below former dam site | NDCA | Excellent (non-impaired) | Acceptable | Rainbow tr., dace, and sculpin | 2.5 CFS 9/11/06 | Total P = .01mg/l Total N = 1.35 mg/l (1992) | 71°F (7/01/92) |
| | 2 | Second Cr., Yates Rd. | Sand and buried hard rubble and LWD | Good (slightly impaired) | Acceptable | Brown tr., sculpin | 9.3 CFS 6/10/09 9.8 CFS 8/7/09 | NDCA | 59°F (6/10/99) |
| | 3 | Third Cr., Thompsonville Rd. | NDCA | | | | 8.8 CFS 8/5/09 | | 72°F (June 1999) |
| | 4 | Dutchman Cr., Tomas Rd. | NDCA | | | | 9 CFS 8/10/09 | | NDCA |
| | 5 | Bear Cr., Leffew Rd. | NDCA | Collected 2006, not published | NDCA | Rainbow, brook tr., also brown tr., coho and Chinook with pop. est. — Other species recorded, but no pop. est. | 36.9 CFS 8/5/09 | | Range 78–63°F (July, Aug. 2005, 2006) |
| | 6 | Little Bear Cr., Big 4 Rd | Sand, LWD limited gravel and silt | Good (slightly impaired) | Acceptable | NDCA | 21.5 CFS 6/11/19995.2 CFS 8/22/06 | | NDCA |
| | 7 | Lemon Cr., Pac Rd. | Sand, LWD and gravel | Excellent (non-impaired) | Acceptable | Brook tr., dace, sculpin | 1.8 CFS 6/11/19994.3 CFS 9/10/06 | | 64.5°F (6/10/99) |
| Shared Location | 8 | Bear Cr., 13 Mi. Rd. | NDCA | | | | 219 CFS 8/9/09 | Total P = 0.01 mg/l Total N = 0.37 mg/l (1991) | Range 55.3–74.3°F (June, July, & Aug. 2008) |

| | Site # | Location | Substrate | Habitat | Macro-invertebrates | Dominant fish species | Flow | Water quality | Stream temperature |
|---|---|---|---|---|---|---|---|---|---|
| Middle Subwatershed | 9 | Halls Cr., Lahti Rd. | NDCA | | | | .03 CFS 9/12/02 | NDCA | |
| | 10 | Horseshoe Cr., Big 4 Rd. | | | | | 2.1 CFS 9/14/02 | | |
| | 11 | Beaver Cr., Jouppi Rd. | | | | | 6 CFS 8/7/09 | | |
| | 12 | Little Beaver Cr., Chief Rd. | Sand, little gravel | Fair | NDCA | | | | |
| | 13 | Cedar Cr., Johnson Rd. | Sand, some gravel | Excellent (non-impaired) | Acceptable | Brown & rainbow tr., sculpin | 11.3 CFS 6/10/99 | Total P = 0.03 mg/l Total N = 0.66 mg/l (1992) | 60.5°F (6/10/99) |
| | 14 | Podunk Cr., High Bridge Rd. | Sand | Narrow, shallow, tree lined | NDCA | | 1.8 CFS 6/10/99 | NDCA | 58.5°F (6/10/99) |
| | 15 | Bear Cr., Kerry Rd. | Sand and gravel | Good (slightly impaired) | Acceptable | Rainbow tr., dace, sculpin, suckers | 151 CFS, 6/10/1999 105 CFS 7/01/92 | Total P = 0.024mg/l Total N = 0.43mg/l (1992) | 62.5°F (7/01/92), 64.5°F (6/10/99) |
| | 16 | Boswell Cr., High Bridge Rd. | Sand, Gravel in Scour Holes | Good (slightly impaired) | NDCA | | 2.02 CFS 6/10/99 | NDCA | 69°F (6/10/1999) |
| Shared Location | 17 | Bear Cr., Coates Rd (Spirit of the Woods Club) | Gravel and rubble (70%), sand (22%) | Good (slightly impaired) | Acceptable | Rainbow brown, & brook trout Also salmon with pop. est.—other species recorded no pop. est. | 160.66 CFS July, 2008 144 CFS 8/4/2009 | TP = 0.03, TN = 0.83 mg/l (1992) DO Range 7.8–10.4 mg/l (2002–2010) | 52.2–71.4°F (7/23/08), 59.0°F (June & July 2007) |
| Lower Subwatershed | 18 | Bear Cr., River Rd. Near confluence with Manistee River. | Shifting sand, silt, LWD | Slow current, heavily vegetated riparian banks, LWD | Rich in total taxa with Shannon Index of 1.67 to 2.23 | 19 Species, coldwater (trout and salmon, sculpin), coolwater (northern pike, and warmwater species | 196–92.3 CFS July–August 2002 | TP Range 0.12–0.01 mg/l TN Range 2.11–0.21 mg/l DO Range 17.8–5.25 mg/l (2002–2010) | Range 23.5–0.30°C (2002–2010) |

SOURCE: Public Sector Consultants Inc., 2011, from various sources cited in text.
Note: NDCA: No data currently available; LWD: Large woody debris

## *Subwatersheds*

The **Bear Lake Subwatershed** encompasses the surface area and related groundwater that drains toward Bear Lake. The existing studies and information on Bear Lake were described earlier. The lake has no major influent tributary streams. The Bear Lake Subwatershed, therefore, is not included in the summary of subwatershed data included in Exhibit 72.

Bear Lake discharges to Little Bear Creek, which is part of the **Headwaters Subwatershed**. In addition to Little Bear Creek, several other tributaries are within the Headwaters Subwatershed including First, Second, and Third creeks and Dutchman Creek. There is extensive state forest land ownership in this subwatershed. Bear Creek and its tributaries have a low gradient with considerable wetlands adjacent to the river in the Headwaters Subwatershed. Fishing is limited to the regular trout season from the last Saturday in April through September. The dividing line between the Headwaters Subwatershed and the Middle Subwatershed is 13 Mile Road, which is the upper stream limit of the portion of Bear Creek that is open to year-round fishing. Lemon Creek enters Bear Creek at 13 Mile Road and is the last downstream tributary of the Headwaters Subwatershed

The **Middle Subwatershed** on Bear Creek itself (between 13 Mile Road and Coates Highway) begins just downstream of the point where Lemon Creek joins Bear Creek. Halls Creek is the first named tributary feeding into Bear Creek in the Middle Subwatershed, followed downstream by Horseshoe, Beaver, Little Beaver, Cedar, Podunk, and Boswell creeks as well as a number of unnamed, smaller tributary streams, nearly all of which are classified trout streams. The relatively high gradient streams in this subwatershed, including Bear Creek itself, provide spawning for steelhead and salmon in exposed gravel areas and offer the best year-round fishing. Bear Creek and tributaries in this subwatershed are difficult to access due to the fact that the vast majority of riparian land is privately owned.

The **Lower Subwatershed** begins at Coates Highway and extends to the point where Bear Creek discharges to the Manistee River. This lower end of the watershed has a low gradient and the stream bottom is dominated by sand and silt with minimal amounts of exposed gravel. Wetlands are common along riparian state and federal forest lands that are extensive in this subwatershed.

### *Headwaters Subwatershed*

The Michigan Department of Natural Resources (MDNR) established a Fixed Site Index Station on Bear Creek in the Headwaters Subwatershed for its fisheries Status and Trends Program in 2005 (Tonello 2011b). MDNR sampling from 1983, 1997, 2005, 2006, and 2007 provides the longest, site-specific, continuous record of trout and salmon abundance in Bear Creek. The index station is located at Leffew Road (Old Iron Bridge) on Bear Creek several miles upstream of the point that Little Bear Creek joins Bear Creek. In the five years of sampling for trout and salmon the survey results indicate that brown trout abundance ranged from 31to 78 individuals/acre with an estimated range of standing crop from 7.21 to 39.96 lbs/acre; brook trout ranged from 609 to 1,473 individuals/acre and standing crop from 43.1 to 34.28 lbs/acre; rainbow trout (steelhead) from 938 to 2,021 individuals/acre and standing crop from 17.42 to 49.45 lbs/acre. In the last three years, coho and Chinook salmon were counted as well with estimated coho numbers at 100 to just over 200 individuals/acre and Chinook at 21 to nearly 200 individuals/acre. In 2005 the index site was increased from 595 to 1,000 feet for a total sampling area of 0.84 acres. Continuous recording thermometers in place at this Bear Creek index station in the Headwaters Subwatershed indicated that the maximum water temperature occurs during July and August, when temperatures reached a maximum of 78.1 degrees Fahrenheit (°F) during 2005 and 2006. Although mid to upper 70s temperatures are not normally considered ideal for trout and salmon, sources of cooler groundwater seeps entering the stream in this section may provide adequate refuge for trout and salmon when summer stream temperatures exceed preferred levels.

Under the established protocol for an established Fixed Site Index Station, fish sampling will occur again at this location in 2013. In addition, during one year of these planned fish sampling events, habitat data will be collected (Tonello 2011b). The numbers and variety of trout and salmon of various sizes collected at this station over a 24-year period would indicate high water quality meeting or exceeding Michigan Water Quality Standards (WQS) for coldwater (trout) streams.

Prior to periodic chemical treatments to eliminate sea lamprey, the U.S. Fish and Wildlife Service (USFWS) conducted various habitat, flow, and chemistry surveys in Bear Creek. Records from field data sheets from various years between 1990 and 2009 provide, among other data, useful information on stream flows and dissolved oxygen in the Headwaters Subwatershed from July through September.

### *Middle Subwatershed*

In June and July 2009 the Water Bureau of the Michigan Department of Natural Resources and Environment (now part of the Michigan Department of Environmental Quality) surveyed Bear Creek at the upstream limit of the Middle Subwatershed (13 Mile Road) and at a downstream station at Kerry Road (MDEQ 2010). At both sampling stations, the water quality was determined adequate for a coldwater stream; the glide/pool habitat was rated good (slightly impaired) and the macroinvertebrate populations were determined to be acceptable using Great Lakes and Environmental Assessment Section Procedure 51 (GLEAS 51) (Schneider 2000). At the 13 Mile Station the substrate was almost entirely shifting sand, with the small amount of gravel present embedded in sand. Woody debris was present at 13 Mile Road and offered the only material available for invertebrates requiring stable substrates. At the Kerry Road site there was a mixture of sand and gravel, with the gravel again embedded in sand. Shallow pools were dominant over deep pools at the Kerry Road Station and there was evidence of erosion where the banks were steep and trees were lacking. The riparian vegetative zone, except in the erosion areas, appeared to be intact (MDEQ 2010).

The Kerry Road Station on Bear Creek was sampled previously in both 1999 and 1992 by the then Water Division of the Michigan Department of Environmental Quality (MDEQ 2004). The biological surveys in those two years were also conducted under the GLEAS 51 procedure. The habitat evaluation results showed an improvement in individual metrics from 1992 to 1999 and an overall total score habitat metric improvement from 70 (the upper end of a fair rating) to 95 (the upper end of the "good" category). The improvement was attributed to decreased sand loading (and subsequent increased exposure of hard substrate gravel and cobble) and formation of deeper pools. Elimination of a stream cattle crossing in the area and subsequent bank revegetation was noted as an improvement occurring between the two sampling periods. During the 1999 survey, observations also occurred at the Johnson Road crossing of Bear Creek that recorded abundant growths of the aquatic macrophyte *Potamogeton pectinatus*, covering over 80 percent of the river bottom. The plant growth extended upstream some distance from Johnson Road, but abruptly ended some 50 yards downstream of the bridge as the bottom substrate changed from loose sand to firmer gravel (MDEQ 2004).

As noted for the Headwaters Subwatershed, the USFWS conducted habitat surveys, stream flow measurements, and water chemistry in portions of Bear Creek in the Middle Subwatershed. Records from field data sheets from various years between 1990 and 2009 provide useful information on stream flows and dissolved oxygen in this subwatershed from July through September (USFWS 2011).

### *Lower Subwatershed*

In 2008, the Fisheries Division of the Michigan Department of Natural Resources conducted a survey of Bear Creek just downstream of Coates Highway at the upstream boundary of the Lower Subwatershed and located within the Spirit of the Woods property (Tonello 2011c). A 1,200-foot section of the stream was examined for substrate conditions and for trout and salmon populations present in late July. The results of the survey indicated that the substrate was predominantly gravel (37 percent), cobble (33

percent), and sand (22 percent) with clay, wood, and detritus combined making up only 8 percent. The stream flow was measured at 160 cfs (cubic feet per second) and the water temperature was 59.5°F. The estimates of salmonids present based upon mark and recapture were: rainbow trout (steelhead), 619 individuals at 15.17 lbs/acre; brown trout, 46 individuals at 11.06 lbs/acre; Chinook, 110 at 1.27 lbs/acre; brook trout, 1 at 0.15 lbs/acre; and coho, 1 at 0.0 lbs/acre. The report compared the salmon and trout lbs/acre in this section of Bear Creek with other nearby streams and other upstream areas of Bear Creek and found that they were much lower. It concluded that the explanation for the lower numbers was the fact that the area sampled had less habitat heterogeneity, primarily the lack of deep pools and woody materials, and that that the absence of these habitat types was limiting trout recruitment and growth. The report suggested that the historic logging activities that caused channel degradation and the sediment loads from more recent road crossing and riparian land uses were likely responsible for the lack of deep pools. The water temperatures measured during the study period and temperature data collected by the Little River Band of Ottawa Indians (LRBOI) in the same area were well within limits to support trout and salmon reproduction, growth, and survival (Tonello 2011c). No other water quality data were reported in this survey.

As part of a larger survey of water quality at 17 sampling locations within the Manistee River watershed, the LRBOI collected information on the Lower Subwatershed near the confluence with the Manistee River from May 2002 through October 2010 (LRBOI 2010). The survey indicated that Bear Creek at this sampling location had an intact riparian zone (largely federal and state lands) and sufficient amounts of large wooded debris but was limited in available habitat for trout and salmon due to a substrate dominated by shifting sands. Based upon a summary of ten USEPA habitat parameters, this location was rated suboptimal for every year examined from 2001 through 2010. A number of chemical and nutrient measures were identified and compared to the USEPA Ambient Water Quality Criteria Recommendation. A summary of the results indicated that the average concentrations of phosphorus, nitrate-nitrite, total *k.* nitrogen, and turbidity were slightly above the Ambient Water Quality Criteria Recommendations for rivers and streams in Ecoregion VIII (USEPA 2011). Other parameters measured (hardness, alkalinity, dissolved oxygen, pH, and conductivity) were within an acceptable range for support of trout and salmon. In general the report indicated that water chemistry measured in this reach of the Lower Subwatershed was of good quality with the exception of possible sediment issues.

While temperature was reported on the high end of the range preferred by coldwater species, the report notes that proximity and accessibility of the Manistee River would allow temperature-sensitive species to move to cooler waters during brief periods of high temperatures that may occur in the summer. The macroinvertebrate samples taken in 2008 and 2009 indicated high species diversity with amphipods abundance reflecting the slow-moving water (low gradient) and dominance of sand and silt in the Lower Subwatershed. The relative abundance of intolerant and tolerant macroinvertebrate species indicated that water quality was generally high and unpolluted. The fish community was highly diverse, with representatives of coldwater, coolwater, and warmwater species observed. The study noted the presence of juvenile burbot, which may suggest that this area represents an important nursery habitat for this fish species (LRBOI 2010).

The Huron-Manistee National Forests has also conducted stream habitat inventory surveys in portions of the Lower Subwatershed and inventory data sheets from these surveys (conducted in 1992) record habitat type, stream width, depth, substrate, percentage of shade, riparian vegetation, and fish cover. The surveys included stream temperatures in late June/early July 1992 and confirmed that the dominant substrate in the surveyed area was sand (Jackovisk et al. 1992). These detailed habitat data may be useful in the future to determine whether significant substrate or streamside vegetative cover changes have occurred in these sections of the Lower Subwatershed.

As noted in the other subwatersheds, the USFWS conducted habitat surveys, stream flow measurements, and water chemistry in portions of Bear Creek in the Lower Subwatershed. Records from field data sheets

from various years between 1990 and 2009 provide useful information on stream flows and dissolved oxygen in this subwatershed from July through September (USFWS 2011).

### *Subwatershed Summary*

The existing habitat, substrate, water quality, temperature, and flow data on Bear Creek and its tributaries comes from a variety of agencies, each of which had specific objectives when conducting its sampling. However, a collective analysis of the data and descriptions from these past studies identifies key attributes that should be routinely monitored in the future and critical information gaps that need to be filled. Based upon the existing information described in the studies and data sources cited above, a long-term monitoring plan was developed and is described in a later section of this plan.

## GROUNDWATER QUALITY AND QUANTITY

The Greater Bear Watershed represents a significant portion of a natural water resource unique to the northern half of Michigan's Lower Peninsula. The combination of moderate climate (mean annual temperatures between 40 and 50°F), extensive permeable sand and gravel deposits left by the glaciers, the dominant forest land cover, and consistent annual precipitation has created some of the highest quality, groundwater-fed, coldwater trout streams in the world. Historically, Bear Creek and its tributaries supported the now extinct Michigan grayling, and currently provide habitat for brook, brown and rainbow trout (steelhead) as well as Chinook and coho salmon. Based largely on this unique cold, groundwater resource, Michigan has adopted groundwater withdrawal regulations under a series of state laws (Michigan Public Acts 179-190, of 2008) that among other things focus on withdrawals that occur near designated trout streams such as Bear Creek and most, if not all, of its tributaries.

Bear Lake depends primarily upon groundwater inflows to maintain its size and water quality and to support existing uses. Groundwater flow entering Bear Creek and its tributary streams is the primary factor in maintaining cool stream temperatures throughout the year needed to support reproduction, growth, and survival of trout and salmon and related coldwater forage species.

Existing private water supplies, and the two public water supplies in the villages of Bear Lake and Kaleva, are dependent on the high quality of groundwater in the watershed. Exhibit 9 in the, Description of the Greater Bear Watershed section, shows the distribution of water supply wells in the Greater Bear Watershed. There is limited agricultural irrigation in the watershed that also uses groundwater as its water supply. In general the quality of groundwater available for domestic, commercial, and agricultural purposes is of high quality. The discovery of nitrates above state drinking water standards in a domestic well in Manistee County in 1999 and the possible relationship to the historical disposal of high-nitrate paper manufacturing waste in several locations in Mason and Manistee counties, including the Greater Bear Watershed, prompted a series of investigations by the MDEQ. This issue is discussed in greater detail in Designated Protected Uses and Desired Water Uses Section.

# Section F: Designated Protected Uses and Additional Desired Water Uses

Comprehensive watershed plan updates conducted with funding 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 (WQS) established to protect those uses. In addition, watershed plans usually identify other desired uses of the surface waters and groundwater within the watershed and assess the level of protection needed to sustain such uses. This section also describes the future threats, problems, and concerns related to surface and groundwater uses identified by the stakeholders of the Greater Bear Watershed.

## DESIGNATED, PROTECTED USES OF SURFACE WATER

Under Michigan's water pollution control statute (Natural Resources and Environmental Protection Act, Public Act 451 of 1994, Sec. 324.3109), 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, or
- livestock, wild animals, birds, fish, aquatic life, or plants or to their growth or propagation or the value of fish and game.

Promulgated Michigan water quality rules based on this 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 fishery
- Other indigenous aquatic life and wildlife
- Partial body contact recreation
- Total body contact recreation from May 1 to October 31
- Fish consumption

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

- Coldwater (trout) lakes and coldwater (trout) streams are protected for coldwater fisheries.
- Migratory routes for anadromous salmonids
- Public water supply intakes

Under state rules, both numerical and narrative water quality standards are established for designated and protected uses. In all cases where waters are designated for more than one of these protected uses, the most restrictive water quality standards apply. In the case of the Greater Bear Watershed, *Migratory*

*routes for anadromous salmonids (trout and salmon)* and *designated trout streams* would apply as an additional protected use in Bear Creek and its tributaries. The other two conditions for protected uses do not apply. Bear Lake is designated as a warmwater lake for application of water quality standards and it is therefore not protected under the standards for designated coldwater or trout lakes. Likewise, there are no surface water public water supply intakes in the watershed although two communities, the villages of Kaleva and Bear Lake, provide a public water supply from groundwater sources within the watershed.

Every two years the state issues a determination on the status of water quality conditions for designated uses of waterbodies within the state as part of its requirements under the federal Clean Water Act. These determinations are summarized in the Integrated Report, which was reviewed for the Greater Bear Watershed. For each subwatershed in the Greater Bear, Exhibit 74 shows the designated uses and the use determination made by the state. The state categorizes the status of designated uses by the following:

- Fully supporting (the waterbody meets state water quality standards)
- Not supporting (the waterbody does not meet state water quality standards)
- Insufficient information (available information is insufficient to determine if state water quality standards have been met)
- Not assessed (the water body was not assessed to determine if state water quality standards were met)

In instances where there is a lack of information, the state assumes that state water quality standards are being met.

The 2012 Integrated Report indicates that all of the subwatersheds are listed as not attaining the fish consumption standards because of PCBs. The Bear Creek subwatershed is listed as not supporting state water quality standards for the Other Indigenous Aquatic Life and Wildlife designated use because of mercury. The fish consumption advisories and contaminant concerns apply to certain species from contaminant sources outside the watershed that are likely to occur because of atmospheric deposition. These fish consumption advisories are not uncommon throughout Northern Michigan or the Manistee River Watershed to which Bear Creek is a tributary. There are similar use restrictions for the Manistee River upriver and downriver from its confluence with Bear Creek. As of the time of this report, the Michigan Department of Community Health has not issued consumption advisories in the Greater Bear Watershed that are more restrictive than the general advisories for Northern Michigan.

Additional information available from local entities that may not have been evaluated by the state when it made use determinations for the Greater Bear as part of the 2012 Integrated Report was also reviewed as part of this watershed plan and compared to state water quality standards.

Exhibit 75 lists the: (1) categories of designated protected uses under statute and regulations; (2) water quality standards that apply to each designated protected use; (3) existing activities and uses; and (4) existing conditions compared to the water quality standards. There is an absence of current data to determine whether or not full and partial body contact recreation standards (*E. coli* bacteria counts*)* are being met in either Bear Lake or Bear Creek and tributaries. Fish consumption advisories for larger predator species have been established by the Michigan Department of Community Health (MDCH) for certain species in both Bear Lake and Bear Creek due to sources of contaminants generated outside of the watershed.

Exhibit 76 lists potential new or increased future surface water uses that are protected under state regulations. It also outlines the likelihood that such uses would occur and whether or not existing water quality is sufficient to protect these future uses. In general, the water quality standards designed to be protective of total body contact, aquatic life and wildlife, and warmwater fish, or in the case of Bear Creek and tributaries, trout and salmon, are more restrictive than needed to protect most if not all agricultural, industrial, and commercial uses. Current water quality conditions would support such

expanded uses should they occur. It is unlikely that future municipal water supplies would withdraw surface water within the watershed, but would instead rely on groundwater.

**EXHIBIT 74.** Greater Bear Watershed: Designated Protected Use Determinations

| Designated Use | **Dutchman Creek - Bear Creek** (HUC 40601030501) | **Little Bear Creek** (HUC 40601030502) | **Lemon Creek - Bear Creek** (HUC 40601030503) | **Little Beaver Creek - Bear Creek** (HUC 40601030504) | **Bear Creek** (HUC 40601030505) |
|---|---|---|---|---|---|
| Total body contact recreation | Fully supporting/not assessed | Fully supporting/not assessed | Fully supporting/not assessed | Fully supporting/not assessed | insufficient information |
| Partial body contact recreation | Fully supporting/not assessed | Fully supporting/not assessed | Fully supporting/not assessed | Fully supporting/not assessed | Insufficient information |
| Navigation | Fully supporting | Fully supporting | Fully supporting | Fully supporting | Fully supporting |
| Industrial water supply | Fully supporting | Fully supporting | Fully supporting | Fully supporting | Fully supporting |
| Agriculture | Fully supporting | Fully supporting | Fully supporting | Fully supporting | Fully supporting |
| Warmwater fishery | Fully supporting/not assessed | Fully supporting/not assessed | Fully supporting/not assessed | Fully supporting/not assessed | Fully supporting/not assessed |
| Other indigenous aquatic life and wildlife | Fully supporting | Fully supporting/not assessed | Fully supporting/not assessed | Fully supporting/not assessed | Not supporting - mercury in water column |
| Coldwater fishery | Fully supporting/not assessed | Fully supporting/not assessed | Fully supporting/not assessed | Fully supporting/not assessed | Fully supporting/not assessed |
| Fish consumption | Not supporting - pcb in water column | Not supporting - pcb in water column | Not supporting - pcb in water column | Not supporting - pcb in water column | Not supporting - pcb in water column |

SOURCE: Public Sector Consultants Inc., 2013. Using data from the 2012 Integrated Report

## **EXHIBIT 75.** Comparison of Standards for Protected Uses versus State Water Quality Standards

| **Designated protected uses** (Part 31 of Michigan Act 451, 324.3109) | **Michigan Water Quality Standards** | **Existing activities and uses** | **Existing conditions compared to standard** |
|---|---|---|---|
| **Total body contact recreation** (all waterbodies) | Colony counts 130 or less *Escherichia coli* (*E. coli*) per 100 ml monthly average and 300 or less *E. coli* at any time | Swimming, SCUBA, snorkeling, water skiing, tubing, and related full body contact recreation activities | Compliance with standard not known, additional sampling needed |
| **Partial body contact recreation** (all waterbodies) | Colony counts of 1,000 or less for *E. coli* per 100 ml | Canoeing, kayaking, cruising, sailing, and related boating activities | Compliance with standard not known, additional sampling needed |
| **Warmwater fishery (Bear Lake)** | Dissolved oxygen (DO) not less than 5.0 mg/l (ppm)at any time in epiliminion (uppermost layer of the lake) during summer stratification and 5.0 mg/l rest of year<br><br>Limits any increase in temperature from discharges based upon classification of receiving water | Warmwater fish populations for recreational fishing and related aquatic food organisms<br><br>There are no state permitted surface discharges in the Greater Bear Watershed | Existing - one sample per day DO measurements appear to meet standard in Bear Lake; however, early morning readings needed to confirm compliance<br><br>Maximum temperatures in Bear Lake conform to Warmwater Lake standards |
| **Coldwater fishery** (Bear Creek and tributaries) | Dissolved oxygen (DO) not less than 6.0 mg/l (ppm) during summer low flow and not less than 7.0 mg/l rest of the year<br><br>Limits any increase in temperature from discharges based upon classification of receiving water | Trout, salmon for recreational fishing and related coldwater organisms<br><br>There are no state permitted surface discharges in the Greater Bear Watershed | Two locations in 1994 indicated non-attainment of standard. Additional DO testing on diurnal basis needed to confirm compliance with standard<br><br>Bear Creek has areas that exceed the summer maximum temperature of 68°F designed to protect trout and salmon |
| **Fish consumption** | Triggers established by MDCH for mercury and various organic compounds | Recreational fishing in Bear Lake and Bear Creek and tributaries | Fish consumption advisories apply to certain species from contaminant sources outside of watershed |
| **Other indigenous aquatic life and wildlife** (pH, ammonia, nitrate, nitrites, organic nitrogen, phosphorus, and metals) | Various limits primarily on discharges as needed to protect fish, wildlife, and aquatic organisms, and prevent nuisance algae blooms | Fish, wildlife, ecosystem health | Attainment of both numerical and narrative standards for all subwatersheds but Bear Creek, which is listed for mercury because from contaminant sources outside the watershed. |

SOURCE: Public Sector Consultants Inc., 2011.

## **EXHIBIT 76.** Greater Bear Watershed State Designated Uses for Potential Future Uses of Surface Waters, Likelihood of Future Use, and Existing Condition

| **Designated, protected uses** (Part 31 of Act 451, 324.3109) | **Potential future uses** | **Likelihood that designated/surface water use may be made in the future** | **Ability of existing water quality to support use** |
|---|---|---|---|
| **Public water supply** | New public water supply from surface waters | Adequate quality and quantity of groundwater in watershed for expected domestic water demand | Drinking water quality standards higher than existing surface water quality and additional treatment would be required to meet state drinking water standards for surface water sources |
| **Industrial water supply** | New industrial/commercial surface water supplies | Future demand unknown, but likely major industrial use would draw from groundwater resources rather than surface water | Most industrial/commercial uses could be accommodated by exiting surface water quality |
| **Agricultural** | New agricultural surface water uses or expanded small quantity uses for domestic lawn watering and gardens by riparians | Tributary streams too small to support significant agricultural withdrawals and there are not expected significant agricultural uses riparian to Bear Lake | Agricultural uses could be supported by existing water quality in surface waters |

SOURCE: Public Sector Consultants Inc., 2011

## PROTECTED USES OF GROUNDWATER

Groundwater is also protected under Michigan laws and promulgated rules. Under state regulations groundwater discharges must meet a non-degradation standard to protect existing or potential uses such as domestic water supplies, irrigation, stock watering, etc. The greatest threats to groundwater in the watershed are related to the unlawful release of hazardous materials (e.g., from storage and handling facilities or historical disposal sites) and accidental release of contaminants from spills and discharges that either gain direct access to groundwater or which enter otherwise protected groundwater aquifers through improperly plugged and/or abandoned hydrocarbon and mineral wells, or domestic water wells.

The villages of Bear Lake and Kaleva have wellhead protection programs and local regulations that encompass the surface area which contributes groundwater to the well water supplies of both villages.

As noted in the Watershed Conditions section, Michigan has adopted water withdrawal regulations under a series of new state laws (2008, Public Acts 179-190), based in part on this unique coldwater groundwater resource. One of the new laws requiring permits is especially focused on groundwater withdrawals that occur near designated trout streams such as Bear Creek and most, if not all, of its tributaries.

## ADDITIONAL DESIRED USES

Although the focus of the watershed plan is on water-related uses, the surrounding land uses, the economic viability, and the quality of life and related recreational uses are interrelated to the sustainable use and protection of water and other natural resources of the watershed. Thus, certain non-water uses of natural resources and coordinated planning to preserve and protect those uses have been included at the request of stakeholders as additional desired uses. Exhibit 77 lists the additional desired uses that those participating in the Greater Bear Watershed planning process have specifically identified as important to the overall success of a watershed plan. Some of these additional desired uses relate directly to the aquatic resources of the watershed, while others address the need to incorporate those uses that are historically and culturally important to the residents and visitors, and address both the quality of life and economic viability of the watershed area.

## **EXHIBIT 77.** Additional Desired Uses Not Protected under Water Quality Standards

*Location, Purpose, Applicable Laws, and Additional Protections under Consideration to Preserve and Protect these Uses*

| Desired use | Location | Purpose | Applicable laws/regulations/programs | Potential additional protections |
|---|---|---|---|---|
| Maintain existing undeveloped shoreline habitat | Bear Lake and Bear Creek riparian properties | Preserve critical fish habitat, provide filter for land-based storm water runoff, maintain biological diversity | State wetlands and inland lakes and streams laws and regulations | Education of landowners, fee simple purchase or easements by governmental or nonprofit conservation organizations, adoption of local ordinances/zoning related to new development, natural river zoning, control of invasive species |
| Preserve diverse upland ecotypes | Need to identify | Maintain ecological diversity, habitat for rare and endangered species, study sites for understanding ecological functions/processes | State and federal laws for the protection of critical habitat for endangered and threatened species, and state/local property tax exemptions | Education of landowners, fee purchase or easements by governmental or nonprofit conservation organizations, local ordinances or zoning, control of invasive species |
| Preserve economically important and historically unique agricultural activities | Selected areas or zones | Maintain examples of cultural heritage of region for the education/ enrichment of residents and visitors | Michigan Centennial Farm recognition program, Farmland Preservation Act, land conservancy programs, accommodation of local zoning requirements | Promotion of locally grown agricultural products through market days, farm roadside products, and tourist information, featuring locally grown produce in area restaurants and markets |
| Protect and preserve culturally and/or historically significant buildings and sites | Selected areas or zones | Increase awareness and understanding of historical uses of the natural resources of the area by Native Americans and early European settlers by maintaining and developing sites and preserving buildings of interest to residents and visitors | Designation as Michigan/National Historical Site | Collaboration with Little River Band of Ottawa Indians and local historical groups to identify, interpret, and map sites of significance |
| Maintain scenic vistas | Selected areas or zones | Continue to provide aesthetically pleasing landscape views for residents and visitors to the area | State and local highway rest areas, picnic areas, and scenic turnouts, local parks, nonprofit conservation areas, federal and state recreation lands | Provide public information on scenic road touring, education of landowners, promotion with local, state, federal, and tribal landowners and agencies |
| Encourage sustainable economic development | Selected areas | Provide opportunities that support permanent employment which stems out-migration of youth and enhances community stability and diversity of age groups | State, federal, local, and private grants/loans targeted for sustainable economic development | Encourage use of local businesses by residents and visitors for basic needs and services, seek grants to support investments in sustainable economic development |

SOURCE: Public Sector Consultants Inc., 2011

### *Public Access to Bear Creek and Conflicts with the Use of Private Property*

During the preparation of this Greater Bear Watershed Management Plan the concerns of private property owners on Bear Creek over trespass and related issues associated with public fishing and boating on the river were heightened when the Department of Natural Resources (MDNR) purchased a parcel on the river to provide public access near 9 Mile Road west of the village of Kaleva. While intended to accommodate public use, primarily fishing, in an area where public access was limited and trespass of private property by anglers was a significant problem, many nearby property owners believed that providing unlimited public angler access and boat launching at this location would further accelerate the problems they were experiencing with abuses that had significantly impacted their use of their private properties along the river. A public open house in October of 2012 hosted by the MDNR at the nearby Big Bear Sportsman's Club provided the property owners and well as public recreational users of Bear Creek an opportunity to express their concerns and suggest design, permitted public uses and operation/maintenance of the access site that would minimize conflicts. Following the open house the MDNR, indicated that they would take into consideration the legitimate concerns of the property owners in the final design and allowed public uses on the property. The final MDNR determination on the design and use of the site was still pending at the time this report was finalized.

