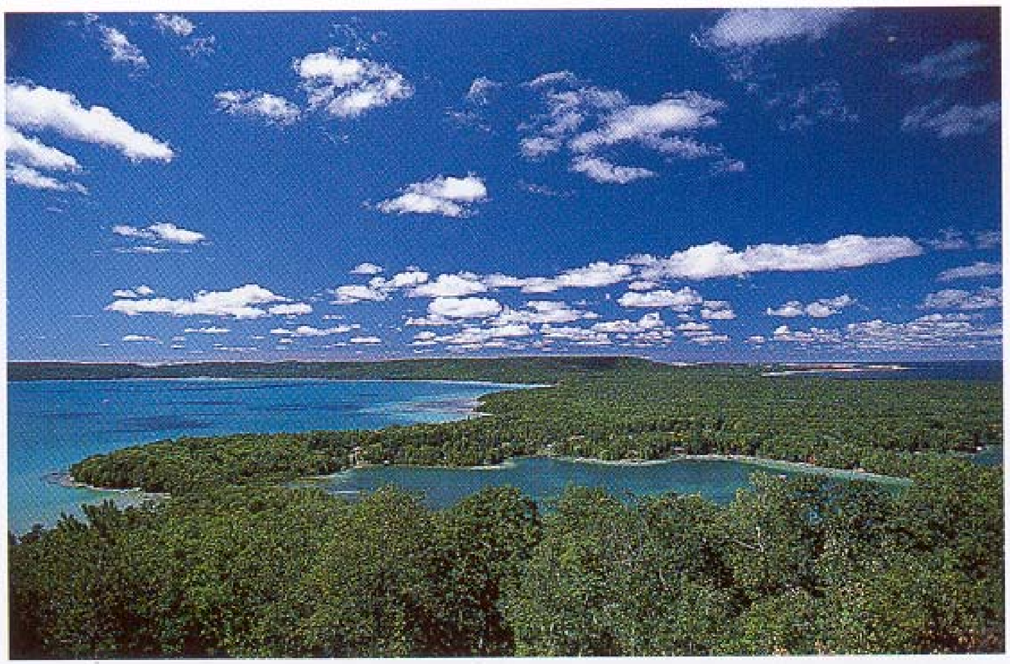
GLEN LAKE-CRYSTAL RIVER WATERSHED MANAGEMENT PLAN



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Introduction

Glen Lake, framed by a dramatic rise of the Sleeping Bear sand dunes to the west, and surrounded by high-forested moraines to the east and south, presents one of the most recognizable landscapes in Michigan. The waters of Glen Lake are so pure that with increasing depth, on a clear day the water colors shift from sandy hues of the shallows through aquamarine to some of the deepest blue known anywhere. To the thousands of visitors who view the lake from Pierce-Stocking Drive, Inspiration Point, or the Narrows Bridge, the lake and its surrounding watershed are simply breathtaking.

While Glen Lake is widely known for its scenic beauty, its value as a biological resource is just as important. Recent studies have documented that the lake's pristine water quality has changed little over the past century. Big Glen is among a handful of Midwestern lakes with extremely low nutrient and algae levels. The lake maintains its high water quality because it is surrounded by nutrient-poor sandy soils, and because the surrounding forests and wetlands are largely intact, filtering out potential pollutants before they reach the lake or its tributaries.

The Watershed Planning Process

In January 2003, an initial Glen Lake-Crystal River Watershed Management Plan was prepared by the Leelanau Conservancy with collaboration and input from major watershed stakeholders including the Glen Lake Association, The Friends of the Crystal River, Sleeping Bear Dunes National Lakeshore, Conservation Resource Alliance and local units of government. Four years later, the same groups again got together to update the watershed plan to include additional information according to newly implemented EPA requirements. The current watershed plan provides a description of the watershed (including such topics as bodies of water, population, land use, municipalities, and recreational activities) and outlines current water quality conditions in the lakes and rivers. Water quality threats were identified and efforts to address these issues were researched, developed, and prioritized. This 2009 updated plan also includes additional information on pollutant sources and concentrations, load reduction estimates of various Best Management Practices (BMPs), fisheries management, critical areas of the watershed, measurable milestones to guide plan implementation progress, and a set of criteria to evaluate the effectiveness of implementation efforts.

Watershed Characteristics

The Glen Lake-Crystal River (GL-CR) watershed is located in beautiful northwest Michigan's Leelanau County and drains approximately 46 square miles of land (29,721 acres). The watershed encompasses all land areas that drain into Glen Lake and its outlet via the Crystal River to Lake Michigan. It is home to portions of the majestic Sleeping Bear Dunes National Lakeshore (a National Park), and contains high-quality hardwood forests around its ridgelines. The only major tributary feeding Glen Lake is Hatlem Creek, entering on the south shore of Big Glen Lake. All other flow into Glen Lake comes from numerous small, groundwater fed tributaries and seeps along the shoreline of both lakes.

The GL-CR watershed is comprised of portions of four townships within Leelanau County: Glen Arbor, Cleveland, Kasson and Empire Townships. In addition to the jurisdictions of these four units of local government, the federal government manages the Sleeping Bear Dunes National Lakeshore, which comprises about 30% of the watershed (excluding the portion of watershed covered by water, the National Park covers almost 40% of the land).

Rich in land and water resources, Leelanau County is home to more than 22,000 people sharing their living space with bobcats, coyotes, deer, great blue herons, lady slippers and trillium. According to the last census, Leelanau County grew at one of the fastest rates in Northwest Michigan. From 1990 to 2000 the county's population rose 28% and future projections indicate a steady growth rate for years to come. In addition, the area is one of the most popular tourist destinations in the Midwest, with growing numbers of visitors each year.

The GL-CR watershed is blessed with over 55% of its land in a forested condition. Northern hardwood stands comprise the single largest land use of the watershed and, with sustainable management, provide an economic resource. At the same time, these forests have vital ecological roles. Following behind forests, water (22%) and open shrub/grasslands (12%) cover the majority of the remaining portions of the watershed. The major human land use of the watershed is residential homes, which comprise nearly 5% of the watershed.

A detailed, scientific study of Glen Lake in 1992, including a hydrological and nutrient budget, shows that approximately 3,560 lb phosphorus (P) enter Glen Lake each year. Of that total, a surprising 62% was from direct precipitation (atmospheric deposition), 26% from subsurface groundwater, and 12% surface water. It was further estimated that no more than 10% of the total P load to the lake each year was attributed to cultural influence, specifically from septic system effluent (Keilty 1992). The study also estimated that 214,860 lb nitrogen (N) enter Glen Lake each year; 37% from direct precipitation, 47% from subsurface groundwater inputs, and 16% surface water. These loading estimates also included storm events. This study did not include any of the GL-CR watershed past the outlet of Fisher Lake.

Hatlem Creek discharges approximately 125 lb P and 7,925 lb N (5,283 lb of which is Nitrate+Nitrite-N) to Glen Lake each year and the Crystal River annually carries approximately 640 lb P and 22,135 lb N (2561 lb Nitrate+Nitrite-N) to Lake Michigan.

Designated Uses and Their Pollutants, Sources, and Causes

Michigan water quality standards and identified designated uses for Michigan surface waters were used to assess the condition of the watershed. Each of Michigan's surface waters is protected by Water Quality Standards for specific designated uses (R323.1100 of Part 4, Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended). These standards and designated uses are designed to 1) protect the public's health and welfare, 2) to enhance and maintain the quality of water, and 3) to protect the state's natural resources. Protected designated uses as defined by Michigan's Department of Environmental Quality include: agricultural, industrial water supply, public water supply (at point of intake), navigation, warm water and/or cold water fishery, other indigenous aquatic life and wildlife support, fish consumption, and partial and total body contact recreation.

None of the designated uses for the GL-CR watershed are impaired on a watershed wide scale. However, in some cases, activities and resulting pollutants in the watershed may prove to be a threat to water quality and designated uses. Threatened waterbodies are defined as those that currently meet water quality standards, but may not in the future. Currently, the designated uses of the GL-CR watershed are threatened from increasing human development along with exotic species introduction and proliferation. The GL-CR Watershed Management Plan will focus on five designated uses to protect in order to maintain water quality throughout Glen Lake and its watershed. The designated uses include the warmwater/coldwater fishery, other indigenous aquatic life and wildlife, total body contact, navigation, and fish consumption. Threatened designated uses were ascertained through scientific research reports, water quality monitoring reports, steering committee members, and personal contact with watershed residents and scientific experts on the GL-CR watershed.

For each designated use to protect in the GL-CR watershed there are a number of different pollutants and environmental stressors that adversely affect each of the designated uses, or have the potential to. The term environmental stressor is used to describe those factors that may have a negative effect on the ecosystem, but aren't necessarily categorized as contaminants that change water chemistry. It is meant to address the wide range of environmental degradation experienced in the watershed. By avoiding the traditional approach of labeling a negative impact as a pollutant, the management plan hopes to engage a wider community support base. This plan will refer to classic watershed pollutants such as nutrients, sediment, and toxic substances, as well as environmental stressors such as habitat and wetland loss. The term pollutant and environmental stressor will be used interchangeably. Environmental stressors representing activities and conditions that negatively impact the designated and/or desired uses of the GL-CR watershed include invasive species, loss of habitat, excess nutrients, sediment loading and more.

Overall, loss of habitat, invasive species, nutrients, and sediment are the top environmental stressors in the watershed. Other issues that threaten these designated uses include changes to hydrologic flow, toxic substances, pathogens, and thermal pollution. All of these factors degrade water quality, destroy aquatic habitat, and reduce the number and diversity of aquatic organisms.

A Comprehensive Watershed Management Table was developed listing sources and causes of watershed pollutants and environmental stressors to help identify water quality problems and provide guidance for future implementation projects to protect the quality of the watershed. This table summarizes key information necessary to begin water quality protection, provides specific targets to act upon for watershed management, and forms the basis for all future implementation projects to protect the quality of the watershed. It may be used as a reference to distinguish what the major sources of pollutants are on a watershed-wide scale.

Prioritization of Pollutants

The project steering committee noted that it is extremely difficult to rank and prioritize all the pollutants and environmental stressors in the watershed because all of them are important and should be priorities for maintaining the health of the GL-CR watershed. Environmental stressors often have synergistic effects on water quality with each pollutant having some effect on the other that allows it to cause more degradation than it would alone.

As stated earlier, loss of habitat, invasive species, nutrients, and sediment are the top environmental stressors in the watershed, in no particular order. Maintaining the excellent water quality and low productivity (oligotrophic status) for Glen Lake will require minimizing the amount of nutrients loading into the lakes and streams through stormwater runoff and groundwater seeps. Nutrients often attach to soil particles, thereby linking sediment and nutrient pollution. Because Glen Lake is oligotrophic and low in nutrients overall, nutrient loading (both Nitrogen and Phosphorus) is a significant threat since the lake has very little aquatic macrophytes to especially in shallow, near shore areas where excessive nutrients cause increased algae and plant growth (as seen from recent Cladophora surveys discussed later in plan).

The project steering committee decided that the specific sources for each pollutant and stressor were the most important items to rank and prioritize in this management plan because that is where one can actually stop pollution from entering waterways. Additionally, as noted above, because most of the pollutants and stressors are interconnected, dealing with one source and its causes could actually reduce a number of different pollutants and stressors from affecting a stream or waterbody. This concept is discussed more in-depth in Chapter 7.

Critical Areas

Although watershed management plans address the entire watershed, there are certain areas within the GL-CR watershed that warrant more extensive management consideration. These are deemed the critical watershed areas. Critical areas in the GL-CR watershed are defined as the portions of the watershed that are most sensitive to environmental impacts and have the greatest likelihood to affect water quality and aquatic habitat. They are areas that may contribute the greatest amount of pollutants to the watershed, either now or in the future, and are considered targets for future water quality improvement efforts. Defining critical watershed areas are even, perhaps, more important than prioritizing watershed pollutants.

Critical areas for the GL-CR watershed were identified by analyzing the Comprehensive Watershed Management Tables and identifying the major areas where most of the threats to water pollution exist. The critical areas for the GL-CR watershed cover roughly a quarter of the watershed and include the following areas:

- **Riparian Corridors**: Areas within 1,000 feet of bodies of water
- **Forested Ridgelines:** Steep, forested slopes comprised of highly permeable soils susceptible to erosion, which drain directly into the lake or tributaries
- **Hatlem Creek Subwatershed:** ecologically rich wetland complex
- **Crystal River Dune Swale Complex:** rare and ecologically rich dune swale complex
- **Groundwater Recharge Areas**: Areas where there is a greater amount of groundwater recharge (significant overlap with Hatlem Creek area).

Watershed Goals, Objectives, and Recommendations

The overall mission for the Glen Lake-Crystal River Watershed Management Plan is to provide guidance for the implementation of actions that will reduce the negative impact that pollutants and environmental stressors have on the designated watershed uses. The envisioned endpoint is to have Glen Lake, the Crystal River, and its watershed continue to support their appropriate designated and desired uses while maintaining their distinctive environmental characteristics and aquatic biological communities.

Using stated goals from the first edition of the GL-CR Watershed Management Plan, suggestions obtained from Steering Committee meetings, and examples from other watershed management plans, the project steering committee developed six broad goals for the GL-CR watershed. Working to attain these goals will ensure that the threatened designated uses described Chapter 4 are maintained or improved. Watershed goals are as follows:

- Protect the integrity of aquatic and terrestrial ecosystems within the watershed.
- Protect and improve the quality of water resources within the watershed.
- Establish and promote land and water management practices that conserve and protect the natural resources of the watershed.
- Enhance the quality of recreational opportunities.
- Establish and promote educational programs that support stewardship and watershed planning goals, activities, and programs.
- Preserve the distinctive character and aesthetic qualities of the watershed, including viewsheds and scenic hillsides.

In an effort to successfully accomplish the goals and objectives, specific and tangible recommendations, called implementation tasks, were developed based on the prioritization of watershed pollutants, sources, and causes while also looking at the priority areas in the watershed. These implementation tasks represent an integrative approach, combining watershed goals and covering more than one pollutant at times, to reduce existing sources of priority pollutants and prevent future contributions.

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

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

Evaluation Procedures

An evaluation strategy will be utilized to measure progress during the Glen Lake-Crystal River Watershed Management Plan's implementation phase and to determine whether or not water quality is improving. The timeline for the evaluation is approximately every 5 years, with ongoing evaluation efforts completed as necessary. The first aspect of the evaluation strategy measures how well we are doing at actually *implementing* the watershed management plan and assesses if project milestones are being met. The second aspect is to evaluate how well we are doing at *improving water quality* in the watershed.

Priority Tasks and Future Efforts for Implementation

The Glen Lake Association, Friends of the Crystal River, Leelanau Conservancy and other project partners will continue to build partnerships with various groups throughout the watershed for future projects involving the implementation of recommendations made in this watershed plan. Continued support and participation from key partner groups, along with the availability of monies for implementation of the plan is necessary to keep the momentum generated by planning efforts. Partners responsible for the implementation of the plan are encouraged to review the plan and act to stimulate progress where needed and report to the larger partnership.

Important issues facing the watershed include: increasing development and the associated pollution it brings, invasive species, and residential runoff into waterways. Priority will be given to implementation tasks (both BMPs and educational initiatives) that work to reduce the effects from these sources.

Priority tasks that should be conducted over the next 1 – 3 years are as follows, with the most important tasks listed first:

- Continue monitoring programs
- Begin initial outreach and education efforts outlined in the education strategy – focusing on general watershed information, invasive species prevention, benefits of water quality protection ordinances and conservation easements, wetland preservation, and pollution stemming from residential areas
- Initiatives to preserve land and wildlife corridors (i.e. conservation easements)
- Establish riparian buffers in priority areas
- Assist with developing or revising Master Plans and Zoning Ordinances to include more water quality protection (i.e. buffer setbacks and septic system point of sale ordinances)
- Wetland assessment, restoration, and protection

Implementing the Education and Outreach Strategy is perhaps the most critical and important long-term task to accomplish. It highlights actions needed to successfully maintain and improve watershed education, awareness, and stewardship for the GL-CR watershed. Additionally, it lays the foundation for the collaborative development of natural resource programs and educational activities for target audiences, community members, and residents. Environmental awareness, education, and action from the public will grow as the Education and Outreach Strategy is implemented and resident awareness of the watershed is increased.

CHAPTER 2 INTRODUCTION

Glen Lake, framed by a dramatic rise of the Sleeping Bear sand dunes to the west, and surrounded by high-forested moraines to the east and south, presents one of the most recognizable landscapes in Michigan. The waters of Glen Lake are so pure that with increasing depth, on a clear day the water colors shift from sandy hues of the shallows through aquamarine to some of the deepest blue known anywhere. To the thousands of visitors who view the lake from Pierce-Stocking Drive, Inspiration Point, Miller Hill, or the Narrows Bridge, the lake and its surrounding watershed are simply breathtaking.

While Glen Lake is widely known for its scenic beauty, its value as a biological resource is just as important. Recent studies have documented that the lake's pristine water quality has changed little over the past century. Big Glen is among a handful of Midwestern lakes with extremely low nutrient and algae levels. The lake maintains its high water quality because it is surrounded by nutrient-poor sandy soils, and because the surrounding forests and wetlands are largely intact, filtering out potential pollutants before they reach the lake or its tributaries.

Watersheds are defined as the area of land that drains into a common water body. As water makes its way down the drainage basin following the path of least resistance, it is influenced by the landscape through which it flows. As a result, all activities within a watershed affect the quality of water as it percolates through and runs across developed landscapes.

The Glen Lake-Crystal River (GL-CR) watershed is home to portions of the majestic Sleeping Bear Dunes, and contains high-quality hardwood forests along its ridgelines. The watershed drains via the Crystal River into Lake Michigan. The overall health of the watershed is remarkably good, although increased development pressure threatens to degrade the function of the land necessary for high water quality. The GL-CR watershed has pristine and sensitive wetland areas associated with its groundwater tributaries and riparian corridors. The lush and diverse biological communities of these areas help to absorb excess nutrients and runoff from adjacent land as well as support many rare and endangered plants and animals. The direct link of wetlands and recharge areas to high water quality demonstrates the influence of land use on bodies of water.

A healthy ecosystem is why people love to live in the Glen Lake area. Many people also live in this region because of the numerous forms of recreation it provides. But, if pollution is unchecked and degradation of this natural resource continues, many of the activities enjoyed by residents and visitors alike will be in jeopardy. Contamination of the lake and river from numerous sources may lead to unsafe swimming and increased blooms of aquatic plants, which are an annoyance to swimmers and boaters. Recreational fishing is also impacted by water pollution; Glen Lake and the other small lakes in the watershed already have fish consumption advisories due to heavy metal contamination. Other forms of recreation that many people enjoy on a daily basis are at stake as well, including swimming, kayaking, canoeing, and hiking.

In order to maintain the quality of this resource, local governments, concerned citizens, and numerous agencies all need to work together towards a common goal – protecting the Glen Lake, Crystal River, and its watershed from further environmental degradation.

Watershed protection means not only responsible lake and stream management, but also conscientious stewardship of all land within the watershed. A watershed management plan summarizes existing water quality conditions, while also outlining and prioritizing major watershed pollutants and offering recommendations on how to reduce the impact and amount of pollution entering the system. The plan also provides a description of the watershed including such topics as bodies of water, population, land use, jurisdictions, current and historical water quality measurements, and recreational activities.

In January 2003, an initial Glen Lake-Crystal River Watershed Management Plan was prepared by the Leelanau Conservancy with collaboration and input from major watershed stakeholders including the Glen Lake Association, The Friends of the Crystal River, Sleeping Bear Dunes National Lakeshore, Conservation Resource Alliance and local units of government. Three years later, the same groups again got together to update the watershed plan to include additional information according to newly implemented EPA requirements. This 2009 revised plan includes additional information on pollutant sources and concentrations, load reduction estimates of various BMPs, measurable milestones to guide plan implementation progress, and a set of criteria to evaluate the effectiveness of implementation efforts.

By addressing all of these watershed uses, the management plan will gain a broad support base throughout the community. If we protect our land, so do we protect our water, thereby ensuring the enjoyment of future watershed residents and visitors.

This watershed management plan was written as a planning framework to be used by watershed stakeholders to maintain and improve the water quality of the GL-CR watershed. The intent of the management plan is to assist lake associations, local governments, volunteer groups, and many others in making sound decisions to help improve and protect water quality in their area. It is important to note that the implementation of any element of this plan by a responsible party does not obligate any other party or stakeholder, to participate beyond their respective organizational objectives.

CHAPTER 3 DESCRIPTION OF THE GLEN LAKE-CRYSTAL RIVER WATERSHED

3.1 Location and Size

The Glen Lake-Crystal River (GL-CR) watershed is located in beautiful northwest Michigan's Lower Peninsula and drains approximately 46 square miles of land[1]. The watershed encompasses all land areas that drain into Glen Lake and its outlet via the Crystal River to Lake Michigan (Figure 1). It is home to portions of the majestic Sleeping Bear Dunes National Lakeshore (SLBE) (Figure 1a), and contains high-quality hardwood forests around its ridgelines. While the GL-CR watershed is small on the scale of most other watersheds in Michigan, it is big on natural beauty and pristine water quality.

3.2 Water Bodies

Glen Lake is comprised of two connected, but quite different, lakes – Big Glen and Little Glen. Big Glen Lake has a surface area of 4,870 acres and includes 10.5 miles of shoreline. The lake has a maximum depth of 130 feet and a mean depth of 70 feet. It has been classified as an oligotrophic lake and is considered to have excellent water quality.

The much shallower Little Glen Lake has a surface area of only 1,400 acres and includes 6.5 miles of shoreline. The lake has a maximum depth of 13 feet and a mean depth of 6.2 feet. It is classified as a mesotrophic lake and is considered to have good water quality. Big and Little Glen Lakes are joined by a shallow channel under the causeway of M-22, known locally as The Narrows.

From Glen Lake water flows through Fisher Lake and the Crystal River into Sleeping Bear Bay in Lake Michigan (Figure 1). The flow of the Crystal River is regulated by a dam at the outlet of Fisher Lake. For a detailed discussion on the Crystal River Dam see Section 3.6: Hydrology and Groundwater Recharge. Crystal River has excellent water quality and is a designated coldwater trout stream due to annual returns of anadromous salmon and steelhead from Lake Michigan.

The only major tributary feeding Glen Lake is Hatlem Creek, entering on the southern shore of Big Glen Lake. All other flow into Glen Lake comes from numerous small, groundwater fed tributaries and seeps along the shoreline of both lakes.

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[1] It should be noted that this value is the topographical watershed area. We area aware of the fact that the hydrological boundary for the watershed may be considerably more. A preliminary hydrological study on groundwater flow and its origin is due out sometime in 2009, however, initial data suggest that the hydrological boundary of the watershed is about 60 mi^2.

FIGURE 1: GLEN LAKE CRYSTAL RIVER WATERSHED – BASE MAP

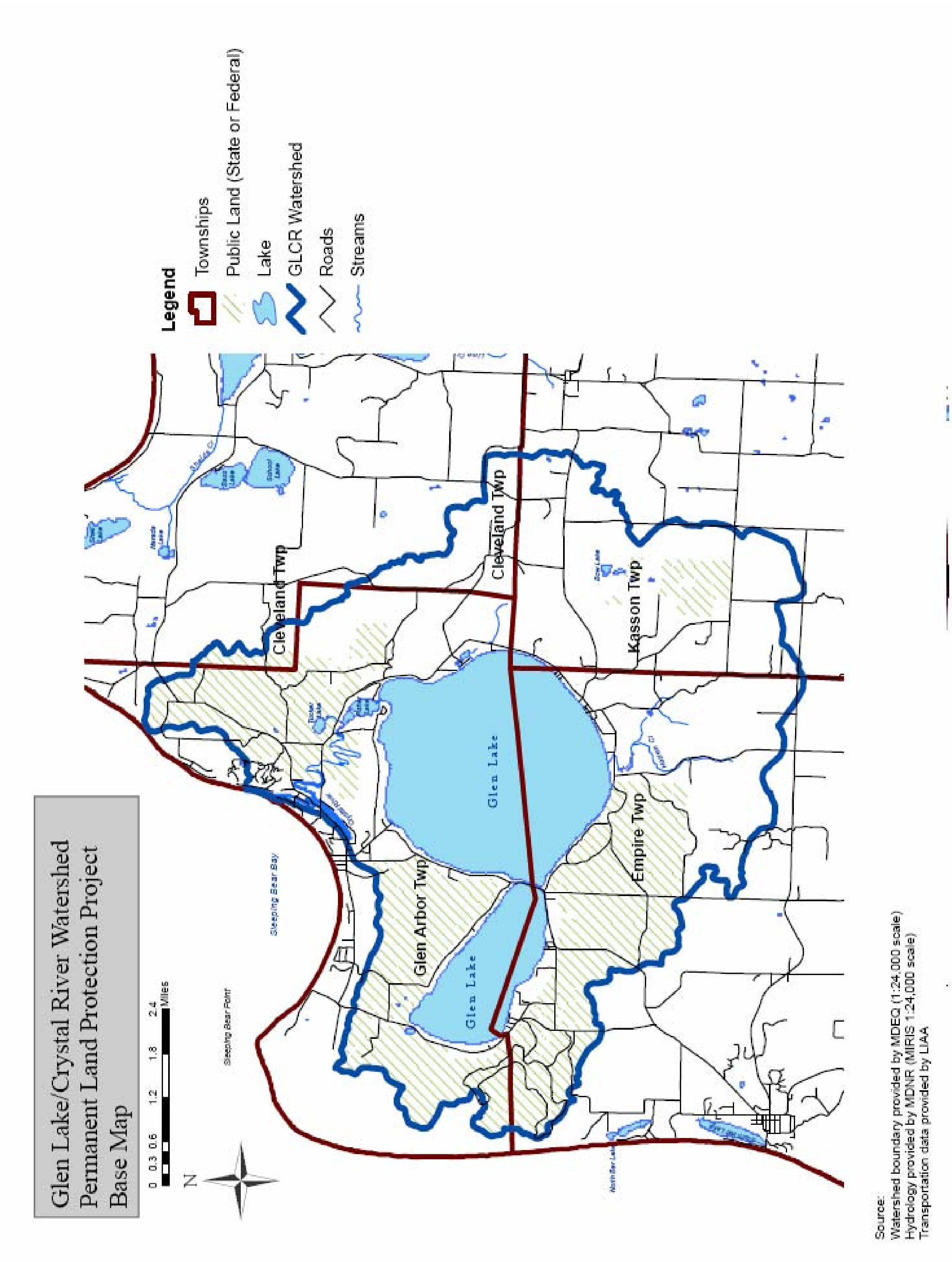
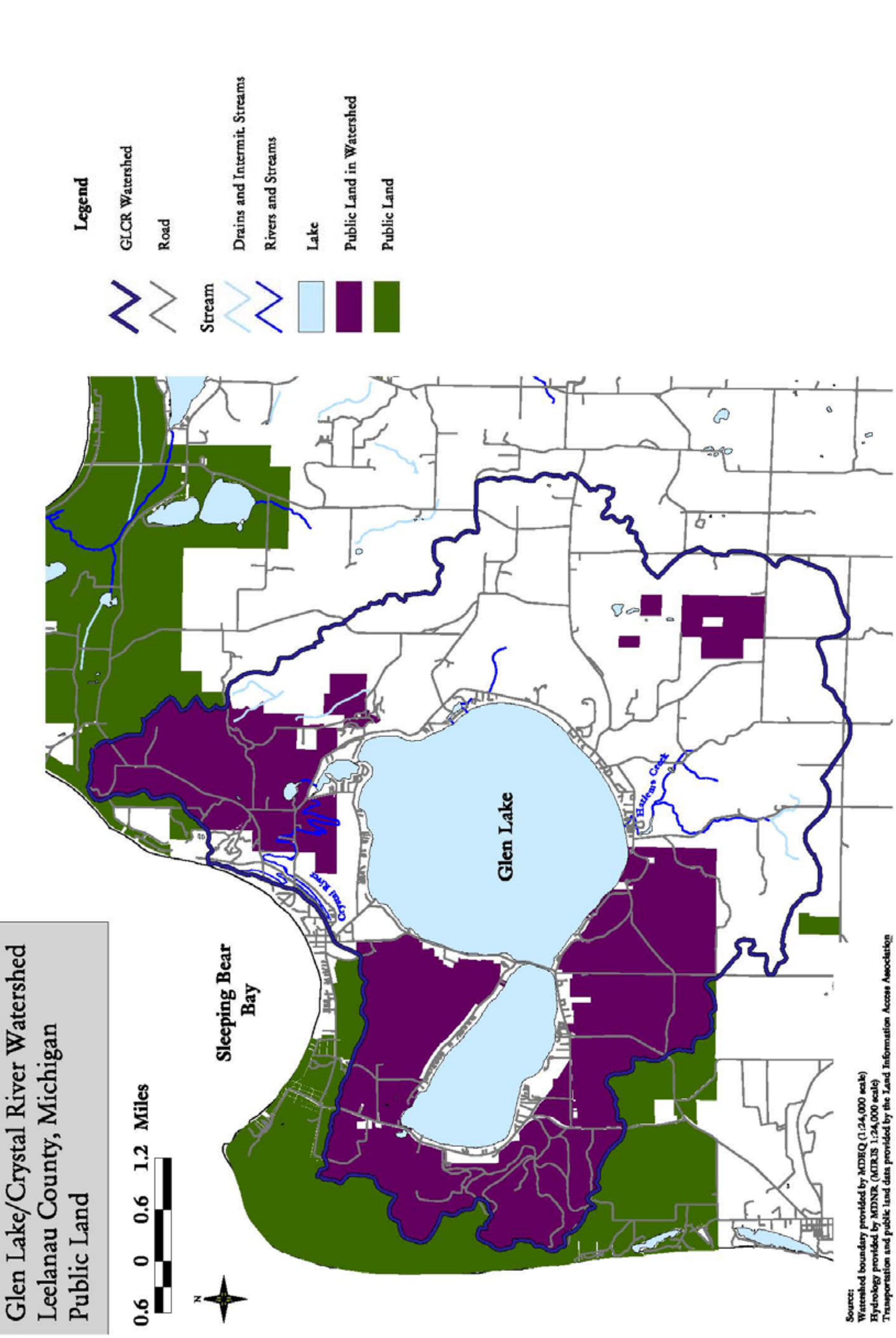


FIGURE 1A: NATIONAL PARK LANDS IN THE WATERSHED



3.3 Jurisdictions

The GL-CR watershed is comprised of portions of four townships within Leelanau County (Figure 1, Table 1). Glen Arbor, Cleveland, Kasson and Empire Townships all influence the location of population centers as well as land use decisions and zoning ordinances within their particular coverage area of the watershed.

In addition to the jurisdictions of these four units of local government, the federal government manages the SLBE (Figure 1a), which comprises about 30% of the watershed (Table 2) (excluding the portion of watershed covered by water, SLBE covers almost 40% of the land). Federal management policies addressing public access, exotic species management and proposed expansion of park boundaries are vitally important to proper watershed planning.

TABLE 1: PERCENT OF EACH TOWNSHIP WITHIN THE WATERSHED

Township	Acres in Watershed	% of Township in Watershed	% of Watershed
Glen Arbor	12,915	57	44
Empire	9,541	39	32
Kasson	5,608	24	19
Cleveland	1,547	7	5

TABLE 2: PUBLIC AND PRIVATE LAND IN THE GLEN LAKE-CRYSTAL RIVER WATERSHED

Jurisdiction	Acres	% of Watershed
State of Michigan	3	0.01
Federal Government	9,276	31.2
Private	14,031	47.2
Water	6,411	21.6
Total	29,721	

How communities manage their land use has a direct impact on the community's water resources. Zoning, master plans, and special regulations are a few of the more commonly used land management tools. Zoning ordinances establish the pattern of development, protect the environment and public health, and determine the character of communities. In 2008, PA 33, titled Michigan Planning and Enabling Act, was signed into law. This law consolidated previous planning acts under one statute, creating a standard structure for all local planning commissions and one set of requirements that will apply to the preparation of all master plans. Since protecting water quality requires looking at what happens on land, zoning is an important watershed management tool.

Planners must recognize that stream quality is directly related to land use and the amount of impervious surfaces is particularly important. Land use planning techniques should be applied that preserve sensitive areas, redirect development to those areas that can support it, maintain or reduce impervious surface cover, and reduce or eliminate nonpoint sources of pollution.

Zoning's effectiveness depends on many factors, particularly the restrictions in the language, the enforcement, and public support. Many people believe the law protects sensitive areas, only to find otherwise when development is proposed. Zoning can be used very effectively for managing land uses in a way that is compatible with watershed management goals. A wide variety of zoning and planning techniques can be used to manage land use and impervious cover in the watershed. Some of these techniques include: watershed based zoning, overlay zoning, impervious overlay zoning, floating zones, incentive zoning, performance zoning, urban growth boundaries, large lot zoning, infill/community redevelopment, transfer of development rights (TDRs), and limiting infrastructure extensions.

Local officials face hard choices when deciding which land use planning techniques are the most appropriate to modify current zoning. Table 3, adapted from the Center for Watershed Protection's Rapid Watershed Planning Handbook, provides further details on land use planning techniques and their utility for watershed protection (CWP 1998). While most of these techniques are for watersheds much bigger than the GL-CR watershed, it still presents a good picture of available land use planning techniques. In addition, the DEQ has published a book titled *Filling the Gaps: Environmental Protection Options for Local Governments* that equips local officials with important information to consider when making local land use plans, adopting new environmentally focused regulations, or reviewing proposed development (Ardizone, Wyckoff, and MCMP 2003). These NPS guidelines are directly accessible at WWW.michigan.gov/deqnps.

See Section 5.5 for further discussion on how Master Plans and Zoning Ordinances may impact water quality.

TABLE 3: LAND USE PLANNING TECHNIQUES

Land Use Planning Technique	Description	Utility as a Watershed Protection Tool
Watershed-Based Zoning	Watershed and subwatershed boundaries are in the foundation for land use planning.	Can be used to protect receiving water quality on the subwatershed scale by relocating development out of particular subwatersheds.
Overlay Zoning	Superimposes additional regulations for specific development criteria within specific mapped districts.	Can require development restrictions or allow alternative site design techniques in specific areas.
Impervious Overlay Zoning	Specific overlay zoning that limits total impervious cover within mapped districts.	Can be used to protect receiving water quality at both the subwatershed and site level.
Floating Zones	Applies a special zoning district without identifying the exact location until land owner specifically requests the zone.	May be used to obtain proffers or other watershed protective measures that accompany specific land uses within the district.
Incentive Zoning	Applies bonuses or incentives to encourage creation of amenities or environmental protection.	Can be used to encourage development within a particular subwatershed or to obtain open space in exchange for a density bonus at the site level.

TABLE 3: LAND USE PLANNING TECHNIQUES CONT'D

Land Use Planning Technique	Description	Utility as a Watershed Protection Tool
Performance Zoning	Specifies a performance requirement that accompanies a zoning district.	Can be used to require additional levels of performance within a subwatershed or at the site level.
Urban Growth Boundaries	Establishes a dividing line that defines where a growth limit is to occur and where agricultural or rural land is to be preserved.	Can be used in conjunction with natural watershed or subwatershed boundaries to protect specific water bodies.
Large Lot Zoning	Zones land at very low densities.	May be used to decrease impervious cover at the site or subwatershed level, but may have an adverse impact on regional or watershed imperviousness.
Infill/ Community Redevelopment	Encourage new development and redevelopment within existing developed areas.	May be used in conjunction with watershed based zoning or other zoning tools to restrict development in sensitive areas and foster development in areas with existing infrastructure.
Transfer of Development Rights (TDRs)	Transfers potential development from a designated "sending area" to a designated "receiving area".	May be used in conjunction with watershed based zoning to restrict development in sensitive areas and encourage development in areas capable of accommodating increase densities.
Limiting Infrastructure Extensions	A conscious decision is made to limit or deny extending infrastructure (such as public sewer, water, or roads) to designated areas to avoid increased development in these areas.	May be used as a temporary method to control growth in a targeted watershed or subwatershed. Usually delays development until the economic or political climate changes.

Table adapted from Center for Watershed Protection's Rapid Watershed Planning Handbook – page 2.4-5 (CWP 2001)

3.4 Population

Rich in land and water resources, Leelanau County is home to more than 22,000 people sharing their living space with bobcats, coyotes, deer, great blue herons, lady slippers and trillium.

According to the last census, Leelanau County grew at one of the fastest rates in Northwest Michigan. From 1990 to 2000 the county's population rose 28% (Table 4) and future projections indicate a steady growth rate for years to come. This means that over 10,000 more people will be moving into the county by the year 2020. They will be attracted to Big and Little Glen Lakes and the surrounding area partly because of the pristine water quality and the recreational attractions. But, as more and more people discover how beautiful these lakes and this region are, the more difficult it will be to maintain their current outstanding water quality (Stone 2005).

Most of the population in the watershed is primarily confined to a fairly narrow band along the lakeshore. Scattered homes exist along arteries leading to the lakeshore. Interesting to note is that the community of Glen Arbor, located directly next to Glen Lake, is technically not in the watershed area and water drains right to Lake Michigan.

The Northwest Seasonal Population Model, completed in 1996, estimates that during the summer months, Leelanau County's population almost doubles (note: study only included overnight visitation and daily visits, 'day trips', to the area were not measured) (LCPD 2004.

A seasonal population study discussing residency, land values, seasonal and permanent residents, taxable value, and building permits was completed by Leelanau County in 1999 and 2000 as a working paper for the Leelanau General Plan. This study concluded that the seasonal population continues to grow at a faster rate than the year-round population. The study also concluded that approximately 69% of the housing units in Glen Arbor Township are seasonal (Table 5) (Personal Communication – Leelanau County Planning and Community Development Director).

As more and more seasonal residents are moving to the region on a permanent basis and having more dramatic impacts on the lake, a prime example being a septic system operating for 12 months out of the year, instead of six. A 1995 study by the MSU Department of Parks, Recreation and Tourism suggests that more and more people are turning their seasonal homes into year-round residences. The study indicated that 40% of seasonal home owners in Leelanau County considered themselves "very likely" or "likely" to convert their seasonal homes to permanent residences (LCPD 2004, LCPD 2000).

TABLE 4: POPULATION AND POPULATION CHANGE

Township	1990	2000	2005*	% Change (1990-2000)
Glen Arbor	644	788	814	22
Empire	858	1,085	1,156	27
Kasson	1,135	1,577	1,739	39
Cleveland	783	1,040	1,119	33
Total	***3420***	***4490***	***4828***	Average: 30.3
Leelanau County	*16,527*	*21,119*	*22,157*	*28*

**Estimate – Population Division, U.S. Census Bureau*

TABLE 5: SEASONAL RESIDENCY PERCENTAGES BY TOWNSHIP

Township	Percent Seasonal Residents
Glen Arbor	69
Empire	42
Kasson	16
Cleveland	46
Leelanau County Average	*36*

**Personal Communication with Leelanau County Planning and Community Development Director*

3.5 Land Use/Land Cover

The GL-CR watershed is blessed with over 55% of its land in a forested condition (Table 6, 7, Figure 2). Northern hardwood stands comprise the single largest land use of the watershed and, with sustainable management, provide an economic resource. At the same time, these forests have vital ecological roles. Following behind forests, water (22%) and open shrub/grasslands (12%) cover the majority of the remaining portions of the watershed (Table 7).

The major human land use of the watershed is residential homes, which comprise nearly 5% of the watershed (Table 7). Agriculture activities within the watershed are insignificant. The major field crop in Leelanau County is cherries, and there are very few potential growing sites within the GL-CR watershed because of the severe limitation imposed by the soil and/or topography (Red Tart Cherry Site Inventory 1973 – in Keilty 1992).

The lack of significant industry in the watershed is a legacy of the 1950's resort era that followed the crash of the resource dependant early 1900's economy. The economy of the watershed has become more reliant seasonal tourism and summer residents that are drawn to the natural scenery found few other places. The high percentage of forested land use in the watershed protects scenic beauty enjoyed by thousands of annual tourists while simultaneously providing wildlife habitat, groundwater recharge and important water quality functions.

TABLE 6: LAND USE/COVER IN THE GLEN LAKE CRYSTAL RIVER WATERSHED

Land Use/Cover	Acres	% Total
Beach, Riverbank	3.36	0.01
Commercial, Services, Institutional	86.41	0.29
Confined Feeding	2.80	0.01
Coniferous	2,068.38	6.96
Cropland	352.22	1.19
Deciduous	14,721.18	49.53
Extractive	24.62	0.08
Herbaceous	1,853.27	6.24
Industrial	3.16	0.01
Lake	6,398.20	21.53
Open Land, Other	120.53	0.41
Orchards, Vineyards	245.46	0.83
Other Agriculture	11.52	0.04
Permanent Pasture	38.43	0.13
Residential	1,432.46	4.82
Sand Dune	554.32	1.87
Shrub	1,657.25	5.58
Streams, Waterways	12.55	0.04
Wetland	134.44	0.45
Total	**29,720.56**	100%

TABLE 7: GROUPED LAND USE/COVER

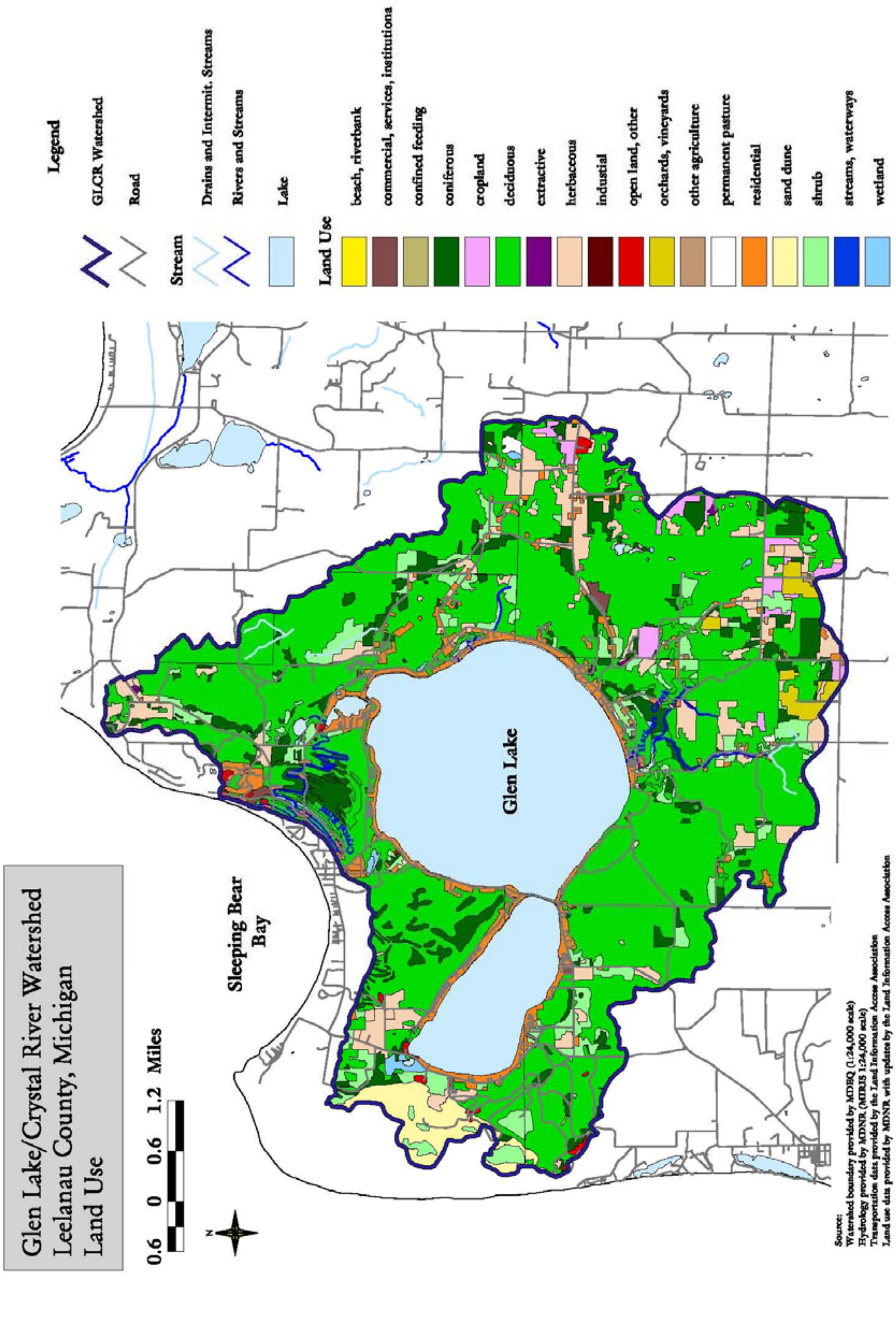
Land Use/Cover Category*	Acres	% Total
Forested	16,789.56	56.5
Agriculture	650.43	2.2
Open Shrub/Grassland	3,631.05	12.2
Urban	1,546.65	5.2
Water	6,410.74	21.6
Wetlands	134.44	0.5
Barren (beaches, dune, rock)	557.68	1.9
Total	29,720.56	

Land Use Groupings:

- *Forested: coniferous, deciduous*
- *Agriculture: confined feeding, cropland, orchards/vineyards, other agriculture, permanent pasture*
- *Open Shrub/Grassland: herbaceous, open land/other, shrub*
- *Urban: commercial/services/institutional, extractive, industrial, residential*
- *Water: lake, streams/waterways*
- *Wetlands: wetlands*
- *Barren: beach/riverbanks, sand dune*

As stated earlier, SLBE comprises just over 40% of the watershed (Table 2). Within the park region in the watershed, the vast majority is forested with 15% as sand dunes in additional to a very small wetland.