## EXISTING CONDITIONS COMPARED TO STATE STANDARDS

### *Human Pathogens – Full and Partial Body Contact Recreation*

Public swimming, wading, and related non-boating, nearshore recreational water uses occur at the Michigan Department of Natural Resources (MDNR) boating access site and Hopkins Park on Bear Lake. Similarly, full and partial body contact recreational activities occur at road endings where the public has access to the water, in front of riparian properties, and in the open water of Bear Lake in association with various boating and water sports activities. Periodic bacteria samples were taken at various locations in Bear Lake between 1991 and 2007 (ASI Environmental Technologies, Inc. 2007). These sample results were reported as coliform bacteria colonies per 100 milliliters (col/100 ml) rather than the *E. coli* bacteria col/100 ml standard that is established under the WQS. Coliform bacteria include *E. coli* as well as other bacteria found in fecal matter associated with warm blooded animals. Both measures are used as an indicator of possible fecal contamination associated with serious disease causing bacteria, viruses, protozoa, and multi-cellular parasites. The WQS for ***Full-Body Contact Recreation*** is 130 or less *Escherichia coli (E. coli)* colony counts per 100 milliliter sample (130 *E. coli* col/100 ml or less) based upon a monthly geometric mean, or 300 *E. coli* col/100 ml or less at any time. The WQS for ***Partial-Body Contact Recreation*** is 1,000 *E. coli* col/100 ml or less.

The results for the 1991 through 2007 sampling period identify several locations where coliform counts were elevated. Repeat samples were not taken at the same sites over a monthly period in order to determine the monthly means. During the 17-year period, samples were taken at 42 different dates at 10 locations in Bear Lake and at 2 locations at the outlet in Little Bear Creek. Only 14 of the sample dates in this 17-year period were during June, July, and August when water temperatures favoring bacteria growth are ideal, the maximum recreational uses are expected to occur, and when the loadings to onsite wastewater treatment systems (OWTS) (e.g., septic tanks and tile fields, dry wells, gray-water barrels) around the lake would be the greatest. Of the 154 samples taken on the 16 days during June, July, and August in Bear Lake, over 11 percent showed elevated coliform levels (50 col/100 ml or greater) with the highest being 1,842 col/100 ml and the next highest 399 col/100 ml. Every lake site sampled had at least one coliform result over 100 col/100 ml during the 16 years of sampling. The two sites sampled on Little Bear Creek below the outlet to Bear Lake showed the most consistent elevation of coliform levels with many sample results over 200 col/100 ml.

*E. coli* standards to protect for full body contact recreation in Bear Lake may not be met during the heavy use period of June, July, and August. Additional sampling targeted during this critical period at the popular public swimming areas would provide better information on whether or not the standard intended to protect public health is being met. Only one sample in 1992, in one location on Bear Lake, of the 154 samples taken during June, July, and August, indicated that the partial body contact recreation standard, based on coliform bacteria data, was not met. That sample was taken at the northeast side of Bear Lake off Little Bay. Repeated samples since that time at the same location during the same time of year did not indicate that the partial body contact recreation standard was exceeded.

The only known samples for bacteria from Bear Creek and its tributaries are those taken just below the outlet of Bear Lake in Little Bear Creek. Those samples from Little Bear Creek below the Bear Lake outlet showed consistent elevated levels of coliform bacteria, many of which would suggest the total body contact standard for *E. coli* is not being met all of the time during the summer season. Follow-up sampling of Bear Creek is needed to confirm that the *E. coli* standards for both full and partial body contact recreation are not being exceeded.

### *Hazardous Materials, Fish Consumption Advisories, and other Water Quality Limits*

There are no National Pollutant Discharge Elimination System (NPDES) permits for commercial, industrial, or municipal discharges into Bear Lake, Bear Creek, or any Bear Creek tributary. There are no known current surface water discharges or discharges from historical releases to Bear Lake or Bear Creek and its tributaries containing chemicals at concentrations known to be causing injury to fish, wildlife, or aquatic organisms. There are no recent chemical contaminant analyses of tissue from fish collected from either Bear Lake or Bear Creek and its tributaries. However, based upon the migratory habits of at least larger brown trout, steelhead, and Chinook and coho salmon caught in Bear Creek and tributaries, the fish consumption warnings currently applicable to those species in the Manistee River, Manistee Lake, and Lake Michigan would apply to fish taken in Bear Creek and its tributaries. Atmospheric deposition of mercury, largely due to the burning of fossil fuels, and potentially similar air depositions of PCBs (Polychlorinated Biphenyls) from burning waste, likely concentrate in certain species in Bear Lake at or above levels that trigger fish consumption warnings. The most recent Michigan fish consumption advisories can be found on the MDCH website (Michigan Department of Community Health 2011).

Because no test results are specifically available for fish from Bear Lake, the MDCH recommends the general fish consumption guidance given in Exhibit 78.

**EXHIBIT 78.** Michigan Department of Community Health
General Fish Consumption Guidance

| Eat one meal or less per WEEK of ONE of the following: | Eat one meal or less per MONTH of ONE of the following: |
|---|---|
| • Rock bass (over 9 inches long)<br>• Yellow perch (over 9 inches long)<br>• Crappie (over 9 inches long)<br>• Largemouth bass (any size)<br>• Smallmouth bass (any size)<br>• Walleye (any size)<br>• Northern pike (any size)<br>• Muskellunge (any size) | • Rock bass (over 9 inches long)<br>• Yellow perch (over 9 inches long)<br>• Crappie (over 9 inches long)<br>• Largemouth bass (any size)<br>• Smallmouth bass (any size)<br>• Walleye (any size)<br>• Northern pike (any size)<br>• Muskellunge (any size) |
| *Advisory for males 15 years or older and females 45 years or older. | Advisory for boys and girls under the age of 15 and females ages 15–45 years old. |

SOURCE: Michigan Department of Community Health, 2011.

All the species of fish listed in the general consumption guidance have been identified in Bear Lake with the exception of muskellunge.

Historical test results and observations on Bear Lake, Bear Creek, and tributary streams indicate there are no current exceedances of numeric or narrative WQS intended to protect designated uses with possibly two exceptions. A dissolved oxygen value of less than the minimum 24-hour standard was reported at two locations in Little Bear Creek within the Headwaters Subwatershed in 1994. The pH values recorded for Bear Lake, Bear Creek, and tributary streams in the various studies cited previously show a range of pH values (6.3–8.2) that are within the range established to protect designated uses. Other chemical parameters including nitrites, nitrates, ammonia, organic nitrogen, phosphorus, and alkalinity levels reported from both Bear Lake (warmwater lake) and Bear Creek and tributaries (trout streams) are all within the range of values expected from warmwater lakes and designated trout streams in Michigan.

While control of invasive Eurasian milfoil is an issue in Bear Lake, nuisance algal blooms, the prevention of which is specifically stated in the WQS standards, is not a significant problem according to lake residents. Temperature is also a regulated water quality standard. Permitted discharges to surface waters are limited in temperature depending upon the classification of the receiving river or lake. While there are no permitted discharges to surface waters of Bear Creek, water temperatures above the standard for trout streams (summer maximum of 68 degrees Fahrenheit) have been recorded in portions of Bear Creek and are most likely related to the removal of streamside shade trees and sedimentation resulting from historical logging practices in the watershed.

# Section G: Threats, Problems, and Concerns Related to Protected and Desired Uses

The threats, problems, and concerns identified by stakeholders are grouped into six main categories: Human Pathogens (protection of public health); Ecosystem Health (excessive nutrients and habitat alterations); Hazardous Materials (contaminants that threaten fish, wildlife, and aquatic organisms, and generate fish consumption warnings); Groundwater (threats to domestic water supplies and groundwater); Invasive Species; and Other Concerns (aesthetics, storm water, riparian rights, public use of natural resources, coordinated local planning, etc.). Obviously the categories overlap in many respects and have been selected to help organize the information to provide appropriate emphasis to the concerns identified.

## HUMAN PATHOGENS

The highest priority to protect water users from potential human disease threats associated with human or animal waste is to monitor the areas with relatively high-density development around the lake and adjacent to streams that are currently dependent upon onsite wastewater treatment systems (OWTS). This includes all of Bear Lake as well as the riparian properties along Bear Creek and its tributaries. The age, number of people served, size of the drainage field, soil type, depth of groundwater, and the waste volume entering the systems are all factors in determining the effectiveness of existing systems to prevent pathogens from entering surface waters. Cottages once used as residences for a few weeks a year have been converted to year-round homes. More residences have been constructed in recent years. Dishwashers, washing machines, and garbage disposals formally limited or non-existent in homes adjacent to surface waters in the watershed are now commonplace.

### *Bear Lake*

The capacity of existing OWTS, particularly those over 30 years of age, to treat increased waste loads for both human pathogens and nutrients (e.g., phosphorus and nitrogen) is limited. Two separate reports were prepared by Bear Lake residents and members of the Bear Lake Property Owners Association in 2005 and 2006 to determine the number of residences and businesses on the shores of and adjacent to Bear Lake that have upgraded their OWTS since 1973 (Bear Creek Property Owners Association 2005; Bear Creek Property Owners Association 2006). The reports were based upon information obtained from the Manistee County Health Department, the Manistee County Equalization Department and the Special Assessment District (SAD), that was proposed to fund a public sewer disposal system as developed by the Bear Lake-Pleasanton Areas Utilities Authority. The first report (2005) concluded that only 36 percent of the residences and businesses in Bear Lake Township within the SAD had obtained a permit since 1973 to upgrade their OWTS and only 42 percent in Pleasanton Township had done so. The second report (2006) indicated that in the Village of Bear Lake, 51 percent of the residences and businesses obtained a permit to upgrade their OWTS since 1973. The reports make clear that the vast majority of OWTS adjacent to Bear Lake riparian property, including those on back lot property within the SAD, are more than 30 years old and fewer than half have upgraded in the period from 1973 to 2005.

### *Bear Creek and Tributaries*

There is no similar systematic analysis of OWTS for residences and businesses along Bear Creek and tributaries. Riparian lot sizes are bigger and the density of homes along Bear Creek and tributaries is lower than that found near Bear Lake. While the potential for pathogens and nutrients to reach the water in Bear Creek and tributaries from OWTS is less of a threat than it is in Bear Lake, areas where residences are clustered and close to the river may constitute a potential localized source of nutrients or human pathogens. Agricultural practices involving the grazing of farm animals and the application of

chemicals, fertilizers, and manure in close proximity to Bear Creek and tributaries has been observed and may represent a threat to the health of stream users and create the potential for excessive nutrient loadings.

# ECOSYSTEM HEALTH

The primary threats to water quality essential to the protection of existing fish and wildlife populations and related fishing opportunities are primarily related to changes in the trophic status or productivity (nutrient) level in Bear Lake. Alterations in the remaining natural habitat essential to reproduction, survival, and growth of fish and wildlife and related food organisms are also a significant threat in both Bear Lake and Bear Creek and tributaries. The following describes the ecosystem health concerns, threats, and problems identified in the Greater Bear Watershed.

## *Nutrient Loadings*

### *Bear Lake*

Phosphorus is the limiting nutrient in Bear Lake. Incremental increases in phosphorus loading over time can significantly alter the productivity of Bear Lake and result in changes in water chemistry (such as decreased dissolved oxygen below acceptable levels), increased algal and aquatic plant growth (e.g., nuisance algal blooms and excessive rooted aquatic plant growth), and decreased quality of fishing, boating, swimming, and other water-related activities. Increases in urbanization and other significant land use changes have been shown to be a significant factor in the eutrophication or increased productivity in other inland lakes. Future growth around Bear Lake, including expanded use of existing residences (i.e., the addition of appliances that generate wastewater, expanded period of occupancy, and increased number of household members), is a potential concern since no central wastewater system is available. However even without significant new growth around Bear Lake, as noted in the previous section on Human Pathogens, existing uses, particularly OWTS, pose a significant threat that needs to be monitored and corrective action must be taken as needed.

Models are useful in determining the annual phosphorus loadings to a lake. Although models are based upon estimates, they can be used to identify controllable sources of phosphorus where nutrient levels are of concern. There are several potential sources of phosphorus entering a lake including groundwater, inflowing rivers and streams, surface runoff from surrounding land draining directly to the lake, rainfall and snow falling on the lake surface, direct point source discharges from wastewater treatment facilities, and leachate from commercial and residential OWTS such as septic tanks and tile fields. Estimates from each of these sources can be used to determine the annual phosphorus loading to a lake. In the case of Bear Lake, there are no significant streams or rivers entering the lake and there are no point source discharges from commercial, industrial, or municipal wastewater treatment facilities. The primary sources of phosphorus loadings to Bear Lake are from groundwater, leachate from OWTS, runoff from adjacent lands that drain directly to the lake, and precipitation. In some lakes, phosphorus accumulated in sediments can be released to the water column above, particularly when anoxic (dissolved oxygen concentration near zero) conditions occur near the lake bottom. Re-suspension of phosphorus from bottom sediments is not likely a significant source of phosphorus in Bear Lake.

Because OWTS are of great concern in the watershed, high and low estimates for phosphorus loading in Bear Lake were developed. Many factors need to be considered in order to approximate phosphorus loading from Bear Lake OWTS, including soil type, age of system, condition of system, and proximity of the system to ground and surface water. A rough estimate can be calculated using U.S. Census information and data from previous studies (see Appendix 3 for additional information on the methods used to estimate phosphorus loading from OWTS as well as the high and low estimates).

In 2005, a group of local citizens reviewed records at District Health Department #10 for parcels located within the proposed SAD around most of Bear Lake (BLPOA 2005). That assessment district excluded the Village of Bear Lake but included the majority of parcels directly adjoining Bear Lake and some parcels up to about three-quarters of a mile away from the lake in areas adjacent to the proposed sewer.

A 2006 study by the same group of property owners included a review of requested permits for well and OWTS between 1973 and 2005 (BLPOA 2006). The group then compared the list of requested permits to parcels of property with residential or commercial dwellings to determine the number of parcels that had updated their OWTS and those that had not. Few OWTS are designed to last more than 30 years without substantial renovation that would likely require a permit from the health department. Thus, OWTS on developed properties for which there is no record of a OWTS between 1973 and 2005 were determined to be potentially lower functioning systems. The review found 308 properties with a house or business within the proposed SAD that did not have a permit on file. These 308 properties likely have lower functioning OWTS.

A summary of the high and low estimates in Bear Lake along with a comparison to nearby Portage Lake in Manistee County and Red Cedar Lake in Wisconsin is included in Exhibit 79. The annual phosphorus loading contribution from atmospheric sources to Bear Lake was estimated based upon a range of concentration values for phosphorus in rainfall reported for Beaver Island and Silver Lake, Michigan (USEPA 1975). The contribution of phosphorus from groundwater sources was estimated based upon the volume of Bear Lake (32,690,970 kiloliters) divided by the hydraulic residence time (2.19) multiplied by the average concentration of phosphorus (0.01mg/l) in groundwater reported for rural areas (Nolan and Hitt 2003). The estimate for the phosphorus contribution from immediate runoff (nearshore) was calculated using the land area approximately 1,300 feet from the shore of Bear Lake and applying the U.S. Environmental Protection Agency (USEPA) Spreadsheet Tool for Estimating Pollutant Load (STEPL) model for projecting phosphorus runoff from that area based upon land uses – 50 percent urban (cottages, homes, and businesses), 25 percent forested, and 25 percent cropland. The model was designed by Tetra Tech, a private consulting company, for the USEPA.

The methods used in estimating the total annual phosphorus loading for each of the three lakes included in Exhibit 79 were similar. Each estimated the contribution of OWTS based upon annualized per capita phosphorus discharges from literature-reported values, similar to those used for Bear Lake in Appendix 3. The contributions from other sources were estimated using either literature- reported values or actual measurements. In the case of Bear Lake, available data on the age of OWTS and the date of the last upgrades were used to classify systems that were assumed to be effective (upgraded in the last 30 years) in removing phosphorus at a rate of 85 percent, while the systems that had not been upgraded in the last 30 years were estimated to be 50 percent efficient (low estimate) or 15 percent efficient (high estimate) in removing phosphorus. Data on the age of OWTS on the other two lakes were not available. The efficiency of OWTS in removing phosphorus in these other two other lake studies were assumed to be 85 percent for Portage Lake and 70 percent for Red Cedar Lake based upon then reported values in the literature available at the time the reports were prepared.

There are significant differences among the three lakes. Bear Lake and Portage Lake are classified as mesotrophic lakes (P = 7.6 to 11.4 µg/l) while Red Cedar Lake is classified as a eutrophic lake (30.2 µg/l mean P level). Both Red Cedar Lake and Portage Lake have significant inflowing rivers and streams while Bear Lake has no significant inflowing surface watercourses. Bear Lake has the highest number of OWTS adjacent to the lake and the highest estimated phosphorus loading from OWTS. Despite the differences, the three lakes have similar total yearly phosphorus loading per capita results that range from 0.21 to 0.67 kilograms/year. The groundwater contribution of phosphorus to Red Cedar Lake is relatively high due to the presence of larger bodies of water and development immediately upstream that contribute to the groundwater inflow.

The estimated total phosphorus loading by sources in Bear Lake indicates that a substantial reduction in phosphorus inputs could be achieved by providing municipal wastewater service to the homes and businesses located adjacent to the lake. Reductions can also be achieved by application of best management practices (BMPs) to reduce phosphorus in storm water runoff from properties that drain directly to Bear Lake. Together, OWTS and storm water runoff from adjacent lands represent over 80 percent of the estimated phosphorus loadings to Bear Lake. Atmospheric deposition and groundwater, while contributing to the total annual phosphorus loading of Bear Lake, are either from natural occurring sources or, in the case of air depositions, from distant sources beyond local control.

Exhibit 79 compares estimates of P inputs and levels for Bear Lake, Portage Lake (both in Manistee County, Michigan), and Red Cedar Lake in Wisconsin. A high and low estimate was generated for Bear Lake. The figures for Portage Lake show the highest estimate of phosphorus entering the lake. The study in Red Cedar Lake reported only single numerical estimates for phosphorus loading from various sources.

**EXHIBIT 79.** Comparison of Phosphorus Loading and Other Parameters for Bear Lake (Manistee Co., Mich.), Portage Lake (Manistee Co., Mich.), and Red Cedar Lake (Barron and Washburn Co., Wisconsin)

| | Bear Lake | | Portage Lake[a] | Red Cedar Lake[b] |
|---|---|---|---|---|
| | High Estimate | Low Estimate | High Estimate | Estimate |
| **Loadings (kilograms phosphorus/year)** | | | | |
| Extended Runoff (inflowing streams) | None | None | 1,054 | 7,235 |
| Immediate Runoff (nearshore) | 554 | 554 | | 1,147 |
| Groundwater | 149 | 149 | | 653 |
| Septic Loading Estimate | 445 | 280 | 884 | 88 |
| Atmospheric | 92 | 39 | 261 | 53 |
| Sub-Total Non-Point Source Phosphorus | 1,240 | 1,022 | 2,199 | 9,176 |
| Sub-Total Point Source Phosphorus (state permitted discharges) | None | None | None | None |
| **Total Annual Phosphorus Loadings** (kilograms phosphorus/year) | **1,240** | **849** | **2,199** | **9,176** |
| **Other Lake Parameters** | | | | |
| Lake Area (hectares) | 745.84 | 745.84 | 815.85 | 744.62 |
| Maximum Depth (meters) | 7.32 | 7.32 | 18.29 | 16.15 |
| Mean Depth (meters) | 4.39 | 4.39 | 5.79 | 7.83 |
| Hydraulic Residence Time (years) | 2.19 | 2.19 | 3.50 | 0.21 |
| Lake Volume (kiloliters) | 32,690,970 | 32,690,970 | 48,659,626 | 58,343,692 |
| OWTS (number of septic systems) | 507 | 507 | 570 | 348 |
| OWTS Capita/yr (full-time equivalent residents/year ) | 1,033 | 1,033 | 1,311 | 418 |
| **Total Yearly Phosphorus/Capita from OWTS** (kilograms) | **0.43** | **0.27** | **0.67** | **0.21** |
| OWTS Annual Phosphorus Loading/Hectare (kilograms) | 0.60 | 0.38 | 1.08 | 0.12 |
| OWTS Capita Year / Hectare (number) | 1.39 | 1.39 | 1.61 | 0.56 |
| **Micrograms/Liter of Phosphorus Measure (µg/l)** | **High[c]** | **Low (mean)[c]** | **Reported Mean** | **Reported Mean** |
| Phosphorus Concentration (µg/l) | 10.00 | 7.60 | 11.40 | 30.20 |

SOURCE: PSC 2011 with data from ASI Environmental Technologies, 2007b; Bear Lake Property Owners Association, 2005; Bear Lake Property Owners Association, 2006.
[a] Public Sector Consultants, 2008.
[b] Robertson 2003
[c] Michigan Clean Water Corps., 1976–2010.

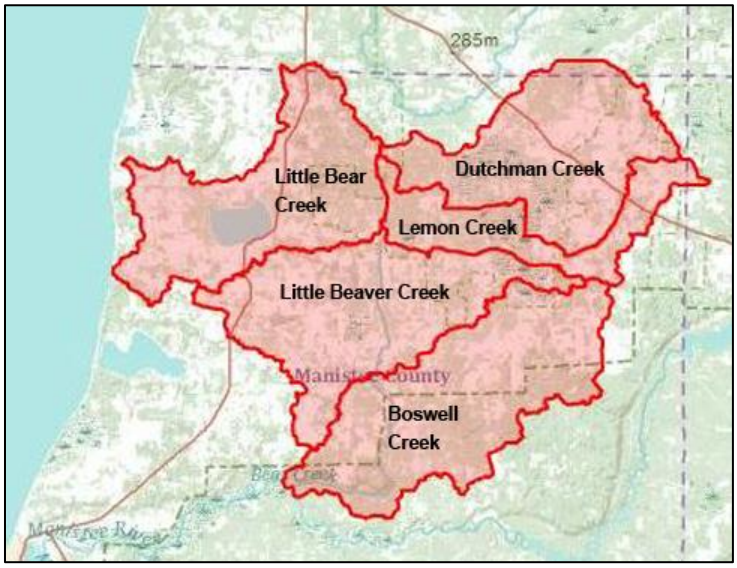
### *Bear Creek and Tributaries*

The application of agricultural fertilizers and manure and the grazing of livestock on lands immediately adjacent to Bear Creek and tributaries may be a concern specifically where no vegetative buffer strips separate tilled or grazed land from the adjacent stream. Bear Creek and its tributaries are less vulnerable to nutrient loadings as a whole from OWTS. Although there are relatively few households and businesses adjacent to these waterways, there is the potential for impairments to stream sections where homes and cottages are relatively close together on Bear Creek or in Little Bear Creek immediately downstream of the outlet of Bear Lake. Because of the predominance of permeable sand and gravel glacial deposits, surface water runoff into Bear Creek is minimal and the length and size of tributary streams reflects the fact that most water entering Bear Creek and its tributaries is from groundwater sources. Significant land use changes in the Bear Creek watershed could pose a threat if increased storm water runoff is conveyed directly to surface waters. The application of agricultural BMPs for existing and future farming activities, and routine maintenance or replacement of failing OWTS adjacent to the streams, can effectively control nutrient loadings to Bear Creek and its tributaries.

Because water from Bear Lake flows into Bear Creek, an overall watershed runoff analysis was completed using the STEPL model. Expected nonpoint source pollution loadings to waterbodies in the Greater Bear Watershed were estimated using the STEPL model which is based on annual precipitation, land uses, agricultural practices, OWTS use, and soil conditions. Common sources of nutrient loading include riparian OWTS, fertilizer uses, livestock wastes, and storm water runoff.

Exhibit 80 shows the location of the five subwatersheds used for this analysis and the estimated phosphorus and sediment loads for these subwatersheds used by the STEPL model[1] and the Greater Bear Watershed as a whole.

**EXHIBIT 80.** STEPL Model Estimated Phosphorus and Sediment Loads




[1] The number of subwatersheds within a broader watershed can differ depending on the scale of analysis. The local Greater Bear Watershed Steering Committee developed four subwatersheds for analysis. The STEPL model uses five subwatersheds.

**EXHIBIT 80.** STEPL Model Estimated Phosphorus and Sediment Loads (cont.)

| STEPL Subwatershed | Acres | Hectares | P Load | | | Sediment Load | | |
|---|---|---|---|---|---|---|---|---|
| | | | lb/year | kg/year | lb/acre/year | ton/year | kg/year | ton/acre/year |
| Little Beaver Creek-Bear Creek | 29,999 | 12,140 | 6,972 | 3,162 | 0.23 | 1,103 | 1,000,625 | 0.04 |
| Lemon Creek-Bear Creek | 12,459 | 5,042 | 2,135 | 968 | 0.17 | 367 | 333,028 | 0.03 |
| Dutchman Creek-Bear Creek | 25,099 | 10,158 | 4,263 | 1,934 | 0.17 | 791 | 717,946 | 0.03 |
| Boswell Creek-Bear Creek | 33,555 | 13,580 | 6,461 | 2,930 | 0.19 | 910 | 825,085 | 0.03 |
| Little Bear Creek | 26,575 | 10,755 | 6,010 | 2,726 | 0.23 | 865 | 784,624 | 0.03 |
| **Total** | **127,686** | **51,675** | **25,840** | **11,721** | **0.20** | **4,036.0** | **3,661,398** | **0.03** |

SOURCE: Calculations generated using the STEPL model.
NOTE: Different sources that estimate the total acreage of the Greater Bear Watershed vary slightly (less than 1 percent difference among estimates used in this report) based on different underlying data sets used to estimate watershed boundaries. Additional differences can occur due to rounding of figures.

The STEPL model estimated phosphorus load for the Greater Bear Watershed is almost 25,840 pounds per year or 0.2 pounds per acre per year.

The STEPL model estimated sediment load is 0.03 tons per acre per year or approximately 0.078 tons per hectare per year (t/ha/yr). A study of 226 mixed use watersheds (combination of forestland, cities, and other land uses) in the eastern United States found a mean sediment load of 0.35 t/ha/yr and a range of loads between 0.02 and 4.42 t/ha/yr (Brooks 2003). The same study also analyzed 65 forested watersheds within the eastern United States and found a mean sediment load of 0.17 t/ha/yr and a range of 0.02–2.44 t/ha/yr. It should be noted that sediment loading occurs naturally as a result of erosion; sediment loading in the Greater Bear Watershed based upon the model is relatively low when compared to these other watersheds. However, the general model used does not consider sedimentation that occurs in areas with bare eroding sand banks that are a legacy from the historical logging practices in the Greater Bear Watershed in the late 1800s and early1900s

## *Habitat Alterations*

### *Shoreline Vegetation—Bear Lake*

Bear Lake, like many other inland lakes in Michigan, has undergone significant habitat alterations over the last 150 years. The most significant changes have been the alteration of shoreline and nearshore habitat due to the construction and use of homes, cottages, and businesses. The wetlands areas adjacent to the lake have been reduced; shoreline vegetation has been physically removed and in some areas replaced with hardened breakwalls. Naturally occurring large woody debris, at least in nearshore areas, has been removed to accommodate recreational uses. All these natural elements of the shoreline or nearshore areas are essential habitat for the reproduction, survival, and growth of fish, wildlife, and aquatic food organisms. In addition, shoreline vegetation of native plants and wetlands serve as filters for runoff of nutrients and contaminants from nearby impermeable services such as roads, driveways, and roofs. Protecting remaining wetlands, reducing the use of hardened breakwalls, and protecting or reestablishing native plants in shoreline areas, including the use of rain gardens, are steps that can be taken to mitigate the impairments that have already occurred to the valuable shore and nearshore habitat and related protected uses.

### *Water Levels—Bear Lake*

The level of Bear Lake is currently controlled by a structure constructed at the outlet of the lake when the last major improvements were made to U.S. 31 at the bridge crossing of Little Bear Creek. In the past, the level of Bear Lake has fluctuated based upon both natural precipitation rates and the historical modifications at the outlet. The lake does not have a legally established lake level, and unless boards are placed in the slots in the concrete structure at the bridge crossing, the maximum height is controlled by the elevation of the fixed concrete structure at the bridge. Some residents would prefer higher lake levels at particular times of the year and others prefer lower levels depending on their location on the lake, the setback of their home or cottage, and their intended use. The unauthorized placement of boards at the lake outlet structure has occurred in the past in an attempt to raise the level and the boards have been subsequently removed to restore the outlet to the normal fixed level.

Although it is possible to maintain Bear Lake at a constant level or range of levels to accommodate various property owners or uses, natural fluctuations in lake levels are an important component of maintaining wetlands and other nearshore vegetation that are essential cover, food, and reproduction areas for important aquatic species including fish. In addition, property owners downstream of the Little Bear Creek outlet are affected and their uses impacted when lake levels are artificially manipulated. In general, lake residents have learned to live with the levels maintained by the current fixed level outlet structure and recognize that natural precipitation and evaporation rates will normally reduce lake levels during the late summer period. Nonetheless, preserving the ability to temporarily block the lake outlet to respond to emergencies could be important. Accidental releases of hazardous materials into the lake (such as oil, grease, gasoline, etc.) from highway accidents could be prevented from entering Little Bear Creek through temporary blocking of the outflow while cleanup activities contain and remove the contaminants from the lake.

### *Habitat—Bear Creek and Tributaries*

Bear Creek and its tributaries have undergone considerable change since the mid-1800s when logging of the area began. Bank destruction and sand and silt erosion from the cleared land during and following extensive timbering activities in the latter part of the 1800s and early 1900s are still evident today. Historical evidence and physical alterations of the river banks indicate that the logging practices have had severe habitat impacts in the watershed. Grayling were the dominant species prior to the beginning of the twentieth century. Early logging practices and associated habitat degradation has been cited as the primary reason for the extirpation of grayling in Michigan's Lower Peninsula. The regeneration of the forested land and the conversion of land to agricultural crop production have allowed stream systems, such as Bear Creek, to slowly recover. However, remaining severe historical bank erosion sites (see Exhibit 82), current road crossings (see Exhibit 83), and the related erosion of sand and silt into the river system remain a concern. Historical logging practices removed tress that once provided streamside cover – a source of large woody debris – and prevented stream widening. Although bank restoration activities in the last decade have addressed many of the most serious erosion sites, increased stream temperatures, the lack of in-stream woody debris habitat, and sand deposition still limit trout and salmon reproduction, survival, and growth in some areas. Residential and agricultural practices have also reduced natural streamside vegetation and increased the rate of storm water and snow melt runoff resulting in accelerated erosion and increased stream temperatures.

### *Road Crossings and Barriers to Fish Migration—Bear Creek and Tributaries*

Construction, repair, and maintenance of road crossings over Bear Creek and its tributaries remain a concern for area residents and visitors (see Exhibit 83). The use of culverts for road crossings can block the free movement of fish species and prevent access to upstream habitat. The bottom elevation, particularly in older road crossing culverts, can be significantly higher than the downstream water level creating an upstream barrier to fish passage during most of the year. Enlargement of the culvert and/or

lowering the bottom elevation of the culvert have been completed in some locations and, while fish passage has been improved, the former eroded pool below the improved crossing is eliminated. While the public has expressed concern over the loss of these accessible "fishing holes" below road crossings where these improvements have been made, the stream is actually returning to a natural condition that would have existed prior to the construction of the original road crossing.

Inadequately maintained road crossings, both at culverts and bridges, can be a source of eroding sand and soil resulting in increased sedimentation in downstream areas. Public use of stream crossings for public access, inadequate design or maintenance, and major precipitation events can accelerate erosion of disturbed soils that contribute to the sediment loading of Bear Creek and tributaries. Erosion at these sites can be reduced by increasing the number and location of managed public access sites other than at road crossings and placing erosion control devices such as steps at popular public access road crossings. The use of bridges rather than culverts can also reduce erosion, address fish passage concerns, and lower erosion control maintenance cost; the additional capital expense to replace a culvert with a bridge, however, is significant.

## HAZARDOUS MATERIALS

Aside from the fish consumption warnings that currently apply to fish populations in Bear Lake and Bear Creek and tributaries that are attributed to sources *outside* of the watershed, there are no known sources of hazardous waste within the watershed that are currently affecting the surface waters within the Greater Bear Watershed. In August each year, a county-wide program operated by the Manistee County Conservation District and various local partners provides for the drop-off and disposal of household hazardous waste including automotive products and fuels, paint products, yard and garden products, household cleaners, electronic products, and pharmaceuticals (Manistee County Conservation District 2011). In addition, state and federal regulations control the use, storage, and disposal of hazardous materials used in industrial and commercial facilities. In spite of these protections, citizens remain concerned about potential surface and groundwater contamination through the storage, use, and disposal of hazardous materials from households, public agencies, and commercial, industrial, and agricultural sources.

### *Storm Water Discharges*

Storm water runoff from the surface of the riparian lands and through drainage systems can transport litter, yard waste, fertilizer, pet waste, hazardous chemicals, and an array of other materials deposited on the land and roads into surface waters. Bear Lake is more susceptible to storm water discharges from urban uses while Bear Creek is more likely to be affected by agricultural runoff. While storm water discharges can include threats related to human health (pet and livestock waste), ecosystem health (fertilizers and yard waste), habitat degradation (eroded sand and silt), and aesthetics (litter and discarded metal, paper, and plastic), the greatest threat in many instances is the accidental release of hazardous chemicals from road accidents or poor handling, storage, or disposal practices by homeowners, commercial and industrial operators, and farmers.

#### *Storm Water—Bear Lake*

In 2008, the BLPOA, Surface Water Subcommittee, prepared a Storm Drain Report (BLPOA 2008). In the absence of a readily available printed record of the storm drain systems that discharged into Bear Lake, the subcommittee members visually inspected grated storm drain locations, probable storm water drainage ways, retention ponds, and open fields and ditches which drained into Bear Lake. The report identified 36 grated storm drain entrances, and a number of under-the-road drainages, retention ponds, culverts, and pipes that drained toward Bear Lake. The report contained hand drawn maps of the grated storm drain locations as well as the sites of the 12 lake exit drains and one road-run, lake exit into Bear

Lake. The report ,and mapping of the storm drainage system revealed the vulnerability of Bear Lake to storm water pollutants coming from residences, businesses, and transportation corridors served by or connected to the storm drain system surrounding the lake. Additional analysis is needed to determine the exact location of these drains and the stormwater collection boundaries.

Many of the property owners served by the grated storm sewers in the Village of Bear Lake may not be aware that the drains – where they might dispose of household waste material – lead directly to the lake. More important, a busy state highway (U.S. 31) parallels Bear Lake for some distance and the storm water runoff from this area of roadway flows into Bear Lake. Normal automobile contaminants found on the highway, as well as potential accidental spills of hazardous materials routinely being transported on U.S. 31, represent a potential threat to Bear Lake.

Educational materials targeted for homeowners and businesses served by storm drains discharging to the lake would be helpful in preventing inappropriate disposal of polluting substances and encouraging practices that properly contain areas used for the storage, handling, and use of hazardous materials. The current household hazardous waste collection and disposal program operated by the Manistee County Conservation District can help residents find a safe and acceptable method to dispose of hazardous materials. Storm drain stenciling of grated storm water drains can help residents understand that how they use the land and dispose of waste affects the lake. Vegetated retention basins and rain gardens placed near the outlets of exit drains can reduce the amount of litter, nutrients, and other waste that enters the lake. Most important, local first responders to road accidents need to have contingency plans that avoid, to the extent possible, washing or sweeping of hazardous materials into drains leading directly to the lake.

### *Storm Water—Bear Creek and Tributaries*

In addition to the potential threat of nutrient loadings from adjacent farm lands and failing domestic OWTS outlined in earlier sections, storm water runoff from agricultural lands can include pesticides and other chemicals commonly used to produce crops. The application of best management agricultural practices, including the use of natural vegetative buffer strips between active row crop, grazing, orchard, and tree nursery areas, as well as adjacent watercourses, can reduce the potential for transport of these chemicals to Bear Creek and tributaries. In general, road accidents do not pose as great a risk to Bear Creek and tributaries since the only areas of likely runoff would be from road accidents involving the release of hazardous materials at or in close proximity to stream road crossings. Still, first responders should be made aware that clean-up of hazardous materials from accidents should avoid discharges to nearby waterways whenever possible.

## GROUNDWATER

Existing regulations protect groundwater from permitted waste discharges, leaking underground storage tanks, and other discharges from land uses involving the storage, disposal, transportation, and use of hazardous materials that threaten the groundwater resources in the watershed. Groundwater is virtually the only source of potable water in the watershed and it is a major contributor of cool clean water to Bear Lake, Bear Creek, and its tributaries. Groundwater pollution is not only a threat to drinking water but potentially to protected uses of surface waters. Residents of the watershed express concerns about past and current practices that they feel may impact the quality of both drinking water supplies and water quality of area lakes and streams.

Recently reported contamination of domestic water wells by the application of paper waste materials to agricultural properties in the county has heightened concern that closed township dump sites, former food processing sites, abandoned gas stations, hydrocarbon extraction facilities, or the unconfined storage of agricultural soil enhancement materials in the watershed may represent potential sources of groundwater

contamination that threaten water supplies or surface water quality. Since many of the older water wells serving domestic homes in the watershed are shallow, failing OWTS also pose a risk to nearby shallow-well domestic water supplies.

There is no information to indicate that any of the potential groundwater contamination sources identified are having a negative impact on *surface waters* of the watershed. The two municipal water supplies, in the villages of Bear Lake and Kaleva, engage in regular testing of their domestic water supplies for a range of contaminants and have instituted groundwater protection programs to protect against surface or subsurface uses that could contaminate their water supply aquifers. Individual domestic wells near sites of known sources of contamination such as the paper waste land applications have been evaluated as part of an investigation by the Michigan Department of Environmental Quality (MDEQ), in cooperation with the local health department. Investigation of individual sites of potential groundwater contamination, such as areas that may contain spills or leaks from commercial operations, are routinely evaluated by the MDEQ and scored for follow-up investigation according to their potential for contaminating nearby water wells or surface waters.

### *Packaging Corporation of America Land Application of Sludge*

From 1986 to 1997, cardboard manufacturing waste sludge from Packaging Corporation of America's Filer City, Michigan, facility was used to enhance soils at golf courses, gardens plots, farm fields, and nurseries in Mason and Manistee counties. Under the MDEQ's Program for Residual Management (PERM), the paper waste was approved for limited application as an organic matter supplement to poor soils. Groundwater contamination from the application of this paper sludge was first suspected at a site in Filer Township in Manistee County when a former resident tried to sell their home and their water well test came back with levels of nitrates considerably above the state safe drinking water standards. The suspected source of the nitrate contamination was a nearby tree farm that had routinely received waste sludge from the Packaging Corporation of America. A civil lawsuit involving the nitrate contamination issue was settled in 2002, but the concern soon spread to other sites where the sludge had been deposited.

Under the direction of the MDEQ, the local health department sampled water wells within one-quarter mile of 52 sites, some of which are within the Greater Bear Watershed, which received 100 or more truckloads of the paper sludge. Of the 114 wells tested, seven showed nitrate levels at or above the drinking water standard of 10 milligrams per liter (10mg/l). MDEQ investigations have been unable to establish that the application of the low concentration of nitrates found in the paper waste was responsible for nitrate contamination of groundwater at the numerous sites examined. Nitrate contamination of groundwater has been noted in other rural areas throughout Michigan and the nation and it has been attributed to the widespread use of nitrogen fertilizers, runoff from livestock holding areas, infiltration from sewage treatment lagoons, and various manufacturing waste disposal practices. The state has provided funds for both temporary bottled water for affected Manistee County residences and the cost of new wells where deeper protected water supplies are available. While the disposal of paper mill waste in Manistee and Mason counties has received considerable attention in the local press, MDEQ investigators found that the most likely source of the high nitrates found in groundwater is from the application of high nitrate fertilizers.

### *Uncovered Storage of Lime for Agricultural Soil Enhancement*

The public has expressed concern about outside stockpiling of lime in the watershed prior to its application to farm fields as a soil conditioner. There is perhaps some confusion between agricultural lime (calcium carbonate) and other products such as quick lime (calcium oxide). The latter, calcium oxide, is extremely caustic and potentially harmful to humans through direct contact. Agricultural lime is routinely stockpiled for later application to farm fields for a variety of purposes including reduction of soil acidity, increasing soil calcium levels, and enhancement of nutrient uptake. Unless stockpiled on the ground

immediately adjacent to a watercourse, agricultural lime does not represent a risk to surface water or groundwater.

### *Closed Township Dump Sites*

Hundreds of former township dump sites throughout the state were closed in the 1970s and early 1980s following the passage of new solid waste management laws at the state and federal levels. Former local dump sites used by nearby industrial or commercial businesses for the disposal of large quantities of hazardous solid or liquid waste have been investigated and cleanups implemented where migrating contaminated groundwater posed a human health or environmental threat. For the most part, closed township dumps that served primarily rural communities contained mostly domestic waste and were isolated from nearby domestic water supplies and surface waters. No additional action has been taken and no further remedial actions are planned at closed rural dump sites unless new problems are discovered or the site is disturbed. The former, closed township dump sites in the Greater Bear Watershed fall into this category.

### *Hydrocarbon Development*

Manistee County has had extensive oil and natural gas exploration and development over the last 25 years (see Exhibit 21, Description of the Greater Bear Watershed). Recent increased interest in hydraulic fracturing of natural gas wells in Michigan has prompted public concerns over the safety of this practice and the use and disposal of water used in the process. In Michigan, more than 12,000 wells have been hydraulically fractured, primarily in the Antrim Shale Formation gas wells in the northern Lower Peninsula. While horizontal drilling technology has been available since the 1980s, it has seldom been used for the extraction of natural gas. The combination of hydraulic fracturing and horizontal drilling has increased the interest in producing natural gas from shale formations where the tightly locked gas can only be commercially produced by hydraulic fracturing or fracking.

Concerns over fracking for natural gas focus on five primary issues: (1) migration of gas or fracture fluids to the surface or into freshwater aquifers, (2) water use, (3) management of produced water (i.e., water that is returned to the surface and must be disposed), (4) surface spills of drilling liquids and produced water, and (5) hazards associated with chemical additives (Michigan Department of Environmental Quality 2011).

- **Migration of fluids:** Michigan has regulations to prevent the migration of gas or fluids that require intermediate casing; wells must be set 100 feet into bedrock and 100 feet from any fresh water zones and cemented from the bottom of the casing to the ground surface. The production casing is required to be set and cemented at the gas reservoir depth before fracking can occur. Prior to drilling, the state inspects the area to assure that no nearby abandoned or production wells provide a conduit for migration of gas or drilling fluids.
- **Water use and withdrawals**: Fracking of Antrim Shale gas formations typically requires approximately 50,000 gallons of water. The Utica/Collingwood Shale gas formations may consume 5,000,000 gallons or more when fracked. While oil and gas operations are exempt from Michigan's new water withdrawal laws, state oil and gas regulations require owners/operators to conduct the same water withdrawal impact assessment as they would for other proposed large quantity water withdrawals and prohibit fracking operations that are likely to cause a significant adverse impact to groundwater or surface water. The regulations also require the installation and monitoring of an observation well if there is a freshwater supply well within one-quarter mile of the production well.
- **Management of produced water:** The water used during the fracking process is either left in the deep gas producing formation or recovered at the surface and disposed of in a deep injection well disposal site approved by state and federal authorities. The produced water containing salts from deep formation and chemicals used to facilitate the extraction of gas from the shale ranges from 25 to 75 percent of the water injected into the formation. Under Michigan oil and gas regulations, all the

produced fluids must be contained in steel tanks and disposed of at an MDEQ and USEPA approved deep well disposal location.

- **Surface spills:** Secondary containment is required under tanks, wellheads, and other areas where spills may likely occur. Under state requirements, spills must be reported immediately and actions taken to promptly recover and clean up impacted areas.
- **Chemical additives:** All chemical additives in the fracking and production of gas must be reported to the state with specific information on Material Safety Data Sheets (MSDS) such that the state can appropriately respond to concerns related to production operations and can prepare potential spill responses. The MDEQ posts information from the MSDS on its website for public review.

Michigan is considered a national leader in the development and implementation of model regulations for hydraulic fracking of natural gas and as such has avoided the problems encountered by other states where such exploration and production has occurred. While fracking of deep shale gas such as that found in the Utica/Collingwood Shale requires significant amounts of water, the MDEQ is proposing well spacing density of up to 640 acres per well versus the 40–80 acre spacing historically required for oil and gas development, which means that many fewer wells will be needed.

## AQUATIC INVASIVE SPECIES

Despite the apparently successful control of Eurasian milfoil in Bear Lake through the annual application of selective, approved aquatic plant herbicides, the residents who live around and use Bear Lake are concerned about both the long-term impacts and costs of annual chemical treatments. Biological controls offer a potential defense against Eurasian milfoil in the future, but for now the carefully managed chemical control program represents the best available technology to assure that this invasive species does not expand to the point that it materially interferes with the various recreational uses of the lake. There is some evidence from other lakes in Michigan that long-term application of chemicals, specifically those containing copper sulfate, has reduced the abundance of certain sensitive invertebrate organisms that are important food sources for fish A broad spectrum of herbicides and algaecides are now approved for use in Bear Lake under a permit issued by the state. Since the herbicide 2, 4, D has been demonstrated to be an effective chemical for the control of Eurasion Milfoil, the authorization for the use of other chemicals should be removed from the annual state permit until a demonstrated need has been established. Two additional invasive plant species—phragmites (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*)—are a concern in Bear Lake. An organized effort to identify and eradicate these two species when they are first identified in wet areas adjacent to the lake is seen by residents as an essential activity to protect the remaining wetlands adjacent to Bear Lake.

Zebra mussels (*Dreissena polymorpha*) are already established in Bear Lake and the residents and users are concerned that the changes that have occurred in Bear Lake related to food chain disruptions caused by this invasive species may be exacerbated if a closely related organism, the quagga mussel (*Dreissena rostriformis bugensis*), finds its way into Bear Lake from the Great Lakes or other inland lake sources. Anecdotal evidence from residents suggests that zebra mussels in Bear Lake have reached their peak abundance and are now declining. Some residents have observed that the number of zebra mussel shells found on the beaches and live mussels attached to domestic irrigation intake pipe laid nearshore on the lake bottom have significantly decreased in the last few years.

# OTHER CONCERNS

## *Public Use of Bear Creek and Conflict with Riparian Owners*

Preceding the initiation of the Greater Bear Watershed planning effort, a number of conflicts occurred and continue to this day between public users of Bear Creek and Bear Creek riparian property owners. Public use of the river increased with the introduction of Pacific salmon in the mid-1960s and recent state-targeted enforcement to minimize illegal salmon snagging (hooking a fish anywhere other than in the mouth) on the nearby Manistee River at Tippy Dam has apparently increased snagging on the less visible stretches of Bear Creek. The vast majority of the shoreline property on either side of Bear Creek from 13 Mile Road downstream to Coates Highway is in private ownership with public access limited to public bridge crossings. Following the increase of snagging in Bear Creek and the attendant trespassing, littering and boisterous and sometimes threatening behavior of some fishermen, the Bear Creek property owners began to question the public's right to navigate and fish the river. Some attempts have been made by property owners to place fences or other barriers in the river to prevent boating or wading anglers from using the river. In 2011, a property owner was fined for harassing an angler fishing the river from a guide boat.

### *Formation of Special Bear Creek Access Subgroup*

Recognizing this conflict, the Greater Bear Steering Committee formed a special subgroup representing a private fishing guide service that uses the river, Bear Creek property owners, the MDNR, and other interested members of the Greater Bear Steering Committee. One of the first tasks undertaken by the subgroup was to determine the status of Bear Creek as a navigable and therefore public river open to public boating and fishing. The subgroup reviewed various legal opinions by Michigan courts on whether or not Bear Creek is a navigable stream and finally settled on the most recent decision of the Michigan Supreme Court, which determined that a crucial test for whether or not a stream is navigable is evidence that the stream was used for the historical transport of logs. The subgroup invited Steven Harold, Curator for the Manistee Historical Museum, to present evidence available on logging activities in the late 1800s and early 1900s adjacent to and in the proximity of Bear Creek in Manistee County.

Mr. Harold provided historical information on lumber camps and lumber staging areas adjacent to Bear Creek upstream of 13 Mile Road and at other locations within the Bear Creek watershed. This information led him to conclude that there is strong evidence that Bear Creek and tributaries were used to transport logs to saw mills located at the mouth of the Manistee River in the City of Manistee, since neither roads nor rail were available to transport logs during the early logging period. Mr. Harold had recently testified as an expert on historical logging operations in the upper Boardman River, where the court subsequently determined that the river was indeed navigable based upon the evidence of it being used for the floating of logs. The observation that Bear Creek shows signs even today of stream bank log rollaways at several locations would appear to confirm Mr. Harold's conclusion that Bear Creek was used for the transport of logs and is therefore a navigable river available to the public for floating, wading, and fishing.

### *MDNR Purchase of New Bear Creek Public Access*

Between meetings of the subgroup, the MDNR completed the final purchase of private property on Bear Creek to increase long-sought-after increased public access to Bear Creek. At a public meeting in Kaleva on the Greater Bear Watershed Plan, several Bear Creek property owners expressed dismay at the prospect of even more public use of Bear Creek based upon the litany of existing unresolved conflicts.

Despite reaching the conclusion that Bear Creek is indeed navigable, subgroup members expressed support for developing and advocating solutions to the legitimate issues facing the Bear Creek property owners. The subgroup asked the Bear Creek Watershed Council to prepare a comprehensive list of the

issues that Bear Creek property owners believe should be addressed and pledged its support to help find solutions for legitimate problems.

The Bear Creek Watershed Council surveyed its members and other property owners along Bear Creek and the following concerns were identified related to the potential increase in public use due to the state's recent purchase and future development of a new public access site on the river

### *In-stream and Streamside Habitat Changes*

- Accelerated bank erosion at road crossing sites where no managed egress/ingress is provided
- Expanded illegal tree cutting and bank brush removal on public and private riparian properties
- Damage to in-stream bottom habitat from use of larger vessels during low water conditions

### *Uses at New Access Site and Expanded Uses at Related Bridge Crossings Access Points*

- Overnight partying at site and dumping of trash
- Decreased value of private properties adjacent to site
- Lack of enforcement and site maintenance on site due to shortfalls in funding
- Increased shoulder parking, congestion, and related traffic hazards at Milks, Johnson, and Kerry road bridge crossings due to expected increase in dropoff and pickup of watercraft/anglers

### *Value of Private Riparian River Properties and Enjoyment by Residents*

- Accelerated trespass issues with boaters and wading anglers leaving the river and using private property between ingress and egress points
- Increased amount of loud, vulgar, and threatening behavior of groups using the river both during the day and at night that reduce the quality of life and land values for those who reside on private property adjacent to the river
- More trash and litter on stream banks and in the river from careless river users

### *Fishing Violations and Over-fishing for Resident Trout*

- Increased opportunity for snagging of salmon and steelhead and increased difficulty of enforcement
- Increased fishing pressure on resident trout populations resulting in potential decline in the number of trout available to anglers

### *Recommendations*

There are several mechanisms and tools available to address the legitimate concerns of Bear Creek property owners without excluding or severely restricting the public from reasonable use of the river. Some involve better information to public users, such as signage at the new public access site about the fact that the property on both sides of the river is private and that removal of tree limbs or brush or trespassing on private property is unlawful. Formal rules and effective enforcement of restrictions on the use of public access sites (such as prohibitions on overnight use, partying, camping) as well as enforcement of the prohibitions on salmon snagging can discourage use by those individuals and groups that have been the source of major conflicts with property owners. Improved bank stabilization and or stairs on pathways at bridge crossings can reduce stream bank erosion caused by launching or retrieving vessels and foot traffic. The acquisition of public property to provide additional parking at strategic points may also be needed to reduce congestion and road hazards. Voluntary agreements with guide services that use the river on the size of guide boats, frequency of use, and assistance in litter control and river stewardship can help reduce conflicts as well and have been effective in other rivers in Michigan. Special fishing regulations can be used to minimize the number of those who come to the river to illegally snag

salmon in the fall, or to reduce the pressure on resident trout should population monitoring indicate further harvest limitations are needed.

The best combination of these tools that will be most effective in reducing conflicts will take some time to develop, implement, and evaluate. As a minimum, three divisions of the MDNR (Parks and Recreation, Fisheries, and Law Enforcement), representatives of commercial fishing guides and kayak and canoe rental services, members of the current Greater Bear Steering Committee, and interested Bear Creek property owners need to be involved in the selection and implementation of alternatives to help minimize conflicts between public users and private property owners on Bear Creek. A permanent subgroup of the Greater Bear Watershed implementation team should be identified to take the steps needed to assemble an advisory group so that actions can be taken soon by the appropriate agencies in anticipation of expanded public use of the river. In the event that some proposed actions will require additional funding (such as printed informational materials for public users, signage, acquisition of property for off-road parking at strategic locations, bank stabilization/steps at critical bridge crossings), priority should be placed on seeking grants or other contributions needed to implement those improvements.

## *Aesthetics*

Two aesthetic concerns were voiced by the public during the development of this plan. Residents of the watershed expressed concern over what they believe are the growing number of blighted properties in the watershed and the effect these properties have on the quality of life and property values of area residents and the perception of visitors who come to the area to recreate, buy vacation homes, or retire. A significant number of people in the watershed have also expressed concerns about proposals to locate clusters of large-tower wind turbines in the area that could change the natural scenic vistas that attract many to buy homes or recreate in the area.

### *Urban and Rural Blight*

A number of people attending the public hearings on development of the plan expressed concern about the lack of uniform local regulation or the uneven enforcement of existing regulations to control the accumulation of inoperable vehicles, broken machinery, unused trailers, and other large discarded materials on residential and commercial properties. They also expressed concerns about abandoned residences and commercial structures. They believe that blight in both the small villages and rural areas in the watershed can affect nearby property values and undermines community efforts to encourage people to live, locate, and operate businesses and recreate in the watershed. The public cited this issue as an example of the need for better coordination between local units of government to develop and implement cooperative and consistent development goals, plans, and regulations to better serve the current and future residents of the Greater Bear Watershed.

### *Wind Turbines*

Growing interest in the development of alternative and sustainable energy sources in Michigan and government incentives to encourage investments in these new renewable energy sources has fostered new investments in wind turbines. The sites with sustained winds needed to support this emerging electric energy source in Michigan are limited, and some are found within the Greater Bear Watershed. A proposal by a major energy company to erect 100 or more utility-scale wind turbines in Benzie and Manistee counties has created significant conflict among residents. Those seeking employment opportunities or leasing income to preserve their family farming operations, and supporters of renewable energy in general are set against those opposed to the project because of negative visual impacts to the area and other concerns.

Because of the concerns expressed by residents about the potential negative impacts of large clusters of tall wind turbines, Manistee County Alliance for Economic Success has sponsored a number of public

meetings where citizens have been able to express their concerns or support or ask questions, and were provided information on the planned development of wind turbine energy. While there is broad support for the development of renewable energy sources and economic development in general by residents, many are seeking more information before endorsing the large proposed wind turbine development. More information on the subject of wind energy and the specific proposal in Manistee and Benzie counties is available from the Manistee County Alliance for Economic Success (Manistee County Alliance for Economic Success 2011).

# Section H: Critical and Priority Areas

Areas of particular significance for restoration and protection within the Greater Bear Watershed are described below. Critical areas represent those where restoration may be necessary; priority areas represent those where protection is important. These areas are described in Exhibits 81 and 87 along with the known or suspected pollutant or threat. Some of the identified critical and priority areas are broad because of limited information of specific sources or because they may be susceptible to impairment in the future and are in need of ongoing protection. These areas were identified to help develop goals and objectives and to guide future monitoring, planning, and management efforts. The areas described are either the sources of pollutants identified or those areas most susceptible to activities that could degrade water quality or valuable aquatic habitats.

## CRITICAL AREAS

As described earlier, controllable sources of phosphorus entering Bear Lake include leaching from onsite wastewater treatment systems (OWTS) adjacent to the lake and runoff from land areas that drain directly to the lake. It is estimated that there are more than 500 OWTS within 500 feet of the lake, a majority of which are over 30 years old. There are 36 identified grated storm drains connected to discharge points along the shore of Bear Lake and 13 known exit storm drains entering the lake. While nutrient loading is the primary concern from these priorities, the potential health risks from human pathogens entering the lake from OWTS and from runoff (household pets, farm animals, and large concentrations of waterfowl) are also a concern. Storm water runoff from urbanized impermeable surfaces and agricultural lands adjacent to the lake can also be a source of hazardous materials, sediments, and litter that can degrade the quality of Bear Lake.

The historical removal of shoreline vegetation concurrent with residential and business development on the shoreline of Bear Lake and on riparian properties along portions of Bear Creek and its tributaries has had an impact on the quality and quantity of nearshore aquatic vegetation and riparian natural vegetative buffers. The remaining wetlands (see Exhibit 29) adjacent to these watercourses serve a valuable function in filtering storm water runoff and providing aquatic habitat. Restoration and enhancement of native vegetation on the shoreline to provide a natural buffer strip between existing shoreline uses and the water can help reduce nutrients and other pollutants from entering the waterway from storm water runoff as well as enhance near shore aquatic habitat. Modification of existing hardened shoreline erosion devices (concrete, wood, or metal breakwalls) and the design of any new shoreline structures to incorporate features to filter storm water runoff and encourage nearshore aquatic habitat would be valuable.

Bear Creek and its tributaries are less susceptible to degradation from OWTS since the density of riparian residences and businesses adjacent to the river is less than that adjacent to Bear Lake. However, where homes and temporary residences are concentrated and immediately adjacent to Bear Creek, the localized, potential problems of nutrients and human pathogens leaching from OWTS into the stream are a concern. In addition, a number of sites have been identified during past surveys indicating that row crop production and animal grazing occurs to the edge of the stream that allows runoff and eroded bank materials to directly enter the waterway, increasing the risk of nutrient loading, sedimentation, and the transport of agricultural chemical residues.

Historical logging practices in the area left many raw banks exposed without vegetation to control erosion and sedimentation in the areas adjacent to Bear Creek and its tributaries. While substantial stream bank erosion control practices and in-stream habitat improvement have been implemented at a number of sites over the last decade to address these concerns, some work remains to be completed and long-term maintenance may be needed at some sites. Re-establishment of trees and shrubs on the banks that were

removed during the clear-cutting logging era is necessary to provide shade to maintain stream temperature favorable to trout and to establish streamside cover and a source of wooded debris for in-stream habitat.

Road stream crossings and foot paths used by recreationalists are also a source of eroded sand and silt to the river. It is important to improve and maintain road crossings and erosion control at river recreational access areas in order to prevent active erosion sites from contributing to sedimentation of the river system. Road stream crossings can also act as a barrier to aquatic species as they attempt to move through a water course if they are not designed appropriately.

**EXHIBIT 81.** Critical Areas of Concern in the Greater Bear Watershed

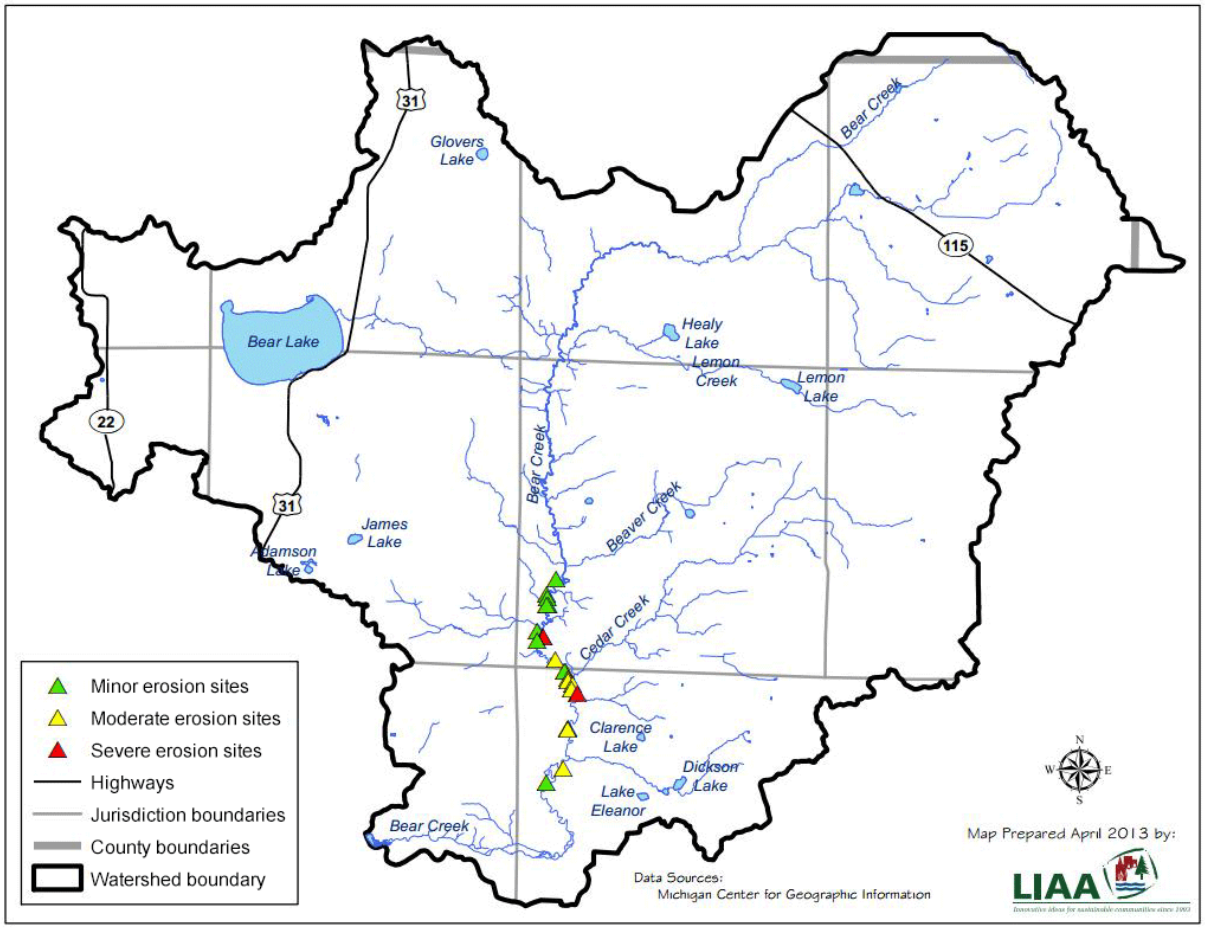
| Critical Area | Description | Pollutant/Threat |
|---|---|---|
| Riparian lake and stream properties where all streamside vegetation has been removed, hardened bank/shore erosion devices have been installed | Occupied waterfront properties where restoration/enhancement of shoreline vegetation is possible. A shoreline inventory along Bear Lake is recommended to further refine the extent of this critical area. | Loss of natural vegetation to prevent nutrients and other storm water pollutants from entering waterway and loss of critical shoreline and nearshore aquatic habitat. |
| Private agricultural lands adjacent to and within 300 feet of Bear Lake, Bear Creek and tributaries. | Active crop and grazing riparian lands without protective vegetative buffers and/or fencing. Information is not available at this time to further refine the areal extent of this critical area. An agricultural inventory is recommended using 2013 aerial photos commissioned by Manistee County. If lands adjacent to Bear Lake are identified as agricultural lands that are within this buffer, then they would be of a higher priority than Bear Creek due to the residence time of the lake. | Nutrients (fertilizers and manure), hazardous chemicals, sediments, and pathogens. |
| Active stream bank erosion sites in Bear Creek and tributaries related to historical logging practices and recreational access on public and private lands | High and moderate erosion sites identified in stream surveys that have not been addressed, or are in need of maintenance. | Sand and silt sedimentation causing impairment of stream habitat and increases in stream temperature. |
| Road stream crossings along Bear Creek and tributaries. | Road stream crossings that limit aquatic connectivity of native species, affect water chemistry, as well as nutrient and sediment transport. | Nutrient and sediment transport and can affect aquatic populations. |
| Locations where the lack of streamside shade and in-stream cover limits trout and salmon abundance | DNR Fisheries has identified a critical area of high public use at Coates Road and downstream of there as an area where fish populations can be enhanced. | Reduction in available year-round habitat for adult trout and juvenile salmon due to high temperatures and lack of cover. |
| OWTS located at permanent residences, vacation homes, and businesses adjacent to Bear Lake | Occupied properties within 500 feet of Bear Lake with OWTS in the Village of Bear Lake, and Bear Lake and Pleasanton townships. Information is not available at this time to further refine the areal extent of this critical area. | Nutrients, human pathogens and other contaminants potentially leaching to the lake from OWTS. |
| OWTS located at permanent residences, vacation homes and businesses adjacent to Bear Creek and tributaries. | Occupied properties within 500 feet of Bear Creek and tributaries; primarily in the river area located between Coates Road and 13 Mile Road. | Nutrients, human pathogens and other contaminants potentially leaching to the river from OWTS. |

SOURCE: Public Sector Consultants, 2012.

### *Stream Bank Erosion Sites*

The Conservation Resource Alliance (CRA), through collaborative efforts with local partners, maintains an inventory of stream bank erosion sites that it has prioritized for restoration. As of July 2012, the CRA identified 21 stream bank erosion sites in the Greater Bear Watershed, two of which are identified as the highest priority for restoration along Bear Creek (see Exhibit 82). The CRA has indicated that few stream bank erosion sites exist in the northern portion of the watershed because of restoration efforts that have occurred. More information is available on the CRA-supported website: www.northernmichiganstreams.org.

**EXHIBIT 82.** Greater Bear Watershed Stream Bank Erosion Sites

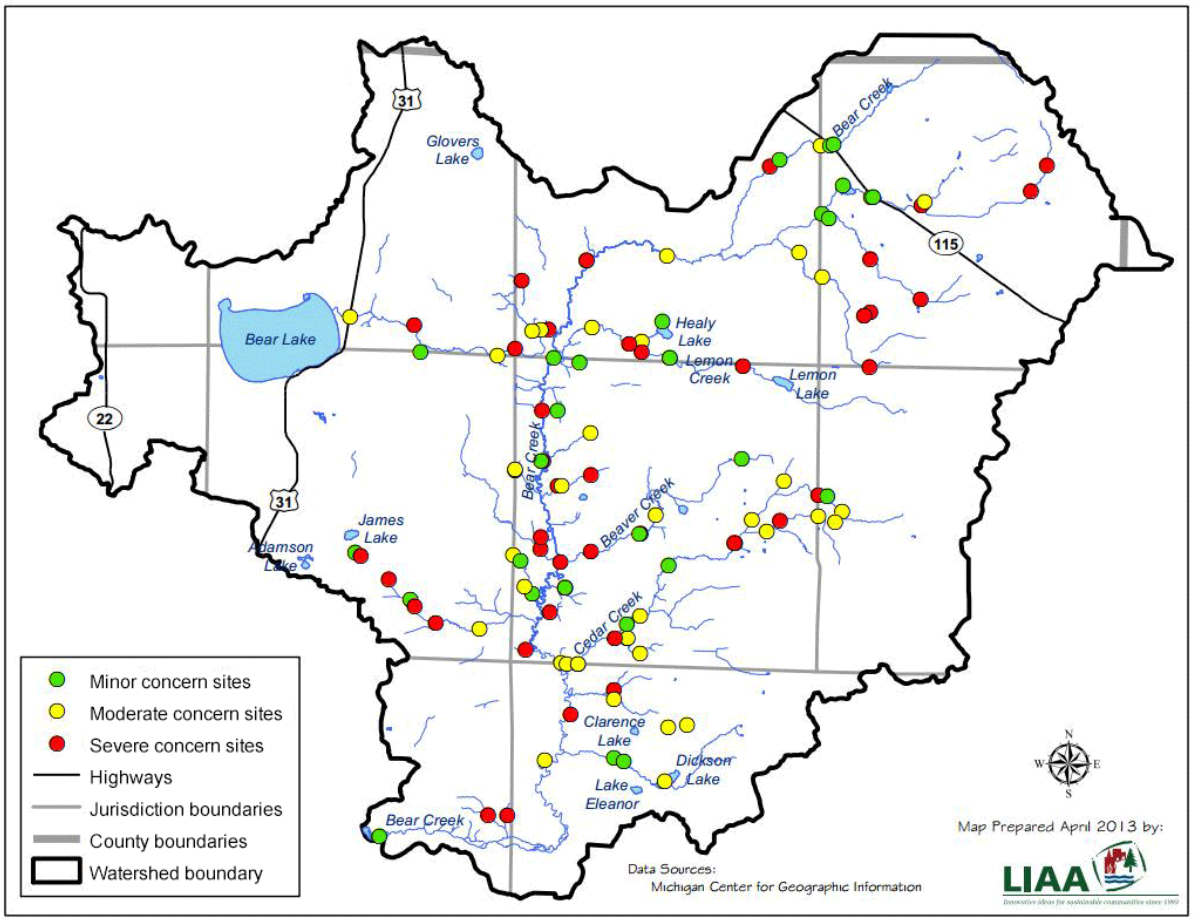



SOURCE: Land Access Information Association using information from the Conservation Resource Alliance, 2013.