FIGURE 2: LAND USE IN THE GL-CR WATERSHED



3.6 Geology and Soils

Geology

Visitors to the Glen Lake area are often struck by the grandeur of the scenery. Hills are steeper and higher than in similar glaciated areas, and transitions between features are more abrupt (Figures 3a, 3b). Despite its complex history, the ecologically varied landscape of high moraines, sandy lakeplains, dunes, bogs and cedar swamps that characterize the Glen Lake/Crystal River watershed (Figure 3c) are the product of two dominant processes of formation.

First, only 11,000 years ago the waning remnants of the great Wisconsin Ice Sheet stalled out for an extended period of time near the shoreline of what is now northern Lake Michigan. Repeated advances and meltbacks of this continental glacier dumped huge thicknesses of outwash deposits along the southern border of Leelanau County. Today these deposits also form the southern rim of the Glen Lake basin.

These outwash deposits consist of generally well-sorted sand and gravel, as rushing floodwaters carried smaller particles of clay and organic matter further south. To the north, high hills called moraines were formed along the margin of glacial ice. In the Glen Lake area, large “lobes” of glacial ice raced up valleys with each advance, depositing high “interlobate moraines” on their borders that run generally parallel to the direction of ice flow. These moraines are composed of a jumble of clay, sand, and gravel. The Glen Lake Basin first formed as a deep pit when glacial ice occupying its valley finally retreated about 10,000 years ago.

The second major process in the formation of the Glen Lake watershed is still active today. As the glacier receded, water filled low areas between the ice margin and the high moraines to the south. These impounded waters were part of the ancestral Great Lakes. At Glen Lake several successive lake stages are evident. These impounded waters left wave-washed sands in valleys, and cut notches into the flanks of hills. These proto-Glen Lakes also left behind evidence in the form of their drainage channels, such as the ancient riverbed through which M-22 runs between Glen Lake and Empire. Historically water levels in the Glen Lake basin were 820, 725, 620 and 605 feet above sea level, compared to the present average of approximately 580 feet.

Glen Lake was finally separated from Lake Michigan as sand eroded from high bluffs to the east (Pyramid Point) and west (Sleeping Bear) and deposited large amounts of sand in Sleeping Bear Bay. Glen Lake is therefore known as an “embayment” lake - one that forms as a thickening sand bar cuts off a bay from the larger body of water.

While the glacial and postglacial history of the Glen Lake basin is complex and fascinating, today the most important legacy of this time is observed in the deep blue, crystal clear waters of the lake itself. Because sandy moraines surround Glen Lake, generally with nutrient-poor soils, the water flowing into the lake from its watershed is extremely low in nutrients. Glen Lake therefore has always been “ultra-oligotrophic” or extremely low in nutrient levels. This water purity is not a product of human activity, but rather a legacy of the glaciers and the postglacial shoreline processes that created and sculpted the Glen Lake watershed.

FIGURE 3A: GL-CR WATERSHED TOPOGRAPHY

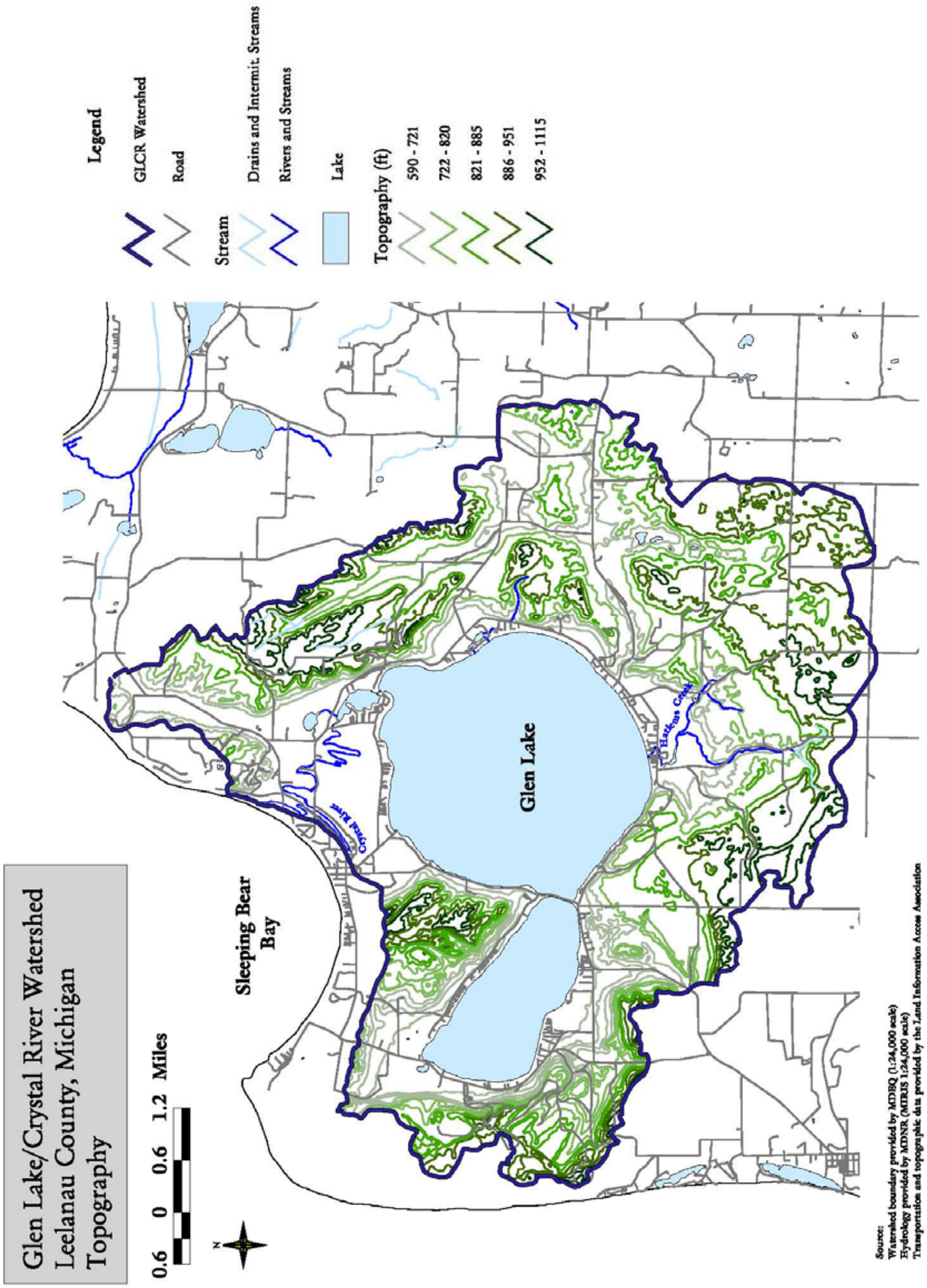


FIGURE 3B: GL-CR WATERSHED HILLSHADE

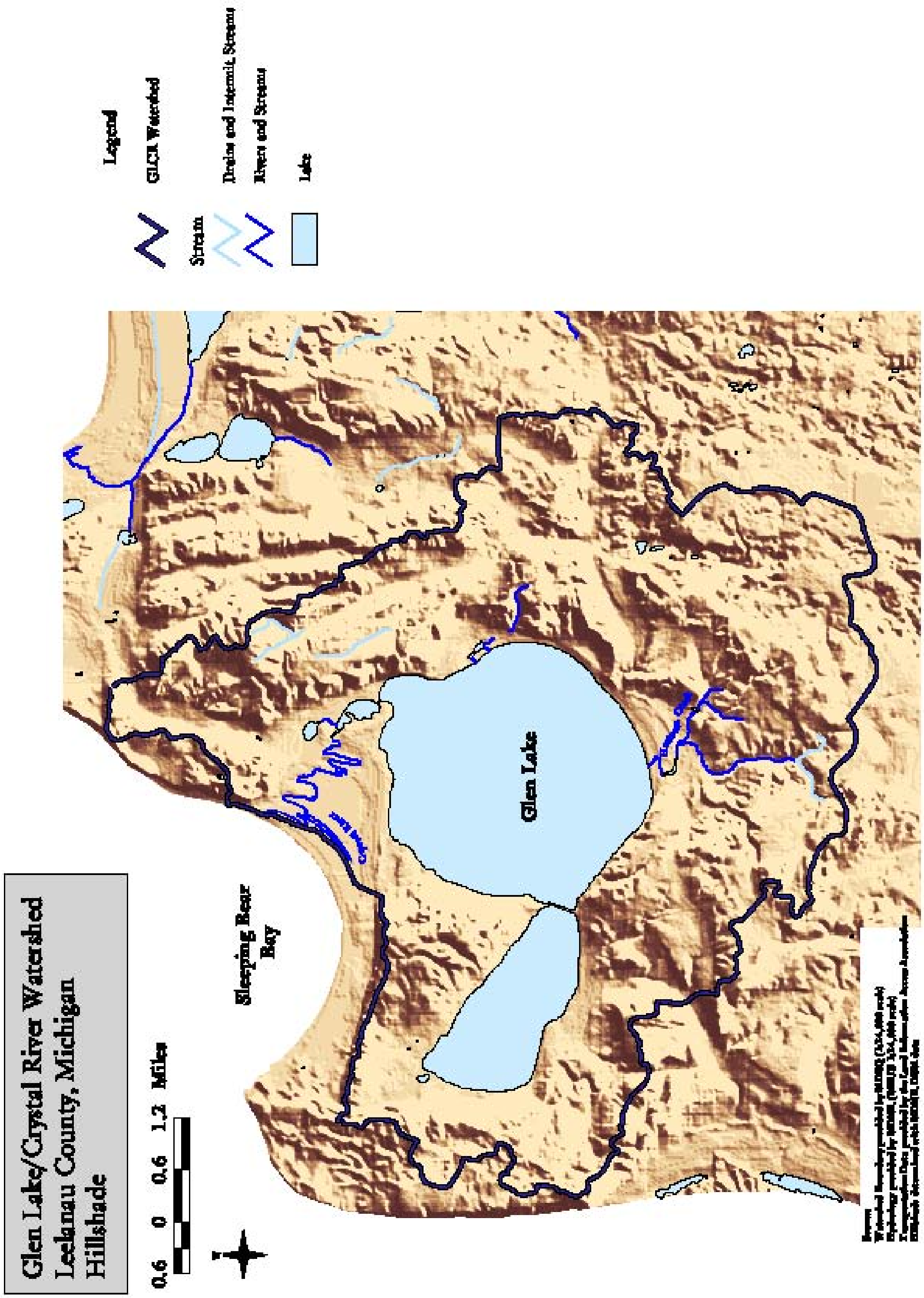
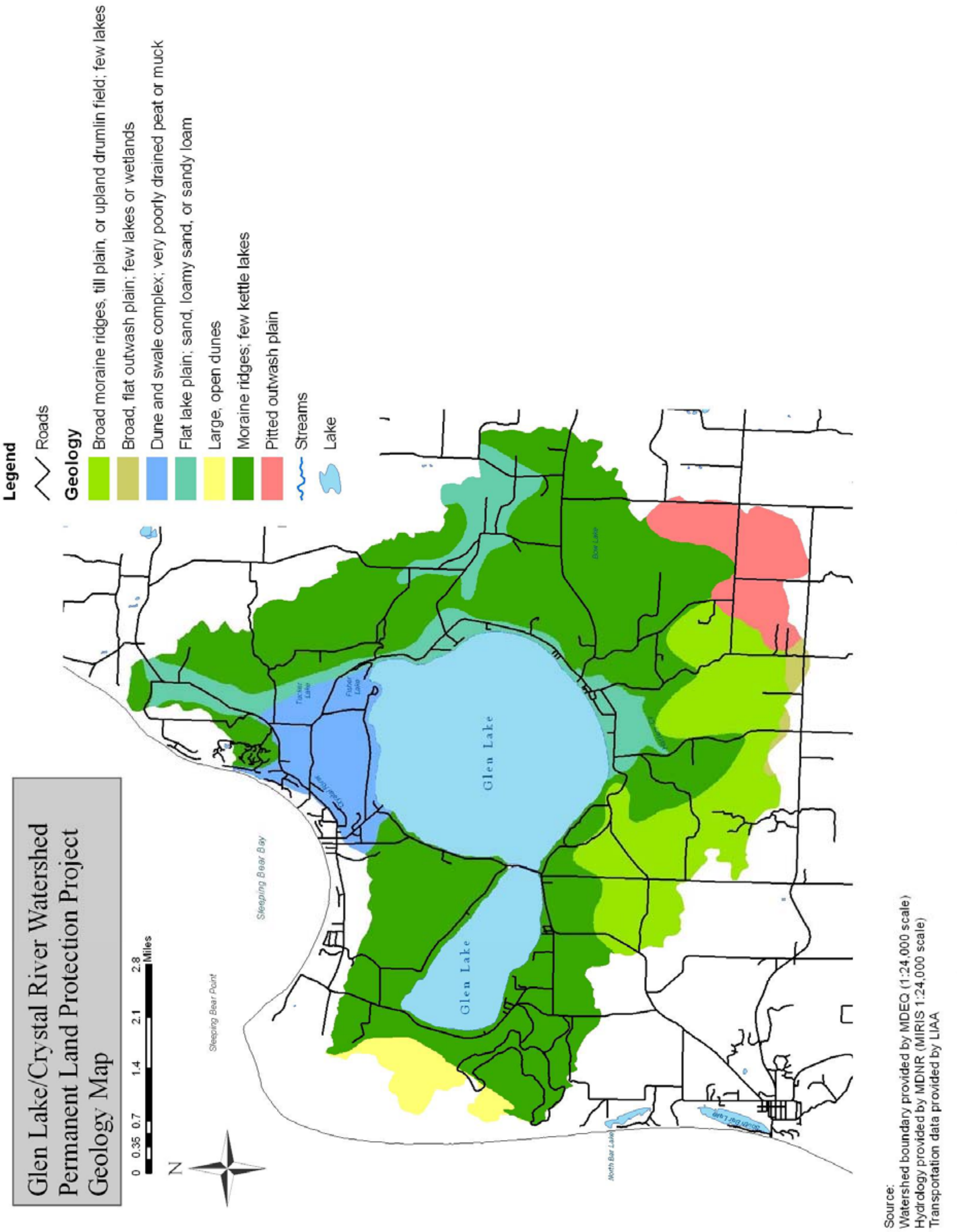


FIGURE 3C: LAND TYPE ASSOCIATIONS (GEOLOGY) IN THE GL-CR WATERSHED



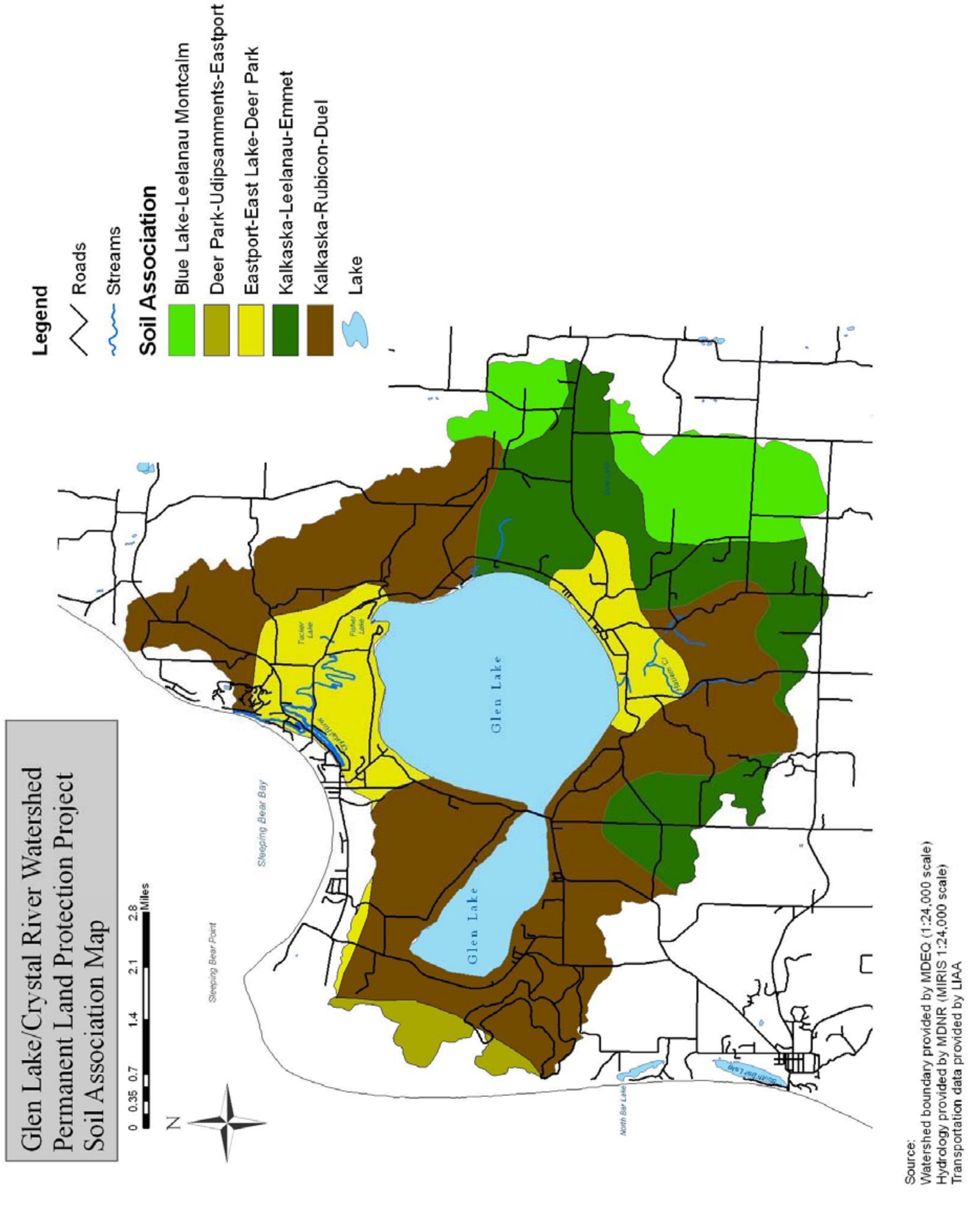
Soils

There are four main soil associations in the Glen Lake/Crystal River watershed: Deer Park-Dune Association, East Lake-Eastport-Lupton association, Kalkaska-East Lake association and Kalkaska-Mancelona association (Figure 4).

The Blue Lake association is characterized by well-drained, nearly level to strongly sloping, gravelly, loamy and sandy soils on outwash plains. The Deer Park association is made up of sandy soils that are well drained and strongly sloping to very steep. Eastport associations are well to moderately well drained, nearly level to gently sloping, sandy soils. Nearly level to strongly sloping sandy soils on outwash plains characterize the Kalkaska-Leelanau association. In contrast, the Kalkaska-Rubicon association is found on moraines.

There is considerable variability in the potential of these soils to absorb excess nutrients, such as phosphorus, as water percolates through the soil, thereby reducing the nutrient loading of receiving surface water bodies, such as lakes and streams. An analysis of riparian soils around Glen Lake in 1991 indicate that the majority are capable of immobilizing P from septic effluent for the foreseeable future (Keilty 1992).

FIGURE 4: SOIL ASSOCIATIONS OF THE GL-CR WATERSHED



3.7 Hydrology and Groundwater Recharge

A detailed, scientific study of Glen Lake, including a hydrological budget, was completed by Keilty in 1992 (Table 8)[2]. Results show that Glen Lake receives 52% of its water supply from subsurface groundwater discharge, another 27% from precipitation, and the remaining 21% from surface flow. Additionally, a good portion of the measured surface flow values in this study include groundwater seeps, which flow over the land a small ways before reaching the lake.

Groundwater is an extremely important factor in the hydrological budget of Glen Lake. Therefore it is essential that groundwater is replenished or “recharged”. This underscores the importance of protecting upland areas from impervious surfaces or other development that can inhibit the percolation of precipitation through the soil into the groundwater and decrease groundwater recharge. Areas that have a low slope gradient combined with permeable soils in general have a higher potential for groundwater recharge, especially when adjacent to high slope gradient uplands.

The major source of outflow from Glen Lake is the Crystal River (59%), followed by evaporation (24%). Keilty’s study also estimated that Glen Lake recharges deep groundwater sources at the bottom of the lake, making up 16% (13.25 cfs) of the total outflow of water.

TABLE 8: WATER BUDGET FOR GLEN LAKE AND CRYSTAL RIVER: 1990/91*

	Total CFS	Percent
Outflow		
Mean surface outflow – Crystal Dam/River	48.60	59%
Evaporation	20.04	24%
Groundwater Outflow	13.25	16%
Change in Storage**	0.43	
Annual Outflow Total	82.32	
Inflow		
Surface inflow	17.46	21%
Subsurface inflow	43.00	52%
Precipitation	21.86	27%
Annual Inflow Total	82.32	

**Table adapted from “Table 3: Summary of Hydrology Budget” in Keilty 1992 – does not include water budget downstream of Crystal River Dam. Because the lake level was controlled using boards at the dam, three distinct hydrologic periods were observed. A rating curve was established for each period for the dam gauge. All annual averages (outflow, evaporation, surface inflow, etc.) were calculated on a time-weighted basis.*
***Change in Storage: The change in lake storage was determined from extensive records kept during the study by the Glen Lake Association.*

[2] Once again, it should be noted that a preliminary hydrological study on groundwater flow and its origin in the watershed is due out sometime in 2009. We area aware of the fact that the hydrological boundary for the watershed may be considerably more than originally calculated.

Hatlem Creek and the Crystal River are the two main river systems in the GL-CR watershed. As stated before, Hatlem Creek is the only major tributary to Glen Lake and has an annual average discharge of approximately 6.28 cfs (Keilty and Woller, 2002).

Crystal River is the main outflow of water from the watershed. Until recently, a USGS gauging station was located near its outlet to Lake Michigan. Data from the 2005 Water Year (Oct 2004-Sept 2005) shows an annual average discharge of 46.1 cfs (USGS 2005). A total of 10.9 billion gallons of water is discharged to Lake Michigan annually.

Direct overland runoff to the lake is insignificant, as rainwater quickly infiltrates soils and becomes integrated with the groundwater and surface spring inputs to the lake. Thus, land use practices in the entire watershed have a much greater potential to impact water quality than is the case for many other watersheds in the State with less permeable soils.

Hydrological studies using the Darcy groundwater flow model indicate that the areas with the highest potential for groundwater recharge in the Glen Lake/Crystal River watershed are along the south and northeast side of Big Glen Lake (Figure 5). The area of recharge along the southern portion of Big Glen Lake is associated with sensitive wetland areas in Hatlem Creek, which contains habitat for rare and endangered species, included a well documented population of the Federally Endanged Michigan Monkey Flower, *Mimulus glabratus michiganensis*. Careful land use decisions in the watershed will help to ensure ecological diversity while protecting the hydrologic stability integral to maintaining the high water quality.

A Word about the Crystal River Dam

In its early years, the Glen Lake Association organized around the issue of water levels. In the 1920s and 30s, the dam on the Crystal River was no longer functioning and the level of Glen Lake and the Crystal River fluctuated widely on the weather. In 1938, the Fisher Mill site at the headwaters of the Crystal River was deeded to the Glen Lake Improvement Association – the precursor to the Glen Lake Association. However, even after the dam was rebuilt, balancing water levels in Glen Lake and Crystal River was a continuing challenge. Finally, after a survey of riparians in 1944 the county court set the level at 596.75 feet above sea level and established the measurement point at the south pier of the Narrows Bridge. Some years later, the circuit court directed the GLA to assume control of the lake level and the dam (Stone 2005).

Crystal River Dam

For over 50 years, GLA volunteers have operated the Crystal River dam and monitored the levels of both Glen Lake and the Crystal River. GLA also maintains the dam and recently rebuilt the structure with GLA funds. Though water levels have spawned some controversy in recent years, GLA is dedicated to maintaining appropriate levels for both the river and the lake. The GLA Water Level Committee now consists of riparian landowners from both the lake and river. They interface with the GL-CR Technical Committee which is comprised of representatives of the GLA Water Level Committee, National Park Service, DEQ and the Leelanau County Drain Commissioner (Stone 2005). Recently due to drought conditions in this region and repairs of the water control structures on the dam there has been an increase in interest by downstream riparian owners to identify release levels from Glen Lake that would protect instream aquatic resources. Both lake and riparian owners, including the GLA and SLBE, recognize the need to identify releases from Glen Lake that protect the aquatic ecosystem and biota of both the lake and river while not prohibiting multiple water uses, including both river and lake-based recreation.

The USGS recently completed a study in September 2007 along the Crystal River to try and determine the optimum flow rate for the river during different seasons. This study also took into account the effects on fish and other river biota as well as the effect recreation has on the river substrate at different times of the year (Nichols et. al 2007). Due to a lack of historical information available on fish and other aquatic life, the USGS study also worked to establish baseline data on the relationship between water levels and aquatic biota in the Crystal River. Habitat maps detailing the relationship between water levels, substrate, and vegetation cover were created at 13 index stations along the river at varying flow rates. The amount of water and in-stream habitat loss (due to decreased water levels), percent of river totally dewatered, and percent of deep pool area at each site and water level varied according to local topography (Nichols et. al, 2007).

Concerns for fish and other aquatic life arise when outflow of the dam is reduced during summer months to hold water in Glen Lake, which can sometimes drastically reduce water levels in the Crystal River. The lower water levels in summer result in some sections of the river, previously underwater, to be completely dewatered and have steelhead, trout, and salmon spawning beds completely exposed. Additionally, lower, shallower water levels cause water temperatures to rise dramatically and reach dangerous levels for trout (See Section 5.4 on Thermal Pollution for further discussion of water temperatures and fish).

The document contains a wealth of information in the discussion section, too much to go into depth in this management plan, however, some conclusions were drawn:

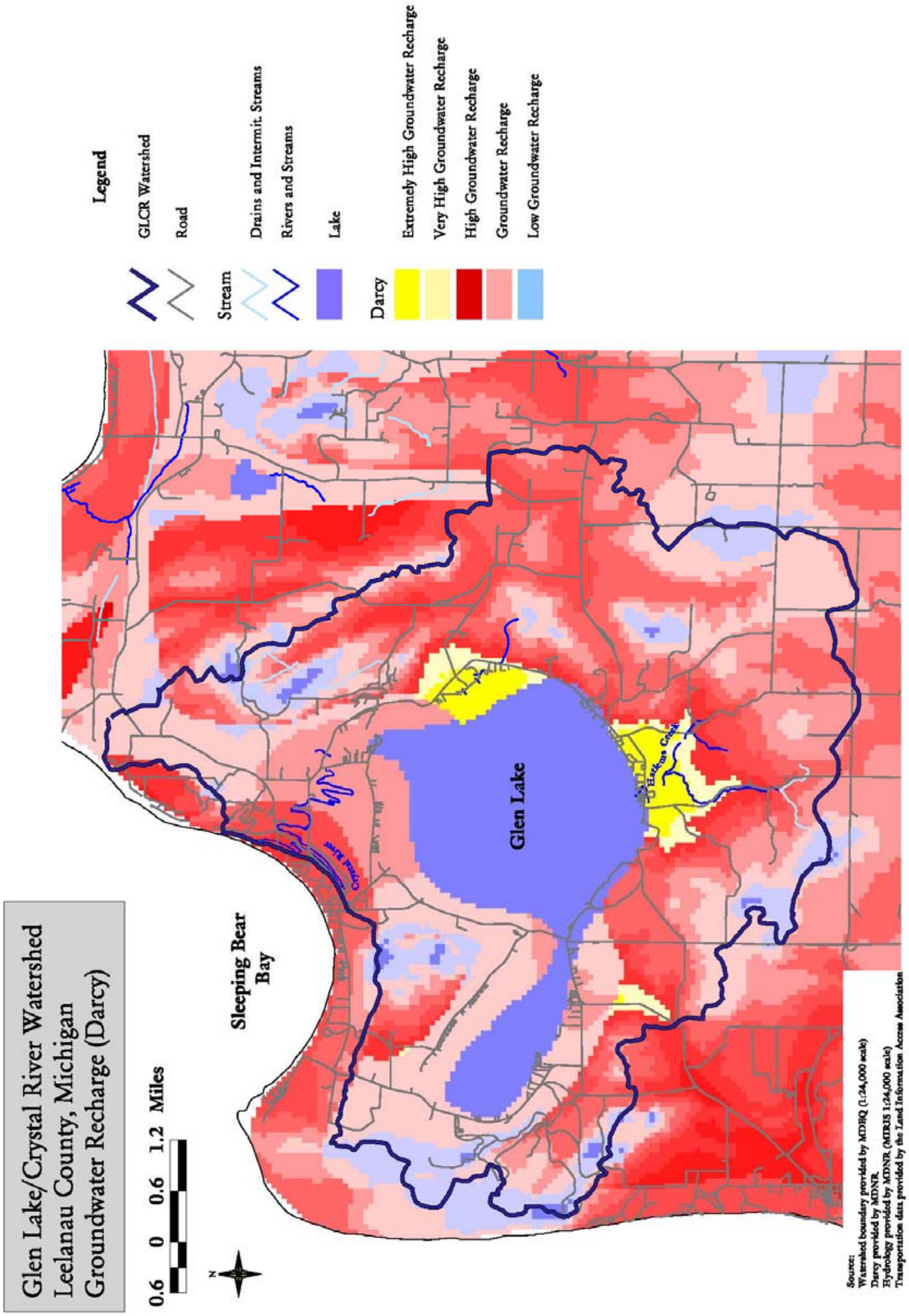
- The Crystal River is a biologically diverse river, and the types and life cycles of stream biota living there are directly tied to its seasonal water levels.
- The distribution and reproduction of at least some of the fish are being affected by summer low water levels. Even so, the river contains a diverse fish community that is successfully surviving and reproducing overall.
- Even though it is a regulated stream, the type of fish and invertebrate species found in the river indicate that water quality is basically good and that seasonal water level cues are sufficient to trigger life cycle events.
    - Identified 64 invertebrates that are key indicators of good habitat and water quality.

    - Identified schools of hornyhead chubs, an environmentally sensitive species.
    - Identified spawning salmon and other salmonids.
- Invertebrates are more resilient to water management than fish – as long as preferred substrate, suitable oxygen and water temperatures are present, the invertebrate population will continue to thrive; fish are more influence by the timing and duration of specific water levels.
- Anchor Ice formation in winter is a potential concern.

Additionally, the following recommendations were put forth:
- The minimum summer water level should not drop below 10.75’ (as measured by the gage just below the dam).
- Preferred minimum summer water level of 10.88’ or higher.
- The minimum winter water level should not drop below 11.00’.
- Preferred minimum winter water level is >11.00’.
- Public education efforts should take place to educate river users about using watercraft with shallower drafts to minimize impact on the river substrate when water levels are below 10.88’.

(Nichols et. al, 2007)

FIGURE 5: GL-CR GROUNDWATER RECHARGE (DARCY MODEL)



3.8 Wetlands

Wetlands comprise a vital link in the preservation of high water quality in the Glen Lake/Crystal River watershed. Intact and healthy wetland communities take up excess nutrients swept from the soil and land surface by filtering storm and melt water as it flows down the landscape. Wetlands also help to minimize flooding by absorbing surface runoff and stormwater and releasing it slowing into streams and groundwater. In addition to the water quality benefits of intact wetlands in the Glen Lake/Crystal River watershed, several threatened and endangered plants and animal species require these sensitive habitats to support their dwindling populations. The diversity of micro-habitats found within wetlands allows them to host more types of plants and animals than any other biological community.

These unique habitats are often quite rare across the landscape as a whole, making them vital to the existence of species that require the conditions found only within that particular portion of the wetland area. The Glen Lake/Crystal River watershed is home to several species which are either of concern, threatened or endangered on both the state and federal levels. Additionally, the watershed is home to a large and healthy dune and swale wetland community, which is considered by the MNFI and other management agencies as a globally rare ecological community (see Section 5.3, Critical Areas).

In order to perpetuate the enjoyment and use of the Glen Lake/Crystal River watershed it is essential to protect sensitive wetland areas. Recreational interests such as birding, fishing, hunting and wildlife viewing are all enhanced by the healthy and intact wetland areas adjacent to Glen Lake and the Crystal River. Unfortunately, Leelanau County had the highest number of wetland fill permit applications of any county in Northwest Lower Michigan for most of the 1990's (personal communication with Mark Tonello, MDNR fisheries biologist in 2003). Development in and adjacent to wetland areas threatens to degrade the aquatic resources, which are the heart of this watershed's desirability and attractiveness.

Currently the Federal Army Corps of Engineers and the State of Michigan regulate wetlands that are 5 acres or greater or connected to the Great Lakes. Additionally, the State of Michigan also protects wetlands under state law PA 451 of 1994 if they meet any of the following conditions:

- Located within 1,000 feet of one of the Great Lakes or Lake St. Clair.
- Connected to an inland lake, pond, river, or stream.
- Located within 500 feet of an inland lake, pond, river or stream.
- Not connected to one of the Great Lakes or Lake St. Clair, or an inland lake, pond, stream, or river, and less than 5 acres in size, but the DEQ has determined that these wetlands are essential to the preservation of the state's natural resources and has notified the property owner.

A study to identify potential wetland areas, combining different sources of wetland information using Geographic Information Systems (GIS) software, was completed in early 2000 by the Northwest Michigan Council of Governments (NWMCOG) through the Special Wetland Area Management Project (SWAMP), coordinated by the Michigan Department of Environmental Quality (DEQ). The dataset is a composite of three sources of wetland information:

1. The National Wetland Inventory (NWI), conducted by the U.S. Fish and Wildlife Service.

2. The U.S. Soil Conservation Service Soil Survey, which identifies hydric soils and soils with hydric inclusions and/or components.
3. The Michigan Resource Inventory System (MIRIS) Land Cover interpretation from aerial photographs.

Section 5.3, Critical Areas of the Glen Lake/Crystal River watershed, describes the most important wetland areas in the watershed for maintaining water quality and sustaining rare plants, animals and habitats. The largest wetland areas within the watershed are found on the NW end of Little Glen, portions of the south-central shore of Little Glen, the riparian corridors adjacent to Brooks and Tucker Lakes, between Big Glen and the Crystal River, and the Hatlem Creek area (Figure 6). Hatlem Creek, the largest surface water tributary to Glen Lake, meanders through an ecologically rich wetland that provides a diverse habitat for many threatened and endangered species. The undisturbed wetland located there is critical to the creek's biological diversity and its preservation is a high priority in the GL-CR wetland. Poor logging practices on adjacent forested ridgelines in years past has caused significant sedimentation that literally buried adjacent portions of the Hatlem Creek wetland community, including Michigan monkey flower colonies, which were downstream from the upland logging activity.

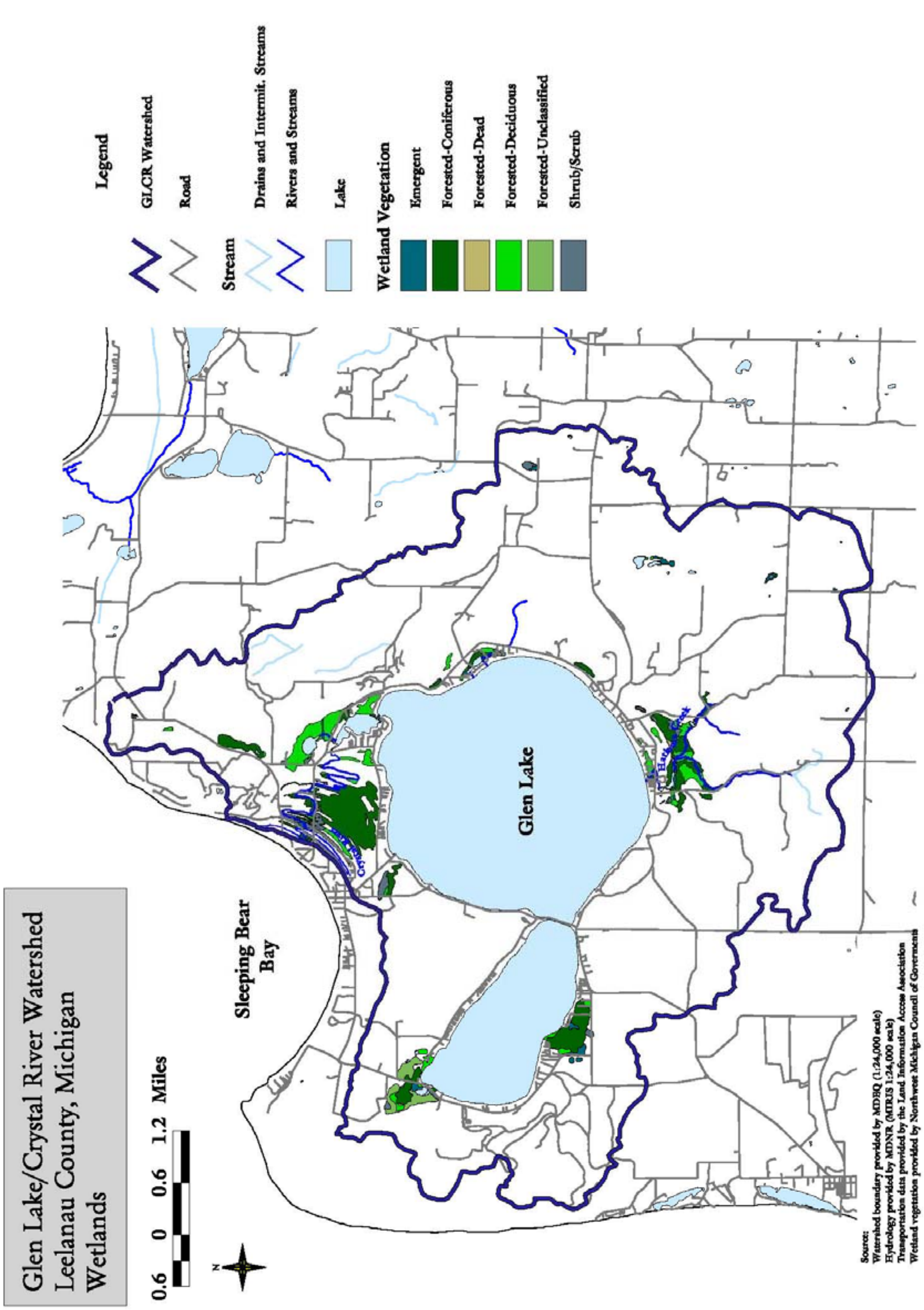
Looking at the data in Table 9, the total wetland area in the GL-CR watershed is approximately 1,247 acres (1.95 mi^2) or 4.2% of the total watershed area, compared to only 0.45% using only the land use data (Tables 6 and 7, Figure 2). These data provide a useful tool in determining the location of potential wetland areas, but because the data has not been field checked, it does not guarantee the presence or absence of a wetland. It should be used only for general planning purposes.

TABLE 9: COMPOSITE WETLAND AREAS IN THE GLEN LAKE-CRYSTAL RIVER WATERSHED

Type of Wetland	Acres	% of Watershed
Emergent	67.4	0.23
Forested:		
Conifer	655.8	2.21
Dead	7.0	0.02
Deciduous	292.4	0.98
Unclassified	72.0	0.24
Open Water	49.3	0.17
Shrub Scrub	103.1	0.35
Total	1247.0	4.2

**The wetland descriptor in the land use tables (Tables 6 and 7) do not contain all wetlands. Total wetlands are delineated in the table above, and cover 4.2% of the watershed. As an example of this difference, Table 6 represents cedar swamp areas as coniferous forest, as opposed to the 'forested-conifer' wetland description in the above table.*

FIGURE 6: COMPOSITE WETLANDS OF WATERSHED



3.9 Fisheries

We know from historical records that a more diverse and plentiful fish population once inhabited Glen Lake. The fish could move freely from Lake Michigan to Glen Lake and even Hatlem Creek. No doubt, the shoals of Glen Lake and its tributaries were important spawning grounds for Lake Michigan fish. With the construction of the dam on the Crystal River, fish access to and from Lake Michigan was impeded. Today, some introduced salmonid species can move back and forth between Lake Michigan and Glen Lake, but native smallmouth bass, white suckers, yellow perch and other native species are still prohibited. However, the dam does help prevent sea lamprey, round goby and other harmful exotics from migrating up the system from Lake Michigan.

Todd Kalish, Central Lake Michigan Unit Manager for the Michigan Department of Natural Resources (MDNR) Fisheries Division, supplied the following stocking and fish survey histories along with current MDNR management recommendations for Big Glen, Little Glen, Fischer, Tucker and Brooks Lakes.

Stocking History: Big Glen Lake is a large lake (approximately 4,800 acres) with a long and diverse stocking history as part of the management of its popular recreational fishery. A variety of cool-water fish (bluegills, smallmouth and largemouth bass, yellow perch, and walleye) were stocked from 1894-1944. A Statewide policy was issued in 1946 that discouraged the stocking of cool-water fish (specifically smallmouth and largemouth bass, bluegills, and yellow perch) because natural reproduction of these species is usually sufficient to sustain an adequate fishery. The trout stocking protocol began in 1894. Lake trout were sporadically stocked into Glen Lake from 1894-1980. The current lake trout stocking protocol of 20,000 yearlings annually began in 1996 and continues today. Splake were stocked sporadically from 1966-1981 and yearly from 1981-1995 (app. 20,000 yearlings/year). Splake were stocked as a substitute for lake trout which were in limited supply in the 1980s. The splake stocking program was discontinued in 1995 due to poor returns and catch rates. Rainbow trout were sporadically stocked from 1956-1972. Michigan strain winter steelhead were also stocked in 1973 and 1983. The current rainbow trout stocking program began in 2004 and continues to date. The current rainbow trout stocking program is designed as a research project (MI DNR Fisheries Research project F-80-R-7, study # 743) to evaluate potential differences in catchability, survival, recruitment, and growth between Eagle Lake strain rainbow trout and MI strain winter steelhead. Fisheries Division annually stocks 10,000 Eagle Lake strain (LP clip) and 10,000 MI steelhead (RP clip) into Big Glen Lake. This research project is being assessed through angler reports and surveys. Brown trout were stocked into Glen Lake annually (15,000-26,000 yearlings) from 1985-1997. The brown trout stocking program was discontinued in 1997 due to poor returns. Fisheries Division conducted a survey to assess the brown trout stocking program in 1997, and none were collected. Lake whitefish were stocked into Glen Lake in 1956 (1,000 fry) and 1959 (4,000 fry). Brook trout were stocked into Glen Lake from 1960-1962 (20,000 fingerlings total).

Little Glen Lake has only been stocked twice in recent history. Fisheries Division stocked 3,000,000 walleye fry in 1991, and 2,000,000 walleye fry in 1993. Fisheries Division conducted a boomshocking survey in 1994 to assess the walleye stocking program. No walleye were collected during the survey. Therefore, the stocking program was deemed unsuccessful and was discontinued.

Big Glen and Little Glen Lake survey history
Big Glen Lake has a diverse survey history that extends into the early 1900s. However, for the purposes of this analysis, we will assess only the most recent surveys; 1973 to present.

Fisheries Division conducted a survey in Big Glen Lake in 1973 with gill nets to evaluate the splake stocking program. Fisheries Division collected 276 lake herring (8-12 in. in length and 9 in. average length), 192 yellow perch (6-10 in. in length and 7 in. average length), 43 splake (8-14 in. in length and 10 in. average length), and 71 common white suckers. Fisheries Division also collected minimal numbers of smallmouth bass, rock bass, and lake trout. This survey indicated good survival of the recent splake plants.

Fisheries Division conducted a survey to assess the splake and lake trout populations within Big Glen Lake in 1979. Fisheries Division used Great Lakes gill nets to collect 200 lake herring (7-10 in. in length and 9 in. average length), 73 yellow perch (5-10 in. in length and 7 in. average length), and minimal numbers of lake trout, splake, smallmouth bass, northern pike, and rock bass. Fisheries Division also surveyed Little Glen Lake in 1979. They used one Great Lakes gill net set for one night to collect 44 yellow perch (4-11 in. in length and 7 in. average length), and minimal numbers of largemouth bass, northern pike, lake herring, rock bass, and common white suckers.

Fisheries Division conducted a survey to assess the splake populations with gill nets in Big Glen Lake in 1987. Fisheries Division collected 58 walleye (9-24 in. in length and 21 in. average length), 18 lake trout (10-23 in. in length and 29 in. average length), 33 smallmouth bass (5-22 in. in length and 15 in. average length), 16 northern pike (19-25 in. in length and 21 in. average length, 21 yellow perch (5-8 in. in length and 7 in. average length). Fisheries Division also collected minimal numbers of bluegills, lake herring, largemouth bass, smelt, gar, common white suckers, splake, brown trout, and rock bass. Growth analysis indicated exceptional growth rates for walleye (+2.2) and smallmouth bass (+1.9) and acceptable growth rates for smelt, yellow perch, and rock bass. Northern pike were growing significantly below state average (-3.0). This survey reinforced the 1973 results which documented a large and diverse forage base, as indicated by exceptional growth rates of walleye and smallmouth bass.

Fisheries Division conducted a survey to assess the splake and lake trout stocking program in Big Glen Lake in 1991. Fisheries Division used Great Lakes gill nets to collect 232 yellow perch (5-11 in. in length and 7 in. average length), lake herring (8-12 in. in length and 9 in. average length), lake trout (28-36 in. in length and 33 in. average length), and minimal numbers of common white suckers, rock bass, splake, smallmouth bass, coho salmon, and brown trout. The lake trout collected were growing above state average and age-class analysis indicated minimal natural reproduction. The yellow perch were growing slower than state averages, but within acceptable limits. The minimal brown trout and splake collected in the survey indicated that the stocking program for these fish was not producing an adequate fishery. Fisheries Division discontinued the splake stocking program in 1995 based on the results of this survey and angler reports.

Fisheries Division conducted a survey to assess the lake and brown trout stocking program in Big Glen Lake in 1997. Fisheries Division used Great Lakes gill nets to collect 726 yellow perch (5-13 in. in length and 7 in. average length), 228 lake herring (8-19 in. in length and 9 in. average length), 7 lake trout (33-37 in. in length and 36 in. average length), and minimal numbers of common white suckers, lake whitefish, rock bass, silver redhorse, smallmouth bass, and splake. Yellow perch and lake herring were growing below state averages, -1.4 and -1 respectively. Fisheries Division decided to discontinue the brown trout stocking program based on the results of this and the 1991 survey which indicated poor recruitment, survival, and angler utilization.

Fisheries Division conducted a survey to assess the Eagle Lake and MI Steelhead research project (MI DNR Fisheries Research project F-80-R-7, study # 743) with experimental gill nets in Big and Little Glen Lakes in 2007. Fisheries Division collected 58 MI steelhead (12-27 in. in length and 17 in. average length), 16 common white suckers, 11 rainbow trout (14-24 in. in length and 17 in. average length), 10 smallmouth bass (17-19 in. in length and 18 in. average length), and minimal numbers of lake herring, largemouth bass, northern pike, lake trout, and yellow perch. The preliminary results of this study indicate that MI steelhead are recruiting to the fishery better than the Eagle Lake strain.

Tucker, Brooks, and Fisher Lakes survey history

Fisheries Division surveyed the fisheries population of Tucker Lake in 1969 with trap nets. Fisheries Division collected 17 bluegills (6-8 in. in length and 8 in. average length, and minimal numbers of largemouth bass, bullheads, northern pike, and common white suckers. Fisheries Division estimated that 90% of Tucker Lake (total of 17 acres in size) was inundated with vegetation, and the maximum depth was 15 feet.

The Grand Traverse Band of Ottawa and Chippewa Indians (GTB) surveyed Tucker Lake in 1993. They used fyke nets, gill nets, and minnow traps to collect bluegills, pumpkinseed sunfish, yellow perch, brown bullhead, largemouth bass, northern pike, rock bass, yellow bullhead, central mudminnow, and Iowa darters. The GTB indicated that Tucker Lake likely provides an average fishery (Fessell and Elias, 2007).

Fisheries Division does not have any historical surveys for the Fisher Lakes, Brooks Lake, or the Day Mill Pond. However, the GTB surveyed the Day Mill Pond in 2003 with a back pack electroshocker. They only collected central mudminnows. However, they did observe good fisheries spawning habitat in the form of Chara, potomogeton, and pond lilies. Kelley and Price (1979) collected one northern pike in Day Mill Pond during their survey in 1979. Day Mill Pond provides optimal spawning and rearing habitat for a variety of fish species, particularly northern pike and yellow perch, and every effort should be made to sustain or enhance fisheries passage from Day Mill Pond to Little Glen Lake.

General summary of historical surveys

The common theme among the historical surveys of Glen Lake indicates a diverse and abundant forage base of lake herring, shiners, yellow perch, and cyprinids. Therefore, Big Glen Lake has been stocked with a variety of fish species since the late 1800s. Evaluation of stocking success was sporadic until the 1970s when a consistent evaluation protocol was initiated. The brown trout plantings were unsuccessful based on poor catch rates in subsequent Fisheries Division surveys and angler reports. The splake stocking program was successful in the early years, but declined in the 1990s based on declining catch rates in subsequent Fisheries Division surveys and angler reports. The lake trout fishery has remained consistent throughout the years, even in years where the stocking program was substituted with splake. However, supplemental stocking of lake trout is needed to maintain a viable fishery. The rainbow trout stocking program has been meager and sporadic, and Fisheries Division is currently in the process of evaluating its success. Initial surveys indicate that MI strain winter steelhead outperform the Eagle Lake strain.

The most abundant game fish species in the Glen Lake watershed is yellow perch. Yellow perch, northern pike, and a variety of forage fish require vegetation for successful reproduction and recruitment. Big Glen Lake and Little Glen Lake do not provide optimal spawning habitat for yellow perch or northern pike. However, the interconnected lakes (Fisher, Brooks, Tucker, and Day Mill Pond) all provide optimal spawning and rearing habitat for yellow perch and northern pike. Therefore, Fisheries Division recommends that every effort be made to sustain and enhance fisheries passage among all of these lakes to sustain and enhance the fisheries populations within the Glen Lake watershed.

Management Recommendations

1. Big Glen Lake supports an abundant and diverse forage base of shiners, cyprinids, lake herring, and yellow perch. In addition, it provides optimal habitat for a put, grow, and take fishery for rainbow and lake trout. Fisheries Division should continue the current stocking program (Prescription 1197) until sufficient evidence exists to modify it. The current prescription recommends stocking 20,000 yearling lake trout annually and 20,000 (10,000 Eagle Lake and 10,000 MI winter steelhead annually). In addition, Fisheries Division should collaborate with the Glen Lake Association to identify a suitable stocking location that minimizes predation by cormorants and other predatory birds. The ideal stocking location will have appropriate large truck access to within 50 feet of the waters edge and a flowing stream in the vicinity to encourage migration to deep water, or under the ice. Fisheries Division should also attempt to stock trout early in the year (March) to minimize the negative affects of predatory birds.

2. Fisheries Division should work collaboratively with the National Park Service, the Grand Traverse Band of Ottawa and Chippewa Indians, the Glen Lake Association, the MDEQ, and the various non-profit environmental agencies (Leelanau Conservancy, Leelanau Conservation District, CRA, etc.) to identify aquatic connectivity barriers and sustain or enhance aquatic connectivity among all the basins within the Glen Lake watershed (specifically Day Mill Pond, Brooks Lake, Fisher Lakes, and Tucker Lake). Enhanced aquatic connectivity will help sustain healthy fish populations in perpetuity.

3. DNR Fisheries Division should continue to monitor and evaluate the Glen Lake fishery by conducting general fisheries surveys at least every 10 years.

4. DNR Fisheries Division should continue to work collaboratively (and provide aquatics expertise) with the stakeholders involved in the lake-level control structure on the Crystal River.

5. DNR Fisheries Division should comment on MDEQ permit applications that have the potential to negatively affect water quality, aquatic populations, or aquatic habitat within the Glen Lake watershed.

Crystal River fishery
The Crystal River has a limited fishery for smallmouth bass and rock bass in the summer months, along with a marginal anadromous fishery for steelhead in the spring and salmon in the fall. The Crystal River has been designated a coldwater trout stream due these annual returns of salmon and steelhead from Lake Michigan. There are no stocking records for any species into the Crystal River; however, since the late 1960's, returning adult Coho and Chinook salmon annually stray into the river. A fishery survey from 1991 found a small number of naturally reproducing Coho salmon residing in Glen Lake. It was theorized that the fish were descendents of Coho that came up the Crystal River into Glen Lake and then migrated into Hatlem Creek to spawn. (See Section 3.7 – for more information on fisheries in Crystal River.)

Hatlem Creek is a designated trout stream by the MDNR with naturally reproducing populations of brook trout and annual returns of Coho salmon and steelhead. The Hatlem Creek area is also unique in that it hosts a huge population of emerald shiners, which return to the creek in hoards every year to spawn. Additionally, a large population of these emerald shiners returns to the creek in the fall due to the warmer groundwater stream temperatures.

3.10 Existing Water Quality Information and Results for the Glen Lake – Crystal River Watershed

The aging of bodies of water is a natural process that occurs over hundreds or thousands of years. As lakes age, they change from an oligotrophic classification, very low nutrient (nitrogen [N] and phosphorus [P]) levels that limit aquatic plant growth, to a eutrophic classification, overgrown by weeds. This process is often accelerated by increases in nutrients that fertilize aquatic plants. Just 16% of Michigan's inland lakes with public access are defined as oligotrophic (DEQ 2006). Oligotrophic bodies of water are desirable because of their excellent water quality; however, they are highly susceptible to degradation as a result of increases in nutrient concentrations. As a result of these very low levels of nutrients, human contribution of N and P, associated with fertilizers, septic effluents, and other human activities, can have significant water quality impacts.

Data collected by the Leelanau Watershed Council (LWC), the Glen Lake Association (GLA), the Sleeping Bear Dune National Lakeshore (SLBE), and others indicate that the water quality in Glen Lake, Crystal River, and the rest of the watershed is excellent. Glen Lake is classified as an oligotrophic to ultra-oligotrophic lake based on total N and P concentrations. Big Glen Lake is a typical dimictic lake, undergoing spring and fall turnovers. Little Glen does not stratify.

The Crystal River is a designated coldwater trout stream due to annual returns of anadromous salmon and steelhead from Lake Michigan. Water quality monitoring by the LWC, SLBE, and

USGS indicate that the Crystal River has relatively low nutrient levels. Michigan DEQ biological surveys of the river in 1998 indicated that the macroinvertebrate and resident fish populations were impaired slightly by sedimentation in the channel (DEQ 1999 – Crystal River Report). A recent USGS study on the river found the invertebrate population to be typical for good water quality and habitat, even though it is a regulated stream. They identified 64 invertebrate species that are key indicators of good habitat and water quality; 27 types of caddisflies, including a new state record (Trichoptera: Hydroptilidae *Ithytrichis* cf. *clavata*); 20 different dragonflies and damselflies; 12 different mayflies; 2 types of stoneflies; and 2 types of megalopterans (Nichols, et. al 2007).

Hatlem Creek, the largest source of surface water flowing into Glen Lake, is a second order coldwater stream and some sections contain a diverse and healthy population of mayflies, caddisflies and stoneflies, which are classic indicators of high water quality. However, recent macroinvertebrate studies by the GLA at 5 locations on Hatlem Creek show that it ranges from poor to good water quality, with no excellent ratings. Most of these low rankings are in first order tributaries and are due to excessive sedimentation and lack of suitable habitat.

Water Quality Information for Glen Lake, Crystal River, and Hatlem Creek

The information boxes following this section highlight some of the most recent findings on various aspects of water quality in the GL-CR watershed. The information was summarized from the following publications and groups:

- Clean Lakes Program, Glen Lake, Leelanau County, Michigan. Phase I Diagnostic/Feasibility Study (Keilty 1992)
    - This was an extensive study funded by the EPA, MDNR (now the DEQ), and GLA. The project was a one year field study, primarily designed to facilitate the calculation of a nutrient budget. Caution should be used when interpreting this study, as it is over 15 years old. However, this study is the only comprehensive study on Glen Lake investigating hydrological and inflow/outflow data.
- Glen Lake Association Water Quality Monitoring Program
    - Report from their Water Quality Committee summarizing program results from 2001-2005. Parameters measured include: Secchi Disk/Transparency, Chlorophyll a, Total Phosphorus (spring overturn and late summer readings)
    - In addition DO, pH, conductivity, and temperature reading profiles have been taken throughout the year in the deep basins of Big and Little Glen Lake, Big and Little Fisher Lake, Brooks Lake, 3 locations on the Crystal River, and one location on Hatlem Creek
- Sleeping Bear Dunes National Lakeshore Water Quality Monitoring Program
- Leelanau Watershed Council Reports
    - Nutrient Data and Budgets for Leelanau County Streams and Lakes (Canale and Nielsen 1997)
        - This report also contains an excellent summary of lake limnology as it pertains to lakes in Leelanau County, and discusses the relationship between temperature, dissolved oxygen, oxidation-reduction potential, and phosphorus.
    - Water Quality Monitoring Report – A Synthesis of Data from 1990 through 2001 (Keilty and Woller 2002)

General Characteristics: (Temperature, Dissolved Oxygen – DO, Conductivity, pH, Secchi Disk, Oxidation/Reduction Potential)

- **Dissolved Oxygen**
  - Profiles indicate moderate hypolimnetic DO depletion in summer, off-bottom winter levels are high
  - Seasonal stratification – Big Glen Lake experiences spring and fall turnover

- **Conductivity and pH:**
  - Both lakes in normal range for hardwater lakes in Northwest MI**:** 230-250 umhos/cm range
  - Crystal River Conductivity – 2004/5 average: 268 umhos/cm
  - Glen Lake pH – during thermal uniformity generally between 8.0-8.3
  - Glen Lake pH – summer stratification: 7.3-8.0
  - Crystal River pH – 2004/5 average: 8.2

- **Oxidation Reduction Potential:**
  - 1992 data indicate reducing presence of reducing conditions in Oct 1990

"Reducing conditions can be significant in that they can enhance P release from the sediments… However, it was determined that P release from the sediments is insignificant at this time. If conditions continue to deteriorate over time, producing longer and more extensive hypolimnetic oxygen depletions, this could become a significant source of nutrition to the lake." (Keilty 1992)

- **Temperature:**
  - Crystal River experiences wide temperature fluctuations, may be harmful to coldwater trout populations
  - Winter, Spring, and Fall temperatures are cool and in normal range – Dec thru March: 1^{o}C; Apr/May: 11^{o}C; Oct/Nov: 9.7^{o}C
  - Summer temps spike – June: 22.5^{o}C; July: 24.1^{o}C; August: 23.3^{o}C; September: 20.2^{o}C
  - Warm temps caused by low flows, shallow water and dam discharge

Sediment

(Keilty 1992)

- Most soils in the groundwater discharge area have a moderate to high potential for immobilizing P, based on P adsorption tests conducted
- Some study results imply that the sediments in Glen Lake area contributing to the P loading in the lake
  - LCWS report: hypolimnetic TP where DO is less than 2 mg/L are significantly higher than hypolimnetic TP values where DO exceeds 2 mg/L

Secchi Disk

The Secchi disk is a measure of water transparency, which is directly linked to inorganic suspended solids and plankton abundance. Transparency and secchi disk readings vary throughout year, with generally greater readings in Spring.

- Historical GLA/MDNR Data 1979-1989 – as summarized in Kielty 1992
  - Big Glen – 18.6 ft
  - Little Glen – 7.8 ft
- Big Glen
  - 2001: 18.0 ft; 2002: 17.2ft; 2003: 16.6 ft; 2004: 17.5 ft; 2005: 18.1 ft (average 2001-2005 = 17.5 ft)
- Little Glen
  - 2001: 6.9 ft; 2002: 5.4 ft; 2003: 6.0 ft; 2004: 6.8 ft; 2005: 5.1 ft (average 2001-2005 = 6.0 ft)
- Stable levels
- Recent introduction of zebra mussels lead to increases in secchi disk measurements

Note: The cloudy appearance of water during the summertime (particularly noticeable in Big Glen Lake) is a consequence of the depletion of carbon dioxide by phytoplanktonic photosynthesis that results in the precipitation of calcium carbonate in the water column (essentially marl formation). That is, as algae in the water column use carbon dioxide for photosynthesis, they shift the equilibrium in the local carbonate chemistry to favor the precipitation of calcium carbonate. Because of this phenomenon and the other variables associated with secchi data (observer, weather, time of day, etc.), the historical and current secchi data need to be interpreted with caution. Keilty (1992) notes that the precipitation of the calcium carbonate (marl) is somewhat beneficial to the lake system, as P is often co-precipitated, making it unavailable for biological production.

Escherichia coli

- Little Glen Lake public access in SLBE
  - 2004, exceeded limits twice
  - 2005, levels OK (average of 47 col/100mL)
  - 2006, levels OK (average of 20 col/100mL)
- SLBE changed management measures at public access spot in 2005, let vegetation grow more near shoreline. This decreased geese/duck congregation at the shoreline and subsequently E.Coli numbers have decreased and they have not had to close the beach since.
- Hatlem Creek
  - 2007: Three locations tested extremely high (first order tributary on Plowman Road)
  - 2008 @ Mouth of creek: rain event – extremely high, >2419 col/100mL (highest detection limit); dry weather – 44 col/100mL

Note: EPA recommends measuring recreational water quality by the abundance of Escherichia coli (E.coli): Water is unsafe for swimming if measurements are either 1) 130+colonies/100mL in 5 samples over 30-day period or 2) 300+colonies/100mL in any 1 sample

- *See Section 5.2 – Pathogens for a more in-depth discussion of E.Coli*

Nutrients *(Phosphorus – P and Nitrogen – N)*
Notes: In general, TP concentrations greater than 10ug/L are indicative of impaired water quality
The N requirements of microorganisms are about 10 times that of phosphorus. Because N/P ratios exceed 10:1 in most freshwater systems, N is not usually the limiting nutrient. However, N levels are extremely low in Glen Lake compared to surrounding lakes, and N can sometimes be a limiting nutrient in this system.

Total Phosphorus(TP): Growth limiting nutrient for Glen Lake

- 1990-2001 average TP
  - Big Glen 5.09µg/L
  - Little Glen 6.47µg/L (LCWC)
- GLA – TP Spring Overturn (readings considered low)
  - Big Glen – 2001: 5-7µg/L; 2002: 10µg/L; 2003: 4µg/L; 2004: 6µg/L; 2005: 4µg/L (average 2001-2005 = 6µg/L)
  - Little Glen – 2001: 5µg/L; 2002: 8µg/L; 2003: 6µg/L; 2004: 7µg/L; 2005: 4µg/L (average 2001-2005 = 6µg/L)
- GLA – TP Late Summer (indicate level of lake aging)
  - Big Glen – 2001: 5-7µg/L; 2002: 10µg/L; 2003: 4µg/L; 2004: 6µg/L; 2005: 4µg/L (average 2001-2005 = 6µg/L)
  - Little Glen – 2001: 5µg/L; 2002: < 2µg/L; 2003: 3µg/L; 2004: 14µg/L; 2005: 5µg/L (average 2001-2005 = 5.8µg/L)
- Increased levels of late summer P in both lakes in 2004 were of some concern, however lower 2005 levels are a good sign and may indicate the 2004 readings were sampled during an unsuitable collection period or were an anomaly.
- General decrease in TP for both lakes since 1990's
- Nutrients are relatively low, overall productivity low; Both lakes still classified as oligotrophic and P limited
- Other Waterbodies
  - Hatlems Creek – 1992 TP: 13.8µg/L; 1992-1996 TP: 10µg/L (LWC)
  - Crystal River – 1992-1996 TP: 7µg/L (LWC)

Nitrate: Can be growth limiting nutrient for Glen Lake

- 1990/1 TN: Big Glen 214µg/L; Little Glen 375µg/L
- 1990/1 Nitrate-N: Big Glen 17.8µg/L; Little Glen 37.3µg/L
  - Exhibited both vertical and seasonal variability
  - Summer epilimion concentration very low, while some accumulation in hypolimnion
  - Winter constant over depth
- 1990-2001 average Nitrate-N (increase over 1990 average)
  - Big Glen 70µg/L
  - Little Glen 55µg/L
  - These amounts are still low. However, studies have shown large amounts of Nitrate-N entering Glen Lake, but is either utilized by biota, ends up in sediments, or is exported via Crystal River
  - Biotic component utilizing Nitrates
- Other Waterbodies and forms of Nitrogen:
  - Nitrate-N 1992 – Hatlem Creek 367µg/L
  - Nitrate+Nitrite 1992-1996 – Hatlem Creek 424µg/L; Crystal River 28µg/L
  - Kjeldahl N 1992-1996 – Hatlem Creek 180µg/L; Crystal River 196µg/L
  - Ammonia 1992-1996 – Hatlem Creek 32µg/L; Crystal River 18µg/L
  - Spot testing in Hatlem Creek – one location testing high for nitrates (660 µg/L)
  - Total organic N + ammonia ~ 0.2 mg/L, similar to nearby rivers (USGS)

Cladophora

• Branching, bushy-like alga that has recently become problematic in Lake Michigan.
• Presence and size of cladophora mats can be a good indicator for P pollution b/c it uses some portion of P in the water, while the remaining portion is free for use by other forms of algae and aquatic plants.
• GLA has been monitoring the location and relative density of cladophora in Glen Lake since 1977
• Measured through a CSI index (measurement of an existing mat of cladophora): Length [ft] x Width [ft] x Height [in]
• Any CSI more than 50 to be significant for a possible P overload
• 2006/7:
  o 25 out of 207 (or 12%) identified cladophora locations had a CSI over 50 (in 2006 it was 23%)
  o Over half had lawn fertilization noted as the probable source
  o Most cladophora locations are located around the southern portion of The Narrows (SE shore of Little Glen, SW shore of Big Glen) and the North-Central part of Little Glen

Aquatic Plant Survey and Invasive Species
2005 Aquatic Plant Survey • Little Glen: 46 sites sampled with 17 species found • Big Glen: 152 sites sampled with 17 species found • No invasive plants, Eurasian watermilfoil or hydrilla, were found • Some plants that can become nuisance plants were collected: curly leaf pondweed, native milfoil, and sago pondweed. *Exotic Species* • Two aquatic exotic species currently found in watershed: zebra mussels and curly leaf pondweed • Other invasive species: spotted knapweed, common reed, garlic mustard, autumn olive, and black locust

Threatened and Endangered Species
• National Park Service has noted the presence of 12 threatened and endangered speices living within and near the Crystal River corridor including: ginseng, pine-drops, calypso orchid, and walking fern. • In addition, the Hatlem Creek area provides habitat to many threatened and endangered species including: Federal/State endangered Michigan monkey flower, state threatened red-shouldered hawk, and the Eastern box turtle (species of special concern).

Chlorophyll a

- Historical GLA/MDNR Data 1979-1985 – as summarized in Kielty 1992
    - Big Glen - 0.87 μg/L
    - Little Glen - 0.9 μg/L
- Big Glen
    - 1992: 3.2 μg/L; 1990-2001: 1.96 μg/L; 2001: 1.2 μg/L; 2002: 1.4 μg/L; 2003: 1.1 μg/L; 2004: <1.0 μg/L; 2005: 1.0 μg/L <u>(average 2001-2005 = 1.1 μg/L)</u>
- Little Glen
    - 1992: 2.2 μg/L; 1990-2001: 2.31 μg/L; 2001: 2.0 μg/L; 2002: 2.4 μg/L; 2003: 2.2 μg/L; 2004: 1.8 μg/L; 2005: 2.1 μg/L <u>(average 2001-2005 = 2.1 μg/L)</u>
- Recent levels are comparable to previous years and are considered low, indicating no excessive algal growth in either lake
- 2006 readings may be elevated due to excessive algae collected in summer 2006 plankton net

Chlorophyll a is a pigment found in plants that is necessary for photosynthesis. Measurements of chlorophyll a indicate the amount of suspended algae. Many limnologists argue that lower concentrations of chlorophyll a are associated with better water quality, although certain amounts are a normal part of a functioning aquatic ecosystem.

Phytoplankton and Zooplankton

- Data indicate lake is dominated by oligotrohic to mesotrophic forms
- Species composition differences indicate that Little Glen has greater potential for plankton growth than Big Glen
- Phytoplankton communities dominated throughout the year by diatoms
- Zooplankton data indicate a high degree of water quality; overall densities less than 100 organisms/L; 2006 data reveal population is healthy and diversity comparable to recent years
- Phytoplankton populations appear to be less diverse in Little Glen – perhaps due to zebra mussels and the abundance of Microcystis

Pollutant Loading for Nitrogen and Phosphorus

Glen Lake

A detailed, scientific study of Glen Lake, including a hydrological and nutrient budget, was completed by Keilty in 1992 (Table 10). Results show that approximately 3,560 lb P enter Glen Lake each year. Of that total, a surprising 62% is from direct precipitation (atmospheric deposition), 26% from subsurface groundwater, and 12% surface water. It was further estimated that no more than 10% of the total P load to the lake each year was attributed to cultural influence, mainly from septic system effluent (Keilty 1992). (NOTE: Since 1992 there has been significant development along lakeshore areas of the watershed, increasing potential P loading from other sources in addition to septic systems.) The study also estimated that 214,860 lb N enter Glen Lake each year; 37% from direct precipitation, 47% from subsurface groundwater inputs, and 16% surface water. These loading estimates also included storm events. Of that amount, 128,032 lb is in the form of Nitrate-N, which is more readily used by plants than other forms of N. It should be noted that this study did not include any of the GL-CR watershed past the outlet of Fisher Lake. Additionally, Keilty estimated that 182 lbs P and 7,341 lbs N are exported annually from the lake to groundwater systems. Using the annual nutrient export data to groundwater (from the lakes) and flowing out of Fisher Lake (to Crystal River), Keilty further found that 681 lbs P and 25,203 lbs N are annually exported from Glen Lake.

TABLE 10: NUTRIENT BUDGET FOR GLEN LAKE (1990/91)*

Source	**Nutrient Load**		
	Total P (lb/yr)	**NO_3+NO_2 (lb/yr)**	**Total N (lb/yr)**
Surface			
Measured			
Hatlem Creek	188.1	5,291.6	9,650.5
Brook's Pond Outflow	35.1	1,382.1	2,258.8
Little Glen Pond Outflow	1.6	0.3	60.8
Gh20 Station 3	2.9	756.2	814.2
Gh20 Station 4	4.1	585.0	609.1
Gh20 Station 5	8.7	1,767.8	2,721.8
Gh20 Station 6	21.7	1,816.5	2,179.0
Gh20 Station 10	5.1	212.2	314.0
Gh20 Station 11	1.3	122.5	144.0
Estimated			
Unidentified Surface Seeps	133.8	12,415.4	15,529.5
Storm Event Contributions Hatlem Creek Surface Seeps	 16.8 3.6	 170.7 31.1	 369.3 31.1
SURFACE TOTAL **(% of total)**	423 (12%)	24,551 (19%)	34,682 (16%)
SUBSURFACE **(% of total)**	913 (26%)	83,039 (65%)	100,602 (47%)
PRECIPITATION **(% of total)**	2,225 (62%)	20,442 (16%)	79,577 (37%)
TOTAL	**3,560.5**	**128,032.1**	**214,860.5**

*Table adapted from "Table 8: Summary of Nutrient Budget" in Keilty 1992 – does not include information downstream of Crystal River Dam.

Crystal River and Hatlem Creek

Specific P and N loadings from the Crystal River and Hatlem Creek are available using Leelanau Conservancy water quality reports, Keilty's 1992 study, and USGS Crystal River gauge data. Table 11 shows that Hatlem Creek discharges approximately 125 lb P and 7,925 lb N (5,283 lb of which is Nitrate+Nitrite-N) to Glen Lake each year. Note that this figure is different than that shown in Table 10 above, however, Table 11 takes into account discharge and nutrient values averaged over a number of years. (See notes below Table 11.)

Further calculations reveal that the Crystal River carries approximately 640 lb P and 22,135 lb N (2561 lb Nitrate+Nitrite-N) to Lake Michigan annually.

TABLE 11: POLLUTANT LOADING FOR PHOSPHORUS AND NITROGEN FOR HATLEM CREEK AND CRYSTAL RIVER

Waterbody	Flow (cfs)	Av. TP (μg/L)	TP ton/yr	P lbs/yr	Av. TN (μg/L)	TN ton/yr	TN lbs/yr	NO_x* (μg/L)	NO_x ton/yr	NO_x lbs/yr
Hatlem Creek	6.28	10	0.0565	**124.6**	636	3.59	**7,925**	424	2.40	**5,283**
Crystal River	46.1	7	0.2904	**640.3**	242	10.04	**22,135**	28	1.16	**2,561**

**Values are NO_3+NO_2, or Nitrate + Nitrite (in most cases NO_2 – nitrite – adds a negligible amount)*

Data Years Used:
<u>Hatlem Creek:</u> Discharge – 1990-2000
P – 19992-96
All N values – 1992-96
<u>Crystal River:</u> Discharge – 2004/05 USGS
P and all N values – 1992-96

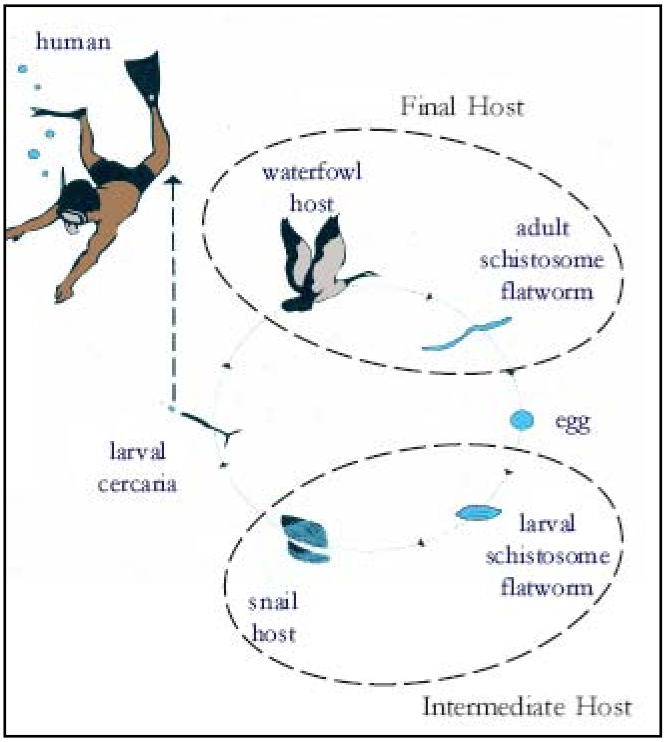
Load Calculation
Ton/yr = Discharge (ft^3/s) x Concentration (mg/L) x L/.035ft^3 x $1x10^{-9}$ton/1mg x $3.15x10^7$s/yr

Lbs/yr = ton/yr x 2204.6 lbs/ton

It should be noted that the loading values for Hatlem Creek and Crystal River do not take into account storm events. Pollutant loading may be more prevalent during spring runoff or stormflow events, the latter of which contributes to something called the 'first flush' phenomenon. First flush refers to the large percentage of pollutant loading that is produced by a relatively small percentage of the runoff volume during the initial stages storm runoff. Therefore the values in Table 11 may potentially be underestimated. It is recommended that water quality measurements be taken during baseflow, storm events, and spring runoff to provide a better estimate of pollutant loading throughout the GL-CR watershed.

Special Note – Swimmer's Itch

Along with all of the other major Leelanau County lakes, Glen Lake has historically had a problem with swimmer's itch. Swimmer's itch is caused by the incidental penetration of a swimmer's skin by the larval form of a minute, parasitic flatworm. The larvae, called cercaria, are about 1/50 of an inch long; they are released into the water daily by snails infected with the parasite. Only about 40% of people exposed to cercaria develop swimmer's itch. In those people sensitive to swimmer's itch, a small, reddened spot appears followed by relatively intense itching that can occur for several days. The life cycle of the flatworm requires the presence of two hosts, therefore the control of either would effectively diminish swimmer's itch.



The following measures can help reduce the likelihood of contracting swimmer's itch:

1. Towel off vigorously upon leaving the water.
2. Apply oils such as suntan or baby oil before swimming.
3. Avoid swimming at midday, since cercaria are released in response to full sunlight.
4. Avoid swimming in nearshore areas exposed to prolonged onshore winds. (Wave action can congregate cercaria in these locations).
5. Do not feed or encourage waterfowl to remain in the area.
6. Implement best management practices (BMPs) for shorelines. (Waterfowl tend to exhibit a preference for mowed lawns that extend to the water's edge).

Glen Lake Association's Merganser Control Program

For years, beginning in the 1950's residents around Glen Lake attempted to control swimmer's itch by applying copper sulfate to the shoals of the lake to kill snails - an intermediate host of the parasitic flatworm that causes swimmer's itch. Unfortunately, this approach was costly, toxic to the environment, and marginally successful. In the early 1980's, research was conducted that resulted in determining which snail species and which avian species completed the life cycle of the flatworm. Once the life cycle was determined, the target species switched from snail to Common Merganser.

Live trapping and relocation of Merganser broods during late May and June resulted in significant reduction in the parasite load in the snail and consequently, significant reduction in swimmer's itch. After a ten year lapse in Merganser relocation, it was brought back into full operation by the GLA in 2003. Plans by the GLA to continue relocating broods will continue until 2009. Since the merganser relocation program was brought back, snail infection rates have been reduced but swimmer's itch continues to affect swimmers. It is difficult to determine how much more severe swimmer's itch would be if Mergansers were allowed to roam the shoals.

Merganser Relocation Program Stats

- 3 broods removed in 2008 vs. 8 in 2005
- 19 resident common mergansers relocated in 2008 vs. 67 relocated in 2005 and 82 in 2004
- 1 Single Merganser uncaptured in 2008 vs. 9 in 2004
- Snail infection rate: 0.2% (*Stagnicola emarginata*)

Reduction in parasite loads in the snail host is the only concrete data on the effectiveness of the merganser relocation program. It only stands to reason that if parasite loads are reduced, swimmer's itch should be less severe and less frequent.

3.11 Human History

The European settlement history of the Glen Lake Watershed is one of initial opportunistic development, overuse and a diminishment of timber resources, and a gradual progression toward appreciation of the area as a vacation and retirement location.

The first European settlers came to the watershed in the mid 1800's John LaRue, a native of Chicago, who had been trading with Native Americans on South Manitou Island, moved to the mainland in 1848 and built a log cabin near the mouth of the Crystal River. While there he established a trading post and continued to trade for furs and fish. John LaRue later persuaded Chicago resident John Dorsey to join him in 1851. Dorsey made barrels for storing and shipping salted fish from LaRue's trading post. The third early American European pioneer, John Fisher from Wisconsin, arrived in 1854 and built a log cabin in the Glen Arbor area. These three early pioneers (the 'Three Johns') paved the way for Glen Arbor to become the largest community within the Glen Lake watershed and the first town within Leelanau County.

John Fisher's wife, Harriet, is credited with naming the community Glen Arbor. Her inspiration was the tall trees and the natural beauty of a nearby quiet hollow that was once used as an Indian council grounds. John Fisher bought 1000 acres of land on the north side of Glen Lake, originally named Bear Lake because of the many bears in the area. This property surrounded a smaller connecting lake, now called Fisher Lake. Fisher convinced many family members and friends from Wisconsin to move to the area.

The first dock and wooding station on the mainland was built in 1857 at Sleeping Bear Bay. This facility was used to supply wood to steamers, the main mode of transportation and shipping in the Great Lakes at that time. In 1859, John Fisher erected a sawmill on the Crystal River.

Initially, there was considerable lumbering in the area mainly to supply cordwood for fueling the Great Lake steam ships. The first large sawmill, the Glen Arbor Lumber Company, was built in 1899 on the west shore of Little Glen Lake by J.O. Nessen. A rail line was built from the mill to the Glen Arbor dock and a steam locomotive hauled logs and lumber to the ships.

In 1855 the steamer 'Saginaw' was the first to bring passengers to Glen Arbor. In subsequent years, Glen Arbor was designated an official U.S. port of entry with its own inspector and special dock. The original post office is now a gift shop on the main street.

Lumbering was originally the main industry in the area. Sawmills, trains, and special log carrying tugs and boats supported the production. In addition, many families took up fishing, barrel making, and farming. Dr. William Walker, for example, took advantage of the local marshes to raise large crops of cranberries each year. He also raised cherries and apples, which he shipped to market in Chicago via steamship.

Glen Arbor was officially recognized in 1856 as a township. By 1867, with the influx of two hundred families, Glen Arbor had four stores, two hotels, a blacksmith, a cooper's shop, and was serviced by three boat docks. Another small community on the east shore of Big Glen Lake, Burdickville, grew following the construction of a saw and gristmill by W.D. Burdick.

In the early 1900's, as lumbering, fishing, and farming became less viable in the Glen Arbor area, the framework for the tourism industry was initialized. Resorts and hotels were erected to accommodate the influx of travelers seeking to get away and relax. The Sylvan Inn, still in operation today, was originally the headquarters of the Glen Arbor Lumber Company. It was later used to house lumberjacks and named the Grady Inn. In 1920 it was converted to an inn following the closing of the lumber company. Another example of how the area evolved from a lumbering, fishing, and agricultural area to a vacation and retirement location stems from the history of the Homestead Resort. Many vacationers visited the area arriving by steamer at the Glen Haven and Glen Arbor docks. At one point there were six boats arriving each week at the Glen Haven dock ('Manitou' four times and 'Puritan' two times a week). The steamer 'Missouri' made weekly trips from Chicago to the Glen Arbor dock for weekend trips. One could depart from Chicago at 6:00 p.m. on Friday, arrive in Glen Arbor at 8:45 a.m. on Saturday, and depart late Sunday and be back in Chicago at 8:30 a.m. Monday.

The Beals family from St. Louis purchased 50 acres in Glen Arbor Township and founded a tutoring and summer camp for boys. At the mouth of the Crystal River where John LaRue had his early trading post, the Beals built a large farmhouse and named it Camp Leelanau. By 1929, the camp was renamed The Homestead, and included the farmhouse, a dormitory, a dinning hall and the camp headquarters. That same year, the Beals started the Leelanau School and The Homestead became a guest inn. Today, The Homestead has grown into a large resort and the Leelanau School a reputable college preparatory school.

Following his arrival in the 1870's, D.H. Day established a sawmill and lumber business, a passenger and shipping steamboat service, a farm for fruit growing and other produce, and the Glen Haven Canning Company. Although D.H. Day's lumbering business was responsible for a great deal of tree clearing in the area, he also made a contribution to the reforestation of the Glen Lake area by helping protect his young trees from fire and cutting. In the 1920's, Day planned and promoted the development of Day Forest Estates, located mainly on what is now called Alligator Hill. The resort was abandoned with the onset of the Great Depression, however its golf course did operate for a few more years. Many trees were cut for resort roads and golf course fairways, which are still apparent to this day.

One of the most important aspects in protecting the watershed has been the establishment of the SLBE. In 1961 Michigan Senator Philip Hart instigated legislation to establish the Sleeping Bear Dunes and surrounding area as a National Lakeshore. Although there was considerable local opposition to the plan, the Park was eventually authorized in 1970. Land acquisition for the National Lakeshore began shortly after the 1970 authorization. Today the Park constitutes approximately 40% of the GL-CR watershed.

3.12 Economy, Tourism, and Recreation

The economy of the watershed has become more reliant on seasonal tourism and summer residents that are drawn to the natural scenery found few other places. The high percentage of forested land use in the watershed protects scenic beauty enjoyed by thousands of annual tourists while simultaneously providing wildlife habitat, groundwater recharge and important water quality functions.

Perhaps one of the most unique characteristics of the watershed is that approximately 40% of the land is owned by the Federal Government as the Sleeping Bear Dunes National Lakeshore (See Section 3.3 on Jurisdictions). In the 1980's 700,000 visitors per year enjoyed the park; that number has increase to close to 1.3 million per year today. The area offers a 7.1 mile scenic drive which offers spectacular views of the GL-CR watershed and its geologic and natural features, hiking trails through forests, meadows and sand dunes, limited hunting under state regulations, a picnic area and swimming beach on Little Glen Lake, and 80 miles of trails marked for cross country skiing.

The surrounding non-park lands have also seen a tremendous increase in recreational use landscape changes including subdivision development and increased support services for seasonal and year-round visitors (See Section 3.4 on Population). The crowded and often conflicting use of the various waters in the area has caused considerable concern on the Crystal River. Visitor canoe use of the Crystal River has increased dramatically over the last decade (Nichols et. al 2007).

Traditionally, SLBE visitors and local and regional residents have used Glen Lake for fishing, swimming, boating, and general recreation. The National Park Service maintains a public beach on the NW shore of Little Glen with a picnic and swimming area (as well as toilet facilities). The only public boat launch on either lake is operated by the MDNR on the NE shore of Little Glen (near 'The Narrows'). It is equipped with a launch ramp, parking area, and toilets. The Glen Lake Association also funds and staffs a boat wash operation at the boat launch. A County park is on the SE shore of Big Glen and has picnic areas, parking, and toilets.

CHAPTER 4 DESIGNATED AND DESIRED USES

4.1 Designated Uses in the State of Michigan

Each of Michigan's surface waters is protected by water quality standards for specific designated uses (Table 12). Designated uses as defined by the State of Michigan Department of Environmental Quality are recognized uses of water established by state and federal water quality laws designed to 1) protect the public's health and welfare, 2) enhance and maintain the quality of water, and 3) protect the state's natural resources.