### *Road Stream Crossings*

Similarly, the Conservation Resource Alliance (CRA), through collaborative efforts with local partners, maintains an inventory of road stream crossings that it has prioritized for restoration. In total, 112 road stream crossings have been identified within the watershed and rated as either minor (31 locations), moderate (37 locations), or severely impaired (44 locations) in terms of their impact on aquatic habitat (see Exhibit 83). Members of the steering committee determined that the CRA's inventory and prioritization process is the most effective way to determine priority locations for restoration. The CRA updates this information as it and other groups continue to restore impaired locations within the watershed. More information is available on the CRA-supported website: www.northernmichiganstreams.org.

**EXHIBIT 83.** Greater Bear Watershed Road Stream Crossing Sites

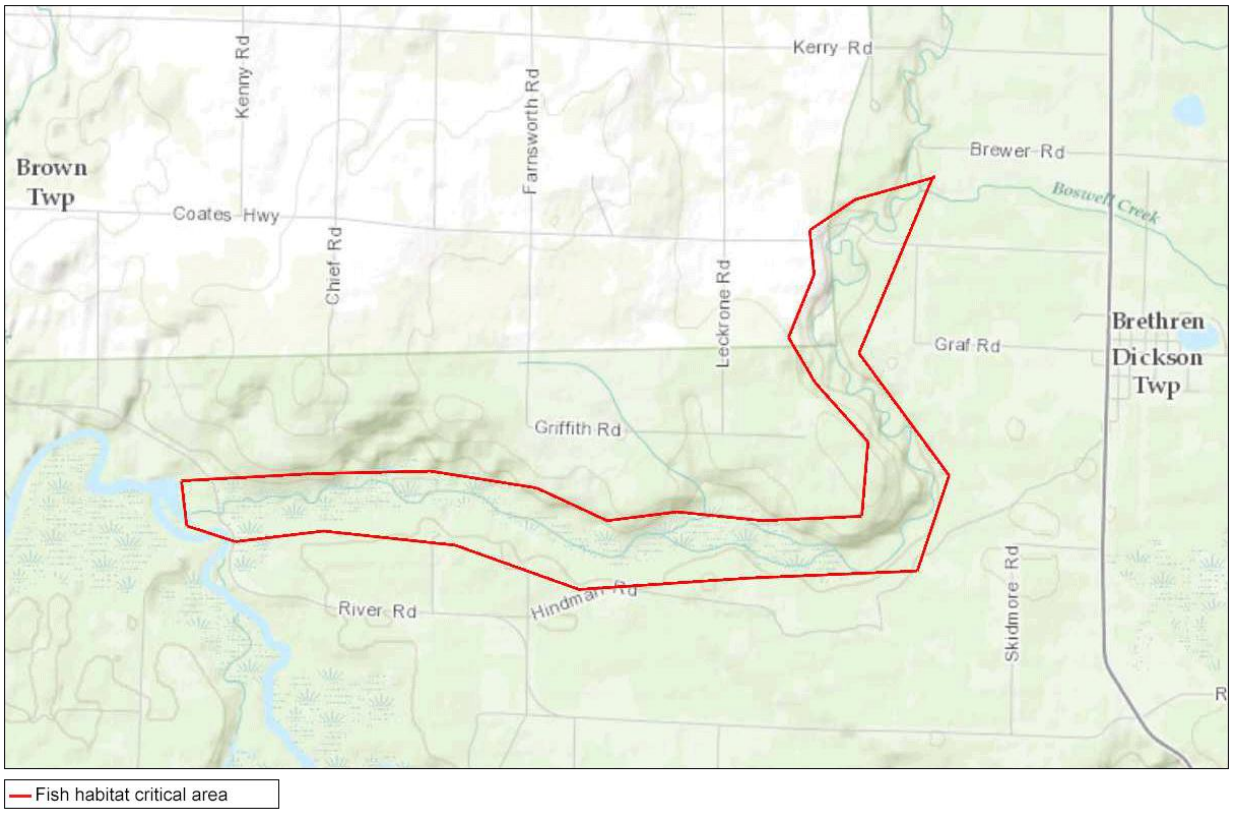



SOURCE: Land Access Information Association using information from the Conservation Resource Alliance, 2013.

### *Fish Habitat*

DNR Fisheries has identified a critical area of high public use on Bear Creek from Coates Road downstream to its confluence with the Manistee as an area where fish populations can be enhanced by improving streamside shade and in-stream cover to enhance trout and salmon abundance. This area is depicted in Exhibit 84.

**EXHIBIT 84.** Fish Habitat Critical Area

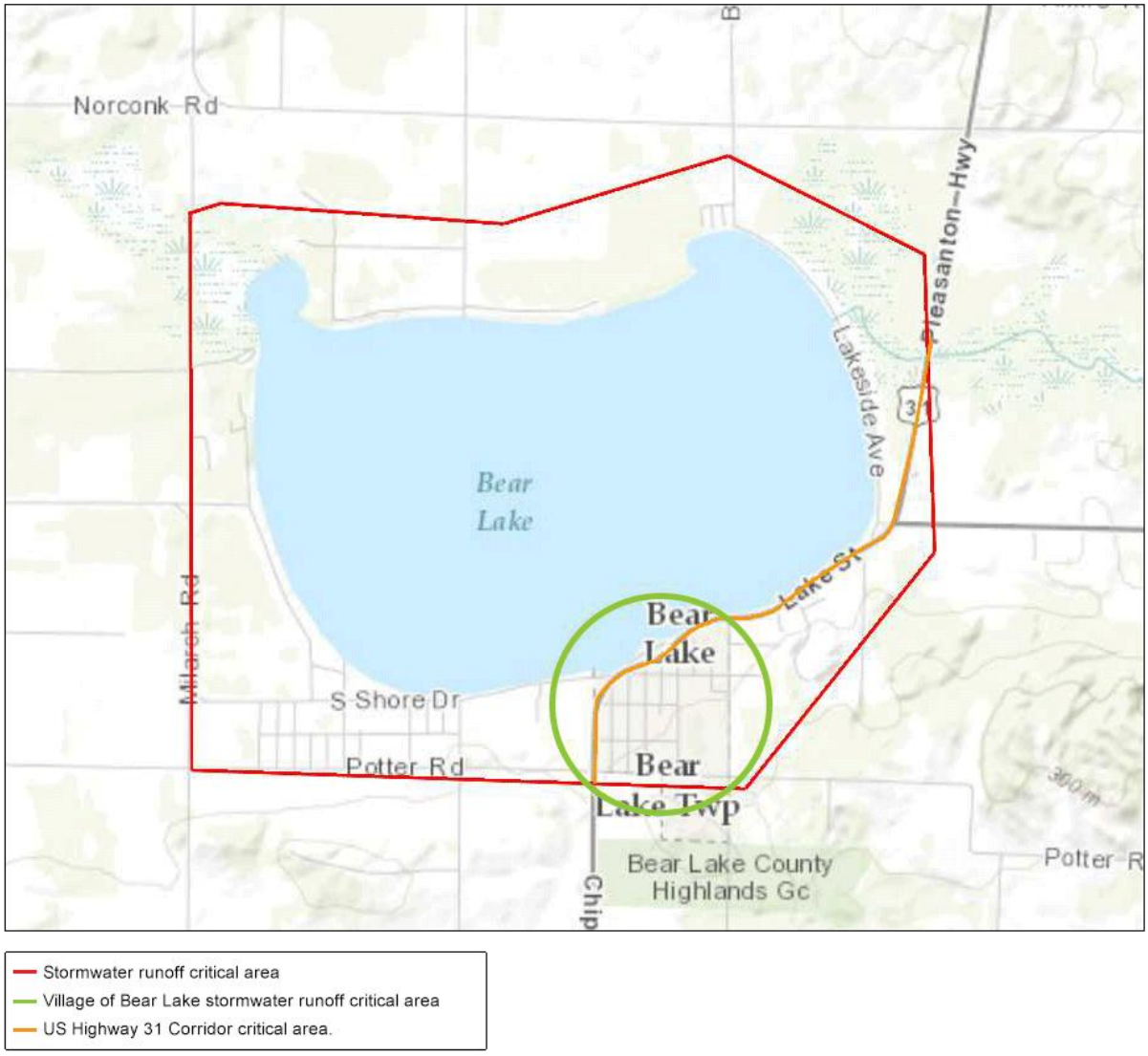



SOURCE: Public Sector Consultants, 2013.

### *Bear Lake Storm Water Runoff*

Storm water runoff from residences, business, agricultural lands, and roadways adjacent to Bear Lake are a potential source of pollution including nutrients, sediments, human pathogens, hazardous materials, and litter. A broad critical area is defined within 1,300 feet surrounding Bear Lake. The Village of Bear Lake is a more significant critical area because of a high amount of impervious surfaces and a storm water sewer system with outlets that drain directly to the lake. Additionally, the U.S. Highway corridor through the Village of Bear Lake is a higher priority critical area due to the potential risk of a spill of hazardous materials. These areas are shown in Exhibit 85.

**EXHIBIT 85.** Storm Water Runoff Critical Areas

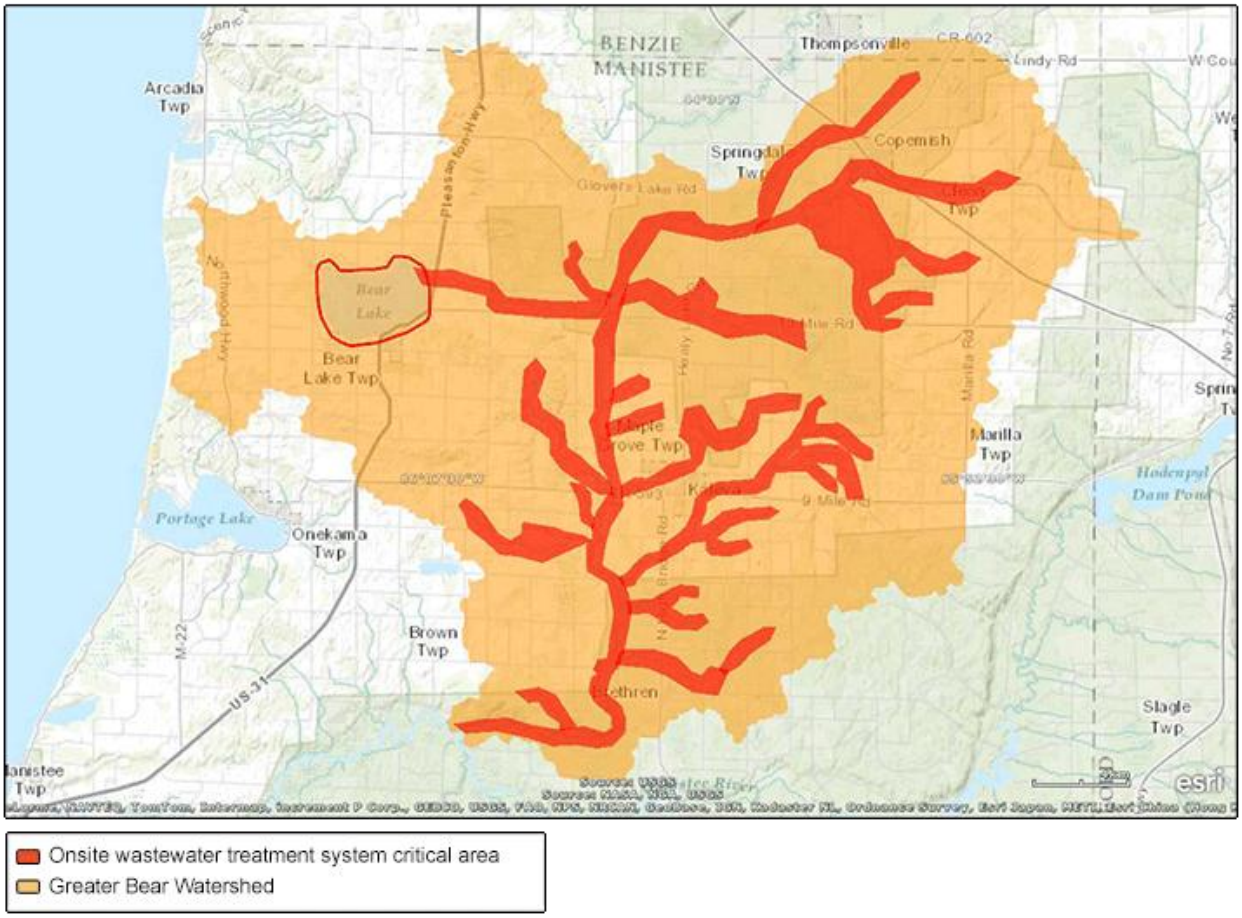



SOURCE: Public Sector Consultants, 2013.

### *Onsite Wastewater Treatment Systems Adjacent to Bear Lake, Bear Creek and Tributaries*

Onsite wastewater treatment systems located at permanent residences, vacation homes, and businesses within 500 feet of Bear Lake and Bear Creek are a potential source of nutrients, human pathogens, and other contaminants to the watershed. A general depiction of these areas is shown in Exhibit 86.

**EXHIBIT 86.** Onsite Wastewater Treatment Systems Critical Area




SOURCE: Public Sector Consultants, 2013.

Over the last 30 years, Bear Lake has seen expanded uses and increasing development in the form of permanent homes and seasonal cottages adjacent to the lake, prompting concerns related to increasing nutrient loadings to the lake. Investigations by property owners revealed that a majority of OWTS serving residences around Bear Lake have not been upgraded for over 30 years. After considerable discussion, a sewer system to serve a majority of residences on Bear Lake was proposed. Michigan Public Act 188 was the basis to develop a special assessment district to pay for the sewer. PA Act 188 requires owners of more than 50 percent of the acres in the district to sign a petition in favor of the sewer. This was accomplished. Considerable vocal opposition was heard at meetings at the Pleasanton and Bear Lake township board meetings when the petitions were presented. By a narrow margin, the boards voted to stop the proposed sewer project before final engineering design and cost estimates were developed.

### *Measures of Increased Productivity (Nutrient Enrichment)*

Thirty years of annual volunteer monitoring of traditional and relatively easily measured parameters of the trophic status (productivity) of Bear Lake, namely transparency (Secchi disk readings) and chlorophyll *a*, has not indicated a significant increase in productivity due to increased nutrient loadings to the lake. Unfortunately, these parameters that are used to measure productivity using a Trophic State Index (TSI) are not very effective in relatively shallow lakes such as Bear Lake, where the majority of productivity may be due to rooted aquatic plants versus algae. Periodic measures of total phosphorus in Bear Lake, an alternative measure used in determining the TSI of lakes, have been infrequent and inconclusive with respect to detecting any trends in productivity. Other measures that can be used to detect changes in productivity in lakes include the increase in the abundance of rooted aquatic plants, the increase in algal species indicative of nutrient enrichment, increasingly wide swings in 24-hour dissolved oxygen concentrations, and changes in abundance of certain bryozoans (freshwater sponges). It is expensive to systematically measure these parameters over time, however, and technical expertise and/or equipment beyond the capability of volunteers is often needed.

The invasion of zebra mussels into Bear Lake is complicating the use of traditional sampling parameters to measure increases in productivity. The water clarity (transparency) of the Great Lakes and large inland lakes has dramatically increased as a result of the introduction of invasive aquatic zebra mussels and, more recently, quagga mussels. Zebra mussels and quagga mussels are extremely efficient filter feeders that consume available algae. The effects of the introduction of zebra and quagga mussels on the food web of aquatic ecosystems can be dramatic, and likewise the effects of these invasive species on traditional measures of productivity in inland lakes are poorly understood.

Another complicating factor in measuring the productivity of Bear Lake is the presence of yet another invasive species, Eurasian milfoil. The ecosystem response over the long term to both the invasion of Eurasian milfoil and the annual chemical treatments to control its abundance is not yet known. While the chemicals used are targeted to milfoil, the herbicides applied may well affect the abundance of other rooted aquatic plants.

### *State Water Quality Standards*

Three water quality standards relate directly or indirectly to inputs from OWTS. The primary standard related to public health is a measure of the abundance of human pathogens as measured by the number of *E. coli* bacteria present in water samples. While pets and wildlife can be a source of *E. coli*, the most likely human source in Bear Lake is inadequate or failing OWTS of adjacent homes and businesses. Unfortunately, no systematic measurements of *E. coli* have occurred in Bear Lake, and bacteria levels at popular swimming and wading areas around the lake are unknown.

The water quality standard most directly related to excessive nutrients is the frequency of nuisance algae blooms that interfere with protected water uses, and no reports of such blooms have surfaced from either members of the Greater Bear Steering Committee or riparian residents on Bear Lake who attended the public hearings.

While the water quality standard for dissolved oxygen is designed to protect fish in Bear Lake, a designated warmwater lake, dissolved oxygen concentration reflects productivity indirectly. Wide fluctuations from super saturation of dissolved oxygen during the day to concentration below the water quality standard in the early morning usually indicate excessive nutrient inputs. Phosphorus is the key limiting nutrient in Bear Lake, and storm water as well as OWTS are the most likely sources of phosphorus in Bear Lake. Only single daytime readings of dissolved oxygen are currently available from Bear Lake, and these are insufficient to determine whether the state warmwater lake standard is being met.

### *Implications for Property Owners*

Manistee County has adopted the District 10 Health Department regulation that requires OWTS to pass an inspection prior to the sale of property. If an OWTS fails to pass inspection (i.e., sewage backs up into the home, it discharges to the ground surface, or contaminates the surface water or drinking water supplies), the homeowner must repair or replace the system to meet current standards before the sale can occur. The inspection criteria are based upon a health standard related to human pathogens and do not take into consideration the potential for an older system to be leaching nutrients such as phosphorus into nearby lakes or streams. If the failure requires construction of a new drain tile field and the lot size or elevation of groundwater prevents replacement, a so-called "mounded" system is approved where additional pervious fill material is brought to the site to add separation between tile field and groundwater.

Riparian property owners with limited lot sizes or near surface groundwater adjacent to Bear Lake have little option but to construct a mounded drain field if they would like to expand the use of their residence by adding bathrooms, a washing machine or dishwasher, or by installing a garbage disposal; any such expanded use is likely to cause their current OWTS to fail.

While physical separation of the tile field and groundwater can be effective in preventing the movement of human pathogens into drinking water supplies or surface water, the capacity of drain field soils to capture and hold nutrients such as phosphorus is limited. Over time the capacity of soils to capture phosphorus is saturated and the nutrients leach to the groundwater and, if near a lake or stream, discharge to a surface water body. In general, septic tile fields with the routine pumping of solids from septic tanks are designed to last for approximately 30 years of year-round use provided the size of the home and the number of wastewater-generating appliances remain the same. The U.S. Environmental Protection Agency estimates that the failure rate for OWTS is between 15 and 20 percent per year. In Michigan counties where inspections at the time of sale have been ongoing for a number of years and the performance of the tile field is tested, a 15 to 20 percent failure rate is common.

### *OWTS Recommendations*

The age and outdated design of existing OWTS surrounding Bear Lake, as well as expanded wastewater inputs into these systems, will likely require residents to replace current systems due to failures at an increasing rate over the next few years. The options currently available are limited to construction of expensive mounded systems or the installation of a holding tank, pump-out system that has a very high operating cost. At some point, property owners are likely to decide that the most cost- effective course will be to construct a municipal sewer system for all or a significant portion of the riparian properties which will preserve their property values and water quality, and protect current uses of Bear Lake. In the interim the following actions, also included in Exhibit 89 in the Goals and Objectives section, are recommended:

- Maintain current voluntary measurements of transparency and chlorophyll *a*
- Expand annual sampling for total phosphorus to determine if this limiting nutrient exceeds acceptable levels for protecting existing uses
- Initiate periodic testing for *E. coli* based upon state standards during the open water season to assure residents, their guests, and visitors that the lake is safe for full and partial body contact recreational uses
- Implement at least one year of sampling to determine whether or not the state water quality standard for minimum dissolved oxygen levels is being met
- Plan and implement a sampling (to occur every five years) to estimate the biomass of aquatic rooted plants in the lake to establish a baseline and trends
- Prepare and distribute to lake residents information on the operation, design, maintenance, and limitations of current OWTS

- Advocate for provisions in the sanitary code that would require new or replacement OWTS be designed in such a way that the cost of conversion to a municipal sewer system will be minimized
- Actively pursue alternatives for control of storm water discharges to the lake to minimize both nutrients and *E. coli* inputs
- Perform an engineering study to identify sources and contribution of pollutants from unmanaged storm water entering the lake and recommend best management practices to reduce loadings
- Explore alternative means to effectively measure trends in lake productivity that may be more sensitive in predicting degradation of water quality

# PRIORITY AREAS

Priority areas within the Greater Bear Watershed are regions where continued protection is important to maintain and enhance the ecological conditions in the watershed. These include existing wetlands and other properties of ecological significance along Bear Lake, Bear Creek, and tributaries, and other upland areas in the Greater Bear Watershed. These priorities are described in Exhibit 87.

**EXHIBIT 87.** Priority Areas of Concern in the Greater Bear Watershed

| Priority Area | Description | Pollutant/Threat |
|---|---|---|
| Existing undeveloped wetlands adjacent to Bear Lake, Bear Creek, and tributaries | Riparian lake and stream properties where valuable shoreline wetlands remain intact. | Loss of natural vegetation to prevent nutrients and other storm water pollutants from entering waterway and loss of critical shoreline and nearshore aquatic habitat. |
| Properties of conservation significance identified through Grand Traverse Regional Land Conservancy (GTRLC) prioritization process | Wetlands and habitat areas adjacent to Bear Lake, Bear Creek, and its tributaries, and other targeted lands in the watershed. | Sedimentation, surface runoff, nutrients, and chemicals. |

SOURCE: Public Sector Consultants, 2012.

## *Wetland Preservation*

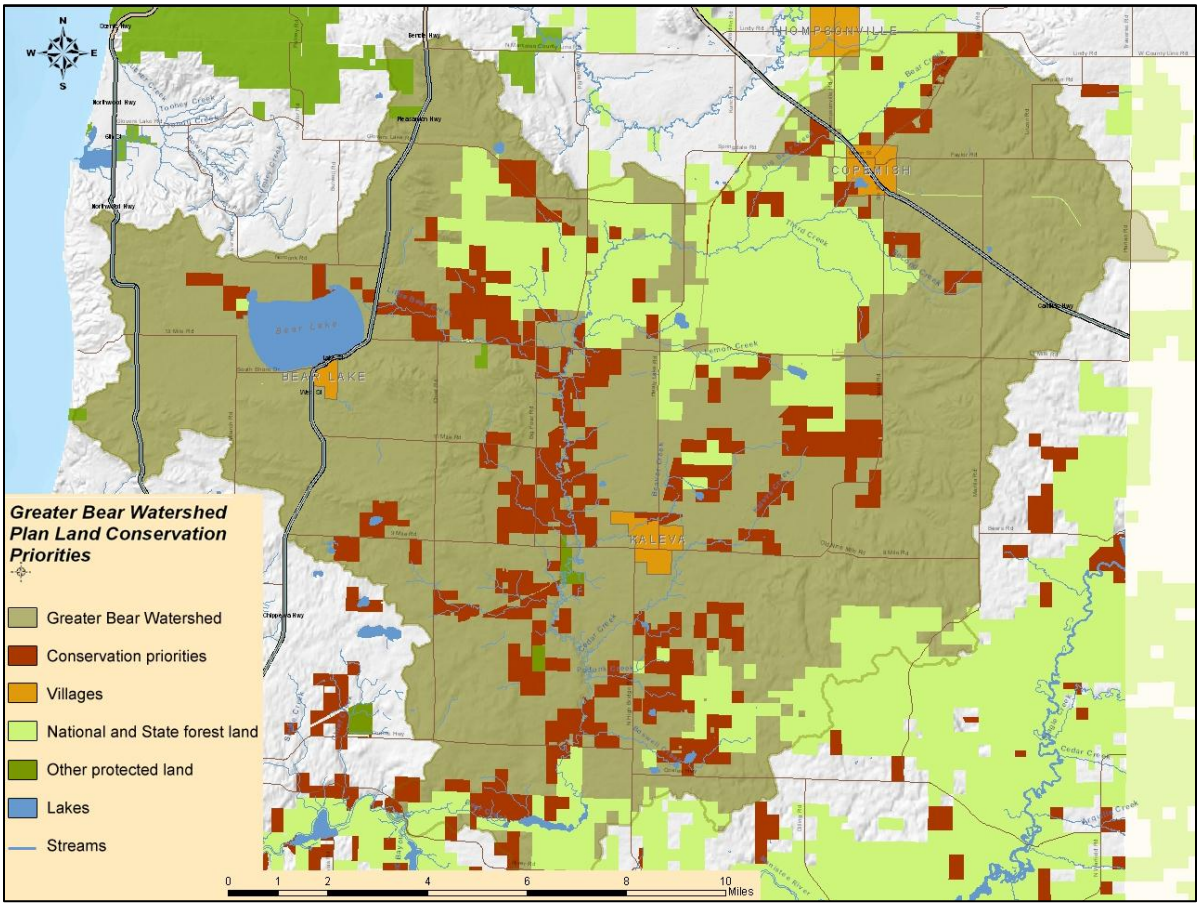
As summarized in the Description of the Greater Bear Watershed section of this report, wetlands provide many ecological services of significance to watershed management. Priority wetlands for continued protection should be further evaluated by Greater Bear Watershed steering committee members to further define those of particular importance. Many of these lands are already within public ownership and many others are included in priority lands for continued preservation described below.

## *Conserved Lands*

The Grand Traverse Regional Land Conservancy (GTRLC) developed an approach to identify priority lands for conservation in the northwest Lower Peninsula, and some of this land is within the Greater Bear Watershed (see Exhibit 88). The factors used to prioritize these lands are parcel area (size), adjacency to protected land, habitat fragmentation, presence and contiguity of wetlands, endangered species occurrence, and shoreline length. This process identified many regions adjacent to Little Bear Creek, and the main stem of Bear Creek, as the highest priorities for conservation. Many other tributaries to Bear Creek are identified as medium priority for conservation.

The information from the GTRLC was reviewed by members of the Greater Bear Watershed Plan Steering Committee; the members agreed that the method is well developed and is the best approach to identify areas for conservation through acquisition of fee simple or lesser interests in land within the watershed. The GTRLC updates its priority list from time to time as new parcels are acquired or as conditions change. More information is available on its website: www.gtrlc.org. In addition to lands identified by the GTRLC, wetlands areas adjacent to Bear Lake were also identified as priorities for conservation.

**EXHIBIT 88.** Greater Bear Watershed Priority Lands for Preservation




SOURCE: Grand Traverse Regional Land Conservancy, prepared for the Greater Bear Watershed Steering Committee.

# Section I: Goals and Objectives

## VISION

The vision of the Greater Bear Watershed Management Plan, developed by the stakeholders in the watershed, is to build a consensus for actions by individuals, private organizations and governmental partners that will achieve common objectives through: cooperative, coordinated efforts that support sustainable use and development of the water resources; encourage closely related wise land use practices; and, enhance historical and cultural amenities that make the area a prosperous, attractive place to live, work, and recreate for present and future generations.

## GOALS AND OBJECTIVES

There are eight major goals for the Greater Bear Watershed and a series of recommended objectives and actions for each of these goals. The first five relate directly to identified protected and desired water uses in the watershed and the categories for the goals follow those established in the report used to identify existing or potential threats to legally protected uses of the surface and groundwater resources within the watershed. The sixth goal reflects the concerns expressed during the public meetings related to the economic well-being and general quality of life in the watershed. The residents of the watershed specifically identified lack of youth employment opportunities, the increasing percentage of the population in the watershed over 65, the value of scenic vistas, and the growing evidence of abandoned and blighted properties as major concerns. The final two goals focus on next steps in the implementation of the watershed plan, namely, plan leadership and periodic evaluation of progress.

- **Pathogens Affecting Humans**—Minimize presence of pathogenic organisms that impair swimming, wading, fishing, boating, water skiing and other full or partial body contact water recreation activities.
- **Ecosystem Health**—Protect and restore essential physical habitat, and maintain compliance with water quality standards designed to protect fish, wildlife, and other aquatic organisms.
- **Hazardous Materia**ls—Prevent future and reduce current impacts on people (fish consumption advisories) and the environment.
- **Invasive Species**—Control abundance and further distribution of exotic species injurious to protected human uses (i.e., swimming, boating, fishing, etc.) and native plants and animals.
- **Groundwater**—Protect quality and quantity of domestic and agricultural water supplies and the source of cool, clean water to surface lakes and streams.
- **Joint Planning and Development**—Coordinated local economic and land use planning to preserve and optimize local assets and expand sustainable economic development and related employment.
- **Sustainable Implementation of Greater Bear Watershed Plan**—Formation of Greater Bear Watershed Management Plan Coordinating Committee and identification of leadership responsibilities.
- **Evaluation and Revision of Management Plan Progress**—Periodic assessment of progress in implementing actions and in meeting objectives, and targets for plan revisions and updates.

## IMPLEMENTING PLAN RECOMMENDATIONS

The Greater Bear Watershed Coordinating Committee is a relatively new group comprising representatives of many organizations involved with different activities that affect the health and quality of the watershed. These groups have a history of collaboratively implementing projects to monitor and improve conditions of the watershed; efforts have frequently been conducted with a subwatershed focus. Many of the highest priority actions for implementing the watershed management plan relate to

developing an organizational framework to ensure plan recommendations are achieved for the watershed as a whole. In 2013 the steering committee will form a Coordinating Committee to implement plan recommendations by partnering with groups active in the development of the plan and groups that indicated a willingness to implement recommendations. Implementation activities related to this effort are summarized under goals 7 and 8 in Exhibit 89.

In addition to formalizing the organizational and implementation structure to achieve plan recommendations selected priority activities expected to commence in 2013 include the items identified below. These activities include items from the Education Plan. Further detail about these actions and others are included Exhibits 89; 91; and 92.

- Maintain and enhance the www.bearwaters.org website to include additional educational materials
- Develop a contact directory of groups and individuals to engage in watershed activities
- Meet with representatives of the local units of government active within the watershed to discuss plan recommendations and opportunities for collaboration
- Conduct sampling for pathogens affecting humans such as *E. coli* in Greater Bear waterways
- Commence planning activities to conduct various land inventories to further assess hardened shoreline around Bear Lake and implement a demonstration project, storm water drains, and agricultural properties and management practices
- Continued monitoring of Bear Lake, Bear Creek, and tributaries for various physical, biological, and chemical parameters
- Continued treatment of Bear Lake for Eurasian milfoil
- Implement stream habitat restoration projects in Bear Creek
- Seek funding to implement one stream bank erosion restoration project on Bear Creek
- Seek funding to implement a restoration project at the first downstream road stream crossing blocking fish passage to Bear Creek and its tributaries.
- Secure funding to implement a pilot project to obtain a portable boat cleaning station to decrease the risk of unintentional spread of invasive species within the watershed, including a staff person for its operation
- Convene representatives of other watershed groups to assess opportunities for collaboration and cooperation to implement plan recommendations

Exhibit 89 outlines the goals, including priorities and estimated costs for the recommended actions to achieve the respective goals. In some instances the exhibit provides specific references in support of the actions recommended. The exhibit also identifies potential agency partners and organizations by the following acronyms:

### *Potential Partners*

- **Nonprofit Organizations**—Bear Creek Watershed Council (BCWC), Bear Lake Improvement Board (BLIB), Bear Lake Property Owners Association (BLPOA), Bear Lake Watershed Alliance (BLWA), Conservation Resource Alliance (CRA), Cooperative Weed Management Area (CWMA), Grand Traverse Regional Land Conservancy (GTRLC), and Manistee County Alliance for Economic Success (AES)
- **Federal Agencies—**Department of Agriculture, Soil Conservation Service (SCS) and United States Forest Service (USFS); and Department of the Interior, United States Fish and Wildlife Service (USFWS)

- **State of Michigan Agencies**—Michigan departments of Natural Resources (MDNR), Environmental Quality (MDEQ), Transportation (MDOT), Community Health (MDCH), and Agriculture and Rural Development (MDARD)
- Michigan State University—Extension (MSUE)
- **Local Government—**Bear Lake, Lake Improvement Board (LIB), Villages of Bear Lake, Kaleva, and Copemish (Villages); townships within the watershed (Twps) [Benzie County: Colfax and Joyfield Townships; Manistee County: Arcadia, Bear Lake, Brown, Cleon, Copemish, Dickson, Maple Grove, Marilla, Onekema, Pleasanton, Springdale Townships; Wexford County: Wexford Township]. See Exhibit 4 in the Description of the Greater Bear Watershed section, for information on the extent to which the watershed extends into these communities.
- **Manistee County Government—**Soil Conservation District (MSCD), Road Commission (MCRC), Planning Department (MCPD), Emergency Response Management (MERM)
- **Native American Tribal Government—**Little River Band of Ottawa Indians (LRBOI)
- **Regional Government—**Northwest Michigan Council of Governments (NWMCOG), District #10 Health Department (D#10HD)

If additional partners not identified express interest in plan implementation they should be engaged as appropriate.