TABLE 12: DESIGNATED USES FOR SURFACE WATERS IN THE STATE OF MICHIGAN

All surface waters in the state of Michigan are designated for and shall be protected for all of the following uses:
1. Agriculture
2. Industrial water supply
3. Navigation
4. Warmwater fishery
5. Other indigenous aquatic life and wildlife
6. Partial body contact recreation
7. Total body contact recreation between May 1 – October 31
8. Fish Consumption
Citation: R323.1100 of Part 4, Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended

If a body of water or stream reach is not meeting the water quality standards set for a specific designated use, then it is said to be in 'nonattainment'. An annually published listing of the bodies of water and stream reaches in the state of Michigan that are in nonattainment can be found in Appendix C of the DEQ's Integrated Water Quality Report – Water Quality and Pollution Control in Michigan (DEQ 2008).

The DEQ uses a rotating watershed cycle for surface water quality monitoring where each of the 58 major watersheds in the state are scheduled for monitoring at least once every five years. The GL-CR watershed was last monitored in 2003, and results show that none of the designated uses are impaired on a wide-scale basis, except for fish consumption (Table 13).

Due to widespread mercury contamination and public health fish consumption advisories, all of Michigan's inland lakes, including Glen Lake, are not meeting water quality standards for fish consumption. Of all the public access lakes monitored that are not meeting water quality standards, the primary cause is fish consumption advisories for PCBs or mercury (DEQ 2008). But, back in 1990 when Glen Lake fish were tested, they also had measured levels of chlordane, a pesticide widely used historically for termites and various agricultural crops. It is suspected that, much like mercury, the probable cause for chlordane levels in Glen Lake are from atmospheric deposition. For further information on mercury sources in the environment and mercury pollution prevention strategies, please refer to publications by Sills (1992) and Mehan (1996), respectively. These two reports resulted from two specific DEQ task force investigations into mercury in the environment, sources, and prevention. The problem of mercury contamination and other related toxic contamination problems (i.e., PCB, chlordane, etc.) in the GL-CR watershed will not be discussed in depth in this Management Plan. The DEQ has taken the lead to develop pollution prevention and abatement strategies throughout the State of Michigan for mercury contamination and other related toxins.

Additionally, certain waters within the designated boundaries of the Sleeping Bear Dunes National Lakeshore have been identified by the State of Michigan as "Outstanding State Resource Waters" (Rule R 323.1098(6)(c)(i) of the Michigan Natural Resources and Environmental Protection Act of 1994: PA 451). These high quality waters are provided the highest level of protection by the state so as to preserve their special qualities. Rule 98 (the "Antidegradation Rule") under the State's Part 4 Rules applies to any action pursuant to Part 31 of PA 451. High quality water bodies designated as "Outstanding State Resource Waters" (OSRW) by the state are protected by applying controls on pollutant sources to the OSRW or tributaries so that water quality in the OSRW is not lowered, except on a temporary, short-term basis (i.e., weeks or months). Therefore, all waters (inland lakes and streams, and Lake Michigan) within the designated boundaries of the National Lakeshore are designated an OSRW. In the GL-CR watershed this would affect both Big and Little Glen Lake and the entire length of the Crystal River (see Figures 1 and 1A).

TABLE 13: SECTIONS OF WATERSHED SUPPORTING DESIGNATED USES*

Designated Use	***Use Support: Glen Lake***	***Use Support: Crystal River***	***Use Support: Hatlems Creek***	**Water quality standards****
Total body contact recreation	Not assessed	Not assessed	Not assessed	Counts of 130 or less for Escherichia coli (E. coli) per 100 ml monthly average and 300 or less for E. Coli per 100 ml at any time
Partial body contact recreation	Not assessed	Not assessed	Not assessed	Counts of 1,000 or less for E. coli counts per 100 ml
Navigation	Fully supporting	Fully supporting	Fully supporting	--
Industrial water supply	Fully supporting	Fully supporting	Fully supporting	--
Agriculture	Fully supporting	Fully supporting	Fully supporting	--
Warmwater fishery	Not assessed	Not assessed	Not assessed	Dissolved oxygen (DO) not less than 5.0 mg/L during summer stratification in the epilimnion (uppermost layer of the lake). Not less than 5.0 mg/L for the rest of the year in entire lake area.
Other indigenous aquatic life and wildlife	Not assessed	Not assessed	Fully supporting	Numerous numeric chemical limits such as pH, ammonia, toxic metals, and organic compounds, as well as narrative limits such as for nutrients (nuisance algal growths) and physical properties (color, temperature, clarity, etc.)
Coldwater fishery	Fully supporting	Insufficient Information	Not assessed	DO not less than 6.0 mg/L in any 24-hour period during summer minimum flow period and not less than 7.0 mg/L rest of the time
Fish Consumption	Not supporting **<u>REASONS:</u>** *Chlordane* *Mercury in Fish Tissue* *PCB in Fish Tissue*	Not assessed	Not assessed	Fish Consumption Advisory trigger levels for toxic heavy metals and organic compounds

**Data from Appendix B2 of DEQ's Integrated Water Quality Report – Water Quality and Pollution Control in Michigan (DEQ 2008)*
***Adapted from Exhibit 43 from Portage Lake Watershed Forever Plan (PLWFP 2008)*
Local organizations have collected additional data on environmental conditions in the watershed affecting these designated uses that are discussed throughout this plan.

4.2 Impacted Designated Uses in the Glen Lake-Crystal River Watershed

None of the designated uses for the GL-CR watershed are impaired on a watershed-wide scale. However, in some cases, activities and resulting pollutants in the watershed may prove to be a threat to water quality and designated uses. Threatened waterbodies are defined as those that currently meet water quality standards, but may not in the future.

Currently, the designated uses of the GL-CR watershed are threatened from increasing human development along with exotic species introduction and proliferation. The GL-CR Watershed Management Plan will focus on five designated uses to protect in order to maintain water quality throughout Glen Lake and its watershed. The designated uses include the warmwater/coldwater fishery, other indigenous aquatic life and wildlife, total body contact, navigation, and fish consumption (Table 14). Threatened designated uses were ascertained through scientific research reports, water quality monitoring reports, steering committee members, and personal contact with watershed residents and scientific experts on the GL-CR watershed.

TABLE 14: THREATENED DESIGNATED USES IN THE GLEN LAKE-CRYSTAL RIVER WATERSHED

Designated Uses	
Warmwater and Coldwater Fishery	Threatened
Other Indigenous Aquatic Life and Wildlife	Threatened
Total Body Contact Recreation (May1-Oct 31)	Threatened
Navigation	Threatened
Fish Consumption	Threatened

4.3 Desired Uses

In addition to designated uses, watershed residents may have uses and concerns particular to their region. Such issues result in the addition of desired uses to the watershed management plan. Desired uses can be defined as the ways in which people use the watershed and think should be protected and/or preserved for future generations. They may be very general or very specific, or somewhere in between. The desired uses are simply how watershed residents might want to use their watershed. Desired uses help to reflect community concerns such as loss of wildlife habitat or deterioration of scenic viewsheds. Desired uses for the GL-CR watershed include uses for recreational, aesthetic, human health, and ecosystem preservation purposes (Table 15).

TABLE 15: GENERAL DESIRED USES FOR THE GLEN LAKE-CRYSTAL RIVER WATERSHED

Desired Use Category	Goal
Recreation	• Provide navigable waters that do not exceed responsible limits for usage. • Development and implementation of an effective swimmer's itch management program.
Aesthetics	• Preserve the distinctive aesthetic character and inherent beauty of the lake and watershed. • Design and promote development that supports privacy, security, visual quality throughout the watershed. • Maintain the 'peace and quiet' usage of lake
Human Health	• Protect potable groundwater sources
Ecosystem Preservation	• Enhance fish and wildlife habitat with emphasis on protecting rare, endangered, and wetland species. • Preserve natural and intact riparian corridors with an emphasis on private landowner stewardship and conservation easements. • Agricultural, irrigation and landscaping (including private homeowner) practices that emphasize current best management practices

CHAPTER 5 WATER QUALITY PROBLEMS

5.1 Threatened Designated Uses: Pollutants, Sources, and Causes

For each designated use to protect in the GL-CR watershed there are a number of different pollutants and environmental stressors that adversely affect each of the designated uses, or have the potential to (Table 16). The term environmental stressor is used to describe those factors that may have a negative effect on the ecosystem, but aren't necessarily categorized as contaminants that change water chemistry. It is meant to address the wide range of environmental degradation experienced in the watershed. By avoiding the traditional approach of labeling a negative impact as a pollutant, the management plan hopes to engage a wider community support base. This plan will refer to classic watershed pollutants such as nutrients, sediment, and toxic substances, as well as environmental stressors such as habitat and wetland loss. The term pollutant and environmental stressor will be used interchangeably.

Environmental stressors representing activities and conditions that negatively impact the designated and/or desired uses of the GL-CR watershed include invasive species, loss of habitat, excess nutrients, and more (Table 16).

TABLE 16: POLLUTANTS AND ENVIRONMENTAL STRESSORS AFFECTING DESIGNATED USES IN THE GLEN LAKE-CRYSTAL RIVER WATERSHED

Pollutant or Environmental Stressor	Designated Uses Affected
Invasive Species	Warmwater/Coldwater Fishery Other Indigenous Aquatic Life Navigation Total Body Contact
Loss of Habitat	Warmwater/Coldwater Fishery Other Indigenous Aquatic Life
Nutrients	Warmwater/Coldwater Fishery Other Indigenous Aquatic Life Total Body Contact
Pathogens **(*E. Coli*)**	Warmwater/Coldwater Fishery Other Indigenous Aquatic Life Total Body Contact
Sediment	Coldwater Fishery Other Indigenous Aquatic Life Navigation
Thermal Pollution	Coldwater Fishery Other Indigenous Aquatic Life
Toxins **(Pesticides, Herbicides, Oils, Gas, Grease, Salt/Chlorides, Copper Sulfate, Microcystis)**	Warmwater/Coldwater Fishery Other Indigenous Aquatic Life Total Body Contact
Changes to Hydrologic Flow	Warmwater/Coldwater Fishery Other Indigenous Aquatic Life Navigation

Note: This is a general list that encompasses pollutants for the entire GL-CR watershed. Not all reaches in the watershed are impacted by all of the pollutants listed above.

Sources and Causes of Pollutants

A Comprehensive Watershed Management Table was developed listing sources and causes of watershed pollutants and environmental stressors (Table 17). This table summarizes key information necessary to begin water quality protection, provides specific targets to act upon for watershed management, and forms the basis for all future implementation projects to protect the quality of the watershed. Sources and causes were identified using a wide variety of methods including: road stream crossing inventories, scientific research reports, water quality monitoring reports, steering committee members, and personal contact with watershed residents and scientific experts on the GL-CR watershed.

TABLE 17: POLLUTANTS, SOURCES, AND CAUSES OF WATER QUALITY DEGRADATION IN THE GLEN LAKE-CRYSTAL RIVER WATERSHED

(COMPREHENSIVE WATERSHED MANAGEMENT TABLE)

Environmental Stressor or Pollutant	**Impaired or Threatened Use**	**Sources** **K = known, S = suspected, P = potential**	**Causes** **K = known, S = suspected, P = potential**
Sediment	*Warm/ Coldwater Fishery *Other Indigenous Aquatic Life *Navigation	Road Stream Crossings (k)	Poor design/construction/maintenance (k) Lack of erosion/surface runoff controls (k) Steep approaches (k) Culverts not aligned to streambed (k) Undersized culverts (k) Failing/eroding culverts/bridges (k)
		Bank/Shoreline Erosion (k)	Removal of riparian vegetation (k) Boat traffic/wakes (k) High flow velocities (k) Recreational activities (k) Sandy soils (k)
		Construction (k)	Poor soil erosion practices (p)
		Urban/Rural Storm Water (k)	Poor storm water management practices (k)
		Lack of Riparian Buffer (k)	Development (k) Clearing by landowner (k) Lack of adequate shoreline setbacks and appropriate native species and deep rooted vegetation (p)
		Wetland Filling (k)	Poor storm water management practices (k) Non-compliance with permits (k) Development (k)
		Forestry Practices (k)	Poor road design, management (k) Poor timber harvest practices (k)
		Visitor Usage (s)	Inadequate facilities (p) Lack of awareness of impact (s) Volume, too much demand for resource (s)
		Dredging (k)	Improper methods (k) Resuspension of particles in water column (s) Non-compliance with dredging permit restrictions (p)
Nutrients	*Warm/ Coldwater Fishery *Other Indigenous Aquatic Life *Total Body Contact	Residential or Commercial Fertilizer Use (k)	Improper application (amount, timing, frequency, location, method, P content) (k)
		Septic Systems (s)	Poorly designed, sited, sized, maintained (s) High density/age of systems (s) Lack of required inspections (s)
		Urban/Rural Storm Water (k)	Poor storm water management practices (k)
		Lack of Riparian Buffer (k)	Development (k) Clearing by landowner (k) Lack of adequate shoreline setbacks and appropriate native species and deep rooted vegetation (p)
		Atmospheric Deposition (k)	Industrial emissions (k)
		Animal Waste (k)	Geese/ducks along shore & beach areas (k)
		Reduction of Wetlands (k)	Development and filling (k)

TABLE 17: POLLUTANTS, SOURCES, AND CAUSES… CONT'D

Environmental Stressor or Pollutant	Impaired or Threatened Use	Sources K = known, S = suspected, P = potential	Causes K = known, S = suspected, P = potential
Changes to Hydrologic Flow	*Warm/ Coldwater Fishery *Other Indigenous Aquatic Life *Navigation	Fluctuating Water Levels (k)	Dams and water-level control structures (k) Urban storm water runoff (k) Inc. development & imperv surfaces (k) Loss of terrestrial vegetation (k) Global warming (k) or drought (k)
		Reduction of Groundwater Recharge (k)	Increasing develop. on recharge areas (k) Loss of terrestrial vegetation (k) Global warming (k) or drought (k)
		Sedimentation (k)	Erosion (k)
		Impoundment and Water-level Control Structures (k)	Changes in operation (p) Creation/destruction of beaver dams (k)
		Road Stream Crossings (k)	Road cross flow, obstructions restrictions (k)
		Reduction of Wetlands (k)	Development on wetlands (k)
		Lowland Filling (k)	Erosion from 1) improper shoreline stabilization, 2) improper dredge spoil disposal, and 3) increase peak flood flows (k) Development (k)
Invasive Species	*Warm/ Coldwater Fishery *Other Aquatic Life *Navigation *Total Body Contact	Landscaping practices (k)	Lack of awareness (s)
		Boat Hulls, Personal Watercraft, Live Wells, Bilges, Trailers, Etc. (k)	Lack of restrictions on boat travel (k) Lack of awareness (k)
		Other Biota (i.e. birds, frogs) (k)	'Hitching' a ride (k)
Loss of Habitat	*Warm/ Coldwater Fishery *Other Indigenous Aquatic Life	Development (commercial and residential) (k)	Poor development and design practices (k) Lack of knowledge on impact (k) New construction (p) Inadequate laws or regulations (p) Lack of adequate enforcement (p) Habitat fragmentation (k) Public demand for vacation/seasonal homes Increasing population
		Visitor Usage (k)	Inadequate facilities Lack of awareness of impact Volume, too much demand for resource
		Permitted Wetland Filling (k)	Public demand for vacation/seasonal homes Increasing population
		Shoreline Erosion & Stabilization (k)	Wave/ice action (k) High lake/river levels (k) Improperly designed/sited sea walls (k) Removal or lack of riparian vegetation (k) Development, public demand for vacation/seasonal home

TABLE 17: POLLUTANTS, SOURCES, AND CAUSES… CONT'D

Environmental Stressor or Pollutant	Impaired or Threatened Use	Sources K = known, S = suspected, P = potential	Causes K = known, S = suspected, P = potential
Thermal Pollution	*Coldwater Fishery *Other Indigenous Aquatic Life	Urban/Rural Storm Water (k)	Poor storm water management practices (k)
		Impervious Surfaces (k)	More roads, roofs, and parking lots due to development (k) Driveway/blacktopping practices (k)
		Lack of Streamside or Shoreline Canopy and Riparian Buffer (k)	Development (k) Clearing by landowner (k) Recreational access (k)
		Ponds, impoundments, and other water-control devices (k)	Top draw structures (k) Hydrology – low flows at times (k)
		Sedimentation in stream channel (see Sediment) (k)	See Section on Sediment
Toxins (Pesticides, Herbicides, Oils, Gas, Grease, Microcystis, Etc.)	*Warm/ Coldwater Fishery *Other Indigenous Aquatic Life	Water Wells (p)	Abandoned Wells (leaking, uncapped) (p)
		Atmospheric Deposition (k)	Industrial emissions (k)
		Contaminated Sediments (s)	Historical spills, disposals, discharges (s)
		Oil, Gas, Hydrocarbon, and Underground Injection Wells (p)	Maintenance (p), Accidents (p), Brine Storage (p) Abandoned Wells (leaking, uncapped) (p)
		Underground Storage Tanks (p)	Leaking tanks (p)
		Automobiles (k)	Oil, gas, and other leaks from cars, farm equipment, etc. (k)
		Urban/Rural Storm Water (k)	Poor storm water management practices (k) Lack of riparian buffer
		Motor Boats (k)	Inefficient (2cycle) or poorly maintained watercraft motors (k) Fuel spills (p)
		Improper Chemical Use and Disposal (s)	Poor public knowledge of consequences (s) Lack of disposal facilities and/or limited hours of operation (s)
		Road Salt in Winter (k)	Runoff from roads (k)
Pathogens (*E. Coli* and Fecal Coliform indicators)	*Total Body Contact	Urban/Rural Storm Water (k)	Poor storm water management practices (k)
		Animal Waste (k)	Geese/ducks/pets along shore, beach areas (k) Riparian Grazing (p)
		Septic Systems (p)	Poorly designed, sited, sized, maintained (s) High density/age of systems (p) Uninspected systems (p)

The Comprehensive Watershed Management Table (Table 17) may be used as a reference to distinguish what the major sources of pollutants and environmental stressors are on a watershed-wide scale. However, they do not distinguish between pollutants and their sources and causes at specific locations. And, as stated earlier, not all of the pollutants listed are a problem everywhere in the watershed.

5.2 Priority Pollutant Ranking

The project steering committee noted that it is extremely difficult to rank and prioritize all the pollutants and environmental stressors in the watershed because all of them are important and should be priorities for maintaining the health of the GL-CR watershed. The series of environmental stressors shown in Table 16 are an interdependent web, with each pollutant having some effect on the other, and each causing degradation in its own way.

Almost always, pollutants and stressors are interconnected with each other and changes in one causes changes to the others. For instance, increasing the hydrologic flow in Hatlem Creek could increase the amount of sedimentation and erosion, which may then increase thermal pollution and the amount of nutrients entering the system. Additionally, losing valuable habitat in a stream could itself be the result of excessive sedimentation and subsequently affect the amount of nutrients and toxins entering the stream, as well as pave the way for invasive species to populate the area.

Overall, loss of habitat, invasive species, nutrients, and sediment are the top environmental stressors in the watershed, in no particular order (Table 18). Maintaining the excellent water quality and low productivity (oligotrophic status) for Glen and Fisher Lakes will require minimizing the amount of nutrient pollution that enter the lakes from adjacent properties, through stormwater runoff, erosion, or the lack of a riparian buffer (or greenbelt). Nutrients often attach to soil particles, thereby linking sediment and nutrient pollution. Even though Glen Lake is oligotrophic and low in nutrients overall, excessive nutrient loading is still a threat (from both Nitrogen and Phosphorus), especially in shallow, near shore areas where excessive nutrients cause increased algae and plant growth (as seen from recent Cladophora surveys discussed later in plan). As influxes of nutrients get washed out into the deeper lake areas, there is some dilution and increased uptake by submerged aquatic vegetation; therefore nutrient levels still remain low. However, if excessive inputs of nutrients continue, levels could increase, causing drastic and harmful changes in the ecosystem. Additionally, excessive nutrients may accumulate in the sediment lining the bottom of the lake. These nutrients (specifically P) may be released back into the water column during certain water conditions and cause sharp increases in plant growth.

Maintaining the excellent groundwater quality in the watershed is a high priority, due to the large role groundwater plays in the hydrological budget. There is no surface-water source for drinking water in the watershed; all residents obtain their drinking water through groundwater wells. And many of the groundwater recharge areas noted in Figure 5 are at risk from development.

Additionally, the impact invasive species may have on the GL-CR ecosystem (both currently and in the future) is of great concern. While not a primary concern throughout portions of the watershed just yet, invasive species are already beginning to drastically change the ecosystem and habitat dynamics in surrounding watersheds and Lake Michigan. The diversity and quality of water-based recreational activities enjoyed throughout the watershed could change drastically from an invasive species.

TABLE 18: POLLUTANT PRIORITIES FOR THE GLEN LAKE-CRYSTAL RIVER WATERSHED

Pollutant	Priority in Watershed
Loss of Habitat	High
Invasive Species	High
Nutrients	High
Sediment	High
Pathogens (*E. Coli*, Botulism)	Medium
Toxins (Pesticides/Herbicides, Oils, Gas, Grease, Salt/Chlorides, Copper Sulfate)	Medium
Thermal Pollution	Medium
Changes to Hydrologic Flow	Medium

The project steering committee has decided that the specific sources for each pollutant and stressor are the most important items to rank and prioritize in this management plan because that is where one can actually stop pollution from entering waterways (Table 19). Additionally, as noted above, because most of the pollutants and stressors are interconnected, dealing with one source and its causes could actually reduce a number of different pollutants and stressors from affecting a stream or waterbody. This concept is discussed more in-depth in Chapter 7.

TABLE 19: POLLUTANT SOURCE PRIORITY RANKING

Environmental Stressor or Pollutant	Sources K = known, S = suspected, P = potential	Priority
Sediment	Road Stream Crossings (k)	High
	Bank/Shoreline Erosion (k)	High
	Construction (k)	High
	Poor Forestry Practices (k)	High
	Urban/Rural Storm Water (k)	Medium
	Lack of Riparian Buffer (k)	Medium
	Wetland Filling (k)	Low
	Visitor Usage (s)	Low
	Dredging (k)	Low
Nutrients	Residential or Commercial Fertilizer Use (k)	High
	Urban/Rural Storm Water (k)	High
	Lack of Riparian Buffer (k)	High
	Reduction of Wetlands (k)	High
	Atmospheric Deposition (k)	Medium
	Septic Systems (s)	Medium
	Animal Waste (k)	Low

TABLE 19: POLLUTANT SOURCE PRIORITY RANKING CONT'D

Environmental Stressor or Pollutant	Sources K = known, S = suspected, P = potential	Priority
Changes to Hydrologic Flow	Impoundment and Water-level Control Structures (k)	High
	Road Stream Crossings (k)	High
	Reduction of Wetlands (k)	High
	Lowland Filling (k)	High
	Fluctuating Water Levels (k)	Medium
	Reduction of Groundwater Recharge (k)	Medium
	Sedimentation (k)	Low
Invasive Species	Boat Hulls, Live Wells, Bilges, Trailers, Etc. (k)	High
	Landscaping practices (k)	High
	Other Biota (i.e. birds, frogs) (k)	Medium
Loss of Habitat	Development (commercial and residential) (k)	High
	Permitted Wetland Filling (k)	High
	Visitor Usage (k)	Medium
	Shoreline Erosion & Stabilization (k)	Medium
Thermal Pollution	Ponds, impoundments, and other water-control devices (k)	High
	Impervious Surfaces (k)	High
	Lack of Streamside/Shoreline Canopy and Riparian Buffer (k)	Medium
	Sedimentation in stream channel (see Sediment) (k)	Medium
	Urban/Rural Storm Water (k)	Medium
Toxins **(Pesticides, Herbicides, Oils, Gas, Grease, Etc.)**	Urban/Rural Storm Water (k)	High
	Atmospheric Deposition (k)	Medium
	Motor Boats (k)	Medium
	Improper Chemical Use and Disposal (s)	Medium
	Road Salt in Winter (k)	Medium
	Automobiles (k)	Medium
	Contaminated Sediments (s)	Medium
	Oil, Gas, Hydrocarbon, and Underground Injection Wells (p)	Low
	Underground Storage Tanks (p)	Low
	Water Wells (p)	Low
Pathogens (*E. Coli* and Fecal Coliform indicators)	Animal Waste (k)	Medium
	Urban/Rural Storm Water (k)	Low
	Septic Systems (p)	Low

5.3 Critical Areas

Although watershed management plans address the entire watershed, there are certain areas within the GL-CR watershed that warrant more extensive management consideration. These are deemed the critical watershed areas.

Critical areas in the GL-CR watershed are defined as the portions of the watershed that are most sensitive to environmental impacts and have the greatest likelihood to affect water quality and aquatic habitat. These are the most ecologically sensitive portions of the watershed which would have a direct negative impact to the high water quality if they are degraded in the future.

The critical areas were identified by analyzing the Comprehensive Watershed Management Tables (Table 17) and identifying the major areas where most of the threats to water quality exist. Other resources used to identify the critical areas include; scientific research reports, the Michigan Natural Features Inventory, water quality monitoring reports and personal contact with scientific consultants of the GL-CR steering committee.

The critical areas for the GL-CR watershed cover roughly a quarter of the watershed and include the following areas (Figure 7):

- **Riparian Corridors**: areas within 1,000 feet of bodies of water (i.e. Glen Lakes, Fisher Lake, Crystal River, Hatlem Creek, etc.)
- **Forested Ridgelines**: steep, forested slopes comprised of highly permeable soils susceptible to erosion that drain into the lake and tributaries.
- **Hatlem Creek Subwatershed:** ecologically rich wetland complex that drains into Glen Lake
- **Crystal River Dune Swale Complex:** globally rare dune and swale wetland community
- **Groundwater Recharge Areas**: areas where there is a greater amount of groundwater recharge (significant overlap with Hatlem Creek area). (See Section 3.6: Groundwater Hydrology and Groundwater Recharge and Figure 5)

Forested Ridgelines and Riparian Corridors

Sandy glacial moraines surround Glen Lake, generally with nutrient-poor soils comprising relatively high and steep slopes. The beech-maple northern hardwood forest community that naturally occupies this area has come under significant threat in recent years due to the growing demand for view parcels looking over lake as direct lakefront becomes unaffordable or unavailable. As vast portions of the hillsides are cleared for residential views, the sandy, loose soils erode very quickly, which creates significant hydrological and water quality issues. The erodable soils quickly are transported downhill with rainfall and spring melt water and collect at the base of the slopes in tributary streams and wetland basins. The small groundwater tributary channels quickly overflow with sediment causing hydrological problems that impact human property and create water quality issues by increasing loading of nutrients, sediment and temperature.

Hatlem Creek and Crystal River Dune Swale Complex

The Hatlem Creek and Crystal River wetland communities support rare and endangered species and their habitats. These two wetland areas also play a prominent role in maintaining the high water quality enjoyed by watershed users.

The ecologically rich Hatlem Creek region (See Wetlands Map – Figure 6) provides diverse habitat for many threatened and endangered species such as the Federal and state endangered Michigan monkey flower (*Mimulus glabratus var. Michiganensis*), the state threatened red-shouldered hawk (*Buteo lineatus*), and the eastern box turtle - a special species of concern (*Terrapene Carolina carolina*). The Michigan monkey flower population found in the Glen Lake/Crystal River watershed is one of the healthiest and most robust populations documented by the Michigan Natural Features Inventory in their most recent review of the status of this endangered species.

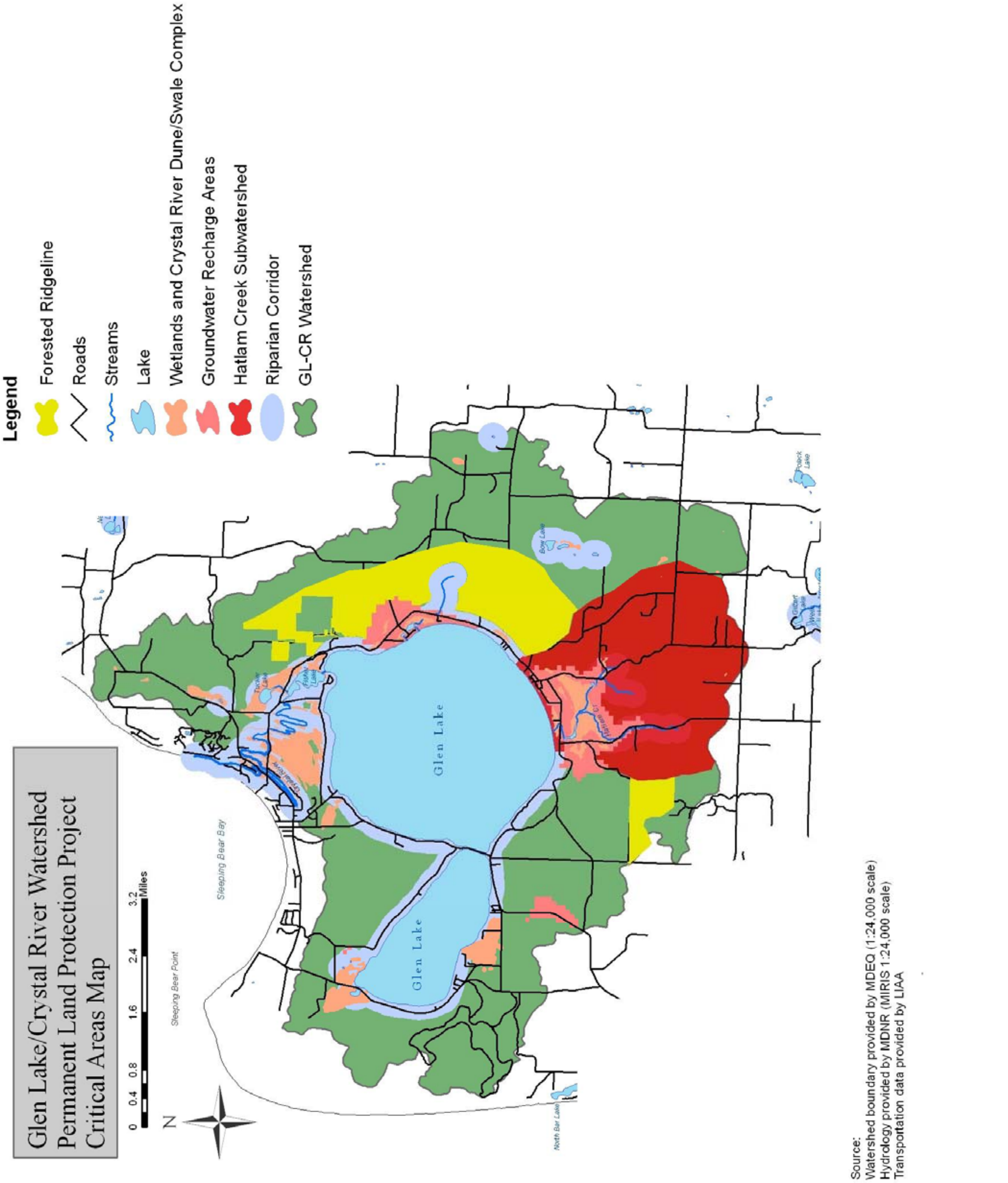
Hatlem Creek itself, the largest single source of surface water flowing into Glen Lake, is a second order coldwater stream and some sections contain a diverse and healthy population of mayflies, caddisflies and stoneflies, which are classic indicators of high water quality. However, recent macroinvertebrate studies by the GLA at 5 locations on Hatlem Creek show that it ranges from poor to good water quality, with no excellent ratings. Most of these low rankings are in first order tributaries and are due to excessive sedimentation and lack of suitable habitat. Hatlem Creek is a designated trout stream by the Michigan Department of Natural Resources (MDNR) with naturally reproducing populations of brook trout and annual returns of Coho salmon and steelhead.

Hatlem Creek also plays a key role in the recreation value of Glen Lake by hosting large runs of emerald shiners, *Notropis atherinoides*, which are the key forage species for the very popular yellow perch sport fishery in Big and Little Glen Lakes. The creek experiences an unusually large migration of emerald shiners in the fall migrations, which is when the popular baitfish has been over harvested in the past by poachers. The MDNR now has special regulations in effect that prohibit the capture of minnows in Hatlem Creek and Glen Lake to help protect this valuable forage species. Protection of the Hatlem Creek corridor will help to ensure the maintenance of the cold temperatures and high water quality required by these and other nutrient and sediment sensitive organisms.

The Crystal River dune and swale community (Figure 3c) was inventoried by ecologists Gary Reese and Michael Penskar, of the Michigan Natural Features Inventory in 1989. By definition, the dune and swale community contains both wetland (swale) and upland (dune) ecosystems intertwined into a single ecological community (Stone 2005). While there are forty wooded dune and swale complexes identified in the State of Michigan, the authors concluded that "…this community type has been heavily impacted by logging throughout the state and that few, if any, higher quality and less impacted examples than the Crystal River site exist... Furthermore, it is unique among occurrences in the Lower Peninsula by virtue of its association with an exemplary aquatic feature, the Crystal River, which courses through some of the interdunal troughs." (MNFI 1989)

The National Park Service (NPS) has noted the importance of riparian and aquatic habitats along this corridor to migratory birds (e.g., yellow warblers, yellow-rumped warblers), wood ducks, mink and long tailed weasels. The NPS has also noted the presence of 12 threatened and endangered species within and near the Crystal River corridor. Among the species of concern are: ginseng (*Panax quinquefolius*), pine-drops (*Pterospora andromedea*), calypso orchid (*Calypso bulbosa*), and the walking fern (*Camptosorus rhizophyllus*).

FIGURE 7: CRITICAL AREAS IN THE GL-CR WATERSHED



5.4 Pollutants of Concern

Nutrients

Nutrients are elements such as nitrogen, phosphorus, carbon, sulfur, calcium, potassium, iron, manganese, boron, and cobalt that are essential to the growth of living things. In particular, nitrogen (N) and phosphorus (P) are critical nutrients for all types of plants, including aquatic species. The N requirements of these species are typically about 10 times that of P. Because N/P ratios exceed 10:1 in most freshwater systems, N is not usually the limiting nutrient. In Michigan, rooted aquatic vegetation and algal growth are most commonly limited by the amount of P in the water column. However, in the case of Glen Lake, P is not always a limiting nutrient (Keilty 1992). Nitrogen values can be extremely low in the lake at certain times of the year, causing the lake to be both P and N limited at times.

Ordinarily, however, as the amount of P in the water column increases, rooted plant and algal growth increase as well. Generally speaking, total P concentrations greater than 10µg/L may contribute to increased aquatic plant growth and are indicative of impaired water quality. Since 2001, P concentrations in both Big and Little Glen Lakes have averaged around 6µg/L. Average levels for N in both lakes from 1990-2001 are 70µg/L for Big Glen, and 55µg/L for Little Glen. This is almost a 10:1 ratio, however, seasonal N values fluctuate and at times both nutrients may cause sharp increases in plant growth. Therefore it is important to control sources of <u>both</u> N and P into Glen Lake. See Section 3.9 for nutrient pollutant load estimated for the watershed.

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

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

Sources of nutrients to the GL-CR watershed resulting from human activities include residential and commercial fertilizer use, stormwater runoff from residential areas and roads (see Section 5.5 for a discussion on stormwater), septic system effluent, lack of riparian buffers, and reduction of wetlands.

Cladophora

Evidence of locally increased concentrations of nutrients (most likely P) in Glen Lake is seen by Cladophora mapping results. Cladophora is a branching, green filamentous alga found naturally along the coastline of most of the Great Lakes, and now in some inland lakes. Historically, Cladophora blooms in the Great Lakes have been linked to high P levels in the water, mainly as a result of human activities such as fertilizing lawns, poorly maintained septic systems, inadequate sewage treatment, agricultural runoff and detergents containing phosphorus. Cladophora blooms lead to unsightly and foul-smelling beaches and have negative economic consequences as a result of the lowered beach use and possible reductions in property value. While there have been some efforts to remove Cladophora from beaches, ultimately the solution to Cladophora problems requires the identification of the factors promoting growth in the lake, and if possible the mitigation of those factors.

Water quality experts feel that the presence and size of cladophora mats can be a good indicator of phosphorus pollution. Cladophora is not harmful to the water, but uses some portion of P in the water column while the remaining portion is free for use by other forms of algae and aquatic plants. Cladophora prefers to grow on hard substrates such as rocks, gravel, or break walls, usually where there is some water movement. GLA has been monitoring the location and relative density of cladophora in Glen Lake for 27 years. The presence of cladophora is measured through a CSI index, which is essentially a measurement of the volume of an existing mat of cladophora (length [ft] x width [ft] x height [in]). The GLA considers any CSI more than 50 to be significant for a possible P overload.

In 2007, 25 out of 207 (or 12%) identified cladophora locations had a CSI over 50 (in 2006 it was 23%) (Table 20). In both years about half of the significantly high spots had lawn fertilization noted as the probable source (Tables 20, 21). Higher nutrient concentrations, most notably P, add to extensive growth of cladophora mats and consequently can be used to identify potential hotspots of contamination (i.e. residential stormwater runoff, leaky shoreline septic systems, etc.). Most of the 2006 and 2007 mapped cladophora locations are located around the southern portion of The Narrows (SE shore of Little Glen, SW shore of Big Glen) and the North-Central part of Little Glen (Figure 8).

TABLE 20: CSI VALUES FOR 2006-07 GLEN LAKE CLADOPHORA SURVEY

CSI Range	2006 Count	2007 Count
0-50	148	182
51-59	4	2
60-99	21	10
100-499	16	11
500-999	2	2
Above 1000	0	0
Total	191	207
Total CSI >50	43	25

TABLE 21: PROBABLE SOURCES FROM 2006 AND 2007 GLEN LAKE CLADOPHORA SURVEYS

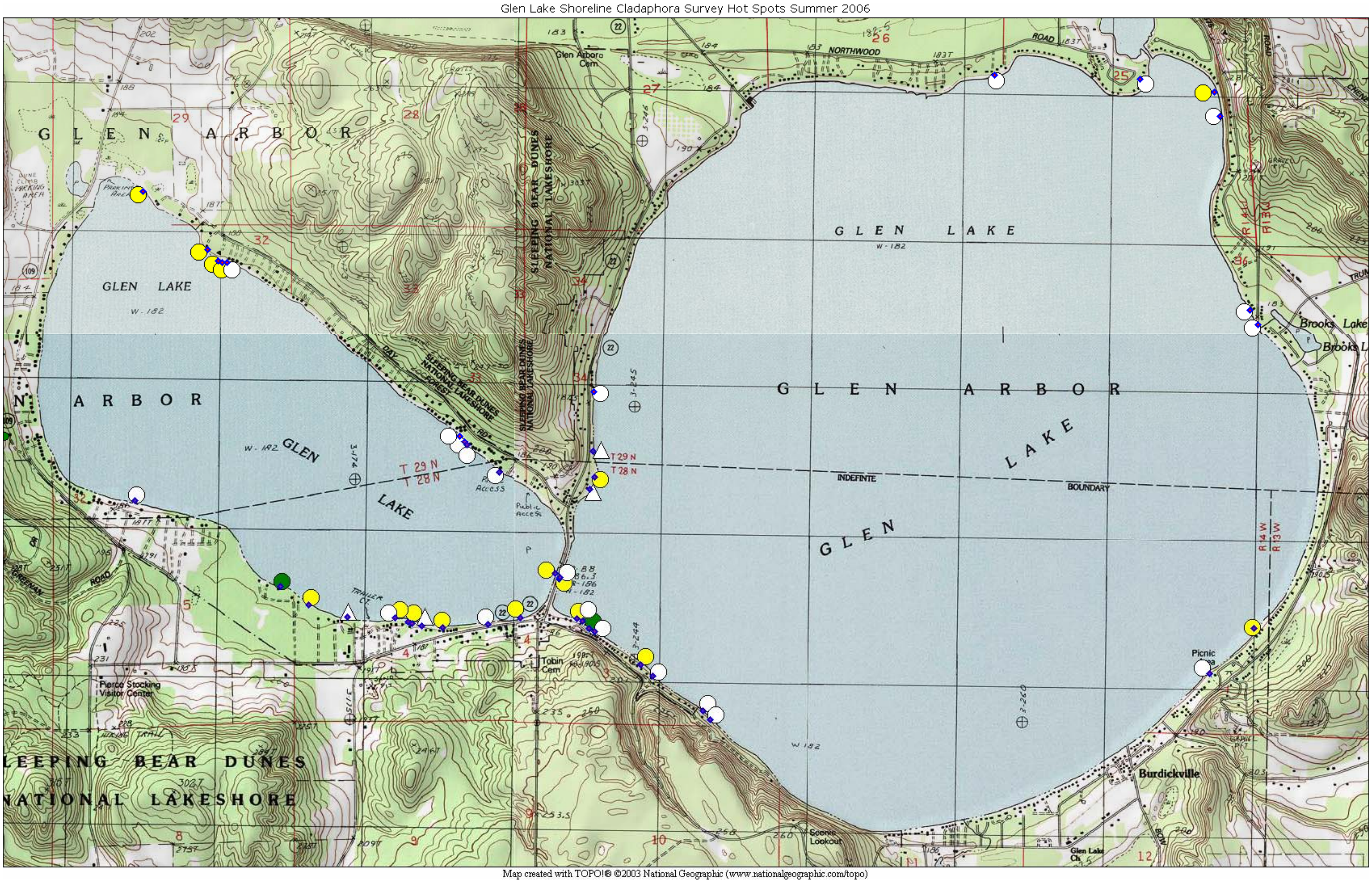
Probable Source (Note: some sites may list more than one source)	2006		2007	
	Sites	Cladophora Sites with CSI >50	Sites	Cladophora Sites with CSI >50
Septic	8	2	13	1
Lawn Fertilization	71	22	66	12
Lakeside Dumping	1	0	14	0
Animal Waste	1	0	3	2
Erosion	35	6	53	4
Tile Drain System	3	1	2	0
Natural Causes	63	12	93	9
Unknown Sources	9	0	2	1

The results of the 2007 Cladophora study show a modest decrease in Cladophora CSI values from 2006. Perhaps this might be due to "drought" conditions in 2007 that resulted in weaker groundwater flow rates into the lake.

Trends over the 27 years indicate that the CSI values will be erratic and yield ups and downs. There seems to be some qualitative and subjective connection between CSI values and rainfall and pollen. Years with high pollen and high rainfall correlate proportionately with CSI; more study should be conducted to support this hypothesis.

It is worth noting that a trailer park development along a 900 foot stretch of shoreline on the south shore of Little Glen Lake has traditionally had high CSI values. Within the last three years a 40 foot greenbelt was added to 90% of this shoreline, along with the elimination of phosphate containing fertilizer, resulting in a decrease in nutrient loadings and lower CSI values in 2007.

FIGURE 8: GLEN LAKE SHORELINE CLADOPHORA SURVEY SUMMER 2006



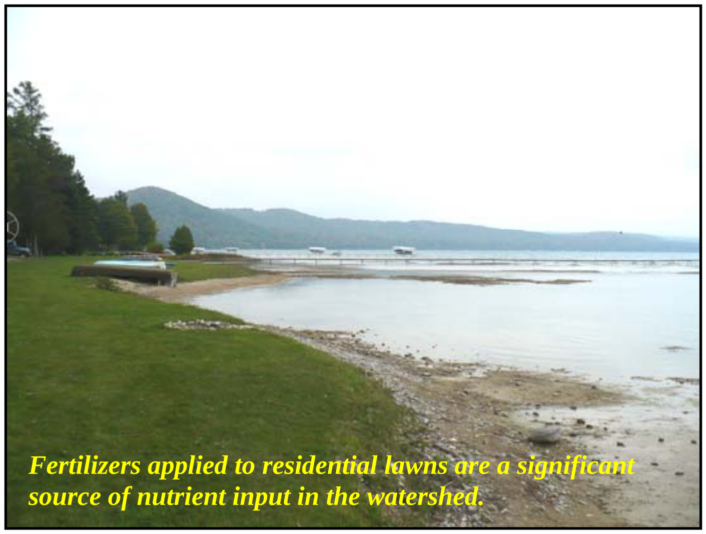
E.W.Litch
11/9/06

KEY

Moderately High: White Triangle
High: White Circle
Very High: Yellow Circle
Extremely High: Green Circle
Highest: Black Circle

Fertilizers

Fertilizers are a large source of nutrient input the watershed. Since P is most often the limiting nutrient in aquatic systems, P concentrations in fertilizers have a dramatic impact in the watershed. While no detailed studies involving nutrient runoff from lawns are available for the GL-CR watershed, information from lawn studies done in Wisconsin indicate a large amount of P in the water stemming from fertilizer use. One study conducted in an urban area reported that lawns accounted for 24% of runoff volume, but 56-70% of P exports (Waschbusch et al. 1999). Another study conducted on a lake with 70% of its shoreline developed with lawns mowed to the water's edge reported that lakeshore lawn drainage area provided just 4% of the water inflow to the lake, but comprised 51% of the total P input (Garn 2002). The same study measured total P concentrations in runoff for different fertilizer categories (no fertilizer, no-P fertilizer, and regular fertilizer) and found that total P concentrations in runoff from lawn sites with the no-P fertilizer applications were similar to that of unfertilized sites (Garn 2002). This indicates that no-P fertilizer use may be an effective, low-cost practice for reducing P in runoff.

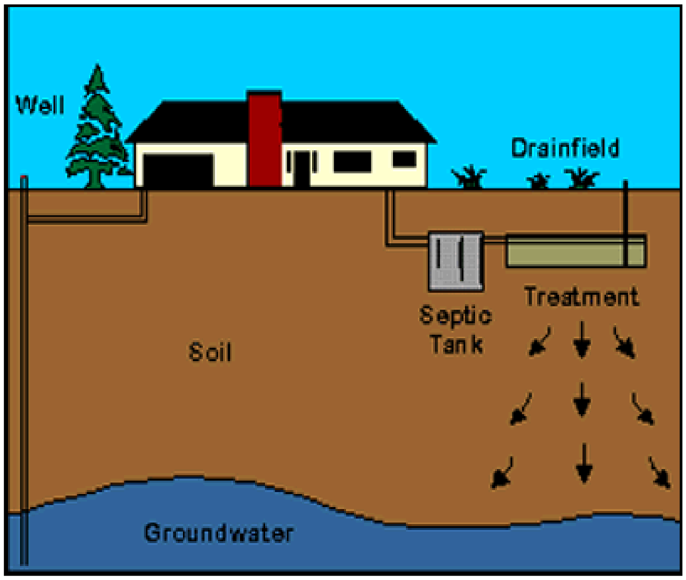


Fertilizers applied to residential lawns are a significant source of nutrient input in the watershed.

Septic Systems

Another potential source of nutrient enrichment in the GL-CR watershed is from septic systems. Septic systems are used to treat and discharge wastewater from toilets, wash basins, bathtubs, washing machines, and other water-consumptive items, many of which can be source of high pollutant loads. They are particularly common in rural or large lot settings, where centralized wastewater treatment systems are not economical. Nationally, one out of every four homes uses some form of septic system, with a combined discharge of over one trillions gallons of waste each year to subsurface and surface waters (NSFC 1995). There is no municipal sewer service in any portion of the watershed, and most likely every housing unit along Glen Lake and the rest of the watershed is serviced by a septic system.

A failing septic system is considered to be one that discharges effluent with pollutant concentrations exceeding established water quality standards. Failure rates for septic systems typically range between one and five percent each year (De Walle 1981) but can be much higher in some regions (Schueler and Holland 2000, Article 123). According to data from the National Environmental Service Center's 1992 and 1998 summary of the status of onsite wastewater treatment systems in the United States, the septic system failure rate in Leelanau County is 1.14%. This means that of the total of 4,021 housing units in the four townships having portions in the watershed (2000 data, LC working paper 11), approximately 45 have septic systems that are currently failing. Identifying and eliminating these possible failing septic systems, especially ones located along Glen and Fisher Lakes, will help control contamination of ground and surface water supplies in the watershed from untreated wastewater discharges.



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

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

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

The effectiveness of septic systems at removing pollutants from wastewater varies depending on the type of system used and the conditions at the site. The fact is, even a properly operating septic system can release more than 10 pounds of N per year to the groundwater for each person using it (Septic System Fact Sheet – www.stormwatercenter.net). The average pollutant removal effectiveness for a conventional septic system is as follows: total suspended solids – 72%, biological oxygen demand – 45%, total nitrogen – 28%, and total phosphorus – 57% (USEPA 1993). This shows that even properly operating conventional septic systems have relatively low nutrient removal capability, and can be a cause of eutrophication in lakes and coastal areas. A 1991 soil study in the riparian areas surrounding Glen Lake indicated that the majority of them are capable of immobilizing P from septic effluent for the foreseeable future (Keilty 1992). However, caution should be taken with this statement as it is now over 15 years later and it doesn't take into account failing or improperly operating septic systems.

A study on Glen Lake study in 1992 estimated that no more than 10% of the total P load to Glen Lake each year was attributed to cultural influence, mainly from septic system effluent (Keilty 1992). While the bulk of P entering the GL-CR watershed is from atmospheric deposition (Table 10), which cannot be impacted by local change, reducing the amount of P and N entering from cultural sources (i.e., surface and subsurface groundwater inputs) can only help the watershed to stay in its current low-nutrient status. Although there has been significant development along lakeshore areas of the watershed since the 1992 study, increasing potential P loading from other sources in addition to septic systems, septic system effluent still remains a concern for the entire watershed area.

Typical Impacts from Excessive Nutrients

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

Impact #2: *Decomposition of algae and weeds removes oxygen from lakes, harming aquatic life and reducing the recreational and commercial fishery. The excess aquatic plant growth resulting from excess nutrients also results in further oxygen depletion during the plant dark phase respiration period.*

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

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

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

Invasive and Nuisance Species

Invasive species (also called exotic or non-native species) have threatened the Great Lakes ever since Europeans settled in the region. Exotic species are organisms that are introduced into areas where they are not native. While many exotic species are introduced accidentally, others are intentionally released, often to enhance recreational opportunities such as sport fishing. The Pacific salmon, which was purposely stocked in the Great Lakes, is an exotic species, but they are not a "nuisance" species. Species are considered a nuisance when they disrupt native species populations and threaten the ecology of an ecosystem as well as causing damage to local industry and commerce. Without pressure from the competitors, parasites, and pathogens that normally keep their numbers in check, invasive species may undergo large population increases.

Stowing away on boat hulls and in bilges is the primary way many invasive species are introduced into a new ecosystem. Other ways of introduction include landscaping practices and lack of awareness by homeowners of the threat (this is how purple loosestrife was introduced to Michigan) and hitching a ride on other biota like frogs and birds.

Invasive species are becoming problematic throughout Michigan's inland lakes as well. Many of these species exhibit vast increases in numbers following their introduction, or following changes in the environment. Exotic species can affect the watershed in many ways. Zebra mussels and Eurasian watermilfoil influence the overall water quality and stability along with recreational use. Zebra mussels also alter the amount of available P by concentrating it on lake bottoms. As shown in both Lake Leelanau and Little Traverse Lake (two nearby lakes), this increase in P may subsequently result in toxic cyanobacterial (blue-green algae) blooms at the height of the recreational season (Keilty and Woller 2004).

The only current documented aquatic invasive species in the GL-CR watershed are the zebra mussel and curly leaf pondweed. Other invasive species like the quagga mussel, rusty crayfish, round goby, ruffe, fishhook water flea, spiny water flea, Eurasian watermilfoil, and Hydrilla have not yet been spotted in Glen Lake or its watershed. The GLA conducts periodic monitoring on the lake to document and note the presence of any new invasive species.

Zebra mussels out-compete many native species in Glen Lake. For example, the native clams of Glen Lake are one of the principal contributors to high water quality and face near to complete mortality in the presence of zebra mussels. Because of the serious impacts of zebra mussels and the threat they present to the water quality of Glen Lake, the GLA encourages watershed users to help keep stop the spread of this invasive species to other portions of the lake without established populations. Boaters should take advantage of the boatwash facility, located at the Glen Lake Public Boat Launch, to minimize the spread of zebra mussels.

Nuisance species may cause problems for inland lakes as well. They may be native to the region, but, in the presence of certain types of water conditions grow at extremely high rates and cause problems. A prime example of a nuisance species is Cladophora, a branching, bushy-like alga that has recently become problematic in Lake Michigan. (See further discussion on Cladophora in Nutrients section above.)

Typical Impacts from Invasive Species

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

Impact #2: *Introduction of a single key species can cause a sudden and dramatic shift in the entire ecosystem's structure. New species can significantly change the interactions between existing species, creating ecosystems that are unstable and unpredictable. (Example: Established populations of zebra mussels promote toxic blue-green algal blooms.)*

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

Sediment

Sediment (soil, sand, etc.) carried into the stream buries fish and macroinvertebrate habitat and causes the river to get shallower and wider. The increased width and shallower depth increases the overall water temperature of the river. As fish and macroinvertebrates are sensitive to temperature changes, this sedimentation results in further degradation of habitat and animal populations.

Sediment is fine inorganic soil or sand particles and sedimentation is the process whereby sediment is deposited in a stream or lake bottom. It occurs naturally in all stream and lake environments due to land erosion by wind and water. However, excessive sedimentation can severely degrade an entire riparian system (Waters 1995) and has been identified as a major cause of degradation to aquatic life in many Michigan streams and rivers (DEQ 1998). Excessive sediment deposition in many of Michigan's streams also severely impacts the amount of suitable habitat needed to support healthy and diverse communities of fish and fish food organisms. When sediment enters a stream it covers gravel, rocky, and woody habitat areas, thereby leading to decreases in habitat diversity and aquatic plant production. Sedimentation caused by streambank erosion may increase channel widening. The increased width and resulting shallower depth increases the overall water temperature of the river. Because fish and aquatic insects are sensitive to temperature changes, this sedimentation results in further degradation of habitat and animal populations.

Sediment is identified as a high priority pollutant in the GL-CR watershed, particularly in the Crystal River and Hatlem Creek, based on field inspections and inventories conducted throughout the watershed. Significant sources of sediment to Crystal River and Hatlem Creek include activities that cause streambank erosion such as road/stream crossings, increased flow levels (rapidly changing stream levels), boat traffic, removing streamside vegetation, and heavy recreational use at poorly designed access sites (Table 17). A suspected significant source of sediment in Hatlem Creek is heavy logging taking place west of Plowman Road.

Another source of sediment in the GL-CR watershed is the clearing of land for construction, development, or other purposes. This creates a host of other erosion related problems including flooding, polluted runoff, loss of topsoil from surface runoff, and a reduction in fisheries and channel depth. Any kind of excavation, earth moving, drainage, bridging, tunneling, or other activity in which soil is disturbed can result in sediment transport to nearby streams. Alexander and Hansen (1988) report that increases in sediment erosion from development are detrimental to aquatic communities. Increased sediment loads also will continue past the development construction phase due to the resulting increase in stormwater runoff from the newly created impervious surfaces. Roads, rooftops, and parking lots are examples of impervious surfaces that replace rural and forestland during development. Development results in decreased water-retention capacities, increased flood frequencies, and rapid filling of stormwater detention systems.

A May 2007 road/stream crossing survey shows that there are at least 14 road stream crossings in the GL-CR watershed; 7 on the Crystal River and 7 on Hatlem Creek (Appendix A). There are possibly many other crossings where groundwater seeps cross roads surrounding Glen and Fisher Lakes that are not documented so far. Of the total 14 road crossings in the watershed none of them are currently ranked as having severe erosion (Figure 9). Crystal River has 5 moderate and 2 minor crossings. Hatlem Creek also has 5 moderate and 2 minor crossings (in addition to other small, undocumented crossings). Most problems at road crossings in the watershed stem from erosion around the culvert openings and failing/eroding retaining walls. Of the 10 moderately ranked sites, the Crystal River crossings at County Road 675 (in SLBE) and the Homestead Resort are the top concerns, due to failing retaining walls, misaligned culverts, altered hydrological flow due to debris, road/bank slumping, and shoulder/ditch erosion.

Since the Crystal River is heavily used for canoeing, erosion stemming from recreational access sites at roadways (portage sites) is of concern as well. Currently, three canoe portage sites on County Road 675 where Crystal River criss-crosses the road are of concern and should be improved to reduce erosion occurring at these sites. Additionally, there is a private road crossing in the Homestead Resort where canoe portage improvements could be made.

Depending on the severity and number of erosion sites and road stream crossings, a significant amount of sediment, and, subsequently, phosphorus (P) and nitrogen (N) may be released into river systems. Sediment erosion estimates for road crossings in the GL-CR watershed were not readily available. However, erosion estimates for road crossings in other portions of Leelanau County were available from the Grand Traverse Bay Watershed Protection Plan (TWC 2005). Using erosion estimates for similar 'moderate' rated crossings in Leelanau County is was estimated that in the GL-CR watershed moderate erosion sites contribute at least 30 cubic yards of sediment each year, in addition to more than 42 lbs of P and 84 lbs of N (Table 22). Sediment contributions for 'minor' rated sites are negligible (TWC 2005).

TABLE 22: ROAD STREAM CROSSING EROSION ANALYSIS

Survey Type	Average Erosion for Severity Type	# of Each Type	Soil Loss/yr	Phosphorus Load/yr	Nitrogen Load/yr
Crystal River	Severe: 10 yd^3/yr	0	0 tons	0 lb	0 lb
	Moderate: 3 yd^3/yr	5	15 yd^3	21 lb	42 lb
	Minor: Negligible	2	Negligible	Negligible	Negligible
Hatlem Creek	Severe: 10 yd^3/yr	0	0 tons	0 lb	0 lb
	Moderate: 3 yd^3/yr	5	15 yd^3	21 lb	42 lb
	Minor: Negligible	2	Negligible	Negligible	Negligible

Calculations used for road stream crossings erosion table:

1 yd^3 soil = 2800 lbs, 0.0005 lb P/1 lb soil, 0.001 lb N/1 lb soil

Calculations used to determine phosphorus and nitrogen load for Table 22 were taken from the MDEQ Pollutants Controlled Manual (DEQ 1999). More discussion regarding calculating streambank and shoreline erosion, as well as phosphorus and nitrogen loads is in Section 7.2.

A detailed streambank erosion inventory has not yet been conducted for the watershed. Conversations with representatives from local agencies and access groups reveal no known major erosion sites of priority. However, a streambank inventory along Crystal River and Hatlem Creek should be conducted by 2011.

Typical Impacts from Sedimentation

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

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

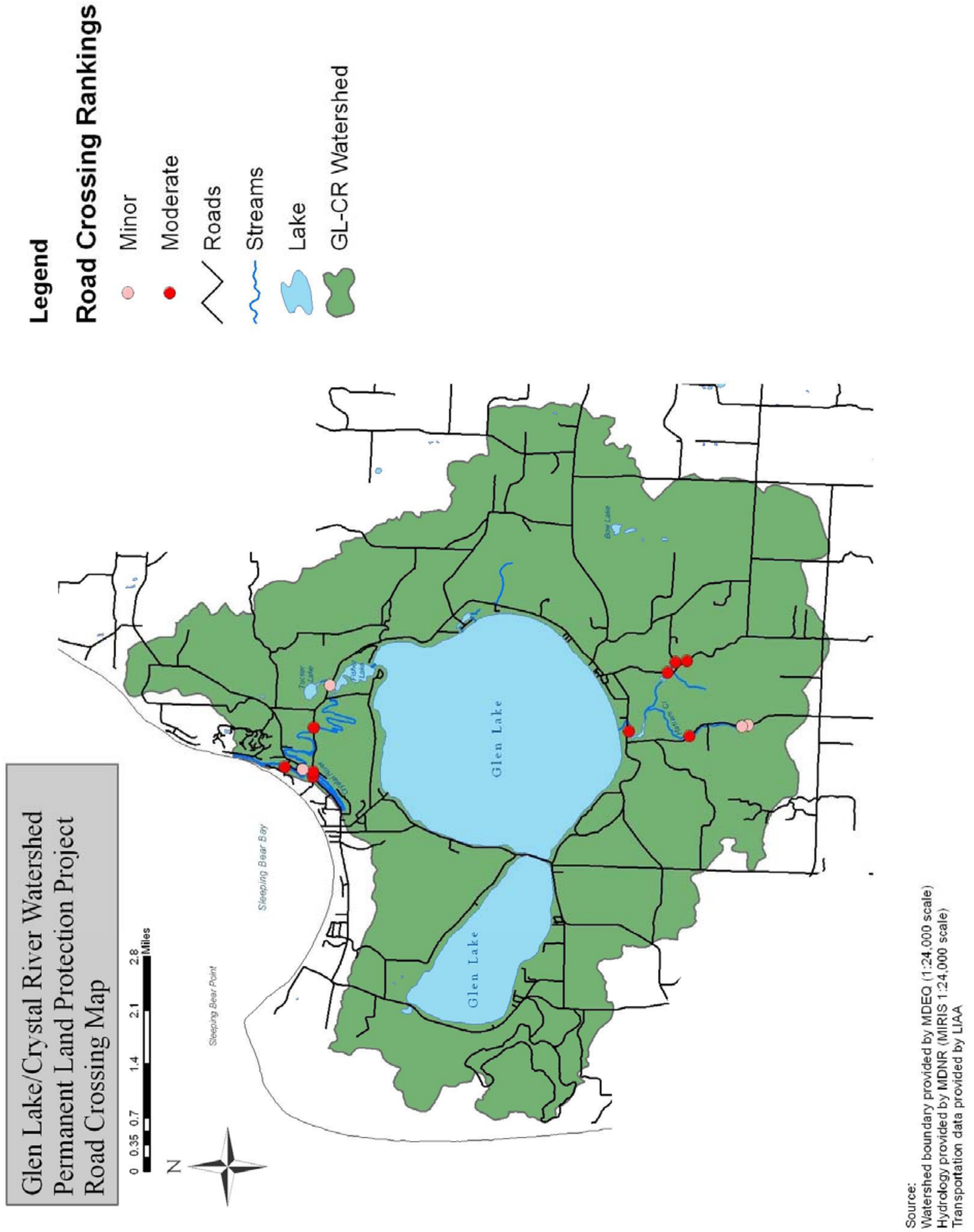
Impact #3: *When more sand and sediment is deposited than can be moved by stream flow, water levels are raised, causing streambank erosion and potential flooding. Excessive sedimentation may also fill lakes, ponds, and wetlands.*

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

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

Impact #6: *Sediment accumulation decreases stream depth, and increase stream width, thereby causing the water temperature to rise.*

FIGURE 9: ROAD STREAM CROSSING RANKINGS



Pathogens

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

Fecal pollution entering the GL-CR watershed may come from stormwater runoff, animals on the land or in the water, illegal sewage discharge from boats, or leaking septic systems. Different sources of fecal pollution may carry different pathogens. Peak *E. coli* concentrations often occur during high flow periods when floodwater is washing away possible contaminants along streambanks and shorelines from waterfowl like ducks and geese.

The only regularly tested location for *E. coli* on Glen Lake is at the Little Glen Lake public access in SLBE. This location is tested by the National Park Service and has not had any high *E. coli* counts since 2004. The Park Service changed management measures at this public access spot in 2005 and let the shoreline vegetation grow higher and denser. This resulted in decreased geese/duck congregation at the shoreline and, subsequently, *E. coli* numbers have decreased and they have not had to close the beach since.

Another source of possible *E. coli* contamination is from improperly functioning septic systems. There is no sewer system around Glen Lake or in any of the watershed area; all homes located in the watershed use septic systems to treat their wastewater. Due to the unknown nature of groundwater flow in some watershed areas and the relatively random location of septic systems, it is very difficult to accurately assess their impact to the watershed. Failing septic systems are a potential source of contamination, especially along the lakeshore where there is a high density of residential development using septic systems. Three locations on Hatlem Creek are tested for *E.Coli* by the GLA, one of which has elevated levels (first order tributary on Plowman Road). Additionally, the GLA tested the mouth of Hatlem Creek after a rain event in 2008 and found extremely high levels of *E.Coli* (above detection limits); testing done a week later in dry conditions showed 44 col/100mL. Improperly functioning septic systems could be the cause of these elevated *E.Coli* levels, however, more testing still needs to be completed.

Typical Impacts from Pathogens

Impact #1: *High levels of pathogens in the water pose a threat to human health and reduce the recreational value of the lake, thereby degrading use and enjoyment of the watershed.*

Habitat Loss

All plants and animals require specific environmental conditions, or habitat, to live and reproduce. Healthy biological communities are diverse, containing numerous kinds of habitat that support unique species of plants, animals, fungi, etc. This diversity makes them stable, and flexible, thereby allowing the community to adapt when the environment changes. As habitat is lost, so are the species that require it.

The population of Leelanau County ballooned by 28% from 1990 to 2000 (U.S. Census). Residential development fragments the panoramic views of forested ridgelines and pristine river corridor that traditionally have enchanted visitors and residents alike. In addition to the development of the few remaining vacant parcels, three other trends have altered wildlife habitat and the surrounding viewshed: conversion of seasonal to year-round homes; replacement of smaller, aging cottages with larger homes; and development of view lots on the ridges overlooking the watershed.

Typical Impacts from Habitat Loss

Impact #1: *Extinction and extirpation of native species.*

Impact # 2: *Habitat fragmentation, increase of edge effect*

Impact #3: *Loss of overall biological community stability and function.*

Impact #4: *Reducing the scenic magnitude of the Glen Lake-Crystal River Watershed strikes at the heart of the region's attraction and draw for over a million annual tourists and residents.*

Thermal Pollution

Not normally thought of as a pollutant, increased water temperatures can potentially wreak havoc on a watershed system. Thermal pollution increases the temperature of a body of water, and even small increases in temperature can dramatically alter natural processes. Water's ability to hold dissolved oxygen decreases as temperature increases; thereby reducing the available amount of oxygen in the water to fish and other aquatic life. Temperature also influences the rate of physical and physiological reactions such as enzyme activity, mobility of gases, diffusion, and osmosis in aquatic organisms. For most fish, body temperature will be almost precisely the temperature of the water. So, as water temperature increases, a fish's body temperature increases, and this then changes their metabolic rate and other physical or chemical processes as well. When thermal stress occurs, fish cannot efficiently meet their energetic demands (Diana 1995). Optimal water temperatures for trout are in the 59-68oF range or even below. The lethal temperature for instance is 75^{o}F for Brook trout, 77^{o}F for Brown trout, and 75-86^{o}F for Rainbow trout depending upon the species.

By far, the greatest amount of thermal pollution in the CL-CR watershed occurs along the Crystal River directly downstream from the dam located at the outlet of Fisher Lake. There is no doubt that water temperatures in the Crystal River downstream from the dam are elevated at certain times of the year (Table 23).

TABLE 23: AVERAGE MONTHLY WATER TEMPERATURES IN CRYSTAL RIVER (OCTOBER 2004 – SEPTEMBER 2005)*

Year	Month	Monthly Mean Temp (°C)	Monthly Mean Temp (°F)
2004	October	12.2	54
2004	November	7.1	44.8
2004	December	1.9	35.4
2005	January	0.4	32.7
2005	February	0.6	33.1
2005	March	1.1	34
2005	April	8.5	47.3
2005	May	13.5	56.3
2005	June	22.5**	72.5**
2005	July	24.1**	75.4**
2005	August	23.3**	73.9**
2005	September	20.2	68.4

**Data obtained from USGS gauging station 04126802 – Crystal River @ CO 675 near Glen Arbor*
***Indicate water temperatures potentially harmful to trout growth.*

Crystal River experiences wide temperature fluctuations in warm summer months that may be harmful to coldwater trout populations. In Summer 2005, water temperatures in the river spiked to harmful, and near lethal in July, conditions for trout. Concerns for these fish and other aquatic life arise when the outflow of the dam is reduced during summer months to hold water in Glen Lake, which may drastically reduce water levels in the Crystal River. These shallower river-water levels, combined with warmed lake-water flowing over the dam, cause water temperatures to rise dramatically and reach dangerous levels for trout. The lower water levels in summer also result in some sections of the river, previously underwater, to be completely dewatered and have steelhead, trout, and salmon spawning beds completely exposed.

The USGS recently completed a study in September 2007 along the Crystal River to try and determine the optimum flow rate for the river during different seasons. This study also took into account the effects on fish and other river biota as well as the effect recreation has on the river substrate at different times of the year (Nichols et. al 2007). See the Crystal River Dam portion of Section 3.7 on Hydrology and Groundwater for an in-depth discussion of the USGS research results. Additionally, the GLA and other partner organizations have developed a water release system/schedule to minimize the chance of thermal pollution of the Crystal River from the Dam on Fisher Lake in order to protect fish and other aquatic life, while still allowing recreational users to enjoy both the Lake and the River. This system is continually monitored and reviewed for improvement opportunities. If the Dam is set such that too little flow results in shallow river conditions the water temperatures may rise excessively.

Other sources of thermal pollution in the GL-CR watershed are heated stormwater runoff from paved surfaces, the removal of shade vegetation along streambanks and shorelines, and undersized culverts at road stream crossings that create warm pools of retained water upstream, coupled with low flows and shallow pool depth below. Excessive inputs of sediment into streams and lakes may also contribute to thermal pollution. Sediment inputs can fill stream pools and lakes, making them shallower and wider and, consequently, more susceptible to warming from solar radiation. Thermal pollution also occurs in the watershed through solar warming of stagnant pond water (such as Tucker Lake).

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

Typical Impacts from Thermal Pollution

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

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

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

Impact #4: *Excess algae and aquatic plants thrive in warmer waters.*

Impact #5: *Human made impoundments increase stream temperatures creating lethal conditions for cold water species such as brook trout.*

Toxins

Toxic substances such as pesticides, herbicides, oils, gas, grease, and metals often enter waterways unnoticed via stormwater runoff. These types of toxins are perhaps the most threatening of all the watershed pollutants because of their potential to affect human and aquatic health. It is highly probably that at any given moment, somewhere in the watershed there is a leaking automobile radiator, a landowner applying herbicides or pesticides to their lawns, or someone spilling gasoline while filling up their car. Every time it rains, these toxic pollutants are washed from the roads, parking lots, driveways, and lawns into the nearest storm drain or road ditch, eventually reaching nearby lakes and streams. Additionally, farms, businesses, and homes throughout the watershed are potential sites of groundwater contamination from improperly disposed and stored pesticides, solvents, oils, and chemicals. Stormwater runoff from impervious surfaces can also carry oils directly into surface waters or wash them into groundwater recharge basins.

Traditionally speaking, toxic substances such as mercury and other heavy metals have been regarded as the most serious due to their human health impacts. As fossil fuels burn, chemicals are released into the atmosphere. When rain falls through the clouds, it carries these suspended chemicals to the surface water along with the gaseous state of airborne PCBs, via runoff that eventually flows into receiving lakes and streams. In addition to transporting airborne pollutants and chlordane, which was used as a pesticide until 1983 when it was outlawed and yet remains in the soil, surface runoff can also leach these toxic compounds that have accumulated in soil or on impervious surfaces, such as roads, into streams and lakes. The Michigan Department of Health has issued a consumption warning for fish in Glen Lake as a result of high chlordane, mercury and PCB (polychlorinated biphenyl) concentrations. The toxins bioaccumulate through the foodweb, and therefore the oldest higher vertebrates, in this case fish, contain the greatest concentrations. Such toxins can cause severe human health risks and consumption warnings should be followed.

In addition to the substances noted above, other potentially toxic substances in the GL-CR watershed include copper and sodium chloride. Copper sulfate has historically been used as a treatment method for swimmer's itch, and can accumulate in sediments and lead to mutations and even death in aquatic animals. High concentrations of copper can pose serious human heath risks. At the present time the use of copper sulfate has been discouraged because merganser duck control is being used to control swimmer's itch. In recent past however, a group of riparians did apply copper sulfate. This event caused great concern to several adjacent riparian owners. A swimmer on a nearby property suffered significant eye irritation. Local authorities were called to determine the cause, being alerted by this and the change in water color. Sodium chloride enters the watershed primarily as a result of road salt application in the winter and subsequent runoff in the winter and spring.

A Word About Microcystis

An emerging issue with a potential threat to Glen Lake is recent research by the Leelanau Watershed Council (LWC) that supports previous evidence linking zebra mussel densities and filtering capacities to peak, observed concentrations of *Microcystis aeruginosa*, a potentially toxic bacteria, in nearby Lake Leelanau and Little Traverse Lake (Keilty and Woller 2004).

Microcystis is a type of bacteria called 'cyanobacteria' that naturally occurs in most lakes at low concentrations. This organism forms small colonies that look like floating yellowish-green pollen or sand grains. At high populations, wind can push the colonies toward shore, forming a very dense blanket. Although *Microcystis* is present in most lakes, it is rarely noticeable. In recent years, though, some lakes have experienced much higher than normal concentrations.

There is much speculation in the scientific community about why this is occurring, but one of the suspected culprits is invasion by zebra mussels, a non-native pest that was introduced to the Great Lakes region in the early 1980s. These thumbnail-size mussels filter and digest large quantities of algae, but appear to "spit out" *Microcystis*. With competing algae reduced, *Microcystis* may build to greater concentrations than normal (Kellogg Biological Station website: www.kbs.msu.edu/extension/microcystis/INDEX.HTM).

Microcystis can produce natural toxins, called microcystins, which can be harmful to wildlife and humans. Studies indicate that the toxin can kill wildlife if a sufficient quantity is ingested, and can cause liver damage in animals if smaller quantities are eaten over a long period of time. The effects on humans are not known, however there are some reports of individuals developing gastrointestinal distress after exposure to dense accumulations of *Microcystis*. It normally does not pose any health risk to humans, pets or wildlife. Only when unusually large blooms occur does the potential exist for enough toxin to be produced to cause a problem. Furthermore, *Microcystis* blooms may or may not produce toxin. When the bloom dies off and dissipates, toxin levels in the water decline over days or weeks (Kellogg Biological Station website: www.kbs.msu.edu/extension/microcystis/INDEX.HTM).

Measured microcystin concentrations in Big and Little Glen Lakes in 2004 were below World Health Organization drinking water guidelines of 1μg/L with Big Glen averaging 0.0046 μg/L and Little Glen averaging 0.0755 μg/L (Keilty and Woller 2004). The GLA has actively been following this research and conducted a *Microcystis* sampling project on Glen Lake in Summer 2006 (results not available at the time this was written) to monitor levels in the lake.

Typical Impacts from Toxins

Impact #1: *Toxic chemicals entering waterbodies harm stream life, potentially causing entire reaches of a stream to be killed off if the concentrations of contaminants are high enough. Lower level continuous toxin concentrations can be even more lethal than a one time spill. Additionally, reproductive processes may be harmed.*

Impact #2: *Persistent toxic pollution in a stream may put human health and recreation at risk. Serious human health risks include liver failure, kidney disease, and cancer.*

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

Changes to Hydrologic Flow

Sometimes excessive hydrologic flow in a watershed system may cause problems. The term hydrologic flow encompasses all the factors affecting the stream flow and discharge in a watershed. By far, the most notable and significant alteration in hydrologic flow in the GL-CR watershed is from the Crystal River Dam. Surges of water from dam may cause peak stream flows in the Crystal River to increase, leading to unstable bottom substrates and sedimentation which destroys aquatic habitats and may cause property damage (while also changing stream hydrology further). Concerns for fish and other aquatic life arise when the outflow of the dam is reduced during summer months to hold water in Glen Lake, which may drastically reduce water levels in the Crystal River. Besides effects from thermal pollution (see previous section on Thermal Pollution), lower water levels in summer also result in some sections of the river, previously underwater, to be completely dewatered, leaving steelhead, trout, and salmon spawning beds completely exposed. Conversely, increased shoreline erosion may occur in both Glen and Fisher Lakes by too much water being kept in – high lake levels can pose erosion problems in certain wind conditions, especially in spring when the ice starts to break up on the lake.

As stated earlier, the USGS and other agencies have conducted research along the Crystal River to try and determine the optimum flow rate for the river during different seasons. These studies also take into account the effects on fish and other river biota as well as the effect recreation has on the river substrate at different times of the year. Additionally, the GLA and other partner organizations are working continuously on a water release system/schedule to prevent thermal pollution and harmful effects of changing hydrologic flow to the Crystal River from the Dam on Fisher Lake in order to protect fish and other aquatic life, while still allowing recreational users to enjoy both the Lake and the River.

Other factors that may lead to fluctuations in hydrologic flow are caused by stormwater runoff (see Stormwater discussion in Section 5.5), excessive sedimentation, and channelization by road culverts. Changes in hydrologic flow may also be affected by the amount of groundwater recharge in the watershed. As more and more development paves over forests and fills wetlands, valuable recharge areas are cut off, and stream base flows may eventually be affected. Freshwater ecosystems have specific requirements in terms of the quantity, quality, and seasonality of their water supplies. In order for the system to be sustainable, it must fluctuate within a range of natural variation. If the quantity of the water flow through a system is disrupted, long-term sustainability within the system will be lost.

Typical Impacts from Changes to Hydrologic Flow

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

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

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

5.5 Special Sources of Concern: Stormwater, Lack of Riparian Buffer, and Master Plans and Zoning Ordinances

Stormwater

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

Road and roof runoff are two sources of stormwater. Photo Copyright 1999, Center for Watershed Protection

Residential subdivisions in the watershed produce greater amounts of stormwater flow due to the increased amount of impervious surfaces relative to more rural settings within the watershed. Impervious surfaces are those areas on land that cannot effectively absorb or infiltrate rainfall. Areas such as these may include: roads, streets, sidewalks, parking lots, driveways, and rooftops. Research suggests that there is a threshold to the amount of impervious cover that can occur within a watershed at which the degradation of aquatic systems occurs. Findings reveal that stream and lake degradation consistently occurs when impervious surface levels in a watershed reach between 10-20% (CWP 1994). Due to its large amount of forested and parkland area, impervious surface levels in the GL-CR watershed as a whole are nowhere near this threshold. However, there may be some instances of localized degradation from stormwater in residential subdivisions throughout the watershed along riparian areas. By far, the biggest stormwater problems in the watershed are runoff from residential lawns, driveways, rooftops, and roads, none of which go through a traditional stormwater conveyance system with a pipe outlet.

When added up, all these small inputs of stormwater can result in a significant amount of pollution entering the GL-CR watershed. Most often the pollution coming from stormwater runoff is at its worst during heavy rain and snowmelt events. Data from the Rouge River National Wet Weather Demonstration Project (Cave et al. 1994) in Southeast Michigan present the typical pollutant concentration in stormwater from various land uses (Table 24). As expected, developed land uses (such as residential and commercial) and impervious surfaces have noticeably higher concentrations of pollutants compared to forest and open spaces.

TABLE 24: TYPICAL STORMWATER POLLUTANT CONCENTRATIONS FROM LAND USES IN SOUTHEAST MICHIGAN

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

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

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

Stormwater can increase stream velocities and carry pollutants (like sediment) downstream.

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

Lack of Riparian Buffer

Riparian buffers are widely considered one of the best ways to control and reduce the amount of non-point source pollution entering a water body. Also called vegetated stream buffers, filter strips, or greenbelts, these buffers consist of strips of trees, shrubs, and other vegetation lining a stream corridor or lakefront. These linear strips of vegetation serve as a stream's last line of defense against human activities such as lawns, septic systems, erosion and development.

Riparian buffers help to reduce the impact of almost all of the pollutants that currently threaten the GL-CR watershed: sediment, nutrients, toxins, thermal pollution, pathogens, changes to hydrology, and loss of habitat.

Benefits of Riparian Buffers:

Stabilization of Streambanks – The deep rooted vegetation binds the soil along stream and lake banks, which prevents bank erosion during periods of high runoff.

Improved Water Quality – Trees, shrubs, and deep rooted grasses along waterfront remove sediment, nutrients, pesticides, pathogens, and other potential pollutants before they enter surface water. Fertilizers and other pollutants that originate on the land are taken up by tree roots and stored in leaves, limbs and roots of the vegetation instead of reaching the water. Studies have shown dramatic reductions of 30% to 98% in nutrients (nitrogen and phosphorus), sediment, pesticides, and other pollutants in surface and groundwater after passing through a riparian forest buffer (Chesapeake Bay Program website: www.chesapeakebay.net).

Reduced Flooding and Sedimentation – Trees and shrubs help to retain runoff longer, improve infiltration, and filter out sediment that might otherwise be delivered to the water during floods.

Reduction of Thermal Pollution (Stream Warming) – The canopy provided by the leaves of the vegetation provide shading to the stream, which moderates water temperatures and protects against rapid fluctuations that can harm stream health and reduce fish spawning and survival. Cool stream temperatures maintained by riparian vegetation are essential to the health of aquatic species. Elevated temperatures also accelerate algae growth and reduce the amount of dissolved oxygen the water can hold, further degrading water quality. In a small stream, temperatures may rise 1.5 degrees in just 100 feet of exposure without a leaf canopy. The leaf canopy also improves air quality by filtering dust from wind erosion and construction.

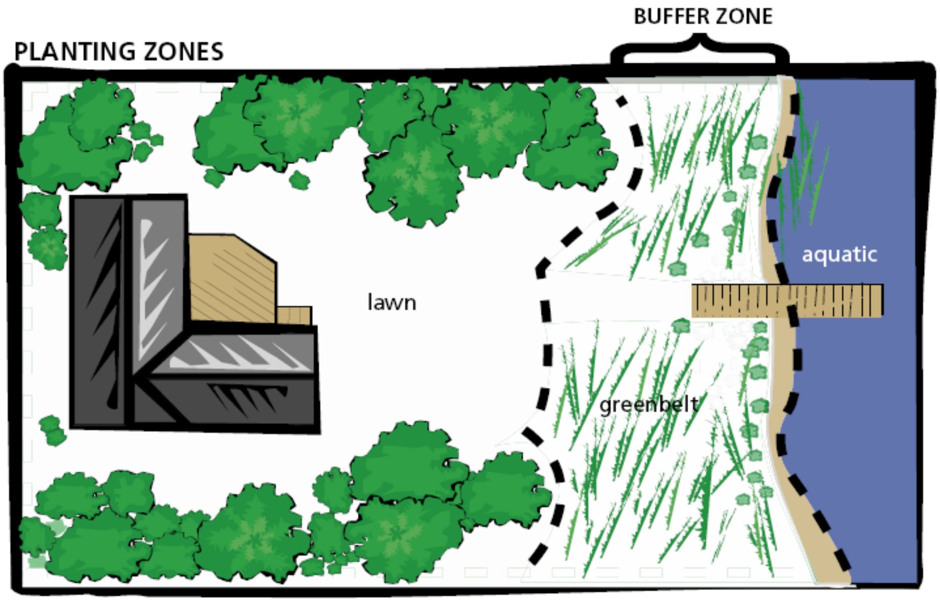
Enhanced Wildlife Habitat – The trees and shrubs contained in a riparian buffer supply a tremendous diversity of habitat and travel corridors for many wildlife species in both the aquatic and upland areas. Travel corridors are particularly important where habitat is limited. In addition, woody debris (fallen trees and limbs) in the stream and along the lakeshore provides both habitat and cover for fish and other macroinvertebrate species. Leaves that fall into a stream are trapped on woody debris and rocks where they provide food and habitat for small bottom-dwelling creatures (i.e. crustaceans, amphibians, insects and small fish), which are critical to the aquatic food chain.

Improved Scenery (Desired Uses) – Strips of trees and shrubs along waterfront add diversity and beauty to the landscape.

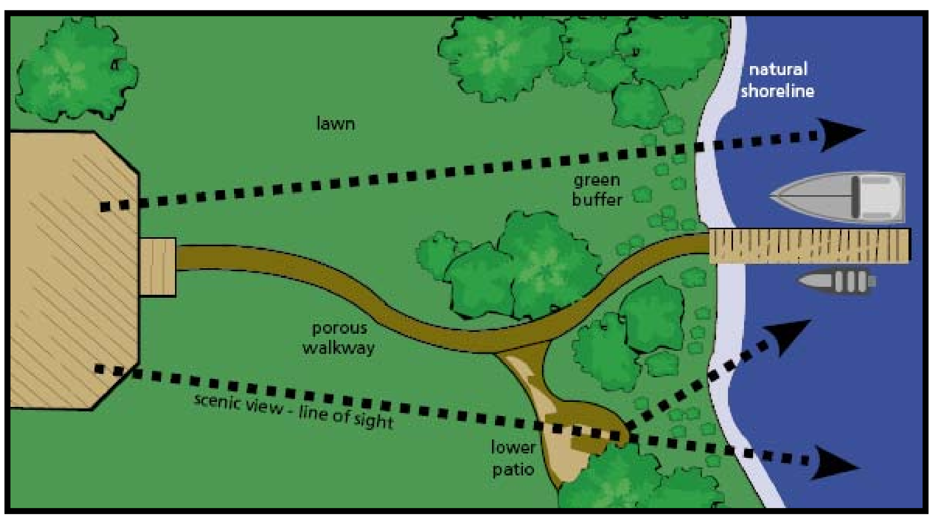
Riparian buffers vary in character, effectiveness, and size based on the environmental setting, proposed management, level of protection desired and landowner objectives. To protect water quality, a buffer at least 55 – 100 feet wide should be preserved or created around all bodies of water and wetlands, with strip widths increasing with increasing slope. Research shows that when the buffer is less than 100 feet, stream quality begins to diminish (DEQ 2001).

Streamside and lakeshore areas lacking a riparian buffer have a reduced filtering capacity and do not effectively filter out watershed pollutants. While the lack of a riparian buffer along a stream or lakefront does not *add* any pollutants to the watershed and is technically not a *source* of pollution, the lack of a buffer significantly increases the possibility of pollutants reaching a body of water. The actual sources of the pollution are coming from another place and the buffer only reduces their effects on the watershed. For the purposes of this management plan, the lack of a riparian buffer (and streamside canopy) is referred to as a source of pollution and environmental stress in the watershed, with the general understanding that increases in the amounts of riparian buffers will decrease the amount of various pollutants entering the watershed.

While there are two stream systems in the GL-CR watershed, Hatlem Creek and Crystal River, the more critical area that needs to be considered for buffer zones are the lakes-Little and Big Glen, Fisher and Brooks Lakes. It is an area where GLA has in the past successfully worked hard with riparian landowners on designing and implementing buffer zones.



The figures shown here are conceptual drawings of a lakefront buffer zone taken from The Watershed Center Grand Traverse Bay's *Living on an Inland Sea* shoreline landowner's guide.



Most riparian buffers are composed of three zones, the width of each determined by site conditions and landowner objectives. This three-zone concept provides a conceptual framework in which water quality, habitat, and landowner objectives can be accomplished. The picture and accompanying text below describes the components of each zone.