### *Estimated Cost and Timeline*

The timeline begins when the plan is completed. Prioritization of tasks should be re-evaluated two years after the plan is approved. Estimated costs for implementing the goals over the 10-year horizon of the plan are identified by task in Exhibit 89. Estimates are subject to change as new information becomes relevant or as conditions in the watershed change.

Exhibit 89 contains a timeline that begins from plan completion. Many tasks will not be implemented immediately and may occur over many years of watershed plan implementation. Years in which recommendations are suggested to occur are indicated as such with an "X" in a box corresponding to the year. If conditions change or opportunities to pursue tasks emerge, the Greater Bear Watershed Plan implementation partners should re-evaluate the relative priorities and distribution of resources. Similarly, many tasks will require ongoing actions throughout the course of this plan. Information and education activities are also an important aspect of achieving the eight watershed goals. Many supporting information and education activities are included in Exhibit 92.

## **EXHIBIT 89.** Recommended Actions to Achieve Watershed Plan Goals

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GOAL 1. Pathogens Affecting Humans** – Minimize presence of organisms that impair swimming, wading, fishing, boating, water skiing and other full or partial body contact water recreation activities. | | | | | | | | | | | | | | | |
| **1.A.** Monitor Bear Lake for bacteria on routine basis to assure residents and visitors that the state WQS for total body contact recreational activities is being met from May 31-October 1 of each year. | **1.A.1.** Conduct *E. coli* bacteria sampling at the Township Park, the MDNR access site and at three other locations on Bear Lake every two weeks during the months of June, July, and August for three years. Thereafter, adjust sampling frequency and locations based upon previous three years' results. (see Monitoring Plan) | **BLPOA, BLWA,** D#10HD, , Bear Lake Twp, Bear Lake Village, Pleasanton Twp | High | Establish monitoring plan in '13<br><br>Annual monitoring | $20,000–$30,000 | X | X | X | X | X | X | X | X | X | X |
| **1.B.** Assure that Bear Creek meets state WQS for partial body contact recreational activities throughout the year. | **1.B.1.** In conjunction with the first year of sampling in Bear Lake, conduct additional *E. coli* sampling twice during the summer period at 4 bridge crossing locations on Bear Creek for one year. Thereafter, adjust locations and frequency based upon first year results (see Monitoring Plan) | **BCWC,** CRA, D#10HD, LRBOI | High | Establish monitoring plan in '13<br><br>Sampling as necessary | $10,000–$30,000 | X | X | X | X | X | X | X | X | X | X |

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.C.** Reduce sources of human pathogens | **1.C.1.** Support adoption of local ordinances that prohibit artificial feeding of waterfowl in or on the riparian properties adjacent to Bear Lake | BLPOA, BLWA, Twps, Bear Lake Village, **MCPD** | Medium | I/E materials on Web in '13<br><br>Provide sample language to Twps and village '15 | $10,000 | | | X | X | X | X | X | X | X | X |
| | **1.C.2.** Seek funding to develop and distribute educational materials to area residents and visitors that: explains the human health risks associated with artificial feeding of waterfowl, uncontrolled pet and livestock waste, and failing onsite wastewater treatment systems, and the BMPs that minimize these sources of human pathogens (see Education Plan) | **BCWC, BLPOA, BLWA**, Villages, MCPD | High | I/E materials on Web in '13<br><br>Triennial distribution (see Education Plan | Estimated cost included in I/E plan | X | X | | | X | | | X | | |
| | **1.C.3.** Seek funding for and implement demonstration projects that would encourage the application of BMPs to reduce sources of human pathogens along Bear Lake, Bear Creek and/or tributaries | BCWC, BLWA, BLPOA, CRA, MSCD, MDEQ, MDNR | Medium | ID sites in '13 (see 1.B.1);<br>Provide I/E materials to ag land owners '14;<br>Prepare proposal in '15;<br>Implement '16/'17 | $75,000 | X | X | X | X | X | | | | | |

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Goal 2. Ecosystem Health** – Protect and restore essential physical habitat, and maintain compliance with water quality standards designed to protect fish, wildlife and other aquatic organisms. | | | | | | | | | | | | | | | |
| **Nutrient Management** | | | | | | | | | | | | | | | |
| **2.A.** Reduce nutrients and other surface runoff pollutants from entering Bear Lake, incorporating principles of Low Impact Design | **2.A.1.** Perform engineering study to identify sources and contribution of pollutants from unmanaged storm water entering the lake and recommend storm water BMPs to reduce loadings | BLPOA, **BLWA**, CRA, MCPD | High | Field work '13; GIS Maps '14; Die Test '15; ID BMPs '16; | $35,000–$100,000 | X | X | X | X | | | | | | |
| | **2.A.2.** Implement cost-effective BMPs for management of storm water discharged by conduits and drains to the lake using the principles of Low Impact Design. | BLPOA, **BLWA**, MCRC, Twps, Village | High | Complete 2.A.1 As necessary | $100,000–$250,000 | | | | | X | X | X | X | X | X |
| | **2.A.3.**Stencill storm water drains indicating they flow to Bear Lake | BLPOA, **BLWA**, MCRC, Twps, Village | High | Complete 2.A.1 20%/year '15 -20 | $10,000 | | | X | X | X | X | X | | | |
| | **2.A.4.** Seek funding for and implement demonstration projects that would encourage the application of BMPs on private riparian property to retain and filter runoff | **BCWC, BLWA, BLPOA,** CRA, MDEQ, MDNR | Medium | Secure funding & complete 1 project '13–'14 | $25,000 | X | X | | | | | | | | |
| | **2.A.5.** Distribute educational materials on BMPs that can be used by homeowners to retain and filter runoff from impervious surfaces on their property (see Education Plan) | **BCWC, BLPOA**, **BLWA**, CRA, MSCD, MCPD | Medium | I/E materials on Web in '13<br><br>Triennial distribution (see Education Plan) | Estimated cost included in I/E plan | X | X | | | X | | | X | | |

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2.B.** Reduce nutrients and other pollutants from entering Bear Creek and tributaries from riparian properties | **2.B.1.** Produce and distribute educational materials to residential, business, and farming riparian property owners on how to apply BMPs to reduce nutrient & sediment loading to Bear Creek and tributaries (see Education Plan) | **BCWC**, MSCD | Medium | Materials on Web '13; Educational forum '14; ID properties '15 | Estimated cost included in I/E plan | X | X | X | | | | | | | |
| | **2.B.2** Conduct an assessment of agricultural properties and management practices with the farming community to determine properties to implement BMPs | BCWC MDARD, MDEQ, **MSCD** | High | Aerial inventory '13; ID Ag land '14; ID Parcels '15; Approach land owners '15-'22 | $35,000 | X | X | X | X | X | X | X | X | X | X |
| **2.C.** Monitor productivity of Bear Lake | **2.C.1.** Measure transparency, chlorophyll *a* and/or total phosphorus throughout the open water season to detect changes in trophic status (see Monitoring Plan) | BLIB **BLPOA**, BLWA, Twps, Villages | High | Annual Monitoring | $20,000 | X | X | X | X | X | X | X | X | X | X |
| | **2.C.2.** Measure rooted plant biomass to measure changes (see Monitoring Plan) | BLIB **BLPOA**, BLWA, Twps, Villages | Medium | Sample '16 Compare to prior studies '17 | $5,000–$10,000 | | | | X | X | | | | | |

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Habitat Protection** | | | | | | | | | | | | | | | |
| **2.D.** Protect remaining wetlands and natural shore vegetation on Bear Lake, Bear Creek, and tributaries to maintain natural filter for nutrients and other pollutants contained in storm water runoff and provide habitat for aquatic species | **2.D.1.** Develop and distribute educational materials to riparian property owners on the value and importance of riparian wetlands and vegetative shoreline areas (See Education Plan) | **BCWC**, **BLPOA**, BLWA, CRA | High | I/E materials on Web '13<br>Triennial distribution (see Education Plan) | Estimated cost included in I/E plan | X | X | | | X | | | X | | |
| | **2.D.2.** Support adoption/enforcement of congruent local regulations that require impervious surface setbacks from waterbodies, and other provisions to reduce impacts on aquatic habitat | Twps, Villages, **MCPD** | Medium | I/E materials on Web '13;<br>Draft sample language/manual '14;<br>Meet with local officials '15 (ongoing) | $20,000 | X | X | X | X | X | X | X | X | X | X |
| | **2.D.3.** Conduct an assessment of remaining wetlands and determine highest priority parcels for continued preservation. Acquire fee ownership and/or easements by public or private entities to provide long-term protection. | **GTRLC**, MDNR | Medium | Landowner Workshop '13/14<br>80 Acres/year on average | $1,000,000 | X | X | X | X | X | X | X | X | X | X |
| **2.E.** Restore in-stream and shoreline habitat/vegetative cover | **2.E.1.** Insert woody debris in selected areas in Bear Creek where MDNR Fisheries has determined lack of natural cover is limiting resident trout populations like the area proximate to the Coates Highway bridge (Tonello 2011) | BCWC, **CRA, MDNR**, LRBOI | Medium | ID locations '13<br>Write proposals '14<br>Complete 5 sites/10 yrs | $50,000 | X | X | X | X | X | X | X | X | X | X |
| | **2.E.2.** Establish shoreline trees and/or shrubs along Bear Creek where the lack of shade is a contributing factor to summer stream temperatures higher than WQS for trout and salmon (Tonello 2011) | BCWC, **CRA, MDNR,** LRBOI | Medium | ID locations '13<br>Write proposals '14<br>Complete 5 sites/10 yrs | $100,000 | X | X | X | X | X | X | X | X | X | X |
| | **2.E.3.** Implement at least one demonstration project on Bear Lake where hardened erosion protection is modified to incorporate habitat restoration | **BLWA,** CRA, MSCD, MDNR | High | ID property '13<br>Implement '14<br>Hold I/E event '15 | $50,000 | X | X | X | | | | | | | |

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2.E.4.** Develop a shoreline inventory of Bear Lake to identify priority locations for restoration projects | BLPOA, **BLWA**, MDNR, MDEQ, MCPD | High | Develop methodology '13; Field Assessment '14; Develop map '15 | $10,000–$30,000 | X | X | X | | | | | | | |
| **2.F.** Restore bank stability on Bear Creek where historical logging practices and related activities or current uses have removed natural vegetative cover | **2.F.1.** Continue to restore severely and moderately eroding priority sites and evaluate effectiveness at previously restored sites using inventory and ranking of bank erosion sites compiled by the Conservation Resource Alliance; update the inventory as appropriate www.northernmichiganstreams.org | **CRA**, LRBOI, MDNR, BCWC | High | 5 sites/5 yrs | $1,500,000 | X | X | X | X | X | X | X | X | X | X |
| **2.G** Minimize barriers to fish migration associated with road crossing and reduce their sediment load on Bear Creek and tributaries | **2.G.1** Enhance fish migration where blockage now exists and reduce sediment load at road stream crossings using the road stream crossing inventory compiled by Conservation Resource Alliance; update the inventory as appropriate www.northernmichiganstreams.org | **CRA**, LRBOI, MDNR, BCWC | Medium | 5 sites/5 yrs | $1,500,000 | | X | X | X | X | X | X | X | X | X |
| **2.H** Monitor fish populations in Bear Lake, Bear Creek and tributaries | **2.H.1** Conduct routine fish population monitoring surveys for three consecutive years commencing '11-13 and '17-19 (see Monitoring Plan) | **MDNR,** LRBOI | High | Completed (Y/N) | $25,000 | X | | | | X | X | X | | | |

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Goal 3. Hazardous Materials** – Prevent future and reduce current impacts on people (fish consumption advisories) and the environment | | | | | | | | | | | | | | | |
| **3.A** Control use, storage, and disposal of hazardous materials | **3.A.1** Support and encourage use of current household hazardous waste disposal program provided by the Manistee Soil Conservation District and promote use of non-toxic materials www.manisteecd.org/programs_hazard.html | **MSCD,** See long list of partners on their website | Medium | I/E Materials to Web '13; Meet with MSCD to assess needs '15/16 | $10,000 | X | | X | X | | | | | | |
| | **3.A.2.** Develop and distribute information to residents, private businesses, municipal governments, and schools on BMPs to prevent release of hazardous materials into the environment, including the new statewide ban on burning of certain waste (see Education Plan) | **MSCD,** See long list of partners on their website | Medium | I/E materials on Web '13<br>Triennial distribution (see Education Plan) | Estimated cost included in I/E plan | X | | X | | | X | | | X | |
| **3.B.** Update contingency roadway accident spill response plans | **3.B.1.** Support development of a locally generated and state approved contingency plan and training for first responders for road accidents involving fuel or other hazardous materials to minimize runoff to surface waters of Bear Lake, Bear Creek and its tributaries that includes the accessibility and deployment of temporary booms, absorbent materials, and the ability to temporarily prevent discharges from Bear Lake into Little Bear Creek | BLPOA, BLWA, BCWC, MERM, Michigan State Police, MDEQ, Twps | High | Review existing plans '13; Determine if equipment and materials is available '14 Obtain supplies as needed; Conduct training as needed | $25,000–$75,000 | X | X | | | | | | | | |
| **3.C.** Reduce human exposure to hazardous materials from atmospheric sources outside of the watershed that bioaccumulate in area fish | **3.C.1.** Provide updated and reliable information to anglers on consumption guidelines for fish contaminated with PCBs and mercury from atmospheric disposition (see Education Plan) | **MDCH**, MDNR | Low | Link to MDCH on website '13 Add I/E materials to Web '13 | Estimated cost included in I/E plan | X | | | | | | | | | |

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Goal 4. Invasive Species** – Control abundance and further distribution of exotic species injurious to protected human uses (i.e., swimming, boating, fishing, etc.) and native plants and animals | | | | | | | | | | | | | | | |
| **4.A.** Control abundance of Eurasian milfoil in Bear Lake | **4.A.1.** Continue control of Eurasian milfoil following annual assessments by using selective herbicides in targeted areas and limiting herbicide application to 24D or other chemicals specifically targeted to control of Eurasian milfoil. Limit signs and information provided to residents to use advisories for the chemicals actually used in treatment. | BLIB, **BLPOA, BLWA**, MDNR | High | Complete annually | $200,000–$1,000,000 | X | X | X | X | X | X | X | X | X | X |
| | **4.A.2.** Promote the development and use of biological controls or other alternatives to reduce or avoid the use of chemical controls | **BLPOA, BLWA,** MDNR; Other watershed groups | High | Meet with statewide and local groups beginning ’14 | $10,000 | | X | X | X | X | X | X | X | X | X |
| **4.B.** Limit the spread of wetland invasive species such as *Phragmites sp.* and purple loosestrife | **4.B.1** Formalize existing efforts to monitor and remove *Phragmites sp*. and purple loosestrife from wetland areas adjacent to Bear Lake | BCWC, BLIB, BLPOA, BLWA, CRA, **CWMA**, MSCD | High | Summarize/review existing efforts ‘14<br><br>Develop action plan ‘15 | $10,000 | | X | X | X | X | X | X | X | X | X |
| **4.C.** Control the unintentional introduction and spread of invasive plant and animal species in the watershed including general watershed technical assistance in Manistee county | **4.C.1.** Support the development of a pilot program that would involve distribution of information to the public, landscapers, and property developers on the harmful effects of invasive species on native flora and fauna and methods of control, and support monitoring programs to identify problem species and sources (see Education Plan). | BCWC, BLIBBLPOA, Manistee Co. BLWA, CRA, USFS | Medium | Initiate cooperative program between USFS and Manistee Co ‘13<br><br>Re-evaluate annually | $800,000 (tasks 4.C.1 & 4.C.2) | X | X | X | X | X | X | X | X | X | X |
| | **4.C.2**<br>As part of pilot program, purchase a portable boat cleaning station and provide staff support for its operation at public access sites on Bear Lake | BLPOA, BLIB, BLWA, MDNR, Manistee Co USFS | High | Initiate cooperative program between USFS and Manistee Co ‘13<br><br>Re-evaluate annually | | X | X | X | X | X | X | X | X | X | X |

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Goal 5. Groundwater –** Protect quality and quantity of domestic and agricultural water supplies and the source of cool, clean water to surface lakes and streams | | | | | | | | | | | | | | | |
| **5.A.** Protect existing quality of drinking water supplies | **5.A.1.** Support enforcement of wellhead protection ordinances in villages of Bear Lake and Kaleva http://www.bearlakemichigan.org/wellhead.html | **MCPD**, **Villages**, MSUE, MDEQ | High | Add materials to Web '13<br><br>Triennial distribution | $10,000 | X | | | X | | | X | | | X |
| | **5.A.2** Provide information on testing individual water supplies and BMPs to prevent contamination including need to effectively plug abandoned water wells, mineral wells, and hydrocarbon wells (see Education Plan) | D#10HD, **MSUE, MDEQ** | Medium | Obtain existing info; add to website '13<br><br>Triennial distribution | Estimated costs included in I/E plan | X | | | X | | | X | | | X |
| **5.B.** Protect quality/ quantity of groundwater to Bear Lake and Bear Creek | **5.B.1** Encourage Manistee County to continue to monitor the regulation of new agricultural and industrial groundwater withdrawals/uses to assure no significant adverse impacts on the quantity or quality of groundwater | **MDEQ**, BCWC, MCPD | Medium | Manistee Co continues to review permit applications on an ongoing basis | $50,000 | X | X | X | X | X | X | X | X | X | X |
| | **5.B.3** Support the development and distribution of materials to encourage watershed residents, commercial entities, and visitors to conserve water (see Education Plan) | BLPOA, BLWA, BCWC, **NWMCOG**, Twps, Villages | Low | Materials added to Web '13<br><br>Triennial distribution | Estimated cost included in I/E plan | X | | | X | | | X | | | X |

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Goal 6. Joint Planning and Development** – Coordinated local economic and land use planning to preserve and optimize local assets and expand sustainable economic development and related employment | | | | | | | | | | | | | | | |
| **6.A.** Encourage sustainable economic development and job creation | **6.A.1.** Support ongoing efforts to expand informal collaboration and formal joint planning and economic development by local governmental units that maximize the potential of local natural and human assets, including the Lakes to Land regional initiative, Comprehensive Economic Development Strategy (CEDS), Kaleva and Maple Grove Township joint Recreation Plan, USFS Forest Management Plan, State Forest Management Plan, Manistee Co Recreation Plan and others | **AES**, **MCPD**, **NWMCOG**, MDNR, USFS, Twps, Villages | High | Lakes to Land regional initiative Convention of Communities '13<br><br>State Forest Management Plan '14<br><br>Ongoing based on planning cycles | $1,000,000 | X | X | X | X | X | X | X | X | X | X |
| **6.B.** Reduce urban and rural blight | **6.B.1** Encourage coordinated local township and village adoption and enforcement of clean-up requirements for blighted properties to preserve property values and quality of life for watershed residents and visitors | **AES**, **MCPD**, **NWMCOG**, Twps, Villages | High | Complete ordinance/ enforcement review '14<br><br>Analysis & recommendations '15 | $50,000 | | X | X | | | | | | | |
| **6.C.** Protect scenic vistas, cultural and historical sites | **6.C.1.** Identify sites and establish land use plans and zoning that preserve scenic vistas and cultural and historical sites that can be promoted for the enjoyment of residents and visitors | **AES**, **MCPD**, **NWMCOG**, LRBOI, Twps, Villages | Medium | Manistee Co Recreation Plan inventory '15 | $50,000 | | | X | | | | | | | |

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6.D.** Improve public recreational access to surface waters through the Explore the Shores and other programs | **6.D.1.** Identify sites to add additional recreational access to watershed resources to support natural resource–based tourism | AES, MCPD, MDNR, NWMCG, BLWA, BLPOA, BCWC, Twps, Villages | Medium | Identify new sites by ‘15 | $10,000 | X | X | X | | | | | | | |
| | **6.D.2** Coordinate with stakeholders to design and implement additional public access sites within the watershed | AES, MCPD, MDNR, NWMCG, BLWA, BLPOA, BCWC, Twps, Villages | Medium | Complete plan ‘17<br><br>Implement ’18 - 22 | $100,000–$500,000 | | | | | X | X | X | X | X | X |
| | **6.D.3.** Improve wayfinding to access areas through signage, maps within the watershed and electronic resources such as the Explore the Shores website | AES, MCPD, MDNR, NWMCG, BLWA, BLPOA, BCWC, Twps, Villages | Low | Complete ‘19 | Estimate included in I/E plan | X | X | X | X | X | | | | | |
| **6.E** Coordinate watershed planning and implementation with other organizations | **6.E.1** Convene other watershed councils/organizations, including the Lakes to Land Regional Initiative and Explore the Shores to assess opportunities for collaboration and cooperation among watershed groups and organizations. | **AES**, LRBOI, MCCF, NWMCOG, MDARD, MDEQ, USFWS | High | Convene ‘13<br><br>Strategy developed ‘15<br><br>Secure implementation funding ’16-‘17 | $35,000 | X | X | X | X | X | X | X | X | X | X |

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Goal 7. Sustainable Implementation of Greater Bear Watershed Plan** – Formation of Greater Bear Watershed Management Plan Coordinating Committee and identification of leadership responsibilities | | | | | | | | | | | | | | | |
| **7.A.** Establish the infrastructure for GBWMP Implementation | **7.A.1.** Designate current Greater Bear Watershed Management Plan Steering Committee as interim Coordinating Committee | Existing Coordinating Committee | High | Completed '13 | $500 | X | | | | | | | | | |
| | **7.A.2** Obtain written commitments from individuals and organizations on the Coordinating Committee to cooperate in plan implementation | Existing Coordinating Committee | High | Draft MOU '13<br><br>Distribute and Execute MOUs '13 and ongoing | $5,000 | X | X | X | X | X | X | X | X | X | X |
| | **7.A.3.** Expand Implementation Partners to include other interested organization/individuals critical to implement the elements of the plan | Existing Coordinating Committee/ Implementation Partners | High | Engage community stakeholders '13 and ongoing | $2,500 | X | X | X | X | X | X | X | X | X | X |
| | **7.A.4.** Adopt operating procedures for the coordinating committee, elect officers and appoint committees, establish meeting frequency of at least twice a year. Accept offers by implementation partners to serve as the default fiduciary for grant management in the absence of other capacity to manage grant applications and administration. | Existing Coordinating Committee/ Implementation Partners | High | Draft operating procedures '13<br><br>Adopt procedures '13/14<br><br>Evaluate/revise operating practices '15<br><br>Ongoing implementation | $2,500 | X | X | X | X | X | X | X | X | X | X |
| **7.B** Establish a charitable giving & philanthropic strategy to support plan implementation . | **7.B.1** Establish a fund(s) at the MCCF and explore other philanthropic opportunities to finance plan implementation. | MCCF, Implementation Partners | High | Fund established '13/14 | $1,000–$10,000 | X | X | X | | | | | | | |

| Objectives | Actions | Potential Partners (lead in **bold**) | Priority | Milestone(s) | Estimated Cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Goal 8. Evaluation and Revision of Management Plan Progress** – Periodic assessment of progress in implementing actions and in meeting objectives, and targets for plan revisions and update. | | | | | | | | | | | | | | | |
| **8.A.** Annual assessment of progress | **8.A.1** Formalize the process by which the Coordinating Committee and Implementation Partners collect and track data to monitor implementation of the plan including financial support. | Implementation Partners | High | Complete in '13/'14<br><br>Document process '13/14 | $1,000–$5,000 | X | X | | | | | | | | |
| | **8.A.2.** Review progress in implementing actions identified in plan and make appropriate adjustments in timelines. Summarize progress and activities annually (See Education Plan). | Implementation Partners | High | Complete annually<br><br>Distribute annual fact sheet | $50,000 | X | X | X | X | X | X | X | X | X | X |
| | **8.A.3.** Determine progress in meeting goals and objectives, particularly attainment of State Water Quality Standards, and establish, with public input, targets/revised goals and objectives for the next decade | Implementation Partners & Coordinating Committee | High | Complete '22 | $50,000–$100,000 | | | | | | | | | | X |

SOURCE: Public Sector Consultants, and the Greater Bear Watershed Management Plan Steering Committee, 2013.

Estimated costs for each task identified above by goal and the total cost are summarized in Exhibit 90. The estimated cost of implementing goals and objectives ranges from $7,072,500 to $8,655,500 for the 10-year horizon of the plan. These figures are estimated costs and include staff time, volunteer time, supplies, and materials. Estimates are subject to change as additional information becomes available. Additional costs are calculated for the Education Plan.

**EXHIBIT 90.** Estimated 10-Year Costs to Achieve Tasks by Plan Goal

| **Goal** | **Estimated Cost** (Low) | **Estimated Cost** (High) |
|---|---|---|
| Pathogens Affecting Humans | $115,000 | $145,000 |
| Ecosystem Health | $4,485,000 | $4,725,000 |
| Hazardous Materials | $35,000 | $85,000 |
| Invasive Species | $1,020,000 | $1,820,000 |
| Groundwater | $60,000 | $60,000 |
| Joint Planning and Development | $1,245,000 | $1,645,000 |
| Sustainable Implementation of Greater Bear Watershed Plan | $11,500 | $20,500 |
| Evaluation and Revision of Management Plan Progress | $101,000 | $155,000 |
| **Total** | **$7,072,500** | **$8,655,500** |

SOURCE: Public Sector Consultants, and the Greater Bear Watershed Management Plan Steering Committee, 2013.
NOTE: Estimated costs include multiple resources such as volunteer time, staff time, materials, and equipment.

# Section J: Information and Education Plan

This Information and Education (IE) strategy addresses communication needs associated with implementing the Greater Bear Watershed Plan. The goal of the information and education strategy is to **improve understanding and awareness of how actions on the land and water within the watershed can have a critical effect on protection of water quality and watershed resources.**

During the development of the watershed plan a variety of means were used to inform the public and other stakeholders about the planning process and seek input on plan development. A series of public forums was held in both 2011 and 2012; a survey for watershed residents and users was available online and in hard copy at various public locations throughout the watershed; meetings of the steering committee were open to the public; presentations were made at meetings of various organizations and property owners' associations; and information was included in newsletters, newspapers, the project website, and websites of organizations represented on the steering committee. These efforts helped engage the community in the development of the plan and educate residents about the planning process and the benefits of developing a comprehensive watershed plan for the Greater Bear Watershed.

The watershed survey, conducted by Draze Consulting in 2011, included questions to help inform the goals and objectives of the watershed plan and the information and education strategy. The following recommendations were developed after the review of watershed conditions, using input provided by community members throughout the watershed.

- Survey responses and high participation in the public forums indicate that watershed residents (permanent and seasonal) value good water quality and associate high environmental quality with a high quality of life and economic prosperity. Thus, information and education efforts do not need to focus on establishing the importance of protecting water quality.
- Survey respondents were asked where they obtain their information about the watershed and which sources they trust. Local newspapers were the most cited source, followed closely by Internet sources and newsletters. Many organizations were considered trustworthy sources. Those rated among the highest were: the Forest Service, the Conservation District, the Grand Traverse Regional Land Conservancy, local watershed councils and neighborhood associations, the Michigan Departments of Environmental Quality and Natural Resources, Michigan State University Extension, and the County Health Department. This information helped shape and inform the goals and objectives of the watershed plan and identify needs and strategies for public engagement.
- Survey responses indicate that many respondents are not aware of current water quality conditions within the Greater Bear Watershed. Information and education materials should include information about current conditions and management practices that influence those conditions, much of which is available in this plan.
- Many respondents indicated that the cost of implementing best management practices and a lack of access to information and equipment are barriers preventing implementation. Information and education materials could include cost estimates for implementing specific actions at the property level, and identify potential sources of technical assistance. For example, informational materials could be distributed regarding non-regulatory manure management planning assistance available through the USDA Natural Resource Conservation Service (NRCS) to livestock operators which identify the potential costs of preparing and implementing a plan.
- Many other respondents indicated that there are few impediments to implementing best management practices on their properties (cost and equipment are not limiting factors) but that not everyone is aware of what practices could be put in place on their property. Demonstration projects and associated events highlighting management practices should be prioritized.

- Information and education efforts should focus on coordinating with village, township, and county representatives who can affect plan implementation. Additionally, state and federal agencies with a presence in the Greater Bear Watershed should continue to be included in ongoing outreach efforts.
- Information and education efforts should focus on coordinating among units of government, non-profit entities, and businesses within the watershed and outside the watershed. Many of the watersheds within the northwestern Lower Peninsula of Michigan are positioned similarly to the Greater Bear Watershed in terms of current environmental conditions, public awareness, and available funding; economies of scale may be achieved through partnerships with organizations throughout the region.
- Given a high level of interest from community members as reflected by significant attendance at public forums throughout the development of this plan, the Implementation Team should hold Watershed Open Houses periodically to update and continue to engage community members.

## INFORMATION AND EDUCATION IMPLEMENTATION STRATEGY

Since the Greater Bear Watershed Management Plan Coordinating Committee is a relatively new group, the strategy focuses on building organizational capacity in the short term by implementing general IE tasks identified in Exhibit 91. The www.bearwaters.org website will become a central repository for educational and informational materials. In the beginning efforts will focus on compiling existing materials identified in IE tasks and adding them to the website, and developing a contact list for distributing materials in 2013. Following this effort the Implementation Team will target educational efforts on two individual plan goals in each year of plan implementation. This approach recognizes the importance of IE actions relating to each goal and the limited resources (staff/volunteer time and materials) to implement watershed tasks.

The Implementation Team's focus on two goals each year (goals 1-6) will be repeated on a triennial cycle commencing in 2014. The general implementation timeline is summarized in Exhibit 91. Specific implementation tasks for each goal are identified in Exhibit 92 and in some instances depart from this general strategy because information may become especially relevant (i.e., if bacteria monitoring samples identify that water quality standards are not met) or represent more discrete tasks such as placing signs along roadways at the watershed boundary. The last two watershed goals (goals 7 and 8) have tasks relating to ongoing implementation and evaluation of the plan, and these should be completed each year. Estimated costs for implementing the IE strategy for the 10-year horizon of the plan are identified by goal in Exhibit 91 and by task in Exhibit 92. Estimates are subject to change as new information becomes relevant or as conditions in the watershed change.

## **EXHIBIT 91.** General Information and Education Timeline and 10-Year Cost

| Watershed Goals | Implementation Years | Estimated 10-Year Cost |
|---|---|---|
| **Total Estimated 10-Year Costs for IE Plan Implementation** | | **$580,000** |
| **General Information and Education Activities**—Such as maintaining the www.bearwaters.org website; maintaining a distribution/contact list; issuing a watershed newsletter; etc. | Each Year | $119,500 |
| **Pathogens Affecting Humans**—Minimize presence of pathogenic organisms that impair swimming, wading, fishing, boating, water skiing and other full or partial body contact water recreation activities. | 2014<br>2017<br>2020 | $40,000 |
| **Ecosystem Health**—Protect and restore essential physical habitat, and maintain compliance with water quality standards designed to protect fish, wildlife, and other aquatic organisms. | 2014<br>2017<br>2020 | $60,000 |
| **Hazardous Materials**—Prevent future and reduce current impacts on people (fish consumption advisories) and the environment. | 2015<br>2018<br>2021 | $21,000 |
| **Invasive Species**—Control abundance and further distribution of exotic species injurious to protected human uses (i.e., swimming, boating, fishing, etc.) and native plants and animals. | 2015<br>2018<br>2021 | $30,000 |
| **Groundwater**—Protect quality and quantity of domestic and agricultural water supplies and the source of cool, clean water to surface lakes and streams. | 2016<br>2019<br>2022 | $60,000 |
| **Joint Planning and Development**—Coordinated local economic and land use planning to preserve and optimize local assets and expand sustainable economic development and related employment. | 2016<br>2019<br>2022 | $40,000 |
| **Sustainable Implementation of Greater Bear Watershed Plan**—Formation of Greater Bear Watershed Management Plan Coordinating Committee and identification of leadership responsibilities. | Each Year | $180,000 |
| **Evaluation and Revision of Management Plan Progress**—Periodic assessment of progress in implementing actions and in meeting objectives and targets for plan revisions and updates. | Each Year | $30,000 |

SOURCE: Public Sector Consultants and the Greater Bear Watershed Management Plan Coordinating Committee, 2013.

The IE strategy is intended to outline and promote educational activities that can support effective implementation of the Greater Bear Watershed goals, objectives, and tasks. Exhibit 92 outlines tasks for each goal. As with many of the tasks identified within the watershed goals and objectives, individual educational tasks can fit, to a certain degree, in multiple categories and help advance multiple goals. IE tasks are organized into the category in which they best fit. It is important to note that a substantial amount of educational material already exists on many of the issues that this plan seeks to address. To keep costs down, existing materials should be modified for the Greater Bear as opposed to developing new material. Much of the cost, then, will be in assembling and distributing relevant information through printed sources, online, and at community events such as Bear Lake Days. Noting that many residents rely on the Internet for information, and the relatively low cost of distribution through online avenues, all materials developed through the IE strategy should be made available online in addition to other distribution methods.

Exhibit 92 identifies potential agency partners and organizations using the following acronyms:

## POTENTIAL PARTNERS

- **Nonprofit Organizations**—Bear Creek Watershed Council (BCWC), Bear Lake Property Owners Association (BLPOA), Bear Lake Watershed Alliance (BLWA), Conservation Resource Alliance (CRA), Cooperative Weed Management Area (CWMA), Grand Traverse Regional Land Conservancy (GTRLC), Manistee County Alliance for Economic Success (AES), and Manistee County Community Foundation (MCCF)
- **Federal Agencies—**Department of Agriculture, Natural Resource Conservation Service (NRCS) and United States Forest Service (USFS); and Department of the Interior, United States Fish and Wildlife Service (USFWS)
- **State of Michigan Agencies**—Michigan departments of Natural Resources (MDNR), Environmental Quality (MDEQ), Transportation (MDOT), Community Health (MDCH), and Agriculture and Rural Development (MDARD)
- Michigan State University—Extension (MSUE)
- **Local Government—**Bear Lake, Lake Improvement Board (LIB), Villages of Bear Lake, Kaleva, and Copemish (Villages); townships within the watershed (Twps) [Benzie County: Colfax and Joyfield Townships; Manistee County: Arcadia, Bear Lake, Brown, Cleon, Copemish, Dickson, Maple Grove, Marilla, Onekema, Pleasanton, Springdale Townships; Wexford County: Wexford Township]. See Exhibit 4 in the, Description of the Greater Bear Watershed section, for information on the extent to which the watershed extends into these communities.
- **Manistee County Government—**Soil Conservation District (MSCD), Road Commission (MCRC), Planning Department (MCPD), Emergency Response Management (MERM)
- **Native American Tribal Government—**Little River Band of Ottawa Indians (LRBOI)
- **Regional Government—**Northwest Michigan Council of Governments (NWMCOG), District #10 Health Department (D10HD)

If additional partners not identified express interest in plan implementation they should be engaged as appropriate.

## ESTIMATED COST/YEAR

The timeline begins when the plan is completed. Prioritization of tasks should be re-evaluated two years after the plan is approved. Estimated costs are identified for each action for the full ten-year planning horizon; these costs may change if conditions within the watershed change. These costs include volunteer time, staff time, equipment, and materials.

Exhibit 92 contains a timeline that begins from plan completion. Many tasks will not be implemented immediately and may occur over many years of watershed plan implementation (which has a ten-year planning horizon). Years in which recommendations are suggested to occur are indicated with an "X" in the implementation timeline. If conditions change or opportunities to pursue tasks emerge, the Greater Bear Watershed Plan implementation team should re-evaluate the relative priorities and distribution of resources.

**EXHIBIT 92.** Information and Education Tasks to Achieve Watershed Goals

| I/E task | Corresponding Goals & Objective Task(s) | Target audiences | Frequency | Medium or method | Potential partners (lead in **bold**) | Priority | Milestone | Estimated cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **General I/E Tasks** | | | | | | | | | | | | | | | | | | |
| **General I/E Task (IE)A** Maintain and update the www.bearwaters.org website | All | Watershed residents, visitors, businesses, and local government | As needed | Website | **BCWC, BLPOA, BLWA,** MCCF, AES, MCPD | High | Website actively updated | $12,000 | X | X | X | X | X | X | X | X | X | X |
| **General Task (IE)B** Develop and maintain a contact list to distribute materials relevant to the watershed plan | All | Permanent and seasonal residents, businesses and local government officials | Update annually | Website, e-news lists, | **BCWC, BLPOA, BLWA** | High | Developed and actively maintained | $20,000 | X | X | X | X | X | X | X | X | X | X |
| **General Task (IE)C** Develop and update a watershed fact sheet | All | Permanent and seasonal residents, businesses, visitors and local government officials | Update annually | Website, e-news lists | **GBWP implementation team** | High | Developed and updated | $2,500 | X | X | X | X | X | X | X | X | X | X |
| **General Task (IE)D** Issue a newsletter with updates on plan implementation and watershed information | All | Residents, businesses, and local government | Quarterly | Website, e-news lists | **GBWP implementation team** | High | Distributed quarterly | $25,000 | X | X | X | X | X | X | X | X | X | X |
| **General Task (IE)E** Issue an annual report summarizing watershed plan implementation activities | All | Permanent and seasonal residents, businesses, visitors and local government officials | Annually | Website, e-news lists, printed copies at local government offices and libraries. | **GBWP implementation team** | High | Distributed annually | $20,000 | X | X | X | X | X | X | X | X | X | X |
| **General Task (IE)F** Place signs along major roadways at the boundary of the watershed indicating entrance to the watershed. | All | Permanent and seasonal residents, businesses, visitors and local government officials | Once installed, replace/update as necessary | Signs | AES, MCRC, Twps, | Medium | Signs placed | $40,000 | | X | X | X | X | | | | | |

| I/E task | Corresponding Goals & Objective Task(s) | Target audiences | Frequency | Medium or method | Potential partners (lead in **bold**) | Priority | Milestone | Estimated cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GOAL 1. Pathogens Affecting Humans**—Minimize presence of pathogenic organisms that impair swimming, wading, fishing, boating, water skiing, and other full or partial body contact water recreation activities. | | | | | | | | | | | | | | | | | | |
| **(IE)1.A** Inform stakeholders of results of *E. coli* sampling on Bear Lake and along Bear Creek | 1.A.1<br>1.A.2<br>1.C.2 | Riparian owners, beach owners, local government, tourists | Immediately upon results if WQS exceeded, annual summary | Local and state websites, e-news lists, newsletters, newspaper, kiosk or bulletin board at sampling location | **BCWC, BLPOA, BLWA,** D#10HD, LRBOI, Twps, Villages | High | Added to website annually | $20,000 | X | X | X | X | X | X | X | X | X | X |
| **(IE)1.B** Assemble and distribute existing information on the effects of artificially feeding waterfowl | 1.B.1<br>1.C.2 | Local government, residents, riparian owners, tourists | Triennial distribution continuously available on Web | Brochure, websites, e-news lists, newspaper, newsletter, kiosk, bulletin boards | **BLPOA, BLWA,** D#10HD | Low | Added to website 2013; triennial distribution | $10,000 | X | X | | | X | | | X | | |
| **(IE)1.C** Assemble and distribute existing information on proper maintenance and operation of onsite wastewater treatment systems | 1.C.2 | Residents, riparian landowners, local government, businesses | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website, workshop, speaker(s) | **BCWC, BLPOA, BLWA,** D#10HD, Twps, Villages | High | Added to website 2013; triennial distribution | $10,000 | X | X | | | X | | | X | | |
| **Goal 2. Ecosystem Health**—Protect and restore essential physical habitat, and maintain compliance with water quality standards designed to protect fish, wildlife, and other aquatic organisms. | | | | | | | | | | | | | | | | | | |
| **(IE)2.A** Assemble and distribute existing information on the importance of the nearshore littoral zone | 2.A.4<br>2.A.5<br>2.E.4 | Riparian landowners, local governments | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website | **BCWC, BLPOA, BLWA,** CRA, MDEQ, MDNR | Medium | Added to website 2013; triennial distribution | $10,000 | X | X | | | X | | | X | | |

| I/E task | Corresponding Goals & Objective Task(s) | Target audiences | Frequency | Medium or method | Potential partners (lead in **bold**) | Priority | Milestone | Estimated cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(IE)2.B** Assemble and distribute existing information on best management practices (BMPs) applicable to agricultural operations such as manure management plans, vegetative filter strips, excluding livestock from surface waters, to reduce loading to, Bear Lake, Bear Creek, and tributaries | 2.B.1<br>2.B.2 | Agricultural community, businesses, local government | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website, workshops, speakers | BCWC, BLPOA, BLWA, CRA, MCPD, MSUE, MSCD, GTRLC | Medium | Added to website 2013; triennial distribution | $10,000 | X | X | | | X | | | X | | |
| **(IE)2.C** Assemble and distribute existing information on benefits of conservation easements | 2.D.1<br>2.D.3 | Riparian and other landowners | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website, workshops, speakers | **GTRLC**, BCWC, BLPOA, BLWA, | Medium | Added to website 2013; triennial distribution | $10,000 | X | X | | | X | | | X | | |
| **(IE)2.D** Assemble and distribute existing educational materials on BMPs that can be used by homeowners to retain and filter runoff such as low impact design from impervious surfaces on their property | 2.A.2 – 2.A.5<br>2.B.1<br>2.D.1 - 2.D.3<br>2.E.4<br>3.A.2 | Riparian landowners, local governments | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website | BCWC, BLPOA, BLWA, CRA, | High | Added to website 2013; triennial distribution | $10,000 | X | X | | | X | | | X | | |
| **(IE)2.E** Advocate for scientific and regulatory community to evaluate WQS and sampling practices with respect to ecosystem changes (i.e., nutrient cycling/invasive species) | 2.C.1<br>2.C.2 | Scientific and regulatory community | As needed | Meetings, letters, newspaper, website | GBWP implementation team | Low | Completed as needed | $10,000 | X | X | | | X | | | X | | |

| I/E task | Corresponding Goals & Objective Task(s) | Target audiences | Frequency | Medium or method | Potential partners (lead in **bold**) | Priority | Milestone | Estimated cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(IE)2.F** Distribute results of water quality monitoring of Bear Lake, Bear Creek, and tributaries | 1.A.1<br>1.B.1<br>2.C.1<br>2.C.2<br>8.A.3 | Watershed residents and visitors, local government | Annually | Brochure, newspaper, newsletter, e-news lists, website | **BCWC, BLPOA, BLWA,** D#10HD, LRBOI, Twps, Villages | Medium | Distributed annually | $10,000 | X | X | | | X | | | X | | |
| **Goal 3. Hazardous Materials**—Prevent future and reduce current impacts on people (fish consumption advisories) and the environment. | | | | | | | | | | | | | | | | | | |
| **(IE)3.A** Implement a mechanism to ensure that anglers have the best information on state consumption advisories for fish taken from Bear Lake, Bear Creek, and tributaries | 3.C.1 | Anglers, general public, tourists, local governments | Update as necessary | Website, e-news lists, kiosk or bulletin boards at fishing access locations | **BCWC, BLPOA, BLWA,** D#10HD, LRBOI, MDNR | Low | Added to website 2013 | $1,000 | X | | X | | | X | | | X | |
| **(IE)3.B** Assemble and distribute existing information on BMPs to prevent release of hazardous materials into the environment, including the new statewide ban on burning of certain waste | 3.A.1<br>3.A.2<br>3.B.1 | Residents, businesses, local government, and schools | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website | NWMCOG, MDEQ | Medium | Added to website 2013; triennial distrib. | Estimated costs included in I/E plan | X | | X | | | X | | | X | |
| **(IE)3.C** Develop and distribute information regarding the Manistee County Emergency Manager spill response plan | 3.B.1 | Local government, businesses, riparian owners | Upon development, with updates as necessary | Letter, brochure, workshop, newspaper | MERM, Twps, Villages | High | Added to website 2013; triennial distrib. | $10,000 | X | | X | | | X | | | X | |
| **(IE)3.D** Support the cooperative pollution prevention program to protect groundwater from hazardous chemicals | 3.A.1<br>3.A.2 | Businesses, local government | Triennial distribution continuously available on Web | Letter, brochure, workshop, newspaper | D#10HD, MDEQ, MSCD, LRBOI | Medium | Added to website 2013; triennial distrib. | $10,000 | X | | X | | | X | | | X | |

| I/E task | Corresponding Goals & Objective Task(s) | Target audiences | Frequency | Medium or method | Potential partners (lead in **bold**) | Priority | Milestone | Estimated cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Goal 4. Invasive Species**—Control abundance and further distribution of exotic species injurious to protected human uses (i.e., swimming, boating, fishing, etc.) and native plants and animals. | | | | | | | | | | | | | | | | | | |
| **(IE)4.A** Continue to inform stakeholders when using chemical treatment in waterbodies | 4.A.1 | Residents, riparian landowners, local government | As treatment occurs | Brochure, newspaper, newsletter, e-news lists, website | **LIB, BCWC,** BLPOA, BLWA, MDNR,MDEQ, Twps, Villages | Medium | Annual notices when treat-ment used | Estimated costs included in Goals & Objectives section | X | X | X | X | X | X | X | X | X | X |
| **(IE)4.C** Place informational/ educational signs or flyers at public access points to waterbodies regarding invasive species transfer and control | 4.B.1<br>4.C.1<br>4.C.2 | Residents, visitors, businesses, boaters | Once installed, replace/update as necessary | Signs, kiosk, bulletin boards | BCWC, BLPOA, BLWA, MDNR, CRA, | Med | Signs placed | $10,000 | X | | X | | | X | | | X | |
| **(IE)4.D** Develop and distribute materials with pictures and information on invasive species known to have a presence in the watershed so residents can identify and report them | 4.B.1<br>4.C.1<br>4.C.2 | Residents, visitors, and local government | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website | CWMA, LIB | High | Added to website 2013; triennial distribution | $10,000 | X | | X | | | X | | | X | |
| **(IE)4.E** Assemble and distribute existing information on the harmful effects of invasive species on native flora and fauna and methods of control, and support monitoring programs to identify problem species and sources | 4.B.1<br>4.C.1<br>4.C.2 | Residents, landscapers, and property developers | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website | CWMA, LIB | High | Added to website 2013; triennial distribution | $10,000 | X | | X | | | X | | | X | |
| **Goal 5. Groundwater**—Protect quality and quantity of domestic and agricultural water supplies and the source of cool, clean water to surface lakes and streams. | | | | | | | | | | | | | | | | | | |
| **(IE)5.A** Assemble and distribute existing information on water conservation methods and importance thereof | 5.B.3 | Residents, businesses, and tourists | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website | MSUE, NWMCOG, CRA, MDEQ | Low | Added to website 2013; triennial distribution | $10,000 | X | | | X | | | X | | | X |

| I/E task | Corresponding Goals & Objective Task(s) | Target audiences | Frequency | Medium or method | Potential partners (lead in **bold**) | Priority | Milestone | Estimated cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(IE)5.B** Assemble and distribute existing information regarding groundwater pollution prevention BMPs, including plugging of abandoned water wells | 5.A.1<br>5.A.2 | Well drillers, health dept., residents, businesses, local government | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website | D#10HD, MDEQ | Medium | Added to website 2013; triennial distribution | $10,000 | X | | | X | | | X | | | X |
| **(IE)5.C** Assemble and distribute existing information regarding groundwater pollution prevention BMPs, including plugging of abandoned hydrocarbon wells | 5.A.2 | Well drillers, owners, operators, business, local government, MDEQ | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website | MDEQ | Low | Added to website 2013; triennial distribution | $10,000 | X | | | X | | | X | | | X |
| **(IE)5.D** Assemble and distribute existing information on the important functions of wetlands | 2.D.1<br>2.D.3 | Riparian landowners, local governments | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website | **BCWC, BLPOA, BLWA,** LRBOI, MDNR, MDEQ | Medium | Added to website 2013; triennial distribution | $10,000 | X | | | X | | | X | | | X |
| **(IE)5.E** Assemble and distribute information about cost-effective ways to have drinking water tested for contamination (such as bacteria and nitrates) | 5.A.2 | General public, businesses, local government | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, website, e-news lists | **BCWC, BLPOA, BLWA,** D#10HD, MDEQ | Low | Added to website 2013; triennial distribution | $10,000 | X | | | X | | | X | | | X |
| **(IE)5.F** Assemble and distribute existing information on low-impact design to reduce runoff | 2.A.2 – 2.A.5<br>2.B.1<br>2.D.1 - 2.D.3<br>2.E.4<br>3.A.2 | Local government, businesses, residents | Triennial distribution continuously available on Web | Brochure, newspaper, newsletter, e-news lists, website. | BCWC, BLPOA, BLWA, **MCPD**, Twps, Villages | High | Added to website 2013; triennial distribution | $10,000 | X | | | X | | | X | | | X |

| I/E task | Corresponding Goals & Objective Task(s) | Target audiences | Frequency | Medium or method | Potential partners (lead in **bold**) | Priority | Milestone | Estimated cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Goal 6 Joint Planning and Development**—Coordinate local economic and land use planning to preserve and optimize local assets and expand sustainable economic development and related employment. | | | | | | | | | | | | | | | | | | |
| **(IE)6.A** Meet with representatives from each township and village within the watershed to discuss plan recommendations and opportunities for collaboration | All | Local government | 2013 then as needed | Brochure, newsletters, website | GBWP implementation team, Twps, Villages, MCPD | Very High | Meetings held | $10,000 | X | X | X | X | X | X | X | X | X | X |
| **(IE)6.B** Improve wayfinding to access areas through signage, maps within the watershed, and electronic resources such as the Explore the Shores website | 6.D.2 | Residents and visitors | As needed | Signs, website | AES, Twps, Villages | Low | Signs placed; websites updated | $20,000 | | | X | X | X | | | | | |
| **(IE)6.C** Prepare and distribute information about public access facilities currently available for non-boating users | 6.D.1<br>6.D.2 | General public, tourists | Triennial distribution continuously available on Web | Brochure, websites, e-news lists, newspaper, newsletter, kiosk, bulletin boards | AES, Twps, Villages | Low | Added to website 2013; triennial distribution | $10,000 | | | X | X | X | | | | | |
| **Goal 7. Sustainable Implementation of Greater Bear Watershed Plan**—Formation of Greater Bear Watershed Management Plan Steering Committee and identification of leadership responsibilities. | | | | | | | | | | | | | | | | | | |
| **(IE)7.A** Prepare and distribute information on ways in which stakeholders can support plan implementation | 7.A.1 – 7.A.4 | Residents; businesses; local, state, tribal, federal government; nongovernment organizations | Annually | Brochure, newspaper, newsletter, e-news lists, website. | GBWP implementation team | Very High | Materials prepared & distributed | $10,000 | X | X | X | X | X | X | X | X | X | X |
| **(IE)7.B** Coordinate and collaborate with other watershed groups to share resources and leverage economies of scale | All | Residents; businesses; local, state, tribal, federal government; nongovernment organizations | Annually | Brochure, newspaper, newsletter, e-news lists, website. | GBWP implementation team | Very High | Meetings held; Develop collabor-ative plan | $50,000 | X | X | X | X | X | X | X | X | X | X |

| I/E task | Corresponding Goals & Objective Task(s) | Target audiences | Frequency | Medium or method | Potential partners (lead in **bold**) | Priority | Milestone | Estimated cost | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(IE)7.C** Continue to build public support for groups represented on the Greater Bear steering committee | All | Residents; businesses; local, state, tribal, federal government; nongovernment organizations | Annually | Brochure, newspaper, newsletter, e-news lists, website. | GBWP implementation team | Very High | Materials distributed; increased member-ship | $100,000 | X | X | X | X | X | X | X | X | X | X |
| **(IE)7.D** Develop and distribute information on charitable giving options to support plan implementation | 7.B.1 | Residents; businesses; local, state, tribal, federal government; nongovernment organizations | Annually | Brochure, newspaper, newsletter, e-news lists, website. | MCCF, BCWC, BLPOA, BLWA, GBWP implementation team | Very High | Materials developed; Funds estab-lished; Funds raised | $10,000 | X | X | X | X | X | X | X | X | X | X |
| **(IE)7.E** Distribute information on formation of implementation team and related strategies | 7.A.1 – 7.A.4 | Residents; businesses; local, state, tribal, federal government; nongovernment organizations | Upon development, updated as necessary | Brochure, newspaper, newsletter, e-news lists, website. | GBWP implementation team | High | Materials developed; Increased member-ship | $10,000 | X | X | | | | | | | | |
| **Goal 8. Evaluation and Revision of Management Plan Progress—**Periodic assessment of progress in implementing actions and in meeting objectives, and targets for plan revisions and update. | | | | | | | | | | | | | | | | | | |
| **(IE)8.A** Evaluate progress on implementation of plan I/E tasks; and goals and objectives tasks - make revisions as necessary | 8.A.2 8.A.3 | Residents; businesses; local, state, tribal, federal government; nongovernment organizations | Annually | Revise plan documents - brochures, newspaper, newsletter, e-news lists, website. | GBWP implementation team | High | Completed annually | $10,000 | X | X | X | X | X | X | X | X | X | X |
| **(IE)8.B** Disseminate information on plan accomplishments and updates to the plan itself | 8.A.2 8.A.3 | Residents; businesses; local, state, tribal, federal government; nongovernment organizations | Annually | Brochure, newspaper, newsletter, e-news lists, website | GBWP implementation team | Very High | Completed annually | $20,000 | X | X | X | X | X | X | X | X | X | X |

SOURCE: Public Sector Consultants, 2013.

# Section K: Monitoring and Evaluation

The true test of the efficacy of the watershed management plan will be the implementation and attainment of the plan goals and objectives. Implementation for site-specific activities will require an evaluation to determine the progress and effectiveness of the proposed activities.

## MONITORING PLAN

The monitoring plans outlined in Exhibits 93 and 94 were developed to: (1) address the information gaps identified in the development of this plan; (2) ensure continuation of those monitoring efforts that in some cases have been occurring over a 30-year period; and (3) provide new information to help assure that any water quality or habitat problems or concerns can be detected early and appropriate actions taken before significant adverse changes occur that affect protected or desired uses of Bear Lake or Bear Creek and its tributaries.

Current and historic conditions of environmental quality are extensively documented in the Watershed Conditions section of this report which serve as a baseline against which monitoring efforts should be based. Since the majority of available data and information suggests that watershed conditions meet or exceed state water quality standards a minimal goal and criteria for measuring the efficacy of plan actions is no decline from current conditions.

Implementation costs are estimated and, to a certain extent, are variable based on use of contractors, donated equipment, volunteer, or in-kind staff time. These costs are represented in the watershed goals and objectives section of this report.

### *Bear Lake Monitoring Plan*

Since existing information is inadequate to determine whether or not the water quality standards (WQS) established to protect public health are being met, additional sampling is needed. The monitoring plan in Exhibit 93 includes *E. coli* bacteria sampling at five sites in Bear Lake with high wading and swimming activity every two weeks from June through September on an annual basis. This will assure residents and visitors using the lake that Full-Body Contact and Partial Body Contact WQS are being met.

Similarly, existing information on the concentration of dissolved oxygen in Bear Lake is inadequate to determine whether or not the WQS for a warmwater lake of 5.0 milligrams/liter (mg/l) minimum during a 24-hour period are being met. Dissolved oxygen concentration levels are expected to be at the lowest in early morning hours and highest during late afternoon following peak photosynthetic activity in the open water season. Thus, at least three dissolved oxygen samples are proposed at two locations in Bear Lake for at least one day in June, July, and August. Unless samples reveal levels below WQS, the dissolved oxygen sampling would be for one year only.

Monitoring for phosphorus, chlorophyll *a*, and transparency (Secchi disk readings) has been occurring on Bear Lake for more than 30 years by property owner volunteers in cooperation with the Michigan Lake and Stream Associations and the Michigan Department of Environment Quality (MDEQ). This annual sampling is now part of the Michigan Clean Lakes Program. Over the years the sampling has been adjusted and expanded to include more sampling dates and increased sampling for total phosphorus. The sampling plan for these three parameters in Bear Lake, outlined in Exhibit 93, reflect the changes planned for 2013 and beyond. Any significant changes in phosphorus, chlorophyll *a*, and transparency readings in Bear Lake could signal changes in lake productivity.

Since the chemical treatment for Eurasian milfoil began, surveys to locate and estimate abundance of this invasive species have occurred on an annual basis. This survey work should continue. In addition, once

every five years a survey to estimate the total biomass of rooted aquatic plants (macrophytes) should be completed to provide a measure of plant productivity over time.

Fisheries surveys in Bear Lake are periodically conducted by the Fisheries Division, Michigan Department of Natural Resources (MDNR). Fixed sampling stations and methods have been established to monitor the status of fish populations in Bear Lake with an emphasis on evaluating the walleye stocking program. The Little River Band of Ottawa Indians (LRBOI) also conduct periodic surveys of walleye in Bear Lake and several other nearby lakes of specific interest to the tribe.

### *Bear Creek Monitoring Plan*

The current information on *E. coli* bacteria levels in Bear Creek and tributaries is not adequate to determine whether or not WQS to protect public health are being met. The monitoring plan in Exhibit 94 proposes a one-year sampling effort for *E. coli* at four locations twice during the period from June through August. The four sampling sites would be at Little Bear Creek below the Bear Lake outlet, and three sites in Bear Creek at the 13 Mile Road bridge, at Coates Highway bridge, and at the first bridge above the confluence with the Manistee River. Pending results of these tests, the need for future sampling and the frequency can be evaluated.

Dissolved oxygen samples collected over the last decade in Bear Creek and its tributaries suggest that the WQS of a minimum of not less than 6.0 mg/l in any 24-hour period during summer low flow conditions and not less than 7.0 the rest of the year may not be being met in some locations. The proposed one-year sampling for dissolved oxygen includes paired sampling (1/4 mile upstream and downstream) at a road crossing site downstream of the Bear Lake outlet in Little Bear Creek, one above and below the 13 Mile Road bridge on Bear Creek, and one upstream and downstream of the Coates Road Highway bridge in the Lower Bear Creek. The monitoring would include three sampling times for each day an hour after sunrise, mid-day, and an hour before sundown. The two sampling dates proposed are in mid-July and mid-August at each location. If no problems are detected, a single-year sampling may be sufficient.

The LRBOI has conducted background water quality, habitat, and fisheries surveys in the lower portions of Bear Creek. This periodic sampling by the tribe has contributed to a better understanding of water quality, habitat, and fisheries in the watershed. The MDEQ conducts periodic sampling in Bear Creek for a variety of water quality and habitat parameters in response to specific pollution investigations or as part of routine statewide monitoring. The frequency of the routine monitoring by the MDEQ is dependent upon available funding and statewide priorities.

The U.S. Fish and Wildlife Service, Department of the Interior (USFWS) conducts stream surveys prior to application of chemicals to control sea lamprey in Bear Creek. The information on bottom substrate, stream temperatures, dissolved oxygen, and flows is collected once every three to four years by the USFWS at established sampling locations. In addition, the U.S. Forest Service, Department of Agriculture (USFS) has conducted biological and physical habitat surveys in the downstream areas of Bear Creek for baseline information related to the designation of this portion of the river as a National Scenic River (NSR). Future field work by the USFS to determine any significant changes in the segment of the Bear Creek designated as a NSR has not been established.

The MDNR Fisheries Division has established a Fixed Site Index Station located at Leffew Road (Old Iron Bridge) in the Upper Watershed of Bear Creek as part of its statewide fish population monitoring program. The Leffew Road Index Station will be sampled for three consecutive years beginning in 2011 under the Fixed Site Index Station fish sampling protocol. In addition to electroshocking to determine status of trout and salmon populations, habitat data and 24-hour temperatures will be collected during the three-year sampling period. The next round of three-year index sampling would begin in 2017 unless specific issues require more frequent stream surveys. An electroshocking fisheries survey of Bear Creek

tributaries is being considered and may be implemented when resources are available. MDNR Fisheries Division surveys of other portions of Bear Creek may occur based upon issues or concerns that have been identified in the past or those that may arise in the future.

Monitoring, evaluation, and restoration related to the control of stream bank and road crossing erosion sites have been and will continue to be ongoing activities carried out by the Conservation Resource Alliance, the Bear Creek Watershed Council, and its partnering organizations and agencies. Severe and moderate erosion sites along Bear Creek and major tributaries have been mapped and activities now focus on monitoring restored sites, developing plans, and funding remedial actions on the remaining problem areas.

## **EXHIBIT 93.** Bear Lake Monitoring Plan

| Purpose and type of sampling | Frequency | Start date/ end date | Locations | Total number of samples/year | Responsibility/ potential partners |
|---|---|---|---|---|---|
| *E. coli* (bacteria) swimming/ wading areas | Once every two weeks June through September | 2013 and each year thereafter until results indicate lower or higher frequency appropriate | Township park, MDNR public access site, three other locations (TBD) | Variable with approximately 32 samples days/year | District Health in cooperation with BLWA and BLPOA |
| Fish population surveys | TBD | TBD | Established sampling locations | Sufficient to detect significant changes in abundance/ growth/ reproduction of major species | MDNR Fisheries (potential expanded monitoring by LRBOI) |
| Aquatic plant survey (Eurasian milfoil, etc.) | Once each year | 2013 and thereafter as needed | Established locations | NA | Bear Lake Improvement Board |
| Rooted aquatic plants biomass estimate | Once every five years | Beginning in 2013 | Entire lake | TBD | BLPOA, BLWC |
| Monitor phragmities | Annually | Ongoing | Entire lake | NA | BLPOA, BLWC |
| Conduct hardened shoreline inventory | Commence 2013 | Updated as appropriate | Entire shoreline | NA | BLPOA, BLWA, MDNR, MDEQ, MCPD |
| Transparency (Secchi disk readings) | Once every two weeks from April through Oct. | 2012 and annually thereafter | Established sampling location | 14 samples | Bear Lake property owners, MDEQ, Township/Village, and Public Health District |
| Total phosphorus | Mid April and early September | 2012 and annually thereafter | Established sampling locations/ depth | 4 samples | |
| Chlorophyll *a* | Mid-May through early September | 2012 and annually thereafter | Established sampling locations/ depth | 12 samples | |
| Dissolved oxygen | Once in June, July and Aug. three times/day | 2013 one year sampling | Two sites (TBD) at 5ft. depth | 18 samples | |

SOURCE: Public Sector Consultants, 2012.
NOTE: BLWA=Bear Lake Watershed Alliance; BLPOA= Bear Lake Property Owners Association.

**EXHIBIT 94.** Bear Creek Monitoring Plan

| Purpose and type of sampling | Frequency | Start date/ end date | Locations | Total number of samples/year | Responsibility/ potential partners |
|---|---|---|---|---|---|
| *E. coli* (bacteria) near road crossings | Twice during summer period | One year only unless problems detected | Four locations identified in text | Use of standard WQS protocols | District Health Department, Bear Creek Watershed Council and others |
| Fish population surveys plus 24-hour temperatures | At least one index site *for three consecutive years* | 2012 and 2013, then again in 2017,2018, and 2019 | Leffew Rd. Index Station | NA | MDNR fisheries (LRBOI that may include other locations) |
| Soil erosion and sedimentation control | Yearly | Ongoing activity | Numerous sites on Bear Creek and tributaries | NA | Conservation Resource Alliance, Bear Creek Property Owners and organization and agency partners |
| Prepare agricultural property assessment | Update as necessary | 2013/2014 | Bear Creek and tributaries | NA | BCWC<br>MDARD, MDEQ, MSCD |
| Dissolved oxygen | Three times/ day at each of six locations in July and Aug. | One year unless problems observed | Upstream and downstream at three locations identified in text | 36 with potential use of electronic measuring device | TBD by Implementation Team |

SOURCE: Public Sector Consultants, 2012.

## EVALUATION

The Greater Bear Watershed Committee and Implementation Team will be responsible for evaluating monitoring results and relative attainment of plan goals and objectives. The watershed plan should be re-evaluated every five years beginning in 2018, unless noted otherwise. Results should be compared to existing baseline information and data. If significant adverse changes occur, recommendations will include additional monitoring to further define the concern or corrective actions if water quality or other standards are being exceeded. Currently, the Greater Bear Watershed does not have any total maximum daily load (TMDL) restrictions in place. If TMDLs are implemented in the future, goals of the watershed plan should be amended to coincide with TMDL watershed goals.

Successful implementation of plan recommendations and attainment of goals and objectives will be enhanced by establishing an institutional structure to strengthen coordination of stakeholder groups and assure implementation.

## COST OF PLAN IMPLEMENTATION

The estimated cost of implementing all recommended actions to achieve watershed plan goals and objectives (Exhibit 89 and 90) as well as the information and education actions to achieve watershed plan goals (Exhibits 91 and 92) ranges from $7,654,000 to $9,236,000 over the 10-year horizon of the plan (see Exhibit 95).

## **EXHIBIT 95.** Cost of Plan Implementation

| **Goal** | **Estimated Cost** (Low) | **Estimated Cost** (High) |
|---|---|---|
| General Information & Education Tasks | $119,500 | $119,500 |
| Pathogens Affecting Humans | $155,000 | $185,000 |
| Ecosystem Health | $4,545,000 | $4,785,000 |
| Hazardous Materials | $56,000 | $106,000 |
| Invasive Species | $1,050,000 | $1,850,000 |
| Groundwater | $120,000 | $120,000 |
| Joint Planning and Development | $1,285,000 | $1,685,000 |
| Sustainable Implementation of Greater Bear Watershed Plan | $191,500 | $200,500 |
| Evaluation and Revision of Management Plan Progress | $131,000 | $185,000 |
| **Total** | **$7,653,000** | **$9,236,000** |

SOURCE: Public Sector Consultants, 2013.

# References


ASI Environmental Technologies Inc. 2007a. *Bear Lake Improvement Feasibility Study Report. A Lake Feasibility Study of Bear Lake, Manistee County, Mich*. [Online, accessed 7-26-11.] Available: www.bearlakemichigan.org/lib_html/lib_feas.html

——. 2007b. *Bear Lake Eurasian Milfoil Vegetation Survey Investigative Report: Point-Intercept Grid Survey of Aquatic Vegetation in Bear Lake, Bear Lake, Mich*. [Online, accessed 7-26-11.] Available: www.bearlakemichigan.org/lib-docs/lib-feas-9.pdf

——. 2007c. *Bear Lake Improvement Feasibility Study: A Lake Improvement Feasibility Study of Bear Lake, Manistee County, Mich*. [Online, accessed 7-26-11.] Available: www.bearlakemichigan.org/lib_html/lib_feas.html

——. 2007d. *Bear Lake Improvement Feasibility Study Report*. A Lake Management Plan for Bear Lake, Manistee County, Mich., Village of Bear Lake, Mich. Prepared for Bear Lake Improvement Board. [Online, accessed 1/25/12.] www.bearlakemichigan.org/lib_html/lib_feas.html

*Bear Creek Watershed*. 44°25'15.01"N 86°08'86.31"W elevation 798 feet. Google Earth. July 19, 2004. [Online, accessed 6-15-11.]