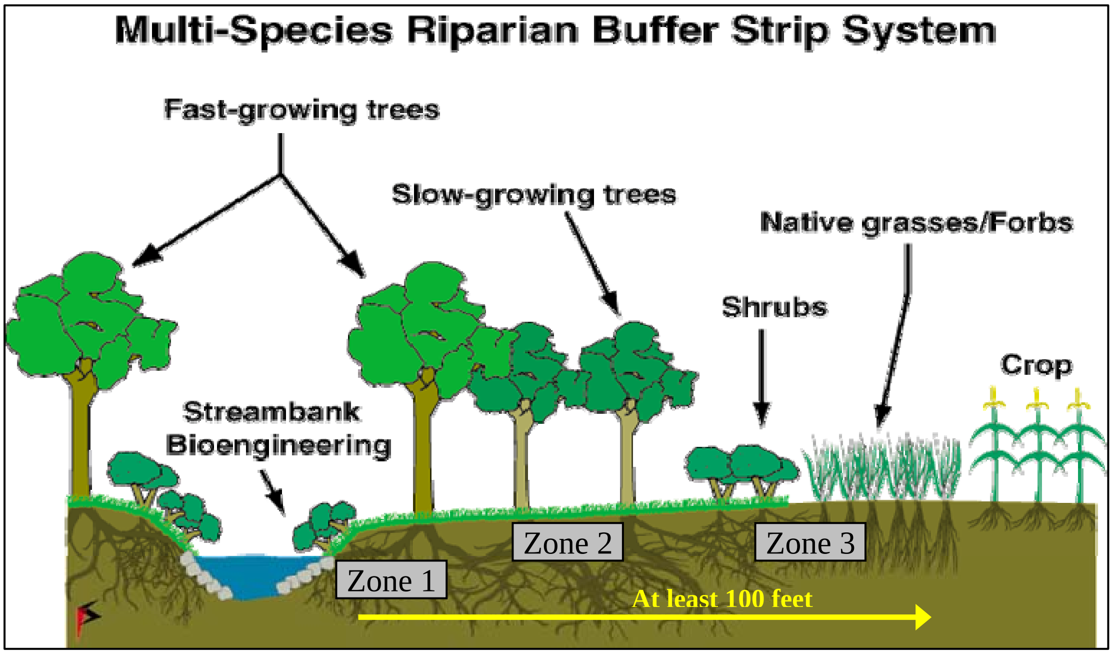


Illustration courtesy of the ISU Forestry Extension Website

<u>Zone Description from the DEQ's Guidebook of Best Management Practices for Michigan Watersheds & the USDA – NRCS website (www.mi.nrcs.usda.gov):</u>

<u>Zone 1 – The Streamside Zone:</u> This zone is usually made up of mature trees and shrubs that provide shade, leaf litter, and woody debris to the stream, as well as erosion protections. The minimum width of this zone is 15 – 25 feet. Land uses in this zone should be limited to footpaths and well-designed watercourse crossings (for utilities, roads, etc.). The mature forest along the edge of the water maintains habitat, food, and water temperature and helps to stabilize streambanks, reduce flood impact, and remove nutrients.

<u>Zone 2 – The Middle Zone:</u> This zone extends from the outer edge of the streamside zone and protects the stream's ecosystem by providing a larger protective area between the stream and upland development. Ideally, this zone will also be composed of mature trees and shrubs and will be between 20 – 50 feet, with widths increasing to ensure the 100-year floodplain. A primary function of Zone 2 is to filter runoff by removing sediment, nutrients and other pollutants from surface and groundwater.

<u>Zone 3 – The Outer Zone:</u> The outer zone extends from Zone 2 to the nearest permanent structure and is composed of grass and other herbaceous cover. This is the main filtering part of the riparian buffer strip. The vegetation included in this zone is useful in spreading and filtering runoff that may be transporting sediment, nutrients, or pesticides.

Master Plans and Zoning Ordinances

While not necessarily a direct source of pollution, local governments' master plans and zoning ordinances have great potential to affect water quality. Zoning ordinances primarily affect land development in a region and are related to site design and access. They are used to regulate permitted uses of the land, for example, setting minimum/maximum lot sizes and setback requirements (from neighbors, roads, water bodies). Overall, zoning ordinances are enacted to protect the use of a property and ensure the public's safety, health, and welfare. As stated in Section 3.3, how communities manage their land use has a direct impact on the community's water resources. Since protecting water quality requires looking at what happens on land, zoning can be an extremely important watershed management tool.

Examples of ways to utilize zoning to protect water quality include requiring vegetative buffer zones along bodies of water (see earlier section on Lack of Riparian Buffer), requiring greenbelt areas, protecting the integrity of soil by having filtered views along stream corridors (protects banks from erosion), or protecting wetlands. Both Garfield and East Bay Townships located in nearby Grand Traverse County have recently passed ordinances requiring riparian buffers along their waterways.

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

Local governance can be a complicated issue. Generally, local governments may enact zoning laws that are more stringent than the next highest ranking form of government, but not less. In any case, all applicable State laws must be followed. All townships located in the GL-CR watershed have both a Master Plan and Zoning Ordinances, while Leelanau County does not have a county-wide zoning ordinance (Table 25).

TABLE 25: MASTER PLAN AND ZONING ORDINANCE STATUS SUMMARY FOR LOCAL GOVERNMENTS IN WATERSHED

Township	Master Plan	Zoning
Glen Arbor	Y (2005)	Y (revisions thru 2005)
Empire	Y (2005)	Y
Kasson	Y (2004)	Y (1997, amendments thru 2001)
Cleveland	Y (2002)	Y (updating in 2006)
Leelanau County	Y	N

Time did not permit for a review and summary of master plans and zoning ordinances for this management plan. However, for the most part, community master plans usually have good intentions when it comes to protecting natural resources. The natural resources of this area are why most people choose to live in the Glen Lake region. In general however, townships and communities often lack the knowledge on how to draft and enact effective, yet enforceable, zoning requirements. The validity of a zoning ordinance, particularly those that are more restrictive is often challenged by developers, among others. Local governments may have trouble obtaining information to back up their ordinances that will stand up in court. Additionally, it is often an argument of property rights vs. the public good, with local governments trying to show and prove that a certain ordinance is important to protect water quality.

Soil Erosion and Stormwater Ordinances

It is important to note that, in addition to zoning ordinances, counties and townships have separate soil erosion and/or stormwater ordinances outlined in Leelanau County's Soil Erosion, Sedimentation, and Stormwater Runoff Control Ordinance. These ordinances come under different state enabling acts than local zoning ordinances. So, even if a township or municipality in the County does not have zoning, they still have to follow soil erosion and stormwater regulations put forth by Leelanau County. These soil erosion and stormwater ordinances are extremely valuable tools in protecting water quality. It is also important to note that there are existing State and Federal statutes regarding soil erosion and stormwater runoff that must be followed as well.

Tough Choices

Local officials face hard choices when deciding which land use planning techniques are the most appropriate to modify current zoning. Table 3 from Section 3.3 provides further details on land use planning techniques and their utility for watershed protection. In addition, the DEQ has published a book titled *Filling the Gaps: Environmental Protection Options for Local Governments* that equips local officials with important information to consider when making local land use plans, adopting new environmentally focused regulations, or reviewing proposed development (Ardizone, Wyckoff, and MCMP 2003). An overview of Federal, State, and local roles in environmental protection is provided, as well as information regarding current environmental laws and regulations including wetlands, soil erosion, inland lakes and streams, natural rivers, floodplains, and more. The book also outlines regulatory options for better natural resources and environmental protection at the local level. A copy of this guidebook is available via the DEQ website: www.michigan.gov/deq → Water → Surface Water → Nonpoint Source Pollution (look under Information/Education heading).

Assisting local governments in updating and enacting strong zoning ordinances to protect water quality and secure natural areas is extremely important in the GL-CR watershed and is a high priority for implementation efforts (Sections 7.3 and 8.1). While the State of Michigan has laws to protect clean water, much more can be done at the local level because townships know their land resources better than the State does.

CHAPTER 6 WATERSHED GOALS AND OBJECTIVES

The Glen Lake-Crystal River watershed is a uniquely beautiful, high water quality area that residents and visitors alike treasure and it should be protected and maintained as such. The overall mission for the Glen Lake-Crystal River Watershed Management Plan is to provide guidance for the implementation of actions that will reduce the negative impact that pollutants and environmental stressors have on the designated watershed uses. The envisioned endpoint is to have Glen Lake, the Crystal River, and its watershed continue to support their appropriate designated and desired uses while maintaining their distinctive environmental characteristics and aquatic biological communities.

Using stated goals from the first edition of the GL-CR Watershed Management Plan, suggestions obtained from Steering Committee meetings, and examples from other watershed management plans, the project steering committee developed six broad goals for the GL-CR watershed (Table 26). Working to attain these goals will ensure that the threatened designated uses described Chapter 4 are maintained or improved.

TABLE 26: GLEN LAKE-CRYSTAL RIVER WATERSHED GOALS

Goal	Designated or Desired Use Addressed	Pollutant/Environmental Stressor Addressed
1. Protect the integrity of aquatic and terrestrial ecosystems within the watershed.	Warm/Coldwater Fishery Other Aquatic Life Desired Use: Ecosystem Preservation	Changes to Hydro Flow Invasive Species Loss of Habitat Nutrients Sediment Thermal Pollution
2. Protect and improve the quality of water resources within the watershed.	Warm/Coldwater Fishery Other Aquatic Life Total Body Contact Desired Use: Human Health	Nutrients Pathogens Sediment Thermal Pollution Toxins
3. Establish and promote land and water management practices that conserve and protect the natural resources of the watershed.	Warm/Coldwater Fishery Other Aquatic Life Navigation Desired Use: Ecosystem Preservation	All
4. Preserve the quality of recreational opportunities.	Warm/Coldwater Fishery Total Body Contact Navigation Desired Use: Recreation	All

TABLE 26: GLEN LAKE-CRYSTAL RIVER WATERSHED GOALS CONT'D

Goal	Designated or Desired Use Addressed	Pollutant/Environmental Stressor Addressed
5. Establish and promote educational programs that support stewardship and watershed planning goals, activities, and programs.	All	All
6. Preserve the distinctive character and aesthetic qualities of the watershed, including viewsheds and scenic hillsides.	Desired Use: Aesthetics	Changes to Hydro Flow Invasive Species Loss of Habitat Nutrients Sediment

Goal #1
Protect the integrity of aquatic and terrestrial ecosystems within the watershed.

Designated Use: Warm/Coldwater Fishery, Other Aquatic Life
Desired Use: Ecosystem Preservation
Pollutant or Stressor Addressed: Changes to Hydrologic Flow, Invasive Species, Loss of Habitat, Nutrients, Sediment, Thermal Pollution

Objective 1.1 Protect and restore critical habitat areas for aquatic organisms and preserve the biodiversity of populations and communities of aquatic organisms in the watershed.

- *Maintain and enhance stream canopy of trees and shrubs.*
- *Restore previously impaired sites back to natural conditions.*
- *Promote proper riparian land management and bank stability practices to reduce the amount of sediment influxes to protect aquatic habitat.*
- *Promote and maintain naturally reproducing native fish populations; improve spawning and rearing conditions.*
- *Manage fish and other animal populations for species appropriate for the area, with an attempt to maintain the diversity of species already present (i.e., stocking, fishing/hunting/trapping regulations, species introductions and reintroductions, habitat improvement efforts).*

Objective 1.2 Work to stop wetland and other types of lowland filling.

Objective 1.3 Establish wildlife corridors and protect critical areas.

Objective 1.4 Protect shoreline habitats by minimizing artificial shoreline alteration (including hardening). Make sure shoreline erosion protective measures are sited, designed, and installed properly to minimize the impact on beaches, nearshore sand drift, and habitat. Support shoreline stabilization procedures that are as natural as possible.

Objective 1.5 Minimize unnatural hydrologic flow fluctuations from Crystal River Dam and other lake-level control structures, as well as from road stream crossings and other sources.

Objective 1.6 Reduce and/or minimize sediment inputs to Glen Lake, Fisher Lake, Crystal River, Hatlem Creek and other small creeks in watershed from the following sources:

- *Bank erosion*
- *Road steam crossings*
- *Recreational access*
- *Boating*
- *Land use/Forestry practices*
- *Dredging practices (try to prohibit dredging by private individuals)*

Objective 1.7 Prevent the spread of existing invasive species and the introduction of new ones via boat hulls and bilges, other biota, and human introductions.

Objective 1.8 Prevent toxic accumulation in aquatic organisms from ineffective exotic species management techniques.

Objective 1.9 Maintain Northern Hardwood forest and preserve the biodiversity of populations and communities of terrestrial organisms in the watershed.

Objective 1.10 Minimize the negative effects of recreational boating and other types of watercraft from pollutants such as sediment, toxins, and pathogens.

Goal #2
Protect and improve the quality of water resources within the watershed.

Designated Use: Warm/Coldwater Fishery, Other Aquatic Life, Total Body Contact
Desired Use: Human Health
Pollutant or Stressor Addressed: Nutrients, Pathogens, Sediment, Thermal Pollution, Toxins

Note: One of the major pathways by which many pollutants get to lakes and streams is through stormwater runoff. Stormwater runoff results when drops of rain fall to the ground, or snow melts, and water flows over the surface of the land. This stormwater flow often dislodges and carries soil or sediment particles to which many pollutants are attached, or directly moves the pollutant itself. Populated areas often produce greater amounts of stormwater flow due to the increased amount of impervious surfaces relative to more rural settings. Any reductions to stormwater flow will decrease the amount of sediment, nutrients, thermal pollution, toxins, and pathogens that enter the watershed. See Section 5.5 for further details regarding stormwater.

Objective 2.1 Control and/or minimize the input of nutrients, pathogens, and toxic compounds (herbicides, pesticides, heavy metals, etc.) into surface water and groundwater.

Objective 2.2 Maintain or decrease levels of phosphorus and nitrogen in Glen and Fisher Lakes.

Objective 2.3 Control and reduce the amount of stormwater runoff entering waterbodies; control and reduce the amount of pollutants in stormwater as well.

Objective 2.4 Control and reduce thermal pollution in the watershed resulting from stormwater inputs, impervious surfaces, lack of stream canopy, design and operation of lake-level control structures (i.e. Crystal River Dam), reduced groundwater inputs, and sedimentation.

Objective 2.5 Protect groundwater and surface water recharge areas.

Objective 2.6 Minimize air deposition into surface water from sources including vehicles and industrial, commercial, and municipal facilities through education initiatives.

Objective 2.7 Maintain and manage existing long term water quality testing program/procedures and system of data storage.

Objective 2.8 Continue implementing appropriate swimmer's itch management program in Glen Lake.

Objective 2.9 Discourage use of persistent pesticides and herbicides.

Objective 2.10 Ensure proper design and maintenance of septic systems.

Objective 2.11 Indentify and map groundwater recharge areas for watershed. Determine if any new/increased threats exist from additional groundwater recharge areas.

Goal #3
Establish and promote land and water management practices that conserve and protect the natural resources of the watershed.

Designated Use: Warm/Coldwater Fishery, Other Aquatic Life, Navigation
Desired Use: Ecosystem Preservation
Pollutant or Stressor Addressed: All

Objective 3.1 Establish and promote land management practices that conserve natural resources and protect water quality throughout the watershed.

- *Avoid development that encroaches upon sensitive or biologically important areas.*
- *Preserve open space, sensitive/important natural areas, wetlands, and desirable species of aquatic vegetation.*
- *Protect critical riparian areas.*
- *Minimize the change of terrestrial vegetation types from forest/shrub species to turf or cropland species.*
- *Limit habitat fragmentation by maintaining compact communities.*
- *Properly manage working lands such as farms and woodlots.*
- *Maintain or reduce the amount of impervious surfaces in the watershed, especially in areas of high groundwater recharge.*
- *Shift development to areas that can support a particular type of land use or density.*

Objective 3.2 Promote voluntary arrangements (i.e. conservation easements) and regulatory tools that help prevent degradation of natural resources.

Objective 3.3 Work with landowners to protect critical habitat and wildlife corridors.

Objective 3.4 Assist townships in developing ordinances to protect water quality and natural resources. Examples of items to address include: adequate setbacks for buildings, minimizing development clearings by landowners, establishing riparian buffers along waterways, and protecting wetlands.

Objective 3.5 Establish and support stormwater best management practices that reduce the amount and harmful effects of stormwater entering waterways. Improve stormwater management throughout the watershed.

Objective 3.6 When new or redevelopment of existing property takes place along shoreline and residential areas, encourage appropriate provisions for water quality and natural resources in the approval process.

Objective 3.7 Increase awareness of developers and townships on the impacts of development on natural resources and biological communities from development.

Objective 3.8 Develop new and maintain existing wildlife corridors to minimize habitat fragmentation.

Goal #4
Preserve the quality of recreational opportunities.

Designated Use: Warm/Coldwater Fishery, Total Body Contact, Navigation
Desired Use: Recreation
Pollutant or Stressor Addressed: All

Objective 4.1 Support appropriate designated and desired uses while maintaining distinctive environmental characteristics and aquatic biological communities throughout the watershed.

Objective 4.2 Maintain desirable sport fishing quality in Glen Lake, Fisher Lake, and Crystal River.

Objective 4.3 Ensure safe and clean areas for public swimming and other types of water recreation.

Objective 4.4 Preserve scenic forested ridgelines.

Objective 4.5 Reduce the impact of invasive species on recreation in the watershed by preventing the spread of existing invasive species and the introduction of new ones via boat hulls and bilges, other biota, and human introductions.

Objective 4.6 Continue implementing swimmer's itch management program in Glen Lake.

Objective 4.7 Maintain recreational use at or below carrying capacity of watershed.

Objective 4.8 Ensure sufficient access to beaches, lakes, and river for public use that does not jeopardize the integrity of the resource.

Objective 4.9 Focus on promoting a balance between environmental, local economy, and societal needs.

Note: *Consider the following items when developing and implementing tasks:*

- *Tourism is a major source of revenue for all areas in the watershed.*
- *The private rights of individuals must be protected while at the same time providing ample opportunity for public recreation.*
- *Balance the factors between supporting a sustainable economy and protecting the environment.*
- *Be sensitive to businesses' rights to profit.*

Goal #5
Establish and promote educational programs that support stewardship and watershed planning goals, activities, and programs.

Public I/E Campaign
Designated Use: All
Desired Use: All
Pollutant or Stressor Addressed: All

Objective 5.1 Establish a successful public Information and Education (IE) Program throughout the GL-CR watershed. This public IE strategy is outlined in Section 7.4 in the management plan.

Objective 5.2 Increase watershed community awareness and concern for water quality; Educate watershed users and the general public about the value of the watershed to the community and of their responsibility to be stewards of this community asset.

Objective 5.3 Target specific outreach efforts to visitors and seasonal residents.

Objective 5.4 Expand involvement in watershed activities from schools and other stakeholder groups.

Objective 5.5 Regularly inform public about the watershed, activities, study findings, success/example projects, and opportunities for contribution (organization to public).

Objective 5.6 Provide focused information to residents, visitors, local governments, and other target groups on priority topics (organization to individual).

Objective 5.7 Educate landowners on the link between land protection and high water quality.

Objective 5.8 Continually evaluate effectiveness of outreach efforts.

Objective 5.9 Involve the citizens, public agencies, user groups and landowners in implementation of the watershed plan through meetings and workshops with individuals or groups.

Objective 5.10 Develop ‘tourism ethic’ for area businesses to pass on to tourists. Market the fact that residents and businesses of the GL-CR watershed are committed to protecting the watershed and that tourists who come here to enjoy our resources should do the same. “If you come here, you must protect it too.”

Goal #6
Preserve the distinctive character and aesthetic qualities of the watershed, including viewsheds and scenic hillsides.

Desired Use: Aesthetics
Pollutant/Environmental Stressor Addressed: Changes to Hydrologic Flow, Invasive Species, Loss of Habitat, Nutrients, Sediment

Objective 6.1 Work with landowners, developers, and others to protect scenic quality of hillsides, riparian corridors, and desirable viewsheds by establishing permanent conservation easements.

Objective 6.2 Maintain open space, parks, riparian buffers, and natural areas to allow for aesthetic enjoyment and to sustain the perception of the high quality of life that brings people to the area.

Objective 6.3 Work with local government to preserve scenic hillsides and riparian corridors through ordinances and education.

Objective 6.4 Decrease erosion from recreational use, inappropriate forest practices, and lack of best management development practices.

Objective 6.5 Support public and private needs while promoting economic sustainability and a sense of community. Preserve existing settings of particular historical and/or cultural importance.

CHAPTER 7 IMPLEMENTATION TASKS

7.1 Summary of Implementation Tasks

In an effort to successfully accomplish the goals and objectives listed in Chapter 6, specific and tangible recommendations were developed based on the prioritization of watershed pollutants, sources, and causes while also looking at the priority areas in the watershed (Tables 16-19). These implementation tasks are listed in Section 7.3 and represent an integrative approach, combining watershed goals and covering more than one pollutant at times, to reduce existing sources of priority pollutants and prevent future contributions. It is intended that these tasks be implemented in priority areas in the watershed (Figure 7, Table 19).

The project steering committee found it helpful to summarize the implementation tasks by the pollutant and/or source it deals with, placing all implementation tasks into various categories. In this way, organizations may work on a specific issue (i.e., land conservation or shoreline restoration) that reduces more than one type of watershed pollutant and meets more than one watershed goal.

The categories and goal(s) they address are as follows:

Category	Goal(s) Addressed
1. Shoreline Protection and Restoration	1, 2, 3
2. Road Stream Crossings	1, 2
3. Habitat, Fish and Wildlife	1, 2, 3, 6
4. Stormwater	1, 2, 3, 6
5. Wastewater	1, 2, 3
6. Human Health	2
7. Wetlands	1, 2, 3
8. Invasive Species	1, 4
9. Land Protection and Management	1, 2, 3
10. Development	1, 2, 3
11. Zoning and Land Use	3
12. Groundwater and Hydrology	1, 2, 3
13. Monitoring and Research	All
14. Desired Uses	4, 6

For each action step, the organization(s) best suited to help implement the task along with estimated costs to implement each item has been identified where possible. A timeframe of 10 years was used to determine the scope of activities and the estimated costs for implementing the tasks. Tasks that should be done in the short term were given a timeframe of 1-3 years. Tasks that should be undertaken annually were given a timeframe of “ongoing.” Funding for most short-term tasks will come from state grant sources (DEQ: CMI, CWA Sec. 319, MiCorps), Federal money (SLBE, USGS budget), private foundations, fundraising dollars from the Lake

Associations and Leelanau Conservancy, and volunteer time. Funding for long-term tasks will be discussed as implementation of the plan begins.

7.2 Best Management Practices

Best Management Practices (BMPs) are any structural, vegetative, or managerial practices used to protect and improve surface water and groundwater (DEQ 2001). It is important to note that 1) no BMP can be used at every site, and 2) no BMP can include so many specifications that all possible uses and all possible conditions are included. Each site must be evaluated, and specific BMPs can be selected which will perform under the site conditions. For Best Management Practices to be effective, the correct method, installation, and maintenance need to be considered for each site. Addressing each of these factors will result in a conservation practice that can successfully prevent or reduce nonpoint source pollution.

Structural BMPs are physical systems that are constructed for pollutant removal and/or reduction. This can include rip-rap along a streambank, rock check dams along a steep roadway or detention/retention basins, oil/grit separators, and porous asphalt for stormwater control.

Non-structural BMPs include managerial, educational, and vegetative practices designed to prevent or reduce pollutants from entering a watershed. These BMPs include buffers and filter strips, but also include education and public involvement programs, land use planning, natural resource protection, regulations, operation and maintenance or any other initiative that does not involve designing and building a physical structure.

Although most of these non-structural BMPs are difficult to measure quantitatively in terms of overall pollutant reduction and other parameters, research demonstrates that these BMPs have a large impact on changing policy, enforcing protection standards, improving operating procedures and changing public awareness and behaviors to improve water quality and quantity in a watershed over the long term. Moreover, they target source control which has been shown to be more cost effective than end-of-the-pipe solutions (i.e. “An ounce of prevention is worth a pound of cure”). Therefore, these BMPs should not be overlooked, and in some cases, should be the emphasis of a water quality management program.

It is important to note that installing a single BMP has the potential to reduce more than one type of pollutant (and source as well). For example, installing a riparian buffer will reduce a number of different pollutants (sediment, nutrients, toxins, etc.), as well as reduce impacts from fertilizer use and streambank erosion. Also, installing more than one BMP at a single site will increase the likelihood of pollutant reduction, but the effects will not be *cumulative*.

Table 27 lists potential systems of commonly used Best Management Practices (BMPs) that deal with various types of pollutant sources, as well as where to find more information about each type of BMP. The table also notes if a potential load reduction estimate is available for a specific BMP. Some of this information was not obtained due to the timeframe and scope of this project, and the fact that some of this type of information is not readily available. In addition, some of the research found was not relevant because it was either conducted in a vastly different region (i.e. southern United States) or done on a much smaller scale.

TABLE 27: BMP EXAMPLES BY SOURCE

Major Source or Cause	Affected Pollutant	Potential Actions to Address Pollution Source/Cause	Potential Load Reduction	BMP Manual or Agency Contact
Bank/Shoreline Erosion	Sediment Habitat Loss	*Stream bank stabilization: bank slope reduction, riprap, tree revetments, vegetative plantings, bank terracing, etc.	Varies *(see milestones in Section 7.3)*	-Guidebook of BMPs for Michigan Watersheds -Michigan Ag BMP Manual
Lack of Streamside Canopy and Riparian Buffer	Nutrients Thermal Poll.	*Improving riparian buffers: reshaping banks, planting vegetation, stop mowing, etc.	See Table 28	-Guidebook of BMPs for Michigan Watersheds -Natural Resources Protection Strategy for Michigan Golf Courses
Stormwater and Impervious Surfaces	Sediment Nutrients Toxins Pathogens Thermal Poll. Changes to Hydro Flow	*Numerous – See Table 28 *Develop stormwater management plans	See Table 28	-Stormwater Management Guidebook -Guidebook of BMPs for Michigan Watersheds -Public Information and Education Strategy -Center for Watershed Protection – Stormwater Center Website
Road Crossings - eroding, failing, outdated	Sediment Changes to Hydro Flow	*Road Crossing BMPs (vary widely – See Road Stream Crossings in Section 7.3)	Varies *(see milestones in Section 7.3)*	-Guidebook of BMPs for Michigan Watersheds
Residential/Commercial Fertilizer Use	Nutrients	*Enact local ordinances to limit fertilizers containing P *Education on proper use of fertilizers including: workshops, brochures, flyers, videos, etc.	Not available See Riparian Buffer	-Public Information and Education Strategy
Reduction of Wetlands	Sediment Nutrients Changes to Hydro Flow	*Restoration of wetlands – reshaping banks, planting vegetation, altering flow	See Table 28	Guidebook of BMPs for Michigan Watersheds Center for Watershed Protection

TABLE 27: BMP EXAMPLES BY SOURCE CONT'D

Major Source or Cause	Affected Pollutant	Potential Actions to Address Pollution Source/Cause	Potential Load Reduction	BMP Manual or Agency Contact
Septic Systems (Leaking)	Nutrients Pathogens	*Conduct education on proper septic system maintenance including: workshops, brochures, flyers, videos, etc. *Mandatory inspections *Ensure proper septic system design *Demo projects for alternative wastewater treatment systems	Varies/ Not available	Public Information and Education Strategy
Development and Construction	Sediment Habitat Loss	*Initiatives to promote open space and land preservation and protection *Encourage 'watershed friendly design' *Implement soil erosion control measures *Utilize proper construction BMPs like barriers, staging and scheduling, access roads, and grading)	Varies/ Not available	Guidebook of BMPs for Michigan Watersheds Public Information and Education Strategy
Erosion stemming from human access problems	Sediment	*Installation of barriers, signs, stairs to prevent human access	Not available	Guidebook of BMPs for Michigan Watersheds
Marinas and Gas Stations	Toxins	*Distribution of spill containment kits	Not available	MDEQ, MDNR
Dams	Thermal Poll Changes to Hydro Flow Sediment	*Dam Removal *Cold Water Outlet Installation *Changes to Management	Not available	MDNR USGS
Purposeful or Accidental Introduction of Invasive Species	Invasive Species	*Boat washing stations *Workshops, Brochures, Flyers, Videos, Etc. *Educational Programs	Not available	Public Information and Education Strategy
Reduction of Groundwater Recharge	Changes to Hydro Flow	*Infiltration basins *Grassed waterways *Plug abandoned wells properly *Groundwater/wellhead protection programs	Not available	Guidebook of BMPs for Michigan Watersheds Stormwater Management Guidebook

Pollutant Reduction Estimates for Stormwater BMPs

The Center for Watershed Protection has compiled a considerable amount of information regarding the effectiveness of selected stormwater BMPs. However, in total, very little information is available regarding the effectiveness of stormwater BMPs. The biggest stormwater problems in the GL-CR watershed are runoff from residential lawns, driveways, rooftops, and roads, none of which go through a traditional stormwater conveyance system with a pipe outlet. Table 28 lists the total percent removal of phosphorus, nitrogen, sediment (total suspended solids), and metals and bacteria for selected stormwater BMPs that could be used for stormwater pollution particular to this watershed.

Listing BMP effectiveness by percentage is a much more useful way of displaying the data rather than using specific values, which can be deceiving depending on the size of BMP implemented or installed. This is because specific values for pollutant removal depend on 1) the size of BMP implemented (feet of riparian buffer installed or acres of stormwater detention ponds), and 2) how much pollution was initially coming from the source.

It should be noted that it is assumed that the percent removal values in Table 28 are comparative numbers that state how much pollutant was removed **compared to no BMP implementation at the site**. For example, it is assumed that Porous Pavement values state the percentage of pollutant removed compared to if regular pavement were there instead; or that Riparian Buffer values state the percentage of pollutant removed compared to if no buffer was there and it was landscaped lawn instead. For more specific information on these stormwater BMPs, please see the Center for Watershed Protection's Stormwater Center website at www.stormwatercenter.net.

Additionally, keep in mind that not every BMP may be the best selection for every site. Some places are better suited for specific kinds of BMPs. There are other factors to consider besides pollutant removal efficiency when deciding which BMP to use at a site. Other factors include the size of site, money available for implementation, and the purpose of the land (i.e., what the site will be used for).

TABLE 28: POLLUTANT REMOVAL EFFECTIVENESS OF SELECTED STORMWATER BMPS FOR POTENTIAL USE IN GL-CR WATERSHED

Management Practice	Total % Phosphorus Removal	Total % Nitrogen Removal	Total % Suspended Solids Removal	% Metal and Bacteria Removal	Other Considerations
Riparian Buffer*	Grass: 39-88 Forest: 23-42	Grass: 17-87 Forest: 85	Grass: 63-89 Forest: N/A	n/a	- Increase in property value - Public education necessary
Porous Pavement	65	82	95	Metals: 98%	\$2-3/ft^2 (traditional, non-porous asphalt is \$0.50-1.00/ft^2)
Infiltration Basin	60-70	55-60	75	Metals: 85-90 Bacteria: 90	\$2/ft^3 of storage for a ¼-acre basin - Maintenance is essential for proper function

TABLE 28: POLLUTANT REMOVAL EFFECTIVENESS OF SELECTED STORMWATER BMPS FOR POTENTIAL USE IN GL-CR WATERSHED CONT'D

Management Practice	Total % Phosphorus Removal	Total % Nitrogen Removal	Total % Suspended Solids Removal	% Metal and Bacteria Removal	Other Considerations
Infiltration Trench	100	42.3	n/a	n/a	\$5/ft^3 (expensive compared to other options)
Bioretention (Rain Gardens, etc.)	29	49	81	Metals: 51-71 Bacteria: -58	\$6.80/ft^3 of water treated - Landscaped area anyway - Low maintenance cost - Note possible export of bacteria
Grassed Filter Strip (150 ft)	40	20	84	n/a	- Cost of seed or sod
Sand and Organic Filter Strip	Sand: 59 +/-38 Organic: 61 +/-61	Sand: 38 +/-16 Organic: 41	Sand: 86 +/-23 Organic: 88 +/-18	Sand: Metals: 49-88 Bacteria: 37 +/-61 Organic: Metals: 53-85	Not much information, but typical costs ranged from \$2.50 - \$7.50/ft of treated stormwater
Grassed Channel/Swale	34 +/-33	31 +/-49	81 +/-14	Metals: 42-71 Bacteria: -25	\$0.25/ft^2 + design costs - Poorer removal rates than wet and dry swales - Note the export of bacteria
Constructed Wetlands** **1) Shallow Marsh** **2) Extended Detention Wetland** **3) Pond/Wetland** **4) Submerged Gravel Wetland**	1) 43 +/-40 2) 39 3) 56 +/-35 4) 64	1) 26 +/-49 2) 56 3) 19 +/-29 4) 19	1) 83 +/-51 2) 69 3) 71 +/-35 4) 83	1) Metals: 36-85 Bacteria: 76 2) Metals: (-80)-63 3) Metals: 0-57 4) Metals: 21-83 Bacteria: 78	- Relatively inexpensive; \$57,100 for a 1 acre-foot facility - Data for 1 and 2 based on fewer than five data points
Stabilize Soils on Construction Sites	n/a	n/a	80-90	n/a	
Sediment Basins or Traps at Construction Sites	n/a	n/a	65	n/a	

*Pollutant removal efficiencies will increase as buffer width increases. Grasses in this case mean native grasses and not regular lawn or turf grass.

** Wetlands are among the most effective stormwater practices in terms of pollutant removal, and also offer aesthetic value. While natural wetlands can sometimes be used to treat stormwater runoff that has been properly pretreated, stormwater wetlands are fundamentally different from natural wetland systems. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands both in terms of plant and animal life. There are several design variations of the stormwater wetland, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.

Values obtained from Center for Watershed Protection's Stormwater Center website (www.stormwatercenter.net) and Practice of Watershed Protection Manual (Schueler and Holland 2000).

It should be noted that information regarding the pollutant removal efficiency, costs, and designs of structural stormwater BMPs is constantly evolving and improving. As a result, information contained in Tables 27 and 28 is dynamic and subject to change.

Pollutant Reduction Calculations for Streambank and Shoreline Erosion

Erosion from streambanks and shorelines can vary widely. In general, one can calculate the sediment and nutrients saved from entering a stream by eliminating the source of erosion using the MDEQ Pollutants Controlled Manual and the Channel Erosion Equation (DEQ 1999):

Sediment Reduced (T/yr) = Length (ft.) x Height (ft.) x LRR (ft./yr.) x Soil weight (ton/ft^3)

LRR: Lateral Recession Rate
Soil weight: Values available in MDEQ Pollutants Controlled Manual, Exhibit 1 (DEQ 1999)

In turn, phosphorus and nitrogen attached to soil particles will be saved from entering the stream. The following calculations may be used to estimate the amount of phosphorus and nitrogen reduced by repairing an erosion source.

Phosphorus Reduced (lb/yr) =
Sediment reduced (T/yr) x 2000 lb/T x 0.0005 lb P/lb of soil x correction factor

Nutrient Reduced (lb/yr) =
Sediment reduced (T/yr) x 2000 lb/T x 0.001 lb N/lb of soil x correction factor

Correction factor: Soil texture correction factors available in
MDEQ Pollutants Controlled Manual, Exhibit 2(DEQ 1999)

Pollutant Reduction Estimates for Land Conservation Practices

In order to maintain the high quality resources of the GL-CR watershed, it is essential to address known sources of pollution while at the same time working towards the reduction of future sources of pollution and watershed disturbance. Protecting critical areas in the GL-CR watershed through conservation easements or the purchase or donation of land are excellent strategies to meet this objective. The Leelanau Conservancy is a local land conservancy using these strategies to protect high quality land in the GL-CR watershed, in addition to the rest of Leelanau County.

Land conservation BMPs are excellent ways to preserve water quality. When dealing with pollutant reduction from these specific BMPs we look at the amount of pollution prevented from entering the watershed by keeping the land in its natural state. The load reduction is essentially the difference between the loading from the current land use and the loading from future land use.

Conservation Easement Establishment Load Pollutant Reduction (lb/yr) = $L_{developed} - L_{existing}$
L = Annual Load (lb)

To determine the annual load for each type of land use the following equation may be used:
Annual Load (lb) = 0.226 * R * C * A
0.226 = Conversion Factor; R = Annual runoff (inches); C = Pollutant Concentration (mg/L); A = Area (acres)

Annual runoff (R) is calculated by:
Annual runoff (in) = $P * P_j * Rv$
P = annual rainfall (in); P_j *= fraction of annual rainfall events that produce runoff (usually 0.9)*
R_v *= runoff coefficient (*R_v *= 0.05 + 0.9 * la [where la = Impervious surface fraction])*

In most cases the actual pollutant concentrations on portions of land are not known, in that case it is possible to use estimated/average pollutant loads for differing land uses from other sources like those listed in Table 29.

TABLE 29: AVERAGE POLLUTANT LOADS BY LAND USE*

Land Use	Residential	Vacant	Open Space
TSS (unsewered) Lbs/acre/yr	154	40	20
TN (unsewered) Lbs/acre/yr	3.1	0.5	0.2
TP (unsewered) Lb/acre/yr	0.4	0.088	0.13

**Table Source: Unit Area Pollutant Load Estimates for Lake County, Illinois Lake Michigan Watersheds. Northeastern Illinois Planning Commission. August 1993*.

Over the past 20 years the Leelanau Conservancy has worked to permanently protect 228 acres in the GL-CR watershed through land conservation practices (118 acres in conservation easements and 110 acres transferred to National Park). Their goal over the next 10 years is to protect an additional 950 acres in the watershed (See Land Protection and Management Goals in Section 7.3). Using average pollutant loads for residential and vacant land uses in Table 29 we can estimate that the Leelanau Conservancy has prevented 25,992 lbs sediment, 592.8 lbs N, and 71.1 lbs P from entering the GL-CR watershed each year. If conservation goals are reached, an additional 108,300 lbs sediment, 2,470 lbs N, 296.4 lb P will be stopped from entering the watershed.

Understanding Conservation Easements

A conservation easement is a legal agreement between a landowner and the Leelanau Conservancy that permanently limits a property's uses in order to protect its conservation values. These agreements are not a new concept in property law, as similar agreements have been in force in parts of the United States since the late 1800's. However, conservation easements were a rarity in Michigan before 1990. They are not a rarity any longer, and the Leelanau Conservancy has received over 100 conservation easements since its founding in 1988.

How Conservation Easements Work

When a person owns land, they also "own" many rights associated with it. These property rights include the right to harvest timber, build structures, grow crops, and so on (subject to zoning or other land use restrictions). When they grant a conservation easement to a land conservancy, they permanently restrict or eliminate some of those rights and retain others. For example, a landowner may restrict the ability to develop more than 1 home site in the future, but retain the right to manage the forest for sustainable timber harvest according to an approved forest management plan and maintain trails and two-track roads. Importantly, all future owners are bound by the conservation easement's terms since they are attached to the deed of the property.

Key Advantages of Conservation Easements

- Leave the property in private ownership, and owners may continue to live on it, sell it, lease it or pass it on to heirs
- They are flexible and can be written to meet the particular needs of the landowner while protecting the property's conservation values
- They are permanent, remaining in force when the land changes hands
- Can provide significant income, property, and estate tax benefits – often making the difference between a family being able to retain land or being forced to divide and sell because of high property and/or estate taxes

Conservation easements can be used to protect a wide variety of land including farms, forests, wildlife habitat, and properties with scenic views. They are drafted in a detailed legal format that spells out the rights and restrictions on the owner's uses of the property as well as the rights and responsibilities of the land conservancy.

The Leelanau Conservancy works with each interested landowner to determine if their land qualifies for permanent protection and helps them determine the most appropriate conservation easement terms to protect the land's conservation values. Thus, each conservation easement is a unique and personalized document. Generally, limitations are made on the number and location of structures and types of land use activities that can take place. A conservation easement can serve as a flexible tool in a family's financial planning as well. Conservation easements may cover all or just a portion of the entire property and they often allow some future construction within an approved area, if that is compatible with the easement's conservation objectives.

Conservation Easement Donations

Conservation easements customarily are donated by landowners who are motivated to protect land for its intrinsic value, and sometimes because they want future generations to enjoy the land and its wildlife as the donor has. Once a landowner has indicated an interest in conveying a conservation easement to the Leelanau Conservancy, a number of steps are required to complete the transaction (i.e. property tour to determine if a conservation easement is appropriate, consultation with legal and tax counsel, negotiation of restrictions to easement, draft documentation and finalize). In addition to recently expanded Federal Income tax incentives for conservation easement donations, the passage of PA 446 late in 2006 gives Michigan property owners the ability to prevent property taxes from skyrocketing when land is passed down in the family by donating a conservation easement over qualifying land before it transfers.

Sales of Conservation Easements:

Watershed protection with permanent conservation easements is a land protection option with great community benefits. While conservation easements are very rarely purchased at full market value due to limited funding, priority protection parcels can qualify for the purchase of a conservation easement when funds are available. In the recent past, the Leelanau Conservancy has had great success utilizing grant funds (awarded by the MDEQ) in combination with private donations to purchase conservation easements over important watershed parcels. Conservation easements are most often are purchased for less than full market value – producing what is known as a bargain sale to a charity. For tax purposes a bargain sale is treated as a "part sale/ part donation." When a conservation easement is sold at less than full market value it can combine the income producing benefit of a sale with the tax-reducing benefit of a donation. The difference between the conservation easement's value as established by an appraisal and its sale price is considered a charitable donation and can be claimed as a Federal income tax deduction as well. The charitable donation component of a bargain sales of a conservation easement is treated exactly the same as an outright gift under federal income tax rules. Additionally, land restricted by a conservation easement, whether the easement was donated or purchased, is not subject to the "pop-up tax" when it is sold or transferred.

More information on establishing conservation easements with the Leelanau Conservancy and the benefits associated with them can be found on their website at: www.theconservancy.com or by calling 231-256-9665 and speaking with Matt Heiman, Director of Land Protection.

7.3 List of Implementation Tasks by Category

IMPLEMENTATION TASKS

Categories:

1. Shoreline Protection and Restoration
2. Road Stream Crossings
3. Habitat, Fish and Wildlife
4. Stormwater
5. Wastewater
6. Human Health
7. Wetlands
8. Invasive Species
9. Land Protection and Management
10. Development
11. Zoning and Land Use
12. Groundwater and Hydrology
13. Monitoring
14. Desired Uses

Organization Acronyms:

BLHD – Benzie-Leelanau Health Department
CRA – Conservation Resource Alliance
CRO – Crystal River Outfitters
EPA – Environmental Protection Agency
FERC – Federal Energy Regulatory Commission
FoCR – Friends of the Crystal River
GLA – Glen Lake Association
ISEA – Inland Seas Education Association
LeeCty – Leelanau County
LC – Leelanau Conservancy
L-CD – Leelanau Conservation District
LCRC – Leelanau County Road Commission
LGOV – Local Governments
MDEQ – Michigan Department of Environmental Quality
MDNR – Michigan Department of Natural Resources
M-DOT – Michigan Department of Transportation
MSU-E – Michigan State University Extension
NPS – National Park Service Water Resources Div.
NRCS – USDA Natural Resources Conservation Service
NWMCOG – Northwest Michigan Council of Governments
OWTTF – Onsite Wastewater Treatment Task Force
SLBE – Sleeping Bear Dunes National Lakeshore
USGS – United States Geological Survey
USCG – United States Coast Guard

Other Organizations:

Leelanau County Chamber of Commerce
Local Realtors, Businesses
Trash Haulers
Schools (The Leelanau School, Glen Lake High School)

Estimated Costs, Timeframes, and Milestones:

For costs associated with salaries, an average watershed technician rate of $35/hour was applied. For tasks to be completed by a specialized consultant, a rate of $50/hour was used. Tasks that will be done on a yearly or site by site basis are noted as such ($X/yr or $X/site). Appendix B lists average rates for costs associated with purchasing materials for and installing standard BMPs. Further details are noted where applicable. In general, funding for short-term tasks (1-5 years) will be attained through state and/or Federal grants, other non-profit grant programs, partner organizations' budgets, fundraising efforts, and private foundations. Funding for long-term tasks will be addressed as needed.

Project milestones for specific tasks were established where feasible. They are meant to guide implementation priorities and measure progress.