Bear Lake Improvement Board, Village of Bear Lake, Mich. Village of Bear Lake Website. June 2011. [Online, accessed 7-26-11.] Available: www.bearlakemichigan.org/lib_html/lib.html

Bear Lake Property Owners Association (BLPOA). 2005. *Efforts to Keep Septic System Updated in the Proposed Sewer Assessment District 1973-2005*. Bear Lake, Mich.: Bear Lake Property Owners Association.

——. 2006. *Results of Study to Determine the Number of Percent of Parcel with Residence/Business in the Village of Bear Lake that Have Received a Permit to Update their Septic System since 1973*. Bear Lake, Mich.: Bear Lake Property Owners Association.

——. 2008. *Surface Water Subcommittee Storm Drain Report*. Bear Lake, Mich.: Bear Lake Property Owners Association.

Brooks, Kenneth N. 2003. *Hydrology and the Management of Watersheds*. Hoboken, N.J.: Wiley-Blackwell.

Carlson, Robert E. 1977. A Trophic State Index for Lakes. *Limnology and Oceanography* 22(2): 361-69.

Carlson, Robert E., and J. Simpson. 1996. *A Coordinator's Guide to Volunteer Lake Monitoring Methods*. North American Lake Management Society (NALMS).. [Online, accessed 7-26-11.] Available: www.secchidipin.org/tsi.htm

Clean Lakes Program, Land Resource Program Division. 1983. *Platte Lake, Benzie County, Michigan Phase I Diagnostic Study*. Lansing, Mich.: Michigan Department of Natural Resources.

Conservation Resource Alliance. 2000. *Bear Creek Watershed Management Plan*. Prepared by the Conservation Resource Alliance, Bear Creek Watershed Council and Project Partners. [Online, accessed 7-26-11.] Available: www.bearwaters.org/Resources.aspx

———. 2004–2008. *River Care. Bear Creek Project Updates*. [Online, accessed 7-26-11.] Available: www.rivercare.org/search/search_results.php?search_type=Project+Update&search_value=Bear+Creek&enter=

———. 2010. *River Restoration in Northwest Michigan—Bear Creek*. [Online, accessed 7-26-11.] Available: www.liaa.info/crabmp/bearcreek.asp

Downing, John A., and E. McCauley. 1992. The Nitrogen:Phosphorus Relationship in Lakes. *Limnol. Oceanogr*. 37 (5): 936–45. [Online, accessed 7-26-11.] Available: http://aslo.org/lo/toc/vol_37/issue_5/0936.pdf

Ducks Unlimited. *Conservation and Recreation Lands* (CARL): GIS Shapefile. [Online, accessed 7-26-2011.] Available: www.ducks.org/conservation/glaro/carl-gis-layer

Environmental Systems Research Institute. 2011. *ArcGIS Explorer Data & Maps*. Redlands, Cal.: Environmental Systems Research Institute.

Huron-Manistee National Forests. n.d. *Bear Creek National Scenic River Management Plan*. Forest Management Plan. Washington, D.C.: U.S. Forest Service, U.S. Department of Agriculture.

Jackovisk, Jon, et. al. June-July 1992. *Huron-Manistee Nation Forests Habitat Inventory*. *Bear Creek Field Data Sheets*. Manistee, Mich.: U.S. Forest Service.

Kevern, Niles, D. King, and R. Ring. 1996. Lake Classification Systems—Part 1. *The Michigan Riparian*, February 1996. Posted on website of Michigan Lake and Stream Associations. [Online, accessed 7-26-11.] Available: www.mlswa.org/lkclassif1.htm

———. Lake Classification Systems—Part 2. 2004. Posted on Michigan Lake and Stream Associations website. [Online, accessed 7-26-11.] Available: www.mlswa.org/lkclassf.htm

Lakeshore Environmental, Inc. February 2009. Bear Lake Aquatic Plant Survey Report. Prepared for Bear Lake Improvement Board. [Online, accessed 7-26-11.] Available: www.bearlakemichigan.org/BearLake%20AnnualReport2008REVISED.pdf

Land Policy Institute at Michigan State University. 2011. Using data from U.S. Geological Survey, 2011, National Land Cover Database 2006 Land Cover. [Online, accessed 7-26-11.] Available at Multi-Resolution Land Characteristics Consortium: www.mrlc.gov/nlcd_2006.php

Little River Band of Ottawa Indians (LRBOI). 2006. *Walleye Recruitment Assessments on Portage Lake, Bear Lake, Tippy Dam Pond, and Big Star Lake 2006*. Natural Resources Report No. 2006-4. Manistee, Mich.: Natural Resources Department, LRBOI.

———. 2010. *Water Quality Program Final Technical Report FY10*. Technical Report for FY09–10, USEPA Grant #I00E56501-1. Manistee, Mich.: Natural Resources Department, LRBOI.

Manistee County Alliance for Economic Success. 2011. *Community Projects, Understanding Wind Energy Initiative*. [Online, accessed 1/11/12.] Available: www.allianceforeconomicsuccess.com/quality-of-life-community-projects.html

Manistee County Conservation District. 2011. *Household Hazardous Waste Clean Sweep Collection Day.* [Online, accessed 1/11/12.] Available: www.manisteecd.org/programs_hazard.html

Michigan Department of Community Health, Division of Environmental Health. 2011. *2011-2012 Michigan Fish Advisory, A Family Guide to Eating Michigan Fish*. [Online, accessed 1/11/12.] Available: http://michigan.gov/documents/FishAdvisory03_67354_7.pdf

Michigan Department of Environmental Quality (MDEQ), Surface Water Quality Division. 1999. *A Biological Survey of Bear Creek and First Creek (1992) in Manistee County, Mich*. Technical Report MI/DEQ/SW-99/018, Lansing, Mich.: MDEQ.

———, Cadillac District Office. 2003. *Bear Creek Road-Stream Crossing Access Data Base*. Cadillac, Mich.: MDEQ

———, Water Division. 2004. *A Biological Survey of Bear Creek and Selected Tributaries (June 1999) in Manistee County, Michigan*. Technical Report MI/DEQ/WD-04/018. Lansing, Mich.: MDEQ.\

——. 2009. *Michigan Community Public Water Supplies*. [Online, accessed 7-26-11.] Available: www.michigan.gov/documents/deq/deq-wb-dwehs-cws-CWSList_247568_7.pdf

———, Water Bureau. 2010. *Biological and Water Chemistry Surveys of Selected Stations (June and July 2009) in the Manistee, Little Manistee, and Big Sable River Watersheds, Grand Travers, Kalkaska, Lake, Manistee, Mason, Osceola and Wexford Counties, Michigan*. Technical Report MI/DEQ/WB-10/016. Lansing, Mich.: MDEQ.

——. 2011. *Concentrated Animal Feeding Operation (CAFO), Permitted/Pending CAFO Facilities*. [Online, accessed 7-26-11.] Available: www.michigan.gov/deq/0,1607,7-135-3313_3682_3713-96774--,00.html and www.michigan.gov/documents/deq/wb-npdes-CAFO-PermitList_269750_7.xls

——. 2011. Michigan Issues New Orders for Fracking: Regulations Increase Environmental Protection and Public Transparency. [Online, accessed 1/11/12.] Available: www.michigan.gov/deq/0,1607,7-135--256844--,00.html

——. 2011. *Storage Tank Information Center*. [Online, accessed 3-14-12.] Available: www.deq.state.mi.us/sid-web/Default.aspx

——. 2012. Bear Creek Watershed: Landscape Level Wetland Functional Assessment.

Michigan Department of Information Technology (MDIT), Center for Geographic Information (CGI). *Bedrock Geology: GIS Shapefile* (MDEQ 1987 data). [Online, accessed 7-26-11.] Available: www.mcgi.state.mi.us/mgdl/

——. *Final Wetland Inventory, Benzie, Manistee and Wexford Counties: GIS Shapefiles* (MDNR 1999, 1978 data). [Online, accessed 7-26-11.] Available: www.mcgi.state.mi.us/mgdl/

——. *Land Cover Circa 1800. GIS Shapefile*. [Online, accessed 7-26-11.] Available: www.mcgi.state.mi.us/mgdl/

——. *LP Michigan Quaternary Geology: GIS Shapefile* (Michigan Natural Features Inventory and MDNR 1998, 1982 data). [Online, accessed 7-26-11.] Available: www.mcgi.state.mi.us/mgdl/

——. *LP Watersheds: GIS Shapefile* (MDEQ 1998 data). [Online, accessed 7-26-11.] Available: www.mcgi.state.mi.us/mgdl/

——. *Michigan DNR Land and Mineral Ownership: GIS Shapefile* (MDNR 2000, data period unknown). [Online, accessed 7-26-11.] Available: www.mcgi.state.mi.us/mgdl/

——. *Michigan Digital Elevation Model: GIS Shapefile*. [Online, accessed 7-26-11.] Available: www.mcgi.state.mi.us/mgdl/

——. *Michigan Geographic Framework All Roads: GIS Shapefile*. [Online, accessed 7-26-11.] Available: www.mcgi.state.mi.us/mgdl/

——. *Michigan Geographic Framework Counties: GIS Shapefile*. [Online, accessed 7-26-11.] Available: www.mcgi.state.mi.us/mgdl/

——. *Michigan Geographic Framework Minor Civil Divisions: GIS Shapefile*. [Online, accessed 7-26-11.] Available: www.mcgi.state.mi.us/mgdl/

——. *Michigan Inland Lake Contours: GIS Shapefile* (N.d., based on MDNR maps 1929-1980). [Online, accessed 7-26-11.] Available: www.mcgi.state.mi.us/mgdl/

——. *Michigan Wells: GIS Shapefile*. [Online, accessed 7-26-11.] Available: www.mcgi.state.mi.us/mgdl/

Michigan Land Resource Project, Public Sector Consultants, 2001, and the Michigan State University Land Policy Institute Picture Michigan Tomorrow Initiative. Lansing, Mich.: Public Sector Consultants Inc.

Michigan Natural Features Inventory (MNFI). 1995. *Wetland Loss Since 1800s: Map. Adapted from interpretation of General Land Office Surveys 1816–1856 and supplemented by National Wetland Inventory from United States Fish and Wildlife Service aerial photos 1975–1983*. Lansing, Mich.: Michigan Natural Features Inventory, Michigan State University Extension. [Online, accessed 7-26-11.] Available: http://web4.msue.msu.edu/mnfi/data/wetchng/manistee.pdf

——. 2007. *Rare Species Explorer* (Web Application). [Online, accessed 7-26-11.] Available: http://web4.msue.msu.edu/mnfi/explorer/

Michigan State University Remote Sensing and GIS Research and Outreach Services. 2006. *Groundwater Mapping Project.* [Online, accessed 3-14-12.] Available: http://gwmap.rsgis.msu.edu/

Minnesota Pollution Control Agency. 2011. *Water–Water Types and Programs*. [Online, accessed 7-26-11.] Available: www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/lakes/lake-water-quality/asessment-definitions-and-notes.html?menuid=&redirect=1

National Oceanic and Atmospheric Association (NOAA). 2000, revised February 2002. *Monthly Station Normals of Temperature, Precipitation and Heating and Cooling Degree Days, 1971–2000: 20 Michigan (Climatography of the United States No. 81)*. Asheville, N.C.: NOAA, National Environmental Satellite, Data, and Information Service, and National Climatic Data Center. [Online, accessed 7-26-11.] Available: http://cdo.ncdc.noaa.gov/climatenormals/clim81/MInorm

Nolan, B.T., and Kerie J. Hitt. 2003. *Nutrients in Shallow Ground Water beneath Relatively Undeveloped Areas in the Conterminous United States*. Water-Resources Investigations Report 02-4289. Denver, Colo.: U.S. Geological Survey.

Northwest Michigan Cooperative Weed Management Area. N.d. *Targeted Species* [Online, accessed 1-16-12.] Available: www.garlic-mustard.org

Odum, Eugene P., in collaboration with Howard T. Odum. 1959. *Fundamentals of Ecology*, 2d ed. Philadelphia: W.B. Saunders Co.

Ontario Ministry of Natural Resources. 2011. *Fish Facts–Fish Biology and Identification*. [Online, accessed 7-26-11.] Available: www.mnr.gov.on.ca/en/Business/LetsFish/2ColumnSubPage/STEL02_165685.html

Reid, George K. 1961. *Ecology of Inland Waters and Estuaries*. New York: Reinhold Publishing Corp.

Robertson, Dale M., William Rose, and Herbert S. Garn. 2003. *Water Quality and the Effects of Changes in Phosphorus Loading, Red Cedar Lakes, Barron and Washburn Counties, Wisconsin.* Water-Resources Investigations Report 03-4238. Denver. Colo.: U.S. Geological Survey. Available: http://pubs.usgs.gov./wri/wrir-03-4238/

Ruttner, Franz. 1953. *Fundamentals of Limnology*. Translated by D. G. Frey and F. E. J. Fry. Toronto: University of Toronto Press.

Schneider, James C., ed. 2000. *Manual of Fisheries Survey Methods II, with Periodic Updates*. Michigan Department of Natural Resources Fisheries Division Publications. [Online, accessed 7-26-11.] Available: www.michigandnr.com/PUBLICATIONS/PDFS/ifr/Manual/SMII%20%20ForewordTOC.pdf

Seites, Heather L. 2011. *Bear Lake–2009 Fisheries Survey Analysis Report*. Field Report. Cadillac Mich.: Michigan Department of Natural Resources, Fisheries Division.

Surface Water Subcommittee, Bear Lake Property Owners Association. 2008. *Storm Drain Report*. Subcommittee Report, Village of Bear Lake.

Tonello, Mark A. 2000. *Bear Lake*. Status of the Fishery Resource Report 2000-6. Lansing, Mich.: Michigan Department of Natural Resources.

———. 2011a. *Bear Creek 1983–2007 Fisheries Surveys*. District Field Survey Report. Cadillac, Mich.: Michigan Department of Natural Resources, Fisheries Division.

———. 2011b. *Bear Creek 2008 Fisheries and Temperature Survey, Spirit of the Woods Club*. District Field Survey Report. Cadillac, Mich.: Michigan Department of Natural Resources, Fisheries Division.

———. 2011c. *Bear Lake–2010 Fisheries Survey Report*. District Field Survey Report. Cadillac, Mich.: Michigan Department of Natural Resources, Fisheries Division.

U.S. Census Bureau. 2000. *United States Census 2000*, Washington, D.C.: U.S. Census Bureau. [Online, accessed 7-26-11.] Available: www.census.gov/main/www/cen2000.html

——. 2010. *United States Census 2010*. Washington, D.C.: U.S. Census Bureau. [Online, accessed 7-26-11.] Available: http://2010.census.gov

U.S. Department of Agriculture. Natural Resource Conservation Service. 1994. *State Soil Geographic (STATSGO) database for Michigan*. GIS Shapefile. [Online, accessed 7-26-11.] Available: www.dnr.state.mi.us/spatialdatalibrary/metadata/statsgo_metadata.htm

——. National Agricultural Statistics Service. 2009. *The 2007 Census of Agriculture*. [Online, accessed 7-26-11.] Available: www.agcensus.usda.gov/Publications/2007/Full_Report/usv1.pdf

U.S. Environmental Protection Agency. 1975. *Inputs of Phosphorus from Precipitation to Lake Michigan.* EPA-600/3-75-005. Duluth Minn.: Environmental Research Laboratory.

———. 2002. *Onsite Wastewater Treatment Systems Manual*. Washington, D.C.: USEPA [Online, accessed 1/19/12.] Available: www.epa.gov/nrmrl/pubs/625r00008/html/625R00008.htm

———. December 2010. *Aquatic Biodiversity*. [Online, accessed 7-26-11.] Available: www.epa.gov/bioindicators/aquatic/carlson.html

———. April 2011. *USEPA Nutrient Criteria Database*. [Online, accessed 7-26-11.] Available: http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/database/index.cfm

———. Spreadsheet Tool for Estimating Pollutant Load (STEPL). Developed for the Environmental Protection Agency by Tetra Tech, Inc. [Online, accessed 2/6/12.] Available: http://it.tetratech-ffx.com/steplweb/

U.S. Fish and Wildlife Service (USFWS). *National Wetlands Inventory: GIS Shapefile*, (1979–1994). [Online, accessed 7-26-11.] Available: www.fws.gov/wetlands/Data/DataDownload.html

———. April 2011. *Stream Flow, Water Quality, Sea Lamprey Spawning Habitat, and Fish Collections, Bear Creek, Michigan*. Data Sheets for Field Collections 1972–2009. USFWS, Sea Lamprey Field Station, Ludington, Mich.

U.S. Geological Survey (USGS). N.d. *Preliminary Maps for a Hydrogeology and Groundwater Resource Assessment of the Northwest Lower Peninsula, Michigan: Surficial Geology and Thickness*. (Data from USGA 1985, Sollar and Packard 1998, MDEQ.) [Online, accessed 7-26-11.] Available: http://mi.water.usgs.gov/images/poster.pdf

Welch, Paul S. 1952. *Limnology*, 2d ed. New York: McGraw-Hill Book Co.

Wetzel, R.G. 1983. *Limnology*, 2d ed. Philadelphia: W.B. Saunders Co.

Wills, Todd C., T. G. Zorn, and A. J. Nuhfer. December 2006. Stream Status and Trends Program Sampling Protocols. Chapter 26, *Manual of Fisheries Survey Methods*, Ann Arbor: Mich.: Michigan Department of Natural Resources Fisheries Division.

Greater Bear
Watershed Management Plan

# Appendix 1A: Summary of Informational Meetings

Informational meetings regarding the Greater Bear Watershed Management Plan were held on August 19, 2011 and September 20, 2011, and were attended by a total of 54 members of the public.

Tim Ervin, of the Alliance for Economic Success, Jim Draze, Chair of the Greater Bear Watershed Steering Committee, and Laura Heintzelman, Executive Director of the Manistee County Community Foundation, kicked off both the evenings by welcoming community members to the event.

At each meeting, the leadership team discussed the importance of watershed planning and how the steering committee came together to develop a watershed plan that will in turn help to create an action plan that the community can use to achieve its vision, goals, and priorities for the future.

Jack Bails and Jon Beard of Public Sector Consultants, the primary consulting firm involved with plan development, were introduced and provided information about the planning process and work that has already been done. They reviewed information that has been collected from other studies and provided information about the Greater Bear Watershed, which encompasses about 220 square miles, mostly in the northern portion of Manistee County.

Attendees were asked to provide their input into the Greater Bear Watershed planning process. They formed small groups and were asked three questions:

- What are some of the things that you do in the watershed?
- What concerns do you have about the watershed?
- What do you want the watershed to look like in 50 years?

A summary of those responses is given below. Detailed responses, as provided by participants, can be found in the Appendix 1B.

**What are some of the things that you do in the watershed?**

Participants gave many examples of activities in which they partake in the watershed including those that relate to recreation, residential uses, and economic activity. Recreational activities included both water- and land-based activities such as fishing, swimming, boating, hiking, biking, and snowmobiling, for example.

Many participants indicated that they reside in the watershed and that the natural resources enhance a way of life for them, their family, and their friends.

Attendees also indicated that they engage in commerce in the watershed, which is enhanced by the natural resources. Some of the commercial activities are tied directly to natural resources

through farming, forestry, and sport fishing; others indicated that natural-resource–based tourism supports other commercial interests in the region such as restaurants and shops.

**What concerns do you have about the watershed?**

Many participants expressed concern regarding degradation of environmental quality, specifically about nutrients and chemicals entering waterbodies from multiple sources including households, businesses, farms, and other sources.

Other concerns identified by participants included stream bank erosion, sedimentation, invasive species, and the health of the fishery. Participants also discussed concerns related to public access to waterbodies and waterways, in conjunction with private property rights.

The group also expressed concern about the lack of financial resources to implement and achieve goals, as well as the long-term economic vitality of communities within the watershed. Members of the group expressed the opinion that strengthening the coordination and collaboration between and among local, state, and federal government, businesses, and the nonprofit community could help address these concerns.

**What do you want the watershed to look like in 50 years?**

Participants expressed a multigenerational vision for the Greater Bear Watershed in terms of how they would like it to look in 50 years. Attendees said that they want to see planned growth and management that maintains and enhances the natural resources of the watershed and the sense of place of the communities within the Greater Bear Watershed. Attendees said that this could be achieved through active partnerships among and between government, business, and nonprofit organizations to realize shared goals, to enhance natural resource assets of the watershed, to help the community retain and attract residents and visitors of all ages, and to support a vibrant economy.

# Appendix 1B: Responses from Participants

Following are individual responses from small group breakout discussions **as identified by participants**. While many of the responses touch on multiple themes, responses were categorized into relevant topics to help identify how people use the resources of the watershed, priority concerns, and goals for the future. Many items identified by participants extend beyond the bounds of watershed planning but are still relevant to resource management.

### *What are some of the things that you do in the watershed?*

*Water-based Activities*

- Fish
- Ice fishing
- Swim
- Wade
- Kayak
- Canoe
- Boat
- Tube
- Water ski
- Sail
- Jet ski
- Windsurf

*Land-based Activities*

- Picnic
- Garden
- Fertilize land
- Walk/hike
- Camp
- Hunt/trap
- Off-road vehicles (snowmobile, ATVs, golf carts)
- Snowshoe
- Cross country ski
- Mushroom hunting
- Use scenic trails
- Horseback riding
- Bicycle
- Golf
- Landscape the property
- Irrigate land

*Other Activities*

- Entertain friends and family
- Reside
- Take photographs
- Own businesses
- View wildlife (bird watching)
- Campfires
- Enjoy scenery
- Educate children and adults
- Wash cars/vehicles

*Resource-based Commercial Activities*

- Logging
- Tourism
- Oil/gas wells
- Charter (fishing) activity
- Gravel/sand mining
- Farm & Cultivate crops

*Community-based Activities*

- Go to school
- Meet as local clubs

## *What concerns do you have about the watershed?*

*Potential Sources of Pollution/Degradation of Resources*

- Fertilizers and septic systems—harming the environment vs. practical need for farming and green spaces
- Oil/gas development
- Storm water runoff
- Oil well fracking
- Disaster from traffic on U.S. 31 that could result in a hazardous spill
- Old dump on Maidens Rd.
- Boat contamination
- Sludge dumping - PCA
- Animal waste
- Waste water dumps into the lake through storm sewers
- Septic or holding tanks
- Phosphate containing products
- Storm drains & runoff
- Waste disposal
- Oil well drilling
- Brine dumped – Fruit production
- Water/air pollution from motors
- Contracts with land owners for sludge dumping
- Runoff from golf course, farm lands, chemicals from businesses
- Three old township dumps

*Other Environmental and Natural Resources Concerns*

- (Degradation of) water quality
- Weed overgrowth
- Water levels
- Tree removal
- Pollution
- Water temperatures
- Erosion
- Litter
- Air pollution
- Sand load in creek
- Water table levels
- Irrigation from the lake
- Adequate water testing
- Drinking water quality
- Crust on bottom of lake
- Overuse (of resources)
- Fires not properly attended
- Landscaping
- Lake outlet maintenance
- Damage to small streams
- Swimming rafts
- Added population putting pressure on streams
- Decrease of resources

*Landowner/ Public Issues*

- Lack of public access to waterways
- Too much public access – like the 9-mile public access site
- (Protecting) Property owner's rights
- ATVs, snowmobiles, etc. in prohibited areas
- People crossing private property to get access
- Misuse of creek by individuals

- Foot traffic
- Public information about state sites on creeks
- Guiding (fishing)

### *Riparian Land Uses*

- Development
- Stabilizing banks
- Proper upland management
- Lack of zoning laws
- Mistreatment of creeks and banks
- Erosion concerns
- Shoreline Best Management Practices (BMPs)
- Keeping banks clean
- Bank erosion, hardening of shoreline
- Building too close to stream
- Blocking stream with illegal dams to create pond
- Boat hoists farther into lake

### *Construction of Road Crossings*

- Road crossing Best Management Practices (BMPs)
- Road Commission practices related to bridge building and repairs
- Sand load – covers gravel
- Installation of culverts has changed nature of creek

### *Aesthetics*

- Wind energy
- Wind power – potential turbines
- Improper disposal of trash, junk, etc.

### *Community & Economic Development*

- No monetary resources
- Opposition to change
- Youth exodus
- Lack of public input before actions and decisions
- Lack of ownership/apathy
- Communication
- Need to identify those who can start and finish
- Local economy
- Blight
- Local government cooperation
- Preserving watershed with collaboration and public input
- Need to get Bear Lake Village and Pleasanton Township involved
- Restrictions – too many and not enough

### *Fisheries & Wildlife*

- Fishing violations
- Fish spawn grounds
- Wildlife habitat
- Fisheries
- Continue to manage weeds (along creeks)
- Jet skis near spawning areas
- Aquatic insect populations
- Sea lamprey
- Non-native invasive species
- Quality of fish and game
- Health of fish
- Invasive aquatic and terrestrial animals
- (Declining) Fish populations
- Improper/illegal usage—snagging

## *What do you want the watershed to look like in 50 years?*

### *Environmental & Natural Resources*

- Cooler water temperatures
- Clean water and air
- Sediment/erosion issues addressed
- Eliminate sand load
- No detrimental species
- Return to natural environment
- Mixed, compatible use of Bear Lake
- Pristine (great fishing, hunting, clean water, clean air)
- Ample flora and fauna
- Limitations on oil and gas wells
- Eliminate dumping
- Everyone understands how to protect watershed
- Pristine woodland and water for entire area with good fishing and hunting
- Beautiful clean lakes and streams
- Educated public and government on conservation issues
- Parks near rivers and lakes
- Water and air quality as good or better than it presently is
- Like it did 50 years ago
- Solid/sustainable businesses
- Like it looks today or better
- Control over invasive species – no new areas or species

### *Water-based*

- High water quality and safe wells
- Higher water levels
- More wood/habitat
- Safeguarded water source
- Excellent water quality
- Good water levels
- All the creeks still there
- Viable fishery

### *Land-based*

- Preserved farm lands
- Land use issues resolved
- Bike/walking path around the lake
- More public trails
- Acres of morel mushrooms

### *Fisheries & Wildlife*

- Larger population of fish
- Invasive species controlled
- Lots of big, healthy fish
- Control over invasive species – no new areas or species
- Abundant fish and wildlife

### *Waste and Pollution Management*

- Non-polluting waste management system
- Sewer system/waste water management plans
- Safe disposal of human and household wastes

### *Community & Economic Development*

- Spirit of cooperation among and between governmental entities
- Improved communities – Kaleva and Bear Lake – without blighted conditions
- Improved economies
- We are communities of choice for people to live, work, and play
- Collaboration among and between governments, communities and agencies
- Active participation in schools and churches
- Economically viable community
- Village plan
- More shared knowledge about the watershed and its care
- Regular and dependable communications among and between community members
- Community collaboration
- Local governments cooperating
- Balance development and public opinion and environmental issues
- Diversity of age and employment in community and in businesses
- Viable economy and halt of "brain drain"
- Population growth
- Population growth while maintaining a rural setting
- A master plan that we are following as a blueprint
- Listed concerns resolved
- Habitable buildings/no blight
- Greatly increased tourism and recreational activity
- Water drainage from all sources is properly and safely managed
- Recreation plan implemented
- An active and attractive village
- Updated commerce and business
- Stop practices that are harmful
- Involved and concerned citizens

### *Other*

- Very few lights at night
- Great grandchildren enjoying clean waters of the watershed
- Remain a special place for family
- Need for oil diminished so oil production is no longer a threat
- Respect for resource/owners
- Better educations on BMPs for our area and for future generations
- Share the resources
- Acquire more public access
- Wonderful media coverage

# Appendix 2A: Greater Bear Watershed Survey Introduction

In conjunction with the development of the Greater Bear Watershed Management Plan, a survey was developed in the spring of 2011 and administered by Draze Consulting between August and December 2011. The survey was constructed using the U.S. Environmental Protection Agency's survey tool and item bank, and was approved by the Michigan Department of Environmental Quality in July 2011.

The survey asked residents and others who use watershed resources a number of questions that are intended to provide the steering committee and project consultants with information about how people use watershed resources, their knowledge of various natural resource management practices, their priorities for and concerns about the watershed, as well as other information.

The survey was available online and hard copies were made available to individuals without online access. Hard copies were available at the public libraries, the schools, and the Bear Lake and Maple Grove Township Halls. Since respondents were self-selected (not a random sample), survey results are not statistically significant. In other words, the results of the survey provide information about respondents' preferences and the way they use the watershed, but survey results cannot be extrapolated to provide information about all users in the watershed. It is also likely that people who are generally more aware of watershed issues and engaged in the plan process responded to the survey in greater numbers, which likely affected the results.

The results of the survey are still informative because they provide information about how respondents use the watershed, their knowledge of watershed management practices, and their priorities and concerns for natural resources in the region. This information is being used to inform the development of the Greater Bear Watershed Management Plan.

# Appendix 2B: 2011 Survey of Residents in the Greater Bear Watershed

*All percentages reported in tables are the percentage of all respondents who answered that particular question (including those who answered "don't know.")

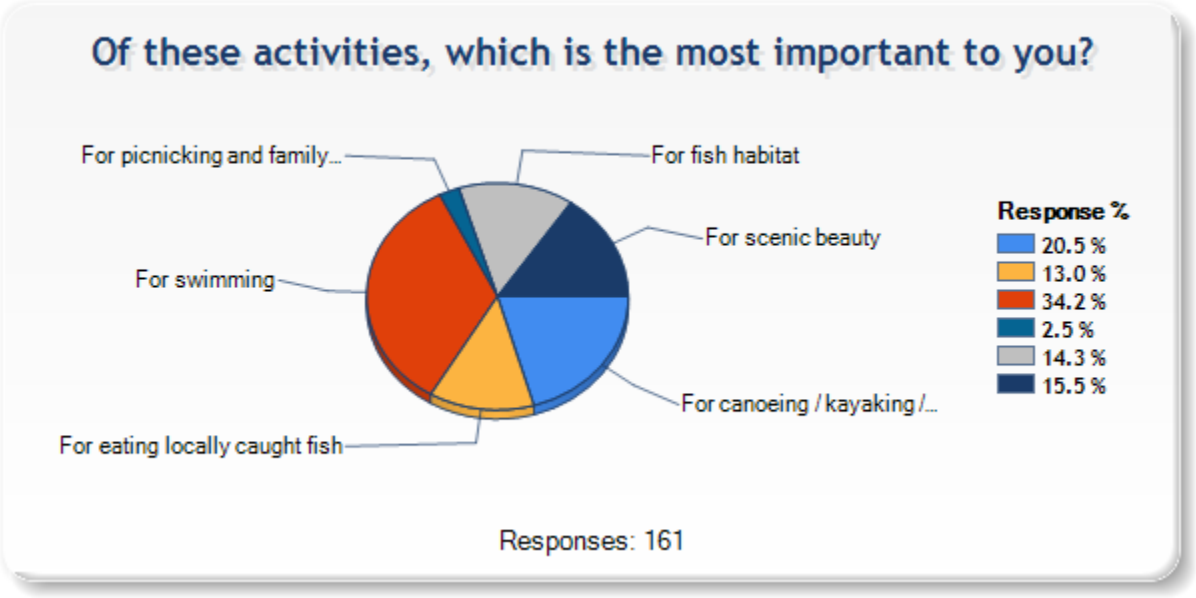
## Ratings of Water Quality

| | Poor | OK | Good | Don't Know | Total Responses |
|---|---|---|---|---|---|
| 1. For canoeing / kayaking / other boating | 1.9% | 9.9% | 83.9% | 4.3% | 161 |
| 2. For eating locally caught fish | 3.1% | 21.0% | 64.8% | 11.1% | 162 |
| 3. For swimming | 4.3% | 19.3% | 70.2% | 6.2% | 161 |
| 4. For picnicking and family activities | 3.1% | 14.2% | 79.0% | 3.7% | 162 |
| 5. For fish habitat | 6.2% | 29.8% | 49.1% | 14.9% | 161 |
| 6. For scenic beauty | 1.2% | 8.7% | 90.1% | 0.0% | 161 |

How has the fishing changed in the past five years?

| | Worse | Stayed the same | Improved | Don't Know | Total Responses |
|---|---|---|---|---|---|
| 1. In Bear Lake? | 18.5% | 21.6% | 17.3% | 42.6% | 162 |
| 2. In Bear Creek or tributary streams? | 5.1% | 12.7% | 5.7% | 76.4% | 157 |

## Water Resources



68.9% of respondents indicated they knew where the rain water goes when it runs off of their property. (161 respondents)

Where does your rain water drain to? (100 respondents)

- 43% into Bear Lake
- 26% into the ground (including swamps, ponds, woods, wetlands, fields, etc.)
- 16% into Bear Creek or tributaries
- 5% watershed or water table
- 4% into other Lakes (Glovers Lake, Lake Michigan, Manistee Lake)
- 3% flows down roads or streets
- 3% into a retention pond or sewer system

## Water Access

| How do you typically access Bear Lake & Bear Creek and tributaries? | Bear Lake (156 responses) | Bear Creek & tributaries |
|---|---|---|
| Public access site | 32.1% | 27.0% |
| Dock, mooring or launching from your own property or friends' property | 48.1% | 13.8% |
| Road end or dedicated easement | 2.6% | |
| Road crossing | | 11.3% |
| Village Park boating access site | 3.8% | |
| My household does not access | 13.5% | 47.8% |

| How would you rate the quality of the access? | Bear Lake (160 responses) | Bear Creek & tributaries |
|---|---|---|
| Poor | 3.8% | 5.6% |
| Fair | 16.9% | 22.5% |
| Good | 41.2% | 18.8% |
| Excellent | 30.6% | 5.0% |
| Do not know | 7.5% | 48.1% |

## Opinions

| | Strongly Disagree | Disagree | Neither agree nor disagree | Agree | Strongly agree | Total responses |
|---|---|---|---|---|---|---|
| 1. The way that I care for my lawn and yard can influence water quality in local streams and lakes. | 5.6% | 4.4% | 7.5% | 35.0% | 47.5% | 160 |
| 2. It is my personal responsibility to help protect water quality. | 0.6% | 1.2% | 9.4% | 35.6% | 53.1% | 160 |
| 3. It is important to protect water quality even if it slows economic development. | 1.9% | 3.2% | 19.2% | 37.8% | 37.8% | 156 |
| 4. My actions have an impact on water quality. | 3.2% | 0.6% | 11.0% | 34.8% | 50.3% | 155 |
| 5. I would be willing to pay more to improve water quality (for example: through local taxes or fees). | 15% | 13.1% | 22.5% | 29.4% | 20.0% | 160 |
| 6. I would be willing to change the way I care for my lawn and yard to improve water quality. | 2.5% | 5.6% | 18.0% | 39.8% | 34.2% | 161 |
| 7. The quality of life in my community depends on good water quality in local streams, rivers and lakes. | 0.6% | 3.1% | 8.8% | 40.6% | 46.9% | 160 |

## Water Impairments

| | Not a Problem | Slight Problem | Moderate Problem | Severe Problem | Don't Know | Total responses |
|---|---|---|---|---|---|---|
| 1. Sedimentation (dirt and soil) in the water | 21.9% | 26.2% | 26.9% | 5.6% | 19.4% | 160 |
| 2. Bacteria and viruses in the water (such as *E.coli*/coliform) | 25.3% | 26.5% | 15.4% | 6.2% | 26.5% | 162 |
| 3. Trash or debris in the water | 24.2% | 41.6% | 15.5% | 7.5% | 11.2% | 161 |
| 4. Oil and grease | 32.7% | 29.0% | 11.1% | 6.2% | 21.0% | 162 |
| 5. Algae in the water | 16.8% | 31.7% | 29.2% | 5.6% | 16.8% | 161 |
| 6. Invasive aquatic plants and animals | 7.5% | 13.7% | 40.4% | 22.4% | 16.1% | 161 |
| 7. Habitat alteration harming local fish | 13.0% | 21.7% | 24.2% | 13.0% | 28% | 161 |
| 8. High water temperature | 28.0% | 21.7% | 16.1% | 3.7% | 30.4% | 161 |
| 9. Excessive nutrients | 13.8% | 20.8% | 18.2% | 7.5% | 39.6% | 159 |
| 10. Hazardous chemicals | 30.6% | 16.2% | 5.0% | 8.8% | 39.4% | 160 |
| 11. Dams and water withdrawals | 38.5% | 13.7% | 9.3% | 3.1% | 35.4% | 161 |

## Sources of Water Pollution

| | Not a Problem | Slight Problem | Moderate Problem | Severe Problem | Don't Know | Total responses |
|---|---|---|---|---|---|---|
| 1. Soil erosion from shorelines and/or streambanks | 20.0% | 32.5% | 30.0% | 7.5% | 10.0% | 160 |
| 2. Excessive use of lawn fertilizers and/or pesticides | 10.1% | 18.9% | 30.2% | 18.2% | 22.6% | 159 |
| 3. Grass clippings and leaves entering lakes and streams | 20.6% | 19.4% | 26.2% | 6.9% | 26.9% | 160 |
| 4. Improper disposal of household wastes (chemicals, batteries florescent light bulbs, etc.) | 26.5% | 21.6% | 11.1% | 10.5% | 30.2% | 162 |
| 5. Improperly maintained septic systems | 9.3% | 16.0% | 25.3% | 23.5% | 25.9% | 162 |
| 6. Manure from farm animals | 26.6% | 21.5% | 16.5% | 5.7% | 29.7% | 158 |
| 7. Excessive use of fertilizers for crop production | 18.0% | 21.7% | 21.7% | 8.7% | 29.8% | 161 |
| 8. Timber harvesting/residue management | 27.7% | 20.6% | 12.9% | 7.1% | 31.6% | 155 |
| 9. Highway/road/bridge runoff | 9.3% | 16.7% | 32.7% | 16.0% | 25.3% | 162 |
| 10. Removal of riparian vegetation | 10.6% | 26.1% | 16.1% | 8.7% | 38.5% | 161 |
| 11. Streambank or shoreline modification/destabilization | 13.7% | 23.0% | 21.7% | 7.5% | 34.2% | 161 |
| 12. Drainage/filling of wetlands | 18.9% | 23.3% | 18.9% | 7.5% | 31.4% | 159 |
| 13. Spills | 24.1% | 25.3% | 8.2% | 6.3% | 36.1% | 158 |
| 14. Removal of vegetation bordering the water by property owners | 12.4% | 31.1% | 17.4% | 8.7% | 30.4% | 161 |
| 15. Oil and grease from cars, ATVs, boats or snowmobiles | 14.1% | 30.8% | 25.6% | 8.3% | 21.2% | 156 |

## Consequences of Poor Water Quality

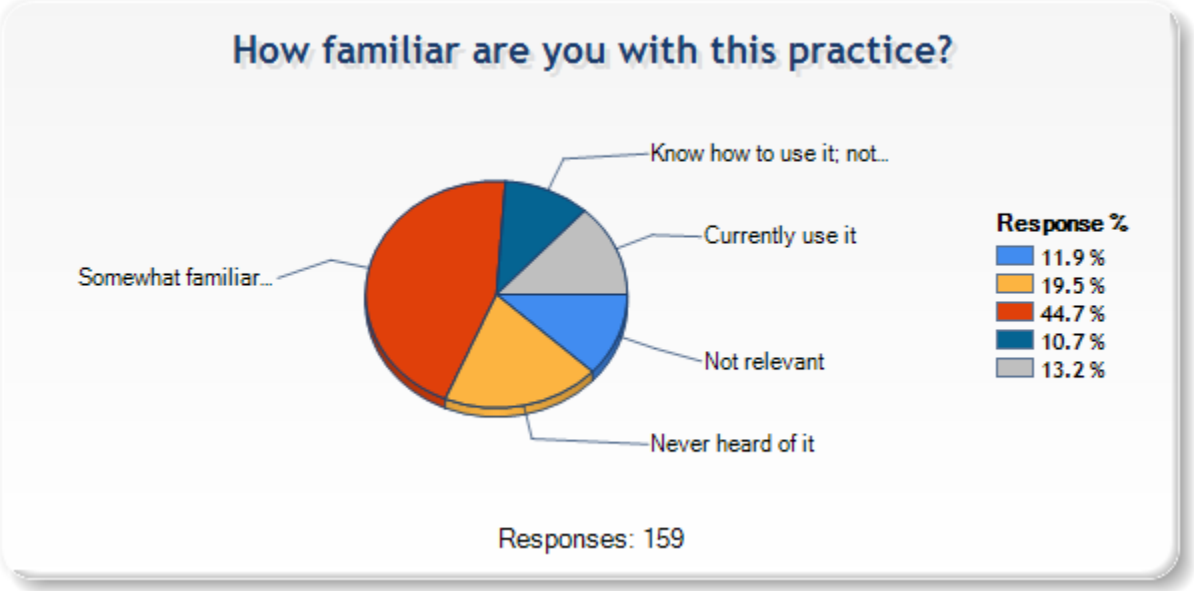
| | Not a Problem | Slight Problem | Moderate Problem | Severe Problem | Don't Know | Total responses |
|---|---|---|---|---|---|---|
| 1. Contaminated drinking water | 44.0% | 27.7% | 13.8% | 3.1% | 11.3% | 159 |
| 2. Polluted swimming areas | 35.8% | 36.5% | 16.4% | 3.1% | 8.2% | 159 |
| 3. Contaminated fish | 37.7% | 21.4% | 13.2% | 7.5% | 20.1% | 159 |
| 4. Loss of desirable fish species | 16.4% | 17.6% | 28.3% | 15.1% | 22.6% | 159 |
| 5. Reduced opportunities for water recreation | 47.2% | 20.1% | 13.8% | 6.3% | 12.6% | 159 |
| 6. Excessive aquatic plants or algae | 10.1% | 28.5% | 38.0% | 8.2% | 15.2% | 158 |
| 7. Lower property values | 27.4% | 24.8% | 17.2% | 7.6% | 22.9% | 157 |

## Practices to Improve Water Quality

| . | Not relevant for my property | Never heard of it | Somewhat familiar with it | Know how to use it; not using it | Currently use it | Total responses |
|---|---|---|---|---|---|---|
| 1. Following the manufacturer's instructions when fertilizing lawn or garden | 21.9% | 0.6% | 10.0% | 20.0% | 47.5% | 160 |
| 2. Use a mulching lawn mower | 19.0% | 1.3% | 9.5% | 19.0% | 51.3% | 158 |
| 3. Keep grass clippings and leaves out of the roads, ditches, and gutters | 20.0% | 2.5% | 8.1% | 8.8% | 60.6% | 160 |
| 4. Use phosphate free fertilizer | 25.6% | 4.4% | 7.5% | 21.2% | 41.2% | 160 |
| 5. Regular servicing of septic system | 8.8% | 1.3% | 7.5% | 8.2% | 74.2% | 159 |
| 6. Use rain barrels | 24.1% | 9.5% | 19.6% | 39.9% | 7.0% | 158 |
| 7. Restore native plant communities | 27.6% | 10.9% | 25.6% | 22.4% | 13.5% | 156 |
| 8. Restore/enhance wetland | 35.2% | 7.5% | 28.9% | 18.9% | 9.4% | 159 |

## Specific Constraints of Practices

*Forest Management Plan:* *A plan describing methods for timber management, harvest and culture that also protects wildlife habitat, watersheds, aesthetics and endangered and threatened plant and animal species. (Responses to questions 1-3 are below, and then the balance of the responses continue in the table that follows.*




11% respondents explained this was not relevant to them because they lived in a village or had no woodlands on their property.

Of the 150 individuals who responded to the question "are you willing to try this practice?",

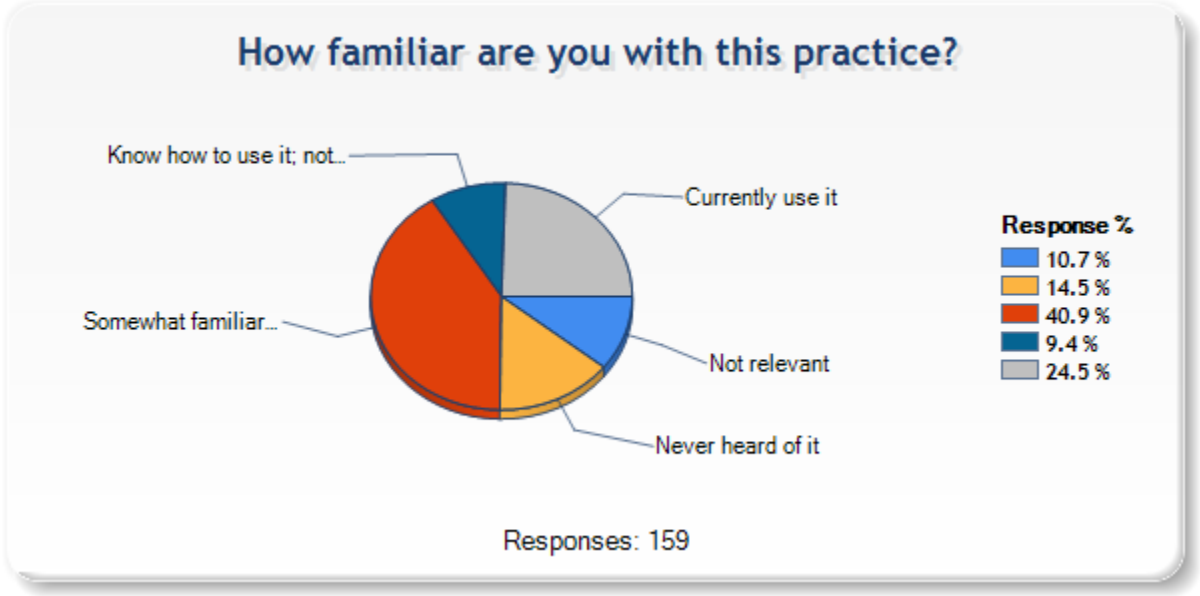
- 42% indicated "Yes or already do"
- 46.7% indicated "Maybe"

- 11.3% indicated "No."

**Limitations to Implementation of Forest Management Plans**

| | Not at all | A little | Some | A lot | Don't know | Total responses |
|---|---|---|---|---|---|---|
| 4. Don't know how to do it | 29.6% | 16.9% | 21.8% | 12.7% | 19.0% | 142 |
| 5. Time involved | 27.8% | 17.4% | 18.8% | 13.2% | 22.9% | 144 |
| 6. Cost | 21.0% | 13.3% | 20.3% | 16.1% | 29.4% | 143 |
| 7. The features of my property make it difficult | 26.0% | 11.6% | 18.5% | 17.1% | 26.7% | 146 |
| 8. Insufficient proof of water quality benefit | 38.9% | 8.3% | 13.2% | 6.2% | 33.3% | 144 |
| 9. Desire to keep things the way they are | 28.9% | 16.2% | 21.1% | 12% | 21.8% | 142 |
| 10. Physical or health limitations | 49.6% | 13.5% | 10.6% | 2.8% | 23.4% | 141 |
| 11. Hard to use with my farm system | 51.0% | 4.2% | 8.4% | 1.4% | 35.0% | 143 |
| 12. Lack of equipment | 36.1% | 4.9% | 13.9% | 14.6% | 30.6% | 144 |

*Vegetated Steambank/Shoreline Protection:* *Maintaining vegetation that grows along streams, rivers or lakes acts as a protective buffer between the land and the water to reduce runoff and sediments flowing into the water. (Responses to questions 13-15 are below, and then the balance of the responses continue in the table that follows.)*




7.5% respondents explained this was not relevant to them because they lived in a village or had their property had no water frontage. 5% of the respondents believed this item was not relevant to them for other reasons (property slopes away from water, no time to implement practices, nature made plans are used, have seen no changes in 28 years).

Of the 145 individuals who responded to the question "are you willing to try this practice?",

- 51% indicated "Yes or already do"
- 37.2% indicated "Maybe"

- 11.7% indicated "No"

### Limitations to Implementation of Practices to Protect Vegetated Streambanks and Shorelines

| | Not at all | A little | Some | A lot | Don't know | Total responses |
|---|---|---|---|---|---|---|
| 16. Don't know how to do it | 43.3% | 10.6% | 21.3% | 8.5% | 16.3% | 141 |
| 17. Time involved | 39.3% | 14.3% | 18.6% | 10.7% | 17.1% | 140 |
| 18. Cost | 38.4% | 5.8% | 19.6% | 15.2% | 21.0% | 138 |
| 19. The features of my property make it difficult | 33.3% | 14.9% | 11.3% | 22.0% | 18.4% | 141 |
| 20. Insufficient proof of water quality benefit | 46.0% | 12.2% | 12.2% | 5.0% | 24.5% | 139 |
| 21. Desire to keep things the way they are | 42.1% | 11.4% | 18.6% | 10.7% | 17.1% | 140 |
| 22. Physical or health limitations | 54.0% | 12.2% | 12.2% | 5.0% | 16.5% | 139 |
| 23. Hard to use with my farm system | 50.4% | 5.0% | 6.5% | 5.0% | 33.1% | 139 |
| 24. Lack of equipment | 37.2% | 8% | 13.9% | 13.1% | 27.7% | 137 |

### Limitations on Making Decisions for Property

| | Not at all | A little | Some | A lot | Don't know | Total responses |
|---|---|---|---|---|---|---|
| 1. Personal out-of-pocket expense | 23.7% | 13.7% | 24.5% | 25.9% | 12.2% | 139 |
| 2. My own physical abilities | 50.7% | 16.7% | 14.5% | 8.7% | 9.4% | 138 |
| 3. Not having access to the equipment I need | 26.1% | 13.8% | 29.0% | 16.7% | 14.5% | 138 |
| 4. Lack of available information about a practice | 29.0% | 15.9% | 26.1% | 14.5% | 14.5%% | 138 |
| 5. No one else I know is implementing the practice | 40.6% | 10.1% | 17.4% | 10.1% | 21.7% | 138 |
| 6. Approval of my neighbors | 59.1% | 10.2% | 10.2% | 3.6% | 16.8% | 137 |
| 7. Don't know where to get information or instructions about those practices | 40.3% | 14.4% | 21.6% | 10.8% | 12.9% | 139 |
| 8. Environmental damage caused by the practice | 46.0% | 11.7% | 11.7% | 5.8% | 24.8% | 137 |
| 9. Legal restrictions on my property | 48.5% | 6.6% | 13.2% | 6.6% | 25.0% | 136 |
| 10. Concerns about resale value | 49.3% | 8.0% | 14.5% | 8.7% | 19.6% | 138 |
| 11. Not being able to see a demonstration of the practice. | 43.0% | 7.4% | 15.6% | 15.6% | 18.5% | 135 |
| 12. The need to learn new skills or techniques | 40.1% | 10.9% | 20.4% | 11.7% | 16.8% | 137 |

### Support and Opposition to Practices to Protect the Water Quality

| | Strongly oppose | Some-what oppose | No opinion | Some-what support | Strongly support | **Total responses** |
|---|---|---|---|---|---|---|
| 1. Involving students in watershed protection activities | 0.6% | 1.9% | 9.7% | 22.1% | 65.6% | 154 |
| 2. Better planning for future growth | 0.7% | 2.0% | 9.2% | 22.2% | 66.0% | 153 |
| 3. Improving bridge and stream crossings to reduce erosion and sedimentation | 0.7% | 0.7% | 11.8% | 25.0% | 61.8% | 152 |
| 4. Addressing unplugged and abandoned oil, gas and mineral wells to prevent groundwater pollution | 1.9% | 0.6% | 11.7% | 13.0% | 72.7% | 154 |
| 5. Expanding use of storm water detention basins, rain gardens and other methods to reduce surface runoff pollution | 1.3% | 1.3% | 13.0% | 22.1% | 62.3% | 154 |
| 6. Protecting and expanding the natural vegetative strips along shoreline areas of lakes, rivers, and streams | 0.7% | 3.4% | 12.1% | 27.5% | 56.4% | 149 |

### Priorities for Protecting and Enhancing the following sites and resources:

| | Not a priority | Low priority | Medium priority | Highest priority | Don't know | **Total responses** |
|---|---|---|---|---|---|---|
| 1. Centennial farms, orchards, and other productive agricultural lands | 4.5% | 11.7% | 40.9% | 32.5% | 10.4% | 154 |
| 2. Scenic vistas | 2.0% | 11.8% | 35.9% | 46.4% | 3.9% | 153 |
| 3. Public access to lakes and streams | 5.2% | 9.2% | 30.7% | 53.6% | 1.3% | 153 |
| 4. Natural features such as wetlands and natural vegetation along lakes | 1.9% | 6.5% | 33.1% | 56.5% | 1.9% | 154 |
| 5. Unique lands identified or owned by local land conservancies | 5.9% | 7.8% | 33.3% | 44.4% | 8.5% | 153 |
| 6. Native American cultural sites | 15.0% | 23.5% | 31.4% | 22.9% | 7.2% | 153 |
| 7. Lake and stream fishing opportunities | 1.3% | 5.9% | 25.5% | 66.0% | 1.3% | 153 |
| 8. Other | 15.9% | 4.9% | 3.7% | 19.5% | 56.1% | 82 |

## About respondents:

1. 84.2% make the home and lawn care decisions in your household.

2. 64.3% **male**, 35.7% **female**

3. **Median age**: 56

4. **Education level** (151 respondents)

| | |
|---|---|
| 4.6% Some formal schooling | 29.1% 4 year college degree |
| 11.3% High school diploma/GED | 23.8% Post-graduate degree |
| 19.9% Some college | |
| 11.3% 2 year college degree | |

5. **Approximate size of residential lots** (153 respondents)
   20.3% ¼ acre or less
   28.1% More than ¼ acre but less than 1 acre
   25.5% 1 acre to less than 5 acres
   26.1% 5 acres or more

6. 92% own their residence (150 respondents)

7. Mean number of years respondents have lived in their home: 17.42 (144 respondents)

8. **Description of property** where respondents live. (153 respondents)
   36.6% In a town, village, or city
   31.4% In an isolated, rural, non-farm residence
   22.9% Rural subdivision or development
   9.2% On a farm

9. In addition to residences, other property that is owned or managed: (152 respondents)
   8.6% An agricultural operation
   17.8% Forested land
   9.9% Rural recreation property
   74.3% None of these

10. **Professional lawn care service** (152 respondents)
   5.9% Yes, just for mowing
   3.9% Yes for mowing and fertilizing
   6.6% Yes, just for fertilizing and pest control
   2.0% Yes, for mowing, fertilizing, and pest control
   **81.6% No**

11. Average number of people live in households: 2.01 (154 respondents)

**Property description:** (percentage calculated on total # of surveys-164)
Street addresses were requested to determine whether there was broad representation across the watershed. Using Google earth to determine location of all addresses, the following describes the respondents.

- 56.1% live in Bear Lake/Pleasanton Twp. area
- 23.8% live in the Bear Creek and tributary area
- 1.8% live in Manistee or Traverse City but have recreational property in watershed
- 18.3% refused to give address

**Property locations** (154 respondents)
   45.5% on Bear Lake
   4.5% on Bear Creek or tributary stream
   5.2% on another waterbody
   10.4% agricultural land
   34.4% property not located on water body or farm property

91.5% maintain a **grass lawn** at your residence (153 respondents)

24.8% have a **seawall** or similar constructed retention structure on the lake-streamside of their property (153 respondents)

48.4% **fertilize their lawn** (155 respondents)

90.3% have a **washing machine** (154 respondents)

37% have a **garbage disposal** (154 respondents)

65.2% have a **dishwasher** (155 respondents)

Average number of **bathrooms**: 2 (154 respondents)

Average age of **septic systems**: 18.4 years—83.6% indicated their system has been pumped out in the last 5 years. (152 respondents)

What is your opinion of **hydraulic fracturing** (sometimes called "fracking" or "hydrofracking" for oil and gas exploration or production? (153 respondents)

19% Strongly oppose
13.7% Somewhat oppose
28.1% No opinion
7.2% Somewhat support
7.8% Strongly support
24.2% I have no knowledge of this process

## Agricultural Operations

Management decisions are made by: (26 respondents)

61.5% Respondent and spouse
7.7% Respondent and landowner
7.7% Respondent and business partners
☐ Other
11.5% Respondent and family partners (siblings, parents, etc.)
0% Respondent and tenant (s)
15.4% Someone else makes the decisions for the operation

**Property use**: (24 respondents)

54.2% Tillable acreage
25.0% Rangeland or grazing acreage
79.2% Woodlot
20.8% An orchard
25.0% Tree farm

Tillable acreage (owned and/or rented) of your farming operation this year. (28 respondents)

35.7% — 0 acres
57.1%— 1-99 acres
3.6%— 500-999 acres
0%— 100-400 acres
3.6%—1,000 or more acres

Few agricultural operations included livestock. The total number of livestock reported was 1 beef cattle, 32 chickens, 18 horses, and 8 sheep, goats or alpaca. (25 respondents)

Of the 7 respondents who raised livestock, only 1 person managed manure according to an approved nutrient management plan. None of these 7 respondents had a grazing management plan.

17.6% use fencing to exclude animals from critical areas? (35 respondents). 79.4% indicated they did not have animals.

33.3% manage the harvest of trees on your land under a timber management plan. (36 respondents). 36.1% indicated they did not have woodlands.

## Sources of Information:

People get information about water quality from a number of different sources. To what extent do you trust those listed below as a source of information about soil and water?

| | Level of Trust | | | | | |
|---|---|---|---|---|---|---|
| | Not at all | Slightly | Moderately | Very much | Am not familiar | Total respondents |
| 1. U.S. Environmental Protection Agency | 8.5% | 19.0% | 38% | 28.2% | 6.3% | 142 |
| 2. Local garden center | 14.8% | 31.9% | 37.0% | 11.1% | 5.2% | 135 |
| 3. Lawn care company | 30% | 29.3% | 24.3% | 10.0% | 6.4% | 140 |
| 4. Local community leader | 11.5% | 27.3% | 39.6% | 15.8% | 5.8% | 139 |
| 5. Neighbors/friends | 10% | 29.3% | 42.1% | 15.0% | 3.6% | 140 |
| 6. Little River Band of Ottawa Indians | 36.0% | 21.3% | 25.0% | 7.4% | 10.3% | 136 |
| 7. Manistee Conservation District | 14.1% | 12.7% | 34.5% | 28.2% | 10.6% | 142 |
| 8. U.S. Forest Service | 14.9% | 10.6% | 34.0% | 30.5% | 9.9% | 141 |
| 9. Regional Land Conservancy | 14.1% | 12.7% | 27.5% | 30.3% | 15.5% | 142 |
| 10. Michigan Land Use Institute | 16.7% | 12.3% | 23.9% | 22.5% | 24.6% | 138 |
| 11. Bear Creek Watershed Council | 9.9% | 11.3% | 29.6% | 31.7% | 17.6 | 142 |
| 12. Bear Lake Watershed Alliance | 7.0% | 16.9% | 28.9% | 33.8% | 13.4% | 142 |
| 13. Bear Lake Property Association | 8.3% | 18.1% | 36.8% | 25% | 11.8% | 144 |
| 14. Michigan Dept. of Natural Resources | 10.5% | 12.6% | 37.8% | 33.6% | 5.6% | 143 |
| 15. Michigan Dept of Agriculture | 12.5% | 16.9% | 33.8% | 27.9% | 8.8% | 136 |
| 16. Michigan Dept. of Environmental Quality | 15.4% | 14.0% | 37.1% | 28.0% | 5.6% | 143 |
| 17. Manistee County Health Dept. | 11.1% | 19.4% | 40.3% | 25% | 4.2% | 144 |
| 18. Michigan State University Extension Services | 10% | 8.6% | 35.7% | 36.4% | 9.3% | 140 |
| 19. Spirit of the Woods Conservation Club | 14.6% | 9.5% | 35.8% | 14.6% | 25.5% | 137 |

**Information sources used to learn about water quality** (146respondents)

- 47.7% Local newspapers
- 14.4% Local cable access television
- 34.2% Newsletters delivered through mail
- 33.6% Bear Creek Watershed Council
- 8.9% Information bulletin boards
- 42.5% Internet sources
- 6.8% Other
- 34.2% Local television news
- 29.5% Public meetings
- 8.9% Radio public service announcements
- 32.2% Bear Lake Property Owners Association
- 11% Hand-outs at public library
- 37% Bear Lake Watershed Alliance

## Concerns about the watershed:

- The most important problem at the present time are the drains used for runoff water that empty into Bear Lake.
- Survey is a little long, which may discourage participation. The purpose isn't clear because the questions are so far ranging.
- DEQ is to be complimented for a totally goofy set of question in the middle as well as sets of responses that are totally irrelevant! Otherwise, thanks for opportunity to be heard. NOTE - additional info should be available from a previous attempt at a comprehensive joint master plan as well as from MSU Small Town Design Initiative public hearings.
- In the 28 years we have owned this property, it has been a week-end or summer home. I found many of the questions not very easy to give a meaningful answer. However I feel it is very important to do everything I can to preserve quality and prevent threats to this watershed. One of our biggest problems is to work together with all local {rich and poor} and the non-voting temporary residents like our household.
- I would like to see this community get the state more involved with money – grants.
  Bear lake is a mess- the swimming is poor - the temp rises quickly and the aqua herbicide applications that happen over the summer deter me from even wanting to swim in bear lake. I was not aware of the practice until I lived in the area for a few years.
- I live on Glovers Lake and would appreciate you including GL in your watershed.
- I don't believe the average person knows much about phosphates and how they destroy water quality. Use of fertilizers, septic improvement and shoreline vegetation and trash are all things that cost nothing but not enough info is presented to the public to raise awareness.
- Thank you very much for compiling this data. I hope it's beneficial.
- Caution. Looking out for water quality is a much needed and desirable objective, but if the process trumps property rights to an unreasonable degree, failure is inevitable.
- Our Bear Lake Property is a second home. We however there all 4 seasons of the year and most of the summer. Thank you.
- Need to continue to limit access to Bear Creek to ensure no further damages to banks and property. Adding boat launches along Bear Creek will have a detrimental effect on fishing, bank management and stopping litter.
- I do not live in the watershed but use it frequently. I responded as a citizen living in Manistee but using the Bear Creek seasonally
- I do not want my local, Michigan or Federal taxes to go up. I do not want new laws that will force me or others to spend money and time, when there are laws already in the books.
- Very pleased and thankful we have the Bear Lake Property Owners Assoc., BL Watershed Alliance and the volunteers who give so much time to these organizations. Look forward to the day I'm retired and can participate more.
- Wind turbines--_why are they trying to stop something that will be good for all who are involved?
- Will there be enough funds to correct our concerns and watershed problems?

# Appendix 3: Estimates for Phosphorus Loading in Bear Lake

Some assumptions were necessary in preparing the high and low P loading estimates. The following is a summary of those assumptions. While some of the properties within the Special Assessment District (SAD) are businesses, the majority are residential properties. And because it was impossible to use a single estimate for water use due to the varying nature of businesses, the water use rate for residential properties was used for all parcels.

- Using the best demographic estimates for the watershed (see Exhibit 61 in the Description of the Greater Bear Watershed section), it was assumed that 26 percent of the parcels were seasonal housing units and 74 percent were permanent housing units.
- The estimate assumes that permanent housing units are occupied 365 days per year. Seasonal residents were assumed to occupy the housing units 50 percent of the year. This figure may represent a longer stay for some seasonal residents but it was noted that many seasonal occupants regularly entertain friends and family during the summer recreation season. Assuming a 50 percent occupancy rate may offset the lower estimate of 2.35 people per parcel for seasonal residents.
- The U.S. Environmental Protection Agency (USEPA) estimates average daily wastewater flows of approximately 50 to 70 gallons per person per day (USEPA 2002). To estimate mean wastewater flows the mean of the high and low values was used (60 gallons or 227 liters per person per day).
- The USEPA approximates the P concentration of residential effluent to be 6-12 mg/L (UESPA 2002). For the purposes of the Bear Lake loading, the mean of the high and the low was used (9mg/L) to approximate residential phosphorus (P) concentrations.

The USEPA estimates that well designed and maintained onsite wastewater treatment systems (OWTS) are between 85 and 95 percent effective in capturing P (USEPA 2002). For the Greater Bear Watershed, higher functioning OWTS were considered to be 85 percent effective in capturing P. High and low estimates were also generated by calculating different P capture rates for lower functioning OWTS (those that were not updated between 1973 and 2005). To generate the low estimate it was assumed lower functioning OWTS were 50 percent effective in capturing P. To generate the high estimate it was assumed lower functioning OWTS were 15 percent effective in capturing P.

## Low Estimate

| | Parcels | People Per Parcel | Effluent Per Person (Liters/Day) | Days Per Year | Effluent Residential Phosphorus (P) Concentration (mg/L) | Total Effluent (Liters/year) | Total P in Effluent (mg/year) | P Loss Rate | Max Estimated Pollutant Load (mg/yr) | Kg/yr |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lower Functioning** | | | | | | | | | | |
| Potentially lower functioning onsite wastewater treatment systems (OWTS) permanent residents | 228 | 2.35 | 227.00 | 365.00 | 9 | 44,378,132 | 399,403,190 | 0.50 | 199,701,595 | 200 |
| Likely low functioning OWTS seasonal residents | 80 | 2.35 | 227.00 | 183.00 | 9 | 7,817,518 | 70,357,659 | 0.50 | 35,178,830 | 35 |
| **Total** | **308** | 2.35 | 227.00 | NA | 9 | 52,195,650 | 469,760,850 | 0.50 | **234,880,425** | **235** |
| **Higher Functioning** | | | | | | | | | | |
| Potentially higher functioning OWTS permanent residents | 147 | 2.35 | 227.00 | 365.00 | 9 | 28,622,260 | 257,600,338 | 0.15 | 38,640,051 | 39 |
| Potentially higher functioning OWTS seasonal residents | 52 | 2.35 | 227.00 | 183.00 | 9 | 5,076,310 | 45,686,792 | 0.15 | 6,853,019 | 7 |
| **Total** | **199** | 2.35 | 227.00 | NA | 9 | 33,698,570 | 303,287,130 | 0.15 | **45,493,069** | **45** |
| **Total P Load** | **507** | 2.35 | 227.00 | NA | 9 | **85,894,220** | **773,047,979** | 0.15 | **280,373,494** | **280** |

## High Estimate

| | Parcels | People Per Parcel | Effluent Per Person (Liters/Day) | Days Per Year | Effluent P Concentration (mg/L) | Total Effluent (Liters/year) | Total P in Effluent (mg/year) | P Loss Rate | Max Estimated Pollutant Load (mg/yr) | Kg/yr |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lower Functioning** | | | | | | | | | | |
| Potentially lower functioning OWTS permanent residents | 228 | 2.35 | 227.00 | 365.00 | 9 | 44,378,132 | 399,403,190 | 0.85 | 339,492,712 | 339 |
| Likely low functioning OWTS seasonal residents | 80 | 2.35 | 227.00 | 183.00 | 9 | 7,817,518 | 70,357,659 | 0.85 | 59,804,010 | 60 |
| **Total** | **308** | 2.35 | 227.00 | NA | 9 | 52,195,650 | 469,760,850 | 0.85 | **399,296,722** | **399** |
| **Higher Functioning** | | | | | | | | | | |
| Potentially higher functioning OWTS permanent residents | 147 | 2.35 | 227.00 | 365.00 | 9 | 28,622,260 | 257,600,338 | 0.15 | 38,640,051 | 39 |
| Potentially higher functioning OWTS seasonal residents | 52 | 2.35 | 227.00 | 183.00 | 9 | 5,076,310 | 45,686,792 | 0.15 | 6,853,019 | 7 |
| **Total** | **199** | 2.35 | 227.00 | NA | 9 | 33,698,570 | 303,287,130 | 0.15 | **45,493,069** | **45** |
| **Total P Load** | **507** | 2.35 | 227.00 | NA | 9 | **85,894,220** | **773,047,979** | NA | **444,789,792** | **445** |