	Categories/Tasks	**Priority:** *High (H), Med (M), Low (L)* **Duration** (yrs)	Estimated Cost	Milestone	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners	Objective(s) Addressed
CATEGORY 1 – SHORELINE PROTECTION **(Goals addressed: 1, 2, 3)**																
1.1	Inventory riparian area to determine priority areas where riparian vegetated stream and lakeshore buffers should be installed. (See Section 5.5 of protection plan for a discussion about buffers.)	H 3	$5000	• 1/3 of lakeshore and river shore each year over period	X ——	——	X								L-CD, GLA, FoCR, SLBE	1.2, 1.4, 1.5, 2.1, 2.2, 2.3, 2.8, 3.4 ,3.5, 3.6
1.2	Work with municipalities and other government organizations to install riparian buffers on publicly owned property in the watershed (including road ends and SLBE).	H 7	$5000/yr	• 20% by 2012 • 30% by 2014 • 40% by 2016 • 50% by 2018			X	——	——	——	——	——	——	→	GLA, FoCR, CRA, L-CD, Local Gov, SLBE	1.2, 1.4, 1.5, 2.1, 2.2, 2.3, 2.8, 3.4, 3.5, 3.6
1.3	Work with interested landowners to install riparian buffers in priority areas.	H 7	$5000/yr	• 10% by 2012 • 20% by 2014 • 30% by 2016			X	——	——	——	——	——	——	—— →	CRA L-CD GLA FoCR	1.2, 1.4, 1.5, 2.1, 2.2, 2.3, 2.8, 3.4, 3.5, 3.6
1.4	Research and develop possible incentive program that financially rewards the installation or presence of buffers along waterways in the watershed.	H 3	$5000	• Pilot program by 2010, full program if viable by 2011	X ——	——	X								GLA FoCR Local Gov.	1.2, 1.4, 1.5, 2.1, 2.2, 2.3, 2.8, 3.4, 3.5, 3.6
1.5	Conduct, or evaluate existing, streambank and shoreline erosion/sedimentation surveys to determine sites where bank stabilization and restoration is needed and compile list of priority areas. Conduct streambank erosion inventory for Crystal River and Hatlem Creek.	H Ongoing, Update every 3 years	$5000 (over 10 years)	• 1/3 of lakeshore and river shore each year over rotating 3 year period	X ——	——	——	——	——	——	——	——	——	—— →	GLA, FoCR, SLBE, USGS, CRO	1.4,1.6, 2.2, 3.6, 3.7

Categories/Tasks		Priority: *High (H), Med (M), Low (L)* Duration (yrs)	Estimated Cost	Milestone	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners	Objective(s) Addressed
CATEGORY 1 – SHORELINE PROTECTION *(CONT'D)*																
1.6	Stabilize streambanks and lakeshore at priority sites and use biotechnical and soft stabilization methods where possible. Include costs and time for maintenance of stabilized sites.	H 10	Lakeshore stabilization: $80/ft Estimate: 1000ft = $8,000 Stream bank Erosion Sites: $3,000/ea Estimate: 10 sites = $30,000	• 10% per year of needed area	X →									→	GLA, FoCR, SLBE Local Gov, CRO, L-CD, Riparian Landowners	1.4,1.6, 2.2, 3.6, 3.7
1.7	Install barriers, signage, or stairs where needed to manage human access to stream and lakeside banks at risk of erosion (steep slopes, sandy soils) from recreational foot traffic.	M 10	$3000/yr (Estimated 10 sites)	• 50% in 5 years • 100% in 10 years (approx. 1 site/yr)	X →									→	GLA, FoCR, MDNR, L-CD, SLBE, CRO, Others	1.4,1.6, 2.2, 3.6, 3.7
See also: Zoning & Land Use																
CATEGORY 2 – ROAD STREAM CROSSINGS **(Goals addressed: 1, 2)**																
2.1	Redo road stream crossing inventory every 10 years, including an evaluation of the prioritized road stream crossings needing remediation. Obtain any new data regarding completed improvement projects. When evaluating road stream crossings, include an evaluation of canoe portage sites as well (determine if excessive erosion exists or if water quality impairments are present).	H 3	$10,000									X		X	CRA, L-CD, LGOV, FoCR, CRO, LCRC, MDOT	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 3.5

	Categories/Tasks	Priority: *High (H), Med (M), Low (L)* Duration (yrs)	Estimated Cost	Milestone	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners	Objective(s) Addressed
CATEGORY 2 – ROAD STREAM CROSSINGS *(CONT'D)*																
2.2	Where priority road stream crossings and canoe portage sites have been identified, improve, repair, or replace outdated, failing, or eroding road stream crossings by implementing appropriate BMPs from the following: 1. Road Crossings Remove obstructions that restrict flow through the culvert; Replace undersized (too small or too short) culverts; Remove and replace perched or misaligned culverts to avoid erosion and provide for fish passage; Install bottomless culverts and bridges where possible; Replace culverts with a length that allows for ≥ 3:1 slope on embankments; Re-vegetate all disturbed or bare soils on embankments 2. Road Approaches Create diversion outlets and spillways to direct road runoff and stormwater away streams; Pave steep, sandy approaches where feasible; Dig or maintain ditches where needed and construct check dams if required 3. Road Maintenance Encourage Road Commissions to look at the long-term savings of crossing improvements over cumulative maintenance costs 4. Road Construction and Closure Minimize the number of access roads needed for oil, timber and gas exploration; When constructing new roads, avoid streams if possible and maintain natural channels to greatest extent possible.	H 10	$83,000	• 2010: Isolate at least 2 sites for work • 2013: Complete one site • 2016: Complete 2nd site • 2017: Isolate 2 more sites, Repeat cycle until all prioritized sites are repaired or upgraded. *There are currently 2 priority road stream crossing sites on Crystal River, with a total of 10 moderately ranked crossings (see page 72)	X	→	→	→	→	→	→	→	→		CRA, L-CD, FoCR, LCRC, MDOT	2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 3.5
2.3	Redesign 2 high priority canoe portage sites to reduce erosion and water quality impairments (see page 72 for description of sites).	H 6	$10,000 ($5,000/ea)	• 2011: Identify first portage site and complete redesign • 2013: Complete 1st site • 2014: Identify 2nd site and redesign • 2015: Complete 2nd site		X	—	—	—	—	X				CRA, L-CD, LGOV, FoCR, CRO, LCRC	1.4, 1.6, 6.4

Categories/Tasks		Priority: *High (H), Med (M), Low (L)* Duration (yrs)	Estimated Cost	Milestone	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners	Objective(s) Addressed
CATEGORY 3 – HABITAT, FISH AND WILDLIFE **Goals addressed: 1, 2, 3, 6**																
3.1	Update inventory of aquatic conditions every 5 years	M Once every 5 years	$10,000 ($5,000/ update)						X					X	CRA, MDNR, L-CD, FoCR, SLBE, NPS	1.1, 1.2, 1.4, 1.6, 1.7, 2.11, 3.3, 3.4, 3.6, 3.7, 4.8
3.2	Install lake and stream habitat improvements according to the inventory in Task 1 (i.e., lunker structures, large woody debris, submerged fish structures)	M Ongoing	$30,000	• Install 30% of improvements by 2011 • 60% by 2014 • 90% by 2017	X	—	—	—	—	—	—	—	—	→	CRA, MDNR, L-CD, FoCR, SLBE, NPS	1.1, 1.4, 1.6, 3.1, 3.4, 3.6, 4.2, 6.3
3.3	Implement Conservation Resource Alliance's Wild-Link program to identify, protect and enhance fish and wildlife habitat on private property within ecological corridors throughout the watershed.	H Ongoing	$25,000 - $50,000/ year	• Establish 2 Wildlink projects by 2012 • 4 by 2014 • 8 by 2018	X	—	—	—	—	—	—	—	—	→	CRA	1.1, 1.3, 1.9, 3.2, 3.3, 3.8, 6.4
See also: Land Protection and Management																
CATEGORY 4 – STORMWATER **Goals Addressed: 1, 2, 3**																
4.1	Conduct impervious surface assessments in watershed. Map and count number of culverts/storm drain outlets that drain to Glen Lake, Fisher Lake, Hatlem Creek, and Crystal River.	M 5	$35,000 Consultant	Map culvert and storm drains to lakes: • 2011 Big Glen • 2012 Little Glen • 2013 Hatlem Ck and Crystal River	X	—	—	—	X						LGOV, GLA, FoCR	1.6, 2.1, 2.3, 2.4, 2.6, 3.5

	Categories/Tasks	**Priority:** *High (H), Med (M), Low (L)* **Duration** (yrs)	Estimated Cost	Milestone	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners	Objective(s) Addressed
CATEGORY 4 – STORMWATER *(CONT'D)*																
4.2	Work with local governments, area businesses, and property owners to install stormwater BMPs where appropriate. See Section 7.2 for stormwater BMP ideas and their pollutant removal effectiveness. BMPs may include: • Vegetative Filter Strips • Stormwater Filtering Systems • Infiltration Practices: Infiltration Trench/Basin, Porous Pavement • Other Low Impact Design (LID) Elements: Rain/Roof Gardens, Native Plantings, Riparian Buffers	H 6	$5,000/yr Salary cost $60,000 ($20,000/ BMP)	• 2012: Identify 3 highest problem drains Installation: • 2013 Have 1st drain improved • 2015 Have 2nd drain improved • 2017 Have 3rd drain improved				X	X	—	—	—	X		GLA, LGOV, L-CDs, FoCR, Local Businesses	1.6, 2.1, 2.3, 2.4, 2.6, 3.5
CATEGORY 5 – WASTEWATER & SEPTICS **Goals Addressed: 1, 2, 3**																
5.1	Develop plan for evaluating, prioritizing, and addressing potential pollution from septic systems.	H 3	$5,000	• Develop plan by 2011	X	—	X								GLA, FoCR, SLBE, LGOV, BLHD	2.2, 2.10
5.2	Revisit shoreline cladophora survey each year to determine potential sites where there may be improperly working septic systems. Work with landowners to conduct dye testing to determine which septic systems are leaking, if any, in potential sited areas.	H Ongoing	$1,500/yr	• Survey conducted each year in August	X	—	—	—	—	—	—	—	—	→	GLA	2.2, 2.10
5.3	Work with local governments and BLHD to establish mandatory septic system inspections at the time of sale or purchase of existing residence (through ordinances or by other means).	H 3	$2,500/Yr	• Create and adopt county ordinance by 2012	X	—	X								GLA, BLHD, MDEQ, OWTTF	2.2, 2.10

Categories/Tasks		Priority: High (H), Med (M), Low (L) Duration (yrs)	Estimated Cost	Milestone	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners	Objective(s) Addressed
CATEGORY 5 – WASTEWATER & SEPTICS *(CONT'D)*																
5.4	Work with BLHD officials who issue permits for new septic systems to ensure property owners implement proper septic system design for the site conditions and consider their proximity to Glen/Fisher Lakes, Hatlem Creek and ground water.	H Ongoing	$1,500/Yr	• Establish an annual meeting with BLHD by 2010	X									→	BLHD, OWTTF, GLA	2.2, 2.10
5.5	Work with MDEQ and BLHD to address improper land application of septage from pumped septic tanks.	H Ongoing	$1,500/Yr		X									→	GLA, BLHD, LGOV	2.2, 2.10
CATEGORY 6 – HUMAN HEALTH **Goals addressed: 2**																
6.1	Monitor/Track effectiveness of Swimmers' Itch Merganser program and planned refinements. (Snail infection level sampling.)	H 4	$5,000/yr	• 2012: Evaluate effectiveness			X			X					GLA, SiCon Corp.	2.8, 4.6
6.2	Monitor microcystis levels in Little Glen.	H Ongoing	$2,000/yr	• Annually	X									→	GLA, CLMP	1.7
6.3	Continue E.Coli monitoring program at Little Glen Lake access site in SLBE and Hatlem Creek. Consider other sampling locations.	H Ongoing	$2,500/yr Hatlem Creek	• After heavy rain events each year (2x/yr)	X									→	SLBE, BLHD	2.1, 2.10
See also: Wastewater and Septics, Monitoring																

	Categories/Tasks	**Priority:** *High (H), Med (M), Low (L)* **Duration** (yrs)	Estimated Cost	Milestone	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners	Objective(s) Addressed
CATEGORY 7 – WETLANDS **Goals addressed: 1, 2, 3**																
7.1	Work with local governments, landowners, Leelanau Conservancy, and other organizations to restore wetlands and establish at least 1 demonstration site. Help enroll eligible landowners in the NRCS Wetland Reserve Program.	M Ongoing	$100,000 total ($25,000/ project)	• Establish Demo site by 2011 • Complete next by 2014 • 2 more by 2018	X									→	NRCS, CRA, L-CD, GLA, LC, SLBE	1.1, 1.2, 1.4, 2.2, 3.3
7.2	Monitor enforcement of possible wetland filling violations.	H Ongoing	$25,000 ($2,500/yr)	• Annually	X									→	GLA, FoCR, LGOV	1.2, 3.4
See also: Land Protection and Management; Development, Zoning and Land Use																
CATEGORY 8 – INVASIVE SPECIES **Goals addressed: 1, 4**																
8.1	Increase number of days and hours at boat wash station to avoid spread of invasive species. Build self boat wash station adjacent to manned station for after hour coverage	H Ongoing	$35,000 Addl labor, (existing boatwash) $150,000 (Self wash station)	• 2010: establish hours of 6:00am-8:00pm May through Oct. Boat Station: • 2011: Plans, permissions • 2012: Obtain funding • 2013: In service		X								→	NPS, DNR, GLA	4.5
8.2	Monitor spread of specific invasive species in watershed-aquatic and terrestrial	H Ongoing	$10,000	• Annually: conduct invasive aquatic plant survey • 2009: Determine baseline • 2010: Survey terrestrial exotics	X									→	GLA, NPS, L-CD	1.1, 1.7, 1.9

Categories/Tasks		<u>**Priority:**</u> ***High (H), Med (M), Low (L)*** <u>**Duration**</u> **(yrs)**	**Estimated Cost**	**Milestone**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Potential Project Partners**	**Objective(s) Addressed**
CATEGORY 8 – INVASIVE SPECIES *(CONT'D)*																
8.3	Develop invasive species eradication program if necessary Primary focus should be on prevention of introduction. Follow NPS strategies for terrestrial exotic plant eradication	H Ongoing	$15,000	• Annually: Harvest, digging of invasive aquatic plants • As needed: Use of milfoil eating beetle for Eurasian milfoil	X →										GLA, NPS, LGOV	1.7 1.8, 1.9
8.4	Advocate with township zoning and master planning groups to develop ordinances that protect against the spread of invasive species	H	$5,000	• 2009: Pass ordinance in Glen Arbor and Empire Township	X										GLA, LGOV	1.7
CATEGORY 9 – LAND PROTECTION AND MANAGEMENT **Goals addressed: 1, 2, 3**																
9.1	Establish permanent conservation easements with private landowners to protect identified Critical Areas, forested ridgelines, wildlife corridors, sensitive habitats (such as wetlands, riparian corridors, groundwater recharge, etc.), and habitat for threatened and endangered species.	H Ongoing	$3,000,000	• Establish at least 2 CEs that protect 50 acres each by 2012 • 4 by 2015 • 6 completed by 2019 (protecting at least 300 acres total)	X →										LC, MDEQ, GLA, FoCR, SLBE, LGOV	1.1, 1.3, 1.6, 1.9, 2.2, 2.3, 2.4, 2.5, 3.1, 3.2, 3.3, 3.8, 4.4, 5.7, 6.1, 6.4
9.2	Create a $1.5 million endowment fund to assist the Leelanau Conservancy in purchasing conservation easements on key priority parcels within the Glen Lake-Crystal River watershed. Priority protection parcels would contain sensitive physical and hydrologic features that are essential to preserving water quality (e.g. wetlands, water frontage, groundwater recharge, steep slopes, etc.).	H Ongoing	$8,000	• Raise $300,000 by 2011 • $600,000 by 2013 • $900,000 by 2015 • Remainder by 2019.	X →										LC, GLA, FoCR	3.1, 3.2, 3.3, 6.1

	Categories/Tasks	**Priority:** *High (H), Med (M), Low (L)* **Duration** (yrs)	Estimated Cost	Milestone	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners	Objective(s) Addressed
CATEGORY 9 – LAND PROTECTION AND MANAGEMENT *(CONT'D)*																
9.3	Assist local units of government, the State of Michigan, and the Department of the Interior (Sleeping Bear Dunes National Lakeshore) and acquire additional land for preservation of water quality and sensitive ecological features.	H Ongoing	$1,000,000	• Secure funding and complete 1 addition by 2014 • 2 by 2019.	X									→	LC, MDNR, State of MI, US Dept. of Interior	1.3, 1.9, 3.8, 6.2, 6.3
9.4	Work with landowners to assure that forest management practices are in compliance with current Best Management Practices, as outlined in "Water Quality Management Practices on Forest Land," (1994) MDNR	H Ongoing	$5,000	• Introduce forestry BMPs to 5 landowners by 2014 • Work with 10 total by 2019	X									→	CRA, L-CD, LC	1.6, 1.9, 2.4, 2.5, 3.1, 3.3, 5.6, 6.1, 6.4
See also: Habitat, Fish & Wildlife																
CATEGORY 10 – DEVELOPMENT **Goals addressed: 1, 2, 3**																
10.1	Work with homebuilders associations, contractors, or developers to encourage 'watershed friendly' design, construction and maintenance of new and existing developments in the watershed and work to establish showcase/demonstration sites.	H 6	$5,000/yr	• 2010: Identify 1 builder to work with on model construction. • 2014: Establish showcase site for other builders and prospective new homeowners.	X					X					GLA, FoCR, LGOV, L-CD, Local Businesses	1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.10, 3.1, 3.3, 3.4, 3.5, 3.6, 3.7,

Categories/Tasks		**Priority:** *High (H), Med (M), Low (L)* **Duration** (yrs)	**Estimated Cost**	**Milestone**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Potential Project Partners**	**Objective(s) Addressed**
CATEGORY 10 – DEVELOPMENT *(CONT'D)*																
10.2	Work with appropriate local government agencies (i.e., County Drain Commission) to recommend BMP's for developers on construction sites and to ensure compliance with those BMP's. Establish potential systems of BMPs to require including: access roads, construction barriers, grading, staging, and proper scheduling for other BMPs.	H Ongoing	$5,000/yr	• 2012: Establish connection with township land use offices to be alerted when development plans are initiated to encourage BMPs.	x									→	GLA, FoCR, LGOV, L-CD, Local Businesses	1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.10, 3.1, 3.3, 3.4, 3.5, 3.6, 3.7,
10.3	Work with Leelanau County Drain Commissioner and other appropriate local government entities to implement proper soil erosion control measures at construction sites.	H 9	$25,000/yr (portion of Drain Comm salary)			x								→	GLA, LGOV, L-CD, Local Businesses	1.6, 3.4, 3.5
10.4	Monitor Soil Erosion and Sedimentation construction permits to determine the amount and location of new developments throughout the watershed	M 10	$5,000		x									→	GLA, LGOV, L-CD, LeeCty	1.6, 3.4, 3.5

	Categories/Tasks	**Priority:** *High (H), Med (M), Low (L)* **Duration** (yrs)	Estimated Cost	Milestone	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners	Objective(s) Addressed
CATEGORY 11 – ZONING AND LAND USE **Goals addressed: 3**																
11.1	Inventory current Master Plan and Zoning Ordinances for Leelanau County, Empire-Glen Arbor-Kasson Townships to determine types of protection given to water quality and natural resources.	H 3	$5,000	• 2010: Secure document access • 2011: Complete survey • 2012: Tabulation and dissemination of results		X	X	X							NPS GLA LGOV	1 all 4 all 6 all
11.2	Advocate for zoning, master plans and ordinances that protect water quality and natural resources: setbacks and buffers along lakes and river, overlay zones, clearing of shoreline, ridgeline, wooded hillsides. Financial Assistance to county and townships.	H Ongoing	$15,000/Yr Salary $28,000 To local gov't	• Research and write initial draft of ordinances, 1 per year	X	→	→	→	→	→	→	→	→	→	LGOV GLA FoCR	1.1, 1.2, 1.3, 1.4, 1.9, 3.1, 3.4, 3.6, 4.1, 4.4, 6.3
11.3	Work with Glen Arbor, Kasson and Empire Township, Leelanau County and State Government to enact ordinance or law to restrict use of phosphorus in fertilizers and dishwashing soap.	H 4	$5,000	• 2009: Present to townships and county, rationale for ordinance and draft of ordinance • 2010: Passage of ordinance & Meeting with state senator and representative with rationale for law and draft • 2013: Passage of law	X	→	→	→	X						LGOV GLA FoCR	2.2
11.4	Develop workable and practical strategies (including financial assistance) to strengthen enforcement of existing land use regulations, soil erosion programs, and ordinances by appropriate local government bodies.	H Ongoing	$20,000	• 2011: Begin tracking of enforcement in developed format	X	→	→	→	→	→	→	→	→	→	SLBE, LGOV, GLA, FoCR	2.2

	Categories/Tasks	**Priority:** *High (H), Med (M), Low (L)* **Duration** (yrs)	Estimated Cost	Milestone	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners	Objective(s) Addressed
CATEGORY 12 – GROUNDWATER AND HYDROLOGY **Goals addressed: 1, 2, 3**																
12.1	Map groundwater flow and major aquifers in the watershed. Confirm source and volume of groundwater recharge and inflow to watershed. (Preliminary work needs to be done to 1) identify and gather groundwater data sets useful in mapping and modeling groundwater flow and major aquifers in the watershed, and 2) produce preliminary groundwater-flow direction and aquifer maps.)	H 3	$200,000	• Sub-watersheds by 2009 • Influents by 2010 • Effluents by 2011	X	—	X								GLA, FoCR, SLBE, USGS, MDEQ, Universities	1.5, 2.5, 2.11
12.2	Develop a water supply model (water budget) for the GL-CR watershed to assist wise and efficient management of Glen Lake water levels and Crystal River in-stream flows.	H 3	$100,000	• Review existing information 2009 • Glen Lakes 2010 • Remaining watershed 2011	X	—	X								GLA, MDEQ, MDNR, LC, SLBE, FoCR	1.5, 2.11, 3.1, 3.5
12.3	Research the hydrological effects of gravel pit mining in the GL-CR watershed.	M 10	$40,000	• Map existing sites by 2011. • Determine known threats by 2013. • Determine potential threats by 2015. • Recommend mgmt options by 2016	X	—	—	—	—	—	—	—	—	→	GLA, FoCR, SLBE, LC, USGS, MDEQ, Universities	1.6, 2.1, 2.3, 2.4, 2.5, 3.1, 3.2, 3.3, 3.4
12.4	Distribute maps of identified priority groundwater discharge and recharge areas to local governments and other organizations in the watershed.	H 3	$2,000	• Distribute as info is developed in task 12.1		X	—	X							GLA, FoCR, SLBE, LC, USGS, MDEQ, LGOV, Universities	2.5, 2.11, 3.1, 3.2, 3.4, 3.7

Categories/Tasks		**Priority:** *High (H), Med (M), Low (L)* **Duration (yrs)**	**Estimated Cost**	**Milestone**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Potential Project Partners**	**Objective(s) Addressed**
CATEGORY 12 – GROUNDWATER AND HYDROLOGY *(CONT'D)*																
12.5	Work with owners and operators of lake-control structures on Hatlem Creek to ensure these structures are operated or modified to protect the Hatlem Creek ecosystem, including encouraging various BMPs (i.e., cold water outlet).	M 6	$1,500/yr	GLA Lake Biologist contact • 1st private owner by 2011 • 2nd by 2012 • Modification by 2015 if viable		X	—	—	—	—	X				GLA, FoCR, USGS, LC, MDEQ, L-CD	1.5, 1.6, 2.3, 2.4, 3.5
12.6	Encourage and advocate ecological restoration of gravel pits in the watershed by attaining restoration plans from existing businesses and meeting with gravel extraction owners in the watershed.	M Ongoing	$1,000/yr	• 2010 Procure restoration plans from Fairmount Minerals and others. • 2011 and ongoing meet with gravel extraction owners in the watershed	X	—	—	—	—	—	—	—	—	→	GLA, FoCR, SLBE, LC, USGS, LGOV, MDEQ, Universities	1.6, 2.1, 2.3, 2.4, 2.5, 3.1, 3.2, 3.3, 3.4
12.7	Inventory and summarize the status of wellhead protection plans.	L 3	$5,000		X	—	X								GLA, FoCR, SLBE, LGOV, FERC	2.1, 2.11
12.8	Locate abandoned and poorly capped wells and correct properly to prevent contaminants from moving into and among groundwater aquifers via this route. Tasks will be to 1) inventory existing abandoned wells through surveys, well logs, and landowner interviews and 2) properly plug the abandoned wells.	M 8	$20,000 (Consultant to assist in interviews, location and prioritizing) $10,000/yr thereafter	• 2011 Begin inventory • 2012 prioritize biggest offenders • 2013 Initialize plugging			X	—	—	—	—	—	—	→	GLA, FoCR, SLBE, USGS, MDEQ,	2.1, 2.11
12.9	Work with area businesses and property owners to encourage proper maintenance and monitoring of underground fuel storage tanks and improperly stored vehicles (i.e., junkyards) and replace them when there is a risk of leakage from tank age, poor maintenance, or damage.	L 9	$15,000/yr	• 2011 Begin locating sites • 2012 Begin working with responsible parties to remediate		X	—	—	—	—	—	—	—	→	GLA, FoCR, SLBE, LC, LGOV, MDEQ,	2.1, 2.5

Categories/Tasks		Priority: *High (H), Med (M), Low (L)* Duration (yrs)	Estimated Cost	Milestone	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners	Objective(s) Addressed
CATEGORY 13 – MONITORING **Goals addressed: All**																
13.1	Centralize all water quality data for GL-CR watershed in one common location and format.	H Ongoing	$4,000/yr	• 2010 Have data in GLA office • Maintain annually	X	—	—	—	—	—	—	—	—	→	GLA, FoCR, SLBE, USGS, LC, CLMP	2.7
13.2	Identify, collect, and interpret historic water and watershed related data for the GL-CR watershed that has yet to be gathered and evaluated by project partners. Perform a 'gap analysis' to recommend critical watershed data and study needs.	M 5	$10,000	• 2010: Identify sources • Outside sources collected by 2014 • Interpret by 2015					X	—	—	—	X		LC, GLA, FoCR, USGS, SLBE	2.7, 2.1, 2.2
13.3	Annually evaluate monitoring results gathered from other groups conducting work in the watershed and assist with efforts when needed. (Update results in GL-CR water quality database – See Task #1). Analyze for long-term trends.	H Ongoing	$2,500	• 2009 Review long term trends • Analyze every 3 years thereafter	X	—	—	—	—	—	—	—	—	→	GLA, FoCR, LC, SLBE, NPS, USGS, MDEQ	2.7, 2.1, .2.2
13.4	Continue volunteer macroinvertebrate monitoring in Hatlem Creek	H Ongoing	$2,000/yr	• 2 times per year, spring and fall	X	—	—	—	—	—	—	—	—	→	GLA, FoCR, Schools	2.1

Categories/Tasks		Priority: High (H), Med (M), Low (L) Duration (yrs)	Estimated Cost	Milestone	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners	Objective(s) Addressed
CATEGORY 13 – MONITORING *(CONT'D)*																
13.5	Continue nutrient, cladophora, and other water quality parameter monitoring in lakes and other GL-CR watershed waterbodies. **<u>GLA Monitoring:</u>** ***Big Glen, Little Glen, Fisher Lake, Brooks Lake (all in proximity of deep basin) -*** - Spring and late summer phosphorus - Chlorophyll a 1x/month May-Sept - Water transparency (Secchi) 2x/month - Ponar Dredge Sediment – conduct Michigan 10 metals analysis 2x/yr (deep basin and selected littoral areas) - Plankton horizontal and vertical collection 2x/yr. (within May to Sept time frame) -Hydrolab water column surface to bottom – DO, %DO, Conductivity, pH, Temperature ***Little Glen -*** -Microcystis sampling (late summer) when indicated ***Crystal River -*** - Hydrolab - mid-depth DO, %DO, Conductivity, pH, Temperature (3 sites) ***Hatlem Creek -*** - Hydrolab: mid-depth DO, %DO, Conductivity, pH, Temperature (2 sites) – Macroinvertebrate collection and stream rating 2x/year, (spring and fall)	H Ongoing	$35,000/yr		X ⟶	⟶	⟶	⟶	⟶	⟶	⟶	⟶	⟶	⟶	GLA, FoCR, SLBE, LC, USGS	2.1, 2.2, 2.9

Categories/Tasks		**Priority:** *High (H), Med (M), Low (L)* **Duration** (yrs)	**Estimated Cost**	**Milestone**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Potential Project Partners**	**Objective(s) Addressed**
CATEGORY 13 – MONITORING *(CONT'D)*																
13.6	Determine levels of Copper Carbonate (CuCO3) in lake bottom sediments (Copper Sulfate has been a widely used treatment for the control of swimmers' itch.)	M 3	$10,000	• Little Glen by 2013 • Big Glen by 2015					X	—	X				MDEQ, MDNR, GLA, FoCR, LC, SLBE, USGS	1.8, 2.8, 4.6
13.7	Maintain current MDNR monitoring program of fish surveys and angler creel counts to track changes in watershed.	M Ongoing	$100,000	• Evaluate trends every 5 years	X	—	—	—	—	—	—	—	—	→	MDEQ, MDNR, SLBE	4.1, 4.2
CATEGORY 14 – DESIRED USES **Goals addressed: 4, 6**																
14.1	Develop recreational carrying capacity model for Crystal River and Glen Lake.	H 10	$100,000	• Model developed by 2017							X	—	X		GLA, FoCR, LC, SLBE, USGS, NPS	6

Category Costs

The total cost for implementation efforts for all categories was determines (Table 30). The total cost for implementation of the GL-CR Watershed Plan (excluding outreach activities) is just under $6.9 million.

TABLE 30: SUMMARY OF IMPLEMENTATION TASK COSTS BY CATEGORY

Category	Cost
Shoreline Protection and Restoration	$153,000
Road Stream Crossings	$103,000
Habitat, Fish, and Wildlife	$290,000
Stormwater	$125,000
Wastewater and Septics	$57,500
Human Health Issues	$65,000
Wetlands	$125,000
Invasive Species	$215,000
Land Protection and Management	$4,013,000
Development	$310,000
Zoning and Land Use	$208,000
Groundwater	$581,000
Monitoring	$532,500
Desired Uses	$100,000
Grand Total	**$6,878,000**

7.4 *Information and Education Strategy*

One of the most important tools to use when implementing watershed protection is an effective outreach and education campaign. Watershed residents, local leaders, and tourists alike are often under-educated when it comes to watershed issues. This Information and Education (IE) Strategy addresses the communication needs associated with implementing the Glen Lake-Crystal River Watershed Management Plan.

A variety of means have already been used by the GLA and other organizations to inform the public regarding water quality issues for both Glen Lake and Crystal River. Both the GLA and Leelanau Conservancy have effective outreach strategies and philosophies. The GLA has produced two separate handbooks associated with Glen Lake and the GL-CR watershed. The first was the Glen Lake-Crystal River Watershed Landowner's Handbook (Stone 2005), which explains a multitude of watershed concepts and outlines existing and potential threats to the watershed. It also discusses BMPs and actions landowners and residents can take to reduce pollution impacts to the watershed. The second was the Glen Lake-Crystal River Watershed Stewardship Checklist which further outlines actions residents can take on their property to protect water quality (Litch 2005).

Local Research Findings

The Glen Lake Crystal River watershed is unique in character; much of the watershed is located within National Park boundaries and is rural in nature. Many, if not most, riparian landowners are not permanent residents, which provides a dilemma on how best to educate this important segment of watershed residents that are only here part time.

There has not been any local research regarding public knowledge of watersheds and water quality issues, but a survey completed in nearby Grand Traverse Bay watershed by The Watershed Center Grand Traverse Bay in 2002 identified a major gap in knowledge amongst watershed residents. 60% of the respondents answered "don't know" when asked which watershed they lived in (TWC 2005). This basic fact indicates that watershed organizations have a long way to go in informing and engaging the public in watershed issues.

The same study pointed out that though many area residents routinely express concern about environmental issues, there is a lack of understanding of the key issues that face the watershed. Residents in the Grand Traverse Bay watershed perceive that business and industry (17%) and sewage treatment plants (16%) are the main causes of water pollution to the bay. In truth, the Grand Traverse Region is dominated by non-smokestack industries and comparatively few discharge permit holders. Additionally, when asked what they believe to be the least cause of water pollution in the Bay, and area lakes, streams and rivers, respondents indicated the "day to day actions of individuals" as the second least likely pollutant. These two findings would seem to indicate that the general public sees sources outside their individual control to be more responsible for existing and potential water quality problems (TWC 2005)

Information Source	Percent
Newspaper	46.6%
TV News	13.7%
Environmental organization newsletters	7.3%
Friends, neighbors, coworkers	5.2%
Other organizations (churches, clubs, etc)	2.6
Magazines	2.3
Radio	1.6
Schools	1.3

Other key findings relevant from the Grand Traverse survey point out that most people get their information about the environment and water quality from newspapers and television. When this question was cross-tabulated with the respondents' age, more detail was revealed about where specific age demographic groups obtain their information about the environment (TWC 2005).

Age Range	Preferred Source		Education Level	Preferred Source
18-25	Schools		**Graduate Degree**	Environmental newsletters or friends, neighbors and relatives
26-35	TV News		**Some post grad**	Environmental group newsletters, newspapers
36-55	Newspapers		**College degree**	Environmental group newsletters, newspapers
56-65	Environmental Newsletters		**Some college, high school or some high school**	Television news
66+	Newspapers			

Summary of Regional Environmental Education and Outreach Research

Note: *The following is an excerpt from the IE Strategy outlined in Chapter 7.3 in the Grand Traverse Bay Watershed Protection Plan (TWC 2005). Even though the two watersheds differ immensely in size, the summary of research findings is relevant to the GL-CR watershed and will be helpful when implementing the outreach plan. When it comes to watershed education in Northern Michigan, most of the same issues and attitudes are the same across watershed and municipal boundaries.*

Recent regional and national research surveys regarding the environment confirm the basic findings of the Grand Traverse Bay surveys. A recent Roper study (Roper 2001) indicates that while there is increasing public concern about the environment, the majority of the public still does not know the leading causes of such problems as water pollution, air pollution and solid waste. This finding was also confirmed in work done by The Biodiversity Project (2003) as part of their Great Lakes Public Education Initiative. Their research involved both a public opinion poll and a survey of organizations, agencies and institutions engaged in public education efforts on Great Lakes topics. An excerpt follows:

> "...organizations are making a concerted effort to provide reliable information to people who can make a difference when it comes to improving the environmental conditions in the Great Lakes Basin. However, the public opinion poll shows that, for the most part, people are just not grasping the importance of the issues facing the Great Lakes in three important ways: the seriousness of the threats, the

need for urgency in taking action to address the threats, and ways that individuals can make a difference. This led us to examine the discrepancy between the level and focus of current communications and public education efforts and the gaps in public awareness. Because of this discrepancy, we concluded that the public knowledge gaps are likely to be attributed to other factors besides the content and volume of materials. Likely factors include the following three points.

- Limited use of targeting (tailoring messages and delivery strategies to specific audiences).
- Heavy reliance on printed materials and the Web – reaching already interested knowledge seekers; limited use of television and other communication tools that reach broader audiences.
- Multiple, complex, detailed information as opposed to broad, consistent unifying themes."

The report goes on to conclude that educators need "to pay attention to a full spectrum of factors that act as barriers to the success and impact of public outreach." Factors to be considered include:

- **Targeting** – Avoid the one-size-fits-all approach.
- **Delivery** – As resources allow, use the mediums and venues that best reach the target audience. Brochures are easy, the web is cheap, but television is the most used source of information about the environment.
- **Content** – Facts and figures are important to validate a point, but it is important to address the emotional connection needed to address why people should care, why the issue is relevant, effective solutions and what your audience can do about it.
- **Context** – Many environmental threats are viewed by the public as long term issues. Issues need to be communicated in a way that makes them more tangible. Beach closings, toxic pollution, sewage spills and water exports tend to feel more immediate than loss of habitat, land use planning and other big picture issues that citizens feel more disconnected from.

The study identified a list of educational needs and actions that should be incorporated consistently in educational efforts:

- Promote understanding of the system.
- Make the connection to individuals.
- Be local and specific.
- Include a reality check on "real threats." (For example, industrial pollution was a hot topic ten years ago but, many organizations have shifted their education focus to other current and emerging threats, such as stormwater runoff, biodiversity, etc, but the public has not caught up with this shift.)
- Emphasis on "why is this important to you" messages.
- Make the connection to policy.

Both local and regional research indicates that there are considerable gaps in the public's knowledge and understanding of current environmental issues. But, this knowledge gap is tempered by keen public interest and concern for the environment. Watershed organizations need to do a better job of making issues of concern relevant to their audiences. There is a need for ongoing, consistent and coordinated education efforts targeted at specific groups, addressing specific threats.

The following IE strategy addresses some of these concerns. Both local and regional opinion research findings should be considered carefully when developing messages and delivery mechanisms for IE strategy implementation.

Goals and Objectives

The goal of the IE strategy is to ***"Establish and promote educational programs that support effective watershed preservation and increase stewardship."*** Fixing an erosion problem at a road stream crossing does not involve a high degree of public involvement. But, developing and carrying out a regional vision for stewardship of water resources will require the public and community leaders to become more knowledgeable about the issues and solutions, more engaged and active in implementing solutions and committed to both individual and societal behavior changes.

The objectives of this plan focus on building awareness, educating target audiences, and inspiring action. Five major objectives have been identified:

- To raise community awareness and knowledge about Glen Lake, the Crystal River, and the rest of the watershed, the interconnectedness of the system and the role that an individual's day-to-day activities can play in protecting the resource.
- To develop a set of consistent messages that can be used by partners in a variety of communications.
- To involve citizens, public agencies, user groups and landowners in the implementation of the watershed management plan.
- To regularly inform stakeholders about the watershed, implementation activities and successes and opportunities to participate.
- Motivate target audiences to adopt behaviors and implement practices that result in water quality improvements.

Target Audiences

A number of diverse regional audiences have been identified as key targets for IE strategy implementation. The targets are divided into user groups and decision-making groups.

<u>User Groups</u>

Households – The general public throughout the watershed.

Riparian Landowners – Due to their proximity to a specific waterbody, the education needs of riparian landowners are different.

Tourists – Tourism is the number one industry in the region. This area is known for its scenic beauty and recreational opportunities; the SLBE alone receives more than one million visitors a year. This seasonal influx of people puts a noticeable strain on area infrastructure and often the environment. There is a growing concern that this important economic segment could eventually destroy the very reason why it exists, and that the region's tourism "carrying capacity" may soon be reached. There is clearly a growing need to educate tourists about their role in protecting the GL-CR environment.

Builders/Developers/Real Estate – This region is one of the fasting growing areas in Michigan in terms of population and land use. Increasingly, homes around and near Glen Lake are being converted from small seasonal cottages to larger year round homes. Additionally, new developments are popping up all over the watershed. Members of the development industry segment play a crucial role in this growth and providing ongoing education opportunities about their role in protecting water quality and environmental health is critical.

Education – Area educators and students, primarily K-12.

Special Target Audiences – In addition to the above, certain user groups such as recreational boaters, other sports enthusiasts, garden clubs or smaller audience segments may be targeted for specific issues.

Local Government Decision Makers

Elected/Appointed Officials – Township, village, city, and county commissioners; planning commissions; zoning board of appeals; road and drain commissioners; etc.

Staff – Planners, managers, township supervisors, zoning administrators, etc.

Message Development

General message outlines have been established for each target audience. These messages will be refined as implementation moves forward. They may also be modified or customized depending on the message vehicle.

Target Audience	Messages
Households	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Water quality-friendly lawn and garden practices • Housekeeping practices and the disposal of toxic substances • Septic maintenance • Managing stormwater on your property
Riparian Landowners	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Riparian land management including the importance of riparian buffers • Water quality-friendly lawn and garden practices • Septic system maintenance • Housekeeping practices and the disposal of toxic substances
Tourists	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Help us protect the beauty that you enjoy when you are a guest • Clean boating practices • Role in controlling the spread of aquatic invasive species • Carrying capacity limits

Target Audience	Messages
Builders, Developers, Real Estate	• Advantages of and opportunities for Low Impact Development • Identification and protection of key habitats and natural features: aquatic buffers, woodlands, wetlands, steep slopes, etc. • Advantages of and opportunities for open space protection and financial incentives for conservation • Minimize the cutting of trees and vegetation • Impact of earthmoving activities, importance of soil erosion and sedimentation control practices, construction BMPs • Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed
Education	• Adoption and promotion of a state-approved watershed curriculum in K-12 schools. • Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Connection between watershed organization's programs and school activities • Active participation in watershed protection activities and stewardship
Local Government Decision Makers	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • The leadership role that local governments can play in protecting the watershed • The importance of establishing sound, enforceable natural resource protection ordinances • Economic impact and advantages of environmental protection

**Table adapted from Grand Traverse Bay Watershed Protection Plan (TWC 2005)*

Action Plan to Implement Strategies

A complete list of tasks by category follows this narrative; the categories are the same as those used to outline the implementation tasks in Section 7.3. Several priority areas for the GL-CR watershed have been identified and the plan for rolling out the IE Strategy will correspond to these priority areas (Section 5.3, Table 18 and 19, Figure 7). Additionally, the IE Strategy will support other implementation efforts to control nutrient loading, sedimentation, the impacts of invasive species in the watershed, and other pollutants outlined in Section 7.3. Considerable effort has already been put into introducing stakeholders to the original watershed management plan and its various findings and conclusions.

The IE Strategy tasks use a diverse set of methods and delivery mechanisms. Workshops, presentations, demonstration projects, brochures, public and media relations, web sites and other communications tools will be used for the different tasks and target audiences. Broadcast media, most importantly television, is beyond the reach of most area partner organizations – at least at a level of reach, frequency and timing that can be expected to have any impact on awareness and behavior. This is a barrier to utilizing this effective medium, but effort should be placed on building coalitions that can pool resources to address larger picture issues through broader-based, more long-term communications efforts.

INFORMATION AND EDUCATION STRATEGY IMPLEMENTATION TASKS

GOAL 6: Promote and establish educational programs that support watershed planning goals, objectives and tasks, and increase stewardship.
Pollutants Addressed: All

Categories:

- G. General
- 1. Shoreline Protection and Restoration
- 2. Road Stream Crossings
- 3. Habitat, Fish and Wildlife
- 4. Wastewater
- 5. Human Health
- 6. Wetlands
- 7. Invasive Species
- 8. Land Protection and Management
- 9. Development
- 10. Zoning and Land Use
- 11. Groundwater and Hydrology

Note: The stormwater and Monitoring categories from the previous section are not included in the IE plan.

Organization Acronyms:

BLHD – Benzie-Leelanau Health Department
CRA – Conservation Resource Alliance
CRO – Crystal River Outfitters
EPA – Environmental Protection Agency
FERC – Federal Energy Regulatory Commission
FoCR – Friends of the Crystal River
GLA – Glen Lake Association
ISEA – Inland Seas Education Association
LeeCty – Leelanau County
LC – Leelanau Conservancy
L-CD – Leelanau Conservation District
LCRC – Leelanau County Road Commission
LGOV – Local Governments
MDEQ – Michigan Department of Environmental Quality
MDNR – Michigan Department of Natural Resources
M-DOT – Michigan Department of Transportation
MSU-E – Michigan State University Extension
NPS – National Park Service Water Resources Div.
NRCS – USDA Natural Resources Cons Service
NWMCOG – Northwest Michigan Council of Governments
OWTTF – Onsite Wastewater Treatment Task Force
SLBE – Sleeping Bear Dunes National Lakeshore
USGS – United States Geological Survey
USCG – United States Coast Guard

Other Organizations:

Area Libraries
Boat/Marine Retailers
Garden Centers
Landscaping Companies
Leelanau County Chamber of Commerce
Local Realtors, Businesses
Trash Haulers
Schools (The Leelanau School, Glen Lake High School)

Target Audiences Include:

Builder/Developer/Realtor
Education
Households
Local Governments
Riparian Landowners
Tourists
General

Estimated Costs, Timeframes, and Milestones:
For costs associated with salaries, an average watershed technician rate of $35/hour was applied. For tasks to be completed by a specialized consultant, a rate of $50/hour was used. Tasks that will be done on a yearly or site by site basis are noted as such ($X/yr or $X/site). The Glen Lake Association employs a Watershed Biologist who will be doing much of the education work both on the lake and throughout the watershed area over the course of implementing the strategy. Appendix B lists average rates for costs associated with educational materials. Further details are noted where applicable. In general, funding for short-term tasks (1-5 years) will be attained through state and/or Federal grants, other non-profit grant programs, partner organizations' budgets, fundraising efforts, and private foundations. Funding for long-term tasks will be addressed as needed.

Milestones for the IE Strategy were harder to define because many of the tasks are ongoing. Additionally, the best way to conduct outreach activities is continually evolving and depends on the audience one is trying to reach. This is why many of the IE tasks are general and only outline the audience to reach and the message to convey, but don't include specifically how to convey that message. All of the tasks in the following pages outline the target audience reached for each task, as well as what frequency the task should be performed and the method or medium that should be used to reach the audience (i.e., newsletter, website, workshop, etc.).

IE Categories/Tasks		Priority: *High (H), Med (M), Low (L)* Duration (yrs)	Estimated Cost	Target Audiences	Frequency	Medium or Method	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners
IE CATEGORY G - GENERAL																	
G.1	Publish Newsletter every 4 months to GL-CR Watershed residents	H Ongoing	$3,500/yr (staff and printing costs)	Households	3 times a year	Newsletter	X									→	GLA
G.2	Provide watershed information and news to local and regional media on regular basis	M Ongoing	$1,000/yr (staff costs)	General	6x/year	-Leelanau Enterprise articles -Record Eagle articles	X									→	GLA, NPS, LC
G.3	Maintain and promote current GLA Website with info about watershed: include videos	H Ongoing	$1,000/yr (staff costs)	Riparians General LGov Agencies	Monthly Update	-Website	X									→	GLA, NPS, LC
G.4	Develop GL Watershed steward awards	H Ongoing	$300/yr (staff costs)	Riparians LGov Agencies Education Households	1x/year	-Awards in Newsletter -Awards in media -Presented at Annual Meetings	X									→	GLA, NPS, LC
G.5	Watershed maps for landowners, government and others	H Ongoing	$2,000 (reprint costs)	Riparians Agencies LGov	Ongoing via Handbook	-Ongoing distribution	X									→	GLA, MI MAPS
G.6	Develop public attitude survey (as well as follow up surveys) to determine and monitor the public's awareness regarding watershed and water quality issues	H Ongoing	$15,000 each survey (consultant)	Households	Every 5 years	-phone calls or mailed survey		X					X				GLA, FoCR, NPS, LGov
G.7	Watershed display for existing kiosks in Glen Arbor and Empire	L 8	$200/year (staff costs)	General	Update every 6 months yearly	-Develop -Post -Updates			X							→	GLA, NPS, FoCR

	IE Categories/Tasks	Priority: High (H), Med (M), Low (L) Duration (yrs)	Estimated Cost	Target Audiences	Frequency	Medium or Method	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners
IE CATEGORY 1 – SHORELINE PROTECTION AND RESTORATION																	
Educate the public, new home owners, contractors/builders, landscapers, and garden centers about:																	
1.1	the need for soil testing prior to fertilizer application	H Ongoing	($5,000/yr Portion of Watershed biologist salary)	Riparians Lawn care providers	Biologist visits and follow up-10/year Article 1x/year	-Newsletter article -Handbook -Home Visit by Lake biologist	X →	→	→	→	→	→	→	→	→	→	GLA
1.2	proper use of residential and commercial fertilizers, pesticides, herbicides	H Ongoing	↓	Riparians Lawn care providers	Biologist visits and follow up-10/year Article 1x/year	-Newsletter article -Handbook -Home Visit by Lake biologist	X →	→	→	→	→	→	→	→	→	→	GLA
1.3	environmentally-friendly lawn care contractors, availability of non-phosphorus fertilizers, alternative pest management	H Ongoing	↓	Riparians	Article 1/year Spring Newsletter	-Newsletter article -Handbook -Home Visit by Lake biologist	X →	→	→	→	→	→	→	→	→	→	GLA
1.4	greenscaping, natural shorelines, and naturalization	H Ongoing	↓	Riparians Lawn care providers	Biologist visits and follow up-10/year	-Newsletter article -Handbook -Home Visit by Lake biologist -Annual meeting tri-folds	X →	→	→	→	→	→	→	→	→	→	GLA
IE CATEGORY 2 – ROAD STREAM CROSSINGS																	
2.1	Work with the Leelanau County Road Commissioners and Drain Commissioner regarding BMP at road crossings to reduce harmful sedimentation and stormwater runoff	L Ongoing	$45/hour (Estimate ~ 40 hrs/yr)	Leelanau Road & Drain Comm.	As needed	-Meetings with department heads	X →	→	→	→	→	→	→	→	→	→	LoGOV, LCD, DEQ

	IE Categories/Tasks	**Priority:** *High (H), Med (M), Low (L)* **Duration** (yrs)	Estimated Cost	Target Audiences	Frequency	Medium or Method	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners
IE CATEGORY 3 – HABITAT, FISH, AND WILDLIFE																	
3.1	Educate public re the importance of maintaining diverse wildlife habitats and wildlife corridors on their property	M Ongoing	$100/yr (printing costs)	General Households	1x/year	-Newsletter Article -Annl.Mtg brochure		X	→	→	→	→	→	→	→	→	GLA, CRA, LC, L-CD
3.2	Educate public re the detrimental effects of herbicides/pesticides on fish and wildlife	H Ongoing	$100/yr (printing costs)	General Households		-Newsletter Article -Annl.Mtg brochure		X	→	→	→	→	→	→	→	→	GLA, FoCR, MSU-E, LC, L-CD
IE CATEGORY 4 – WASTEWATER AND SEPTIC																	
4.1	Provide public education regarding using proper septic system design for site conditions, new technology, and maintaining existing systems	H Ongoing	$5,000/yr (Portion of Watershed biologist Salary)	General Households		-Newsletter -Biologist Visits -Annl.Mtg brochure	X	→	→	→	→	→	→	→	→	→	GLA, FoCR, BLHD
IE CATEGORY 5 – HUMAN HEALTH																	
Provide public education regarding:																	
5.1	feeding waterfowl and birds	H Ongoing	$3,000/yr (printing costs)	General Riparians	1x/year	-Newsletter -Handbook	X	→	→	→	→	→	→	→	→	→	GLA
5.2	use of pesticides/herbicides	H Ongoing	↓	Riparians	1x/year	-Newsletter -Handbook	X	→	→	→	→	→	→	→	→	→	GLA
5.3	improper disposal of hazardous wastes including electronics and drugs	H Ongoing	↓	Riparians Households	1x/year	-Newsletter -Handbook	X	→	→	→	→	→	→	→	→	→	GLA
5.4	results of E.coli monitoring	H Ongoing	↓	Riparians NPS	As needed	-Website -Newsletter	X	→	→	→	→	→	→	→	→	→	GLA, NPS, BLHD
5.5	results of water quality monitoring	H Ongoing	↓	Riparians NPS LGov	1x/year	-Website -Newsletter	X	→	→	→	→	→	→	→	→	→	GLA, NPS, BLHD
5.6	results of mycrocystis monitoring	H Ongoing	↓	Riparians NPS General	As needed	-Website -Newsletter	X	→	→	→	→	→	→	→	→	→	GLA, NPS, BLHD

	IE Categories/Tasks	**Priority:** *High (H), Med (M), Low (L)* **Duration** (yrs)	Estimated Cost	Target Audiences	Frequency	Medium or Method	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners
IE CATEGORY 6 - WETLANDS																	
6.1	Educate public, local governments, developers, contractors regarding the benefits of existing wetlands and restoring them.	H Ongoing	$7,000/yr (staff and printing costs)	Riparians LGov Developers Contractors	Ongoing As needed	-Website -Newsletter -Brochures -Maps Consultation	X									→	GLA, L-CD, DEQ, NPS, LC
IE CATEGORY 7 – INVASIVE SPECIES																	
Educate local residents, visitors, garden centers regarding:																	
7.1	The negative impacts of and appropriate control/eradication measures for both aquatic and terrestrial invasive species	H Ongoing	$2,000/yr (staff and printing costs)	Riparians Tourists	Ongoing	-One newsletter article a year -Website -Handbook	X									→	GLA, NPS, L-CD, LC
7.2	Distribute existing fact sheet/brochure to use as handout at garden centers regarding terrestrial invasive species	M 3	$1,000 (printing)	Riparians	Ongoing	-Develop brochure -Distribution to 8 Garden centers			X		X						GLA, NPS, L-CD, LC
7.3	Distribute resource list for native plant species	H Ongoing	$100/yr (staff costs)	Riparians Landscapers Garden Centers	Ongoing	- One newsletter article a year -Website -Sources at Annual Meeting	X									→	GLA, L-CD, JF New
7.4	Create/maintain signs/displays on invasive species prevention at road ends and DNR boat launch	M 7	$5,000	Riparians General	Yearly maintenance	-Plan signs -Secure funding - Obtain permission -Installation				X						→	GLA, L-CD, Leelanau Road Commis-sion

IE Categories/Tasks		**Priority:** *High (H), Med (M), Low (L)* **Duration (yrs)**	Estimated Cost	Target Audiences	Frequency	Medium or Method	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners
IE CATEGORY 8 – LAND PROTECTION AND MANAGEMENT																	
Educate landowners regarding:																	
8.1	voluntary conservation easements	H Ongoing	$200/yr (Partial newsletter cost)	Watershed Riparians	Yearly	-Handbook -Newsletter -Website	X	→	→	→	→	→	→	→	→	→	GLA, LC
8.2	other available land protection measures	H 9	$200/yr (Partial newsletter cost)	Watershed Riparians	Yearly	-Handbook -Newsletter -Website		X	→	→	→	→	→	→	→	→	LC
8.3	ecologically sound riparian shoreline and wetland management practices	H Ongoing	$200/yr (Partial newsletter cost) $5,000/yr (Partial salary of Watershed Biologist)	Watershed Riparians	Yearly And Biologist Home Visits	-Handbook -Newsletter -Website -10 Home Visits by Watershed Biologist	X	→	→	→	→	→	→	→	→	→	GLA, DEQ

IE Categories/Tasks		**Priority:** *High (H), Med (M), Low (L)* **Duration** (yrs)	**Estimated Cost**	**Target Audiences**	**Frequency**	**Medium or Method**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Potential Project Partners**
IE CATEGORY 9 - DEVELOPMENT																	
Educate realtors developers/contractors regarding:																	
9.1	stormwater and sediment management	H Ongoing	$5,000/yr (Partial salaries of Watershed Biologist and Drain Comm.)	Developers Contractors	Every year	-Visit by Watershed Biologist And Drain Commissioner at blding sites	X									→	L-CD, GLA
9.2	environmental laws	M 8	$3,000 (printing costs)	Developers Contractors Realtors	Every year	-Information packets distributed at new building sites			X							→	GLA, NMC, NPS, LoGOV
9.3	improvement and protection of water quality on properties in the watershed	H 9	$5,000/yr (Partial salary of Watershed Biologist and Drain Comm.)	Developers Contractors	Every year	-Visit by Watershed Biologist And Drain Commissioner at blding sites		X								→	GLA, NPS, DEQ
9.4	BMPs for hilltops, hillsides, and lake/river stream construction/development	M 8	$3,000 (printing costs)	Developers Contractors Realtors	Every three years	-Brochure distribution to local builders			X							→	GLA, L-CD

IE Categories/Tasks		Priority: High (H), Med (M), Low (L) Duration (yrs)	Estimated Cost	Target Audiences	Frequency	Medium or Method	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Potential Project Partners
IE CATEGORY 10 – ZONING AND LAND USE																	
Educate planning commissioners and township boards regarding:																	
10.1	the GL-CR Management Plan	H 1	$2,500 (staff costs)	NPS LGov	Initial Distribution	-Distributed to Township Managers, NPS, Road Commission	X										LC, GLA, FoCR, NPS
10.2	information on planning, zoning, and design to protect water quality	H Ongoing	$1,500/yr (staff costs)	LoGOV Rd Com-mission NPS	1x/year	-System of sharing developed -Implement		X→	→	→	→	→	→	→	→	→	LoGOV, GLA
10.3	sharing by townships of model ordinances to protect water/natural resources	H Ongoing	$1,500/yr (staff costs)	GA, Empire and Kasson Township	As needed	-System of sharing developed -Implement		X→	→	→	→	→	→	→	→	→	LoGOV, GLA
IE CATEGORY 11 – GROUNDWATER AND HYDROLOGY																	
11.1	Educate local government, developers/contractors, regarding headwater/groundwater recharge areas and why it is important to protect them	H 1	$10,000 (consultant and staff costs)	GLA, NPS, LGov	Initial Distribution	-Workshops and flyer	X										GLA, NPS, L-CD

The total cost for implementation efforts for all categories was determined (Table 30). The total cost for implementation of the Information and Education Strategy for the GL-CR Watershed Plan is $534,900.

TABLE 31: SUMMARY OF INFORMATION AND EDUCATION TASK COSTS BY CATEGORY

Category	Cost
General	$91,600
Shoreline Protection and Restoration	$50,000
Road Stream Crossings	$18,000
Habitat, Fish, and Wildlife	$2,000
Wastewater and Septics	$50,000
Human Health Issues	$30,000
Wetlands	$70,000
Invasive Species	$27,000
Land Protection and Management	$55,000
Development	$101,000
Zoning and Land Use	$29,500
Groundwater	$10,000
Grand Total	**$534,900**

7.5 Evaluation Procedures

An evaluation strategy will be utilized to measure progress during the Glen Lake-Crystal River Watershed Management Plan's implementation phase and to determine whether or not water quality is improving. The timeline for the evaluation is approximately every 5 years, with ongoing evaluation efforts completed as necessary. The first aspect of the evaluation strategy measures how well we are doing at actually *implementing* the watershed management plan and assesses if project milestones are being met. The second aspect is to evaluate how well we are doing at *improving water quality* in the watershed. The following sections address each of these issues.

Evaluation Strategy for Plan Implementation

This aspect of the evaluation strategy was developed to measure progress during the implementation phase of the watershed management plan and to provide feedback during implementation. The evaluation will be ongoing and will be conducted through the existing Steering Committee. The Steering Committee will meet once a year to assess progress on plan implementation and to learn and share information about existing projects throughout the watershed. In addition, plan tasks, priorities, and milestones will be assessed every 5 years to ensure that the plan remains current and relevant to the region and that implementation is proceeding as scheduled and is moving in the right direction.

The evaluation will be conducted by analyzing the existing watershed management plan goals and objectives, as well as the implementation tasks and 'milestones' in Sections 7.3 and 7.4 to determine progress. Key milestones include establishing riparian buffers and public demonstration sites, protecting critical land areas, and assisting townships with enacting ordinances to protect water quality. The proposed timeline for each task will also be reviewed to determine if it is on schedule. Other anecdotal evidence (not attached to specific plan milestones) also will be noted that indicates the management plan is being successfully implemented, such as an increase in the amount of updated or new zoning ordinances that deal with water quality and natural resource protections in watershed townships and municipalities.

Additionally, a number of other evaluation tasks will be completed due to the variety of tasks involved in the watershed plan. They will include but are not limited to the following:

- Document the effectiveness of BMP implementation by taking photographs, completing site data sheets and gathering physical, chemical and/or biological site data.
- Utilize focus groups to evaluate specific projects throughout plan implementation as needed.
- Conduct targeted surveys of project partners by direct mail, phone or by website to assist in information gathering.
- Maintain a current list of future target projects, the status of ongoing projects, and completed projects, along with their accomplishments. Keep track of the number of grants received and the dollars committed in the watershed region to implement aspects of the plan.

The purpose of the evaluation strategy is to provide a mechanism to the Steering Committee to track how well the plan is being implemented and what can be done to improve the implementation process. Additional development of the strategy will occur as the implementation phase unwinds.

Measuring and Evaluating Social Milestones

Section 7.4 outlines an Information and Education Strategy that addresses the communication needs associated with implementing the management plan. The strategy is important because developing and carrying out a vision for stewardship of the region's water resources will require the public and community leaders to become more knowledgeable about the issues and solutions, more engaged and active in implementing solutions and committed to both individual and societal behavior changes. Residents, local officials, homeowners, and the like must be educated and motivated to adopt behaviors and implement practices that result in water quality improvements.

In this respect, it is important to measure and keep track of the social impacts of the GL-CR Management Plan. The GLA and other organizations conducting outreach must find out what types of outreach are working in the community and what types aren't, along with how people's attitudes and behaviors are impacted. Just how much is social behavior changing because of the plan implementation? To answer this question, social impacts must be included when evaluating the progress of plan implementation.

Key social evaluation techniques that will be used to assess the implementation of the IE Strategy, as well as other watershed BMPs, include:

- Continued cooperation between area organizations submitting proposals to implement aspects of management plan.
- Social surveys (and follow up surveys) for homeowners, local officials, etc. to determine watershed and water quality awareness.
- Determining any increases in 'watershed friendly' design and construction (anecdotal evidence will be used).
- Increased awareness (from both the general public and local government officials) regarding the necessity of stormwater improvement.
- Increase in the number of communities implementing water quality protection related ordinances.
- Incorporating feedback forms into educational and public events and posting them on he Glen Lake Association's website www.glenlakeassociation.com.
- Maintaining a list of ongoing and completed projects protecting water quality, along with their accomplishments and who is completing/completed the project. (This task is also found in next section relating to evaluating the water quality improvements.)

Evaluation Strategy for Determining Water Quality Improvement

The EPA dictates that watershed management plans must outline a set of criteria to determine whether proposed load reductions in the watershed are being achieved over time and that substantial progress is being made towards attaining water quality standards. **In the case of the GL-CR watershed, overall water quality is excellent (Section 3.11) with some pollutant threats; therefore no specific watershed goals were made regarding load reductions.** Instead, the project Steering Committee made a broad goal to maintain current levels of phosphorus and nitrogen in Glen and Fisher Lakes (Chapter 6: Goal #2, Objective #2).

However, since the watershed area itself has threats and problem areas, it is stressed that improvements must be made now in order to maintain the current water quality and protect it into the future. Most watershed goals outlined in Chapter 6 seek to maintain or improve the current state of water quality and habitat, as well as increase awareness of this valuable resource. Additionally, the Steering Committee will focus on land protection measures to protect the critical, high quality groundwater recharge areas that are so important to maintaining excellent water quality.

In addition to conducting an evaluation every 5 years regarding protection plan implementation, the Steering Committee will evaluate whether or not water quality in Glen Lake, Crystal River, and its watershed is declining, improving, or staying the same. Criteria or milestones to be used to evaluate changes are outlined in Table 32:

TABLE 32: CRITERIA TO EVALUATE WATER QUALITY GOALS IN GL-CR WATERSHED

Criteria Used	**Current Conditions** ***(For more details see Section 3.10)***	**Source**
No statistically significant increases in averages of Phosphorus or Nitrogen concentrations in Glen Lake or Crystal River	**Phosphorus** Big and Little Glen Lakes: Spring overturn – 2001-2005 average = 6µg/L Late Summer – 2001-2005 average = 6µg/L (5.8µg/L for Little Glen) Crystal River: 1992-1996 TP: 7µg/L (LWC	Glen Lake Association Leelanau Conservancy
	Nitrogen Big Glen Lake: 1990-2001 average Nitrate-N = 70µg/L Little Glen Lake: 1990-2001 average Nitrate-N = 55µg/L Crystal River: 1992-1996 Nitrate+Nitrite = 28µg/L	Glen Lake Association
Documented decrease (or no statistically significant change) in the CSI value of cladophora beds/mats along Glen Lake	CSI values over 50 - 2007: 25 out of 207 (12%) 2006:43 out of 191 (23%) *Over half have lawn fertilization noted as the probable source	Glen Lake Association
No *E.Coli* levels exceeding Michigan and USEPA water quality standards for both single day measurement and 30-day geometric mean measurement	Little Glen Lake public access in SLBE: 2006 levels averaged 20 col/100mL Hatlem Creek: 2007 – Three locations tested extremely high in 2007 (on first order tributary on Plowman Road - see page 76 for discussion)	Sleeping Bear Dunes National Park Glen Lake Association

**For State water quality criteria see Table 13*

In addition, the following will also be used:

- Monitoring results that indicate no harmful changes to water quality or biological indicators measured throughout the watershed.
- Determine number of environmental efforts/projects in the watershed and how many organizations are currently working to protect water quality in the area. Maintain a list of ongoing projects and completed projects, along with their accomplishments. (This task is also found in previous section relating to evaluating the plan implementation.)
- Stream macroinvertebrates surveys throughout the watershed indicating excellent water quality (DEQ P51 studies showing station rankings from good to excellent).

CHAPTER 8 FUTURE EFFORTS

The Glen Lake Association, Friends of the Crystal River, Leelanau Conservancy and other project partners will continue to build partnerships with various groups throughout the watershed for future projects involving the implementation of recommendations made in this watershed plan. Continued support and participation from key partner groups, along with the availability of monies for implementation of the plan is necessary to keep the momentum generated by planning efforts. Partners responsible for the implementation of the plan are encouraged to review the plan and act to stimulate progress where needed and report to the larger partnership.

In order to monitor the water quality in the watershed, the Leelanau Conservancy, Glen Lake Association, and the Sleeping Bear Dunes National Lakeshore plan to continue their extensive baseline monitoring programs. Any noted increases in nutrient and other water quality parameters will be noted.

The Leelanau Conservancy will continue to evaluate the extent of development on parcels in critical areas deemed important to protecting high water quality and fish and wildlife habitat, along with the region's scenic and natural character. Conservation easements established with interested landowners will help to reduce the development rate of such parcels, as well as prevent additional pollutants from entering the watershed. The Conservancy has a goal of protecting an additional 450 acres of critical watershed area and 500 acres of scenic forest ridgelines by 2018.

Important issues facing the watershed include: increasing development and the associated pollution it brings, invasive species, and residential runoff into waterways. Priority will be given to implementation tasks (both BMPs and educational initiatives) that work to reduce the effects from these sources.

It is expected that the implementation phase will last more than 10 years, with some efforts expected to be conducted on a yearly basis indefinitely (i.e., monitoring). Grant funds and other financial sources will be used to implement tasks outlined in Chapter 7, including the continuation of water quality assessment and monitoring, installation and adoption of various Best Management Practices (Section 7.3), and educational tasks outlined in the IE Strategy (Section 7.4 In general, funding for short-term tasks (1-5 years) will be attained through state and/or Federal grants, other non-profit grant programs, partner organizations' budgets, fundraising efforts, and private foundations. Funding for long-term tasks will be addressed as needed. The GL-CR Watershed Steering Committee should continue to meet yearly during the implementation period.

Priority tasks that should be conducted over the next 1 – 3 years are as follows, with the most important tasks listed first:

- Continue monitoring programs
- Begin initial outreach and education efforts outlined in the IE strategy – focusing on general watershed information, invasive species prevention, benefits of water quality protection ordinances and conservation easements, wetland preservation, and pollution stemming from residential areas
- Initiatives to preserve land and wildlife corridors (i.e. conservation easements)
- Establish riparian buffers in priority areas
- Assist with developing or revising Master Plans and Zoning Ordinances to include more water quality protection (i.e., buffer setbacks, septic system point of sale ordinances, etc.)
- Wetland assessment, restoration, and protection

Public Outreach

The GL-CR Watershed Information and Education Strategy (Section 7.4) highlights the actions needed to successfully maintain and improve watershed education, awareness, and stewardship for the GL-CR watershed. It lays the foundation for the collaborative development of natural resource programs and educational activities for target audiences, community members, and residents. Environmental awareness, education, and action from the public will grow as the IE Strategy is implemented and resident awareness of the watershed is increased. Implementing the IE Strategy is a critical and important long-term task to accomplish.

Initial IE efforts concerning the GL-CR watershed began a long time ago by the Glen Lake Association. GLA produced a Stewardship Guidebook and Checklist mentioned previously (in Section 7.4, IE Strategy), and continues to distribute these widely throughout the watershed. Additionally, GLA and The Leelanau Conservancy host educational workshops and tours, as well as operate informative websites that seek to educate watershed residents. These outreach activities should be continued and paired with additional ones outlined in this management plan. Considerable time and effort should also continue to be put into introducing stakeholders to the watershed management plan and its various findings and conclusions, as well as providing general information about the GL-CR watershed and its beautiful and unique qualities.

During the implementation phase of the IE Strategy, the critical first steps to take will be to build awareness of basic watershed issues and sources of pollution, as well as how individual behaviors may impact the health of the watershed. It will also be necessary to continue to introduce stakeholders to results and information provided in the revised management plan and show them how they can use the plan to protect water quality in the region.

CHAPTER 9 CONCLUSIONS

The Glen Lake-Crystal River Watershed Management Plan was developed to help guide efforts to protect water quality of Glen Lakes and its surrounding watershed. The initial planning phase of the plan (culminating in January 2003), allowed key decision-makers, organizations, agencies, and the public to learn about the watershed in which they live. The original plan was prepared by the Leelanau Conservancy with collaboration and input from major watershed stakeholders including the Glen Lake Association, The Friends of the Crystal River, Sleeping Bear Dunes National Lakeshore, Conservation Resource Alliance and local units of government.

Three years later, the same groups again got together to update the watershed plan to include additional information according to newly implemented EPA requirements. This 2009 revised plan includes additional information on pollutant sources and concentrations, load reduction estimates of various BMPs, measurable milestones to guide plan implementation progress, and a set of criteria to evaluate the effectiveness of implementation efforts. The recommendations outlined in Chapter 7 of this plan will provide guidelines to all types of organizations for taking action during the implementation phase of the project and will be a useful tool in addressing current and future water quality threats to the watershed. The GL-CR Watershed Management Plan is meant to assist decision-makers, landowners, residents, and others in the watershed in making sound decisions to help improve and protect water quality in their area.

The GL-CR watershed is an extremely unique ecosystem with excellent water quality and little development; in fact, most of the watershed area is forested or in the Sleeping Bear Dunes National Lakeshore boundaries. There are, however, some important issues facing the watershed, such as increasing development, the threat of invasive species, and residential runoff into waterways. Priority should be given to implementation tasks (both BMPs and educational initiatives) that work to reduce the effects from these sources. The watershed plan also delineates critical areas to identify specific places in the watershed that are most sensitive to environmental impacts and have the greatest likelihood to affect water quality and aquatic habitat (Figure 7). It is in these areas that the bulk of implementation efforts mentioned above should be focused.

The success of the GL-CR Watershed Management Plan will depend on continued support and participation from key partner groups, along with the availability of monies for implementation of the plan. Partners responsible for the implementation of the plan are encouraged to review the plan and act to stimulate progress where needed and report to the larger partnership.

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APPENDICES

APPENDIX A:
ROAD CROSSING ANALYSIS AND RANKING

Crystal River

Factors	Points	C-1	C-2	C-3	C-4	C-5	C-6	C-7
Road Surface	Paved: 0 Gravel: 3 Sand and Gravel: 6 Sand: 9	0	0	0	0	0	0	0
Length of Approaches	0-40 ft: 1 41-1000 ft: 3 1001-2000 ft: 5 >2000 ft: 7	3	3	3	3	1	3	3
Slope of Approaches	0%: 0 1-5%: 3 6-10%: 6 >10%: 9	3	0	3	3	0	6	0
Width of road, shoulders, and ditches	<15 ft: 0 16-20 ft: 1 >20 ft: 2	2	2	2	2	2	2	2
Extent of Erosion	Minor: 1 Moderate: 3 Extreme: 5	1	5	3	3	1	3	1
Embankment Slope	Bridges: 0 >2:1 slope: 1 1.5-2:1 slope: 3 Vertical or 1:1 slope: 5	5	5	3	5	0	5	5
Stream Depth	0-2 ft: 1 >2 ft: 2	1	1	1	1	2	1	1
Stream Current	Slow: 1 Moderate: 2 Fast: 3	1	2	1	1	1	1	1
Vegetative cover of shoulders and ditches	Heavy: 1 Partial: 3 None: 5	3	3	3	3	2	2	1
TOTAL		19	21	19	21	9	23	14
RANK		mod	mod	mod	mod	min	mod	min

- C-1 (Fisher Lake outlet u/s Crystal River Dam) – moderate (road runoff and culvert erosion)
- C-2 (CR 675, in SLBE boundary) – moderate (failing retaining wall, misaligned culvert)
- C-3 (CR 675, middle of three crossings) – moderate (culvert, streambank, shoulder erosion)
- C-4 (CR 675, close to M-22) – moderate (road runoff, ditch/embankment/culvert erosion)
- C-5 (M-22) – minor (recently redone, open bottom bridge w/ runoff control features)
- C-6 (Homestead Resort) – moderate (failing retaining walls, culvert filling in, woody debris blocking and altering flow, road/bank slumping, shoulder/ditch erosion)
- C-7 (Tucker Lake outlet to Fisher Lake) - minor

Hatlem Creek

Factors	Points	HC-1	HC-2	HC-3	HC-4	HC-5	HC-6	HC-7
Road Surface	Paved: 0 Gravel: 3 Sand and Gravel: 6 Sand: 9	0	0	6	0	0		
Length of Approaches	0-40 ft: 1 41-1000 ft: 3 1001-2000 ft: 5 >2000 ft: 7	3	3	3	3	3		
Slope of Approaches	0%: 0 1-5%: 3 6-10%: 6 >10%: 9	6	5	6	2	2		
Width of road, shoulders, and ditches	<15 ft: 0 16-20 ft: 1 >20 ft: 2	2	2	1	2	2		
Extent of Erosion	Minor: 1 Moderate: 3 Extreme: 5	1	1	3	3	1		
Embankment Slope	Bridges: 0 >2:1 slope: 1 1.5-2:1 slope: 3 Vertical or 1:1 slope: 5	3	3	5	5	5		
Stream Depth	0-2 ft: 1 >2 ft: 2	1	1	1	1	1		
Stream Current	Slow: 1 Moderate: 2 Fast: 3	2	2	2	2	1		
Vegetative cover of shoulders and ditches	Heavy: 1 Partial: 3 None: 5	1	1	1	1	1		
TOTAL		19	18	28	19	16		
RANK		mod	mod	mod	mod	mod	min	min

APPENDIX B:
AVERAGE RATES FOR COSTS OF INSTALLING STANDARD BMPS

[AS FOUND IN GRAND TRAVERSE BAY WATERSHED PROTECTION PLAN (TWC 2005) & COMPILED BY: FISHBECK, THOMPSON, CARR & HUBER, INC. – 2002]

Average Rates for Costs of Installing Standard BMPs –
As compiled by Fishbeck, Thompson, Carr & Huber, INC. 2002

Best Management Practices Cost Estimates*

Task	Costs	Units	Output	Notes	Source
Agriculture					
Conservation Tillage	$ 10.00	acre			NRCS
Fertility Testing	$ 2.75	acre		Lab testing done to MSU standards	MDA Conservation Service 1992 adjusted for inflation
IPM	$ 5.75	acre			MDA Conservation Service 1992 adjusted for inflation
Windbreaks	$ 2.00	foot		4200 feet needed for a square 40 acre field. Protects ten times as trees are high	NRCS
Cover Crop	$ 14.00	acre		sweet clover if using forage for harvest results in gain of $125/acre	NRCS
Critical Area Planting	$ 1,300.00	acre		Includes: grading, planting, herbicides, mulch, and labor.	NRCS
Livestock Exclusion	$ 3.50	foot			NRCS
Agriculture Crossing	$ 1,200.00	crossing	2/day		NRCS
Watering site	$ 5,100.00	site	.5/day	Well, pump, pipe and water facility	NRCS
Rental Rate	$ 58.00	acre		10 year lease $150/acre with grants	NRCS
Riparian Forested Buffer	$ 900.00	acre		Use of herbicides and establishiment and maintenance	NRCS

Riparian Herbaceous Buffer	$ 225.00	acre		On tilled land includes establishment and maintenance	NRCS
Filter Strip	$ 190.00	acre		establishment, herbicides, fertilizer, and lease	NRCS
Zebra Mussel Control	$ 440.00	acre		Irrigation system to control Zebra Mussels for a 1800 acre establishment	American Water Works Association, 1990 adjusted for inflation
Solar Irrigation Pump	$ 2,500.00	unit	3/day	Pump, controller, pipe, and collector	www.solarelectric.com
Waste Storage Lagoon	$ 45,000.00	unit			NRCS
Stream Erosion					
Live crib wall	$ 25.00	square foot	25 ft/day	see habitat restoration	Rogue River National Wet Weather Demonstration Project
Live staking	$ 2.50	stake		with 3 crew and foreman	Rogue River National Wet Weather Demonstration Project
Vegetated geogrid	$ 20.00	square yard		with 3 crew and foreman	Rogue River National Wet Weather Demonstration Project
Live fascine	$ 9.00	foot		with 3 crew and foreman	Rogue River National Wet Weather Demonstration Project
Brush layer	$ 13.00	foot		with 3 crew and foreman	Rogue River National Wet Weather Demonstration Project
Branch packing	$ 25.00	foot		with 3 crew and foreman	Rogue River National Wet Weather Demonstration Project
Coconut roll	$ 15.00	foot		with 3 crew and foreman	Gull Lake Shoreline Project
Joint Planting	$ 9.00	stake		with 3 crew and foreman	Rogue River National Wet Weather Demonstration Project 4 member crew with foreman
Riprap	$ 60.00	square yard		includes geotextile fabric: 2 member crew and foreman using heavy equipment	Means 1996 and adjusted for inflation: Includes heavy equipment rental

Tree revetments	$ 12.00	foot	with 3 crew and foreman	Means 1996 and adjusted for inflation
Bank Shaping	$ 15.00	cubic yard	With Heavy Equipment	NRCS
Average Bio-Engineering	$ 22.00	foot	Using soft methods only	NRCS
Average Streambank Restoration	$ 32.00	foot	Using hard methods and bioengineering	NRCS
Hydroseeding and Mulch	$ 2,200.00	acre		NRCS
Tile Outlet				
Riprap	$ 75.00	square yard	includes geotextile fabric: 2 member crew and foreman using heavy equipment	Means 1996 and adjusted for inflation
Vegetated geogrid	$ 20.00	square yard	includes geotextile fabric: 2 member crew and foreman	Means 1996 and adjusted for inflation
Pipe	$ 30.00	linear foot	10" pipe steel: 3 member crew, foreman, backhoe	Means 1996 and adjusted for inflation
Inlet/outlet structure	$3,500	each	concrete with riprap splash pool and vegetated geogrid slopes	Means 1996 and adjusted for inflation
Soil Stabilization/Repair	$2.50	square yard	2 member crew and foreman with heavy equipment	Means 1996 and adjusted for inflation
Trash and Debris				
Volunteer Mobilization	$ 60.00	day	Includes flyers, meetings, and memberagement	
Tree removal	$ 325.00	hour	includes crew, equipment, and removal fees	Means 1996 and adjusted for inflation: Includes heavy equipment rental
Waste hauling fees	$ 75.00	load	should include a $2 tip fee for each tire	

Heavy Obstructions	$ 890.00	each		includes, crew, equipment, and removal fees	Means 1996 and adjusted for inflation: Includes heavy equipment rental
Rill and Gully					
Berm and Tube	$ 1,500.00	each		with 3 crew, foreman, heavy equipment and materials	NRCS
Water Bars	$ 300.00	each			NRCS Nebraska Cost Estimator
Grassed Waterway	$ 690.00	acre		Best case Scenario with loose soil, no brush, and already tilled ($2245 ave.)	Means 1996 and Rogue River National Wet Weather Demonstration Project
Grassed Waterway	$ 3,800.00	acre		Worst Case Scenario in hard soil, with brush and dense vegetation ($2245 ave.)	Means 1996 and Rogue River National Wet Weather Demonstration Project
Stone Spillway	$ 9.50	square yard		3 member crew, foreman, heavy equipment and material	Means 1996 and adjusted for inflation
Diversions	$ 3.75	linear foot		grassed terrace to divert flow from tilled earth	NRCS and Means 1996
Habitat restoration					
Wetland Restoration	$ 2,350.00	acre		average of $500/acre and up	NRCS and Zbiciak
Channel block	$ 340.00	log structure	3-4/day	single log	Rogue River National Wet Weather Demonstration Project
Channel block	$ 480.00	log structure	2-3/day	triple height log	Rogue River National Wet Weather Demonstration Project
Channel block	$ 1,600.00	log structure	.5-1/day	crib wall: requires heavy equipment	Rogue River National Wet Weather Demonstration Project
Boulder Cluster	$ 59.20	cluster	25/day	varies depending on distance moved: requires heavy equipment	Rogue River National Wet Weather Demonstration Project
Cover logs	$ 290.00	log structure	5-10/day	3 member crew (requires heavy equipment)	Rogue River National Wet Weather Demonstration Project

Root wads	$ 300.00	wad	6-8/day	4 member crew (requires heavy equipment)	Rogue River National Wet Weather Demonstration Project
Tree Covers	$ 172.00	tree	8-12/day	If dropped in place or already in stream (requires heavy equipment)	Rogue River National Wet Weather Demonstration Project
Tree Covers	$ 215.00	tree	4-8/day	If they must me moved to site (requires heavy equipment)	Rogue River National Wet Weather Demonstration Project
Crib wall	$ 9.50	square foot	120+ feet/day	If done with heavy equipment	Rogue River National Wet Weather Demonstration Project
Crib wall	$ 36.50	square foot	20-30 feet/day	If done by hand	Rogue River National Wet Weather Demonstration Project
Log or Bank Shelter	$ 1,080.00	log structure	2/day	use in small streams with a low gradient (requires heavy equipment)	Rogue River National Wet Weather Demonstration Project
Deflectors	$ 390.00	log structure	2 pairs/day	requires highly experienced foreman to correctly size and place the structure	Rogue River National Wet Weather Demonstration Project
Channel Constrictors	$ 2,520.00	structure	1 pair/day	requires highly experienced foreman to correctly size and place the structure	Rogue River National Wet Weather Demonstration Project
Cross log	$ 680.00	structure	1-2/day	requires highly experienced foreman to correctly size and place the structure	Rogue River National Wet Weather Demonstration Project
Wedge and "K" dams	$ 1,360.00	dam	1/day	requires highly experienced foreman to correctly size and place the structure	Rogue River National Wet Weather Demonstration Project
Soil Stabilization					
Mulch	$ 500.00	acre		Using farm equipment	NRCS
Geotextile Fabric	$ 4.50	square yard		3 member crew, foreman, and material	Means 1996 adjusted for inflation
Seeding	$ 450.00	acre		includes site preparation using heavy equipment and 3 member crew	Means 1996 adjusted for inflation

Sodding	$ 13,068.00	acre	includes site preparation using heavy equipment and 3 member crew	Means 1996 adjusted for inflation
Check Dams	$ 15.00	linear foot	includes site preparation using heavy equipment and 3 member crew	Rogue River National Wet Weather Demonstration Project
Silt fence	$ 1.75	linear foot	Done with 3 member crew	Rogue River National Wet Weather Demonstration Project
Sediment Trap	$ 175.00	each	Done with 3 member crew	Rogue River National Wet Weather Demonstration Project
Road Crossing				
Box Culvert	$ 382.00	linear foot	36" culvert: excavation, crew, foreman, transporation, and installation	NPC Inc.
Bridge	$ 1,125.00	linear foot	72" culvert: excavation, crew, foreman, transporation, and installation	Bark River Culvert and Equipment
Cleaning	$ 8.50	cubic yard	Backhoe excavation of sediment	Rogue River National Wet Weather Demonstration Project
Equipment and Operator Rental				
Loader	$ 150.00	hour	includes operator	Rogue River National Wet Weather Demonstration Project
Excavator (backhoe)	$ 175.00	hour	includes operator	Rogue River National Wet Weather Demonstration Project
Dozer	$ 150.00	hour	includes operator	Rogue River National Wet Weather Demonstration Project
Crew	$ 30.00	hour		Rogue River National Wet Weather Demonstration Project
foreman	$ 50.00	hour		Rogue River National Wet Weather Demonstration Project
Design & legal			typically 25% to 30% of construction costs	Rogue River National Wet Weather Demonstration Project

Mobilization			3 to 5% of construction costs	Rogue River National Wet Weather Demonstration Project
Land Clearing	$ 300.00	acre	clearing and grading smooth	NRCS
Excavation	$ 3.50	cubic yard		Means 1996 and NRCS
Backfill	$ 12.00	cubic yard		Means 1996 and NRCS
Grade and Compact	$ 2.00	square yard		Means 1996 and NRCS

*** Prices are in 2002 dollars**

Information and Education Cost Estimates

Task	Costs	Units	Notes	Source
Promotional				
Flyer	$ 0.28	each	black and white	Grand Valley Community Survey
T-shirts	$ 12.50	each	Three color m,l, and XL	Grand Valley Community Survey
Video Production	$ 6,000.00	each		Grand Valley Community Survey
Telephone book inserts standard	$ 0.07	each	min order of $2500	Verizon Super Pages
Telephone book inserts new resident	$ 0.20	each	min order of $2500	Verizon Super Pages
Bathroom Advertising	$ 75.00	each/month	monthly rate for 11"x 17" plus $95 design and $2 reproduction	Johnny Avertising
Bathroom Advertising	$ 35.00	each/month	monthly rate for 8.5" x 11" plus $95 design and $2 reproduction	
Newspaper Ad	$ 32.00	square inch	Sunday paper full page ad about $4000	Muskegon Chronicle
Newspaper insert	$ 0.05	each	Cost of service only, reproduction is not included (1 sheet max)	Berrien County Drain Commission
Utility bill inserts	$ 0.50	each	Reproduction and distribution	Grand Valley Community Survey
Yellow Pages Ad	$ 5,000.00	each/year	Half Page Add in Yellow Pages	Verizon Super Pages

Watershed Logo Signs	$ 90.00	each	11x17" sign	Grand Valley Community Survey
Operational				
Project Manager/year	$ 29,120.00	$15/hour		Bear Creek Watershed Project
Intern/year	$ 20,800.00	$10/hour		Bear Creek Watershed Project
Vehicle/year	$ 15,000.00	each	does not include maintenance or insurance	Bear Creek Watershed Project
Mileage	$ 3,840.00	$0.32/mile		MDEQ
Fringes (20%)	$ 13,752.00		20 percent of total	MDEQ
Community Development				
Oridinance Development	$ 8,000.00		lawyer fees and meetings	Grand Valley Community Survey
Education				
School Presentation	$ 250.00	each	plus 20 hours preparation	Grand Valley Community Survey
4H Program	$ 39,000.00	annually	Management, Staff, and programs	Bear Creek Watershed Project
Demonstration Sites				
Agriculture	$ 1,350.00	each		Grand Valley Community Survey
demonstration booth	$ 200.00	each		Grand Valley Community Survey
Outreach				
Riparian Club	$ 8,000.00	annually		Grand Valley Community Survey
field trips	$ 16.00	each student		Grand Valley Community Survey
phone hotline	$ 1,142.00		first year startup	Bell South
Oil recycling container	$ 2.79	each	min order of 300 and $750 delivery	GEOPlastics
Adopt-a-Stream Program	$ 3,200.00	annually		Grand Valley Community Survey
Evaluation				
Water Quality Monitoring	$ 180,000.00	annually		Bear Creek Watershed Project
Stream Monitoring	$ 25,000.00	annually		Bear Creek Watershed Project
Fieldwork				
Canoe trip	$ 250.00	each		Grand Valley Community Survey

Watershed tours	$	200.00	each		Grand Valley Community Survey
Public Relations					
Public Meetings	$	250.00	each		Grand Valley Community Survey
Workshop	$	500.00	each	plus 40 hours preparation	Grand Valley Community Survey
Committee Meeting	$	25.00	each		Grand Valley Community Survey
Newsletters					
Mailing	$	0.30	each	bulk non-sorted	USPS
	$	0.12	each	presorted bulk mail rate	USPS
	$	600.00	year	application and accounting fees for bulk mailing	USPS
Color glossy	$	2.30	each		Allegan Conservation District
Inserts	$	0.12	each	black and white	Berrien County Drain Commission
Envelopes	$	0.03	each	business envelopes box of 500	Staples.com
Letter	$	0.27	each	envelop, postage, and form letter	